Before the National Green Tribunal
Principal Bench at New Delhi

OA No. 606 of 2022

In the matter of:

Public Action Committee …Applicant

Versus

State of Punjab & Ors. …Respondents

Response of the Applicant to the oral application of the company seeking approval from this Hon’ble NGT for continuing of the fuel ethanol plant

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Place: New Delhi,

Date: 21.11.2025

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1. These submissions are divided into two parts: **Part (I) presents the scientific and technical grounds establishing that the Fuel Ethanol Plant is inherently more polluting than a distillery, that fuel ethanol production is environmentally unsustainable, and that authoritative global and Indian scientific evidence demonstrates the serious air, water, soil, and public-health hazards associated with such units**.

2. **Part (II)** outlines the legal and regulatory grounds demonstrating that the Fuel Ethanol Plant at Zira cannot be permitted to operate under any circumstances, including the **absence of a valid Environmental Clearance, the illegality of its Consent to Operate, the facility's record of pollution, site contamination, and the severe groundwater stress in the region**.

Part-I

Fuel Ethanol Plants Emit Toxic Pollutants

3. The scientific material compiled in the Memorandum Regarding the Environmental and Economic Impacts of Ethanol (**Annexure A-1**) and the Memorandum of Concerns Regarding Environmental Clearances for Grain-Based Ethanol Plants in India at (**Annexure A-2)** herein confirms that the fuel ethanol plants release hazardous compounds such as **acetaldehyde, formaldehyde, and acrolein**. A fuel-grade anhydrous ethanol unit therefore imposes significantly higher air, water, and energy pollution loads than a potable distillery. Yet this distinction is absent from the Respondent's Environment Clearance amounting to material non-disclosure and violation of Paragraph 7(ii) of the EIA Notification, 2006. The Respondent's attempt to treat the "distillery" and "ethanol unit" as separate entities is an afterthought designed to evade accountability for non-compliance.

Why Fuel Ethanol Plants are Inherently Environmentally Unsustainable: Scientific Perspectives on Environmental and Economic Impacts of Ethanol

4. Contrary to the popular narrative of ethanol being a "green" or "clean" alternative to fossil fuels, multiple scientific and expert studies establish that ethanol manufacturing facilities are inherently environmentally harmful and economically inefficient. The applicant has attached herewith the research as **Annexure A-1 at (page no. 35-43)** to substantiate this position. The memorandum prepared by the scientific community examines the environmental and economic implications of ethanol production. It notes:

> “While proponents often cite ethanol as a "greener" alternative to fossil fuels, a growing body of scientific evidence reveals a starkly different reality. This document presents a compilation of expert analysis and peer-reviewed research, demonstrating that corn-based ethanol production, far from being a sustainable solution, imposes significant environmental burdens, economic inefficiencies, and potential public health risks.”

5. The Summary of the research at Annexure A-1 compiles leading global scientific research demonstrating that ethanol, particularly grain-based or corn-based ethanol, is fundamentally unsustainable and environmentally harmful. The scientific consensus reflected in this annexure shows that **ethanol production increases greenhouse-gas emissions, accelerates land-use change, raises fertilizer consumption, intensifies nitrate pollution, and places significant stress on water resources.** Several authoritative peer-reviewed studies establish that the lifecycle emissions of ethanol are equal to or worse than gasoline. The material also highlights that ethanol production depends heavily on land, water, and subsidies, and therefore cannot be considered a green or low-impact industry.

   This material establishes that ethanol plants impose substantial environmental costs and operate in conflict with sustainability, climate protection, food security, and water-resource protection. It provides strong scientific grounding to show that ethanol production is not a benign or environmentally sound activity, and that the environmental risks of such plants are inherent and unavoidable.

Concerns Regarding Environmental Clearances for Fuel Ethanol Plants in India

6. The research further critiques the economic inefficiency of ethanol production, driven by government subsidies and diversion of food crops (such as maize and sugarcane), leading to rising food prices and unsustainable agricultural practices. It further identifies systemic regulatory deficiencies in the environmental clearance (EC) process for ethanol plants in India. It observes that **current EC assessments narrowly focus on boiler emissions**, while **ignoring process emissions** from **fermentation and distillation** that include **hazardous air pollutants** such as **acetaldehyde** and **formaldehyde**, both known **carcinogens**. It highlights that ethanol, often promoted as a sustainable fuel, in reality generates substantial environmental costs. The scientific findings contained in (**Annexure A-2, page no. 44-45)** unequivocally demonstrate that:

Volatile Organic Compound (VOC) emissions from ethanol plants are grossly under reported, with actual emissions being up to **30 times higher** than official estimates;

Ethanol units consume excessive quantities of groundwater, posing serious risks of long-term aquifer stress; and

Environmental monitoring and reporting standards in India are significantly weaker than international norms, such as those mandated under the U.S. Clean Air Act, where ethanol producers must disclose and regulate toxic emissions.

Increased greenhouse gas emissions from land-use changes and fertilizer application for feedstock crops; and High energy consumption in fermentation and distillation processes, which often offset the purported carbon savings of ethanol use.

7. It demonstrates that the environmental clearances issued to grain-based ethanol plants in India suffer from a fundamental and systemic defect: **they fail to assess or even acknowledge process emissions that arise directly from ethanol production**. The clearance documents focus almost entirely on boiler emissions, while scientific literature has repeatedly shown that the fermentation, distillation, dehydration, and drying stages of ethanol manufacturing release significant quantities of volatile organic compounds, aldehydes, and hazardous air pollutants. These emissions include carcinogenic and toxic substances such as acetaldehyde, formaldehyde, acrolein, and hexane. The annexure establishes that such emissions are scientifically proven, internationally documented, and quantitatively measured across multiple studies, yet Indian environmental clearances treat these emissions as nonexistent. This omission undermines the credibility and legality of the clearance process and presents serious risks to air quality, groundwater, and public health.

8. The material establishes that **ethanol plants are significant sources of carcinogenic emissions** and that India's EC framework fails to evaluate these pollutants at all. This structural omission means that ethanol plants operate without regulatory scrutiny of their principal pollution streams, creating heightened risks for rural communities and environmentally sensitive regions. The annexure therefore provides strong scientific and regulatory grounds for concluding that the environmental clearance process for ethanol plants is inadequate, incomplete, and incapable of safeguarding public health and the environment. The scientific material in (Annexure A-1 and A-2) **clearly establishes that grain-based ethanol**

plants are not low-impact facilities but inherently polluting and resource-intensive industries.

9. Some more independent international studies are given below to drive home the point that fuel ethanol production is significantly polluting.

   (a) **Farm to Fumes investigation** establishes that biofuel refineries emit unusually high levels of hazardous air pollutants like acetaldehyde, formaldehyde, acrolein and hexane, often exceeding emissions from petroleum refineries and marked by widespread permit violations. This report is at **Annexure A-3 at (page no.56-93)** hereto and the relevant parts are as under:

> **"biofuel manufacturing plants release significantly greater amounts of certain hazardous air pollutants than oil refineries. These include formaldehyde (a carcinogen), acetaldehyde (a probable carcinogen), hexane (which can attack the central nervous system and cause dizziness, nausea, and headaches) and acrolein (which can cause nausea, vomiting, diarrhea, lung and eye irritation, and shortness of breath). More acrolein is emitted from the biofuels industry than any other source in the U.S., according to reporting to EPA's Toxics Release Inventory. The same four pollutants also contribute to the formation of ground-level ozone, or smog, which is linked to a wide variety of respiratory ailments; as well as microscopic, soot-like particulates that can trigger heart and asthma attacks. Many biofuels plants violate their air**

> **pollution control permits, releasing illegal amounts of contaminants that threaten the health of downwind communities. And although biofuel facilities release less carbon dioxide on average than petroleum refineries, biofuel plants still emit large quantities of greenhouse gases for an industry that portrays itself as climate-friendly." (p3)**
>
> **"One *recent study, published by the National Academy of Sciences, found that corn-based ethanol's life-cycle greenhouse gas emissions are "no less than gasoline and at least 24 percent higher." (p18)***

(b) **Brady and Pratt's analysis of U.S. dry-mill ethanol plants** confirms systematic under-reporting of VOC emissions dominated by ethanol, acetaldehyde, acetic acid and ethyl acetate, with enforcement actions triggered once regulators uncovered the scale of non-compliance. This report is at **Annexure A-4** at **(page no. 94-106)** hereto and the relevant parts are as under:

> **"The enforcement actions uncovered underreported emissions and resulted in consent decrees that required pollution control equipment be installed." (p1)**
>
> **"Most facilities consistently reported detectable levels of acetaldehyde, acetic acid, ethyl acetate, formaldehyde, ethanol, and methanol at one or more emissions units." (p4)**

(c) **De Gouw et al.'s airborne** measurements further demonstrate that ethanol-plant VOC emissions are underestimated by factors of 5–30 and are significant regional sources of NO_x, SO_2, secondary ozone and aldehydes. This report is at **Annexure A-5** at **(page no.107-119)** hereto and the relevant parts are as under:

> **"fuel ethanol refinery represents 68.0% of sulfur dioxide (SO2), 50.5% of nitrogen oxides (NOx = NO + NO2), 67.2% of volatile organic compounds (VOCs), and 95.9% of ethanol emissions." (p1)**
>
> **"estimated emissions of several VOCs, notably ethanol, formaldehyde, and acetaldehyde, are significantly higher (factors of 10–30) than the NEI-2011 emissions, which is well outside the 50% uncertainty in the flux estimates." (p7)**

(d) These air-quality findings align with the parallel evidence on liquid waste as **Chowdhary, Khan and Bharagava** in their paper shows that distillery and ethanol-plant effluent contains extremely high COD/BOD, toxic organics and dissolved solids that contaminate groundwater, degrade soil health and damage crops even at low levels of leakage. This report is at **Annexure A-6** at **(page no.120-123)** hereto and the relevant parts are as under:

> **"It is analyzed that distillery wastewater, highly polluted and having very high COD and BOD, and dark brown reddish colour." (p1)**

> **"Distillery wastewater contains various types of recalcitrant organic pollutants including endocrine disrupting chemicals like phthalates… causing hormonal imbalance and leading to carcinogenesis." (p1)**

The true copies of the studies on fuel ethanol have been annexed herewith as Annexure A-3, A-4, A-5, A-6 at page nos 56-123

10. These findings applied to the present case in Zira where groundwater beneath the site is already contaminated and where illegal reverse-boring and waste dumping have been documented, these scientific findings assume immediate relevance. An industry known to emit hazardous pollutants cannot be permitted to operate on an environmentally compromised aquifer under a clearance that has never assessed its actual emissions. The risks to groundwater, public health, and the surrounding community are unacceptable, and the plant cannot lawfully continue operations on this site.

Part-II

Fuel Ethanol Production Unit source of Pollution

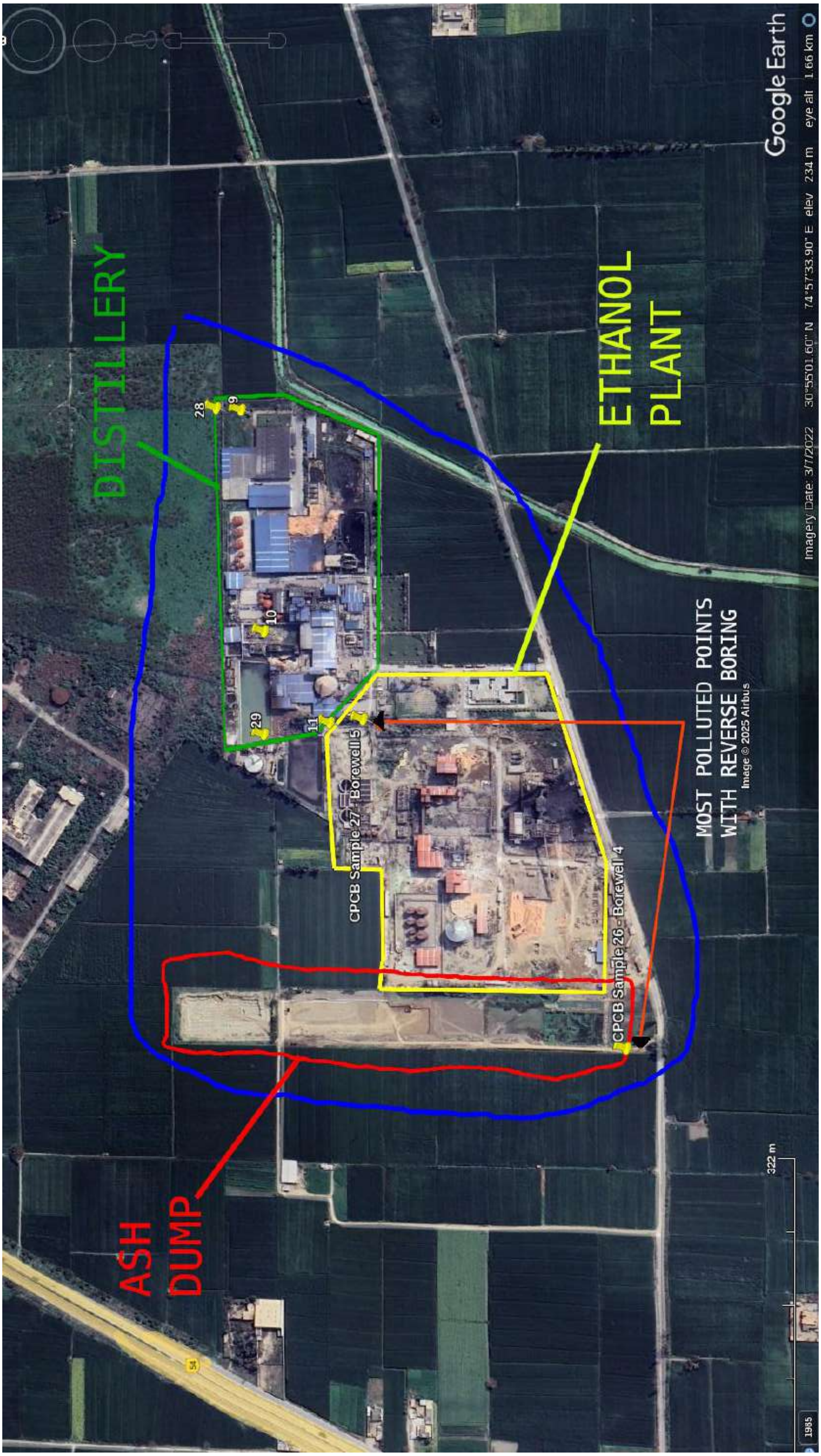
Worst CPCB Water Samples from Fuel Ethanol Plant Site itself.

11. **The Fuel Ethanol Plant began functioning in February 2022, following its Consent to operate in November 2021 from the PPCB,**

making a direct link between the commencement of <u>fuel</u> ethanol production and the pollution at the site also resulting in illegal dumping of fly ash in open areas. Though the earlier reports regarding pollution from the factory such as the Vidhan Sabha Report of 2006 was pollution coming from the **beverage ethanol plant** which produced ethanol of 95% purity, the subsequent pollution reports after the setting up of the **<u>fuel</u>** ethanol plant in February 2022 and the closure of the alcohol producing distillery in July 2022, was specifically and only in respect of the production of fuel ethanol. That these reports show heightened levels of pollution demonstrates that **fuel ethanol production is many times more hazardous and polluting than beverage ethanol production**.

12. The practice of reverse boring, conclusively established by the CPCB report dated 17.05.2023 identifies borewell samples **Nos. 26 and 27**, located **<u>within or adjoining the Fuel Ethanol Plant premises,</u>** as the **most contaminated** among all samples collected.

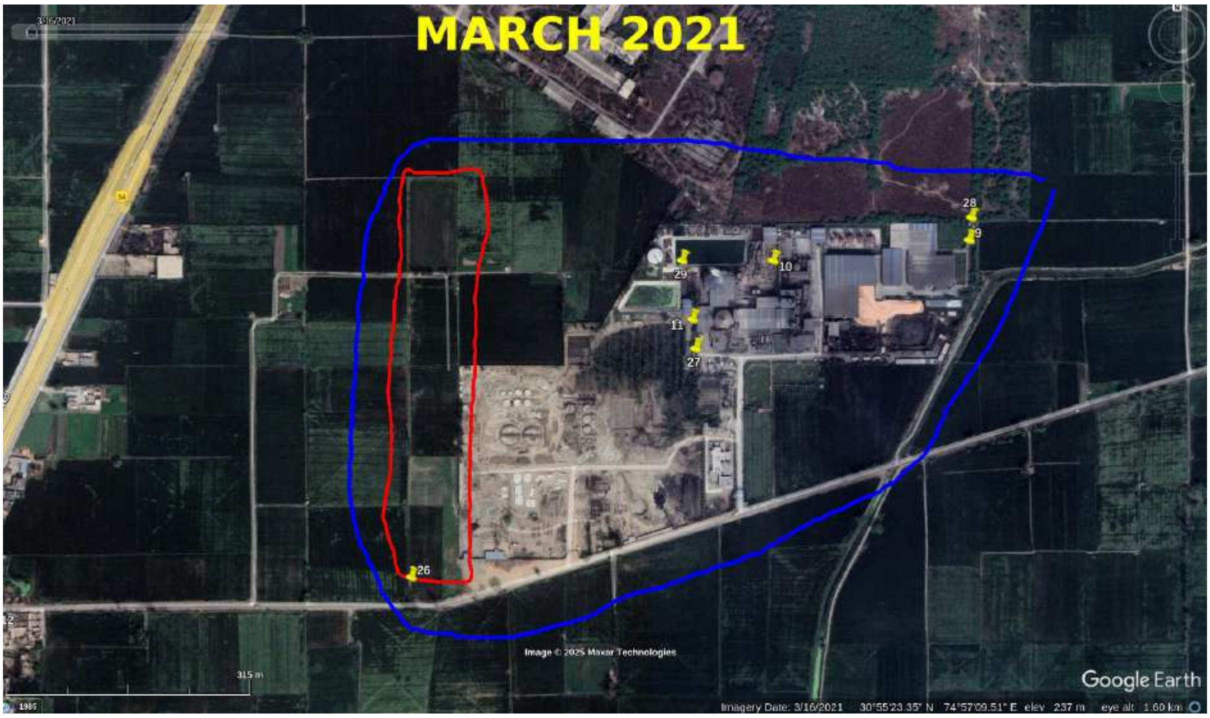
13. Sample 26 lies on the south-west side of the Fuel Ethanol Plant, distant from the old distillery. Sample 27 lies on the north-east side, within the Fuel Ethanol Plant boundary. This correlation between the highest contamination levels and the **<u>Fuel Ethanol plant site confirms its direct contribution to groundwater pollution.</u>**


DISTILLERY
ETHANOL PLANT
MOST POLLUTED POINTS WITH REVERSE BORING
ASH DUMP
28
9
10
29
11
CPCB Sample 27 - Borewell 5
CPCB Sample 26 - Borewell 4
Image © 2025 Airbus
Google Earth
Imagery Date: 3/7/2022 30°55'01.60" N 74°57'33.90" E elev 234 m eye alt 1.66 km
322 m
1985
54

Fly Ash resulted from operation of Fuel Ethanol Plant

14. The respondent industry has unequivocally admitted before this Hon'ble Tribunal that it dumped fly ash by excavating extensive areas within its factory premises. This admission is independently corroborated by satellite imagery (Google Earth). Satellite images from March 2021 depict a 10-acre site **adjacent to the Fuel Ethanol Plant** in an entirely pristine and undisturbed condition.

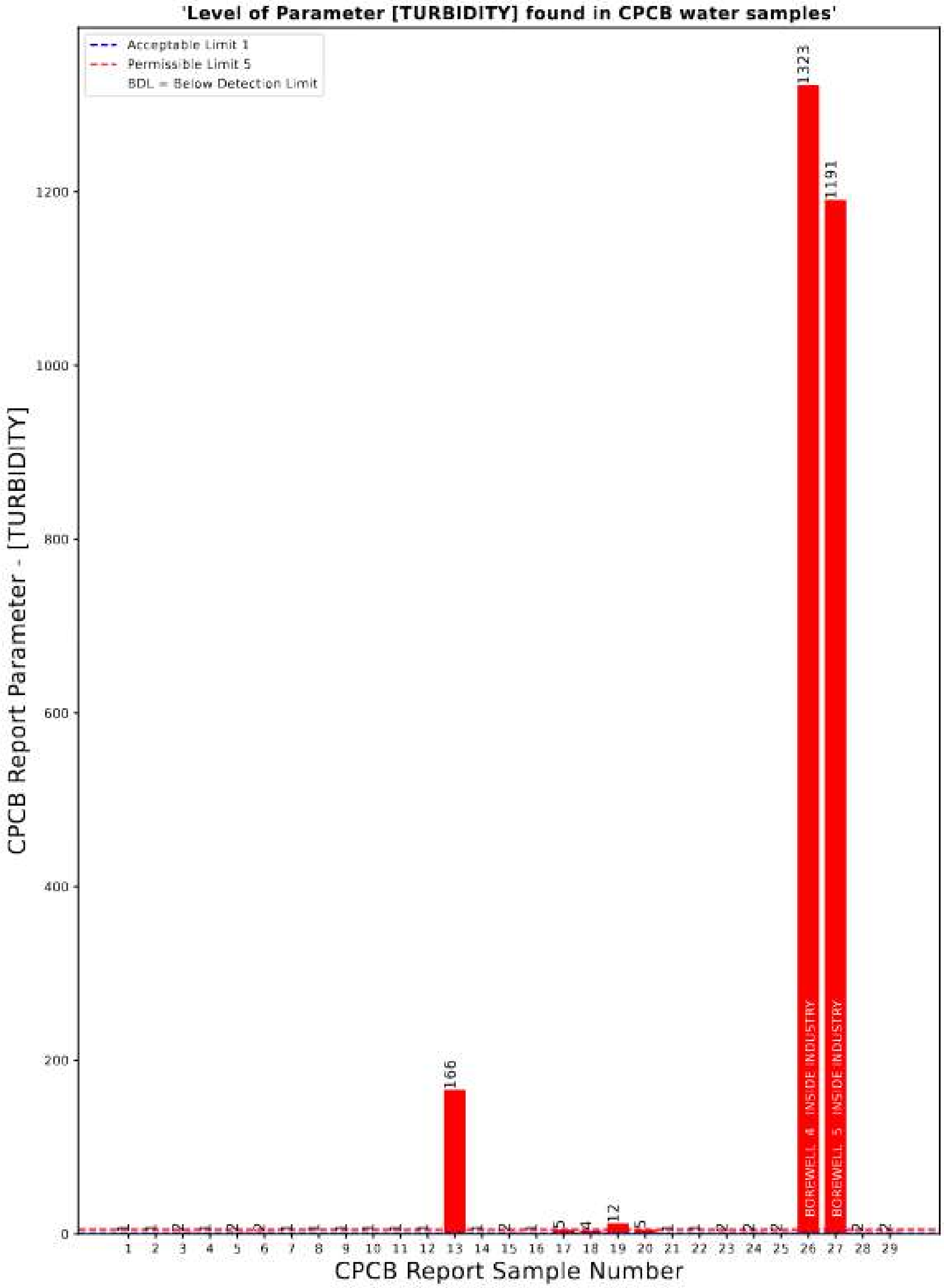
15. However, by April 2022, the same area is shown to have been **completely excavated and subsequently filled with fly ash**. **Crucially, this transformation occurred after the commencement of operations of the Fuel Ethanol Plant, leaving no ambiguity that the excavation and dumping activity and therefore the resultant pollution, directly emanated from the functioning of the Fuel Ethanol Plant. This establishes a clear causal link between the fuel ethanol plant's operations and the environmental degradation at the site.**

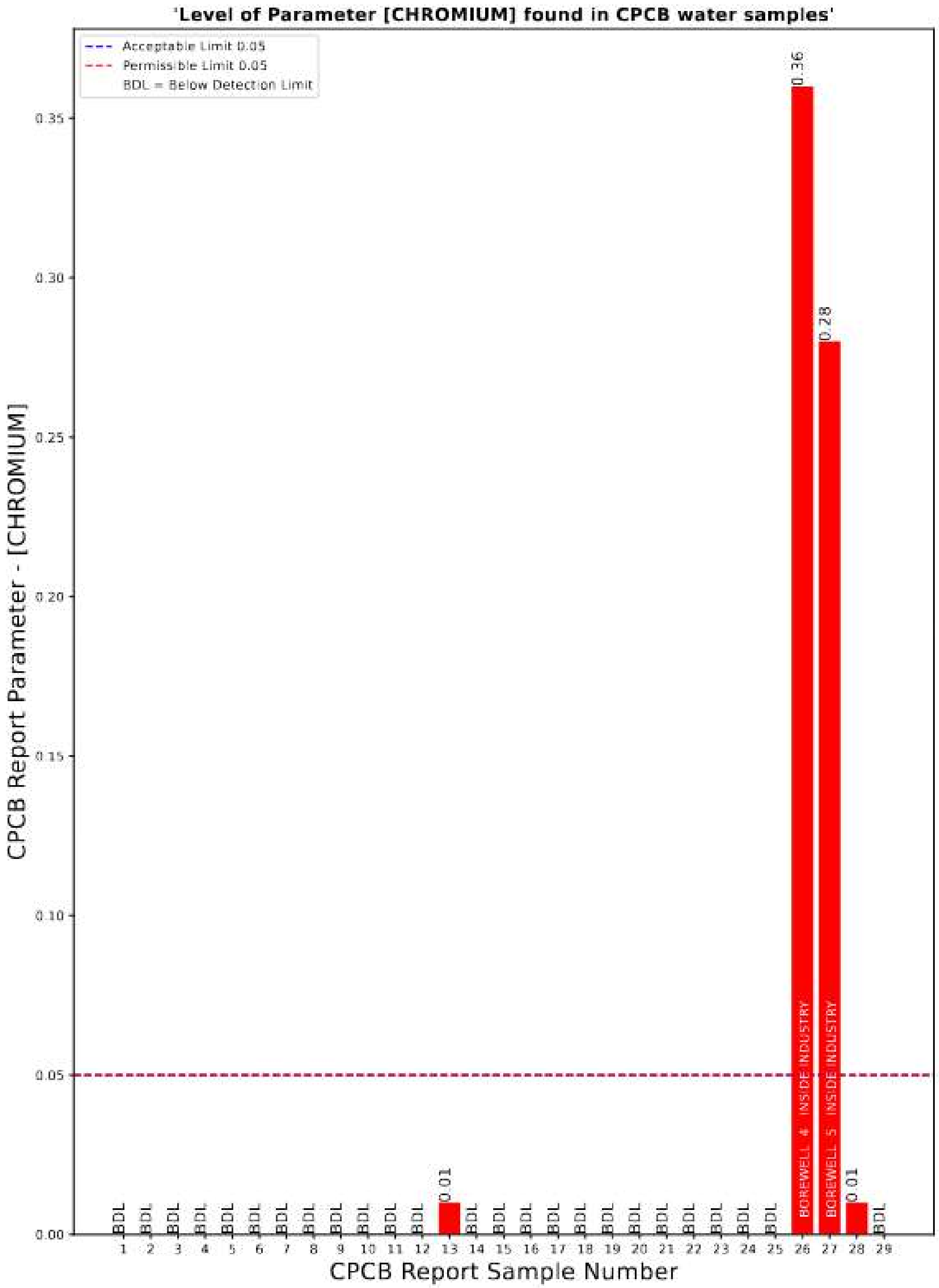

MARCH 2021
3/16/2021
28
9
29
10
11
27
26
315 m
Image © 2025 Maxar Technologies
Google Earth
Imagery Date: 3/16/2021 30°55'23.35" N 74°57'09.51" E elev 237 m eye alt 1.60 km

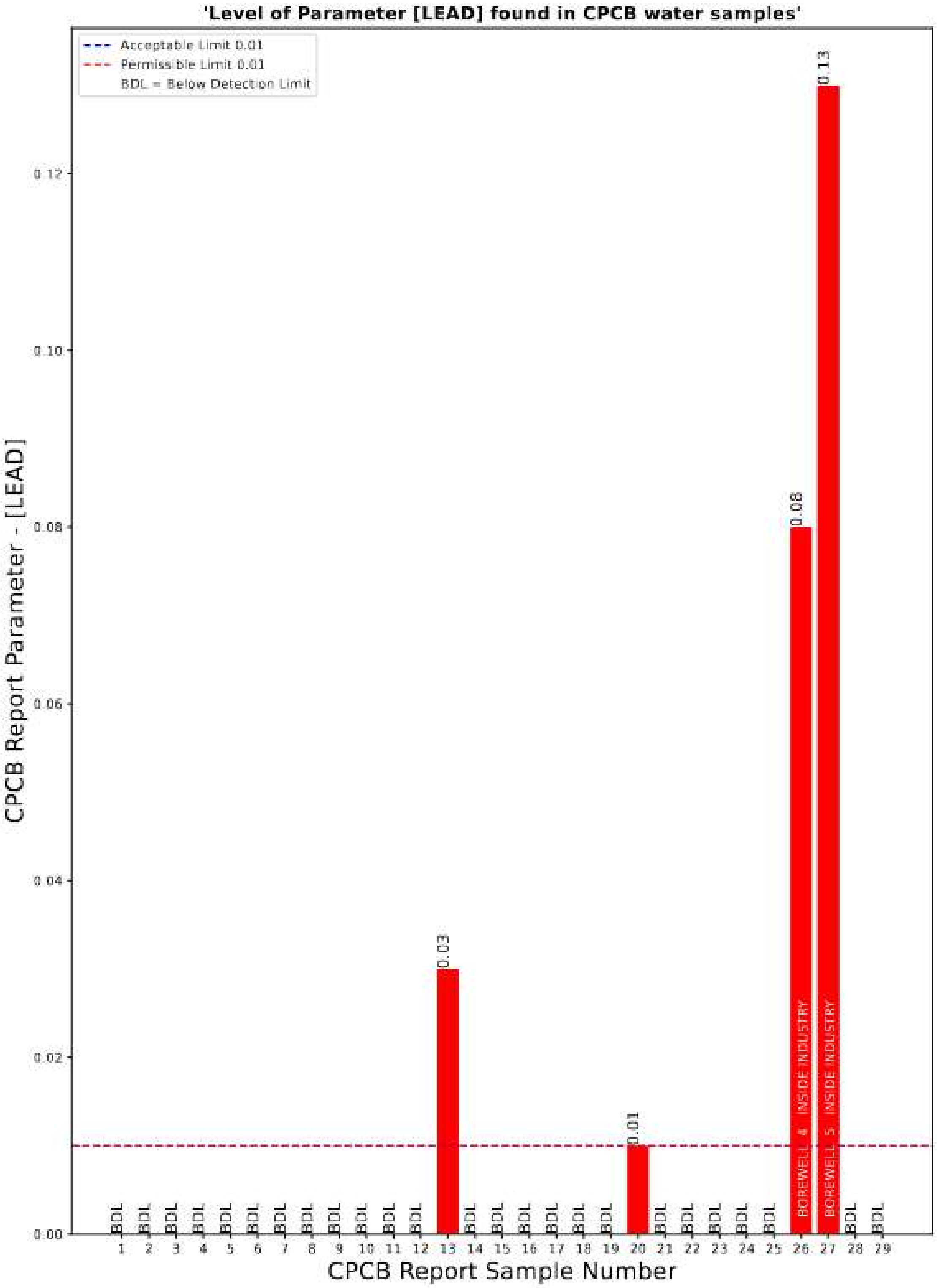

APRIL 2022
28
9
29
10
11
27
26
315 m
Image © 2025 Maxar Technologies
Google Earth
Imagery Date: 4/10/2022 30°55'07.80" N 74°57'29.78" E elev 233 m eye alt 1.60 km

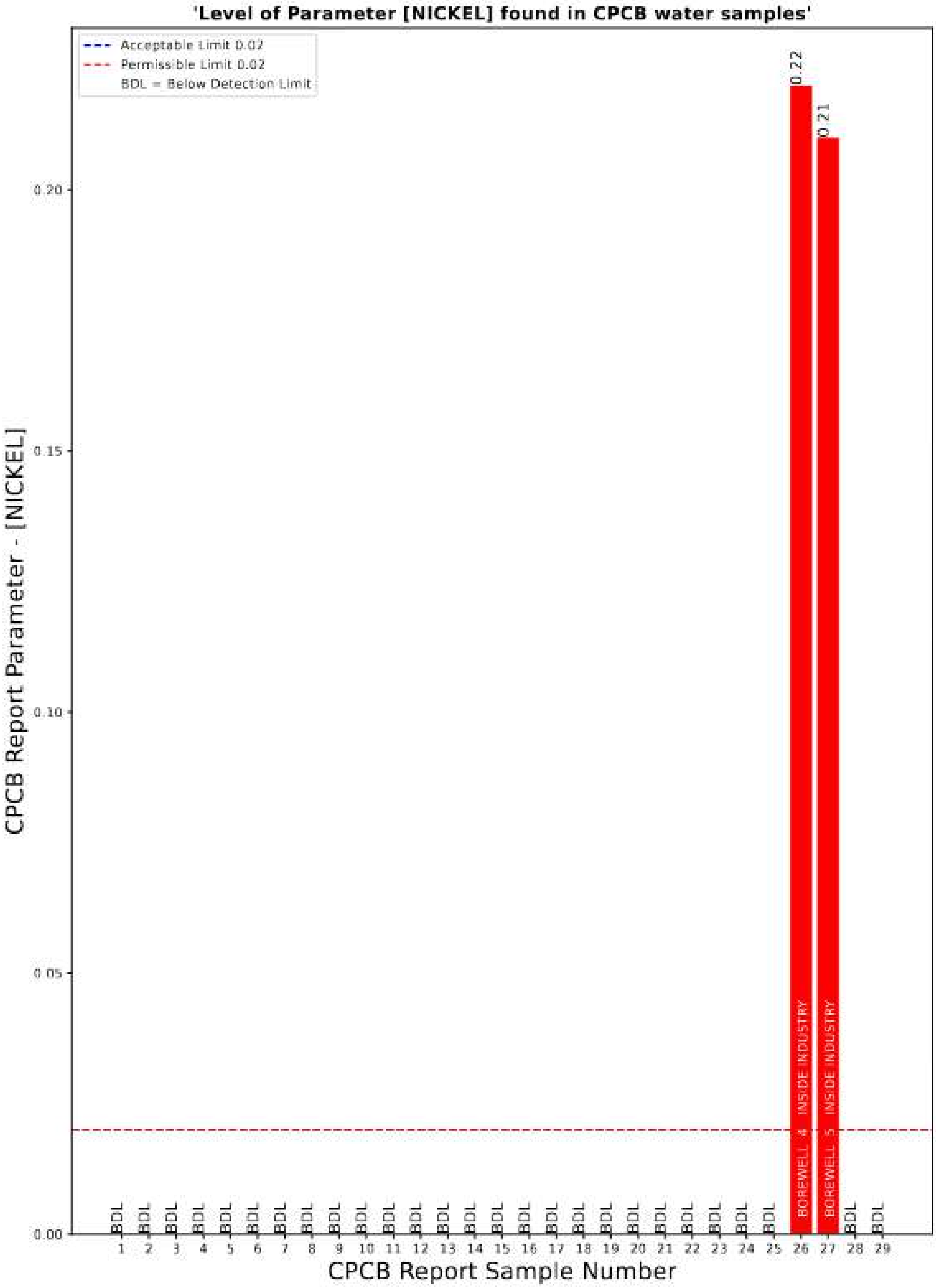
16. This dumping as illustrated above has resulted in fly ash dispersal, affecting ambient air quality and posing health hazards. This has also been demonstrated in video evidence already submitted to the Tribunal. **(CD enclosed in earlier written submission of original applicant and R-8**). Further, as stated by the villagers, photographic evidence shows that the Respondent’s illegal fly ash dump was also used for sprinkling effluent, which percolated into the groundwater due to the removal of the topsoil layer (excavated up to 20 feet). Further, the District Mining Officer has issued a challan to the Respondent for this illegal excavation, as reflected and annexed on page no. 148–149 of the case record.

Samples of water found by CPCB in Fuel Ethanol Plant Borewells turned out to be the MOST TOXIC.


'Level of Parameter [TURBIDITY] found in CPCB water samples'
Acceptable Limit 1
Permissible Limit 5
BDL = Below Detection Limit
CPCB Report Parameter - [TURBIDITY]
CPCB Report Sample Number
0
200
400
600
800
1000
1200
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
1
1
2
1
2
2
1
1
1
1
1
1
166
1
2
1
5
4
12
5
1
1
2
2
2
1323
1191
2
2
BOREWELL 4 INSIDE INDUSTRY
BOREWELL 5 INSIDE INDUSTRY


'Level of Parameter [CHROMIUM] found in CPCB water samples'
Acceptable Limit 0.05
Permissible Limit 0.05
BDL = Below Detection Limit
CPCB Report Parameter - [CHROMIUM]
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
CPCB Report Sample Number
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
BDL BDL BDL BDL BDL BDL BDL BDL BDL BDL BDL BDL 0.01 BDL BDL BDL BDL BDL BDL BDL BDL BDL BDL BDL BDL 0.36 0.28 0.01 BDL
BOREWELL 4 INSIDE INDUSTRY
BOREWELL 5 INSIDE INDUSTRY


'Level of Parameter [LEAD] found in CPCB water samples'
Acceptable Limit 0.01
Permissible Limit 0.01
BDL = Below Detection Limit
CPCB Report Parameter - [LEAD]
CPCB Report Sample Number
0.00
0.02
0.04
0.06
0.08
0.10
0.12
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
BDL
0.03
0.01
0.08
0.13
BOREWELL 4 INSIDE INDUSTRY
BOREWELL 5 INSIDE INDUSTRY


'Level of Parameter [NICKEL] found in CPCB water samples'
Acceptable Limit 0.02
Permissible Limit 0.02
BDL = Below Detection Limit
CPCB Report Parameter - [NICKEL]
CPCB Report Sample Number
0.00
0.05
0.10
0.15
0.20
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
BDL
0.22
BOREWELL 4 INSIDE INDUSTRY
0.21
BOREWELL 5 INSIDE INDUSTRY

Correlation of Metals Found by CPCB with Coal/Pet-Coke Ash

17. The EIA/EMP report in the R-7's own reply to IA states that the industry uses coal and pet-coke as 15% auxiliary fuel in its boilers. Ash from these fuels is known to contain **heavy metals such as chromium, copper and lead.** The CPCB report dated 17.5.23 and the Chief Secretary's Committee report found exactly these metals inside the Malbros premises, including chromium, copper and lead in soil and groundwater samples. Since the company dumped large quantities of ash in unlined excavated pits within the factory and is proven to have pumped effluent into the groundwater through reverse boring, this combination presents a credible pathway for these metals to reach the aquifer.

18. Peer-reviewed scientific investigations **of combustion residues from coal and** coal–petroleum-coke blends—most notably the trace-element analyses conducted by *Henke et al.* **(Annexure-7 at page no.124-137) and** the Indian leaching study by *Sarode et al.* **(Annexure-8 at page no. 138-143)** establish that fly ash generated from these fuels contains a distinct suite of toxic heavy metals**,** including nickel, vanadium, chromium, lead, manganese, copper, and zinc**.**

19. These metals become enriched on the surface of ash particles during high-temperature combustion. Both studies further confirm, using standardised leaching protocols such as TCLP and batch/pH-dependent tests, that several of these metals can mobilise under typical disposal, ponding, or wet-contact conditions**.** Thus, it is a scientifically recognised fact that coal- or coal–petcoke-based ash has an inherent potential to release heavy metals into the soil and groundwater**.**

20. Collectively, these findings provide a clear and well-documented scientific mechanism by which industrial operations using coal/petcoke as auxiliary fuel can generate fly ash capable of contaminating groundwater if improperly handled, disposed of, or allowed to infiltrate the subsurface environment**.**

Legal and Regulatory Grounds for Closure of the Fuel Ethanol Plant

2018 Environmental Clearance only for expansion of distillery
Not for fuel ethanol plant

The word used in the clearance is merely Ethanol and not Anhydrous Ethanol.

Thus ethanol means beverage ethanol not fuel ethanol

However, intention of company was to make an entirely different product in the guise of ethanol production. Deliberately done to start Anhydrous Ethanol Production silently.

2006 EC wrongly used for production of a different product.

21. **The EC dated 15.01.2018 was granted solely for the expansion of the distillery to 600 KLD, expressly permitting the production of ENA and Industrial Alcohol (both producing 95% purity).** The said EC contains no reference whatsoever to Anhydrous Ethanol, fuel-grade ethanol, or any associated dehydration unit which the Respondent has been operating. However, the Respondent Company has commenced production of **Anhydrous Ethanol in 2022** which is a *fuel-grade product*

that requires an additional dehydration process, **despite not having been granted Environmental Clearance (EC) for the same.**

22. It is stated that commencement of Anhydrous Ethanol production constitutes a **material change in product mix** and **process configuration**, which under Paragraph 7(ii) of the EIA Notification, 2006, mandates prior appraisal and approval by the competent regulatory authority. It states as under:

> “**7(ii). Prior Environmental Clearance (EC) process for Expansion or Modernization or Change of product mix in existing projects**: All applications seeking prior environmental clearance for expansion with increase in the production capacity beyond the capacity for which prior environmental clearance has been granted under this notification or with increase in either lease area or production capacity in the case of mining projects or for the modernization of an existing unit with increase in the total production capacity beyond the threshold limit prescribed in the Schedule to this notification through change in process and or technology **or involving a change in the product -mix** shall be made in Form I and they shall be considered by the concerned Expert Appraisal Committee or State Level Expert Appraisal Committee within sixty days, who will decide on the due diligence necessary including preparation of EIA and public consultations and the application shall be appraised

> accordingly for grant of environmental clearance.” *(emphasis own)*

23. **However, no such prior approval was taken. Nor a modified Environment Clearance for production of Anhydrous Ethanol is on record.**

24. It is obvious from the reply of R-7 to IA No. 705 of 2025 that Anhydrous Ethanol or Fuel Ethanol was never mentioned in the Environment Clearance and it only appeared in CTO in 2021.

25. The switchover from a 96% beverage ethanol manufacturing plant to a 99.9% fuel/anhydrous ethanol manufacturing plant has been achieved by **skirting around and hoodwinking** the EIA process. The respondent plainly applied only for an expansion of capacity, as is evident from the subject of the Environment Clearance itself and **made no disclosure of any ‘change in product mix**.’

26. **By adding the word ‘ethanol’ into a capacity-expansion application dated 2018, a generic expression was malafidely used to trick the authorities,** because the term ethanol is a generic term **that can cover entirely different products i.e. beverage, industrial and fuel grade ethanol and the term can also include in some circumstances but not in the present case, fuel ethanol. By this sleight of hand the company has misled the authorities and in effect achieved a complete change in product and process without explicitly declaring the new product i.e. fuel ethanol in the Environment Clearance**.

27. Further, the documents placed before the regulatory authority describe a conventional grain-based distillery producing **industrial alcohol and rectified spirit**, **with no mention of the dehydration, denaturation or additional process units required to produce 99.9% anhydrous ethanol used for fuel blending**. Random statements about possible downstream uses cannot replace a **formal declaration of product category** under the EIA framework.

28. What has been done here is not an **oversight but a deliberate device to conceal a process and product transformation that attracts separate appraisal due to change in the product mix**. This is a clear case of **misusing a statutory environmental-clearance mechanism by selective and misleading terminology**. Therefore, its production is in violation of the EIA Notification, 2006 and Section 15 of the Environment (Protection) Act, 1986.

29. The attempts to create confusion by the respondent company continues even now as the respondent's reply to the applicant's IA **deliberately creates confusion** by using the expressions '**industrial alcohol'** (which can be even 95% purity) and '**fuel-grade ethanol**' (99.9% purity) interchangeably, **as though they refer to the same substance and process** but these products are entirely different. Throughout its pleading, particularly in paragraph 8(b), the company alternates between these terms without acknowledging that they **represent fundamentally different products**.

30. **Industrial alcohol as referred to in 2018 Environment Impact Assessment (EIA) clearances, denotes denatured rectified spirit or extra neutral alcohol of 95–96% purity** used for industrial purposes

whereas '**<u>Fuel-grade ethanol</u>,' by contrast, is anhydrous alcohol of 99.9% purity obtained only after an additional dehydration process using molecular sieves or azeotropic distillation**. **<u>By omitting this distinction and presenting both within a single continuum of "ethanol production," the respondent attempts to suggest that the Environmental Clearance for a distillery producing industrial alcohol also covers manufacture of fuel ethanol for petrol blending</u>**.

31. This linguistic and conceptual merging of two distinct products is a **calculated attempt to obscure** the fact that **the dehydration process and its environmental implications of fuel ethanol were never part of the project appraised or cleared by the Ministry. The production of Fuel Ethanol as a product is therefore legally not cleared, not authorized and not allowed.**

32. It is therefore submitted that the Respondent's repeated assertion that the production of anhydrous ethanol is 'covered' under the existing Environmental Clearance dated 15.01.2018 for grain-based ENA/RS/industrial alcohol is misconceived and factually untenable. **<u>The two products fall under separate BIS classifications, operate at distinct purity levels, and require entirely different process technologies, particularly the dehydration step that is absent in ordinary distillation</u>.**

The BIS standard document - IS 15464: 2022 *Anhydrous Ethanol for Use as Blending Component in Motor Gasoline* is attached herewith and marked as **<u>Annexure A-9</u> at page no.144-175 Also IS 323: 2009 Rectified *Spirit for Industrial Use Standard*** is attached herewith and marked as **<u>Annexure A–10</u> at page no.176-190**

So Bureau of Indian Standards clearly treats them as **completely separate** product categories.

33. To remove any remaining doubt, and to eliminate even the slightest ambiguity on this issue, there is clinching evidence that anhydrous or fuel-grade ethanol could not have been part of the Environmental Clearance granted on 15 January 2018. At the time when the Respondent obtained this expansion EC, **the manufacture or supply of fuel-grade ethanol from grain was not legally permissible in India**. The Ministry's own Expert Appraisal Committee (EAC), while considering grain-based proposals during this period, expressly recorded that "**as per the present ethanol tender norms, fuel ethanol production from grain is not permissible**." **Until mid-2018, the Ethanol Blending Programme procured ethanol exclusively from molasses-based routes, and grain-based ethanol was ineligible for blending or supply**.

34. The first policy instrument that permitted the use of grain for fuel ethanol appears only in the National Policy on Biofuels, 2018, issued on 4 June 2018 and notified on **8 June 2018**, which states that "the policy will also allow production of ethanol from damaged food grains like wheat, broken rice etc." **These permissions arose months after the Respondent's expansion EC dated 15.1.18 and therefore could not have formed part of its appraisal**. The 2018 EC cannot, in law or in fact, be construed as authorising an anhydrous or fuel-ethanol plant, and any such production constitutes an **undisclosed and unauthorised change in product mix requiring prior environmental clearance under paragraphs 2(ii) and 7(ii) of the EIA Notification, 2006**.

35. A change of this magnitude in **process configuration**, **product category** and **end-use** cannot, in law, be subsumed under a clearance issued for a 95–96% rectified spirit distillery. The Respondent's attempt to conflate these distinct categories is a **deliberate misstatement intended to escape the mandatory appraisal** under Para 7(ii) of the EIA Notification, 2006.

Fuel ethanol production requires new and advanced technology
Generates severe air and water pollution

36. The manufacture of fuel-grade anhydrous ethanol requires, as a matter of scientific necessity, a dehydration technology such as molecular sieve adsorption or azeotropic distillation processes that generate their own independent **pollution load**, **thermal demand**, **volatile organic emissions**, and **effluent streams.** These processes do not exist in a conventional industrial alcohol distillery and were neither disclosed nor appraised when the EC dated 15.01.2018 was granted. The omission of this additional process line constitutes **material suppression, vitiating the environmental clearance** and **rendering all operations of the anhydrous ethanol plant illegal for want of prior approval**.

PPCB Consent to Operate 2021: both illegal and underhand
A Sleight of Hand to Bypass Mandatory Environmental Clearance

37. Moreover, the consent to operate dated 12.11.21 issued by the Punjab Pollution Control Board to produce Anhydrous Ethanol, notwithstanding the absence of any corresponding approval for such product or process in the valid environmental clearance held by the respondent company is illegal. It violates the provisions of the Water (Prevention and Control of Pollution) Act, 1974, and the Air (Prevention and Control of Pollution)

Act, 1981, where a State Pollution Control Board is empowered to issue **consents only in respect of industrial activities that possess valid prior environmental clearance** where such clearance is mandated under the EIA Notification, 2006.

38. The grant of a CTO is thus contingent upon and subsidiary to the existence of a valid EC; **it cannot, in law, enlarge or modify the scope of the EC issued** under the Environment (Protection) Act, 1986. Accordingly, the inclusion of Anhydrous Ethanol as an approved product in the consent to operate, in the absence of a corresponding EC, renders such consent ultra vires. Any consent issued contrary to or beyond the EC is ultra vires and has no legal effect. The Respondent was therefore required to first obtain an **amended EC** before applying for such consent.

39. In its IA Reply dated 7.11.2025, Malbros has admitted that no modification or amendment of the EC was sought from the Ministry of Environment, Forest and Climate Change. **The company relies solely on the Consent to Operate dated 12.11.2021 issued by the Punjab Pollution Control Board, which for the first time introduces the term 'anhydrous denatured ethanol.'** Such a state-level consent cannot enlarge the scope of a central environmental clearance granted under the EIA Notification. The Pollution Control Board may regulate emissions and effluent standards, but it has no jurisdiction to authorise a new product line or a change in process that was never appraised by the competent authority under the central statute.

40. The regulatory record is therefore clear. The 2006 EC authorised a distillery producing rectified spirit, ENA, and liquor. The 2018 EC authorised only an expansion in capacity of that same activity. Neither

clearance authorised production of anhydrous or fuel-grade ethanol. Commencing such production in 2022, under a CTO that went beyond the scope of the central clearance, constitutes a change in product mix implemented without prior environmental clearance, in direct violation of paragraphs 2(ii), and 7(ii) of the EIA Notification, 2006.

EC must be understood as clearance for alcohol and beverage ethanol

41. It is submitted that respondent company's prayer seeking distinct and continued operation of the Fuel Ethanol Plant was never raised. Every distillery producing alcohol will have within its premises a distillery for the production of beverage alcohol (95% purity). The letter of the company to the authorities dated 15.1.18 has the following heading:

> "Expansion of grain based **distillery** from 100 KLPD to 600 KLPD"

42. **Thus when expansion was sought it was prior to the National Policy on Bio Fuels, 2018 notified on 8.6.18. This expansion had nothing to do with the production of fuel ethanol. Therefore, the word 'ethanol' used in the clearance dated 15.1.18 has nothing to do with fuel ethanol**. A true copy of the National Policy on Bio Fuels, 2018 is attached herewith and marked as **Annexure A-11 at (page no.191-213)**

Fuel Ethanol Production Scale and its direct contribution to Pollution

43. The Respondent industry, Malbros International Pvt. Ltd., has itself admitted in Paragraph 7 of I.A. No. 262 of 2022 that it was producing approximately **75 lakh litres of fuel ethanol per month for the three**

months immediately preceding the plant’s closure following widespread public protests in 2022.

Collectively, therefore, the Respondent’s facility was operating at an effective combined capacity of approximately 280 KLD, producing fuel ethanol at a scale nearly **three times higher** than its original single-unit capacity. Such intensified production would have resulted in a proportional increase in:

- **Effluent discharge and wastewater generation**, particularly from fermentation, distillation, and dehydration processes.
- **Air emissions**, including volatile organic compounds (VOCs) and aldehydes from distillation and dehydration; and
- **Solid waste generation**, notably **fly ash** from increased fuel combustion in boilers.

44. Given that the plant was functioning at this heightened capacity in the immediate period prior to the pollution crisis, it is a reasonable and evidence-based inference that this **intensified fuel ethanol production was a major contributing factor to the severe groundwater contamination and environmental degradation confirmed by the Central Pollution Control Board (CPCB) and other expert studies**. The **operational evidence points conclusively to the fuel ethanol unit functioning as a major source of pollution** that precipitated the environmental crisis and public unrest in Zira.

No Industrial Activity can now continue at Contaminated Site.

45. The site of Malbros International Pvt. Ltd. at Mansoorwal Kalan, Zira has already been found **contaminated** as recorded by the Central Pollution

Control Board in its report of May 2023. Once such contamination is established, the law itself renders the premises ineligible for industrial operations. The Environment (Protection) (Management of Contaminated Sites) Rules, 2025, notified by the Ministry of Environment, Forest and Climate Change vide S.O. 3401(E) dated 24 July 2025, create a statutory bar on any activity at a contaminated site. True copy of the Notification dated 24.7.25 issued by the Ministry of Environment, Forest and Climate Change has been annexed herewith as **Annexure A-12** at **(page no. 214-257)** and the relevant part is as under:

> "4(11) The State Board shall issue a public notice restricting or prohibiting any activity during the preliminary or detailed assessment of the suspected or probable contaminated site, respectively, keeping in view the risks involved to human health and the environment, under intimation to relevant authorities in the State Government."
>
> "5(12) The State Board shall, keeping in view the risks involved in human health and the environment, issue a public notice restricting or prohibiting any activities during the time of remediation of the contaminated site which may include change in land use and transfer or change in ownership of land, or building or any facility on the land."
>
> "5(15) The State Board, after completion of the remediation, shall notify the remediated site specifying the land use fit for carrying out certain activities or restrict any such activity on such site and furnish a report to the Central Board."

46. Under Rule 4(11) provides that during preliminary or detailed investigation, the State Pollution Control Board shall issue a public notice to restrict or prohibit any activity that could adversely affect or exacerbate contamination. Rule 5(12) further mandates that during remediation the State Board shall issue a public notice restricting or prohibiting change in land use, construction, ownership or any activity on the site. These provisions operate together to ensure a continuous prohibition on all forms of industrial or developmental activity **from the stage contamination is identified until remediation is completed** and certified under Rule 5(15).

47. **Therefore, a contaminated site (the factory premises) cannot lawfully continue to host or revive industrial production under any form or label**. Allowing the fuel ethanol unit to operate on the same contaminated land would directly violate the mandatory restrictions contained in Rules 4(11) and 5(12) mentioned above and would frustrate the **precautionary** and polluter-pays principles enshrined in Section 20 of the NGT Act, 2010 and defeat the object of the Environment (Protection) Act, 1986.

48. The only lawful and environmentally tenable course is **permanent closure of the industrial unit**, followed by **remediation** of the contaminated land at the cost and responsibility of the polluter. Further in terms of the undertaking given this Hon'ble Tribunal may direct the company to:

> **To completely shut down and dismantle the distillery plant as well as the entire ethanol production plant(s) be it beverage ethanol or fuel ethanol**.

Anhydrous Ethanol Plant is More Polluting than a Distillery

49. A plant manufacturing **Anhydrous (fuel-grade) Ethanol**, ethanol of 99.9 percent purity for blending with petrol has a **<u>higher pollution potential</u>** than a standard distillery producing **Rectified Spirit (RS)** or **Extra Neutral Alcohol (ENA)** of 95–96 percent purity. Both share common fermentation and rectification stages, but the production of anhydrous ethanol requires an **additional dehydration process to remove residual water**. This process involves either molecular-sieve adsorption, which requires high heat and pressure for regeneration, or azeotropic distillation using benzene, cyclohexane, or pentane, all of which are volatile organic compounds (VOCs).

50. The scientific material compiled in the Memorandum Regarding the Environmental and Economic Impacts of Ethanol (Annexure A-1) and the Memorandum of Concerns Regarding Environmental Clearances for Grain-Based Ethanol Plants in India shows they are **<u>emission-prone,</u>** releasing hazardous compounds such as **acetaldehyde, formaldehyde, and acrolein**. Relevant parts are as under:

> This literature unequivocally documents the release of a multitude of chemical pollutants from various stages of grain-based ethanol production, including volatile organic compounds (VOCs), aldehydes, and other hazardous air pollutants. This omission poses a serious threat to public health and environmental integrity, as it disregards the comprehensive air pollution profile of these facilities.

51. A fuel-grade anhydrous ethanol unit therefore imposes significantly higher air, water, and energy pollution loads than a potable distillery. Yet this distinction is absent from the Respondent's Environment Clearance amounting to material non-disclosure and violation of Paragraph 7(ii) of the EIA Notification, 2006.

52. As per the Central Ground Water Board (CGWB) report (2024), **the groundwater table in Zira, Ferozepur District is already over-exploited by 221%, indicating an acutely unsustainable level of extraction**. The Environmental Clearance (EC) of 2018, the Respondent industry is **drawing its freshwater requirement directly from the groundwater aquifer**. Such extraction, in an area already identified as critically over-exploited, would severely compromise water availability for domestic, agricultural, and ecological needs, aggravating a region-wide water crisis. Allowing continuation of the Fuel Ethanol Plant's operations would therefore directly contradict the principles of sustainable water use and inter-generational equity. A true copy of the groundwater status report of Zira is annexed herewith as **Annexure A-13** at **(page no. 258-265)**

Illegal Substitution of Statutory Public Consultation With Sarpanch Letters

53. The Respondent attempts to rely on letters purportedly issued by the Sarpanches of Ratol Rohi and Mansoorwal Kalan as evidence of 'community consent.'

These letters, even if genuine, cannot substitute the statutory requirement of public consultation under the EIA Notification, 2006. Public hearing is a mandatory step, requiring public notice, open participation, disclosure of impacts, and an opportunity for objections. The selective procurement of signatures from two individuals is neither a legal nor a credible substitute. Such reliance itself demonstrates the Respondent’s disregard for due process and further underscores why its plea for continuation of operations cannot be entertained.

Seeks Revocation of 2018 Environment Clearance for being deliberately vague and illegal.

54. The Applicants have already filed a detailed and substantiated petition before the Ministry of Environment, Forest and Climate Change seeking cancellation of the Environmental Clearance dated 15.01.2018 granted to Malbros, on the grounds of persistent EC violations, undisclosed and illegal operations for large-scale production of fuel Ethanol carried out wholly beyond the scope of the sanctioned clearance.

55. The plea for cancellation specifically documents the Respondent’s unauthorised establishment and operation of the anhydrous ethanol unit, deliberate vagueness in the Environment Clearance to continue Fuel Ethanol plant and Respondent’s failure to disclose the requisite process changes, and the material suppression made during appraisal. All of which render the 2018 Environment Clearance liable to be revoked. A true copy of the letter seeking cancellation of Environment Clearance has been annexed herewith as **Annexure A-14 at (page no. 266-270).**

Place: New Delhi,
Date: 21.11.2025

Filed by: Kawalpreet Kaur

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Annexure A-1

Memorandum Regarding the Environmental and Economic Impacts of Ethanol

Scientific Perspectives

Public Action Committee & others v/s State of Punjab & others.

OA 606 of 2022

"Biofuels may be palliative in the short term in terms of greener energy. But in the long term, we are going to run out of space to grow food, which is more important than finding alternative ways to power Rolls-Royces and superjets."

— Sir David Attenborough in an interview with Nick Harding

Introduction

This Memorandum of Law is submitted to the Hon. NGT in connection with OA 606 of 2022, concerning the environmental and economic impacts of ethanol production and its regulatory framework. It addresses the central issue of whether the current policies and mandates promoting corn-based ethanol align with established environmental protection standards and sustainable economic practices. While proponents often cite ethanol as a "greener" alternative to fossil fuels, a growing body of scientific evidence reveals a starkly different reality. This document presents a compilation of expert analysis and peer-reviewed research, demonstrating that corn-based ethanol production, far from being a sustainable solution, imposes significant environmental burdens, economic inefficiencies, and potential public health risks.

As Sir David Attenborough aptly stated, "Biofuels may be palliative in the short term in terms of greener energy. But in the long term, we are going to run out of space to grow food, which is more important than finding alternative ways to power Rolls-Royces and superjets."[1] This observation underscores the fundamental conflict between prioritizing fuel production and ensuring food security, a conflict exacerbated by the land-intensive nature of corn ethanol.

This memorandum will detail how the scientific consensus, as evidenced by the cited research, establishes that corn ethanol:

Increases greenhouse gas emissions rather than reducing them, primarily due to land-use changes and fertilizer application.

Degrades water quality and increases fertilizer usage, contradicting environmental protection goals.

Diverts valuable agricultural land from food production, contributing to potential food security issues and price increases.

Operates with a low energy return on investment (EROEI), rendering it economically inefficient without substantial subsidies.

Contributes to air pollution, specifically increased ozone levels, posing risks to public health.

By presenting this evidence, this document seeks to demonstrate that the continued support and mandate of corn-based ethanol is inconsistent with sound environmental policy and sustainable economic principles. The information contained herein is relevant to determining the proper regulatory approach to biofuels within the scope of OA 606 of 2022.

[1] https://www.independent.co.uk/news/people/profiles/sir-david-attenborough-this-awful-summer-we-ve-only-ourselves-to-blame-7942405.html

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Scientific Perspectives on Ethanol

“Most prior studies have found that substituting biofuels for gasoline will reduce greenhouse gases because biofuels sequester carbon through the growth of the feedstock. These analyses have failed to count the carbon emissions that occur as farmers worldwide respond to higher prices and convert forest and grassland to new cropland to replace the grain (or cropland) diverted to biofuels. By using a worldwide agricultural model to estimate emissions from land-use change, we found that corn-based ethanol, instead of producing a 20% savings, nearly doubles greenhouse emissions over 30 years and increases greenhouse gases for 167 years.”

— Timothy Searchinger et al (2008), "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change" Science, VOL 319, 1238-40, 29 February 2008

Source https://www.science.org/doi/10.1126/science.1151861

“These changes increased annual nationwide fertilizer use by 3 to 8%, increased water quality degradants by 3 to 5%, and caused enough domestic land use change emissions such that the carbon intensity of corn ethanol produced under the RFS is no less than gasoline and likely at least 24% higher.”

— Lark, T.J., et al. (2022), "Environmental outcomes of the US Renewable Fuel Standard." Proceedings of the National Academy of Science

Source https://www.pnas.org/doi/10.1073/pnas.2101084119

"The paper by Lark et al. provides us with yet more evidence that our corn-based biofuel initiatives run counter to our nation's and the world's environmental, economic, and social goals. It is worth questioning the wisdom, logic, and ethics of continuing to use large expanses of our best farmland to produce a small amount of fuel at great environmental cost when better transportation alternatives exist."

— Jason Hill, "The Sobering Truth About Corn Ethanol," PNAS 2022 Vol. 119 No. 11

Source https://www.pnas.org/doi/full/10.1073/pnas.2200997119

"The global GHG impact of biofuel use remains highly uncertain. Nevertheless, the necessary condition for a biofuel to offer a CO2 mitigation benefit, namely, that the production of its feedstock must increase NEP, can be evaluated empirically. Doing so provides a bounding result that suggests a need for greater caution regarding the role of biofuels in climate mitigation."

— John M. DeCicco, Emeritus Research Professor at the University of Michigan Energy Institute

Source https://link.springer.com/article/10.1007/s10584-016-1764-4

"The only way ethanol makes sense is as a political issue."

— Jason Hill, University of Minnesota

Source https://grist.org/agriculture/despite-what-you-may-think-ethanol-isnt-dead-yet/

"Corn-based ethanol remains too marginal to survive without heavy economic subsidy."

— Cutler J. Cleveland, Charles A. S. Hall, Robert A. Herendeen

Source https://www.science.org/doi/10.1126/science.312.5781.1746

"We need alternative energy. But ethanol from corn is neither scalable nor sustainable. Let's pursue better options."

— Nathan Hagens, Robert Costanza, Kenneth Mulder

Source https://www.science.org/doi/10.1126/science.312.5781.1746

"Corn-based ethanol, instead of producing a 20% savings, nearly doubles greenhouse emissions over 30 years and increases greenhouse gases for 167 years. Biofuels from switchgrass, if grown on U.S. corn lands, increase emissions by 50%."

— Timothy Searchinger et al., "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases through Emissions from Land-Use Change," Science 319, no. 5867 (February 28, 2008): 1238-40.

Source https://www.science.org/doi/10.1126/science.1151861

"When the extra N2O emission from biofuel production is calculated in 'CO2-equivalent' global warming terms, and compared with the quasi-cooling effect of 'saving' emissions of fossil fuel derived CO2, the outcome is that the production of commonly used biofuels, such as biodiesel from rapeseed and bioethanol from corn (maize), depending on N fertilizer uptake efficiency by the plants, can contribute as much or more to global warming by N2O emissions than cooling by fossil fuel savings."

— P. J. Crutzen et al., "N_2O Release from Agro-Biofuel Production Negates Global Warming Reduction by Replacing Fossil Fuels," Atmospheric Chemistry and Physics 8, no. 2 (January 2008) (Paul Crutzen is a Nobel Laureate)

Source https://acp.copernicus.org/articles/8/389/2008/acp-8-389-2008.pdf

"My analysis concludes that the production of biofuels may have led to at least 192,000 additional deaths and 6.7 million additional lost 'disability-adjusted life years' in 2010. These estimates are conservative. Despite the underestimations, these estimates exceed the World Health Organization's estimates of the toll of death and disease for global warming. Thus, policies to stimulate biofuel production, in part to reduce the alleged impacts of global warming on public health, particularly in developing countries, may actually have increased death and disease globally."

— Indur M. Goklany, "Could Biofuel Policies Increase Death and Disease in Developing Countries?" Journal of American Physicians and Surgeons, Volume 16, Number 1, Spring (2011)

Source https://www.jpands.org/vol16no1/goklany.pdf

"Abusing our precious croplands to grow corn for an energy-inefficient process that yields low-grade automobile fuel amounts to unsustainable, subsidized food burning."

David Pimentel, Conell University

Source Cornell Chronicle, "Ethanol fuel from corn faulted as 'unsustainable subsidized food burning' in analysis by Cornell scientist," August 6, 2001.

https://news.cornell.edu/stories/2001/08/ethanol-corn-faulted-unsustainable-subsidized-food-burning

"The government spends more than $3 billion a year to subsidize ethanol production when it does not provide a net energy balance or gain, is not a renewable energy source or an economical fuel. Further, its production and use contribute to air, water and soil pollution and global warming."

David Pimentel, Conell University

Source: Cornell Chronicle, "Cornell ecologist's study finds that producing ethanol and biodiesel from corn and other crops is not worth the energy," July 5, 2005.

https://news.cornell.edu/stories/2005/07/ethanol-biodiesel-corn-and-other-crops-not-worth-energy

“For the U.S. to replace its 37 qBtu/yr oil habit with corn ethanol, it would take six times this much, or 220 qBtu (2.3×10^{20} J) of corn ethanol production each year. If the growing season is 5 months, the solar input is 250W/m^2 on average, and the corn field is 1.5% efficient at turning sunlight into chemical energy, then each square meter of corn-land produces 4.9×10^7 J of energy (150 days times 86,400 seconds per day times 250 W/m^2 times 0.015 gives Joules per square meter produced) and we would therefore need about 5×10^{12} m^2 of land for corn. This is an area 2,200 km on a side (Figure 14.4)! The U.S. does not possess this much arable land (estimated at about 30% of this). About 4×10^{11} m^2 of land in the U.S. is currently used for corn production, which is 8% of what would be needed. And, of course we must still feed ourselves. In 2018, 31% of U.S. corn production went into ethanol. We would somehow need to ramp corn ethanol production up by a factor of 40 to derive our current liquid fuels from corn in a self-sufficient way. Don’t expect to see this fantasy materialize.”

Fig 14.4

Note: A qBtu is a quadrillion British Thermal Units or 10^{15} Btu.

Tom Murphy, Professor, University of California, San Diego

Source Tom Murphy, Energy and Human Ambitions on a Finite Planet, 2021

“Box 14.5: Why Do Corn Ethanol?

If corn ethanol has such low EROEI, why is it pursued in the U.S.?

Why do we have mandates to introduce ethanol into fuel blends?

Don't assume that the world is always scientifically rational and run by "adults" whose interests extend beyond personal gain. Many political factors enter: votes from midwestern swing-states, . . .where corn is grown dependencies, influences from a powerful industry, the appearance of "green" (carbon-neutral) energy . . . compromised by low EROEI if using fossil-fuel inputs to run production all play a role."

Tom Murphy, Professor, University of California, San Diego

Source Tom Murphy, Energy and Human Ambitions on a Finite Planet, 2021

"Biofuels from Crops (Sec. 14.3; p. 230): While corn ethanol may not even be net energy-positive, sugar cane and vegetable oils as sources of biofuel fare better. But these sources compete with food production and arable land availability. So, biofuels from crops can only graduate from "niche" to moderate scale in the context of plant waste or cellulosic conversion.

The abundance and demonstration fields are thus split: food crop energy is demonstrated but severely constrained in scale. Cellulosic matter becomes a potentially larger-scale source but is undemonstrated. . . . to the point that perhaps this should Growing and harvesting annual crops on a relevant scale constitutes even be red a massive, perpetual task and thus scores yellow in difficulty—also driving down EROEI." (P 297)

Tom Murphy, Professor, University of California, San Diego

Source Tom Murphy, Energy and Human Ambitions on a Finite Planet, 2021

"Ozone is harmful to those who breathe it. On average, ethanol used in internal combustion engine vehicles produces more ozone than does gasoline used in vehicles in most regions of the United States." (P 178)

"Another problem with using ethanol as a fuel is water consumption. For example, irrigating only 13.2 percent of U.S. corn (the U.S. average irrigation rate for corn) that is needed to power a U.S. on-road vehicle fleet would require about 10 percent of the U.S. water supply.

Finally, because of the substantial land required for corn or cellulosic ethanol, neither can provide enough energy for more than a few percent of the U.S. vehicle fleet." (P. 181)

Mark Z Jacobson, Professor, Stanford University

Source Mark Z Jacobson, No Miracles Needed: How Today's Technology Can Save Our Climate and Clean Our Air, Cambridge University Press, 2023

"Far more land is taken up to grow corn for ethanol (30 million acres) than is needed for utility PV (17+ million acres) to power the entire U.S. for all energy-electricity, transportation, buildings, and industry after full electrification."

Source https://x.com/mzjacobson/status/1832842177480991137

"Replacing 30 million acres of corn used for ethanol with 13 million acres for utility PV (with the other 4 million acres of PV going on rooftops leaves 17 million acres of corn to be used for food above and beyond all the corn for food today."

Source https://x.com/mzjacobson/status/1832994991486177722

"Next time someone complains about how much land is needed by solar, point out that powering entire US for all purposes with PV replaces 1.24% of US land used for corn ethanol and 1.3% of US land used by fossil industry with 0.7% of land used for PV, part of which can go on roofs."

Source https://x.com/mzjacobson/status/1832925298754814286

"If we look only at the fuel corn ethanol does not seem to be an energy source. If we look at the process of making fuel and animal feed it is a modest energy source. Take your pick!" (P 132)

Charles A S Hall an American systems ecologist and ESF Foundation Distinguished Professor at State University of New York in the College of Environmental Science & Forestry is the founder of the concept of Energy Return on Investment.

Source Charles A S Hall, Energy Return on Investment, Springer, 2017.

Media and Public Commentary on Ethanol

Rolling Stone Magazine (2013): "Ethanol is not just hype — it's dangerous, delusional bullshit."

Source https://www.rollingstone.com/politics/politics-news/the-ethanol-scam-172037/

The Economist (2013): "The ethanol mandate is clearly wasteful, does environmental damage, contributes to higher food prices at home and abroad through the misallocation of agricultural resources, and is a needless tax on everyone who drives in America. Time for it to go."

Source https://www.economist.com/babbage/2013/03/25/difference-engine-end-the-ethanol-tax

The American Interest (2013): "Corn ethanol fails every test a biofuel could hope to pass."

Source http://blogs.the-american-interest.com/2013/04/11/is-the-end-in-sight-for-americas-biofuel-boondoggle/

Slate (2012): "You don't have to be an economist to understand why the ethanol sector is driving food prices higher. This year, about 4.3 billion bushels of corn will be converted into motor fuel. That means that nearly 37 percent of this year's corn crop will be diverted into ethanol production."

Source Robert Bryce, "Food as Fuel," published on robertbryce.com, July 31, 2012

https://robertbryce.com/food-as-fuel/

"Substituting agrofuels for fossil fuels to power this vast and rapidly expanding automobile fleet is simply not viable given the scale of demand. There is simply not enough agricultural land available to grow enough fuel crops to significantly offset fossil fuel use. In 2005, approximately 15 % of the U.S. corn crop yielded only about 2% of the country's non-diesel transport fuel. In Europe more than 20% of the rapeseed crop yielded only 1% of transport fuel.4 This is particularly outrageous given that human population is enormous and rising, as are standards of living in some regions. Feeding people must be a priority." (P 83)

Source The Real Cost of Agrofuels: Impacts on food, forests, peoples and the climate, 2008

https://www.globalforestcoalition.org/wp-content/uploads/2010/10/Truecostagrofuels.pdf

The US dedicates 40 million acres (nearly the size of Florida) to corn ethanol production, just under 45% of US corn production (source: USDA). Corn ethanol is 50-100X less land efficient than solar PV for powering transportation, according to multiple studies.

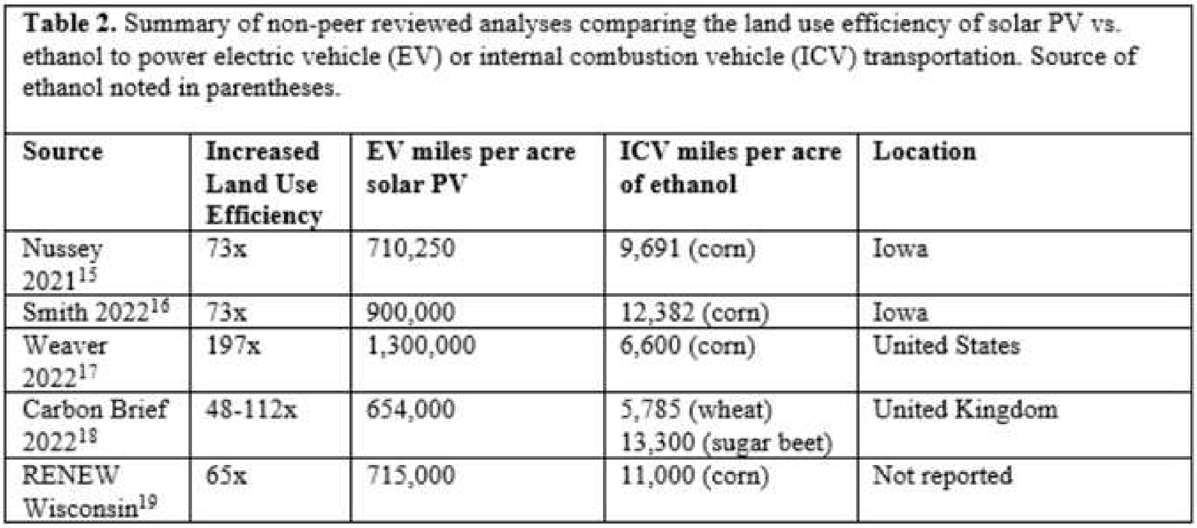

Table 2. Summary of non-peer reviewed analyses comparing the land use efficiency of solar PV vs. ethanol to power electric vehicle (EV) or internal combustion vehicle (ICV) transportation. Source of ethanol noted in parentheses.

Source	Increased Land Use Efficiency	EV miles per acre solar PV	ICV miles per acre of ethanol	Location
Nussey 2021[15]	73x	710,250	9,691 (corn)	Iowa
Smith 2022[16]	73x	900,000	12,382 (corn)	Iowa
Weaver 2022[17]	197x	1,300,000	6,600 (corn)	United States
Carbon Brief 2022[18]	48-112x	654,000	5,785 (wheat) 13,300 (sugar beet)	United Kingdom
RENEW Wisconsin[19]	65x	715,000	11,000 (corn)	Not reported

Tyler H. Norris is a power policy expert and a research fellow at Duke University

Source https://x.com/tylerhnorris/status/1683628769397932032

Freeing Energy (2021): Making ethanol from corn is the least efficient use of farmland

"An acre of solar produces far more energy than corn"

"If you compare the energy utility of an acre of solar panels to an acre of corn, the acre of solar wins by a landslide.

Each year, one acre of corn produces 551 gallons of ethanol, which is the equivalent of 386 gallons of gas. Using the average miles per gallon of a US automobile, this equates to 9,691 miles driven per acre of corn per year.

In Iowa, an acre of solar panels produces 198,870 kilowatt hours each year. A typical EV drives approximately 3.6 miles per kilowatt hour. So, each year, an acre of solar panels produces enough energy for an EV to drive 710,250 miles. This is over 70 times the distance the same acre producing corn could provide.

Unlike ethanol, an acre of solar can power anything attached to the grid. The same Iowa acre, for instance, could also be used to provide 18 average US homes with electricity for the year.

The financial utility of replacing corn with solar also promises huge gains for farmers. For example, it is not uncommon for a farmer to make two to three times more money per acre leasing to solar rather than planting corn. Solar also guarantees a steady stream of revenue, unlike corn which stands the risk of crop failure and price volatility.

Moreover, solar panels can successfully coexist with corn crops using a practice known as "agrivoltaics." This technique has been found to increase corn yield per square meter and to generate nearly five times the amount of revenue of a traditional corn field."

Source https://www.freeingenergy.com/replace-farmland-farm-corn-ethanol-solar-panels/

Annexure A-2

Memorandum of Concerns Regarding Environmental Clearances for Grain-Based Ethanol Plants in India

Air Pollution from Ethanol Plants

Public Action Committee & others v/s State of Punjab & others.

OA 606 of 2022

This Memorandum is submitted to the National Green Tribunal in connection with OA 606 of 2022 to raise critical concerns regarding the adequacy and accuracy of environmental clearances granted to numerous grain and sugarcane-based ethanol projects in India, particularly those supplying the Ethanol Blended Petrol (EBP) program. These clearances, issued by the Ministry of Environment, Forest and Climate Change, are fundamentally flawed due to a significant omission: the failure to accurately account for and address process emissions arising directly from the ethanol production process.

The crux of this memorandum lies in the stark discrepancy between the environmental clearance letters, which primarily focus on boiler emissions from coal or biomass combustion, and established scientific literature. This literature unequivocally documents the release of a multitude of chemical pollutants from various stages of grain-based ethanol production, including volatile organic compounds (VOCs), aldehydes, and other hazardous air pollutants. This omission poses a serious threat to public health and environmental integrity, as it disregards the comprehensive air pollution profile of these facilities.

The rapid proliferation of grain-based ethanol plants, driven by the EBP program, necessitates a rigorous and transparent assessment of their environmental impact. The current clearance process, which overlooks critical process emissions, undermines the very purpose of environmental impact assessments and jeopardizes the sustainable implementation of biofuel policies.

This memorandum will detail:

- The documented scientific evidence of process emissions from grain-based ethanol plants includes specific pollutants and their potential impacts.
- The inadequacy of the environmental clearances highlights the omission of these critical emissions.
- The potential public health and environmental consequences of this oversight.
- The legal and regulatory obligations that mandate a comprehensive assessment of all emissions from these facilities.

By presenting this evidence, we respectfully request the Honourable Tribunal to take cognizance of the serious deficiencies in the environmental clearance process and to direct the relevant authorities to conduct a thorough reassessment of the environmental impacts of grain-based ethanol plants, ensuring compliance with established environmental standards and safeguarding public health. The urgency of this matter cannot be overstated, as the continued operation of these plants under flawed clearances poses a significant and immediate risk to the environment and the well-being of the citizens of India.

Evidence of Ignored Emissions:

University of Nebraska Studies: Master of Science in Environmental Engineering theses of the University of Nebraska by Duerschner (2019) and Al-Faliti (2020) are based on the experimental study of the biological air pollution control of Hazardous Air Pollutants (HAPs) generated in the production of ethanol using the technique of Biotrikling filters (BTFs). The major pollutants generated in the process are Acetaldehyde, Formaldehyde, Acrolein, and Hexane. The data given below show that their odour threshold values are very low and the people in the neighbourhood can recognize the presence of these vapours easily at very low concentrations also. The companies denying causing any odour pollution is vested denial and not factual.

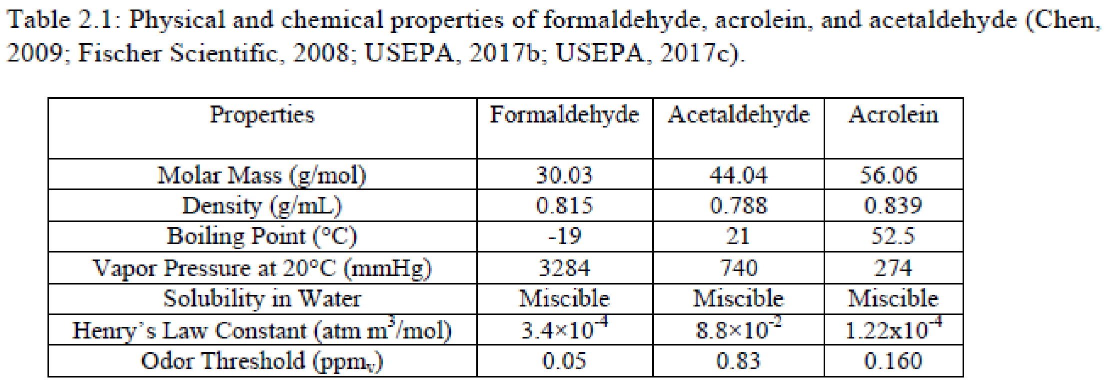

Table 2.1: Physical and chemical properties of formaldehyde, acrolein, and acetaldehyde (Chen, 2009; Fischer Scientific, 2008; USEPA, 2017b; USEPA, 2017c).

Properties	Formaldehyde	Acetaldehyde	Acrolein
Molar Mass (g/mol)	30.03	44.04	56.06
Density (g/mL)	0.815	0.788	0.839
Boiling Point (°C)	-19	21	52.5
Vapor Pressure at 20°C (mmHg)	3284	740	274
Solubility in Water	Miscible	Miscible	Miscible
Henry's Law Constant (atm m^3/mol)	3.4×10^{-4}	8.8×10^{-2}	$1.22x10^{-4}$
Odor Threshold (ppm_v)	0.05	0.83	0.160

The experimental study was conducted at Pacific Ethanol East Plant, Aurora, NE.

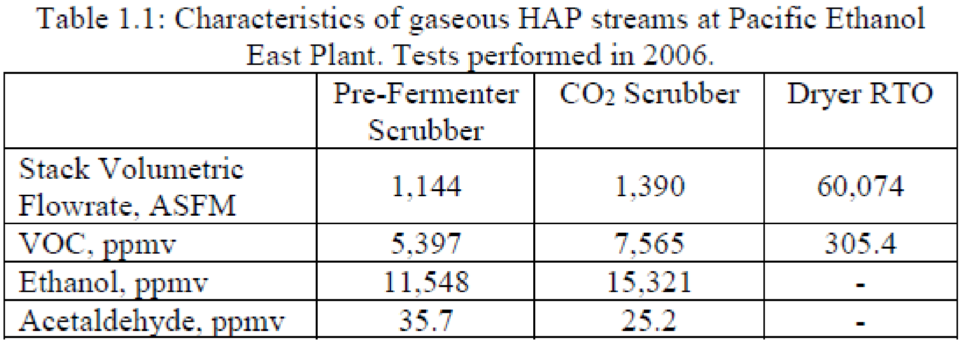

Table 1.1: Characteristics of gaseous HAP streams at Pacific Ethanol East Plant. Tests performed in 2006.

	Pre-Fermenter Scrubber	CO_2 Scrubber	Dryer RTO
Stack Volumetric Flowrate, ASFM	1,144	1,390	60,074
VOC, ppmv	5,397	7,565	305.4
Ethanol, ppmv	11,548	15,321	-
Acetaldehyde, ppmv	35.7	25.2	-

Flow and concentration data for pollutant streams, as presented by Duerschner (2019), indicate that emissions from the dryer are processed through a regenerative thermal oxidizer (RTO). This treatment is justified on the basis that the dryer vapors are at a higher temperature and, crucially, do not contain ethanol vapors, thus preventing the destruction of the product. However, the efficacy of the RTO in mitigating all hazardous pollutants from the dryer emissions requires further scrutiny and independent verification.

Is this not proof of the emissions from ethanol production that are completely ignored in the expert appraisal process?

VOC Emission Underestimation: de Gouw et al (2015) in a study published in J. Geophys. Res. Atmospheres found that VOC emissions from ethanol plants were underestimated by a factor of 5. ".. emissions of several VOCs were underestimated by factors of 5 (total VOCs) to 30 (ethanol)."

Federal Reference Method Inaccuracies: Daniel Brady and Gregory C. Pratt (2007) conducted tests to improve the Federal Reference Method of estimating the total VOC emissions from ethanol plants. "Accurate quantification of emissions had posed problems for facilities and regulators in the past. The results show considerable variability in VOC emissions across the population of facilities in Minnesota, across individual emission units, and over time at a given facility. Thermal oxidizers appear to provide good control of VOC emissions from many of the important emission units at fuel ethanol production facilities. Identifying and quantifying the key constituents in the gas stream provides information that will improve the regulatory process for these facilities."

"Stack test data for total VOCs and individual VOC species were collected at fuel ethanol production facilities in Minnesota. A hybrid testing methodology was developed to address problems in the application of the FRM for testing total VOC emissions at these plants. The data reveal considerable variability among facilities and emission units in terms of the species detected and the mass of emissions. In general, the fermentation scrubbers and fluid bed coolers emitted the largest mass of VOC emissions. Across most facilities and emission units, ethanol, acetaldehyde, acetic acid, and ethyl acetate were the pollutants emitted at the highest rates."

Daniel Brady and Gregory C. Pratt (2007) publication confirms the emission of several chemicals from ethanol plants and quantifies them. The table reproduced from this publication presented below shows the quantitative estimates of the VOCs released from the plants. Neglecting emissions altogether is indefensible.

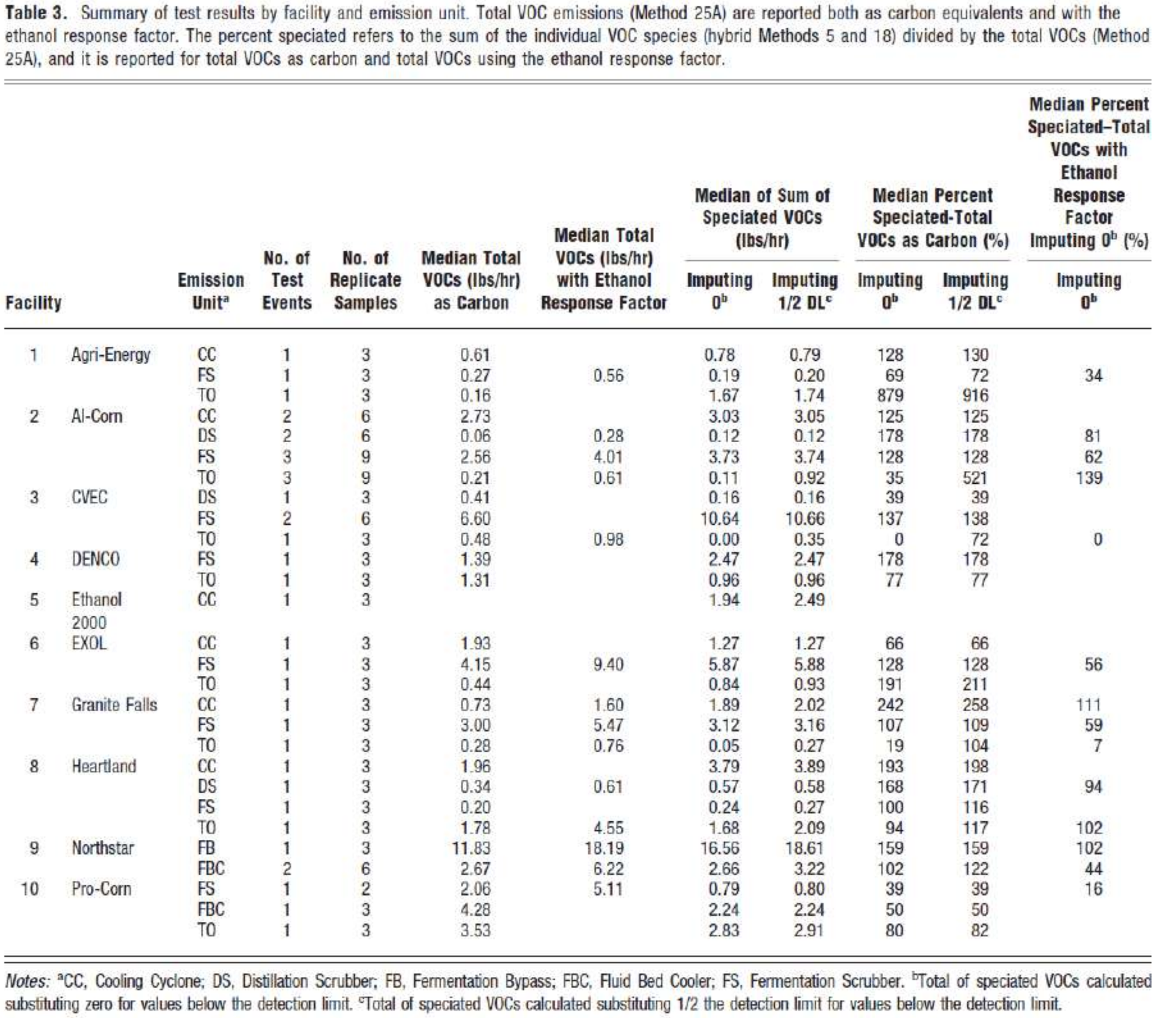

Table 3. Summary of test results by facility and emission unit. Total VOC emissions (Method 25A) are reported both as carbon equivalents and with the ethanol response factor. The percent speciated refers to the sum of the individual VOC species (hybrid Methods 5 and 18) divided by the total VOCs (Method 25A), and it is reported for total VOCs as carbon and total VOCs using the ethanol response factor.

Facility		Emission Unit[a]	No. of Test Events	No. of Replicate Samples	Median Total VOCs (lbs/hr) as Carbon	Median Total VOCs (lbs/hr) with Ethanol Response Factor	Median of Sum of Speciated VOCs (lbs/hr) Imputing 0[b]	Median of Sum of Speciated VOCs (lbs/hr) Imputing 1/2 DL[c]	Median Percent Speciated-Total VOCs as Carbon (%) Imputing 0[b]	Median Percent Speciated-Total VOCs as Carbon (%) Imputing 1/2 DL[c]	Median Percent Speciated–Total VOCs with Ethanol Response Factor Imputing 0[b] (%) Imputing 0[b]
1	Agri-Energy	CC	1	3	0.61		0.78	0.79	128	130	
		FS	1	3	0.27	0.56	0.19	0.20	69	72	34
		TO	1	3	0.16		1.67	1.74	879	916	
2	Al-Corn	CC	2	6	2.73		3.03	3.05	125	125	
		DS	2	6	0.06	0.28	0.12	0.12	178	178	81
		FS	3	9	2.56	4.01	3.73	3.74	128	128	62
		TO	3	9	0.21	0.61	0.11	0.92	35	521	139
3	CVEC	DS	1	3	0.41		0.16	0.16	39	39	
		FS	2	6	6.60		10.64	10.66	137	138	
		TO	1	3	0.48	0.98	0.00	0.35	0	72	0
4	DENCO	FS	1	3	1.39		2.47	2.47	178	178	
		TO	1	3	1.31		0.96	0.96	77	77	
5	Ethanol 2000	CC	1	3			1.94	2.49			
6	EXOL	CC	1	3	1.93		1.27	1.27	66	66	
		FS	1	3	4.15	9.40	5.87	5.88	128	128	56
		TO	1	3	0.44		0.84	0.93	191	211	
7	Granite Falls	CC	1	3	0.73	1.60	1.89	2.02	242	258	111
		FS	1	3	3.00	5.47	3.12	3.16	107	109	59
		TO	1	3	0.28	0.76	0.05	0.27	19	104	7
8	Heartland	CC	1	3	1.96		3.79	3.89	193	198	
		DS	1	3	0.34	0.61	0.57	0.58	168	171	94
		FS	1	3	0.20		0.24	0.27	100	116	
		TO	1	3	1.78	4.55	1.68	2.09	94	117	102
9	Northstar	FB	1	3	11.83	18.19	16.56	18.61	159	159	102
		FBC	2	6	2.67	6.22	2.66	3.22	102	122	44
10	Pro-Corn	FS	1	2	2.06	5.11	0.79	0.80	39	39	16
		FBC	1	3	4.28		2.24	2.24	50	50	
		TO	1	3	3.53		2.83	2.91	80	82	

Notes: [a]CC, Cooling Cyclone; DS, Distillation Scrubber; FB, Fermentation Bypass; FBC, Fluid Bed Cooler; FS, Fermentation Scrubber. [b]Total of speciated VOCs calculated substituting zero for values below the detection limit. [c]Total of speciated VOCs calculated substituting 1/2 the detection limit for values below the detection limit.

Cellulosic Ethanol Emissions: Donna Lee Jones (2010) studied emissions from 7 different cellulosic ethanol demonstration facilities (CEDF). These plants also emit far more VOCs than the petroleum refineries as shown below.

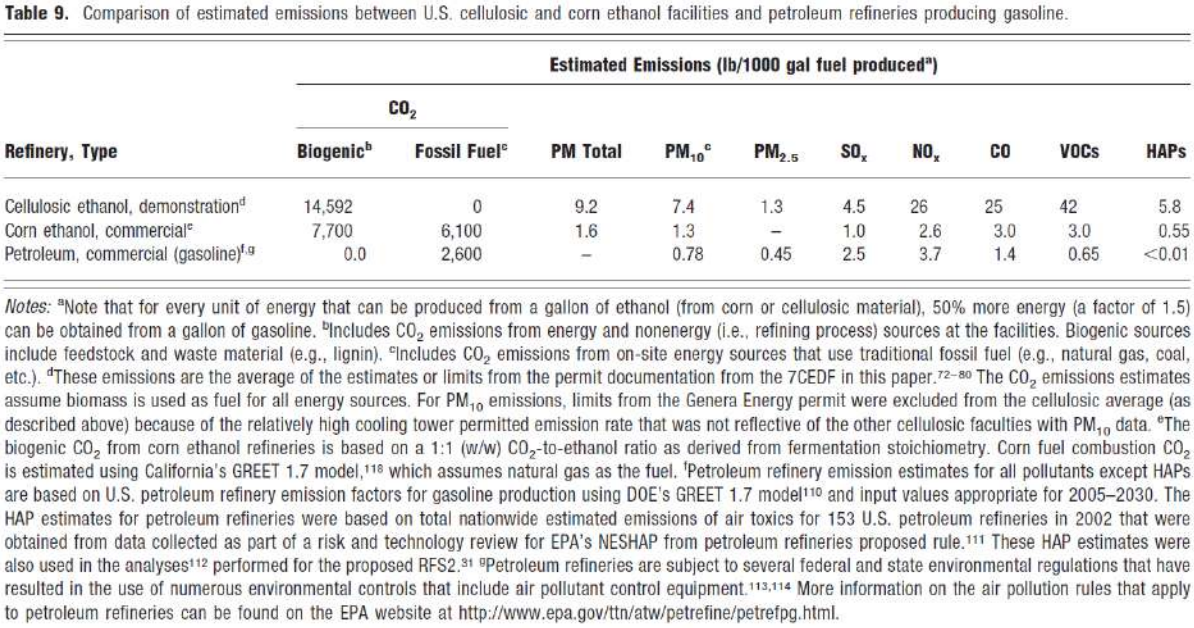

Table 9. Comparison of estimated emissions between U.S. cellulosic and corn ethanol facilities and petroleum refineries producing gasoline.

	Estimated Emissions (lb/1000 gal fuel produced[a])									
	CO_2									
Refinery, Type	Biogenic[b]	Fossil Fuel[c]	PM Total	PM_{10}[c]	$PM_{2.5}$	SO_x	NO_x	CO	VOCs	HAPs
Cellulosic ethanol, demonstration[d]	14,592	0	9.2	7.4	1.3	4.5	26	25	42	5.8
Corn ethanol, commercial[e]	7,700	6,100	1.6	1.3	–	1.0	2.6	3.0	3.0	0.55
Petroleum, commercial (gasoline)[f,g]	0.0	2,600	–	0.78	0.45	2.5	3.7	1.4	0.65	<0.01

Notes: [a]Note that for every unit of energy that can be produced from a gallon of ethanol (from corn or cellulosic material), 50% more energy (a factor of 1.5) can be obtained from a gallon of gasoline. [b]Includes CO_2 emissions from energy and nonenergy (i.e., refining process) sources at the facilities. Biogenic sources include feedstock and waste material (e.g., lignin). [c]Includes CO_2 emissions from on-site energy sources that use traditional fossil fuel (e.g., natural gas, coal, etc.). [d]These emissions are the average of the estimates or limits from the permit documentation from the 7CEDF in this paper.[72–80] The CO_2 emissions estimates assume biomass is used as fuel for all energy sources. For PM_{10} emissions, limits from the Genera Energy permit were excluded from the cellulosic average (as described above) because of the relatively high cooling tower permitted emission rate that was not reflective of the other cellulosic faculties with PM_{10} data. [e]The biogenic CO_2 from corn ethanol refineries is based on a 1:1 (w/w) CO_2-to-ethanol ratio as derived from fermentation stoichiometry. Corn fuel combustion CO_2 is estimated using California's GREET 1.7 model,[118] which assumes natural gas as the fuel. [f]Petroleum refinery emission estimates for all pollutants except HAPs are based on U.S. petroleum refinery emission factors for gasoline production using DOE's GREET 1.7 model[110] and input values appropriate for 2005–2030. The HAP estimates for petroleum refineries were based on total nationwide estimated emissions of air toxics for 153 U.S. petroleum refineries in 2002 that were obtained from data collected as part of a risk and technology review for EPA's NESHAP from petroleum refineries proposed rule.[111] These HAP estimates were also used in the analyses[112] performed for the proposed RFS2.[31] [g]Petroleum refineries are subject to several federal and state environmental regulations that have resulted in the use of numerous environmental controls that include air pollutant control equipment.[113,114] More information on the air pollution rules that apply to petroleum refineries can be found on the EPA website at http://www.epa.gov/ttn/atw/petrefine/petrefpg.html.

Health and Environmental Concerns:

It is all the more of a concern as the innocent rural folk are exposed to carcinogen chemicals released from these plants.

- Acetaldehyde is possibly carcinogenic to humans (Group 2B) because there is inadequate evidence in humans for the carcinogenicity of acetaldehyde, and there is sufficient evidence in experimental animals for the carcinogenicity of acetaldehyde.
- Formaldehyde is carcinogenic to humans (Group 1). There is sufficient evidence in humans for the carcinogenicity of formaldehyde. There is sufficient evidence in experimental animals for the carcinogenicity of formaldehyde.
- Acrolein was classified as "probably carcinogenic to humans" (Group 2A) on the basis of "sufficient" evidence of carcinogenicity in experimental animals and "strong" mechanistic evidence.
- Inhaling n-Hexane can irritate the nose, throat, and lungs. Exposure can cause headache, nausea, vomiting, dizziness, lightheadedness, and passing out. Higher levels can cause coma and death. n-Hexane may damage the nervous system causing numbness, tingling, blurred vision, "pins and needles," and weakness in the hands and feet.

IOWA Emissions Inventory Data: Taking the actual 2022 emissions of VOCs in IOWA published by the Emissions Inventory unit of the Department of Natural Resources, Iowa, the following table is generated for ethanol plants.

Company	VOC emissions, kg/million litres
POET Bioprocessing, Corning, IA	200.9
POET Biorefining FAIRBANK, LLC	216.2
POET Biorefining SHELL ROCK, LLC	290.7
POET Biorefining MENLO, LLC	157.6
POET Biorefining - COON RAPIDS	334.6
POET Biorefining - JEWELL	221.0

Taking the average of these plants' emissions of 236.8 kg/million litres, a 100 KLPD plant will release a minimum of 7815.5 kg or 7.815 T of VOCs per annum. But they are shown as zero and the complaints of odour from the public are brushed aside by our PCBs and their experts.

Toxics Release Inventory study:

The United States of America is the largest producer of corn ethanol for blending with gasoline and has comprehensive regulations on air pollution generated. USEPA has a mandatory Toxics Release Inventory system and the companies report annual releases to air, water, and land under the Emergency Planning and Community Right-to-Know Act (EPCRA).

Environmental Integrity Project (EIP) examined the EPA's Toxics Release Inventory data on hazardous air pollution for the year 2022 and produced a report titled "Farm to Fumes". The biofuel plants reported releasing four hazardous air pollutants at levels significantly greater than petroleum refineries as shown is the table below.

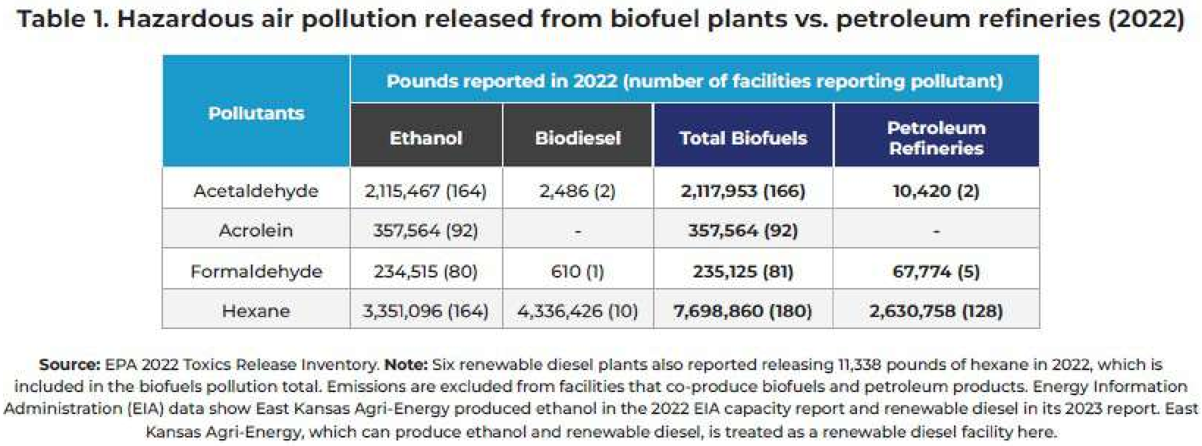

Table 1. Hazardous air pollution released from biofuel plants vs. petroleum refineries (2022)

Pollutants	Pounds reported in 2022 (number of facilities reporting pollutant)			
	Ethanol	Biodiesel	Total Biofuels	Petroleum Refineries
Acetaldehyde	2,115,467 (164)	2,486 (2)	**2,117,953 (166)**	**10,420 (2)**
Acrolein	357,564 (92)	-	**357,564 (92)**	-
Formaldehyde	234,515 (80)	610 (1)	**235,125 (81)**	**67,774 (5)**
Hexane	3,351,096 (164)	4,336,426 (10)	**7,698,860 (180)**	**2,630,758 (128)**

Source: EPA 2022 Toxics Release Inventory. **Note:** Six renewable diesel plants also reported releasing 11,338 pounds of hexane in 2022, which is included in the biofuels pollution total. Emissions are excluded from facilities that co-produce biofuels and petroleum products. Energy Information Administration (EIA) data show East Kansas Agri-Energy produced ethanol in the 2022 EIA capacity report and renewable diesel in its 2023 report. East Kansas Agri-Energy, which can produce ethanol and renewable diesel, is treated as a renewable diesel facility here.

The emissions data presented in the above table shows that ethanol plants collectively emit more of each of the pollutants compared to petroleum refineries.

The report also made the following observations.

HAZARDOUS AIR POLLUTION: Oil refineries, in general, are bigger polluters than biofuel factories. But biofuel manufacturing plants report releasing significantly greater amounts of several dangerous air pollutants. These include more than seven million pounds of hexane in 2022 (the most recent available year), more than two million pounds of acetaldehyde, and more than 200,000 pounds of formaldehyde.

HEXANE: The Archer Daniels Midland ethanol and grain processing plant in Decatur, Illinois – one of the largest ethanol factories in the country – was the single largest emitter of hexane in the U.S. in 2022, regardless of industry, releasing 2.2 million pounds of a pollutant that can damage the nerves and cause dizziness and nausea, according to the company's reporting to EPA's Toxics Release Inventory.

ACROLEIN: The Cargill Inc. ethanol plant in Blair, Nebraska, was the largest emitter of acrolein in the U.S. in 2022, regardless of industry, releasing 34,489 pounds of a chemical that can cause shortness of breath and irritate the lungs and eyes.

ACETALDEHYDE is released during the fermentation process of ethanol production, and when ethanol is eventually broken down by vehicles. The primary short-term effect of inhalation exposure to acetaldehyde is irritation of the eyes, skin, and respiratory tract. At higher exposure levels, erythema, coughing, pulmonary edema, and necrosis may also occur. Acetaldehyde is considered a probable human carcinogen based on human studies conducted thus far and animal studies that have shown nasal tumors in rats and laryngeal tumors in hamsters.[36]

ACROLEIN is also created during the ethanol fermentation process. Effects including weakness, nausea, vomiting, diarrhea, severe respiratory and eye irritation, shortness of breath, bronchitis, pulmonary oedema, unconsciousness, and death have been observed upon accidental exposure. Long-term exposure effects can consist of general respiratory congestion, as well as irritation of the eyes, nose, and throat.[37]

FORMALDEHYDE is created in the fermentation process of ethanol production as well. EPA has preliminarily found that formaldehyde poses unreasonable risk to human health.[38] High levels of exposures to formaldehyde can cause health problems when inhaled and if it is absorbed into the skin. Inhaling high levels of formaldehyde for a short period of time can cause sensory irritation such as eye irritation. Inhaling formaldehyde for longer periods of time can damage the lungs and increase asthma and allergy-related conditions and cause cancer.

HEXANE is used to extract edible oils from seeds and vegetables, as a special-use solvent, and as a cleaning agent. As such, it is heavily involved in the production of most biofuel products. Short-term exposure of humans to high levels of hexane causes mild central nervous system effects, including dizziness, giddiness, slight nausea, and headache. Long-term exposure to hexane is associated with polyneuropathy (nerve damage) in humans, as well as numbness in the extremities, muscular weakness, blurred vision, headache, and fatigue.[39]

FREQUENT VIOLATIONS: More than 41 percent of biofuels plants (98 of 240) violated their air pollution control permits at least once between July 2021 and May 2024, according to a review of EPA's Enforcement and Compliance History Online (ECHO) database.

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[36] EPA, "Acetaldehyde," September 2016.

Link: https://www.epa.gov/sites/default/files/2016-09/documents/acetaldehyde.pdf

[37] EPA, "Acrolein," August 2016.

Link: https://www.epa.gov/sites/default/files/2016-08/documents/acrolein.pdf.

[38] EPA, "Risk Evaluation for Formaldehyde." Accessed April 25, 2024.

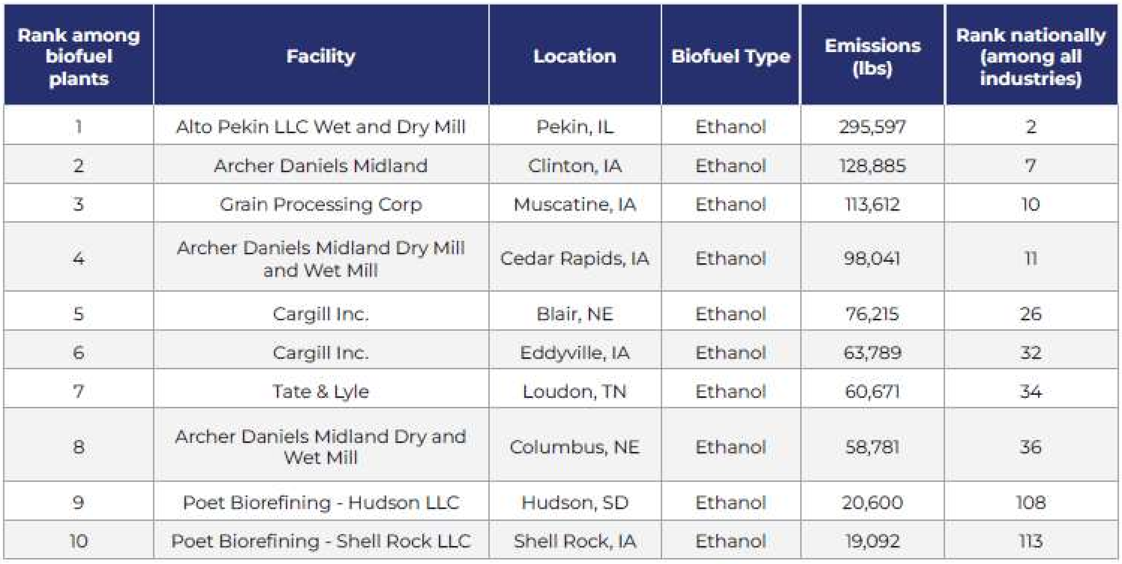
Link:https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-evaluation-formaldehyde

[39] EPA, "Hexane," September 2016.

Link: https://www.epa.gov/sites/default/files/2016-09/documents/hexane.pdf.

Farms to Fumes report presents emissions data for acetaldehyde and hexane and lists the top 10 plants releasing most of these chemicals. Ethanol plants top in these emissions.

Table 2: Top 10 biofuel plants that reported releasing the most acetaldehyde in 2022



Rank among biofuel plants	Facility	Location	Biofuel Type	Emissions (lbs)	Rank nationally (among all industries)
1	Alto Pekin LLC Wet and Dry Mill	Pekin, IL	Ethanol	295,597	2
2	Archer Daniels Midland	Clinton, IA	Ethanol	128,885	7
3	Grain Processing Corp	Muscatine, IA	Ethanol	113,612	10
4	Archer Daniels Midland Dry Mill and Wet Mill	Cedar Rapids, IA	Ethanol	98,041	11
5	Cargill Inc.	Blair, NE	Ethanol	76,215	26
6	Cargill Inc.	Eddyville, IA	Ethanol	63,789	32
7	Tate & Lyle	Loudon, TN	Ethanol	60,671	34
8	Archer Daniels Midland Dry and Wet Mill	Columbus, NE	Ethanol	58,781	36
9	Poet Biorefining - Hudson LLC	Hudson, SD	Ethanol	20,600	108
10	Poet Biorefining - Shell Rock LLC	Shell Rock, IA	Ethanol	19,092	113

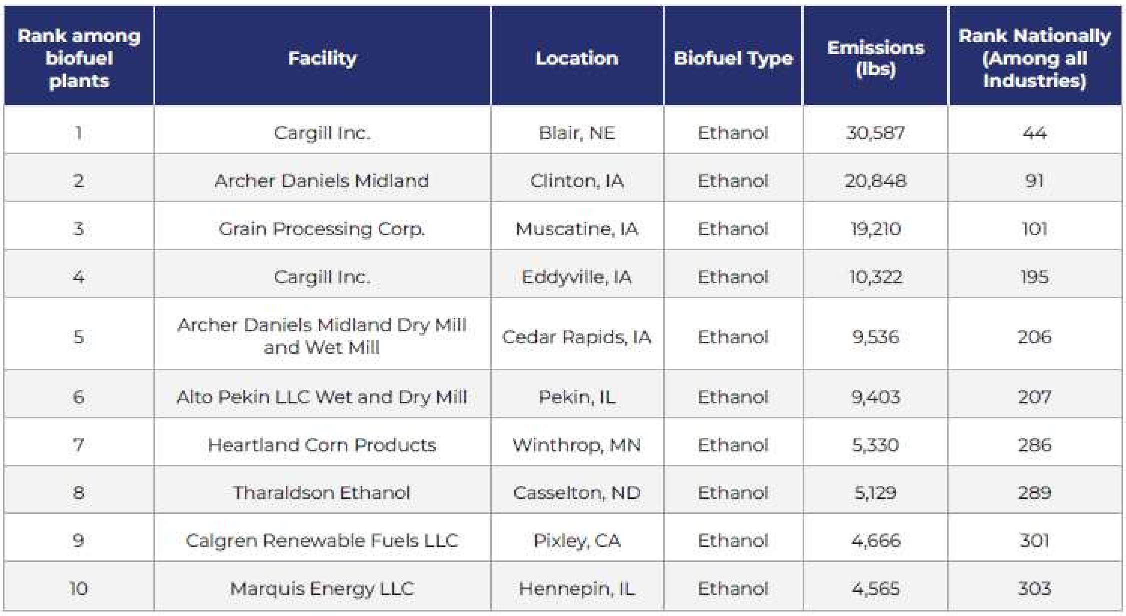
Source: EPA 2022 Toxics Release Inventory.

Top 10 biofuel plants that reported releasing the most acrolein in 2022

Rank among biofuel plants	Facility	Location	Biofuel Type	Emissions (lbs)	Rank Nationally (Among all Industries)
1	Cargill Inc.	Blair, NE	Ethanol	34,489	1
2	Cargill Inc.	Eddyville, IA	Ethanol	20,772	2
3	Archer Daniels Midland Dry Mill and Wet Mill	Cedar Rapids, IA	Ethanol	16,094	3
4	Calgren Renewable Fuels LLC	Pixley, CA	Ethanol	13,151	6
5	Poet Biorefining - Menlo LLC	Menlo, IA	Ethanol	11,050	7
6	Poet Biorefining - Shell Rock LLC	Shell Rock, IA	Ethanol	10,075	8
7	Poet Biorefining - Shelbyville LLC	Shelbyville, IN	Ethanol	9,205	9
8	Southwest Iowa Renewable	Council Bluffs, IA	Ethanol	8,966	11
9	Archer Daniels Midland Dry and Wet Mill	Columbus, NE	Ethanol	8,873	12
10	Green Plains Wood River LLC	Wood River, NE	Ethanol	7,811	13

Source: EPA 2022 Toxics Release Inventory.

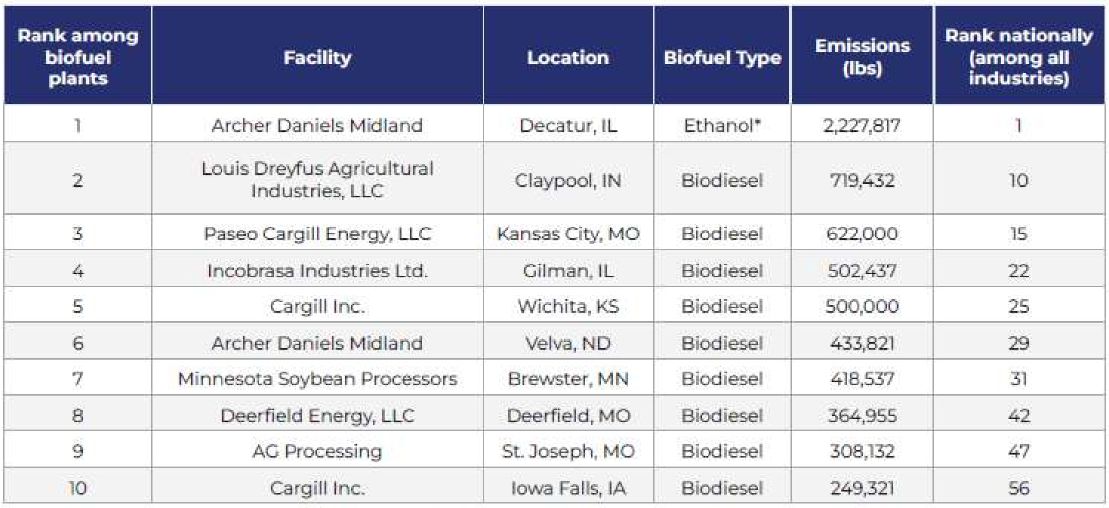
Top 10 biofuel plants that reported releasing the most formaldehyde in 2022



Rank among biofuel plants	Facility	Location	Biofuel Type	Emissions (lbs)	Rank Nationally (Among all Industries)
1	Cargill Inc.	Blair, NE	Ethanol	30,587	44
2	Archer Daniels Midland	Clinton, IA	Ethanol	20,848	91
3	Grain Processing Corp.	Muscatine, IA	Ethanol	19,210	101
4	Cargill Inc.	Eddyville, IA	Ethanol	10,322	195
5	Archer Daniels Midland Dry Mill and Wet Mill	Cedar Rapids, IA	Ethanol	9,536	206
6	Alto Pekin LLC Wet and Dry Mill	Pekin, IL	Ethanol	9,403	207
7	Heartland Corn Products	Winthrop, MN	Ethanol	5,330	286
8	Tharaldson Ethanol	Casselton, ND	Ethanol	5,129	289
9	Calgren Renewable Fuels LLC	Pixley, CA	Ethanol	4,666	301
10	Marquis Energy LLC	Hennepin, IL	Ethanol	4,565	303

Source: EPA 2022 Toxics Release Inventory.

Table 3. Top 10 biofuel plants that reported releasing the most hexane in 2022



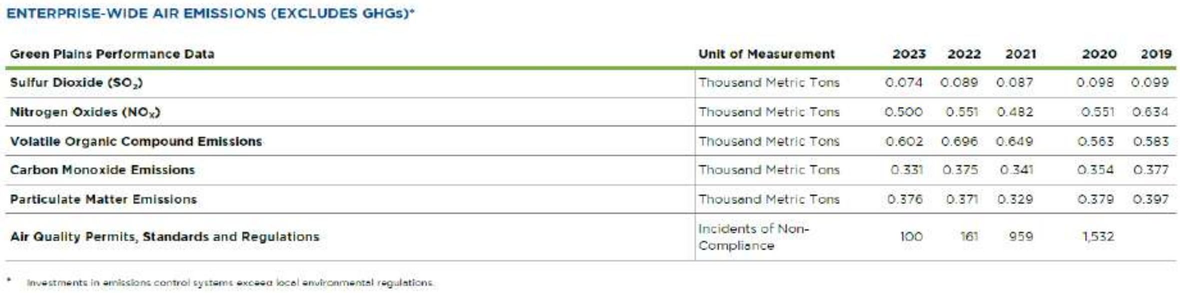
Rank among biofuel plants	Facility	Location	Biofuel Type	Emissions (lbs)	Rank nationally (among all industries)
1	Archer Daniels Midland	Decatur, IL	Ethanol*	2,227,817	1
2	Louis Dreyfus Agricultural Industries, LLC	Claypool, IN	Biodiesel	719,432	10
3	Paseo Cargill Energy, LLC	Kansas City, MO	Biodiesel	622,000	15
4	Incobrasa Industries Ltd.	Gilman, IL	Biodiesel	502,437	22
5	Cargill Inc.	Wichita, KS	Biodiesel	500,000	25
6	Archer Daniels Midland	Velva, ND	Biodiesel	433,821	29
7	Minnesota Soybean Processors	Brewster, MN	Biodiesel	418,537	31
8	Deerfield Energy, LLC	Deerfield, MO	Biodiesel	364,955	42
9	AG Processing	St. Joseph, MO	Biodiesel	308,132	47
10	Cargill Inc.	Iowa Falls, IA	Biodiesel	249,321	56

Source: EPA 2022 Toxics Release Inventory.

*Facility produces more than just ethanol, including citric acid, lactic acid, xanthan gum, dextrose, sorbitol, and corn syrup.

Environmental Metrics of Ethanol Plants:

Presented below is the data taken from the Sustainability Report for the year 2023 of Green Plains Inc., Omaha, Nebraska. No such evaluations are done for any plant in India.

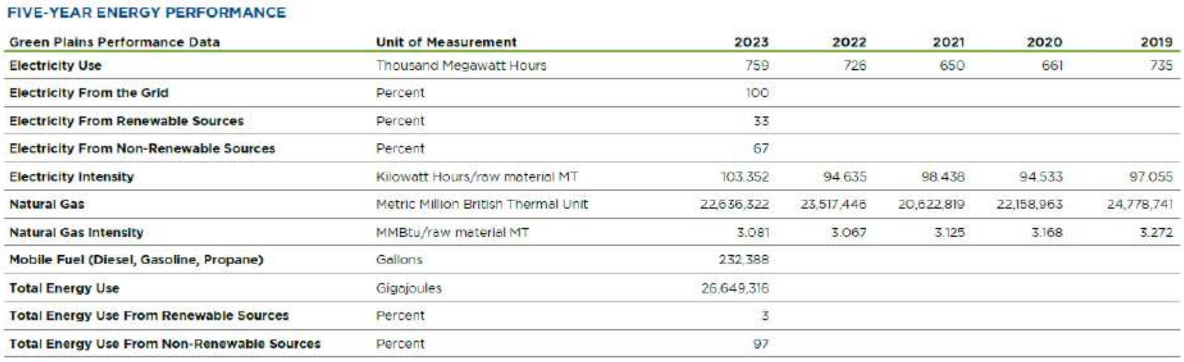


ENTERPRISE-WIDE AIR EMISSIONS (EXCLUDES GHGs)*

Green Plains Performance Data	Unit of Measurement	2023	2022	2021	2020	2019
Sulfur Dioxide (SO_2)	Thousand Metric Tons	0.074	0.089	0.087	0.098	0.099
Nitrogen Oxides (NO_X)	Thousand Metric Tons	0.500	0.551	0.482	0.551	0.634
Volatile Organic Compound Emissions	Thousand Metric Tons	0.602	0.696	0.649	0.563	0.583
Carbon Monoxide Emissions	Thousand Metric Tons	0.331	0.375	0.341	0.354	0.377
Particulate Matter Emissions	Thousand Metric Tons	0.376	0.371	0.329	0.379	0.397
Air Quality Permits, Standards and Regulations	Incidents of Non-Compliance	100	161	959	1,532	

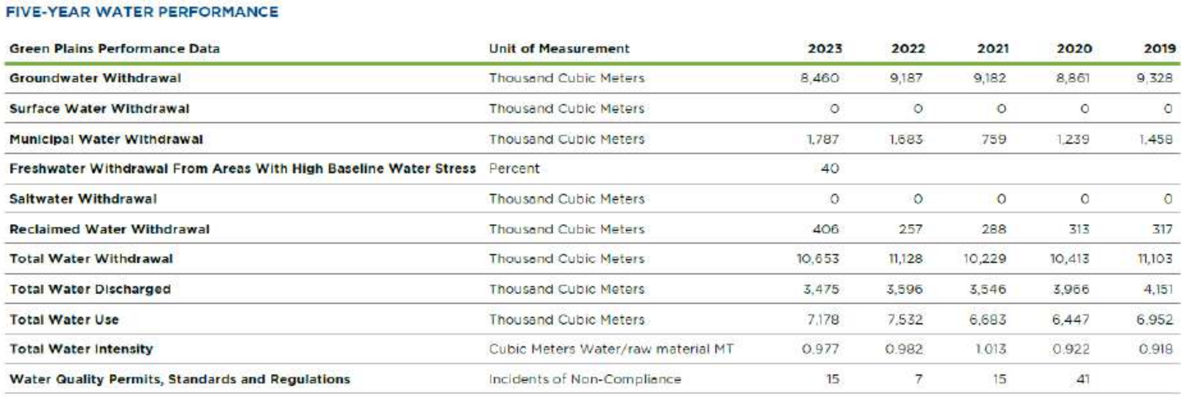
* Investments in emissions control systems exceed local environmental regulations.

VOC emissions cause recognizable odour, but the ethanol companies keep denying any releases while the plants run with superior technologies are not free of these emissions.



FIVE-YEAR ENERGY PERFORMANCE

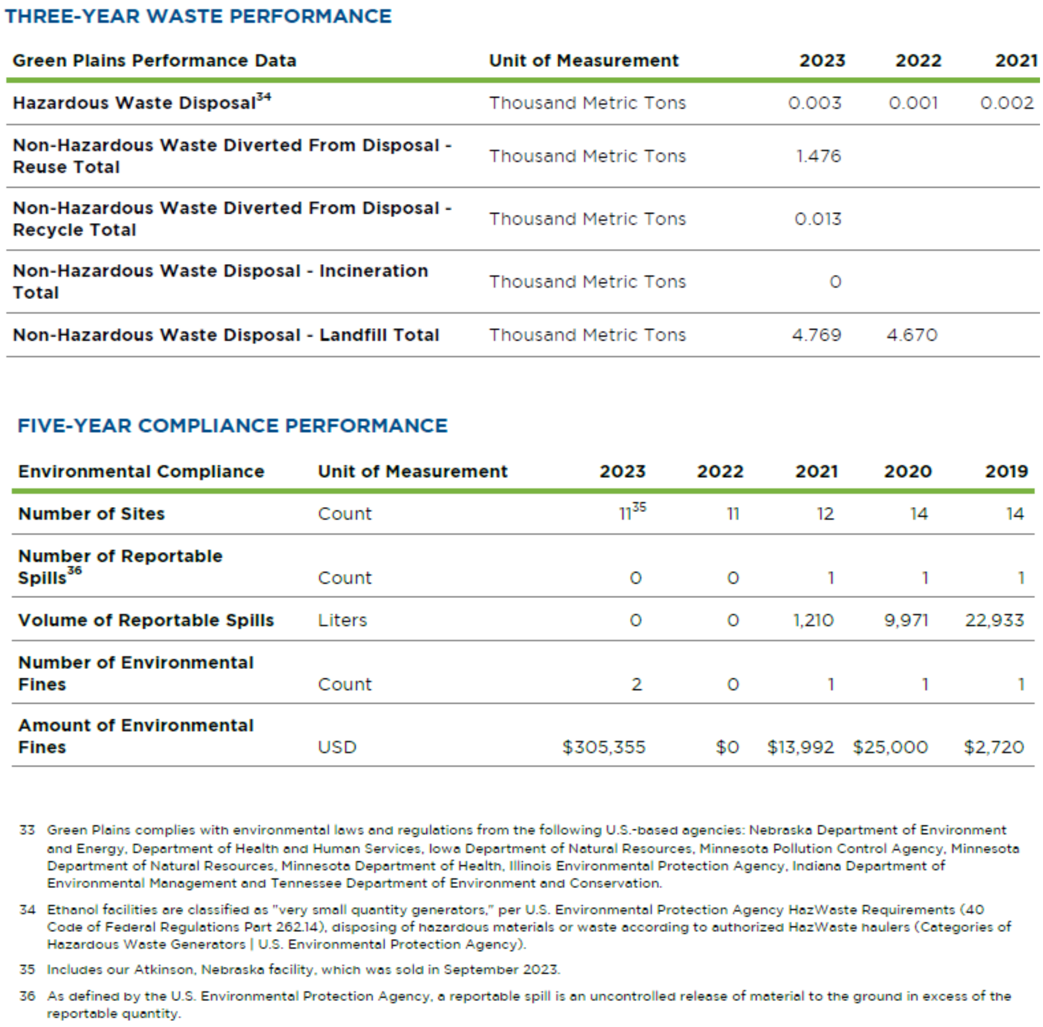
Green Plains Performance Data	Unit of Measurement	2023	2022	2021	2020	2019
Electricity Use	Thousand Megawatt Hours	759	726	650	661	735
Electricity From the Grid	Percent	100				
Electricity From Renewable Sources	Percent	33				
Electricity From Non-Renewable Sources	Percent	67				
Electricity Intensity	Kilowatt Hours/raw material MT	103.352	94.635	98.438	94.533	97.055
Natural Gas	Metric Million British Thermal Unit	22,636,322	23,517,446	20,622,819	22,158,963	24,778,741
Natural Gas Intensity	MMBtu/raw material MT	3.081	3.067	3.125	3.168	3.272
Mobile Fuel (Diesel, Gasoline, Propane)	Gallons	232,388				
Total Energy Use	Gigajoules	26,649,316				
Total Energy Use From Renewable Sources	Percent	3				
Total Energy Use From Non-Renewable Sources	Percent	97				



FIVE-YEAR WATER PERFORMANCE

Green Plains Performance Data	Unit of Measurement	2023	2022	2021	2020	2019
Groundwater Withdrawal	Thousand Cubic Meters	8,460	9,187	9,182	8,861	9,328
Surface Water Withdrawal	Thousand Cubic Meters	0	0	0	0	0
Municipal Water Withdrawal	Thousand Cubic Meters	1,787	1,683	759	1,239	1,458
Freshwater Withdrawal From Areas With High Baseline Water Stress	Percent	40				
Saltwater Withdrawal	Thousand Cubic Meters	0	0	0	0	0
Reclaimed Water Withdrawal	Thousand Cubic Meters	406	257	288	313	317
Total Water Withdrawal	Thousand Cubic Meters	10,653	11,128	10,229	10,413	11,103
Total Water Discharged	Thousand Cubic Meters	3,475	3,596	3,546	3,966	4,151
Total Water Use	Thousand Cubic Meters	7,178	7,532	6,683	6,447	6,952
Total Water Intensity	Cubic Meters Water/raw material MT	0.977	0.982	1.013	0.922	0.918
Water Quality Permits, Standards and Regulations	Incidents of Non-Compliance	15	7	15	41	

Water Consumption: Water consumption of ethanol plants in Telangana is much more than the permitted 4 lit/lit of ethanol. Based on the task force meeting report of TSPCB, the water consumption at that plant is twice the permitted rate. PCB acts as if it is not a violation. The plants in the USA use about 2.75 lit of water per lit of ethanol.



THREE-YEAR WASTE PERFORMANCE

Green Plains Performance Data	Unit of Measurement	2023	2022	2021
Hazardous Waste Disposal[34]	Thousand Metric Tons	0.003	0.001	0.002
Non-Hazardous Waste Diverted From Disposal - Reuse Total	Thousand Metric Tons	1.476		
Non-Hazardous Waste Diverted From Disposal - Recycle Total	Thousand Metric Tons	0.013		
Non-Hazardous Waste Disposal - Incineration Total	Thousand Metric Tons	0		
Non-Hazardous Waste Disposal - Landfill Total	Thousand Metric Tons	4.769	4.670	

FIVE-YEAR COMPLIANCE PERFORMANCE

Environmental Compliance	Unit of Measurement	2023	2022	2021	2020	2019
Number of Sites	Count	11[35]	11	12	14	14
Number of Reportable Spills[36]	Count	0	0	1	1	1
Volume of Reportable Spills	Liters	0	0	1,210	9,971	22,933
Number of Environmental Fines	Count	2	0	1	1	1
Amount of Environmental Fines	USD	$305,355	$0	$13,992	$25,000	$2,720

[33] Green Plains complies with environmental laws and regulations from the following U.S.-based agencies: Nebraska Department of Environment and Energy, Department of Health and Human Services, Iowa Department of Natural Resources, Minnesota Pollution Control Agency, Minnesota Department of Natural Resources, Minnesota Department of Health, Illinois Environmental Protection Agency, Indiana Department of Environmental Management and Tennessee Department of Environment and Conservation.

[34] Ethanol facilities are classified as "very small quantity generators," per U.S. Environmental Protection Agency HazWaste Requirements (40 Code of Federal Regulations Part 262.14), disposing of hazardous materials or waste according to authorized HazWaste haulers (Categories of Hazardous Waste Generators | U.S. Environmental Protection Agency).

[35] Includes our Atkinson, Nebraska facility, which was sold in September 2023.

[36] As defined by the U.S. Environmental Protection Agency, a reportable spill is an uncontrolled release of material to the ground in excess of the reportable quantity.

https://gpreinc.com/wp-content/uploads/2024/04/Green_Plains_Sustainability_Report_2023.pdf

Conclusions:

The discrepancies between the Indian environmental clearance process and established scientific data raise serious concerns. The consistent omission of process emissions, coupled with the documented release of carcinogenic and hazardous pollutants, suggests a critical oversight. It appears that the expert appraisal process in India may be influenced by political considerations, undermining the credibility of the EBP program. The lack of comprehensive environmental evaluations, as demonstrated by the absence of reports similar to Green Plains Inc.'s sustainability report, further exacerbates these concerns.

Recommendations:

- Implement rigorous emission monitoring and reporting requirements for all grain-based ethanol plants.
- Conduct comprehensive environmental impact assessments that include all process emissions.
- Ensure transparency and public access to environmental data.
- Adopt stricter enforcement of environmental regulations.

- Align Indian environmental regulations with international standards, such as those used by REACH.

This information must be considered to protect the health of rural communities.

Dr K Babu Rao Dr K Venkat Reddy Dr Ahamed Khan

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Green Plains Inc., Omaha Sustainability Report 2023 https://gpreinc.com/wp-content/uploads/2024/04/Green_Plains_Sustainability_Report_2023.pdf

Emissions Inventory Unit, Iowa Point Source Emissions Summary 2022 https://www.iowadnr.gov/portals/idnr/uploads/air/emissinv/Iowa_Point_Source_Emissions_Summary_2022.pdf

ANNEXURE A-3

Farm to Fumes

Hazardous Air Pollution from Biofuel Production

ENVIRONMENTAL INTEGRITY PROJECT

JUNE 12, 2024

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The Environmental Integrity Project:
The Environmental Integrity Project is a nonprofit organization dedicated to protecting public health and our natural resources by holding polluters and government agencies accountable under the law, advocating for tough but fair environmental standards, and empowering communities fighting for clean air and clean water. For more information on EIP, visit: www.environmentalintegrity.org

For questions about this report, please contact EIP Director of Communications Tom Pelton at (443) 510-2574 or tpelton@environmentalintegrity.org.

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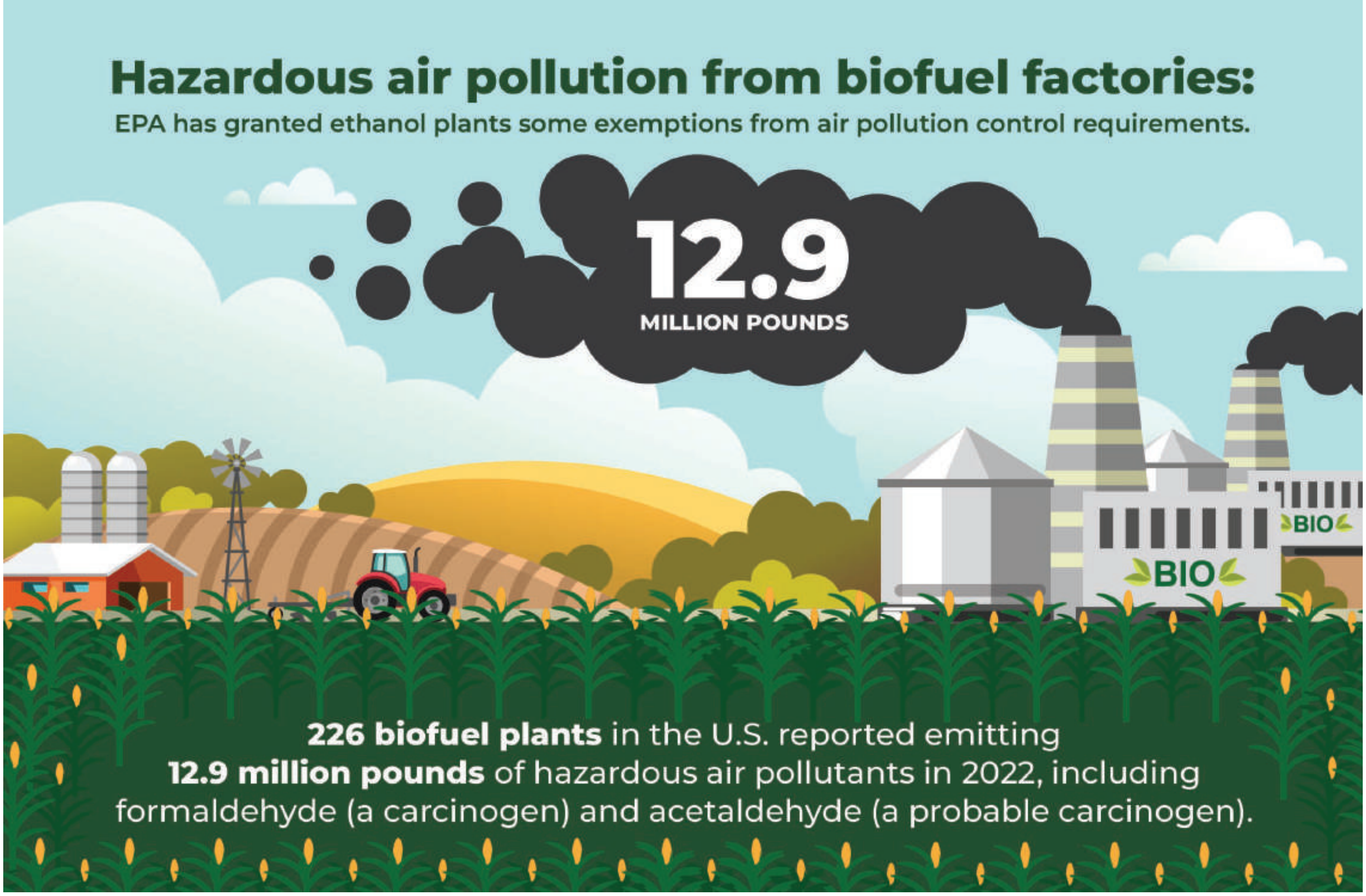
Farm to Fumes

Hazardous Air Pollution from Biofuel Production

EXECUTIVE SUMMARY

Across the spectrum, biofuels like ethanol, biodiesel, and “renewable diesel” are held up by their manufacturers as a greener and more sustainable alternative to petroleum-based gasoline and diesel fuel. The industry is growing rapidly, fueled by federal subsidies, mandates, permitting loopholes and a clean public image of a plant-powered future. But biofuel factories release surprisingly large amounts of hazardous air pollution, often into rural Midwestern communities that suffer from unhealthy air quality despite having no significant pollution sources around them, other than the smokestacks of ethanol refineries.

An examination of emissions records by the Environmental Integrity Project (EIP) found that biofuel manufacturing plants release significantly greater amounts of certain hazardous air pollutants than oil refineries.[1] These include formaldehyde (a carcinogen), acetaldehyde (a probable carcinogen), hexane (which can attack the central nervous system and cause dizziness, nausea, and headaches) and acrolein (which can cause nausea, vomiting, diarrhea, lung and eye irritation, and shortness of breath). More acrolein is emitted from the biofuels industry than any other source in the U.S., according to reporting to EPA’s Toxics Release Inventory.[2] The same four pollutants also contribute to the formation of ground-level ozone, or smog, which is linked to a wide variety of respiratory ailments; as well as microscopic, soot-like particulates that can trigger heart and asthma attacks. Many biofuels plants violate their air pollution control permits, releasing illegal amounts of contaminants that threaten the health of downwind communities. And although biofuel facilities release less carbon dioxide on average than petroleum refineries, biofuel plants still emit large quantities of greenhouse gases for an industry that portrays itself as climate-friendly.



Hazardous air pollution from biofuel factories:

EPA has granted ethanol plants some exemptions from air pollution control requirements.

226 biofuel plants in the U.S. reported emitting **12.9 million pounds** of hazardous air pollutants in 2022, including formaldehyde (a carcinogen) and acetaldehyde (a probable carcinogen).

Here are some of the key findings of EIP's examination of public records about the U.S. biofuels industry. (For a discussion of how we compiled this information, see the methodology section in Appendix A.)

- **RAPID EXPANSION:** The industry has been growing rapidly. The number of ethanol plants in the U.S. nearly quadrupled and their capacity rose eight-fold[3] in the first decade of this century. As of early 2024, there are 191 ethanol plants, 71 biodiesel plants, and 13 stand-alone renewable diesel plants in the U.S.[4] (For a list with details, click here. For an interactive map, click here.)
- **FUTURE GROWTH:** At least 32 new or expanded biofuels facilities are now under construction or proposed that would increase biofuel capacity by another 33 percent over 2023 levels.[5] (Click here for a map or see Appendix B for a list.) About two thirds of these new facilities and expansions – 23 of the 32 – could make jet fuel from wood or plants to create "sustainable aviation fuel."
- **HAZARDOUS AIR POLLUTION:** Oil refineries, in general, are bigger polluters than biofuel factories. But biofuel manufacturing plants report releasing significantly greater amounts of several dangerous air pollutants. These include more than seven million pounds of hexane in 2022 (the most recent available year), more than two million pounds of acetaldehyde, and more than 200,000 pounds of formaldehyde (see table below for specifics).
- **HEXANE:** The Archer Daniels Midland ethanol and grain processing plant in Decatur, Illinois – one of the largest ethanol factories in the country – was the single largest emitter of hexane in the U.S. in 2022, regardless of industry, releasing 2.2 million pounds of a pollutant that can damage the nerves and cause dizziness and nausea, according to the company's reporting to EPA's Toxics Release Inventory.
- **ACROLEIN:** The Cargill Inc. ethanol plant in Blair, Nebraska, was the largest emitter of acrolein in the U.S. in 2022, regardless of industry, releasing 34,489 pounds of a chemical that can cause shortness of breath and irritate the lung and eyes.
- **FREQUENT VIOLATIONS:** More than 41 percent of biofuels plants (98 of 240) violated their air pollution control permits at least once between July 2021 and May 2024, according to a review of EPA's Enforcement and Compliance History Online (ECHO) database.
- **CLIMATE IMPACT:** In terms of climate-warming pollution, biofuel plants in the U.S. reported emitting over 33 million metric tons of greenhouse gases in 2022 – as much as 8.5 coal-fired power plants burning fuel around the clock or 27.5 average oil refineries.[6]

The following is a table with more specific figures for some of the dangerous pollutants released by biofuel plants, and comparisons to oil refineries. It should be noted that EPA classifies all of these as "hazardous air pollutants" under the federal Clean Air Act and as volatile organic compounds (VOCs). The numbers below are likely underestimates because not all facilities report their emissions. Also, a 2015 study found that VOC emissions from ethanol plants may be five times higher than what companies report.[7]

Table 1. Hazardous air pollution released from biofuel plants vs. petroleum refineries (2022)

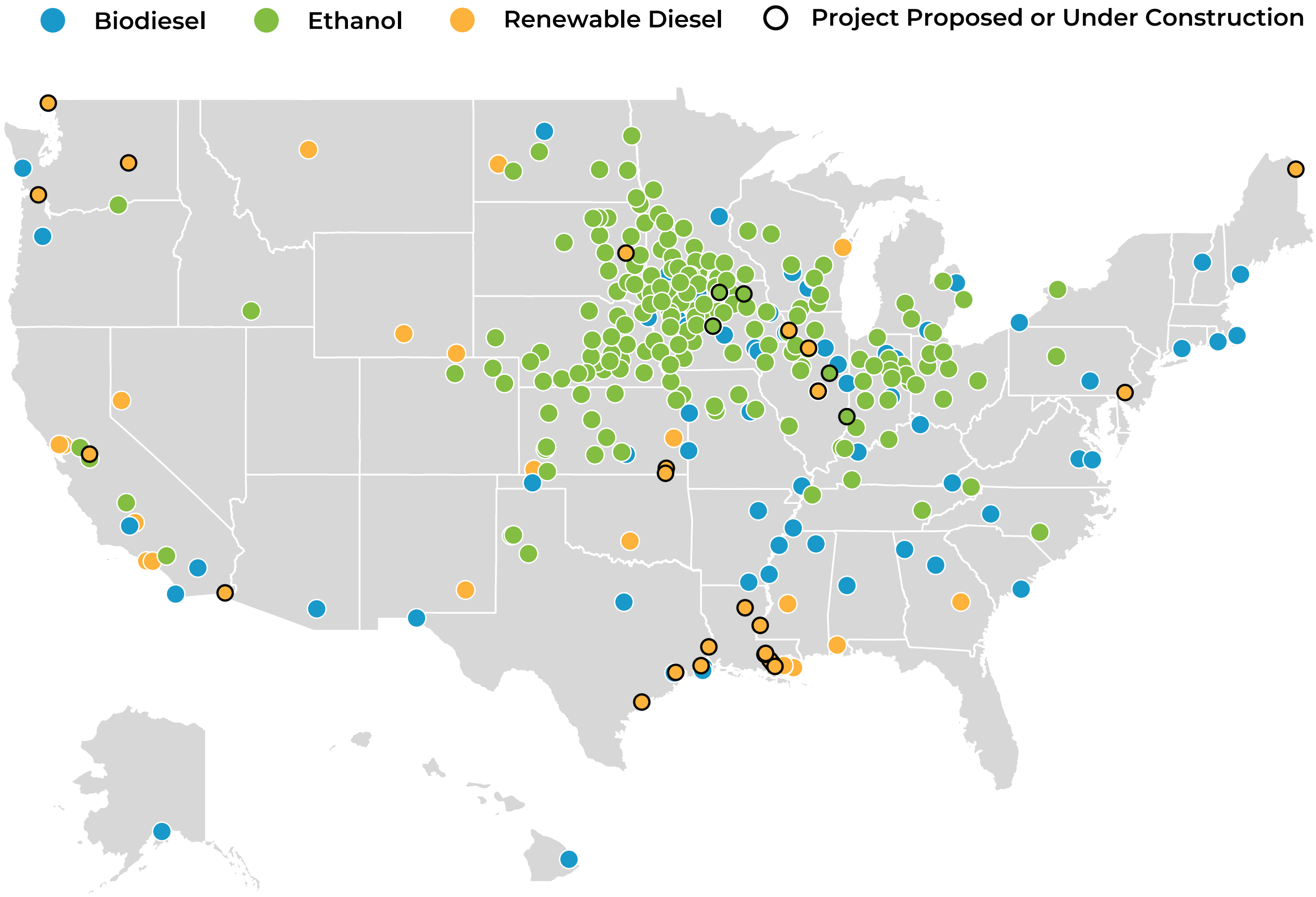
Pollutants	Pounds reported in 2022 (number of facilities reporting pollutant)			
	Ethanol	Biodiesel	Total Biofuels	Petroleum Refineries
Acetaldehyde	2,115,467 (164)	2,486 (2)	**2,117,953 (166)**	**10,420 (2)**
Acrolein	357,564 (92)	-	**357,564 (92)**	**-**
Formaldehyde	234,515 (80)	610 (1)	**235,125 (81)**	**67,774 (5)**
Hexane	3,351,096 (164)	4,336,426 (10)	**7,698,860 (180)**	**2,630,758 (128)**

Source: EPA 2022 Toxics Release Inventory. **Note:** Six renewable diesel plants also reported releasing 11,338 pounds of hexane in 2022, which is included in the biofuels pollution total. Emissions are excluded from facilities that co-produce biofuels and petroleum products. Energy Information Administration (EIA) data show East Kansas Agri-Energy produced ethanol in the 2022 EIA capacity report and renewable diesel in its 2023 report. East Kansas Agri-Energy, which can produce ethanol and renewable diesel, is treated as a renewable diesel facility here.

While most of the petroleum refineries in the U.S. are located along the Gulf Coast or in California, most biofuel plants are located in the Midwest or in rural areas where corn and soybeans are farmed on an industrial scale. (See map below).

As of 2022, 38 percent of corn and 46 percent of soybeans grown in the U.S. were used to make biofuel.[8] Increased demand for biofuels, especially from federal ethanol mandates, has raised the price of food and altered landscapes over the past several decades, replacing forested lands with monoculture crops and causing increased agricultural runoff pollution.[9] Studies have found that growing more corn and soybeans has also increased the use of agrochemicals like nitrogen fertilizer, insecticides, and herbicides.[10]

Map 1. Biofuel Manufacturing Plants Operating, Under Construction, and Proposed



Source: EIA 2022 and 2023 Capacity Reports, EPA ECHO, Permit Documents, State Notices, News Reports.
Note: "Renewable diesel" includes other biofuels excluding ethanol and biodiesel, such as sustainable aviation fuel, renewable naphtha, etc. Locations for some proposed projects may be approximations where permit documents are not yet available. Four new, proposed renewable diesel facilities were excluded from the map due to insufficient location information - Avina Midwest SAF Ethanol Plant (Midwest), Blue Blade Energy (Midwest), SkyNRG (Washington), VertiBlue Fuels (Florida).

Many biofuel plants have a checkered compliance history when it comes to air pollution control laws. EPA considered 22 plants to be 'high priority violators' of the Clean Air Act as of May 2024, according to EPA's Enforcement and Compliance Online (ECHO) database.[11] And all of these — 20 ethanol plants and two renewable diesel plants — had violations that had not been addressed by local, state, or federal agencies as of May 2024. (See Appendix C for a full list of facilities with alleged high priority violations.) One ethanol plant, the Grain Processing

Corp. facility in Muscatine, Iowa, has failed "stack tests" to determine compliance with pollution limits 16 times over the last five years, without being sanctioned by any enforcement actions or penalties, according to the EPA ECHO database.[12] The plant has been out of compliance with the Clean Air Act five of the last 12 quarters (July 2021 - May 2024), according to the database.

This report will discuss these broad environmental problems with the biofuel industry, and then focus on four case studies in California, Iowa, Illinois, and Louisiana (See pages 20-25). In the San Francisco Bay area, an oil refinery was converted into a biofuels plant for the Rodeo Renewed Project and faced opposition from local residents because of the air pollution and greenhouse gas emissions from biofuels manufacturing. In Iowa, Muscatine County – home of the Grain Processing Corp. ethanol refinery that has repeatedly failed air pollution "stack tests" – is one of only a few counties whose air quality violates federal sulfur dioxide standards in the Midwest and the only one to do so in Iowa. In Illinois, the ADM ethanol facility in Decatur has a poor environmental track record and reported releasing three million pounds of hazardous air pollutants in the most recent available year, 2022. In Louisiana, a company proposing to build an enormous refinery that would transform trees into jet fuel is using emission estimates for its hazardous pollutants based on extremely limited lab testing of a single gram of wood.

Momentum to boost biofuels production in the U.S. first began in the 1970s during an oil crisis. It grew in the 2000s to reduce America's dependence on Middle Eastern fuel following the attacks on September 11th, 2001. But even after the spread of new drilling techniques – hydraulic fracturing and horizontal drilling – in following years made America the biggest oil and gas producer in the world, biofuels production also kept expanding, in part because of government ethanol mandates meant to help farmers. At least 25 new biofuel plants have been proposed for the future or are under construction today, along with two refinery conversions, and expansions at five existing facilities. These new and future projects could increase biofuel production capacity by a third – including ethanol production by another 173 million gallons per year and renewable diesel by 4.7 billion gallons per year.

32 biofuel

expansion projects are proposed or underway that would boost U.S. production by a third.

Much of this production and expansion is heavily subsidized with federal tax dollars, coming from a variety of programs. For example, the Inflation Reduction Act of 2022 authorized incentives – tax credits – to support the development of "sustainable aviation fuels." Sustainable aviation fuel, like "renewable diesel," can be produced from plants or wood and used in the same engines and pipelines that use traditional petroleum-based fuels. That makes these newer biofuels – sometimes called "drop-in fuels" because they can be dropped directly into conventional engines – different than ethanol and biodiesel, which must be blended with petroleum products or they will cause problems in conventional engines. Nearly all of the recent and proposed growth in biofuel production capacity - 7.2 of 7.5 billion gallons - is attributed to renewable diesel, sustainable aviation fuel, and these newer biofuel products.

Ethanol manufacturing plants also enjoy some exemptions from air pollution permitting requirements, making it easier for companies to expand or build new facilities without installing or upgrading pollution controls to reduce emissions of health-damaging air pollutants. In 2007, EPA removed corn-based ethanol plants from a list of industrial facilities subject to more stringent emission thresholds under the Clean Air Act. As a result, these ethanol plants can emit more than twice as much pollution – up to 250 tons per year instead of 100 tons per year – before they have to obtain a major source permit that requires stronger pollution controls. Plants built before 1970 enjoy even more freedom to expand and increase emissions without undergoing more stringent review and being subject to tighter pollution control requirements.

This report makes the following recommendations to address the environmental problems caused by the biofuel boom:

1. **END PERMITTING EXEMPTIONS FOR ETHANOL UNDER THE CLEAN AIR ACT:** EPA should reverse its 2007 decision to relax major source permitting thresholds for ethanol manufacturers that allow these plants to emit more than twice the level of air pollution before needing to install better pollution controls.
2. **BETTER MONITORING AND CONTROL OF HAZARDOUS AIR POLLUTANTS:** EPA should require large biofuel plants to install air pollution monitoring devices along their fencelines to detect the levels of hazardous air pollutants, like acetaldehyde and acrolein, that could be drifting into nearby communities. EPA should also establish an 'action level' for these and other highly toxic pollutants, that, if exceeded, would obligate these facilities to identify the sources of the emissions and then fix the problems causing elevated concentrations.
3. **STRONGER ENFORCEMENT OF AIR POLLUTION CONTROL PERMITS FOR BIOFUEL PLANTS:** EPA and state regulatory agencies should more vigorously enforce air pollution control permits for biofuel plants, imposing penalties large enough to discourage future violations and protect downwind communities.
4. **IMPROVE THE ACCURACY OF EMISSIONS REPORTING:** Biofuels producers should be required, during the permit review and approval process, to expand their emissions testing and improve the accuracy of their pollution reporting to both EPA and the states.
5. **END BIOFUEL SUBSIDIES AND MANDATES:** Biofuels are growing at a rapid rate in part because of government funding and regulatory mandates for blending ethanol into gasoline. But the environmental benefits of these government supports are questionable at best. All existing subsidies and mandates for ethanol – including the renewable fuel standard – should be halted – and attention focused instead on clean energy sources like solar and wind and the infrastructure needed to support them.

While plant-based fuels have a role in America's future economic growth, their benefits to the climate should not be exaggerated or their environmental problems ignored. Biofuels should not be granted exemptions from pollution control laws or provided taxpayer funds to encourage more rapid growth than is warranted. In the end, most crops like corn and soybeans should be used to provide affordable food for people, not to feed machines. And most trees and forests should be preserved and protected as natural carbon dioxide capturing systems, instead of cut down and mulched into jet fuel. It is healthier to turn to the sun and wind for clean power, and not to reap carcinogens from corn.

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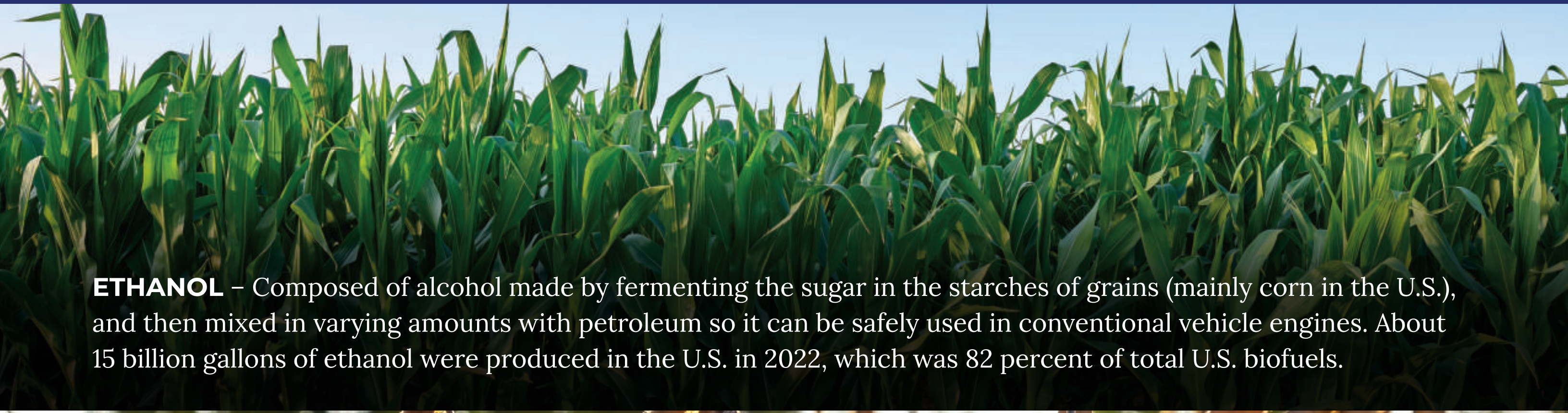
Appendix

Different Types of Biofuels

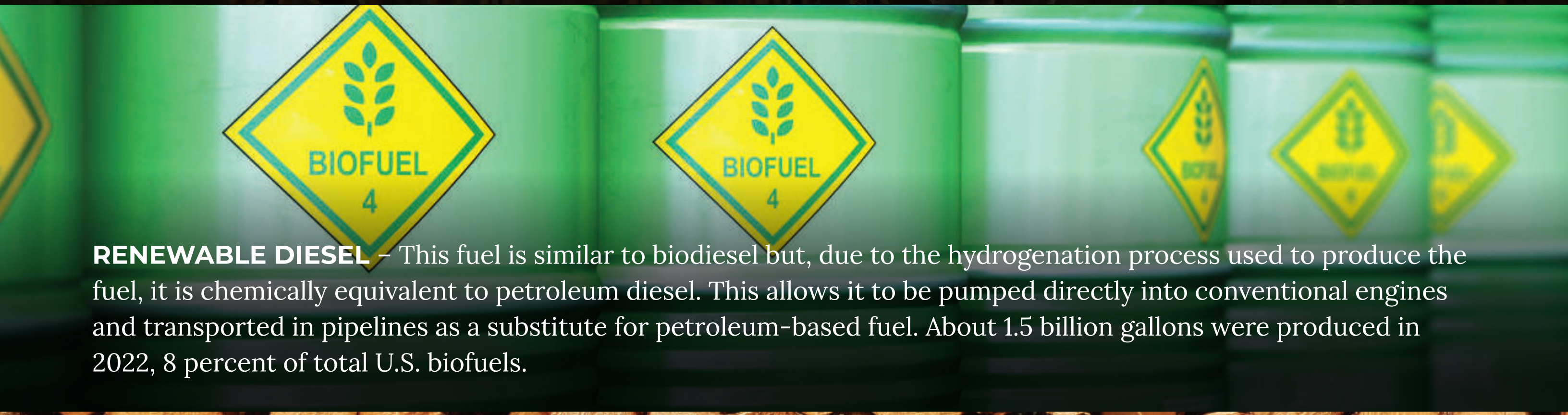
While the term biofuels seems like a simple one, it is an umbrella term that refers to a variety of liquid fuels produced using biomass materials as a feedstock – such as corn, soybeans, or wood – or fuel made from waste products like fat or grease. Industry advocates and government legislation often use different names for the same or similar products, leading to some confusion surrounding the topic.

This report focuses on four categories of biofuels:[13]

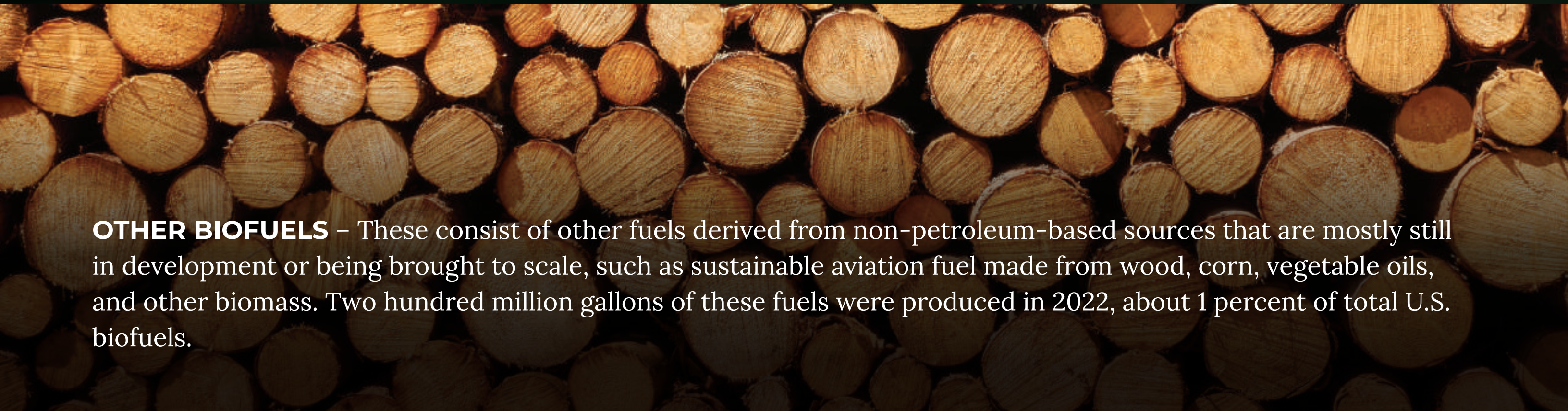


ETHANOL – Composed of alcohol made by fermenting the sugar in the starches of grains (mainly corn in the U.S.), and then mixed in varying amounts with petroleum so it can be safely used in conventional vehicle engines. About 15 billion gallons of ethanol were produced in the U.S. in 2022, which was 82 percent of total U.S. biofuels.

BIODIESEL – Made up of primarily vegetable oils (largely from soybeans) and mixed with petroleum diesel for use in vehicles with diesel engines. Cooking oils and animal fats can be used as a feedstock as well. Biodiesel requires modifications to existing petroleum-based engines and other infrastructure to use. About 1.6 billion gallons were produced in 2022, 9 percent of total U.S. biofuels.



RENEWABLE DIESEL – This fuel is similar to biodiesel but, due to the hydrogenation process used to produce the fuel, it is chemically equivalent to petroleum diesel. This allows it to be pumped directly into conventional engines and transported in pipelines as a substitute for petroleum-based fuel. About 1.5 billion gallons were produced in 2022, 8 percent of total U.S. biofuels.



OTHER BIOFUELS – These consist of other fuels derived from non-petroleum-based sources that are mostly still in development or being brought to scale, such as sustainable aviation fuel made from wood, corn, vegetable oils, and other biomass. Two hundred million gallons of these fuels were produced in 2022, about 1 percent of total U.S. biofuels.

CHAPTER 1

Growth of Biofuel Spurred by Government Incentives and Loopholes

Wood is chipped before being turned into a biofuel.

Growth of Biofuel Spurred by Government Incentives and Loopholes

The U.S. is the world's largest producer of biofuels, churning out about 18.5 billion gallons in 2022,[14] about 40 percent of global production. Brazil follows in a distant second.[15] The Brazilian government was the first to mandate the use of biofuels at a large scale. Back in 1975, during a surge in global oil prices, Brazil – which grows large amounts of sugarcane – started requiring that ethanol created from sugarcane be blended into gasoline to increase its domestic energy security.[16]

The U.S. soon followed suit in trying to promote its own national security through home-grown fuel, instead of relying on petroleum imported from the Middle East and Venezuela. In its origins, the biofuel industry in the U.S. was promoted for geopolitical reasons, not primarily to help the environment. Congress created a tax break in 1978 for gasoline mixed with at least 10 percent ethanol, which in North America is distilled mostly from corn.[17] Congress expanded the subsidy in 1980, providing over $1 billion for the construction of ethanol production plants and a $0.54 per gallon tariff on foreign produced ethanol.[18] Following these government incentives, U.S. ethanol production grew, with a cumulative total of 32.2 billion gallons from 1981 to 2005. Congress passed even more subsidies and mandates in the 1990s and 2000s because of political demands for energy independence following the Gulf War.

The U.S. is the world's largest producer of biofuels, churning out
18.5 billion gallons in 2022

In the Energy Policy Act of 2005, Congress introduced the Renewable Fuel Standard, which mandated the amount of renewable fuels blended into the consumer transportation fuel mix, starting with four billion gallons in 2006 and steadily increasing to 7.5 billion in 2012.[19] The law also made over $1 billion available in grants for renewable fuel production and hundreds of millions of dollars for research and development. By 2008, ethanol production was up 138 percent from 2005 and biodiesel production was up 645 percent.[20]

The U.S. government's support for ethanol – which is politically popular in Midwestern states like Iowa – extends beyond subsidies, tax breaks, and mandates. The industry has also received favored regulatory treatment from EPA. This includes an exemption under a part of the Clean Air Act that requires manufacturing plants to install and operate stronger or weaker air pollution control systems, depending on whether they are considered "major" or "minor" sources of emissions.

In 2007, under significant pressure from the ethanol lobby, EPA decided to make an exception for corn-based ethanol plants. The agency had considered ethanol plants to be chemical processing facilities, which had a threshold of 100 tons of air pollution per year to be considered a "major" source, requiring stronger pollution controls. But EPA relaxed the standard for ethanol plants, changing it to a threshold of 250 tons per year. That meant fewer plants would be required to install "major" source air pollution controls. EPA's rationale for weakening the requirements for ethanol plants was based on maintaining U.S. energy security, not wanting to slow the ethanol industry's growth, and a claim (since disputed) that ethanol has environmental benefits.[21]

Among other government supports for the biofuel industry, the 2021 Infrastructure Investment and Jobs Act signed by President Biden provided $2 billion in grant funding, from 2022 to 2026, for the replacement of conventional diesel school buses with new buses that operate at least in part using alternative fuels, including biofuels.[22] The 2022 Inflation Reduction Act introduced a credit of $1.25 per gallon for producers of "sustainable aviation fuel" that reduces greenhouse gas emissions by at least 50 percent.[23]

In total, there are now 41 federal incentives, programs, laws, and regulations in effect in the U.S. to promote biodiesel, ethanol, and renewable diesel.[24] These do not include agricultural subsidies for biofuel feedstocks like corn and soybeans – estimated at more than $116 billion for corn and $44.9 billion for soybeans since 1995.[25] Today, more than a third of all corn grown and almost half of all soybeans are used not for food, but for fuel. In addition to the federal subsidies mentioned, states have implemented their own forms of incentives to boost biofuel production. California, for example, has its own Low Carbon Fuel Standard (similar to the federal Renewable Fuel Standard) that is driving a substantial amount of renewable diesel production.[26]

With the tremendous amount of taxpayer support biofuels have been given over the last few decades, the public has received little benefit in return. The price of gasoline has been affected very little by the presence of biofuels, with the price of gas rising at about the rate of inflation since the 1980s, despite mandates for blending corn-based fuel into gasoline.[27] Not only has the public not seen a financial gain from biofuels, but U.S. domestic petroleum production has simultaneously grown, causing more environmental harm and reducing the need for home- grown biofuel for national security reasons.

38% of corn and
46% of soybeans
are used to make biofuel

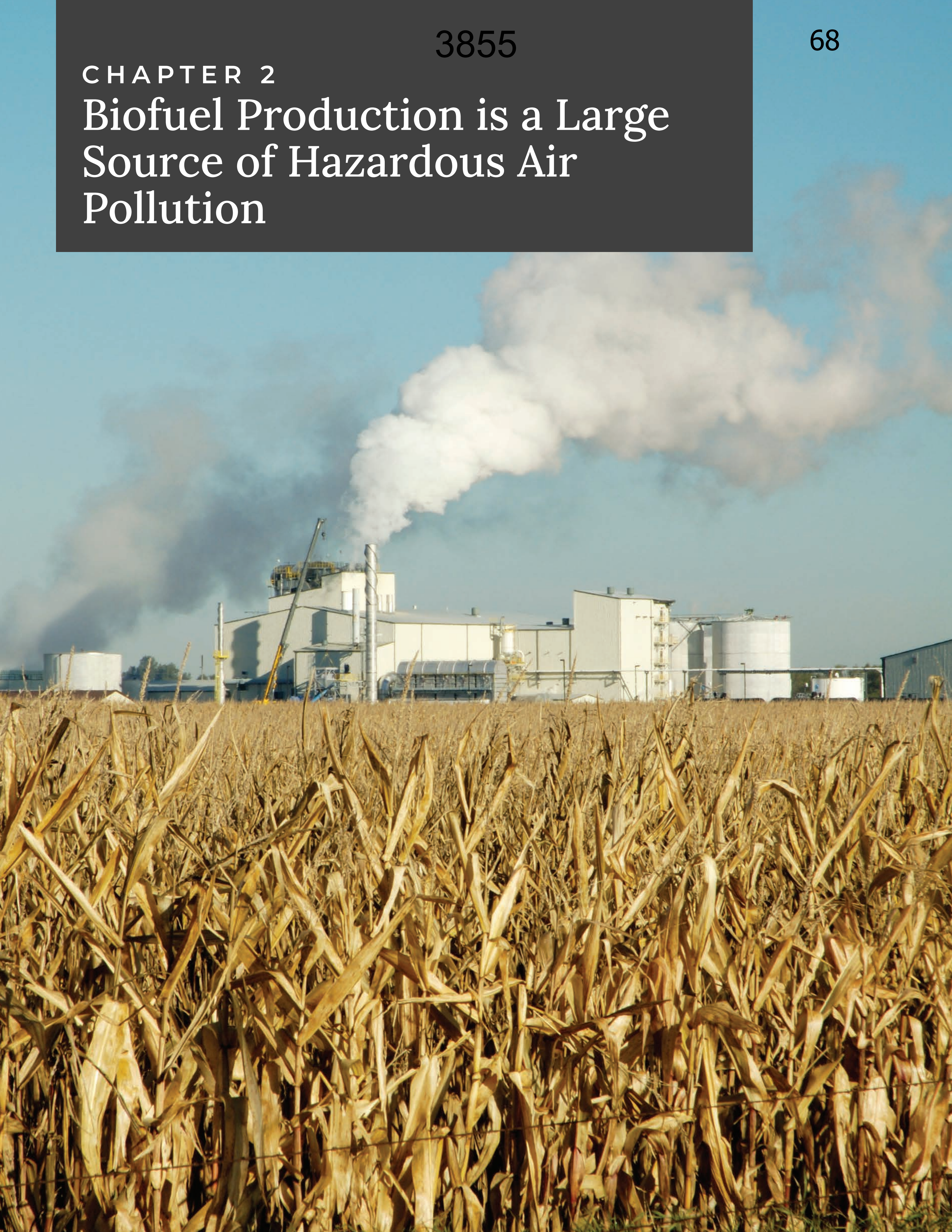
New Growth in the Biofuel Industry

In reaction to all these government supports, the biofuels industry has been expanding rapidly in the U.S. in recent decades. Recent growth in the sector – historically dominated by ethanol – is now driven by renewable diesel and a new generation of emerging renewable fuels, such as sustainable aviation fuel and renewable naphtha (a liquid that can be used to make jet fuel, plastic, and other products).[28]

Since 2022, at least five new biofuel plants have been built, four petroleum refineries have completed conversion projects, and three existing biofuel plants have expanded or restarted – increasing U.S. biofuel production capacity by over 2.6 billion gallons a year.[29] On top of this, at least another 25 proposed new plants, two refinery conversions, and expansions at five existing facilities could add another 4.9 billion gallons to annual production capacity, for a combined increase of over 7.5 billion gallons a year, or a 33 percent increase over the 2023 production capacity of 23 billion gallons a year.[30] Nearly all of this growth is in renewable diesel production. The eight renewable diesel projects that came online between 2022 and early 2024 added 2.5 billion gallons per year of capacity. The 27 additional projects in the works could add at least another 4.7 billion gallons. All together, these projects could more than double renewable diesel capacity in the U.S. compared to 2022.

At the center of this growth in renewable diesel is the expansion of "sustainable aviation fuel," made from wood or plants. The Biden Administration has a goal of the U.S. producing three billion gallons of sustainable aviation fuel annually by 2030 and meeting 100 percent of aviation fuel demand – 35 billion gallons per year – by 2050.[31] Supported by incentives like tax credits and grants,[32] companies have at least 23 sustainable aviation fuel projects proposed or under construction across the U.S.

Though emissions data are still limited, permit documents, where available, show that this recent and proposed growth could increase emissions of hazardous air pollutants by up to 139 tons a year. Emissions of volatile organic compounds from the sector could grow by up to 1,421 tons a year and greenhouse gases by millions of tons (with the total not yet clear).[33] These potential emissions estimates are limited to just 27 projects for which permit documents were available. Another 18 projects have been announced but permit and emissions details have not yet been disclosed.



CHAPTER 2

Biofuel Production is a Large Source of Hazardous Air Pollution

Biofuel Production is a Large Source of Hazardous Air Pollution

While the conversation surrounding biofuels frequently focuses on greenhouse gases, little is mentioned of the significant amount of hazardous air pollutants these facilities emit, along with smog-forming volatile organic compounds. EPA defines certain compounds as "hazardous air pollutants" because they are known, or strongly suspected, to cause cancer or have other grave health effects, such as damage to the neurological or respiratory systems. Benzene, for example, is a known carcinogen and is found in gasoline and its production. EPA has identified 188 different pollutants as hazardous air pollutants under the Clean Air Act.[34] In 2022, 226 biofuel plants in the U.S. reported emitting 12.9 million pounds of hazardous air pollutants.[35]

Compared to oil refineries, biofuel factories reported releasing almost

4X more

of four hazardous air pollutants: acetaldehyde, acrolein, formaldehyde and hexane.

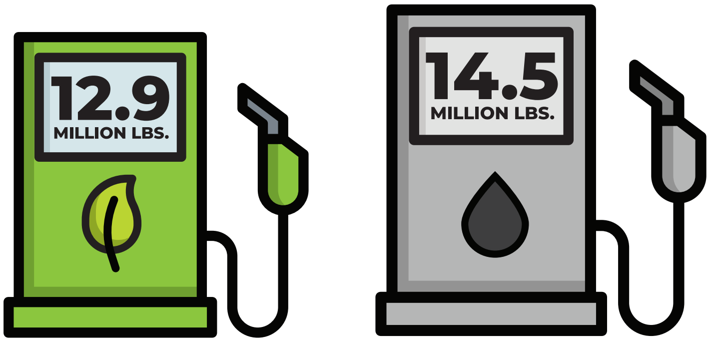
Biofuels plants reported releasing four hazardous air pollutants at levels significantly greater than petroleum refineries.

- **ACETALDEHYDE** is released during the fermentation process of ethanol production, and when ethanol is eventually broken down by vehicles. The primary short-term effect of inhalation exposure to acetaldehyde is irritation of the eyes, skin, and respiratory tract. At higher exposure levels, erythema, coughing, pulmonary edema, and necrosis may also occur. Acetaldehyde is considered a probable human carcinogen based on human studies conducted thus far and animal studies that have shown nasal tumors in rats and laryngeal tumors in hamsters.[36]
- **ACROLEIN** is also created during the ethanol fermentation process. Effects including weakness, nausea, vomiting, diarrhea, severe respiratory and eye irritation, shortness of breath, bronchitis, pulmonary oedema, unconsciousness, and death have been observed upon accidental exposure. Long-term exposure effects can consist of general respiratory congestion, as well as irritation of the eyes, nose, and throat.[37]
- **FORMALDEHYDE** is created in the fermentation process of ethanol production as well. EPA has preliminarily found that formaldehyde poses unreasonable risk to human health.[38] High levels of exposures to formaldehyde can cause health problems when inhaled and if it is absorbed into the skin. Inhaling high levels of formaldehyde for a short period of time can cause sensory irritation such as eye irritation. Inhaling formaldehyde for longer periods of time can damage the lungs and increase asthma and allergy-related conditions and cause cancer.
- **HEXANE** is used to extract edible oils from seeds and vegetables, as a special-use solvent, and as a cleaning agent. As such, it is heavily involved in the production of most biofuel products. Short-term exposure of humans to high levels of hexane causes mild central nervous system effects, including dizziness, giddiness, slight nausea, and headache. Long-term exposure to hexane is associated with polyneuropathy (nerve damage) in humans, as well as numbness in the extremities, muscular weakness, blurred vision, headache, and fatigue.[39]

On a per plant basis, biofuels factories reported releasing, on average, over twice as much acetaldehyde and hexane as petroleum refineries. Biodiesel plants reported emitting over 2,000 percent more hexane than refineries. Ethanol plants reported releasing nearly 150 percent more acetaldehyde than petroleum refineries. Biofuel facilities also reported emitting in 2022 nearly 4,000 pounds of acrolein on average, a pollutant that is not reported by petroleum refineries.

Air pollution from biofuel factories vs. oil refineries

Although biofuels are often portrayed as green and healthy, manufacturing biofuels reported releasing almost as much total hazardous air pollution as oil refineries in 2022.



Hazardous air pollution from biofuel factories

Hazardous air pollution from oil refineries

Note: Biofuel plants release more of four hazardous air pollutants than oil refineries: formaldehyde, acetaldehyde, hexane, and acrolein. But all 188 hazardous air pollutants are included in the 2022 totals above. Totals above are the pollutants reported to EPA Toxics Release Inventory.

Overall, biofuels manufacturing plants reported releasing more than 10.4 million pounds of these four hazardous pollutants in 2022 (acetaldehyde, acrolein, formaldehyde and hexane), which was almost four times as much as oil refineries that year. (See Table 1 on page 4.) However, when other pollutants, such as benzene, are taken into account, oil refineries were, overall, a larger source of all hazardous air pollutants than biofuel plants, although they were relatively close. Refineries reported releasing 14.5 million pounds of all hazardous air pollutants in 2022, compared to 12.9 million pounds from biofuel plants.[40]

In midwestern states like Iowa, Illinois, and Indiana, ethanol refineries are some of the largest sources of these hazardous pollutants, as well as volatile organic compounds. In Iowa and Illinois, the top two highest corn-producing states in the U.S., about 70 percent of all hazardous pollutants reported came from ethanol plants – a total of 5.7 million pounds in 2022. The hazardous air pollutant totals from ethanol plants in Illinois (2.2 million pounds) and Iowa (3.6 million pounds) were similar to the amount reported by oil refineries in Louisiana (2.7 million pounds) that year. Together, the totals from ethanol plants in these two midwestern states were about the same as the amount of hazardous air pollutants reported by petroleum refineries in Texas (5.8 million pounds in 2022).

In Iowa and Illinois,

70%

of all hazardous air pollutants reported come from ethanol plants

Over the course of the last 10 years with data available (from 2013 to 2022), total hazardous air pollutants reported to EPA's Toxics Release Inventory by biofuels facilities rose from 10.8 million pounds to 12.9 million pounds, a 19 percent increase.[41] This came as the number of biofuels plants reporting emissions to EPA increased by 13 percent. Ethanol plants reported an increase from 6.6 million pounds of total hazardous air pollutants to 8 million pounds, a 21 percent increase, as the number of plants reporting rose by 11 percent. Biodiesel plants reported an increase from 4.2 million pounds to 4.9 million pounds, a 17 percent increase, as the number of plants increased by 19 percent. The hazardous pollutants reported by petroleum refineries during this period decreased from 18.1 million pounds to 14.5 million pounds, a 20 percent decrease, while the number of plants reporting fell by five percent.[42]

Top Emitters of Hazardous Air Pollution

As mentioned previously, Iowa and Illinois are home to major emitters of hazardous air pollutants, including acetaldehyde. As can be seen in Table 2 below, six of the top 10 reported emitters of acetaldehyde among biofuel plants nationally in 2022 were located in one of these two states, and all were ethanol plants. Additionally, the three biofuel plants reporting the most acetaldehyde pollution that year were all among the top 10 emitters of this pollutant nationally, regardless of industry. The Alto Pekin ethanol plant in Illinois was the second largest acetaldehyde polluter in the U.S., ranking second only to Eastman Chemical plant in Tennessee, and releasing more than twice as much as the second highest biofuel plant.

Table 2: Top 10 biofuel plants that reported releasing the most acetaldehyde in 2022

Rank among biofuel plants	Facility	Location	Biofuel Type	Emissions (lbs)	Rank nationally (among all industries)
1	Alto Pekin LLC Wet and Dry Mill	Pekin, IL	Ethanol	295,597	2
2	Archer Daniels Midland	Clinton, IA	Ethanol	128,885	7
3	Grain Processing Corp	Muscatine, IA	Ethanol	113,612	10
4	Archer Daniels Midland Dry Mill and Wet Mill	Cedar Rapids, IA	Ethanol	98,041	11
5	Cargill Inc.	Blair, NE	Ethanol	76,215	26
6	Cargill Inc.	Eddyville, IA	Ethanol	63,789	32
7	Tate & Lyle	Loudon, TN	Ethanol	60,671	34
8	Archer Daniels Midland Dry and Wet Mill	Columbus, NE	Ethanol	58,781	36
9	Poet Biorefining - Hudson LLC	Hudson, SD	Ethanol	20,600	108
10	Poet Biorefining - Shell Rock LLC	Shell Rock, IA	Ethanol	19,092	113

Source: EPA 2022 Toxics Release Inventory.

When it comes to hexane emissions, the locations of the top ten polluters are spread out among six states, as can be seen in Table 3. Most of these facilities are biodiesel plants because hexane is heavily involved in biodiesel production. However, the top reported emitter (Archer Daniels Midland in Decatur, Illinois) is an ethanol plant that produces many other products as well, and is the top reported emitter of hexane in the U.S. regardless of industry.

Table 3. Top 10 biofuel plants that reported releasing the most hexane in 2022

Rank among biofuel plants	Facility	Location	Biofuel Type	Emissions (lbs)	Rank nationally (among all industries)
1	Archer Daniels Midland	Decatur, IL	Ethanol*	2,227,817	1
2	Louis Dreyfus Agricultural Industries, LLC	Claypool, IN	Biodiesel	719,432	10
3	Paseo Cargill Energy, LLC	Kansas City, MO	Biodiesel	622,000	15
4	Incobrasa Industries Ltd.	Gilman, IL	Biodiesel	502,437	22
5	Cargill Inc.	Wichita, KS	Biodiesel	500,000	25
6	Archer Daniels Midland	Velva, ND	Biodiesel	433,821	29
7	Minnesota Soybean Processors	Brewster, MN	Biodiesel	418,537	31
8	Deerfield Energy, LLC	Deerfield, MO	Biodiesel	364,955	42
9	AG Processing	St. Joseph, MO	Biodiesel	308,132	47
10	Cargill Inc.	Iowa Falls, IA	Biodiesel	249,321	56

Source: EPA 2022 Toxics Release Inventory.

*Facility produces more than just ethanol, including citric acid, lactic acid, xanthan gum, dextrose, sorbitol, and corn syrup.

For a listing of the biofuel plants releasing the most acrolein and formaldehyde, please see Appendix D.

Other Air Pollutants Released by Biofuel Plants

Another EPA category of pollutants, called "criteria air pollutants" – namely nitrogen oxides, sulfur dioxide, lead, particulate matter, carbon monoxide – are also produced by biofuel manufacturing plants and can also threaten human health. The biofuel plants studied by EIP reported emitting 47,727 tons total criteria pollutants in 2020 (the most recent available year for those pollutants).[43] This broke down into 14,526 tons of nitrogen oxides, 14,782 tons of sulfur dioxide, 7,740 tons of particulate matter, 10,678 tons of carbon monoxide and 240 pounds of lead that year.

Greenhouse Gas Emissions from the Biofuel Industry

In addition to being a large source of toxic air pollution, biofuel refineries also emit a lot of greenhouse gases. Overall, 191 plants in 2022 reported emitting over 33.2 million metric tons of greenhouse gases (expressed as carbon dioxide equivalent tons). That's as much climate-warming pollution as from 8.5 coal-fired power plants operating around the clock or 27.5 average oil refineries. While this was less than the amount all oil refineries in the U.S. reported in total that year, some biofuel plants reported emitting as much as or more than some individual refineries. Emissions are higher at plants that burn coal or other carbon-intensive fuels to power and provide heat for biofuel manufacturing processes.[44]

For example, the Archer Daniels Midland ethanol plant in Decatur, Illinois, reported emitting over 4.1 million metric tons of greenhouse gases in 2022. It was the fourth-largest source of greenhouse gases in the state, ranking above the Wood River oil refinery, which was the fifth-largest source. Two other plants run by Archer Daniels Midland, one in Cedar Rapids and another in Clinton, Iowa, both reported emitting over two million metric tons of greenhouse gases each, making them the fifth and sixth largest sources, respectively, of those pollutants in Iowa. Only 14 of more than 100 oil refineries in the U.S. reported emitting more than these three biofuel plants. Table 4 lists the 10 biofuel plants that emitted the most greenhouse gases in 2022.

Table 4. 10 biofuel plants that reported emitting the most greenhouse gases in 2022

Facility	Location	Biofuel Type	Greenhouse gas emissions (CO_2e, metric tons)	Fuel type(s)
Archer Daniels Midland	Decatur, IL	Ethanol	4,149,749*	Fuel oils, natural gas, tires, biomass gases, coal
Archer Daniels Midland Dry Mill and Wet Mill	Cedar Rapids, IA	Ethanol	2,845,289	Coal, natural gas, biomass gases, agricultural byproducts, biomass waste byproducts
Archer Daniels Midland	Clinton, IA	Ethanol	2,272,456	Natural gas, coal, agricultural byproducts, biomass waste byproducts
Archer Daniels Midland Dry and Wet Mill	Columbus, NE	Ethanol	1,163,383	Coal, natural gas, biomass gases
Biourja Renewables LLC	Peoria, IL	Ethanol	560,401	Fuel oils, natural gas
Cargill Inc.	Blair, NE	Ethanol	530,151	Natural gas, biomass gases
Marquis Energy, LLC	Hennepin, IL	Ethanol	526,801	Natural gas
Cargill Inc.	Eddyville, IA	Ethanol	378,927	Natural gas, fuel oils
Tate & Lyle	Loudon, TN	Ethanol	376,468	Natural gas, biomass gases
Grain Processing Corp.	Muscatine, IA	Ethanol	351,996	Natural gas, biomass gases

Source: EPA 2022 Greenhouse Gas Reporting Program. "CO_2e" means carbon dioxide equivalent tons. Table excludes biofuel facilities that co-produce petroleum products. *Reported sequestering 428,580 metric tons of greenhouse gases emitted by the ethanol plant.

To reduce greenhouse gases from biofuel production, several ethanol companies have committed to capturing carbon dioxide and piping it across the Midwest to where it can be injected deep underground. Overall, companies behind at least 12 of the 32 new or expanded biofuel plants have indicated their plans to use carbon capture and sequestration. However, carbon capture is expensive and largely unproven, on a large scale, and it is not clear if it will work as a strategy to combat climate change.[45] Congress recently more than doubled public subsidies for companies that sequester carbon, from $37.85 to $85 per metric ton. But current U.S. regulations do not require companies that operate sequestration wells to guarantee that carbon stays underground and monitoring requirements are inadequate.[46]

Even if biofuel facilities are successful at capturing their plant-level emissions and sequestering it underground, the lifecycle emissions from biofuels, especially after accounting for land use changes to accommodate additional corn and soybean production, raise serious doubts about whether biofuels offer climate benefits over fossil fuels. One recent study, published by the National Academy of Sciences, found that corn-based ethanol's life-cycle greenhouse gas emissions are "no less than gasoline and at least 24 percent higher."[47]

EPA has also raised concerns about the trade-offs of producing more ethanol and other biofuels. The agency wrote in a 2024 report: "Replacing fossil fuels with biofuels has the potential to reduce some undesirable environmental impacts of fossil fuel production and use, including conventional and greenhouse gas (GHG) pollutant emissions, exhaustible resource depletion, and dependence on unstable foreign suppliers. Demand for biofuels could also increase farm income. Biofuel production and use has drawbacks as well, including land and water resource requirements, air and ground water pollution. Depending on the feedstock and production process, biofuels can emit even more greenhouse gases than some fossil fuels on an energy-equivalent basis."[48]

Clean Air Act Violations at Biofuel Facilities

EIP surveyed EPA's Enforcement and Compliance History Online (ECHO) database for compliance histories on 276 biofuel facilities in the U.S. and identified data from 240 plants.[49] Based on these findings, as of May 2024, 98 plants had a violation reported at the federal, state, or local level in the last three years, and 45 of these had a "high priority violation" reported in that time. Twenty-two of the plants that reported a high priority violation in the last three years have at least one existing violation that has yet to be addressed.

Additionally, of the biofuel plants surveyed, state or federal agencies brought 121 enforcement actions[50] against 61 plants in the last five years. These have included $4.5 million in environmental penalties against 46 of these facilities assessed over the past five years. Table 5 shows the top facilities – eight being ethanol plants – with the most Clean Air Act enforcement actions.

Table 5. Biofuel plants with the most Clean Air Act enforcement actions in the last 5 years

Facility	Location	Biofuel Type	Number of enforcement actions	Total penalty amount assessed
Pelican Renewables LLC	Stockton, CA	Ethanol	17	$205,500
Pennsylvania Grain Processing LLC	Clearfield, PA	Ethanol	7	$66,744
Alto Pekin LLC Wet and Dry Mill	Pekin, IL	Ethanol	4	$308,374
Alto ICP LLC	Pekin, IL	Ethanol	4	$193,516
Bioenergy Development Group LLC	Memphis, TN	Biodiesel	4	$80,988
Dynamic Recycling LLC	Bristol, TN	Ethanol	4	$13,500
Marquis Energy LLC	Hennepin, IL	Ethanol	4	$0
Archer Daniels Midland	Decatur, IL	Ethanol	4	$0
Biourja Renewables LLC (formerly ADM)	Peoria, IL	Ethanol	4	$0

Source: EPA Enforcement and Compliance History Online database.

It should be noted that these violations and enforcement actions came despite relaxed standards for ethanol plants that EPA put in place in 2007 (as discussed earlier). These relaxed standards allow most ethanol plants to call themselves "minor" sources of air pollution, even though they are often large sources that deserve more stringent air pollution control requirements.

Sixty-five out of 182 biofuel plants with available data (36 percent) failed "stack tests" over the last five years. A stack test measures the amount of a specific regulated pollutant to determine if the emissions are in compliance with permits approved under the Clean Air Act. (Some stack tests also measure the efficiency of air pollution control devices or capture systems.)[51] Table 6 below shows the top five plants with the most stack test failures in the last five years that have not had any enforcement actions[52] taken against them or penalties assessed during this time period, according to EPA's ECHO database.

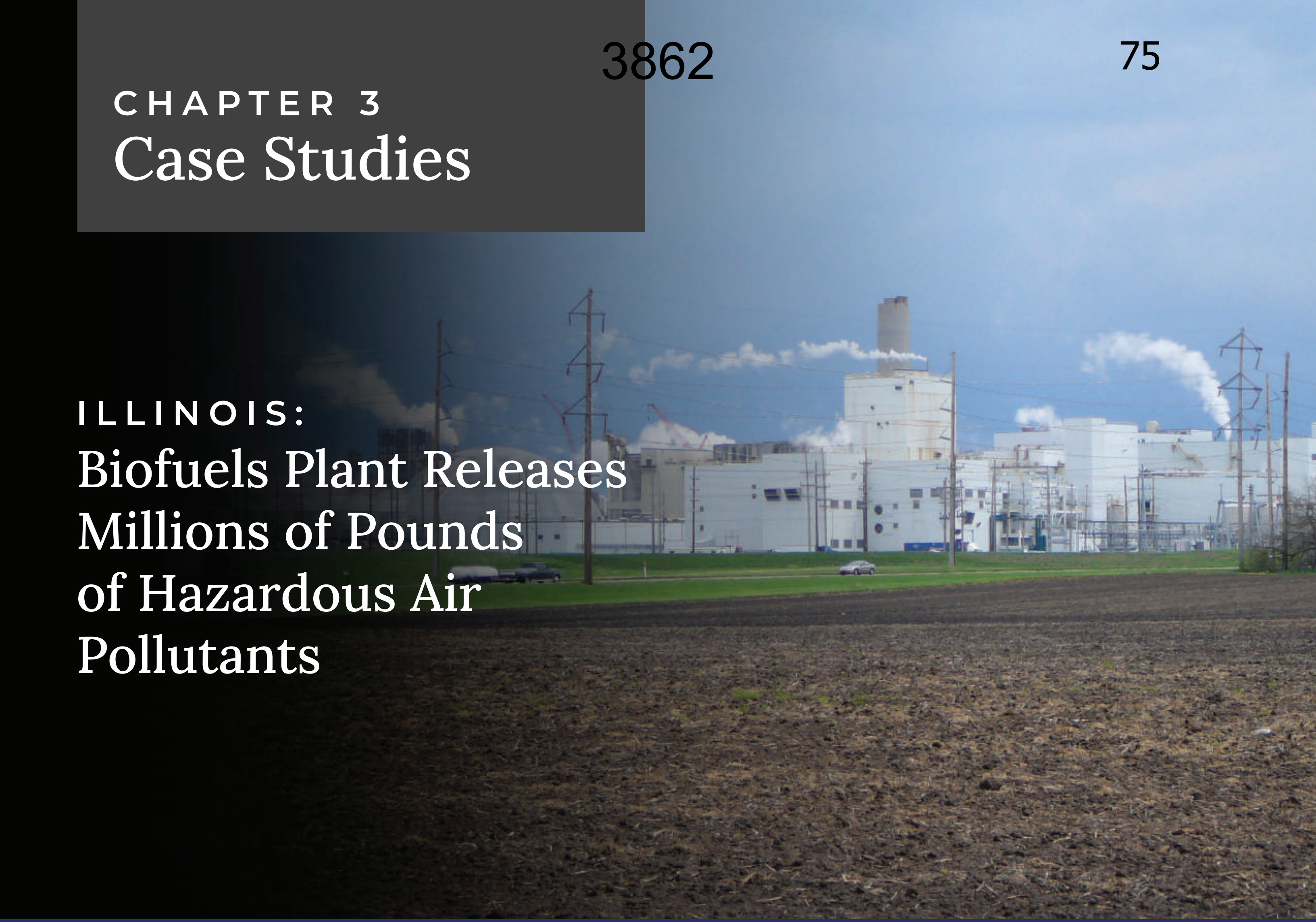
Table 6. Biofuel plants with the most stack test failures in the last 5 years without enforcement actions or penalties

Facility	Location	Biofuel Type	Stack Tests	Stack Test Failures
Grain Processing Corp	Muscatine, IA	Ethanol	78	16
Archer Daniels Midland Dry and Wet Mill	Columbus, NE	Ethanol	29	5
Valero Renewable Fuels LLC	Mt. Vernon, IN	Ethanol	76	5
Poet Biorefining - Marion LLC	Marion, OH	Ethanol	33	5
Golden Grain Energy LLC	Mason City, IA	Ethanol	36	4

Source: EPA Enforcement and Compliance History Online database.

The following are four local examples of environmental problems caused by biofuels plants.

CHAPTER 3
Case Studies



ILLINOIS:
Biofuels Plant Releases Millions of Pounds of Hazardous Air Pollutants

The Archer Daniels Midland ethanol plant in Decatur is the largest emitter of hexane air pollution of any industrial site in the U.S., according to the most recent available EPA Toxics Release Inventory data.

Archer Daniels Midland (ADM), one of the world's largest agribusinesses, is headquartered about three hours southwest of Chicago in the central Illinois town of Decatur. There, the company's largest facility globally houses soybean crushing machinery and one of the biggest corn mills in the world as part of its ethanol manufacturing plant. With the capacity to produce 375 million gallons of ethanol biofuel annually, it is among the largest ethanol plants in the country.[53]

The plant is also a major source of pollution, releasing 3,076,416 pounds of hazardous air pollutants and 4,149,749 metric tons of greenhouse gases[54] in 2022, the most of any biofuel facility that year in both categories. It was also the largest emitter of hexane of any industrial site in the U.S. that year, releasing 2,227,817 pounds.

The ADM plant in Decatur, IL, was the largest emitter of hexane of any industrial site in 2022, releasing

2.2 million pounds

"Industrial ethanol plants like the ADM facility in Decatur negatively impact local air quality," said Hannah Lee Flath, then the Communications Coordinator at Sierra Club Illinois Chapter.[55]

"The food and agricultural production that takes place at ADM's Decatur facility requires immense energy," Flath said. "As of 2018, almost half of the company's energy usage came from burning coal. As Illinois looks to transition away from its reliance on fossil fuels, corporations like ADM should join the effort to rely on energy powered more by wind and solar."

A recent study found that the facility might be significantly underestimating its emissions of hazardous air pollutants. Researchers from the National Oceanic and Atmospheric Administration (NOAA) used air monitors downwind from the ADM plant in Decatur to measure three pollutants: nitrogen oxides (NO_x), sulfur dioxide (SO_2), and volatile organic compounds (VOCs).[56] The researchers then compared the concentrations of these pollutants to models that relied on ADM's reported emissions. While concentrations of NO_x and SO_2 roughly matched the expected results from the modeling, concentrations of VOCs were five times higher than expected.[57] The researchers believe that the most likely explanation is that ADM had significantly under-reported the facility's VOC emissions.

VOC emissions from the ADM plant in Decatur were

5X higher

than expected, a study by NOAA found.

This result aligns with the fact that many sources of VOC emissions at biofuel plants are not subject to rigorous compliance testing requirements. Air permits also lack adequate monitoring requirements to sufficiently quantify fugitive emissions—i.e. emissions from leaks and other points that do not pass through smokestacks.

The ADM Decatur plant also has a history of safety concerns. An explosion at the facility's West Plant in April 2023 resulted in the hospitalization of three employees and extensive damage to a grain elevator. An investigation by the Occupational Safety and Health Administration determined that a lack of preventative maintenance was a main factor in the explosion.[58]

In recent years, with the aid of government funding, ADM has explored the potential of carbon capture and storage at its Decatur ethanol plant. As of July 2022, ADM has sequestered about 3.9 million metric tons of CO_2 into a sandstone formation at its Illinois-Basin Decatur Project and Illinois Industrial Sources Carbon Capture and Storage Project.[59] But that captured carbon made up only about 10 to 12 percent of the carbon dioxide emitted by the entire plant (including not only from its ethanol production, but also from its power plant and grain processing facilities). That meant that 88 to 90 percent of the greenhouse gas was released into the atmosphere, according to EPA data.[60]

Jennifer Cassel, a senior attorney with Earthjustice's Clean Energy Program based in Chicago, said the carbon stored from the ADM facility has already seeped out of the predicted area, "which bodes badly for how well carbon will be sequestered." She said there are nearly two dozen more proposed sequestration wells, more than a few of which would be operated by ADM, currently under consideration in Illinois.[61]

"The scope of what is being proposed in the state is vastly more than what ADM is currently sequestering," Cassel said. "And they haven't even been able to keep track of their small amount of carbon."

IOWA:

Ethanol Plant's Smokestacks Contribute to Rural Area Violating Air Pollution Standards

The Grain Processing Corporation ethanol plant in Muscatine, Iowa.

Muscatine County, Iowa, on the Mississippi River, is one of few counties in the Midwest whose air quality violates federal sulfur dioxide standards, and the only one in Iowa. The county's unusually high levels of sulfur dioxide may be in part because the county is home to an ethanol refinery owned by the Grain Processing Corporation.

The Muscatine plant reported releasing 83 tons of sulfur dioxide in 2020, as well as 113,612 lbs. of acetaldehyde, 3,548 lbs. of acrolein, 19,210 lbs. of formaldehyde, and 10,878 lbs. of hexane in 2022.[62] These last three are volatile organic compounds (VOCs), a class of pollutants that can contribute to smog.

According to EPA's enforcement database, the plant has failed "stack" tests – monitoring for illegal levels of air pollution – 16 times over the last five years.[63] The plant has been out of compliance with the Clean Air Act five of the last 12 quarters and in violation of the Clean Water Act each quarter for the last three years, according to EPA's ECHO database.[64]

The Grain Processing Corp. ethanol plant in Muscatine, Iowa, has failed air pollution "stack tests"

16 times

over the last five years, without any penalties or enforcement actions.

Beginning in the 2000s, EPA, the state of Iowa, and citizens brought numerous enforcement actions against the Grain Processing Corporation for several Clean Air Act violations. These include for exceeding emission limits and failing to report violations, according to EPA.[65] State inspectors even noted an "obvious blue haze generated by the plant and drifting over Muscatine neighborhoods."[66]

These enforcement initiatives did force the company to install new air pollution controls and, in 2015, to switch from burning coal to natural gas.[67] The company was also hit with a class action lawsuit that resulted in a $45 million settlement.[68] Despite changes at the plant, the facility has still faced at least 15 enforcement actions for violating the Clean Air Act since 2017.[69]

The neighboring communities around the ethanol plant are disproportionately low income and people of color. Although much of Muscatine is home to middle to upper-middle class residents, the neighborhoods immediately next to the adjoining the Grain Processing Corporation facility are in the 86th percentile for low-income households and in the 60th percentile for people of color, according to an EPA database.[70]

CALIFORNIA:

East Bay Area Residents Object to Biofuel Projects

Owners of the San Francisco Refinery in Rodeo announced that they were switching from petroleum refining to biofuel production. Local residents would rather have the refineries shut down.

In 2020, a more than century-old oil refinery, owned by Phillips 66 an hour northeast of San Francisco, announced its plans to cease petroleum processing and transition into a biofuel plant.[71]

The owners of the massive facility, located on more than 1,000 acres along San Pablo Bay, said they aim to produce about 800 million gallons per year of renewable diesel and aviation fuel. Deemed the "Rodeo Renewed Project," it would be one of the world's largest biofuel refineries.

However, some local residents protested the plans. And three years after the announcement, the Contra Costa Superior Court ordered Phillips 66 to halt its conversion plans until the company fully complied with environmental review requirements it had previously violated.[72] The Phillips 66 operators then revised their Environmental Impact Report, and in January 2024, the Contra Costa County Board of Supervisors unanimously approved and adopted a "revised final" report, allowing the project to proceed.[73]

More than 75%

of the people living within three miles of the Rodeo Renewed biofuel plant are people of color.

In April 2024, Phillips 66 announced that the Rodeo facility had finally started operations and is now producing 27,000 barrels a day of renewable diesel.[74]

Proponents of the biofuel conversion argue that it will help the state approach its ambitious goal of cutting fossil fuel consumption by a factor of 10 by 2045 and reducing greenhouse gas emissions at least 40 percent below 1990 levels by the year 2030.

The Phillips 66 refinery in Rodeo, along with the nearby Marathon-Tesoro biofuel refinery in Martinez, which also recently converted from a crude oil refinery to a biofuel plant, will require at least 82,000 truck trips, nearly 29,000 railcars, and more than 760 ship and barge visits annually, according to one estimate.[75]

Local residents fear that these projects will lock in traffic congestion and pollution sources that the community has already been dealing with for decades. Local residents opposed to the biofuel plants would prefer the old refineries be shut down altogether. More than three-quarters of the people living within three miles of the Rodeo Renewed facility are people of color.

Kerry Guerin, an attorney with Communities for a Better Environment, a California environmental health and justice organization, said that according to the project's own environmental impact report, the differences in pollution between petroleum and biofuels refining is "small," with some hazardous pollutants actually increasing as a result.[76]

> "It is a fallacy to suggest that there are environmental benefits that justify the production of liquid biofuels over traditional petroleum-based liquid fuels. **It is hocus pocus.**"
>
> - Gary Hughes, coordinator with the advocacy group Biofuelwatch

"And then there are the risks of flaring, explosions, and other chemical releases from refineries," said Guerin. "This was made unfortunately and abundantly clear by a recent fire at the Marathon biofuels refinery nearby in Martinez."

Guerin said biofuel conversions like Rodeo's are, "best understood as a last-ditch attempt by oil companies to extract the remaining profits from their otherwise stranded billion-dollar assets and kick the can down the road. They are postponing the day they have to decommission and, critically, remediate these sites, including the soil and groundwater underneath these refineries that have collected decades of pollution."

The Rodeo Renewed facility has the potential to emit 1,075,100 metric tons of greenhouse gases and 745 tons of criteria air pollutants and their precursors each year, including 72 tons of particulate matter, 216 tons of nitrogen oxides, 111 tons of VOCs, and 295 tons of sulfur dioxide, according to government records.[77] The Martinez Refinery, also located in Contra Costa County, is owned by Tesoro Refining & Marketing Company LLC, a subsidiary of Marathon Petroleum Corporation. It has the potential to emit 813,263 metric tons of greenhouse gases and 333 tons of other air pollutants each year, according to government records.[78]

Gary Hughes, the Americas Program Coordinator with the nonprofit advocacy group Biofuelwatch, said they are strongly critical of the state narrative that incentivizing the production of biofuels at repurposed refineries in the Bay Area offers any relief to local communities or the global climate.[79]

"It is not only about rehabilitating the image of these polluters, it is really fundamentally about California regulatory authorities protecting their stranded assets," he said. "It is a fallacy to suggest that there are environmental benefits that justify the production of liquid biofuels over traditional petroleum-based liquid fuels. It is hocus pocus."

LOUISIANA:

Turning Trees into Jet Fuel, a Fast-Growing Business for Biofuels

Although trees provide many benefits to the environment, biofuel companies want to chop them up to create liquid fuel and fuel pellets.

In Columbia, Louisiana, about four hours north of New Orleans, a company called Louisiana Green Fuels (LGF) is proposing to build an enormous refinery that would transform trees into jet fuel. It would be the first factory of its kind on a large scale.[80]

The $2.5 billion project is an example of one of the fastest-growing segments of the biofuels industry: the use of wood biomass – a euphemism for trees – and other plants as the primary ingredient to produce fuels. Across the U.S., 23 new plants or facility expansions are proposed or under construction to produce “sustainable aviation fuel,” and six of them would use wood as an ingredient.

This mirrors the rapid expansion of another “green” fuel over the last two decades: the wood pellet industry, which chops and compresses trees and wood waste into fuel to burn in power plants.[81] The wood pellet industry has a history of underestimating its emissions of hazardous air pollutants and volatile organic compounds and exceeding pollution limits. A 2018 study of the industry’s permitting and emissions records found that 52 percent of the wood pellet plants in the U.S. had improperly evaded Clean Air Act pollution control requirements, either by failing to keep emissions below legal limits or failing to install required pollution control systems.[82]

52%

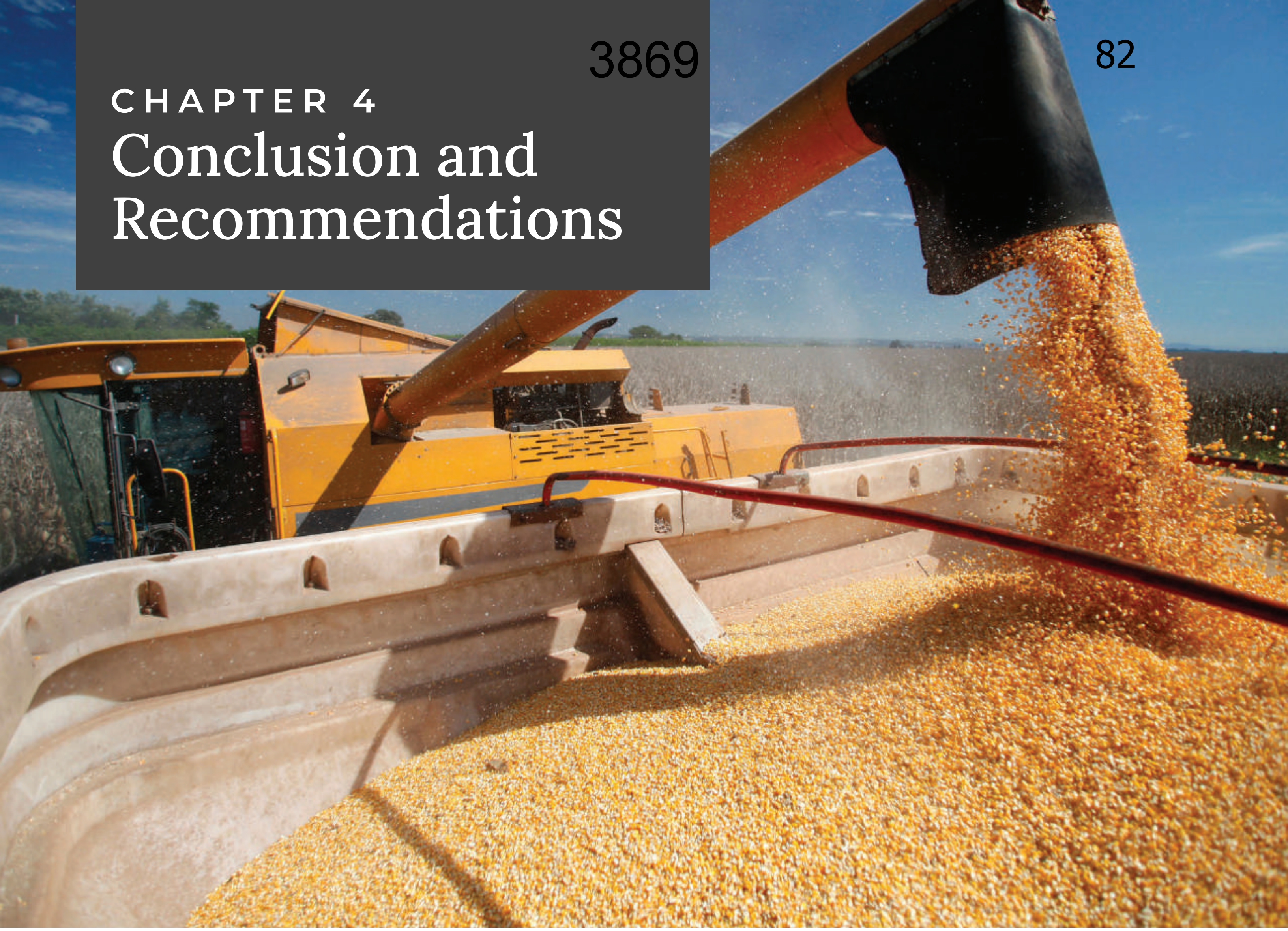
of wood pellet fuel plants violated the Clean Air Act by evading pollution control requirements.

The new wood-to-jet fuel industry appears to be on the same track. For example, the Louisiana Green Fuels facility applied for a permit to operate an 85 megawatt wood-fired boiler, as well as four rotary dryers with a capacity of 665,760 tons per year to convert 1 million tons of trees into 32 million gallons per year of diesel and naphtha (which can be used as a fuel).[83] Despite the large scale of this facility, the company applied for an air permit claiming to be a minor source of both hazardous air pollutants and VOCs. In particular, the company claimed that the facility would emit about 91 tons of VOCs per year – just below the threshold of 100 tons that would trigger "major" permit requirements for stronger air pollution controls. The plant also proposed to release up to 24 tons per year of hazardous air pollution.

However, the company's emission estimates for VOCs and hazardous pollutants were based on extremely limited laboratory testing of a single gram of wood, which was placed in a sealed glass container and heated for just over an hour.[84] The testing methods did not even measure the most common wood-product VOC and hazardous pollutant compounds. The company then utilized this "laboratory testing" report to estimate the emissions from the facility's massive dryers, which would process 31 tons of wood per hour. That's about 28 million times more wood than was involved in the laboratory testing.

In short, Louisiana Green Fuels' entire premise that the facility would be a minor source of air pollutants was based on clearly inadequate testing. By comparison, EPA has compiled a vast database of real-world emissions testing on wood dryers that indicate the company's dryers will more likely emit around 1,000 tons of VOCs and several hundred tons of hazardous air pollutants per year.[85]

Despite these problems, Louisiana regulators accepted the Louisiana Green Fuels application and permitted the facility as a minor source of air pollution.[86] As of February 2024, the company was expected to begin construction in 2025.[87]



CHAPTER 4

Conclusion and Recommendations

Biofuels like ethanol, biodiesel, and renewable diesel are portrayed as a healthier and more sustainable alternative to gasoline and diesel fuel. Yet, they can increase certain types of hazardous air pollution that threaten the health of local communities. Increased public subsidies and government mandates for biofuels have also contributed to increased agricultural runoff pollution, including from expanded use of nitrogen fertilizer, insecticides, and herbicides.

So far, much of the commentary surrounding biofuels has centered around greenhouse gas emissions. Often overlooked are their toxic emissions and lack of compliance with air pollution laws. Biofuel plants are worse than petroleum refineries when it comes to emitting the hazardous air pollutants acetaldehyde, acrolein, formaldehyde, and hexane. And 41 percent of U.S. biofuels plants (98 of 240) violated their air pollution control permits at least once between July 2021 and May 2024, according to EPA's Enforcement and Compliance History Online database. Twenty-two of these plants were considered by EPA to be "high-priority violators" of the Clean Air Act as of May 2024.

Despite these problems, biofuels such as ethanol and renewable diesel have received a significant amount of government support, in the form of subsidies, mandates and tax credits. The ethanol industry has also benefited from a regulatory exemption from EPA that allows large plants to avoid the most stringent air pollution control systems. The result is rapid growth that could lead to the construction of dozens of new biofuel manufacturing plants across the U.S. without adequate emissions controls to protect downwind communities.

We recommend the following policy steps to better control pollution from the biofuels industry:

- **END EXEMPTIONS FOR ETHANOL UNDER THE CLEAN AIR ACT:** EPA should reverse its 2007 decision to relax major source permitting thresholds for ethanol manufacturers that allow these plants to emit more than twice the level of air pollution before needing to install better pollution controls. The ethanol industry has already been heavily subsidized by the public, with little actual benefit for the public. It is wrong for EPA to also allow ethanol plants to release significantly greater amounts of toxic pollutants into surrounding communities than should be permitted.

- **BETTER MONITORING AND CONTROL OF HAZARDOUS AIR POLLUTANTS:** EPA should require large biofuel plants to install air pollution monitoring devices along their fencelines to detect the levels of hazardous air pollutants, like acetaldehyde and acrolein, that could be drifting into nearby communities. EPA should also establish an 'action level' for these and other highly toxic pollutants, that, if exceeded, would obligate these facilities to identify the sources of the emissions and then fix the problems causing elevated concentrations.

- **STRONGER ENFORCEMENT OF AIR PERMITS FOR BIOFUEL PLANTS:** EPA and state regulatory agencies should more vigorously enforce air pollution control permits for biofuel plants, imposing penalties large enough to discourage future violations, which today are common. Tougher penalties would provide an economic incentive to follow the law.

- **IMPROVE THE ACCURACY OF EMISSIONS REPORTING:** Biofuels producers should be required, during the permit review and approval process, to expand their emissions testing and improve the accuracy of their emissions reporting to both EPA and the states.

- **END BIOFUEL SUBSIDIES AND MANDATES:** Biofuels are growing at a rapid rate in part because of government funding and regulatory mandates for blending ethanol into gasoline. But the environmental benefits of these government supports are questionable at best. All existing subsidies and mandates for ethanol – including the renewable fuel standard – should be halted. Federal efforts and funds should be focused instead on clean energy sources like wind and solar and improving our nation's clean energy infrastructure.

While biofuels have been sold as a clean and green alternative energy source, the reality is quite different and the public should be aware of it. Regulators need to carefully scrutinize the industry and vigorously enforce pollution limits, as biofuel plants pose a serious health threat to the people who live downwind from them. And legislators need to cut off the subsidies and mandates that artificially support this industry.

Appendix A. Methodology

Facility Identification:

EIP identified ethanol, renewable diesel, and biodiesel facilities through several data sources.

Existing facilities were identified from EIA's 2022 biofuels production capacity reports released August 8, 2022, updated from EIA's 2023 capacity reports, and reflects operable capacity as of January 1 of each report year. EIA capacity reports combine "renewable diesel" and "other biofuels." For the purposes of this report, "renewable diesel" generally refers to renewable diesel and other renewable fuels (e.g., sustainable aviation fuel, renewable naphtha, etc.). EIA facilities were matched with facilities in EPA's Enforcement and Compliance History Online (ECHO) data. In some cases, a facility may be inconsistently treated as a single or multiple facilities by EIA and EPA. We combined facilities that EIA treated as two plants where EPA data treated the facilities as one (e.g. Archer Daniel Midland's wet and dry corn mills in Cedar Rapids, Iowa). We excluded facilities that news reports or EPA have identified as closed facilities. After reviewing EIA reports and ECHO, we narrowed our universe of "existing facilities" to 191 ethanol plants, 71 biodiesel facilities, and 16 renewable diesel producers. Eight of the 16 renewable diesel producers also co-produce fossil-fuel based petroleum products. Emissions and compliance data for these renewable diesel/ petroleum facilities were excluded in our summary analysis to avoid skewing data, but are included in this linked spreadsheet. We identified one additional ethanol plant and 8 additional renewable diesel plants that have started operating but were not included in the 2023 EIA Capacity Report. Four co-produce fossil-fuel based petroleum products.

We identified new, under construction, and proposed facilities from Oil & Gas Watch, news sources and industry/ trade websites, and some state agencies. Oil & Gas Watch facilities are limited to oil, gas, and petrochemical projects and, for the purposes of this project, could only be used to identify some renewable diesel projects, requiring the use of additional sources for other facilities. We identified nine new five new biofuel facilities, four refinery conversions, and one facility that restarted operations after idling for several years that have started operating but are not reflected in the EIA/ECHO data among "existing facilities." This is in part due to reporting delays - as in, facilities started operating in recent years (2023, 2024) after the most recent year of emissions data. Three projects started operating in 2022 but were not reflected in the most recent 2023 EIA Capacity Report. As such, we've treated these as "new" facilities.

Facility Information:

Facility information for operating biofuel facilities comes from 2022 and 2023 Biofuel Capacity Reports and EPA's Enforcement and Compliance History Online database. Data collected includes, but is not limited to: operable capacity, emissions data, compliance, permit information, etc.

Facility names in our data reflect EIA and ECHO. Datasets may use different names to identify a facility. For example, Paseo Cargill Energy LLC in an EIA Capacity Report and Cargill Energy in EPA's TRI.

The capacity values reflect EIA's estimated total operable capacity, as of January 1 of each reporting year, not actual/total production in that year.

In EPA ECHO data, many facilities have more than one FRS ID, or facility ID – for example, one ID linked to the Clean Air Act (CAA) permit number and compliance and others for the various emissions data sources (see below). Facilities with multiple FRS IDs may therefore have multiple ECHO facility pages. We combined data where necessary - see the shared spreadsheet for more information.

Some biofuel facilities may produce other products, such as animal feed, in addition to biofuels. EPA emissions and compliance data are reported at the facility-level and do not differentiate between emissions or violations associated with biofuel production vs. other industrial processes. We have excluded emissions and violations from biofuel plants that also produce petroleum products throughout the report, unless otherwise noted.

Emissions

Emissions data for operating facilities were collected from multiple EPA sources: 2022 Toxics Release Inventory (TRI) for HAPs, 2022 Greenhouse Gas Reporting Program (GHGRP) for greenhouse gases, and 2020 National Emissions Inventory (NEI) for criteria air pollutants. These reflect the most recently available data. Particulate matter data used consists of particulate matter with a diameter of 10 micrometers or less, consisting of both filterable and condensable materials. Where data appeared erroneous, we referenced state emissions reports. Specifically, we identified a likely error and outlier for particulate matter emissions reported in the 2020 NEI by Blue Flint Ethanol in North Dakota (6,849,956 pounds) and used data from the 2021 North Dakota state emissions inventory (51,600 pounds).

Emissions data for operating facilities likely underestimate actual emissions across the sector due to varying reporting thresholds and requirements for emissions inventories. Notably, not all facilities may be required to report. NEI reporting requirements differ depending on how a facility is categorized: Type A sources (> 250 tons of VOCs, PM_{10}, $PM_{2.5}$, or NH_3 per year; or > 2,500 tons of SO_2, NO_x, or CO per year), Type B (> 100 tons of SO_2, NO_x, VOCs, PM_{10}, $PM_{2.5}$, or NH_3 per year; > 1,000 tons of CO per year; or > 0.5 tons of lead per year), or a Non-Attainment Area source emitting certain pollutants over certain thresholds (Table 1 to Appendix A of Subpart A of Part 51).[88] Further, some pollutants, such as hazardous air pollutants (HAPs), are included by states at their own choice and are only estimates (40 CFR 51.15(a)(4)).[89] The same is true with GHGRP and facilities' GHG emissions, as facilities are required to report under 40 CFR 98 only if they meet the threshold of 25,000 metric tons of CO_2 equivalent per year.[90]

Clean Air Act Compliance

Compliance data used was downloaded from EPA's Enforcement and Compliance History Online data on May 23, 2024, and reflects the data as it was at that time, covering Quarter 3 in 2021 to Quarter 2 in 2024.

It should be noted that a facility's given high priority violation status when downloaded is not necessarily indicative of where it stands currently, as a facility can be identified as having "addressed" their violations in the data downloaded, but when visiting that facility's given detailed facility page in ECHO violations are still listed as ongoing. In these instances, we opted to identify a facility's high priority violation status based on the detailed facility page instead.

Additionally, in the compliance section of the report, we consider enforcement actions to be "formal" enforcement actions, as defined by EPA's Enforcement and Compliance History Online database.

New Projects:

The projects identified during our research are not exhaustive - there may be additional projects we did not identify – and reflect those we identified through March 2024. We limited projects to those that increase production capacity at an existing facility, the construction of a new facility, and conversions (i.e. from fossil-fuel based diesel production to renewable diesel). Not all conversions are full refinery conversions; some refineries may continue to co-produce petroleum-based fuels alongside biofuels. As described above, we identified projects and project details through several sources, including Oil & Gas Watch, industry trade and news sites (e.g., Biomass Magazine, Biodiesel Magazine, Renewable Fuels Association), and state agency websites. We also reviewed public notices, pending permit applications, and draft permits - as available - on state agency websites for the following states: AR, IA, IL, KS, LA, MI, SD, and WI.

Newly operating and constructed projects were included in some cases as they were completed in 2022-2024 to provide emissions information that would not be reflected in data for Operating/Existing facilities from EIA and EPA. Three new facilities (the Artesia Renewable Diesel Unit, the Great Falls Montana Renewable Diesel Plant, and New Rise Renewables) and one expansion (Cargill, Inc. in Wichita, KS) began operating in 2022 but were not reflected in the 2023 EIA Capacity Reports, and were therefore treated here as a new, but operating, project.

Potential emission increases reflect emissions for the projects alone, not facility-wide emissions. Not all projects have applied for construction permits (i.e. announced projects) or permit documents are not yet readily available, and therefore emissions information may still be unknown. Greenhouse gas emissions for the POET Biorefining facility in Cloverdale, IN were unavailable in permit documents, and reflects a 5-year average from 2014-2018 GHGRP data before the facility shut down in 2019 and restarted in 2023.

Location information and coordinates may be approximate where permit documents are not yet available (e.g., based generally on the city identified in a news article). Where proposed locations are limited to a state or region, EIP did not approximate coordinates and these projects were excluded from all maps.

Appendix B: Biofuels Projects Under Construction and Proposed for the Future

Project	Location	Type of Project	Biofuel Type	Planned Capacity Increase (Mmgal/yr)	SAF Announced?	Construction Status
Homeland Energy Solutions LLC	Lawler, IA	Expansion	Ethanol	42	No	Proposed
One Earth Energy LLC	Gibson City, IL	Expansion	Ethanol	50**	No	Proposed
Lincolnland Agri-Energy LLC	Palestine, IL	Expansion	Ethanol	3	No	Under Consturction
Verbio North America Corp	Nevada, IA	New Facility	Ethanol	60	No	Under Construction
New Energy Freedom	Mason City, IA	New Facility	Ethanol	19	No	Proposed
Trainer Refinery*	Trainer, PA	Conversion	Renewable Diesel	TBD	Yes	Proposed
Shell Convent Manufacturing Facility	Convent, LA	Conversion	Renewable Diesel	TBD	Yes	Proposed
Chevron Renewable Energy Group	Geismar, LA	Expansion	Renewable Diesel	325	No	Under Construction
BP Products North America - Cherry Point*	Blaine, WA	Expansion	Renewable Diesel	150	Yes	Proposed
New Energy Chemicals	Port Lavaca, TX	New Facility	Renewable Diesel	TBD	Yes	Proposed
Gron Fuels' Low Carbon Intensity Renewable Fuels Plant	Port Allen, LA	New Facility	Renewable Diesel	920	Yes	Proposed
NEXT Renewable Fuels Refinery - Port Westward	Clatskanie, OR	New Facility	Renewable Diesel	767	Yes	Proposed
Summit Next Gen	Houston, TX	New Facility	Renewable Diesel	526	Yes	Proposed
CVR Energy Coffeyville*	Coffeyville, KS	New Facility	Renewable Diesel	500	Yes	Proposed
DG Fuels Sustainable Aviation Fuel	St. James, LA	New Facility	Renewable Diesel	178	Yes	Proposed
DG Fuels Sustainable Aviation Fuel	Limestone, ME	New Facility	Renewable Diesel	175	Yes	Proposed
HOBO Renewable Diesel	Clinton, IA	New Facility	Renewable Diesel	138	Yes	Proposed
Blue Blade Energy	Midwest	New Facility	Renewable Diesel	135	Yes	Proposed
Azure Cherryvale SAF	Cherryvale, KS	New Facility	Renewable Diesel	135	Yes	Proposed
Marquis Sustainable Aviation Fuel	Hennepin, IL	New Facility	Renewable Diesel	120	Yes	Proposed
Avina Midwest SAF Ethanol Plant	Midwest	New Facility	Renewable Diesel	120	Yes	Proposed
Aemetis Carbon Zero 1	Riverbank, CA	New Facility	Renewable Diesel	120	Yes	Proposed
VertiBlue Fuels	Florida	New Facility	Renewable Diesel	70	Yes	Proposed

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Project	Location	Type of Project	Biofuel Type	Planned Capacity Increase (Mmgal/yr)	SAF Announced?	Construction Status
Texas Renewable Fuels Refinery	Fawil, TX	New Facility	Renewable Diesel	66	No	Proposed
Gevo Net-Zero 1	Lake Preston, SD	New Facility	Renewable Diesel	65	Yes	Proposed
CE+P Sugar Valley Energy	Imperial Valley, CA	New Facility	Renewable Diesel	61	Yes	Proposed
Velocys Bayou Fuels	Natchez, MS	New Facility	Renewable Diesel	35	Yes	Proposed
Louisiana Green Fuels Renewable Fuels Plant	Columbia, LA	New Facility	Renewable Diesel	32	Yes	Proposed
Port Allen Renewable Gasoline Refinery	Port Allen, LA	New Facility	Renewable Diesel	31	No	Proposed
SkyNRG	Washington	New Facility	Renewable Diesel	30	Yes	Proposed
Spindletop Renewable Gasoline Refinery	Nederland, TX	New Facility	Renewable Diesel	15	No	Proposed
Twelve E-Jet	Moses Lake, WA	New Facility	Renewable Diesel	0.04	Yes	Under Construction

Source: Oil & Gas Watch, industry trade and news sites, and state agency websites. See spreadsheet for additional details related to these projects, such as feedstocks, potential emissions, and permit status. Renewable diesel includes sustainable aviation fuel, renewable naphtha, and other biofuels excluding ethanol and biodiesel.

*Facilities that will co-produce petroleum products after project completion and projects that are co-located at petroleum refineries.

**The One Earth Energy LLC expansion is expected in two stages, expanding capacity by 25 million gallons per year, then another 25 million gallons per year after completing the first stage.

Appendix C: High Priority Violators with Existing Violations, July 2021 to May 2024

Facility	Location	Biofuel Type	Quarters with Violations Reported in the Last 3 Years	Quarters with High Priority Violations Reported in the Last 3 Years
Grain Processing Corp	Washington, IN	Ethanol	12	12
Green Plains Mount Vernon LLC	Mount Vernon, IN	Ethanol	12	12
Archer Daniels Midland Dry and Wet Mill	Columbus, NE	Ethanol	12	12
Valero Renewable Fuels LLC	Mount Vernon, IN	Ethanol	12	12
Element LLC	Colwich, KS	Ethanol	12	12
Pelican Renewables LLC	Stockton, CA	Ethanol	12	12
Alto Pekin LLC Wet and Dry Mill	Pekin, IL	Ethanol	12	12
South Bend Ethanol LLC	South Bend, IN	Ethanol	12	12
Altair Paramount LLC	Paramount, CA	Renewable Diesel	12	12
Cardinal Ethanol LLC	Union City, IN	Ethanol	12	12
Seaboard Energy Kansas LLC	Hugoton, KS	Renewable Diesel	12	12
E Energy Adams LLC	Adams, NE	Ethanol	11	11
Green Plains Wood River LLC	Wood River, NE	Ethanol	10	10
Siouxland Ethanol LLC	Jackson, NE	Ethanol	9	9
Central Indiana Ethanol LLC	Marion, IN	Ethanol	8	7
Poet Biorefining - Fairmont LLC	Fairmont, NE	Ethanol	7	7
Redfield Energy LLC	Redfield, SD	Ethanol	6	3
Alto ICP LLC	Pekin, IL	Ethanol	6	5
Quad County Corn Processors Coop	Galva, IA	Ethanol	5	4
Hub City Energy LLC	Aberdeen, SD	Ethanol	3	3
Tate & Lyle	Loudon, TN	Ethanol	3	1
Poet Biorefining - Shell Rock LLC	Shell Rock, IA	Ethanol	2	2

Source: EPA Enforcement and Compliance History Online. Note: Numbers current as of May 2024.

Appendix D.

Top 10 biofuel plants that reported releasing the most acrolein in 2022

Rank among biofuel plants	Facility	Location	Biofuel Type	Emissions (lbs)	Rank Nationally (Among all Industries)
1	Cargill Inc.	Blair, NE	Ethanol	34,489	1
2	Cargill Inc.	Eddyville, IA	Ethanol	20,772	2
3	Archer Daniels Midland Dry Mill and Wet Mill	Cedar Rapids, IA	Ethanol	16,094	3
4	Calgren Renewable Fuels LLC	Pixley, CA	Ethanol	13,151	6
5	Poet Biorefining - Menlo LLC	Menlo, IA	Ethanol	11,050	7
6	Poet Biorefining - Shell Rock LLC	Shell Rock, IA	Ethanol	10,075	8
7	Poet Biorefining - Shelbyville LLC	Shelbyville, IN	Ethanol	9,205	9
8	Southwest Iowa Renewable	Council Bluffs, IA	Ethanol	8,966	11
9	Archer Daniels Midland Dry and Wet Mill	Columbus, NE	Ethanol	8,873	12
10	Green Plains Wood River LLC	Wood River, NE	Ethanol	7,811	13

Source: EPA 2022 Toxics Release Inventory.

Top 10 biofuel plants that reported releasing the most formaldehyde in 2022

Rank among biofuel plants	Facility	Location	Biofuel Type	Emissions (lbs)	Rank Nationally (Among all Industries)
1	Cargill Inc.	Blair, NE	Ethanol	30,587	44
2	Archer Daniels Midland	Clinton, IA	Ethanol	20,848	91
3	Grain Processing Corp.	Muscatine, IA	Ethanol	19,210	101
4	Cargill Inc.	Eddyville, IA	Ethanol	10,322	195
5	Archer Daniels Midland Dry Mill and Wet Mill	Cedar Rapids, IA	Ethanol	9,536	206
6	Alto Pekin LLC Wet and Dry Mill	Pekin, IL	Ethanol	9,403	207
7	Heartland Corn Products	Winthrop, MN	Ethanol	5,330	286
8	Tharaldson Ethanol	Casselton, ND	Ethanol	5,129	289
9	Calgren Renewable Fuels LLC	Pixley, CA	Ethanol	4,666	301
10	Marquis Energy LLC	Hennepin, IL	Ethanol	4,565	303

Source: EPA 2022 Toxics Release Inventory.

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[1] Based on data reported by refineries to EPA's Toxics Release Inventory in 2022, the most recent reporting year.
[2] Ibid.
[3] Occupational Safety and Health Administration, "OSHA Technical Manual (OTM) Section IV: Chapter 5." Accessed April 25, 2024. Link: https://www.osha.gov/otm/section-4-safety-hazards/chapter-5#introduction.
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[5] Includes projects converting petroleum refineries and units to biofuel production. For projects under construction or proposed, see Appendix B and this online spreadsheet.
[6] Coal-fired power plant comparison based on EPA's Greenhouse Gas Equivalencies Calculator. Oil refinery comparison assumes oil refineries, excluding those that co-produce biofuels, emit on average 1.2 million metric tons of CO_2e in 2022, according to the EPA GHGRP; U.S. Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator," Accessed April 25, 2024. Link: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator; U.S. Environmental Protection Agency, "GHGRP Refineries: Number of reporters and emissions in the refinery sector (as of 8/18/2023)," Accessed April 25, 2024. Link: https://www.epa.gov/ghgreporting/ghgrp-refineries.
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[31] Federal Aviation Administration, “United States 2021 Aviation Climate Action Plan,” November 9, 2021. https://www.faa.gov/sites/faa.gov/files/2021-11/Aviation_Climate_Action_Plan.pdf.

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[40] When including renewable diesel plants that co-produce petroleum products, biofuels plants reported releasing 13.5 million pounds of total hazardous pollutants.

[41] These figures do not include renewable diesel plants that co-produce petroleum products.

[42] Figure does not include refineries that co-produce petroleum and biofuel products.

[43] Data from EPA’s 2020 National Emissions Inventory, reported by biofuel facilities EIP identified. Link: https://www.epa.gov/air-emissions-inventories/2020-national-emissions-inventory-nei-data.

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[45] Katharine Sanderson and Carissa Wong, “EU unveils controversial climate target: what scientists think: The goal leans heavily on the largely unproven approach of carbon removal, concerning researchers,” *Nature*, February 6, 2024. Link: https://www.nature.com/articles/d41586-024-00361-9

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[48] EPA, “Biofuels and the Environment.” Accessed April 25, 2024. Link: https://www.epa.gov/risk/biofuels-and-environment

[49] These compliance figures do not include data from eight additional renewable diesel plants that also co-produce petroleum products.

[50] We are considering enforcement actions to be “formal” enforcement actions, as defined by EPA’s Enforcement and Compliance History Online (ECHO) database, and not counting warning letters and other “informal” efforts to get companies to comply with environmental laws.

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[53] Renewable Fuels Association, “Ethanol Production Capacity by Plant.” Accessed April 25, 2024. Link: https://ethanolrfa.org/ethanol-101/ethanol-biorefinery-locations.

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Volatile Organic Compound Emissions from Dry Mill Fuel Ethanol Production

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ABSTRACT

Ethanol fuel production is growing rapidly in the rural Midwest, and this growth presents potential environmental impacts. In 2002, the U.S. Environmental Protection Agency (EPA) and the Minnesota Pollution Control Agency (MPCA) entered into enforcement actions with 12 fuel ethanol plants in Minnesota. The enforcement actions uncovered underreported emissions and resulted in consent decrees that required pollution control equipment be installed. A key component of the consent decrees was a requirement to conduct emissions tests for volatile organic compounds (VOCs) with the goal of improving the characterization and control of emissions. The conventional VOC stack test method was thought to underquantify total VOC emissions from ethanol plants. A hybrid test method was also developed that involved quantification of individual VOC species. The resulting database of total and speciated VOC emissions from 10 fuel ethanol plants is relatively small, but it is the most extensive to date and has been used to develop and gauge compliance with permit limits and to estimate health risks in Minnesota. Emissions were highly variable among facilities and emissions units. In addition to the variability, the small number of samples and the presence of many values below detection limits complicate the analysis of the data. To account for these issues, a nested bootstrap procedure on the Kaplan-Meier method was used to calculate means and upper confidence limits. In general, the fermentation scrubbers and fluid bed coolers emitted the largest mass of VOC emissions. Across most facilities and emissions units ethanol was the pollutant emitted at the highest rate. Acetaldehyde, acetic acid, and ethyl acetate were also important emissions from some units. Emissions of total VOCs, ethanol, and some other species appeared to be a function of the beer feed rate, although the relationship was not reliable enough to develop a production rate-based emissions factor.

IMPLICATIONS

Fuel ethanol production is a rapidly growing industry with potential environmental impacts. Measurements of air emissions of total and speciated VOCs are reported here. Accurate quantification of emissions had posed problems for facilities and regulators in the past. The results show considerable variability in VOC emissions across the population of facilities in Minnesota, across individual emission units, and over time at a given facility. Thermal oxidizers appear to provide good control of VOC emissions from many of the important emission units at fuel ethanol production facilities. Identifying and quantifying the key constituents in the gas stream provides information that will improve the regulatory process for these facilities.

INTRODUCTION

Ethanol production in Minnesota was commercialized around 1990 with 11 million gal produced in the state that year. In 2005, Minnesota generated approximately 420 million gal from 16 plants.[1] There are presently two new plants under construction and several of the existing facilities are planning to expand to produce 100 million gal individually each year. Approximately 10 more facilities are in some stage of planning or review.

In October of 2002, 12 Minnesota ethanol plants entered into consent decrees with the U.S. Environmental Protection Agency (EPA), Minnesota Pollution Control Agency (MPCA), and the U.S. Department of Justice for violations of the Clean Air Act Prevention of Significant Deterioration (PSD) regulations as a result of underestimating emissions. The consent decrees required each facility to pay a monetary penalty and to install control technology equivalent to best available control technology (BACT) to control nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compound (VOC) emissions. The BACT-equivalent requirement for VOC emissions was fulfilled by a thermal oxidizer (TO) achieving at least 95% control efficiency. In addition, the plants were required to test their emission units upon installation of control equipment to demonstrate compliance with the emission limits established in the consent decrees. However, because of a number of unforeseen complications in quantifying VOC emissions from fuel ethanol production facilities, the required testing proved more difficult than expected.

All of the 12 plants named in the consent decrees were dry mill plants, meaning that they dry the distilled grains (a byproduct of the ethanol production process) before shipping them as animal feed. Dry mill facilities account for approximately 55% of all fuel ethanol produced in the United States.[2] Figure 1 provides a schematic diagram of a typical dry mill fuel ethanol plant. In this process, grain corn is initially run through a hammer mill and then is placed into a fermentation tank with yeast and enzyme additions. Fermentation chemistry occurs in a series of fermentation tanks, and then the ethanol-containing mash is processed by distillation and molecular sieves into the final fuel product. The spent wet grain

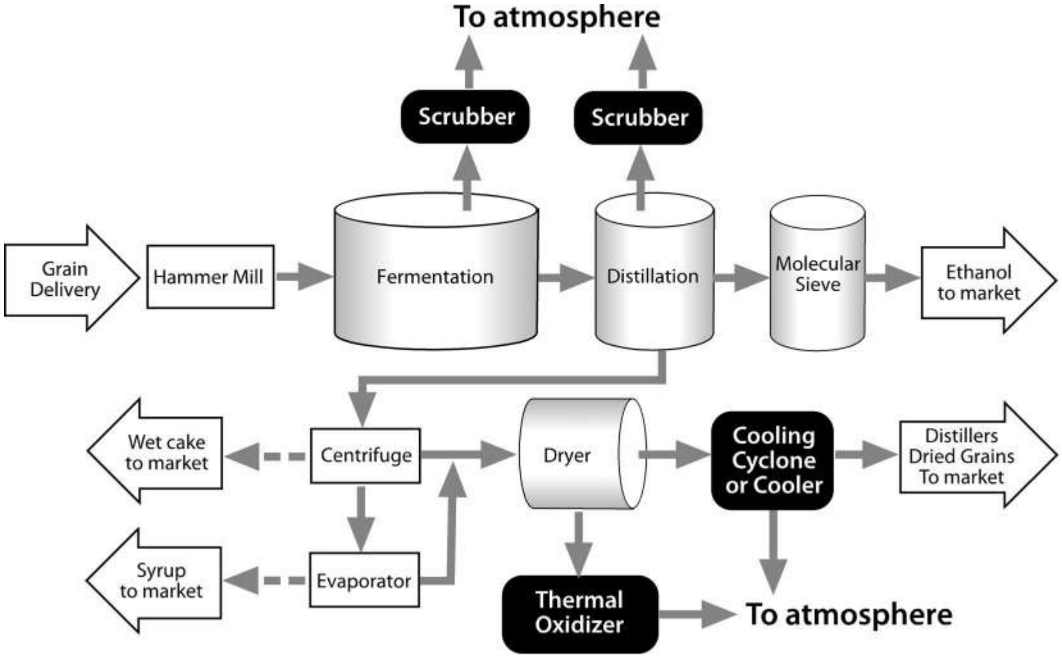

Figure 1. Schematic diagram of a typical dry mill fuel ethanol production facility.

(called wet cake) is usually sent to a centrifuge and then to an evaporator to remove residual water, leaving a syrup. The syrup may either be removed as a byproduct or reintroduced to the wet cake, which is sent to a rotary drum dryer, converted to distillers dried grains (DDG), and then sold as animal feed. Ethanol production from grain corn uses only the starch portion of the corn, which is approximately 70% of the kernel. Leftover nutrients, including protein, fat, minerals, and vitamins, remain in the distillers grain, which is a valuable livestock feed. Wet cake may occasionally be stored for a short period of time before it can be dried or transported off-site. Odors and VOC emissions from wet cake storage are a concern for neighbors. The rotary drum dryer is typically vented to ambient air. It is the primary emission source requiring BACT-equivalent controls for VOCs under the consent decrees.

All of Minnesota's ethanol facilities currently in operation fire natural gas to run their boilers and process and control equipment, with propane typically used as a backup fuel. One plant under construction and another proposed facility intend to burn coal as the primary fuel source. In almost every case, the dryer control equipment was a TO or a regenerative thermal oxidizer (RTO), which recaptures some of the heat energy. Both technologies involve the same principle, are capable of achieving similar levels of control, and are referred to here as simply TOs. The major sources of NO_x emissions from dry mill plants are the boilers and the dryer. VOCs may be emitted from multiple units at the plants including the dryer, distillation columns, TO, wet cake, fermentation tanks, and other equipment associated with fermentation and distillation such as fluid bed coolers, cooling cyclones, and fermentation scrubbers. One of the purposes of this study was to quantify the relative importance of these potential sources of VOCs.

The consent decrees developed for Minnesota ethanol production facilities corrected a calculation and design error that had resulted in underestimated and uncontrolled emissions from fuel ethanol plants. As a consequence they have helped to ensure that future facilities will be constructed with the appropriate control technologies and that emissions will not exceed regulatory limits. The consent decrees also led to the development of stack testing methodologies and data collection that has implications not only for the ethanol industry but also potentially for other industrial processes that involve drying of organic materials.

The conventional stack testing method for measuring total VOC emissions (EPA Federal Reference Method [FRM] 25A[3]) was considered to be inadequate to accurately measure the total VOCs from fuel ethanol plants. Specifically, the method does not capture VOCs present in the aerosol phase of a high moisture content plume, and it may underquantify total VOC mass if a significant proportion of oxygenated species is present. Given these shortcomings, Method 25A was modified with the inclusion of an ethanol response factor, and in addition, a second hybrid method was developed to measure individual VOC species. The working hypothesis was that these new methods would better quantify VOC emissions from ethanol plants.

This innovative source sampling effort produced a baseline dataset of speciated emissions that is the first of its kind and comes at a time of significant growth in this industry. The data show the magnitude of emissions of total VOCs and individual VOC species from points in the ethanol production process, and thus may be of interest to many stakeholders. Unfortunately, the stack testing was not coordinated across facilities in a study design that systematically evaluated the effects of the different test methods over all the facilities and emissions units. This study design shortcoming limits some of the inferences that can be drawn from the data. Nevertheless, the test data obtained pursuant to the consent decrees provide a basis for permit conditions, for VOC stack testing policies, and they may be used to evaluate potential health impacts of air emissions from fuel ethanol production facilities.

STACK TEST AND DATA ANALYSIS METHODS

Stack tests were performed after control equipment was installed as required by the consent decrees. A given facility was tested up to three times. The emissions units tested and the suite of analytes varied among facilities and among the repeat test events at a given facility. All tests were conducted by independent testing consultants. Pretest meetings were held with facility personnel, testing consultants, and MPCA staff to ensure that the test would comply with the combined methodologies described below and to specify how the data would be reported (speciated, total mass, etc.). Typically, three test runs were conducted during each stack test event with each run lasting 60 min. The beer feed rate, a measure of the amount of water and ethanol that is being transferred from the fermentation tanks into the distillation columns (see Figure 1), was measured every 15 min during a test event, and the facility was required to operate at 90% or greater of their maximum achievable production rate. Before submittal to the MPCA, reports were sent to the ethanol facility's management or consultants for review and approval. Reports were then reviewed by the MPCA for accuracy, compliance with approved test methodologies, calibration of equipment, problematic occurrences in the field, chain of custody sample handling procedures, and verification of results. MPCA staff verified test results from 2002 through 2004. The data presented from the 2005 and 2006 test dates went through all of these steps except for the final verification of results by the MPCA. Test reports are on file at the MPCA.[4–21]

A combination of test methods was needed to measure emissions of total VOCs and speciated VOCs. The first test method employed was EPA FRM 25A,[3] which is designed to measure total (unspeciated) VOC mass. In Method 25A a "gas sample is extracted from the source through a heated sample line and glass fiber filter to a flame ionization analyzer (FIA). Results are reported as volume concentration equivalents of the calibration gas or as carbon equivalents." In the tests reported here, propane was used as the calibration gas, but results were converted to carbon equivalents and reported as "total VOC as carbon."

There are two problems with Method 25A for VOC testing at ethanol plants. The first problem involves the method of quantifying total VOCs. As the gas stream passes through the FIA, chemical constituents are ionized, and the ions are drawn to electrodes creating a current that is measured. The current is proportional to the number of carbon atoms for substances containing only carbon and hydrogen.[22] However, organic compounds containing oxygen (or other constituents) generally produce fewer ions and less current per carbon atom than compounds with only carbon and hydrogen. Because the exhaust gas from ethanol plants has significant amounts of oxygenated species, Method 25A may underestimate the mass of VOC emissions.

The second problem with Method 25A is that the moisture content in effluent gas from ethanol plants can be as high as 50%. As a result, the stack gas contains high concentrations of aerosolized water droplets that behave like particles in the effluent stream. The water droplets may absorb significant amounts of organic chemicals that would otherwise be present as gases in a dry effluent stream. Method 25A relies on instruments that draw gas through sampling equipment nonisokinetically. In the method, the sampling probe is stationary in the stack and draws a sample from a single point. It does not traverse the stack as is done in Method 5 to account for stratification of particles or droplets acting as particles across the diameter of the stack. An isokinetic sampling train is designed so that the airstream velocity entering the sample port is equal to the velocity of the airstream bypassing the port. This condition ensures that particles of different sizes will be properly collected in proportion to their presence in the effluent stream. Because sampling is nonisokinetic, Method 25A is likely to inaccurately count VOCs that may be present in an aerosolized state (i.e., contained in or on water droplet particles).

To address the first problem, an ethanol response factor was developed. The FIA instrument was initially calibrated with propane. Then an ethanol/carbon dioxide standard gas was introduced to the analyzer. On the basis of the relative carbon counts of ethanol (2 carbons) and propane (3 carbons), the expected concentration of the ethanol standard gas was calculated. The ethanol response factor was taken as the ratio of the expected instrument reading to the actual reading. For example, in an instrument calibrated to propane, a standard gas containing 495 ppm ethanol, would be expected on the basis of the number of carbon atoms, to produce an instrument response of 330 ppm ($495 \times 2/3$). If the actual response were 165 ppm, the ethanol response factor would be 2 (330/165).

A second method to attempt to resolve the measurement problems resulted in the development of a new, hybrid testing procedure, called the "Midwest Scaling Protocol."[23] This approach consists of applying two existing, promulgated FRMs in combination. Because a major obstacle to traditional VOC testing was the absorption of organic chemicals in or on water droplets, the solution was to sample the stack gases as if the source were emitting a particulate gas stream (FRM 5[3]). The protocol required isokinetic testing and collection of samples of the condensed gas stream in glass impingers, and subsequent analysis of individual chemical species under the requirements of FRM 18.[3] Method 5 is the FRM for sampling particles. In Method 18 the "major organic components of a gas mixture are separated by gas chromatography (GC) and individually quantified by flame ionization, photoionization, electron capture, or other appropriate detection principles." Flame ionization was used here.

FRM 25A requires zero and span gas calibration before every test. Deviations of greater than five percent invalidate the test. Method 25A calibrations were done using propane, and total VOC measurements were reported as carbon equivalents. In addition, in some cases the Method 25A reading was adjusted using an ethanol "response factor." The response factor was established by introducing an ethanol/carbon dioxide standard gas into the calibrated analyzer. The response factor was taken as the expected instrument reading given ethanol's two carbon atoms divided by the actual instrument response to the ethanol standard. The ethanol response factor adjustment was made in 56 of the 110 test runs.

FRM 18 requires that "triplicate analyses of calibration standards fall within 5% of their mean value" and that "analysis results of prepared audit samples are within 10% of preparation values." Under the hybrid approach developed here (EPA's Midwest Scaling Protocol), average spike recoveries between 70 and 130% were considered acceptable. Average spike recovery across all facilities, emissions units, and pollutants was 94% ($n = 144$). Among facilities, spike recoveries averaged 86% (CVEC) to 103% (DENCO). Spike recoveries were poor for acetone (124%, $n = 1$), acrolein (69%, $n = 12$), and formic acid (127%, $n = 1$); better for 2,3-butanediol (111%, $n = 4$), acetaldehyde (82%, $n = 15$), ethyl acetate (86%, $n = 13$) and lactic acid (86%, $n = 2$); and within 10% of complete recovery for the remaining analytes. All data reported to the MPCA were included in this analysis, including data from 3 tests in which one pollutant did not meet the 70–130% spike recovery criterion (2 spike recoveries for acrolein and one for ethyl acetate were below 70%). Laboratory/analytical blanks were analyzed for each 3-run test event using GC and purified lab water. Blank sampling trains were not run. The testing firm that conducted the testing reported that none of the chemicals that were sampled were detected in blanks except for occasional small amounts of acetic acid. No corrections were made to the test results based on blanks (i.e. no blank corrections).

One performance test was conducted to quantify wet cake emissions at the Diversified Energy Company facility in November 2004. The wet cake testing was done using a temporary total enclosure as specified under EPA FRM 204,[3] which was set up around a wet cake pile in the load-out area of the spent grain building. Sampling was done from a single exhaust point in the enclosure, and determinations were made of the same VOC species tested at other emission units. Wet cake was generated at a maximum production rate of 18 tons per hour, and 100% of the spent grain was diverted from the dryer into the enclosure during the test. In addition, an existing pile within the enclosure was simultaneously disturbed during the test to create a "worst-case" emissions scenario.

The ethanol plant VOC emissions data contain many instances of left-censored values. Data containing measurements that are below the limit of detection are commonly referred to as left-censored. For the graphical representations and the correlation and regression analyses, an imputed value of one-half the detection limit was substituted for values reported as below detection.

To calculate means and upper confidence limits (across facilities and test runs), it was necessary to account for the censored data and for the difficulty in determining the distribution of the data (i.e., whether the data fit a normal, log-normal, or some other distribution). We used an approach that combined a nested bootstrap calculation and the Kaplan-Meier method. The Kaplan-Meier method, also known as a product-limit estimate, is an estimator of the survival curve that does not assume any particular parametric family. Although widely used in the medical sciences and astronomy, the Kaplan-Meier method is also recommended for environmental data.[24] To use survivorship (right-censored) methods with environmental data, it is necessary to employ the technique of "flipping," that is, subtracting the measurements from a constant value. This procedure changes left-censored (below detection) data to right-censored data. Once flipping has been done, the mechanics of employing the Kaplan-Meier method are identical for medical survivorship data and environmental data. After the calculations are made, the data are reconverted to the original scale. The statistical package, R, has a routine that performs the flipping calculations automatically.[25]

The data are nested in that multiple facilities were tested, a given facility may have been tested multiple times, and each test event comprised up to three replications. To account for facility, test event, and replication effects and for censored data, a nested bootstrap procedure on the Kaplan-Meier method was used to calculate the arithmetic mean and the 95% upper confidence limit for the arithmetic mean (UCL). The bootstrapping was done first over facilities, then over test events, and lastly over measurements within facility for 1000 repetitions of the Kaplan-Meier mean. The 50th percentile value of the bootstrap Kaplan-Meier means was taken as the mean, and the 95th percentile value was taken as the UCL. Statistical calculations were done in R.[25]

RESULTS

Figure 2 maps the locations, sizes, and number of stack tests for each Minnesota ethanol plant, including those subject to the consent decrees and those built afterwards. The geographic extent of the plants coincides with the corn-growing region of the state. It is also notable that the newer plants tend to be larger. In addition, some of the existing plants have submitted applications to expand production. Table 1 enumerates the characteristics of the population of ethanol plants in Minnesota, including those with emissions measurements and those without measurements.

Table 2 presents summary statistics for the speciated VOC emissions measured using the hybrid method (combined Methods 5 and 18). Most facilities consistently reported detectable levels of acetaldehyde, acetic acid, ethyl acetate, formaldehyde, ethanol, and methanol at one or more emissions units. The amount of each species and the predominant constituent varied widely over facilities and emission units. Acetic acid and ethanol were the predominant emissions from cooling cyclones. Acetic acid was also the predominant species emitted from the fluid bed coolers tested. Acetaldehyde, ethanol, and acetic acid accounted for most of the emissions from thermal oxidizers. Fermentation scrubbers had the most diverse and highest overall emissions with significant amounts of acetaldehyde, acetic acid, ethanol, ethyl acetate, and isoamyl alcohol. Emissions of all substances were low from distillation scrubbers. The fermentation bypass was tested at one

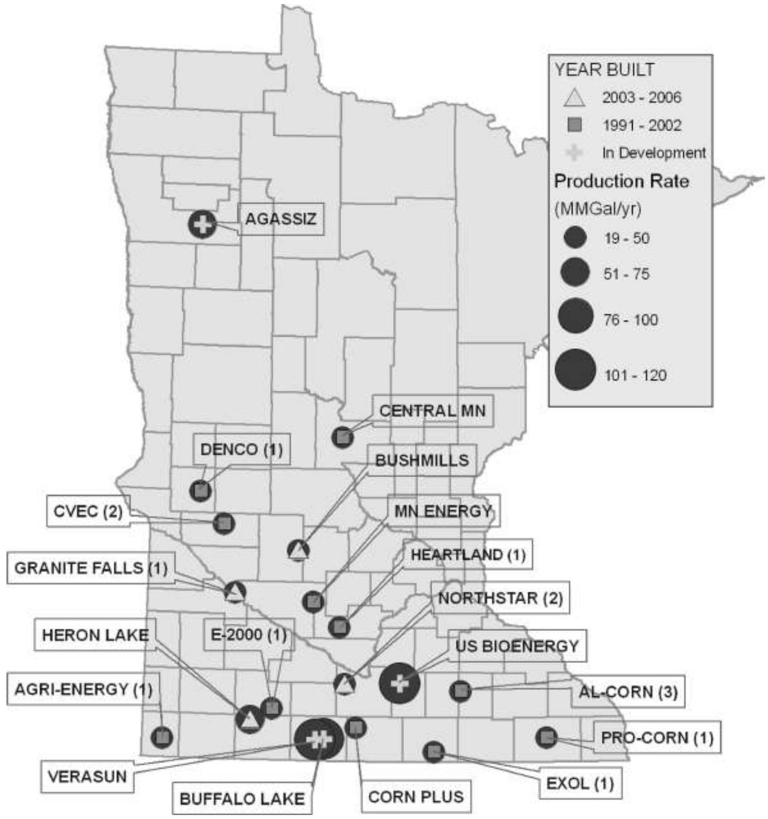

Figure 2. Location of dry mill ethanol plants in Minnesota. The numbers in parentheses after the facility name refer to the number of stack test events at the facility.

facility and had high emissions, but this emission unit is not routinely used.

Figure 3 is a graphical representation of the distribution of emission rates at individual facilities for some of the important chemicals emitted from fermentation scrubbers. Emissions from fermentation scrubbers varied widely among facilities. Emissions of all analytes were low at the Heartland Corn Products and Agri-Energy facilities.

Table 1. Characteristics of dry mill fuel ethanol production facilities in Minnesota.

Facility	Year Built	Subject to Consent Decree	Production Rate (MM·gal/yr)[a]	No. of Tests	Avg. Beer Feed Rate (gal/hr)[c]	Avg. to Temp (°F)[c]
Agassiz Energy	TBD	No	70[b]	0	NA	NA
Agri-Energy	1998	Yes	22	1	225	1467
Al-Corn	1996	Yes	30	3	536	1436
Buffalo Lake Energy	TBD	No	118[b]	0	NA	NA
Bushmills Ethanol	2005	No	49	0	NA	NA
Central MN Ethanol	1999	Yes	22	0	NA	NA
Corn Plus	1994	Yes	44	0	NA	NA
CVEC	1996	Yes	20	2	691	1606
DENCO	1991	Yes	20	1	310	1578
E-2000	1997	Yes	40	1	447	NA
EXOL	1999	Yes	50	1	470	1442
Granite Falls	2004	No	45	1	699	1546
Heartland	1995	Yes	35	1	480	1587
Heron Lake BioEnergy	2006	No	55[b]	0	NA	NA
Minnesota Energy	1997	Yes	19	0	NA	NA
Northstar	2004	No	50	2	580	NA
Pro-Corn	1998	Yes	50	1	510	1699
U.S. Bioenergy	TBD	No	120	0	NA	NA
VeraSun Energy	TBD	No	118[b]	0	NA	NA

Notes: [a]Production rate at time of testing (some facilities have since expanded production). For unfinished facilities the reported value is the expected production rate. [b]Proposed. [c]At time(s) of testing.

Table 2. Summary statistics of stack testing results at Minnesota dry mill ethanol production facilities.

Emission Unit	Statistic	Acetaldehyde	Acetic Acid	Acetoin	Acetone	Acrolein	2,3-Butanediol	2,3-Butanedione	Ethanol	Ethyl Acetate	Formaldehyde	Formic Acid	Furfuraldehyde	Isoamyl alcohol	Lactic Acid	Methanol
Cooling cyclone	N	21	21	3		6	9	9	21	12	21	9	18	12	3	18
	n < dl	0	3	0		6	8	0	3	6	4	9	15	11	3	15
	Min	0.02	<0.06	0.04		<0.02	<0.01	0.01	<0.08	<0.02	0.00[a]	0.00[a]	<0.01	<0.01	<0.12	<0.01
	Max	1.29	0.82	0.07		<0.03	0.46	0.35	4.01	0.18	0.05	<1.01	0.04	0.02	<0.14	0.03
	Median	0.08	0.25	0.05		<0.02	<0.18	0.27	0.43	0.05	0.01	<0.39	<0.02	<0.03	<0.13	<0.02
	Mean	0.28	0.30	0.05		NA	0.06	0.20	1.14	0.05	0.01	NA	0.01	0.03	NA	0.01
	95% UCL	0.59	0.46	NA		NA	0.27	0.31	2.02	0.09	0.02	NA	0.02	0.07	NA	0.02
Distillation scrubber	N	12	12	3		12	3	6	12	12	12	3	9	9	3	12
	n < dl	0	6	3		10	3	6	0	0	6	3	9	3	3	9
	Min	0.02	0.00[a]	<0.0009		0.00[a]	<0.0009	0.00[a]	0.01	0.01	0.00[a]	0.00[a]	0.00[a]	0.00[a]	<0.01	0.00[a]
	Max	0.47	0.012	<0.0011		0.0015	<0.0011	0.00[a]	0.08	0.11	0.0024	0.00[a]	<0.0011	0.0019	<0.01	0.0010
	Median	0.08	0.003	<0.0010		<0.00025	<0.001	0.00[a]	0.02	0.06	0.0002	0.00[a]	0.00[a]	0.00[a]	<0.01	<0.0003
	Mean	0.16	0.005	NA		0.0003	NA	NA	0.03	0.05	0.0005	NA	NA	0.0002	NA	0.0003
	95% UCL	0.30	0.009	NA		0.0001	NA	NA	0.05	0.08	0.0015	NA	NA	0.0009	NA	0.0010
Fermentation bypass	N	3	3						3	3				3		
	n < dl	0	3						0	0				0		
	Min	2.67	<0.02						9.98	3.05				0.38		
	Max	3.18	<0.02						12.58	3.11				0.43		
	Median	3.14	<0.02						11.98	3.06				0.39		
	Mean	3.00	NA						11.51	3.07				0.40		
	95% UCL	NA	NA						NA	NA				NA		
Fermentation scrubber	N	32	32	6	3	29	9	12	32	29	32	6	21	21	3	26
	n < dl	0	18	6	3	27	9	9	0	0	9	6	20	3	3	22
	Min	0.01	0.00[a]	0.00[a]	<0.01	<0.004	0.00[a]	0.00[a]	0.01	0.06	0.00[a]	0.00[a]	0.00[a]	<0.003	<0.03	0.00[a]
	Max	3.52	0.26	<0.02	<0.01	0.02	0.00[a]	0.07	18.27	1.28	0.020	0.00[a]	0.02	0.45	<0.04	0.020
	Median	0.25	0.00[a]	<0.01	<0.01	<0.01	0.00[a]	<0.015	0.94	0.38	0.003	0.00[a]	<0.01	0.07	<0.04	0.010
	Mean	0.71	0.05	NA	NA	0.01	NA	0.01	2.62	0.50	0.005	NA	0.002	0.13	NA	0.005
	95% UCL	1.23	0.09	NA	NA	0.01	NA	0.03	5.31	0.70	0.007	NA	0.006	0.23	NA	0.008
Fluid bed cooler	N	9	9	6		6	6	6	9	6	9	6	6	6		6
	n < dl	0	0	3		6	6	3	0	6	0	6	0	6		3
	Min	0.05	0.36	<0.04		<0.02	<0.21	<0.02	0.16	<0.02	0.00[a]	<0.17	0.22	<0.02		<0.02
	Max	0.22	2.24	0.11		<0.06	<0.89	0.05	5.41	<0.06	0.04	<0.89	0.35	<0.05		0.04
	Median	0.12	0.75	0.06		<0.04	<0.49	0.04	1.21	<0.04	0.01	<0.47	0.28	<0.03		0.04
	Mean	0.12	0.98	0.07		NA	NA	0.02	1.49	NA	0.02	NA	0.28	NA		0.03
	95% UCL	0.16	1.61	0.10		NA	NA	0.04	2.97	NA	0.03	NA	0.32	NA		0.04
TO	N	30	30	9	6	27	9	15	30	24	30	3	12	12	6	30
	n < dl	12	12	6	3	25	9	12	13	19	12	3	12	12	6	24
	Min	<0.03	<0.04	<0.03	<0.03	<0.04	0.00[a]	<0.03	<0.03	<0.02	0.00[a]	0.00[a]	<0.03	<0.04	<0.44	<0.03
	Max	0.73	1.46	0.17	0.06	0.11	<1.16	0.12	2.28	0.11	0.17	0.00[a]	<0.08	<0.09	<0.58	0.20
	Median	0.10	0.40	<0.07	0.040	<0.06	<0.05	<0.05	0.08	<0.05	0.05	0.00[a]	<0.05	<0.06	<0.49	<0.05
	Mean	0.15	0.48	0.06	0.03	0.04	NA	0.03	0.27	0.03	0.06	NA	NA	NA	NA	0.04
	95% UCL	0.26	0.73	0.11	0.05	0.05	NA	0.04	0.58	0.05	0.09	NA	NA	NA	NA	0.07
Wet cake storage	N	3	3						3		3	3	3			3
	n < dl	3	0						0		3	3				3
	Min	<0.001	0.04						0.02		<0.0032	0.00[a]				0.00[a]
	Max	<0.003	0.13						0.03		<0.0044	0.00[a]				<0.0025
	Median	<0.002	0.08						0.02		<0.0043	0.00[a]				0.00[a]
	Mean	NA	0.08						0.02		NA	NA				NA
	95% UCL	NA	NA						NA		NA	NA				NA

Notes: The statistics were calculated across all facilities with test data for the indicated type of emission unit as described in the text. Units are pounds per hour (lbs/hr). [a]Values reported as zero on test report. NA = not applicable.

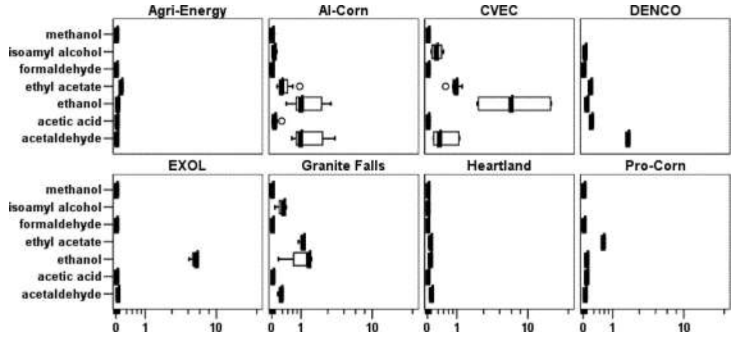

Figure 3. Emissions (lbs/hr) of selected VOC species from fermentation scrubbers at fuel ethanol production facilities. Each panel represents one tested facility, which is identified above the panel. The bar extends from the 25th to the 75th percentile value. The line within the bar represents the median. The lines extending from the bar encompass all the data excluding outliers. Circles indicate outliers. The *x*-axis is scaled logarithmically.

On the other hand, emissions of acetaldehyde, ethanol, and ethyl acetate were higher and more variable at other facilities' fermentation scrubbers.

Table 3 provides a summary of the test results by facility and emissions unit. The number of test events ranged from 1 to 3, and the number of replicate samples ranged from 2 to 9 for a specific emission unit at a given facility. Given the distributional issues with the data, and the fact that it is not possible to use the bootstrap Kaplan-Meier method while summing the speciated emissions,

Table 3. Summary of test results by facility and emission unit. Total VOC emissions (Method 25A) are reported both as carbon equivalents and with the ethanol response factor. The percent speciated refers to the sum of the individual VOC species (hybrid Methods 5 and 18) divided by the total VOCs (Method 25A), and it is reported for total VOCs as carbon and total VOCs using the ethanol response factor.

Facility		Emission Unit[a]	No. of Test Events	No. of Replicate Samples	Median Total VOCs (lbs/hr) as Carbon	Median Total VOCs (lbs/hr) with Ethanol Response Factor	Median of Sum of Speciated VOCs (lbs/hr)		Median Percent Speciated-Total VOCs as Carbon (%)		Median Percent Speciated–Total VOCs with Ethanol Response Factor Imputing 0[b] (%)
							Imputing 0[b]	Imputing 1/2 DL[c]	Imputing 0[b]	Imputing 1/2 DL[c]	Imputing 0[b]
1	Agri-Energy	CC	1	3	0.61		0.78	0.79	128	130	
		FS	1	3	0.27	0.56	0.19	0.20	69	72	34
		TO	1	3	0.16		1.67	1.74	879	916	
2	Al-Corn	CC	2	6	2.73		3.03	3.05	125	125	
		DS	2	6	0.06	0.28	0.12	0.12	178	178	81
		FS	3	9	2.56	4.01	3.73	3.74	128	128	62
		TO	3	9	0.21	0.61	0.11	0.92	35	521	139
3	CVEC	DS	1	3	0.41		0.16	0.16	39	39	
		FS	2	6	6.60		10.64	10.66	137	138	
		TO	1	3	0.48	0.98	0.00	0.35	0	72	0
4	DENCO	FS	1	3	1.39		2.47	2.47	178	178	
		TO	1	3	1.31		0.96	0.96	77	77	
5	Ethanol 2000	CC	1	3			1.94	2.49			
6	EXOL	CC	1	3	1.93		1.27	1.27	66	66	
		FS	1	3	4.15	9.40	5.87	5.88	128	128	56
		TO	1	3	0.44		0.84	0.93	191	211	
7	Granite Falls	CC	1	3	0.73	1.60	1.89	2.02	242	258	111
		FS	1	3	3.00	5.47	3.12	3.16	107	109	59
		TO	1	3	0.28	0.76	0.05	0.27	19	104	7
8	Heartland	CC	1	3	1.96		3.79	3.89	193	198	
		DS	1	3	0.34	0.61	0.57	0.58	168	171	94
		FS	1	3	0.20		0.24	0.27	100	116	
		TO	1	3	1.78	4.55	1.68	2.09	94	117	102
9	Northstar	FB	1	3	11.83	18.19	16.56	18.61	159	159	102
		FBC	2	6	2.67	6.22	2.66	3.22	102	122	44
10	Pro-Corn	FS	1	2	2.06	5.11	0.79	0.80	39	39	16
		FBC	1	3	4.28		2.24	2.24	50	50	
		TO	1	3	3.53		2.83	2.91	80	82	

Notes: [a]CC, Cooling Cyclone; DS, Distillation Scrubber; FB, Fermentation Bypass; FBC, Fluid Bed Cooler; FS, Fermentation Scrubber. [b]Total of speciated VOCs calculated substituting zero for values below the detection limit. [c]Total of speciated VOCs calculated substituting 1/2 the detection limit for values below the detection limit.

we report medians in Table 3. The total VOC emissions, as well as the sum of the speciated VOCs varied by facility and emissions unit over a wide range. The speciated VOC emissions from the TOs were often below detection (Table 2). The sum of the speciated emissions from TOs (combined Methods 5 and 18) shown in Table 3 was affected by the treatment of the values below detection. Imputing one-half the detection limit led to sums that were biased high for the TOs at some facilities.

Correlation, regression, and analysis of variance (ANOVA) calculations were used in an attempt to determine whether emissions were related to facility configuration and to see if emissions were simultaneously high for more than one chemical (i.e., are there systematic relationships among chemical species emissions). Correlations were calculated across all facilities and emission units, and in some cases individual facilities and emission units were explored in detail. For individual VOC species these calculations were done with below detection values substituted by one-half the detection limit and using untransformed data despite the lack of normality. In general, there were no clear systematic relationships among the various species. Statistically significant positive and negative correlations among species were found, but the pattern of these relationships did not appear to have an identifiable logical consistency.

TO temperatures ranged from 1436–1699°F, and across this range there was no systematic effect of TO temperature on total VOC emissions, although there were effects on specific individual VOC species. For example, acetic acid, formaldehyde, and methanol emission rates were significantly ($p < 0.05$ for all subsequent results) positively correlated with TO temperature, whereas 2,3-butanediol, formic acid, and lactic acid were negatively correlated with TO temperature.

Across all facilities and emission units, seven species (2,3-butanedione, acetic acid, acrolein, formaldehyde, furfuraldehyde, methanol, and total VOCs) were significantly positively correlated with annual production rate (in MM·gal/yr). Six species (ethanol, ethyl acetate, isoamyl alcohol, lactic acid, the speciated total, and total VOCs) were significantly positively correlated with beer feed rate (gal/hr), whereas acetic acid, acetoin, and formic acid were negatively correlated with beer feed rate.

There were no censored (below detection) values in the total VOC emissions data, and in addition, the data were approximately log-normally distributed. Thus, ANOVA calculations were done with log-transformed data. Emission unit, test date, beer feed rate, and facility were identified as significant predictors in the ANOVA analysis of log total VOC emissions (both as carbon and with the ethanol response factor). TO temperature, production capacity, and run number were not significant variables in determining log total VOC emissions.

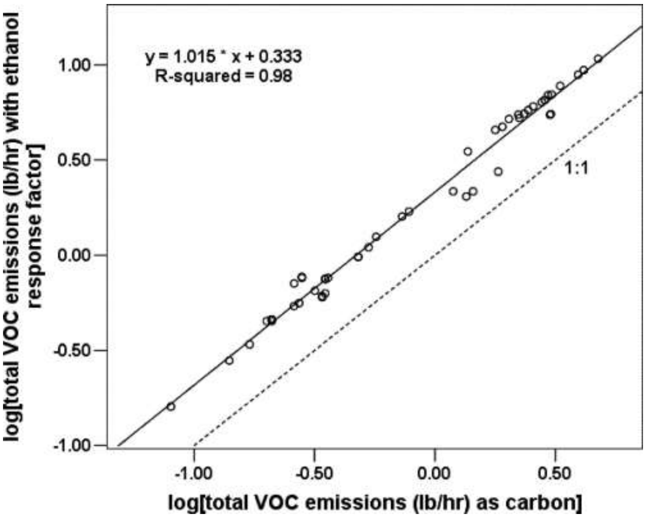

Figure 4. Relationship between total VOC emissions measured by Method 25A as carbon using propane as the calibration gas and total VOC emissions using the ethanol response factor. Both axes are in log base 10 scale.

Figure 4 shows the relationship between total VOCs measured as carbon using Method 25A and total VOCs measured by Method 25A using the ethanol response factor. The two methods were very strongly correlated with the slope of the regression nearly equal to 1 (1.015), but the ethanol response factor emissions were higher by a factor of 2.15 ($10^{0.333}$) on average. Figure 5 shows the relationship between total VOCs measured by Method 25A (both as carbon and with the ethanol response factor) and the sum of speciated emissions from the hybrid method. The graph combines emissions from all facilities and all emissions units. Method 25A as carbon both underestimated and overestimated compared with the sum of speciated emissions. Underestimation was more likely at higher VOC emission rates. Method 25A with the ethanol response factor generally overestimated emissions compared with the sum of speciated emissions. The slopes of both regressions were less than one, so Method 25A would be expected to underestimate compared with the sum of speciated emissions at high VOC emission rates.

Figure 6 shows the emission rates of ethanol as a function of the beer feed rate with a breakdown by emission unit. Emissions tended to be low at low beer feed rates. At higher beer feed rates emissions were variable, ranging from low to high values. In Figure 7, the total facility VOC emissions are plotted as a function of the beer feed rate. The total VOCs (Method 25A) as carbon and using the ethanol response factor, and the sum of speciated emissions (hybrid method) are plotted. In this graph each facility's measurements were averaged by emission unit and then summed over all emissions units with measurements. Values below detection were replaced with one-half the detection limit (results were nearly identical when values below detection were replaced with zero). This figure also shows the general trend of increasing emissions as beer feed rate increases, although it should be recognized that different sets of emission units and different chemicals were tested at different plants (Table 3).

DISCUSSION

This small dataset is currently the most extensive set of speciated and total VOC emissions available for fuel ethanol production facilities. Although these data reveal

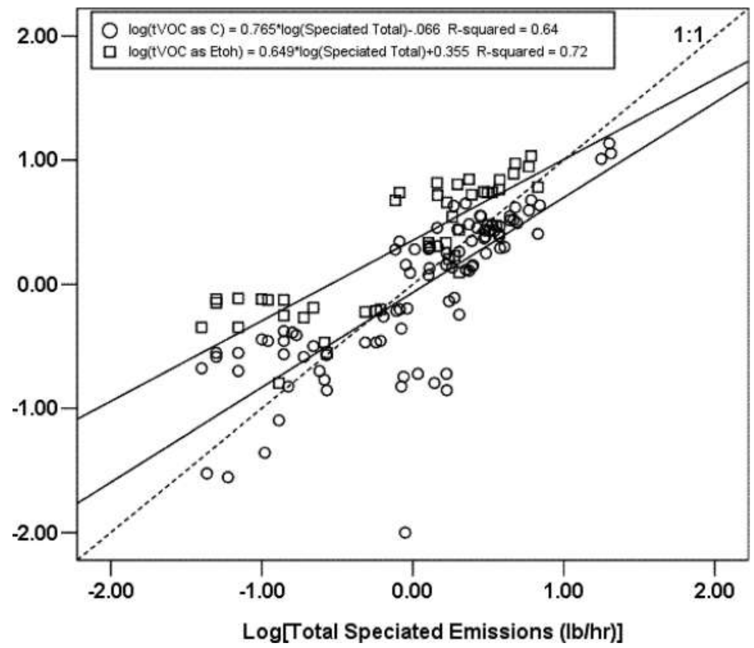

Figure 5. Relationship between the sum of speciated VOC emissions (hybrid of methods 5 and 18) and total VOC emissions measured by Method 25A. The square markers represent Method 25A with the ethanol response factor. The circles represent Method 25A as carbon. Both axes are in units of lbs/hr on a log base 10 scale. The dotted line represents a one-to-one relationship.

some features of VOC emissions from fuel ethanol facilities, further testing is necessary to more thoroughly characterize ethanol plant emissions. EPA staff informally estimated that the hybrid testing methodology used in this study captures approximately 60–90% of the constituents of fuel ethanol facility emissions. The ethanol industry has informally asserted that the percentage characterized is closer to the high end of that range (i.e., near 90%). The discrepancies between these assertions are based on differing professional opinions, and the available data are insufficient to support either contention.

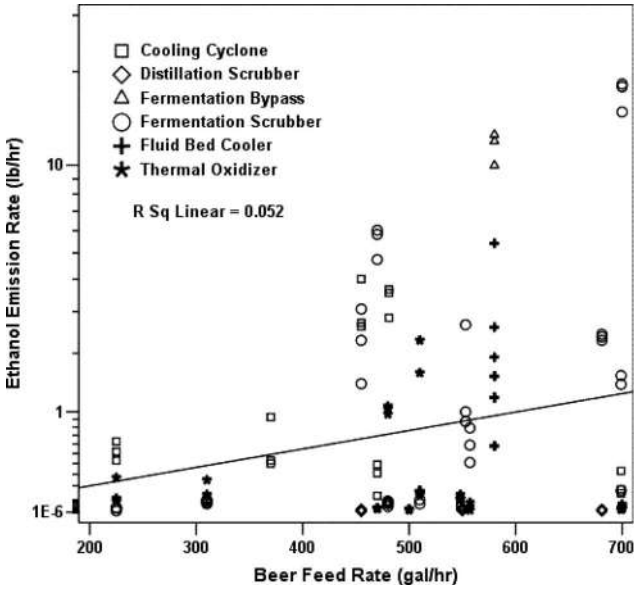

Figure 6. Emissions (lb/hr) of ethanol by emissions unit as a function of beer feed rate. The *y*-axis is scaled logarithmically, and the R^2 value reflects the log-linear scaling.

Emissions of total VOCs and individual VOC species varied widely among emissions units, facilities, and test dates. From our data it is not possible to predict which

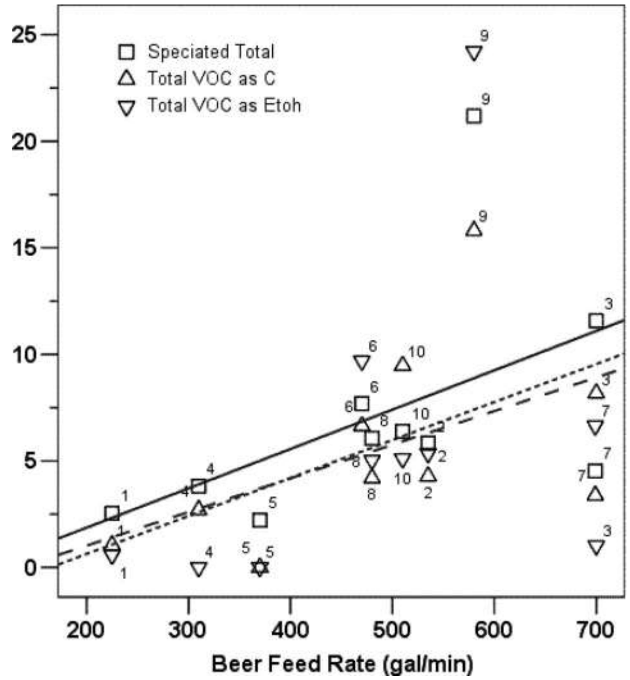

Figure 7. Total facility emissions (lbs/hr) of total VOCs as measured by Method 25A as carbon (△), Method 25A with the ethanol response factor (▽), and the sum of speciated VOCs (hybrid method □). For each facility, measurements were averaged by emission unit and then summed over all emissions units with measurements. Values below detection were replaced with one-half the detection limit (results were nearly identical when values below detection were replaced with zero). The numbers by each marker represent the facility number as listed in Table 3.

emission unit at a given facility will have the highest emission rate, although in general, the fermentation scrubber, cooling cyclone, and fluid bed cooler emission units tended to have higher emissions than other units. We expect that without controls, dryer emissions would have dominated the total emissions pattern from ethanol plants. The fact that dryer emissions were similar to, and sometimes lower than, emissions from other sources indicates that the TOs were controlling dryer emissions. Emissions from specific categories of emissions units also varied among facilities. For example, total VOC emissions from the fermentation scrubber could be as high as 13.7 lbs/hr at one facility or as low as 0.15 lbs/hr at another. When multiple test events were conducted, it was often the case that emissions were lower on the second test. One reason might be that plant personnel improved the operation and maintenance of their equipment over time.

As the desired fermentation product, it is not surprising that ethanol is one of the major pollutants emitted. Most of the other substances are known byproducts of the ethanol fermentation process, but they are usually considered to be contaminants or undesirable byproducts. The inherent variability in biological processes could account for the high level of variability in emissions of VOC species from fuel ethanol production facilities. We hypothesize that small differences in the fermentation conditions among facilities and over time at a given facility could alter the rate at which these byproducts of fermentation are produced and emitted.

The high variability in emissions, both within a given facility and among facilities, prevented strong conclusions about the factors governing emission rates. Figures 6 and 7 illustrate the general trend of increasing emissions with increasing production (beer feed) rate. It is not surprising that emission rates would be affected by the beer feed rate because it is a measure of the amount of materials being processed at the plant at the time of the test. In contrast, the production capacity is an annual value that may not be representative of the activity at a specific time. Emission factors are typically established for individual emission units. Figures 6 and 7 show that the variability in emissions as a function of beer feed rate is greater for individual emissions units than for total plant-wide emissions. This variability precludes the establishment of emissions factors that relate emissions of individual or total VOCs to beer feed rate.

The single test of wet cake emissions precludes statistical analysis or any definitive statements about emission levels. Nevertheless, as the only existing data, the results have been used as emission factors for regulatory purposes and risk analysis in Minnesota. Wet cake emissions are considered a fugitive source and have different characteristics from the other emission units examined. Wet cake production is not a part of routine operations at dry mill ethanol plants but rather a backup process used when dryers or a TO must be shut down.

Although our hypothesis was that total VOC emissions measured by Method 25A as carbon would be lower than the sum of speciated emissions, we found that in 16 of 28 facilities by emission unit combinations (Table 3), the sum of speciated total emissions was lower than the total VOC measurement. In 20 of the combinations the speciated total was within a factor of two of the total VOC measurement. In contrast, when the ethanol response factor was added to Method 25A, calculated total VOC emissions were generally higher than the sum of speciated emissions (Table 3 and Figure 5). The slopes of both regressions between the Method 25A emissions and the sum of speciated emissions were less than one (Figure 5), so Method 25A would be expected to underestimate compared with the sum of speciated emissions at high VOC emission rates. We can reasonably conclude that the sum of speciated emissions is likely to underestimate the true total VOC emissions because it is likely that some emitted species were not determined. Thus, the true total VOC emissions should lie above the one-to-one line in Figure 5.

It is clear from Table 3 that in some cases the total speciated emissions (combined Methods 5 and 18) matched poorly with the total VOC measurement (Method 25A) as carbon or with the ethanol response factor. The discrepancies were greatest for the TO test results at the Agri-Energy and Al-Corn facilities, along with one of the test runs at the EXOL facility. For these measurements, the speciated VOC emissions were much larger than the total VOC emissions. At the Al-Corn facility this finding appeared to be due to the bias introduced by imputing one-half the detection limit for values below detection during the process of summing the speciated emissions (Table 3). The Al-Corn discrepancy was greatly reduced when a value of zero rather than one-half the detection limit was imputed for values below detection. This finding suggests that the true values for the Al-Corn TO measurements reported as below detection are likely closer to zero than to the detection limit. At the Agri-Energy and EXOL facilities imputing zero for values below detection did not greatly reduce the discrepancy between total VOC emissions and the sum of speciated VOC emissions, At other emission units and other facilities the method of substitution for values below detection did not make a substantial difference in the results, and the two test methods were in better agreement, although the variation among the test results was large.

Several limitations in the data should be stated clearly. First, the study design was determined by regulatory policy rather than scientific inquiry. The approach to testing and reporting also evolved as new information became available from the earlier tests. As a result, the emissions units tested varied by facility, and the test methods used varied by emissions unit and facility. Second, not all emissions units were tested for the same analytes, confounding comparisons among units and facilities. There is also considerable variation in the quantities of analytes across facilities (Table 2 and Figures 3 and 6), which we believe represents actual differences among facilities rather than an artifact of the monitoring methodology.

The left-censored data include values reported as zero and values reported as below detection limits. The proper treatment of values reported as zero or below detection is a matter of discussion. Ignoring such values will bias the data and lead to incorrect estimates of emissions. We used a combination of approaches suggested by Helsel[24] comprised of a bootstrap calculation on the Kaplan-Meier method. The results of the statistical analyses are presented as the means and upper confidence limits in Table 2. These two descriptive statistics provide information about the central tendency and the variability in each of the sets of measurements. Because of the small number of observations, the difficulty in determining a distribution, and the presence of nondetects (left-censoring), typical parametric statistics are not appropriate.

The Minnesota Pollution Control Agency has used emissions estimates based on these data in risk analyses for newly proposed ethanol production facilities. For purposes of cancer and chronic noncancer risk assessment, EPA guidance[26] recommends using the 95% UCL of the arithmetic mean of stack test data: "The 95% UCL of a mean is defined as a value that, when calculated repeatedly for randomly drawn subsets of site data, equals or exceeds the true mean 95% of the time. The 95% UCL provides a conservative estimate of the average concentration. Because of the uncertainty associated with estimating the true average emission rate, the 95% UCL of the arithmetic mean should be used because it provides reasonable confidence that the true average emission rate will not be underestimated." The EPA guidance does not address datasets with left-censored (below detection) data. We used a nested bootstrap statistical method that does not rely on the assumption that the data are normally distributed, and it accounts for censored (below detection) data. The nested bootstrap method also accounts for the sampling methodology in that each facility was treated independently, each test event at a given facility is independent, and each replication was nested within that framework. We suggest that the mean is an indicator of the central tendency of the data and that the UCL provides information about the variability. Furthermore, following EPA guidance the UCL values are suitable for use as emission rates in risk analysis of chronic exposure to air emissions from fuel ethanol production facilities.

The percentage of emissions quantified may not be important to the type of controls installed or how the facility routinely operates, but censoring and imprecision in the data complicates accurate analysis of the potential inhalation health effects of emissions from these facilities. Recently, newly proposed fuel ethanol production plants have been asked to perform a risk analysis as part of the environmental review process. Evaluating potential health effects from a facility is something new to ethanol production facilities and, as such, presents challenges. VOC species are usually risk drivers (i.e., account for the majority of the estimated risk) at ethanol plants, so scarcity and imprecision in VOC emissions data leaves gaps in the risk analysis. For most ethanol production facilities, the chemicals that contribute the most to risk are NO_x, acetaldehyde, formaldehyde, acetic acid, and acrolein. Nitrogen oxides are emitted from combustion sources, whereas the other substances result from the fermentation and related processes.

In addition to the issue of selecting an appropriate emission rate, another problem in risk analysis can be the lack of toxicity information for some pollutants. There is considerable toxicological information about a few of the ethanol plant emissions such as acetaldehyde and acrolein, and the respiratory impairments often attributed to NOx are well known. However, toxicity information about most of the rest of the identified species is less certain, and many of the measurable VOC species lack toxicity benchmark values and, therefore, can not be included in a quantitative risk assessment. Other chemicals yet unidentified could possibly increase the risk in one of the exposure scenarios (acute, chronic, subchronic or cancer).

In response to concerns over the lack of health benchmarks or toxicity values, the Minnesota Department of Health in 2005[27] developed interim toxicity benchmarks for 13 substances known to be emitted from ethanol plants. Even with the application of these values only slightly more than half of the VOC mass can typically be assessed quantitatively for inhalation risk. The risk analyses done to date on fuel ethanol production facilities in Minnesota indicate that acute risks (typically assessed over a 1-hr exposure duration) and chronic noncancer risks (evaluated over a 1-yr exposure duration) are of greater concern than cancer risks, often approaching health guidelines or thresholds close to the facilities' property boundaries. We cannot say with certainty whether the data gaps have implications for risk analysis.

The initial data collection reported here was driven by regulatory enforcement activities (i.e., the consent decrees), but that mandate does not require risk analyses at these facilities. The available data are sufficient to allow a screening level human health risk assessment and have been used in the permitting (regulatory) process. However, more emission data collection and toxicological analysis would improve confidence in the assessment of potential health impacts of air emissions from ethanol fuel production facilities.

CONCLUSION

Stack test data for total VOCs and individual VOC species were collected at fuel ethanol production facilities in Minnesota. A hybrid testing methodology was developed to address problems in the application of the FRM for testing total VOC emissions at these plants. The data reveal considerable variability among facilities and emission units in terms of the species detected and the mass of emissions. In general, the fermentation scrubbers and fluid bed coolers emitted the largest mass of VOC emissions. Across most facilities and emission units, ethanol, acetaldehyde, acetic acid, and ethyl acetate were the pollutants emitted at the highest rates. Emissions appeared to be related to the beer feed rate, although an emissions factor based on production rate was not established.

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Airborne measurements of the atmospheric emissions from a fuel ethanol refinery

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Abstract Ethanol made from corn now constitutes approximately 10% of the fuel used in gasoline vehicles in the U.S. The ethanol is produced in over 200 fuel ethanol refineries across the nation. We report airborne measurements downwind from Decatur, Illinois, where the third largest fuel ethanol refinery in the U.S. is located. Estimated emissions are compared with the total point source emissions in Decatur according to the 2011 National Emissions Inventory (NEI-2011), in which the fuel ethanol refinery represents 68.0% of sulfur dioxide (SO_2), 50.5% of nitrogen oxides ($NO_x = NO + NO_2$), 67.2% of volatile organic compounds (VOCs), and 95.9% of ethanol emissions. Emissions of SO_2 and NO_x from Decatur agreed with NEI-2011, but emissions of several VOCs were underestimated by factors of 5 (total VOCs) to 30 (ethanol). By combining the NEI-2011 with fuel ethanol production numbers from the Renewable Fuels Association, we calculate emission intensities, defined as the emissions per ethanol mass produced. Emission intensities of SO_2 and NO_x are higher for plants that use coal as an energy source, including the refinery in Decatur. By comparing with fuel-based emission factors, we find that fuel ethanol refineries have lower NO_x, similar VOC, and higher SO_2 emissions than from the use of this fuel in vehicles. The VOC emissions from refining could be higher than from vehicles, if the underestimated emissions in NEI-2011 downwind from Decatur extend to other fuel ethanol refineries. Finally, chemical transformations of the emissions from Decatur were observed, including formation of new particles, nitric acid, peroxyacyl nitrates, aldehydes, ozone, and sulfate aerosol.

Key Points:

- Emissions from the third largest fuel ethanol refinery in the U.S. were measured
- Emissions of NO_x and SO_2 agreed with the NEI-2011 emission inventory
- Emissions of VOCs were underestimated by the NEI-2011 inventory

Supporting Information:

- Figures S1–S5 and Table S1

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1. Introduction

Since the early 2000s, a growing fraction of gasoline in the U.S. has consisted of E10, a fuel blend of 10% ethanol in gasoline [*de Gouw et al.*, 2012]. Fuel ethanol in the U.S. is made almost entirely from corn, and ~40% of this crop is now grown for fuel production according to data from the U.S. Department of Energy [*Hill et al.*, 2009; *Wright and Wimberly*, 2013]. Fuel ethanol is produced from corn in approximately 200 fuel ethanol refineries across the nation. Quantification of atmospheric emissions from these refineries is essential for determining their impact on air quality and climate and is the subject of this work. Most of the fuel ethanol refining capability is located in the Midwestern states, where corn is grown (Figure 1). The production of fuel ethanol grew rapidly until 2011. At that point, the market acceptance of E10 was almost complete and further increases in ethanol production and use can only occur if E15 (a fuel blend of 15% ethanol in gasoline) was approved as a fuel in standard gasoline vehicles or if the market share of E85 (a fuel blend of 85% ethanol in gasoline) flex-fuel vehicles was to increase.

There has been significant research on the net effects of fuel ethanol use on greenhouse gas emissions. It has been argued that corn ethanol does contribute to reductions in CO_2 emissions, but that larger reductions require the development of cellulosic ethanol [*Farrell et al.*, 2006; *Hill et al.*, 2009; *Wang et al.*, 2012], which is currently only produced in small amounts [*Peplow*, 2014; *Service*, 2014]. Other studies pointed out that any reductions in CO_2 emissions could be partially or completely offset by the carbon release associated

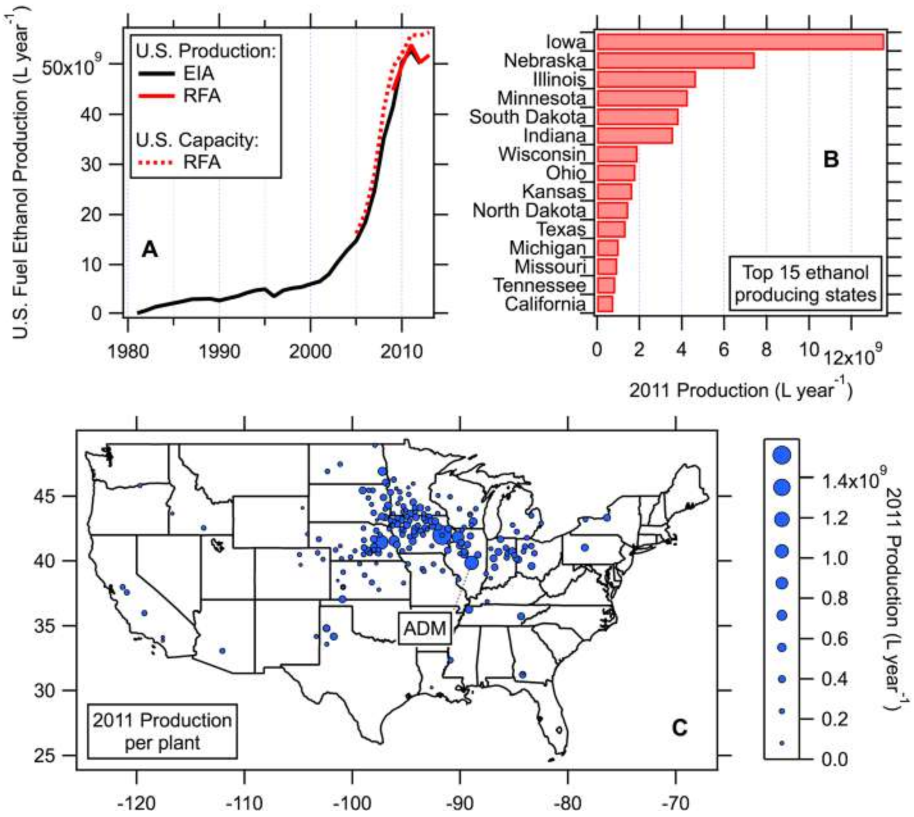

Figure 1. Fuel ethanol production in the U.S. (a) The total production and capacity according the Energy Information Administration (EIA) and Renewable Fuels Association (RFA). (b) Top 15 ethanol-producing states in 2011. (c) The location of all fuel ethanol refineries in the U.S. sized by their 2011 production. The location of the Archer Daniels Midland (ADM) plant in Decatur, Illinois, studied in this work, is indicated in Figure 1c.

with land use changes [*Fargione et al.*, 2008; *Searchinger et al.*, 2008] or by increases in emissions of the greenhouse gas N_2O associated with fertilization [*Crutzen et al.*, 2008; *Smith et al.*, 2012].

Several studies have looked at the effects of fuel ethanol use on air quality [*Hill et al.*, 2009; *Tessum et al.*, 2014]. Measured emissions from motor vehicles that use ethanol fuel blends depend strongly on the fuel blend and on the vehicle model and year. As a general trend, the emissions of nitrogen oxides ($NO_x = NO + NO_2$) tend to be lower for ethanol blends in comparison with gasoline, whereas emissions of volatile organic compounds (VOCs) such as aldehydes tend to be higher [*Graham et al.*, 2008; *Salvo and Geiger*, 2014]. A modeling study indicated that widespread use of E85 fuel in urban areas could lead to increases in acetaldehyde, ozone, and peroxyacetyl nitrate at the surface [*Jacobson*, 2007]. An observational study showed that the atmospheric burden of ethanol in the U.S. has increased over the last decade, but also, that effects on air quality have been overshadowed by the large reductions in motor vehicle emissions that occurred over the same period [*de Gouw et al.*, 2012]. A recent study from Brazil provided evidence that a higher fraction of fuel ethanol use, and therefore reduced NO_x emissions, could lead to higher ozone pollution in urban air [*Salvo and Geiger*, 2014]. There are still many uncertainties about the atmospheric chemistry of ethanol in general [*de Gouw et al.*, 2005; *Naik et al.*, 2010; *Giebel et al.*, 2011; *Millet et al.*, 2012]. For example, ethanol may have large natural sources in addition to the man-made source from fuel ethanol use. These uncertainties limit the predictive capability on the effects of fuel ethanol use.

Several recent studies quantified the emissions of reactive trace gases from various processes associated with ethanol production and their effect on air quality. A few recent papers looked at the emissions of volatile organic compounds (VOCs) from growing biofuel crops [*Eller et al.*, 2011; *Graus et al.*, 2013]. The emissions of VOCs from corn are relatively low compared to those from tree species, but nevertheless, per volume of ethanol produced, the integrated emissions from growing biofuel crops can be of the same order of

Table 1. Measurements On board the NOAA WP-3D Aircraft Used in This Analysis

Measurement	Method	Reference
NO, NO_2, NO_y, O_3	Chemiluminescence	*Pollack et al.* [2010]
CO	Vacuum ultraviolet resonance fluorescence	*Holloway et al.* [2000]
CO_2, CH_4	Infrared laser absorption	*Peischl et al.* [2012]
SO_2	Pulsed UV fluorescence	NA (not applicable)
HNO_3	Chemical ionization mass spectrometry	*Neuman et al.* [2002]
NH_3	Chemical ionization mass spectrometry	*Nowak et al.* [2007]
Aromatic and oxygenated VOCs	Proton-transfer-reaction mass spectrometry	*de Gouw and Warneke* [2007]
Hydrocarbons, ethanol	Whole air sampling–GC-MS analysis	NA
Formaldehyde	Laser-induced fluorescence	*Cazorla et al.* [2014]
Glyoxal	Cavity-enhanced absorption spectroscopy	*Washenfelder et al.* [2008]
Peroxyacyl nitrates	Chemical ionization mass spectrometry	*Slusher et al.* [2004]
Aerosol size distribution	Optical and condensation particle counters	*Brock et al.* [2000]
Aerosol size and composition	Time-of-flight aerosol mass spectrometer	*Canagaratna et al.* [2007]
Black carbon aerosol	Single-particle soot photometer	*Schwarz et al.* [2008]

magnitude as fuel-based VOC emission factors from motor vehicles [*Graus et al.*, 2013]. Other biofuel crops such as hybrid poplars are isoprene emitters [*Eller et al.*, 2012], and their widespread use could have more significant impacts on air quality, crop yields, and mortality [*Ashworth et al.*, 2012, 2013].

In this work, we report airborne measurements of atmospheric emissions downwind from Decatur, Illinois, where the third largest producer of fuel ethanol in the U.S. (Archer Daniels Midland) is located. The measurements are used to estimate the emissions of various trace gases including nitrogen oxides, sulfur dioxide, and VOCs. The results are compared with the 2011 National Emission Inventory (NEI-2011) from the U.S. Environmental Protection Agency, which has not been evaluated in detail for fuel ethanol refineries. Also, we briefly discuss the chemical transformations in the plume using airborne transects at different distances from the source. The analysis is extended to all other fuel ethanol refineries in the U.S. Figure 1 summarizes the U.S. production of fuel ethanol according to the Energy Information Administration (EIA) as well as the Renewable Fuels Association (RFA). By combining the NEI-2011 database with the RFA production numbers, we calculate the atmospheric emissions per mass of ethanol produced for all fuel ethanol refineries in the U.S. and compare these numbers to fuel-based vehicle emission factors. These comparisons give insight into the relative contribution from different important processes in the life cycle of fuel ethanol to the total atmospheric emissions.

2. Aircraft Measurements

Measurements were made from the NOAA WP-3D research aircraft during the NOAA Southeast Nexus project in June and July of 2013 (http://www.esrl.noaa.gov/csd/projects/senex/). The aircraft was operated out of the Smyrna/Rutherford County airport in Smyrna, Tennessee. The NOAA WP-3D was outfitted with a suite of instruments to characterize the chemical composition of gas- and aerosol-phase species, as well as the size distribution, radiative, and cloud-nucleating properties of the aerosol. The measurements that are used in this analysis are summarized in Table 1. Additional measurements on board the NOAA WP-3D that are not used in this analysis have been omitted from this table.

Whole air samples (WASs) were collected in-flight and analyzed postflight for VOCs using a newly developed gas chromatography–mass spectrometry system. The airborne canister sampling system was designed based on the advanced whole air sampler that was developed for the research aircraft operated by the National Center for Atmospheric Research. Up to 72 canisters could be collected in-flight either at predetermined time intervals or under manual control. The fill time at low altitude was typically 4–5 s. The analytical system consists of a two-channel gas chromatograph with a single Agilent 5975C mass spectrometric detector. The system is similar to an instrument that was used for in situ VOC measurements over the last decade [*Gilman et al.*, 2010], but uses a Stirling cooler (Sunpower Cryotel GT) to provide the cryostatic temperatures required for trapping VOCs, as opposed to liquid nitrogen in the previous system. Measurements are generally accurate within 10% but can be affected by losses in the canisters for some higher hydrocarbons. Measurements of ethanol were made from the whole air samples, and results are

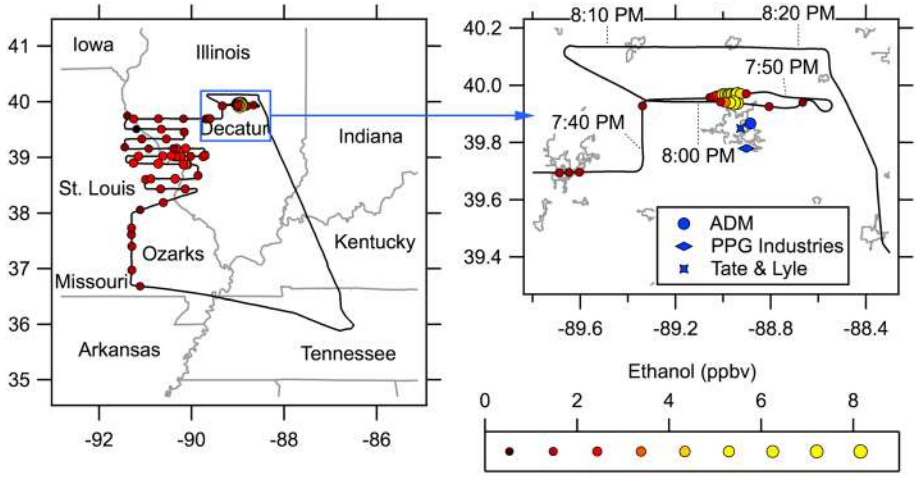

Figure 2. Flight track of the NOAA WP-3D research aircraft on 5 July 2013. The canister sampling locations are indicated by circles and color coded by the measured mixing ratio of ethanol. The gray lines indicate (left) state boundaries and (right) urban boundaries.

included in this study. After the project, the recovery of ethanol from the sampling canisters was investigated in the laboratory. The results of these tests showed that ethanol can be quantitatively retrieved from the canisters (Figure S1 in the supporting information).

3. Measurement Results

Figure 2 shows the flight track of the NOAA WP-3D on 5 July 2013. The aircraft took off from Smyrna, Tennessee, and flew at low level over the Ozarks toward St. Louis, Missouri. Several flight legs upwind, overwind, and downwind from St. Louis were made, before the aircraft transited to Decatur, Illinois. Two passes at 500 m altitude above ground were made shortly downwind from Decatur (12 and 9 km), and one further downwind (30 km), before the aircraft returned to Smyrna.

The circles along the flight track in Figure 2 indicate the locations where whole air samples were collected and the circles are size and color coded by the measured mixing ratio of ethanol in the samples. Modest enhancements of ethanol downwind from St. Louis were consistent with a motor vehicle source (Figure S2 in the supporting information) [*de Gouw et al.*, 2012]. Much higher enhancements were observed directly downwind from Decatur. Unfortunately, no sample canisters were left for the furthest downwind transect.

The three blue symbols in the right of Figure 2 indicate the locations of the three largest point sources of NO_x, SO_2, and VOCs in Macon County, where Decatur is located, according to the NEI-2011. The emissions from these three sources as well as other point sources in Macon County are summarized in Table 2. The Archer Daniels Midland (ADM) plant that includes the fuel ethanol refinery has the highest emissions for all species in Table 2. In addition to fuel ethanol, the ADM plant in Decatur also produces a range of food, animal feed, and industrial products from corn, oilseeds, wheat, and grains. Figure S3 in the supporting information shows the different processes that contribute to the total emissions of different trace gases from the ADM plant. The Tate & Lyle plant in Decatur produces a range of food products and industrial ingredients from corn and is a

Table 2. Emissions of NO_x, SO_2, Total VOCs, and Ethanol From Point Sources in Macon County From the 2011 National Emissions Inventory

	SO_2		NO_x		VOCs		Ethanol	
	$kg\ h^{-1}$	%	$kg\ h^{-1}$	%	$kg\ h^{-1}$	%	$kg\ h^{-1}$	%
ADM	907	68.0	241	50.5	324	67.2	37.7	95.9
Tate & Lyle	414	31.0	38.9	8.1	122	25.2	1.37	3.5
PPG Industries	12.4	0.9	173	36.4	2.27	0.5	0.0354	0.1
Other	1.52	0.1	23.7	5.0	34.1	7.1	0.220	0.6
Total	1335		476		482		39	

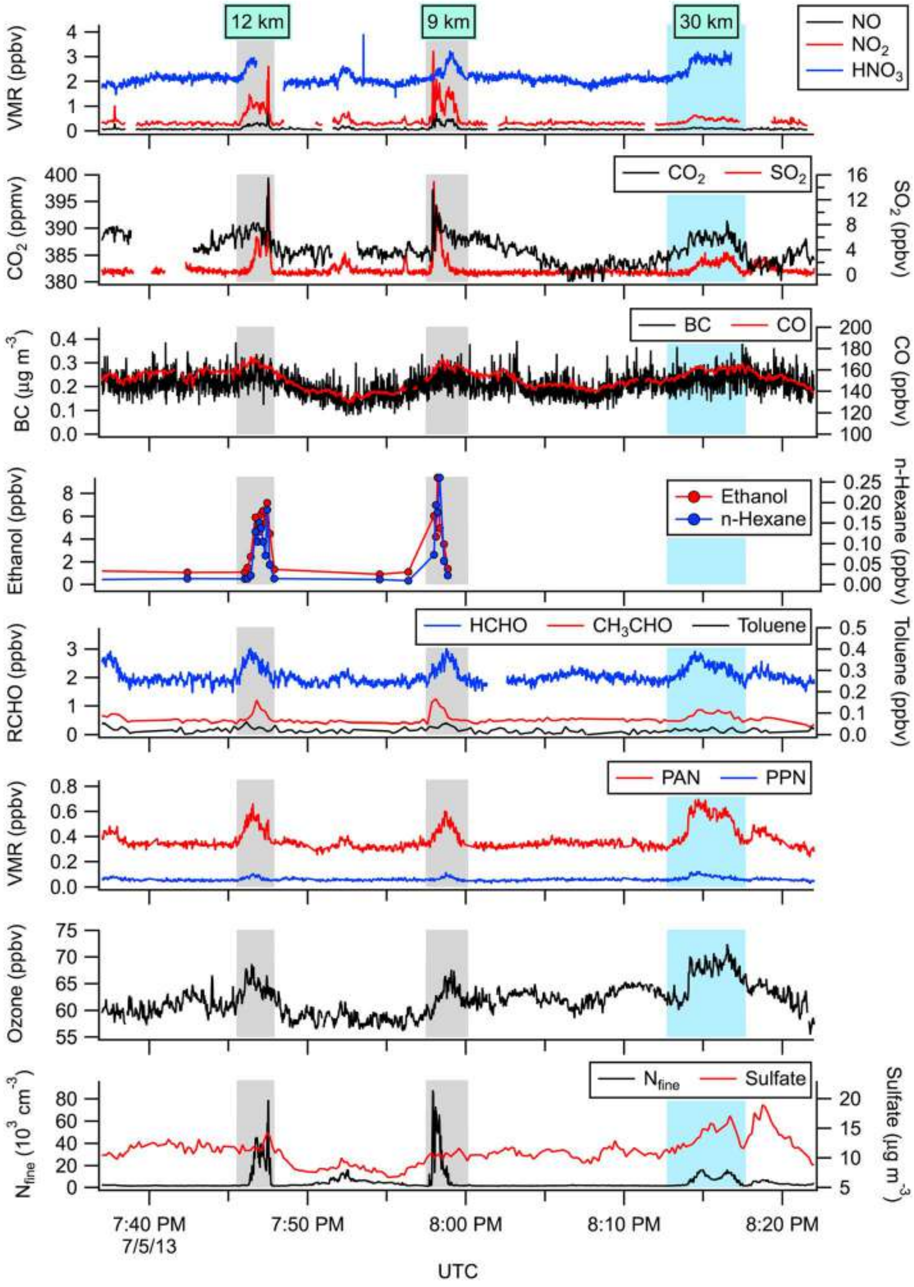

Figure 3. Time series of measurements made from the NOAA WP-3D downwind from Decatur, Illinois. The gray shaded areas indicate plume intersects nearest to Decatur. The blue shaded area indicates the plume intersect furthest from Decatur. VMR stands for volume mixing ratio. RCHO stands for aldehydes.

significant emitter of SO_2 and VOCs but not ethanol. The PPG Industries plant to the south of Decatur manufactures flat glass for use in residential and commercial markets. The plant is a significant emitter of NO_x but not VOCs and ethanol. Because these three sources (ADM, Tate & Lyle, and PPG Industries) are very close, their emissions were not separately observed from the aircraft. Therefore, the observations downwind from Decatur will be compared with the total emission estimates for these three sources in the following analysis.

The time series of several measurements downwind from Decatur are shown in Figure 3. The two peaks on the left, during the gray shaded periods, were obtained directly downwind from Decatur (12 and 9 km), whereas the broader structure on the right, during the blue shaded period, was observed further downwind (30 km). The species that showed clear enhancements immediately downwind from Decatur included NO, NO_2, nitric

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acid (HNO_3), CO_2, SO_2, ethanol, n-hexane, formaldehyde (HCHO), acetaldehyde (CH_3CHO), peroxyacetyl nitrate (PAN), peroxypropionyl nitrate (PPN), and the number concentration of fine particles (N_{fine}).

The ADM and Tate & Lyle plants use coal as an energy source (Figure S3 in the supporting information), which explains the presence of NO_x and SO_2 downwind from Decatur. Black carbon aerosol and carbon monoxide were correlated during this part of the flight, consistent with an influence from motor vehicle emissions, but were not strongly enhanced downwind from Decatur. Toluene, one of the more abundant VOCs in motor vehicle emissions, was also not strongly enhanced during this part of the flight. These observations show that the strong enhancements in most trace gases and aerosol species must be attributed to emissions from the industrial sources in Table 2 rather than to motor vehicles.

Since ethanol is produced in bulk quantities at the ADM plant in Decatur, the emission of ethanol could be expected. The emission of n-hexane was higher than that of the other alkanes. Fuel ethanol refineries use either a dry or wet milling process (http://www.ethanolrfa.org/pages/how-ethanol-is-made). In the wet milling process used at the ADM plant, corn is first soaked in water and dilute sulfurous acid. Subsequently, the corn germs are separated from the corn slurry. Corn oil, one of the valuable by-products from corn ethanol production, is extracted from the germs using n-hexane as a solvent, which likely explains the presence of n-hexane downwind from Decatur.

The presence of formaldehyde, acetaldehyde, PAN, and PPN downwind from Decatur is explained by a combination of direct emissions and chemical transformation in the atmosphere. Other products from the chemical transformation of emissions in the plume are shown in the bottom of Figure 3 and include ozone and sulfate aerosol. These observations will be discussed in more detail below. The number concentration of fine particles was strongly enhanced directly downwind from Decatur and correlated well with the mixing ratio of SO_2. These enhancements are caused by new particle formation in the plume. Further downwind, the number concentration of fine particles had decreased due to dilution and coagulation.

4. Discussion

4.1. Emission Estimates and Comparison with NEI-2011

Emission fluxes were estimated from the measurements in the two plume transects nearest to Decatur. The method involves integrating the enhancements in mixing ratios across the plume and multiplying the integral with the orthogonal wind speed and depth of the boundary layer [*White et al.*, 1976; *Ryerson et al.*, 2011]. Results are presented in Figure 4 and Table S1 in the supporting information. The following values and assumptions were used in the calculations:

1. The boundary layer depth was estimated to be 1175 m with an uncertainty of 20%, as estimated from the measured wind direction and speed, potential temperature, CO, CO_2, and O_3 data during two altitude profiles made before and after the plume transects near Decatur.
2. The average orthogonal wind speed was 4.1 m s^{-1} with an uncertainty of 10% due to the variability in the wind field.
3. Enhancements in mixing ratios are defined as the mixing ratio or mass loading in the plume minus the background measured outside the plume. The backgrounds determined here are given in Table S1 in the supporting information.
4. Measurements of species that were not measured continuously such as the proton-transfer-reaction mass spectrometry (1 data point every 15 s for each species) and WAS (several discrete samples across the plume) were interpolated onto a 1 s time basis for the integration across the plume. For the WAS data, this was only done for the first plume intercept, as the second plume was undersampled.
5. The uncertainty in the fluxes is estimated to be 50% due to the uncertainties in the plume integrals, boundary layer depth, the orthogonal wind speed, and in particular the assumption of uniform vertical mixing [*de Gouw et al.*, 2009; *Ryerson et al.*, 2011].
6. Several species did not show clear enhancements downwind from Decatur (methane, NH_3, propane, butanes, isoprene, ethyne, benzene, methanol, glyoxal, and methylethylketone). For these species, the measurements are used to define an upper limit to the fluxes.

The estimated emissions are compared in Figure 4 with those from the NEI-2011 database. Estimated emissions of SO_2 and NO_x agree with NEI-2011 within the uncertainty. This agreement could be fortuitous

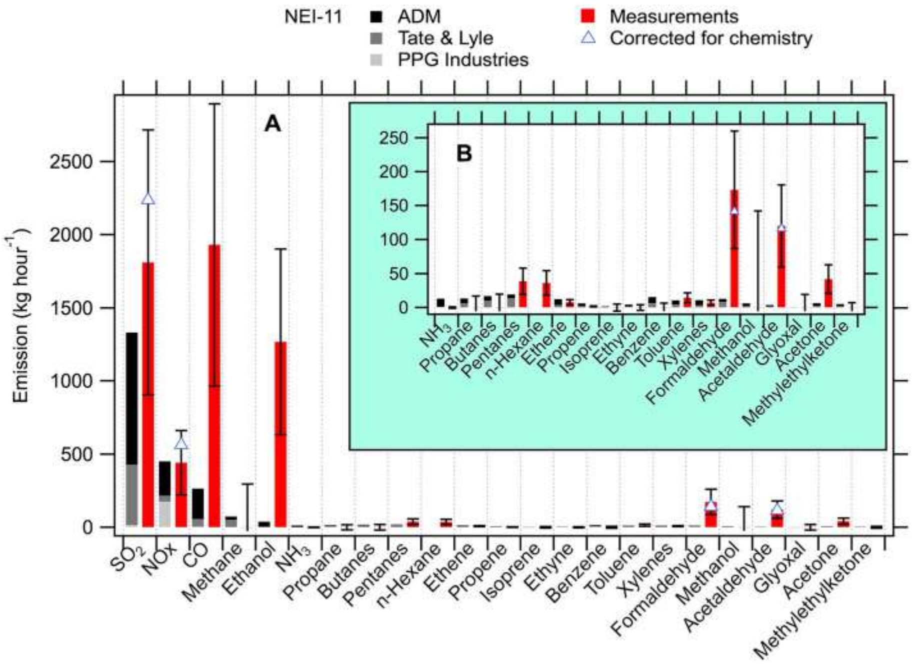

Figure 4. Comparison of the emissions downwind from Decatur, Illinois, between the three largest sources in the National Emissions Inventory in that area and the measurements from the NOAA WP-3D aircraft. (a) All compounds and (b) the compounds from ammonia (NH_3) onward on a smaller scale. The blue triangles show the possible effects of chemical transformations in the plume on the estimated emissions as discussed in section 4.2.

as fluctuations in the emissions do occur, and our measurements only provide two snapshots. However, a strong disagreement would not be expected since the point source emissions of SO_2 and NO_x in NEI-2011, including for many fuel ethanol refineries, are based on continuous emission measurements at the stack. It should be noted that the total SO_2 emissions from the ADM plant in Decatur (7950 t) are not small. For comparison, one of the largest SO_2 point sources in the U.S. is the Homer City electric power plant in Pennsylvania, which emitted 104,000 in 2013 (http://ampd.epa.gov/ampd/), i.e., only about a factor of 13 higher.

In contrast to SO_2 and NO_x, estimated emissions of several VOCs, notably ethanol, formaldehyde, and acetaldehyde, are significantly higher (factors of 10–30) than the NEI-2011 emissions, which is well outside the 50% uncertainty in the flux estimates. As discussed below, some of the formaldehyde and acetaldehyde may have been formed chemically in the plume, but this does not explain the difference with the NEI-2011 emissions. Examination of the SO_2 and ethanol time series obtained downwind from Decatur (Figure S4 in the supporting information) provides further evidence for the issues with the NEI-2011 reported here. Measured enhancements in SO_2 and ethanol were very similar downwind from Decatur, and the emission ratio derived from the measurements was 0.70 kg kg^{-1} (Table S1 in the supporting information). In contrast, the ratio from the emission inventory is only 0.029 kg kg^{-1}. The inventory is therefore inconsistent with the measurements, regardless of the uncertainties associated with estimating absolute fluxes from the measurements. Figure S3 in the supporting information shows the different processes that contribute to the emissions of total VOCs, ethanol, formaldehyde, and acetaldehyde from the ADM plant according to the NEI-2011. The largest fraction of total VOC emissions is attributed to a generic profile (Food and Agriculture: not specified) that is unlikely to be accurate for this specific source. It should also be noted that severe underestimates in VOC emissions from industrial sources are not unprecedented and were observed downwind from petrochemical plants near Houston, TX [*Ryerson et al.*, 2003; *de Gouw et al.*, 2009], and in an oil and gas production region [*Petron et al.*, 2012].

4.2. Chemical Transformation of the Emissions

The emissions intercepted at 30 km from Decatur (blue shaded period in Figure 3) were chemically more processed than the emissions intercepted at 12 and 9 km from Decatur (gray shaded periods in Figure 3).

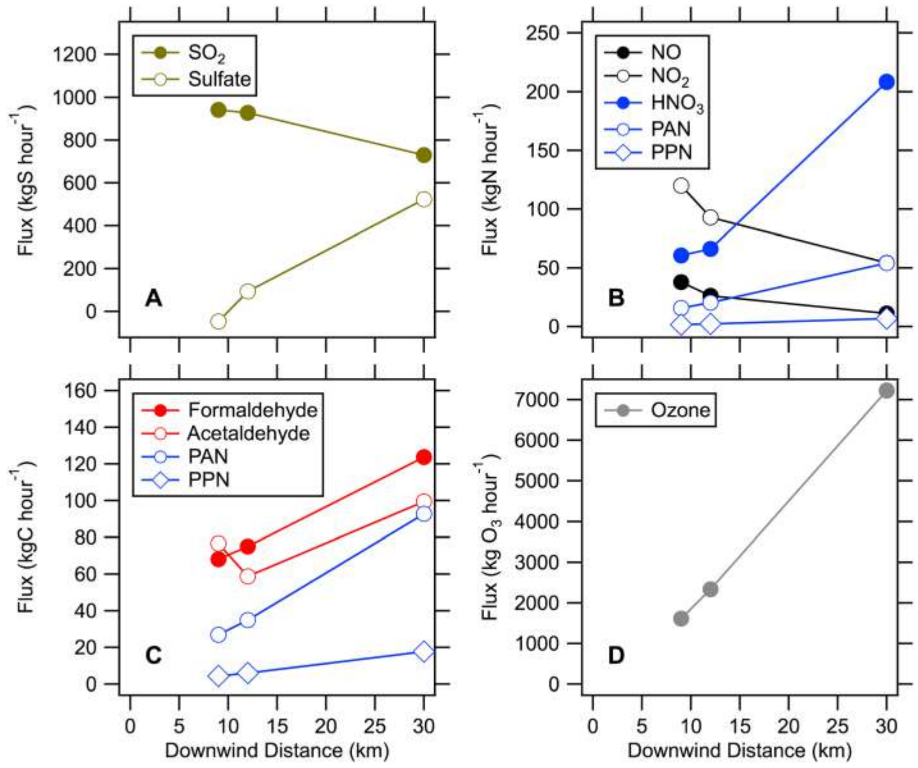

Figure 5. Estimated fluxes of (a) sulfur, (b) nitrogen, (c) organic carbon species, and (d) ozone as a function of distance and transport time from the ADM plant in Decatur. The uncertainties in the estimated fluxes are ±50%.

In Figure 5, the fluxes of various sulfur, nitrogen, and organic carbon species, as well as ozone, are shown as a function of the distance from the sampling location to the ADM plant. Fluxes were determined by the same method as used for the emissions. The plume intercept furthest from Decatur does not include the sulfate enhancement shortly before 08:20 P.M. This particular air mass was observed further east and did not have enhancements in other species such as aldehydes, PANs, and ozone. Based on the measurement location, back trajectories, and plume composition, this plume likely originated from a source further upwind than Decatur and was not included in the data shown in Figure 5.

At the downwind plume intercept, a significant fraction of the SO_2 had been converted into sulfate aerosol. Sulfate showed weak enhancements directly downwind and stronger enhancements of 6–8 $\mu g\ m^{-3}$ further downwind. Total sulfur was conserved within the 50% uncertainty of the flux estimates (albeit ~30% higher downwind). It is possible that the SO_2 emissions derived in the previous section reflect an underestimate because of this chemical removal, although sulfate concentrations were not measurably enhanced at 9 km downwind.

Figure 5b shows the chemical transformations of nitrogen oxides in the plume from Decatur. As the emissions moved downwind, NO and NO_2 reacted to form HNO_3, PAN, and PPN. As in the case of the sulfur species, total nitrogen was not perfectly conserved (~20% higher downwind) but stayed constant within the 50% uncertainty. Nitric acid is formed from the reaction between NO_2 and OH radicals. PAN and PPN are by-products from hydrocarbon oxidation in the presence of nitrogen oxides. Extrapolating the fluxes for these three species back to a zero distance gives values close to a zero flux, suggesting that, indeed, the presence of HNO_3, PAN, and PPN can be fully explained by chemical formation. It should be noted that the "kink" seen in the HNO_3 flux as a function of distance is not significant due to the 50% uncertainties. While some of the uncertainties, like wind speed and boundary layer depth, affect all the fluxes in the same manner, the largest uncertainty is due to the assumption of homogeneous vertical mixing, which cannot be assumed to affect the different data points in the same direction.

Figure 5c shows the fluxes of four organic carbon species. Formaldehyde and acetaldehyde fluxes increased downwind, suggesting that photochemical production of these species occurred in the plume. For acetaldehyde, the relative increase is similar in magnitude as the relative increases in total sulfur and total nitrogen, indicating that acetaldehyde formation cannot be ascertained with complete certainty. These aldehydes can be intermediate products of the same chemistry that formed PAN and PPN. Efficient precursors of formaldehyde and acetaldehyde, such as ethene, propene, and isoprene, were not detected in large amounts downwind from Decatur. Ethanol itself can also be a precursor of acetaldehyde. At an estimated OH concentration of 5×10^6 molecules cm^{-3}, the loss of ethanol would be 11% in the 2 h transport time for the 30 km downwind distance. A simple calculation that takes into account the formation of acetaldehyde from ethanol with a yield of 90%, and a loss of acetaldehyde itself to OH, shows that 50 kg C h^{-1} of acetaldehyde may have been formed from ethanol in this plume, which is in the range of the observations in Figure 5c. A significant fraction of the aldehydes may also have been directly emitted from industrial sources. Consistent with this, extrapolating the formaldehyde and acetaldehyde fluxes back to a zero distance suggests that there are nonzero fluxes, i.e., direct emissions, at the source.

Ozone can be formed from the photooxidation of VOCs in the presence of NO_x. Data in Figure 5d show that the ozone flux steadily increased with downwind distance. The ozone production efficiency [*Ryerson et al.*, 2001; *Neuman et al.*, 2009] was estimated from a scatterplot of ozone versus NO_z ($=NO_y - NO_x$) for the downwind transect. The resulting value for the ozone production efficiency was 6, suggesting that six molecules of ozone were formed for every NO_x molecule removed. This value is in the range of ozone production efficiencies observed in urban air but somewhat higher than what is observed downwind from power plants [*Ryerson et al.*, 2001; *Neuman et al.*, 2009]. The likely explanation is the coemission of VOCs with the NO_x from these industrial sources. In these plumes, however, the VOC reactivity is dominated by oxygenated species, in contrast with urban plumes and those from petrochemical industries. From the product of their respective emission fluxes times the rate coefficients for the reaction with OH [*Atkinson and Arey*, 2003], we estimate that ethanol represents 42%, formaldehyde 26%, and acetaldehyde 20% of the total OH reactivity for all observed VOCs (Figure S5 in the supporting information).

As mentioned above, the chemical transformations observed downwind from Decatur may imply that the emissions estimated above were too low for SO_2, NO_x, and others and too high for the aldehydes that were formed photochemically downwind. To investigate the possible magnitude of this effect, we linearly extrapolated the fluxes of SO_2, NO_x, formaldehyde, and acetaldehyde back to a zero distance. This was done after downscaling the fluxes at 30 km downwind by 25% to account for the nonphysical increase in total sulfur and nitrogen fluxes. The resulting corrected fluxes are shown by the blue triangles in Figure 4 and are well within the uncertainties of the flux estimates. We conclude that chemical transformations downwind from Decatur do not significantly affect our previous conclusions of the comparison between estimated emissions and the NEI-2011 database.

4.3. Emission Intensities of Fuel Ethanol Refineries

Fuel ethanol production numbers from the Renewable Fuels Association (RFA) for 2011 (Figure 1) were combined with emissions from the NEI-2011 database to calculate emission intensities for SO_2, NO_x, VOCs, and ethanol, defined as the pollutant emissions per amount of ethanol produced:

$$\text{Emission Intensity}\left(\text{g kg}^{-1}\right) = \frac{\text{Pollutant Emission}\left(\text{g yr}^{-1}\right)}{\text{Ethanol Production}\left(\text{kg yr}^{-1}\right)}$$

Results are shown as distributions in emission intensities in Figure 6. Out of 215 fuel ethanol refineries listed by the RFA for 2011, we found matching entries in the NEI-2011 databases for 139 plants. Matches were based on names, locations, and the emission description in the NEI-2011 database. Fuel ethanol refineries without a matching entry in the NEI-2011 database were mostly confined to smaller plants. We assume here that the 139 plants with a matching entry in the NEI-2011 database are representative for all U.S. fuel ethanol refineries. The descriptions of the emissions from the NEI-2011 database were also used to distinguish between plants that use coal versus natural gas as an energy source. Out of the 139 plants, 12 plants use coal and are shown separately by the black bars in Figure 6. Four of the plants that use coal are in the top six of ethanol producers; the other eight are more average in terms of ethanol production.

An implicit assumption in the calculation of emission intensities is that all of the emissions from the NEI-2011 database are associated with the fuel ethanol-refining process. However, some plants such as the ADM plant studied here produce other food and animal feed products in bulk quantities from corn, oilseeds, wheat, and

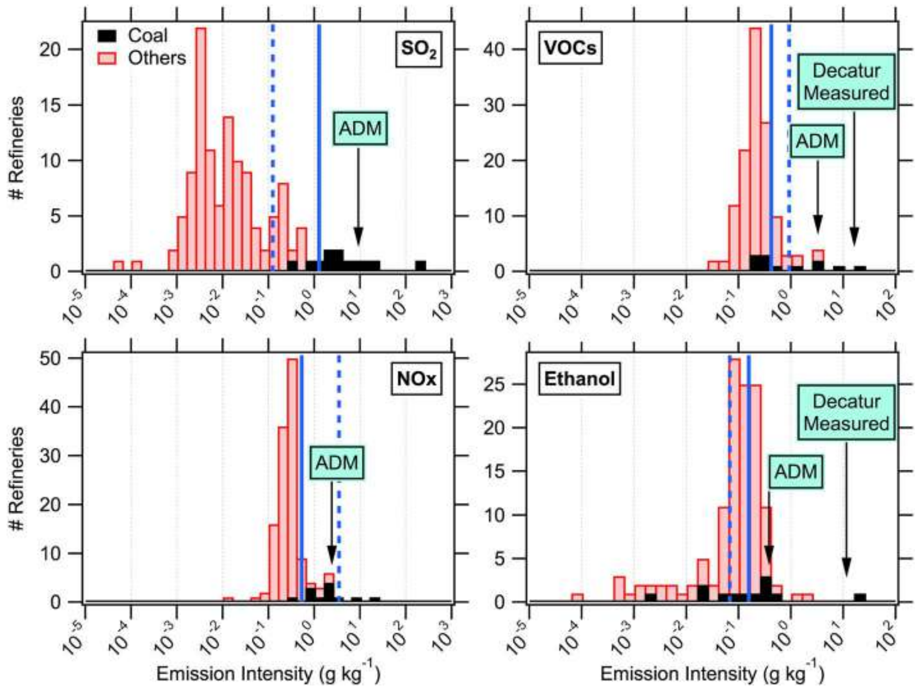

Figure 6. Emission intensities of SO_2, NO_x, VOCs, and ethanol from fuel ethanol refineries derived from combining the 2011 National Emissions Inventory and ethanol production numbers reported by the Renewable Fuels Association. Note that the *x* axes are on logarithmic scales. Average emission intensities (total emissions divided by total production) are shown by the solid blue lines. Plants that use coal are indicated in black, all others in red. Emission intensities for the ADM plant calculated from the NEI-2011 and estimated from the measurements downwind from Decatur here are shown by the arrows. For comparison, fuel-based emission factors from gasoline vehicles are shown by the dashed blue lines.

grains. Attributing all of the emissions to ethanol production is therefore an overestimate. Based on the available information, we cannot separate the emissions into the fraction that is associated with fuel ethanol production only.

The calculation of emission intensities facilitates the comparison with fuel-based emission factors from vehicles and other important processes in the life cycle of corn ethanol. Fuel ethanol is mostly used as E10 in gasoline vehicles. Fuel-based emission factors for NO_x, SO_2, and VOCs from gasoline vehicles that are averaged across a representative vehicle fleet are available from roadside and tunnel studies [*Burgard et al.*, 2006; *Bishop and Stedman*, 2008; *Bishop et al.*, 2012; *McDonald et al.*, 2012; *Gentner et al.*, 2013]. To estimate the vehicle emissions per liter of ethanol, we have to multiply the emissions from 10 L of E10 times the fraction of the emissions that is associated with ethanol only. The latter fraction is not well known, and we assume here that it scales with the volume fraction of ethanol (10%). The two factors of 10 cancel, and thus, we can compare the emission intensities for fuel ethanol refineries with fuel-based emission factors for gasoline vehicles in this section.

4.3.1. Sulfur Dioxide

Emission intensities for SO_2 are shown in the top left of Figure 6. Most plants have emission intensities below 0.04 g SO_2 kg^{-1} of ethanol, but the distribution has a very long tail. Plants that use natural gas have emission intensities up to 1 g SO_2 kg^{-1} of ethanol, whereas plants that use coal emit up to 100 g SO_2 kg^{-1} of ethanol. The solid blue line indicates the average emission intensity (1.3 g SO_2 kg^{-1} of ethanol), calculated from the total emissions divided by the total production.

Recent roadside measurements put the average SO_2 emissions from motor vehicles in 2005 at ~0.125 g SO_2 kg^{-1} of gasoline [*Burgard et al.*, 2006], indicated by the dashed blue line in Figure 6. Emissions in 2011 were likely even lower because of the tightening of the gasoline sulfur standard in 2006 to 30 ppm by weight and the continued turnover of the vehicle fleet. In comparison with the fuel-based SO_2 emission factor, the average SO_2 emission intensity from fuel ethanol refineries (1.3 g SO_2 kg^{-1} of ethanol) is higher. This shows that over the life cycle of ethanol fuel, more SO_2 is emitted from the fuel refinery process than from the fuel use. Two comments need to be attached to this finding. First, most fuel ethanol refineries have SO_2 emission intensities that are well below 0.1 g SO_2 kg^{-1} of ethanol; i.e., a limited number of high emitters including those plants that use coal as an energy source are responsible for most of the SO_2 emissions associated with fuel ethanol refining. Second, SO_2 emissions from highway vehicles (17 kt in 2011) are very small compared to emissions from power plants in the U.S. (4529 kt in 2011) (http://www.epa.gov/ttn/chief/trends/index.html), and therefore, fuel ethanol refining is still a small source nationally.

4.3.2. Nitrogen Oxides

Emission intensities for NO_x are indicated in the bottom left of Figure 6. Most fuel ethanol refineries have NO_x emission intensities between 0 and 0.4 g NO_x kg^{-1} of ethanol. The average, defined as total emissions divided by total production, is at the high end of this range (0.53 g NO_x kg^{-1} of ethanol) as a result of the presence of several high emitters, including the ADM plant in Decatur, that use coal as an energy source.

Fleet-averaged, fuel-based emission factors for NO_x from gasoline vehicles have been determined using tunnel and roadside measurements [*Bishop and Stedman*, 2008; *Bishop et al.*, 2012; *McDonald et al.*, 2012]. From a tunnel study in 2010, an average NO_x emission of 3.5 ± 1.5 g NO_x kg^{-1} of gasoline was determined for gasoline vehicles using mostly E10. This number is 4–10 times higher than the average NO_x emission intensity from fuel ethanol refineries, which shows that the NO_x released from fuel ethanol refining is a smaller but nonnegligible source of NO_x emissions over the life cycle of this fuel.

4.3.3. Volatile Organic Compounds and Ethanol

Emission intensities for VOCs and ethanol are shown in the right of Figure 6. The blue lines indicate the average emission intensities for VOCs (0.42 g VOCs kg^{-1} of ethanol) and for ethanol (0.16 g ethanol kg^{-1} of ethanol). For VOCs, the distribution is relatively narrow with the emission intensities from most plants below 0.6 g VOC kg^{-1} of ethanol. For ethanol, the distribution has a tail toward small emission intensities. Most of the NEI point sources with the lowest ethanol emission intensities did not report ethanol emissions from ethanol/methanol production directly, in contrast to those sources with an ethanol emission intensity greater than 0.01 g ethanol kg^{-1} of ethanol. Several had ethanol emissions assigned only to grain handling and drying, which has a low ethanol/VOC partitioning profile. Several others were assigned VOC profiles for beer production, which also has a small ethanol/VOC ratio within the NEI. It thus seems likely that remaining disparities in the RFA ethanol production database and the emission database are responsible for the long tail toward very low values. Unlike for SO_2 and NO_x, plants that use coal do not appear to have systematically higher emission intensities for VOCs and ethanol than plants that use natural gas. The ADM plant in Decatur has relatively high emission intensities for VOCs and ethanol; it is possible that other production processes than fuel ethanol refining contribute significantly to the total emissions, although for ethanol itself, this may be less likely.

Emissions of VOCs from gasoline vehicles were quantified in detail in a 2010 tunnel study [*Gentner et al.*, 2013]. The emissions of all VOCs that were quantified, including hydrocarbons and oxygenated species, added up to 0.93 g VOC kg^{-1} of gasoline (from 0.68 g L^{-1} using an E10 density of 0.735 kg L^{-1}). Emissions of ethanol in that study were 0.068 g VOC kg^{-1} of gasoline (from 0.026 g C L^{-1} using the same E10 density and after conversion from carbon into ethanol mass). For total VOCs, this fuel-based emission factor is at the high end of emission intensities for VOCs in Figure 6. For ethanol itself, this fuel-based emission factor is lower than most emission intensities from ethanol refineries in Figure 6. These comparisons indicate that fuel ethanol refining could be a significant source of VOCs and, in particular, ethanol compared to vehicle emissions.

In section 4.1, it was shown that VOC and ethanol emissions from the point sources in Decatur exceeded the NEI-2011 emissions by factors of 5 for total VOCs to 30 for ethanol. It is not exactly known to what extent the emissions from the ADM plant contribute to these underestimates. It is likely that the ADM plant plays a significant role in the underestimate of ethanol emissions, since it is the only and a large producer of ethanol in the area. In addition, since ethanol represents a large fraction of total VOC emissions (Figure 4 and Table S1 in the supporting information), it is also likely that the underestimate in total VOC can be attributed significantly to the ADM plant. If emissions of VOCs and ethanol from fuel ethanol refineries are underestimated in general, then the VOC and ethanol emissions due to fuel ethanol refining could actually be higher than those from the fuel use. To illustrate this point, the VOC and ethanol emissions observed downwind from Decatur were divided by the ethanol production from the ADM plant and added to Figure 6.

The suggested emission intensities are well outside the distributions for fuel ethanol refineries calculated from the NEI-2011 and more than an order of magnitude higher than the emission factors from vehicles.

5. Conclusions

Over the past decade, the use of fuel ethanol produced from corn has increased significantly in the United States, and the volume of fuel ethanol is now approximately 10% of the volume of gasoline used. This ethanol is produced in over 200 fuel ethanol refineries in the country, particularly in several of the corn-producing states in the Midwest. In this work, we made atmospheric measurements downwind from Decatur, Illinois, where the third largest fuel ethanol refinery in the U.S. is located. Emissions of SO_2 and NO_x were in agreement with those reported in the 2011 National Emissions Inventory (NEI-2011). However, emissions of VOCs and ethanol were a factor of 5 for VOCs and 30 for ethanol higher than those included in the NEI-2011. Emissions from all fuel ethanol refineries in the U.S. were analyzed by combining emissions from the NEI-2011 with the ethanol production numbers from the Renewable Fuels Association. It is shown that fuel ethanol refining is a smaller source of NO_x and a larger source of SO_2 compared with the emissions from the use of fuel ethanol in motor vehicles. Emissions of VOCs from ethanol refining are similar to those from the use of ethanol in motor vehicles and could be much higher if the underestimates in emissions for the fuel ethanol refinery studied here extend to other refineries.

Acknowledgments
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Mini Review

Distillery Wastewater: it's Impact on Environment and Remedies

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Abstract

Distillery wastewater and its toxicity is a serious concern worldwide. Unfortunately, if discharged into the environment without proper treatment, it causes serious environmental problems and health hazards in human and animals. Due to very high chemical oxygen demand (COD), biological oxygen demand (BOD), it causes inhibition of seed germination and depletion of vegetation by reducing the soil alkalinity and manganese availability in agricultural land whereas in aquatic environments, it reduces sunlight penetration and decreases photosynthetic activity and dissolved oxygen content damaging the aquatic fauna and flora both. Various physico-chemical and biological approaches employing membranes, coagulant, bacteria, fungi, microalgae etc. used for the treatment of distillery wastewater.

Keywords: Distillery wastewater; Toxicity; Health problem; Treatment

Distillery Wastewater and Its Toxicity

Distillery wastewater causes serious concern to living organisms resulting in a greater environmental stress. There are >325 distilleries in India, producing approximately 3 billion liters of alcohol and 45 billion liters of spent wash annually [1] Distillery units are generating huge amount of wastewater during the alcohol production process, which an average of 10-15L of wastewater is released with the production of 1L of alcohol [2,3] In distillery wastewater, the presence of many types of organic and inorganic pollutants such as melanoidin, polysaccharides, reduced sugar, proteins, waxes, N, K, Ca, SO_4-, PO_4- etc. are reported by various researchers [4,5].

Melanoidins are one of the major pollutants causing serious environmental and health problems [6]. Distillery wastewater contains various types of recalcitrant organic pollutants including endocrine disrupting chemicals like phthalates are reported and it causes the hormonal imbalance and disturb the reproductive fitness of living organism and ultimately leading to the carcinogenesis [7-9]. Melanoidin is formed by the reaction between amino acid and carbohydrate called "Maillard reactions" [10,11]. Melanoidins are dark brown to black coloured recalcitrant compounds of sugar and amino acids, which are produced during the processing of sugar cane juice in sugar industries and molasses in fermentation industries [5].

Distillery wastewater mainly affects soil and aquatic region due to the presence of water-soluble recalcitrant colouring organic and inorganic compounds [4]. In aquatic region, distillery wastewater can block out sunlight from rivers and streams, thus reducing oxygenation of the water by photosynthesis and hence, become detrimental to aquatic life. Secondly, it has a high pollution load, which would result in eutrophication of contaminated water sources [2] (Figure 1).

Distillery wastewater also causes soil pollution and acidification in the cases of inappropriate land discharge [2]. It is reported to inhibit seed germination, reduce soil alkalinity, cause soil manganese deficiency, and damage agricultural crops [2]. It also affects the farm animals. They drink it and resulted in increased livestock mortality, poor health, and reduced milk yield. Even the human beings lived in distillery wastewater polluted area is affected by skin allergies, headache, vomiting sensation, irritating eyes, fever, and stomach pain [12]. It is analyzed that distillery wastewater, highly polluted and having very high COD and BOD, and dark brown reddish colour. Some of the contaminants, such as certain level of minerals or compounds are not only harmful to health, but also create a long term effects such as cytototoxic and genotoxic effect [4].

There are several different methods for treatment of distillery wastewater such as:

Coagulation

Reduction of repulsive forces through addition of coagulant, there are many coagulant used in distillery wastewater treatment such as aluminium sulfate ($AlSO_4$), ferric chloride ($FeCl_3$), ferrous sulfate ($FeSO_4$), alum, iron aluminum; calcium salts, polyaluminium chloride (PACl) etc. [13,14].

Flocculation

Physical process by which particle contact and agglomeration occurs.

Ion exchange

To separate ionized molecules (organic as well as inorganic) from aqueous solution as well as contaminants in organic streams.

Membrane technology

The effluent collected from the distillery industry is highly alkaline with pH range of around 8.5. Hence, it is neutralized using sodium hydroxide. The neutralized solution has a lot of suspended solids, so the filtration is carried out to remove the suspended solids with fine-pore thin cloth or by using some membranes [15,16].

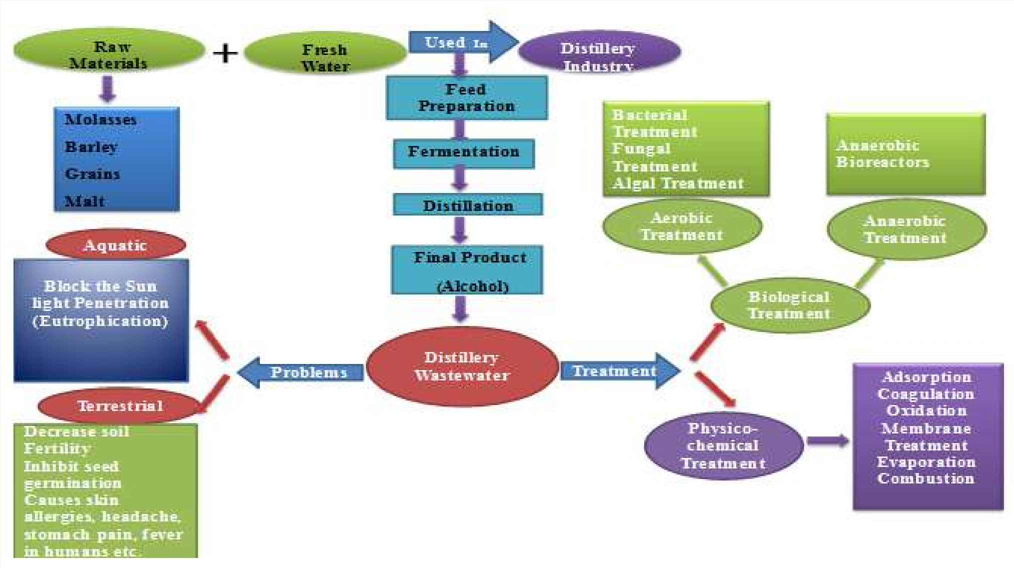

Figure 1: Schematic representation of alcohol production and its impact on environment.

Biological Approaches of Treating Distillery Wastewater

Anaerobic treatment processes have higher nutrient requirements and cause operational difficulties in treating high organic strength wastewaters. These methods in primary treatment of still age would result in lower cost-efficiency and eco-friendly in nature [17]. A mesophilic two-stage system consisting of an anaerobic filter (AF) and an UASB reactor was found suitable for anaerobic digestion of distillery wastewater [2,3]. Aerobic treatment stage still has high organic loading and is high dark brown in colour, hence it is generally followed by a secondary, aerobic treatment.

Bacterial treatment has been reported frequently in past and recent years. Bacterial degradation/decolourization of industrial wastes is an eco-friendly and cost effective alternative to chemical decomposition process of wastes minimization [1]. Fungal treatment which are used in the treatment of distillery wastewater such as basidiomycetes and ascomycetes as well as used in the decolourization of natural and synthetic melanoidins in connection with colour reduction of wastewater from distilleries. Fungal treatment is use to purify the wastewater by consumption of organic compound, thus, reducing its COD and BOD, and at the same time to obtain some valuable products, such as fungal biomass for protein rich animal feed or some specific fungal metabolites [2,18].

Algal treatment attracts researchers not only by treating but also by its products/byproducts, which are in demands for social welfare. Microalgae have the ability to take up its nutrients (majority inorganic compounds) requirement from biomethanated spent wash and energy requirement from the sun [19]. Constructed wetland (CW) is an artificial wetland created for the purpose of treating anthropogenic discharge such as municipal or industrial wastewater, or storm water runoff [20]. It may also be created for land reclamation after mining, refineries, or other ecological disturbances such as required mitigation for natural areas lost to land development [21]. Constructed wetlands are engineered systems that use natural functions of vegetation, soil, and organisms to treat different water streams [4].

Biocomposting is an aerobic, thermophilic process resulting in a product rich in humus, which is thus used as a fertilizer (Torres-Climent et al. 2015). In this process, press mud generated from sugar mills is utilized to produce compost by mixing distillery wastewater. Both anaerobic and aerobic composting systems are practiced. There are several enzymes (e.g., Peroxidases, Oxidoreductases, Cellulolytic enzymes, Cyanidase, Proteases, Amylases, etc.) reported from different sources to play an important role in waste treatment process [22,23].

There are many problems facing by distillery industries, which are described below:

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a) Distillery industry release 91-93% as wastewater causes serve environmental problems.

b) Lack of advance processing techniques and waste treatment technologies in developing countries.

c) Total dissolved solid (TDS) value of distillery wastewater is more problematic.

Thus there is an urgent need to adequate treatment of distillery wastewater and also social awareness for sustainable development.

Conclusion

Environmental sustainability with rapid industrialization is one of the major challenges of the current scenario worldwide. This review article concluded that distillery industries use in huge amount of water, various types of chemicals and raw materials in the production of alcohol, which generate high strength of wastewater. Due to very high BOD and COD, this wastewater is considered as an environmental hazard. Thus, there is an urgent need to address the limitations in the existing methods and to develop integrated treatment processes that provide a complete solution to the treatment of distillery wastewater.

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ANNEXURE A-7

Trace Element Chemistry of Fly Ashes from Co-combusted Petroleum Coke and Coal

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KEYWORDS: petroleum coke, coal, fly ash, trace elements

ABSTRACT

Because of economics, petroleum coke sometimes replaces or supplements coal as a fuel in power plant combustors. Fly ashes were recovered from the combustion of petroleum coke with moderate- to high-sulfur Illinois Basin bituminous coal in a western Kentucky power plant. The fly ashes primarily consist of glass, quartz, mullite and spinels. When compared with ordinary fly ashes from Illinois Basin coals, the petroleum coke-coal fly ashes are relatively enriched in nickel, vanadium, and other metals. Associations between trace elements and compounds within the ashes were identified through the use of distilled, deionized water batch leaching, magnetic separations, and other laboratory techniques.

INTRODUCTION

Petroleum coke is a byproduct of heavy oil refining (Wang *et al.*, 2004, p. 1341). Because it is a high-carbon fuel that is often cheaper than coal, petroleum coke use in power plants has increased in recent years. According to a 2002 survey, petroleum coke represents more than 10% of the fuel in some Kentucky power plants (Hower *et al.*, 2005). At the same time, there are environmental issues associated with the utilization of petroleum coke. For example, the combustion of petroleum coke may release high emissions of SO_2, CO_2 and NO_x (Wang *et al.*, 2004, p. 1341). Additionally, its combustion byproducts are usually enriched in vanadium, nickel, and other potentially harmful metals (Hower *et al.*, 2005).

Although there are environmental and health concerns associated with nickel and vanadium, vanadium and nickel compounds are usually not as toxic to humans as mercury, cadmium, lead, or other “heavy metals.” Specifically, vanadium and nickel are not included on the list of National Primary Drinking Water Standards (40 Code of Federal Regulations [CFR] 141.62) or monitored with the Toxicity Characteristic Leaching Procedure (TCLP) (40 CFR 261.30).

Most health problems related to nickel deal with skin and respiratory exposure. If nickel compounds come into contact with human skin, they may cause severe dermatitis

(Nielsen, 1977, p. 134). Inhalation of nickel carbonyl, nickel subsulfide, and nickel oxide may cause cancer (Nielsen, 1977, p. 136), although these compounds may not occur in oil and petroleum coke combustion byproducts. Although the oral toxicity of most nickel compounds is low, their ingestion may cause some gastrointestinal irritation (Nielsen, 1977, p. 129).

The most common health problems associated with vanadium exposure result from inhalation (Waters, 1977, p. 148, 160). Air emissions and ashes from petroleum coke or oil combustion facilities may cause respiratory problems in humans, especially if V_2O_5 is present (Ress *et al*., 2003; Waters, 1977, p. 149). Common symptoms from respiratory exposure to vanadium include coughing, bronchitis, and eyes, nose and throat irritation (Waters, 1977, p. 160-161).

ASH PRODUCTION

Fly ashes were collected from electrostatic precipitator (ESP) hoppers at a 444 megawatt power plant in western Kentucky (Hower *et al.*, 2005). The pulverized fuel that produced the ashes consisted of at least 58 volume percent (v%) petroleum coke from an unknown source blended with moderate- to high-sulfur Illinois Basin bituminous coal from western Kentucky (Hower *et al.*, 2005). The coal-petroleum coke feed had a moderate ash content of 10.68% and a high concentration of sulfur (3.88%) (Hower *et al.*, 2005). The coal-coke blend also contained 520 ppm of vanadium and 82 ppm of nickel (Hower *et al.*, 2005). The compositions of the coal and petroleum coke prior to blending are unknown.

Hower *et al.* (2005) discusses the chemistry and "mineralogy" of different size fractions of the ashes. In my study, the nickel, vanadium, and major element chemistry of two of the fly ashes (identification numbers: 93067 and 93068) were characterized in detail. Fly ash 93067 was collected in ESP Row 1 and Bin 1E, whereas fly ash 93068 was from Row 2 and Bin 5E. Because flue gases pass first through the ESPs in Row 1 and then proceed on to the second row, first row fly ash 93067 is expected to have more ash with coarser particles than sample 93068 (Hower *et al.*, 2005).

ASH CHEMISTRY

The ash contents of the two bulk (as received) fly ashes were measured with ASTM Method D3174-97, which involves heating the samples to 750°C. Afterwards, the major, minor and trace element chemistry of the uncombusted residues were determined with a Philips PW2404 X-ray fluorescence (XRF) spectrometer using ASTM Method D4326-97. The XRF and ash results are listed in Tables 1-2. Analysis #1 is from Hower *et al.* (2005). Two sets of duplicate ash and XRF analyses were performed and are listed in Tables 1-2 along with averages and 2σ standard deviations. Overall, the major element analyses for each ash are reasonably consistent (Table 1).

However, the standard deviations of many of the trace elements are rather high (Table 2).

Table 1: Major element chemistry of fly ashes 93067 and 93068 after ashing to remove moisture and organic residues.

Fly ash 93067

Wt% Oxide	Analysis #1	Analysis #2	Analysis #3	Mean	Std. Dev. (2σ)
SiO_2	43.31	46.07	44.38	44.59	2.78
Al_2O_3	20.16	20.86	20.83	20.62	0.79
Fe_2O_3	21.20	20.22	20.38	20.60	1.05
CaO	2.50	2.55	2.60	2.55	0.10
MgO	0.88	0.85	0.97	0.90	0.12
K_2O	2.54	2.57	2.52	2.54	0.05
Na_2O	0.24	0.22	0.25	0.24	0.03
P_2O_5	0.20	0.20	0.20	0.20	<0.01
TiO_2	1.08	1.18	1.34	1.20	0.26
SO_3	1.83	1.77	2.25	1.95	0.52
Ash	64.13	64.01	64.44	64.19	0.44

Fly ash 93068.

Wt% Oxide	Analysis #1	Analysis #2	Analysis #3	Mean	Std. Dev. (2σ)
SiO_2	43.31	45.04	45.03	44.46	1.99
Al_2O_3	20.29	20.65	21.12	20.69	0.83
Fe_2O_3	21.17	20.11	20.48	20.59	1.08
CaO	2.56	2.58	2.62	2.59	0.06
MgO	0.91	0.84	0.98	0.91	0.14
K_2O	2.51	2.54	2.52	2.52	0.03
Na_2O	0.25	0.20	0.24	0.23	0.05
P_2O_5	0.20	0.21	0.21	0.21	0.01
TiO_2	1.07	1.15	1.34	1.19	0.28
SO_3	1.79	1.97	2.30	2.02	0.52
Ash	60.44	60.61	60.70	60.58	0.26

Table 2: Minor and trace element chemistry of fly ashes 93067 and 93068 after ashing to remove moisture and organic residues.

Fly ash 93067

Element, ppm	Analysis #1	Analysis #2	Analysis #3	Mean	Std. Dev. (2σ)
Ni	1006	1263	1182	1150	263
V	6558	7893	7606	7352	1405
As	158	65	73	99	103
Ba	723	1329	972	1008	609
Cr	85	635	1079	600	996
Co	69	62	72	68	10
Cu	95	64	80	80	31
Pb	72	54	52	60	23
Mn	429	673	512	538	248
Hg	0.006	---	---	0.006	---
Mo	53	54	33	47	24
Sr	379	396	381	385	19
Zn	237	312	319	289	91

Fly ash 93068

Element, ppm	Analysis #1	Analysis #2	Analysis #3	Mean	Std. Dev. (2σ)
Ni	976	1268	1171	1138	297
V	6585	7808	7627	7340	1320
As	170	80	86	112	101
Ba	766	1323	1003	1031	559
Cr	68	631	1087	595	1021
Co	69	62	72	68	10
Cu	96	67	70	78	32
Pb	79	56	55	63	27
Mn	384	671	518	524	287
Hg	0.006	---	---	0.006	---
Mo	56	36	54	49	22
Sr	377	394	403	391	26
Zn	243	330	317	297	94

Besides fuel chemistry and combustion conditions, the inorganic chemistry of fly ashes is dependent on several other factors, including: the surface area of the ash, flue gas temperature, and the type and amount of carbon in the fly ash (Hower *et al.*, 2005). Overall, the average chemistries of the two ashes are nearly identical (Tables 1-2). Their major element chemistry is consistent with $SiO_2+Al_2O_3+Fe_2O_3 \geq 70\%$ "Class F" fly ashes, which typically result from the combustion of eastern US bituminous coals (ASTM Method C618). The ash contents of the ashes are only 64.19% and 60.58% (Table 1), where carbon dominates the combustible fraction (Hower *et al.*, 2005). Because these and other ashes produced from petroleum coke are relatively rich in carbon (Hower *et al*., 2005), they are usually unsuitable for cement and concrete utilization.

Nickel and vanadium concentrations in Kentucky coal fly ashes (without the addition of petroleum coke, tires or other fuels) rarely exceed 1000 ppm (Hower *et al.*, 2005). As shown in Table 2, petroleum coke has clearly enriched the 93067 and 93068 fly ashes with vanadium and nickel.

ASH "MINERALOGY"

Powder X-ray diffraction (XRD) analyses were performed on the fly ashes with a Philips diffractometer. The XRD scans detected amorphous materials (including glass), quartz, mullite, spinels ("magnetite"), and hematite. Additionally, distilled and deionized (D&D) water leachates of the ashes (see below) are commonly saturated with gypsum ($CaSO_4 \bullet 2H_2O$), which suggests the presence of anhydrite ($CaSO_4$) and/or other calcium sulfates in the ashes.

BATCH LEACHING TESTS

Batch leaching tests are laboratory procedures that provide some estimations of the types and concentrations of potentially toxic contaminants that might be released from a solid combustion byproduct if it comes into contact with groundwater or surface water. The most common batch leaching test in the United States is the U.S. Environmental Protection Agency's Toxicity Characteristic Leaching Procedure (TCLP), which is used to determine toxic hazardousness (40 CFR 261, Appendix II). Because the TCLP uses sodium acetate or acetic acid to simulate leaching conditions in municipal landfills, the test has been widely criticized as inappropriate for evaluating the leaching properties of ashes and other combustion byproducts that would never be codisposed with municipal waste. As an alternative, Kosson *et al*. (2002) present a protocol that is more appropriate for evaluating the leaching properties of fly ashes.

D&D Batch Leaching Tests

Samples of fly ashes 93067 and 93068 were leached with D&D water. The leaching procedure consisted of placing a known mass of ash (Table 3) into a borosilicate glass jar and then filling the jar with a known mass of D&D water (Table 3). The liquid-to-solid (L/S) ratios of the batch leachates varied from 1.71 to 10.4 to simulate relatively wet or dry leaching conditions. The jars were then sealed with Teflon®-lined lids.

Table 3: Batch leaching results (mg/L) on bulk (as received) fly ashes 93067 and 93068.

Fly ash 93067

Leaching Solution	D&D water	D&D water	0.1% HCl	0.1% HCl Blank
g of ash	200.1	40.0	40.2	0
g of liquid	349.4	415.5	421.6	----
Liquid/solid (L/S)	1.75	10.4	10.5	0
Post-filter pH	9.21	9.13	3.82	1.86
Al	9.88	8.90	96.2	0.67
Ca	689	351	602	0.80
Chloride	0.39	---	---	---
Fe	0.52	0.10	3.70	0.11
Fluoride	2.57	---	---	---
K	138	32.5	35.3	0.17
Mg	63.5	6.13	15.6	0.07
Na	105	17.3	19.5	0.02
Sulfate	1870	---	---	---
Zn	0.07	0.01	1.85	<0.01
Ni	<0.01	<0.01	6.74	<0.01
V	8.80	16.8	1.62	0.06

Fly ash 93068.

Leaching Solution	D&D water	D&D water	0.1% HCl	0.1% HCl Blank
g of ash	200.1	40.0	40.0	0
g of liquid	342.5	406.3	431.5	----
Liquid/solid	1.71	10.2	10.8	0
Post-filter pH	9.07	8.97	3.74	1.84
Al	9.15	6.10	110	0.90
Ca	689	376	564	0.84
Chloride	0.34	---	---	---
Fe	0.47	0.07	7.70	0.15
Fluoride	2.91	---	---	---
K	154	31.7	36.8	0.14
Mg	67.5	7.16	15.2	0.09
Na	109	18.6	19.4	0.01
Sulfate	2020	---	---	---
Zn	0.07	0.05	2.11	<0.01
Ni	<0.01	<0.01	7.23	<0.01
V	7.80	14.0	1.38	0.07

The D&D leachates were tumbled on a TCLP end-over-end stirrer for 48 hours. Afterwards, the mixtures were filtered at 0.45 microns. The pH values of the filtrates were determined with a ThermoOrion model 410+ meter using Fisher pH 4, 7 and 10 buffers. For anion analyses, aliquots of the filtrates were refrigerated at zero headspace and analyzed within 48 hours. The remaining filtrates were preserved with 1-2% ultrapure nitric acid, refrigerated, and analyzed for metals.

University of Kentucky Center for Applied Energy Research (CAER) personnel performed the anion and metal analyses on the batch leachates. The metals were analyzed with a PlasmaQuad 3 Inductively Coupled Argon Plasma Mass Spectrometer (ICPMS) using EPA Method 200.8 (US EPA, 1994) and a Spectrometrics Inc. Inductively Coupled Argon Plasma-Atomic Absorption Spectrometer (ICP-AA) using EPA Method 200.7 (US EPA, 1994). Chloride, fluoride, and sulfate concentrations were measured on a Dionex LC-20 ion chromatograph using EPA Method 300.0 (US EPA, 1993).

As shown in Table 3, the D&D leachates are moderately alkaline. The concentrations of aluminum, iron, and other species in the D&D leachates (Table 3) are consistent with alkaline conditions. That is, iron, nickel, and zinc are essentially insoluble (Drever, 1997, chapter 9). Because aluminum is amphoteric, it is probably more soluble at pH 9 than under neutral conditions (Faure, 1998, p. 192). The computer model MINTEQ (HydroGeoLogic, Inc. and Allison Geoscience Consultants, Inc., 1999) indicates that the L/S = 1.75 and 1.71 leachates are saturated with gypsum. The concentrations of magnesium, sodium, and potassium become significantly diluted at L/S = 10. When the magnesium, potassium and sodium concentrations of the D&D leachates are compared with XRF data in Table 1 that have been corrected for ashing with ASTM Method D 3174-97, D&D leaching dissolves about 16-18% of the sodium, 1-3% of the magnesium and only about 2-3% of the potassium in the ashes. The majority of these alkalis may be encapsulated in essentially water-insoluble silicate glass. Magnesium concentrations may also be controlled by hydroxide and carbonate precipitation.

Although the D&D leachates contain up to 17 ppm vanadium, comparisons with the vanadium concentrations in the ashes (Table 2) indicate that only about 0.3% of the vanadium is water soluble in the L/S= 1.7 leachates and about 3% in the L/S =10 leachates. Unlike most other elements, vanadium concentrations in the D&D water leachates are higher in the more dilute L/S = 10 samples. MINTEQ calculations suggest that the water-soluble vanadium exists as $V(OH)_3^+$, $H_2V_2O_4^{2+}$, and perhaps $VOOHCO_3^-$. However, MINTEQ provides no insight on why the vanadium concentrations are higher in the L/S = 10 leachates.

HCl Batch Leaching Tests

Batch leaching tests using 0.1% HCl were performed on various components of the 93067 and 93068 fly ashes. The 93067 samples used a 0.1% HCl solution with a pH of 1.86, whereas the 0.1% HCl leaching solution for the 93068 specimens had a pH of 1.84 (Table 4). Except for the addition of acid, the HCl leaching experiments used the same procedures as the D&D leaching tests. The L/S ratios of all of the HCl batch leachates ranged from 10 to 11 (Tables 3-4), which allowed for comparisons with the L/S = 10 D&D water leachates (Table 3). The HCl-leached samples included bulk ashes (Tables 3 and 4), air dried residues from the L/S=1.7 D&D batch leaching tests (Table 4), and ashes that had been water-washed with most of their magnetic materials removed (Table 4; also see discussions on magnetic separation below). Duplicate HCl leaching tests were performed on the water-washed ashes (Table 4).

The water-washed and magnetically depleted water-washed samples were air dried at room temperature for at least four weeks prior to HCl batch leaching. Water washing and air drying, no doubt, resulted in the oxidation and hydration of some components in the ashes. In particular, any anhydrite might have been hydrated and spinels may have been oxidized. Some carbonates may also have formed through reactions with carbon dioxide in the air.

The pH values of the HCl leachates indicate that the fly ashes were unable to neutralize all of the acidity (Tables 3-4). As expected, the presence of HCl in L/S= 10 bulk ash leachates substantially increased the solubility of most metals, including: nickel (9-10% of the metal dissolved from the bulk ash), zinc (10-11%) and iron (0.04-0.10%) (Table

3). Acidic conditions would also hinder the precipitation of any calcium or magnesium as hydroxides or carbonates, which explain the increases in calcium and magnesium concentrations. In contrast, lower pH conditions had little affect on the solubility of potassium and sodium probably because of the inability of hydrochloric acid to substantially break down silicate glasses and release the remaining alkalis. Unlike other elements, vanadium concentrations dramatically decreased in the presence of HCl (Table 3). MINTEQ calculations were again unable to explain this behavior.

Table 4 compares the HCl leaching results for the bulk, water-washed, and water-washed/magnetically depleted ashes. For both fly ashes, the duplicate leaching results on the water-washed samples are generally very consistent with the originals. A comparison between the bulk and water-washed HCl leachates shows that the water-washed samples generally have less sodium and potassium. This trend is explained by the significant removal of alkalis through water-washing. Calcium and magnesium concentrations were only slightly affected by water-washing, which may be due to the presence of only partially water-soluble salts (such as calcium sulfates or magnesium carbonates) in the ashes. Comparisons between the bulk and water-washed HCl leachates also indicate that water-washing had no appreciable effect on the aluminum, nickel, and zinc concentrations of the leachates. Like the leaching results in Table 3, the leaching properties of vanadium in the samples of Table 4 are not easily explained.

Table 4: HCl (0.1%) batch leaching results (mg/L) on different fly ash components.

Fly ash 93067

Ash type	Bulk	Water washed (Duplicate leachate)	Water washed and magnetically depleted	Acid Blank
g of ash	40.2	41.9 (42.4)	40.8	0
g of liquid	421.6	416.3 (424.1)	420.8	----
Liquid/solid	10.5	9.94 (10.0)	10.3	0
pH	3.82	3.78 (3.77)	3.39	1.86
Al	96.2	101 (100)	558	0.67
Ca	602	554 (566)	554	0.80
Fe	3.70	1.88 (1.96)	7.88	0.11
K	35.3	14.9 (14.9)	5.86	0.17
Mg	15.6	12.3 (12.9)	9.74	0.07
Na	19.5	6.44 (6.28)	12.3	0.02
Zn	1.85	1.85 (1.86)	2.63	<0.01
Ni	6.74	7.06 (5.93)	5.26	<0.01
V	1.62	6.48 (6.25)	4.83	0.06

Fly ash 93068

Ash type	Bulk	Water washed (plus Duplicate)	Water washed and magnetically depleted	Acid Blank
g of ash	40.0	40.0 (40.0)	37.0	0
g of liquid	431.5	415.1 (414.2)	403.9	---
Liquid/solid	10.8	10.4 (10.4)	10.9	0
pH	3.74	3.63 (3.66)	3.15	1.84
Al	110	113 (107)	13.1	0.9
Ca	564	548 (539)	173	0.84
Fe	7.70	3.05 (2.74)	13.1	0.15
K	36.8	19.1 (11.7)	5.72	0.14
Mg	15.2	12.8 (10.9)	10.9	0.09
Na	19.4	9.00 (5.09)	1.19	0.01
Zn	2.11	2.03 (2.04)	2.27	<0.01
Ni	7.23	6.66 (6.04)	5.89	<0.01
V	1.38	4.81 (4.70)	7.00	0.07

For unknown reasons, the HCl leachates of the water-washed/magnetically depleted 93067 and 93068 samples show large discrepancies, especially in their aluminum and calcium concentrations (Table 4). These discrepancies may be due to differences in how thoroughly 93067 and 93068 were water washed. Furthermore, variations in humidity, room temperature, the particle sizes of the drying ashes, and other conditions during air drying could profoundly affect the formation of carbonates, oxides, hydrates, and other species, which would influence the leaching properties of the ashes.

MAGNETIC SEPARATIONS

Magnetic separations were utilized to determine whether nickel and vanadium are preferentially associated with magnetic spinels or the non-magnetic portions of the ashes. Runs with an Eriez magnetic separator suggested that bulk sample 93067 contains about 5 wt% magnetic spinel. However, even after several runs through the separator, the separation was not very effective because the “non-magnetic” portion of the ash still contained large amounts of magnetic materials that could be easily recovered with a magnetic stir bar.

Effective recovery of the magnetic materials was finally achieved by using Teflon®-coated magnetic stir bars. Each stir bar agitated 10.2-12.7 grams (Table 5) of fly ash in about 1.5 liters of distilled and deionized water for several days. Periodically, the stir bars were removed. Loose material on the bars was rinsed back into the suspension, whereas the firmly bonded material was collected onto a preweighed filter. After several days, very little magnetic material was recovered. The recovered magnetic materials were air dried over several days. In some cases, the air dried magnetic samples were placed overnight in an oven at about 110°C. As shown in Table 5, oven drying did not significantly lower the mass of the air dried materials. The separations indicate that both ashes contain about 8 wt% magnetic materials (Table 5).

Table 5: Weight percentages of magnetic materials in fly ashes 93067 and 93068.

Fly ash #	g of ash	g of magnetic material extracted	Wt% magnetic material
93067			
	10.5089	0.7886	7.50
	10.1697	0.8036	7.90
	10.1691	0.8487	8.35 (8.34*)
		Average (air dried only)	7.92
		Std. dev. 2σ	0.84
93068			
	10.9377	0.9098	8.32 (8.31*)
	12.7157	1.0898	8.57 (8.55*)
	10.5254	0.8705	8.27 (8.26*)
		Average (air dried only)	8.39
		Std. dev. 2σ	0.32

*Masses after oven drying at about 110°C.

The magnetic and magnetically depleted materials for both ashes were analyzed by XRF and XRD. Table 6 shows the XRF results for the samples. For comparisons, the average results for the ashed bulk samples (Tables 1 and 2) are also listed. XRD analyses detected no spinels or other magnetic materials in the magnetically depleted samples. Although XRD analyses of the magnetic materials only detected spinel and hematite and not any non-magnetic impurities, some quartz grains and glass cenospheres were visible in the samples under a microscope and XRF analyses of the separations still indicate that SiO_2 is present.

Nickel, zinc and vanadium are known to occur in spinels. For example, the general formula for vanadium spinels is ([Fe,Mg,Mn,Zn,Ni]V_2O_4). Ni^{2+} and Zn^{2+} are also known to substitute for Fe^{2+} in magnetite and other magnetic spinels. Nevertheless, the results in Tables 3-4 and 6 suggest that essentially all of the zinc within the bulk ashes is located in water-insoluble non-magnetic materials.

The XRF results in Table 6 show substantial SiO_2 in the magnetic samples. Because magnetite and other magnetic spinels typically lack silicon, the SiO_2 is probably located in glass surrounding some of the magnetite grains. The XRF data in Table 6 when corrected with the information from Table 5 indicate that no more than 3% of the nickel and 7% of the vanadium in the two ashes are associated with magnetic materials.

Table 6: Chemistry of ashed bulk, magnetic, and magnetically depleted portions of fly ashes 93067 and 93068.

Fly ash 93067

Wt% Oxide or ppm	Average Bulk (after ashing with ASTM Method D 3174-97)	Magnetic Component	Water washed and magnetically depleted
SiO_2	44.59	19.42	51.86
Al_2O_3	20.62	8.07	23.94
Fe_2O_3	20.60	61.91	13.39
CaO	2.55	1.16	1.70
MgO	0.90	0.49	0.92
K_2O	2.54	0.72	2.85
Na_2O	0.24	0.02	0.22
P_2O_5	0.20	0.12	0.23
TiO_2	1.20	0.59	1.30
SO_3	1.95	0.24	1.02
Ni	1150	390	1612
V	7352	6159	8188
Zn	289	<1	460

Fly ash 93068

Wt% Oxide or ppm	Average Bulk (after ashing with Method D 3174-97)	Magnetic Component	Water washed and magnetically depleted
SiO_2	44.46	21.59	50.11
Al_2O_3	20.69	8.77	23.06
Fe_2O_3	20.59	59.00	14.34
CaO	2.59	1.20	1.55
MgO	0.91	0.51	0.90
K_2O	2.52	0.83	2.79
Na_2O	0.23	0.02	0.20
P_2O_5	0.21	0.11	0.23
TiO_2	1.19	0.64	1.29
SO_3	2.02	0.23	1.00
Ni	1138	378	1656
V	7340	5635	8079
Zn	297	<1	496

CONCLUSIONS

Leaching studies and chemical analyses of bulk, magnetic, and magnetically depleted samples of two petroleum coke-bituminous coal fly ashes indicate that vanadium and nickel are largely associated with non-magnetic and water-insoluble materials. Therefore, magnetic extractions of these ashes for the economic recovery or environmental treatment of these metals would probably be ineffective. Currently no primary drinking water standards exist for nickel and vanadium. Nevertheless, batch studies indicate that significant leaching of nickel and vanadium is not expected.

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ANNEXURE A-8

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Original Research

Extraction and Leaching of Heavy Metals from Thermal Power Plant Fly Ash and Its Admixtures

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Abstract

The leachability of heavy metals from fly ash, bottom ash, dumping site ash, cement, and brick samples admixtured with fly ash in the area of a thermal power plant were compared. During these studies, extraction and leaching of various heavy metals like Zn, Ni, Cu, Fe, Pb, Mn, Mg, and Cd was carried out by applying batch leach test and toxicity characteristic leaching procedure (TCLP) to check the possibility of ground water contamination. The ground water samples in the vicinity of ash dumping sites were also analyzed for heavy metal concentrations and results obtained were compared with Indian and WHO permissible limits.

Mg, Mn, and Fe were leached to a larger Zn, Cu, and Pb to moderate, and Ni to a smaller extent, from the ash and admixtured samples. Cd was not leached at all from any sample in batch leach as well as TCLP tests. The concentrations of Zn, Fe, Mn, Mg, and Cd in groundwater samples were below the permissible limits of WHO and Indian standards. The concentrations of Ni and Pb were slightly higher than WHO permissible limits but below the Indian standards. The concentration of Cu was within the WHO permissible limits but slightly higher than Indian Standards. The admixturing of thermal power plant fly ash in cement and bricks seems to be an eco-friendly practice as far as leaching of heavy metals in groundwater is concerned.

Keywords: heavy metals, fly ash, extraction, leaching and water contamination

Introduction

Coal occupies an important position in the Indian energy sector since India has vast reserves of thermal grade coal. Coal is the most abundant and widely spread fossil energy resource in the world [1]. Among the total power generated annually in India, about 70% is produced by thermal power plants. The majority of thermal power plants (about 84%) are running on coal with 70 billion tons of coal reserve, while the remaining 13% run on gas and 3% on oil [2]. About 112 million tons of fly ash is being generated annually in India by thermal power plants as a byproduct of coal combustion. Fly ash quality depends on coal type, coal particle fineness, percentage of ash in coal, combustion technique, air/fuel ratio, and boiler type [3].

In India, studies have been carried out toward management of fly ash disposal and utilization [4, 5]. Fly ash is utilized in cement and construction. However, the rate of production is greater than consumption. The unused fly ash is disposed into holding ponds, lagoons, landfills and slag heaps. Disposal of huge amounts of fly ash in landfills, and surface impoundments or its reuse in construction materials is of environmental concern [6].

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Coal contains significant quantities of various trace elements, and during combustion of coal, trace elements are enriched as a result of carbon loss as carbon dioxide and the trace elements are associated with the surface of the ash particles due to evaporation and condensation. The characteristics of the coal used and the type of the installation employed in generating the solid combustion wastes have a direct influence on chemical and mineralogical composition of fly ash [1].

The disposal of fly ash is considered a potential source of contamination due to the enrichment and surface association of trace elements in the ash particles [7]. The elements Mn, Ba, V, Co, Cr, Ni, Ln, Ga, Nd, As, Sb, Sn, Br, Zn, Se, Pb, Hg, and S in coal are volatile to a significant extent in the combustion process. However, the elements Mg, Na, K, Mo, Ce, Rb, Cs, and Nb appear to have smaller fractions volatilized during combustion, whereas Si, Fe, Ca, Sr, La, Sm, Eu, Tb, Py, Yb, Y, Se, Zr, Ta, Na, Ag, and Zn are either not volatilized or show only minor trends related to the geochemistry of mineral matter [8]. During transport, disposal, and storage phases, the residues from coal combustion are subjected to leaching effects of rain and part of the undesirable components in the ashes may pollute both ground and surface waters [1]. These solid residues (fly ash) can be leached in higher concentrations than drinking water standards and can cause contamination in drinking water sources. Fly ash contains trace amounts of toxic metals that may have negative effects on human health and on plants [9].

Disposal of fly ash in surface water sources disrupts aquatic life, whereas toxic metals leached contaminate underground water resources. Therefore, it is important to predict the leaching behavior of residues to prevent the environmental effects, especially for the aquatic environment when ash is in contact with water. The toxic elements leached from fly ash can contaminate soil, ground water and surface water. Therefore, effective water management plans are required for fly ash disposal [10, 11]. Although chemical composition of coal waste can give us an idea about the pollutants passing through water, in order to quantify these phenomena it is necessary to carry out leaching tests. Lau and Wong (2001) found that different elements have different leaching behaviors because of differences in elemental properties and pH of the solution and leaching time, which strongly influence leaching behavior [12]. Seferinoglu et al. (2003) reported that trace-element leaching from bottom ash is slower and often requires that the entire bulk matrix be dissolved [13].

Fly ash is an alumino-silicate glass consisting of the oxides of Si, Al, Fe, and Ca, with minor amounts of Mg, Na, K, Zn, and S, plus various trace elements. The concentration associated with the ash may be either adsorbed on the surface of a particle or incorporated into its matrix [14]. A mechanism that appears to be common for all ashes during their formation is the condensation of metal and metalloid vapours on refractory core materials. As the ash particles and gas stream exit from the combustion chamber and proceed up to the flue gas, this results in locally higher concentrations of many trace elements at the surface of ash particles and accounts for the generally higher concentration of these elements as particle size decreases [15]. The association between trace elements and major elements/minerals may be an important factor in determining the leachate composition of water in contact with ashes. It is recognized that the health hazards and environmental impacts from coal-fired thermal power stations result from the mobilization of toxic elements from ash. The large amount of ash that accumulates in thermal power plants, its possible reuse and the dispersion and mobilization of toxic elements from it requires greater attention [16]. Mobilization of various elements from the ash into the environment depends on climate, soils, indigenous vegetation and agricultural practices [17].

The aim of this study was to investigate the leaching behavior of fly ash disposed in the ash pond at Bhusawal Thermal Power Plant (M.S.) in India, and to investigate the potential influence from the ash disposal on ground water quality. In these studies, the leaching of heavy metals like Zn, Ni, Cu, Fe, Pb, Mn, Mg, and Cd from fly ash and its admixtures were investigated in order to predict potential environmental pollution [18].

Experimental Procedures

The main method of disposal of fly ash from the power plant throughout the world is mixing with water. The resultant slurry is transferred to an ash disposal pond. Samples of freshly generated fly ash have been collected from the electrostatic precipitators in the Bhusawal Thermal Power Plant. The other samples were collected from the surrounding area of the Thermal Power Plant. Five different types of samples were selected, like fine fly ash (FA-1), bottom ash (FA-2), cement sample (FA-3), brick sample (FA-4) and dumping site ash (FA-5). After sampling, the samples were stored in a polyethylene bottle and kept in a refrigerator (4ºC) until the leaching tests were performed and heavy metal analysis was carried out [19].

Sample Storage and Pretreatment for Leaching

Extraction was carried out by shaking the samples of ash with the extractant in polypropylene bottles. The extraction was carried out using ash samples in as-it-is form instead of dried samples, since according to Kosson et al. (2002) it is preferable to avoid sample drying before extraction in order to minimize possible chemical and/or microbiological changes in the ash during the extraction procedure [20]. After the extraction, the extracts were separated from the solid residue by filtration through a Whatmann No. 42 filter paper. Few drops of 1 N nitric acid were added to it, and extracts were stored in a refrigerator (4ºC) until the element determination. The element concentrations in the acid digested extracts, batch leach, and TCLP were determined using an atomic absorption spectrophotometer, AAS (Thermo Scientific, U.K. make, Solaar S series model).

Batch Leaching Tests

A series of batch leaching tests were conducted in the laboratory. In order to better simulate the natural conditions and susceptibility to release, a lower liquid-to-solid (L/S) ratio was used. Therefore, 5 g fly ash samples were mixed with 25 ml of deionized water, giving a liquid:solid ratio of 5. Triplicate extractions with the same weight of sample and same volume of extracting reagent were applied for one type of sample. A gentle stirring was continued during extraction (24 h) on a rotary shaker (Steelmate Novatech India, Tabletop model). Heavy metal analysis was carried out on AAS. The results were expressed as averages of triplicate analyses.

Toxicity Characteristic Leaching Procedure (TCLP)

The toxicity characteristic leaching procedure (TCLP) requires the use of an extraction fluid made of buffered acidic medium to run the test. For this the selection of the extraction fluid was made prior to conducting the test [21]. 1M sodium acetate buffer was used as an extraction liquid; pH was maintained at 4.99 as per United States Environmental Protection Agency (USEPA) procedure [22]. A 4 g fly ash sample was taken and then extraction fluid equal to 20 times the amount of sample taken was added to it. The system was tightly closed and then placed on the rotary shaker for 18 hours, rotating at 30±2 rpm at a room temperature of about 25ºC. Triplicate extractions were performed using the same weight of the sample and the same volume of the extracting reagent. Heavy metal analysis was carried out on AAS and the results are expressed as averages of results of triplicate estimations.

Extraction of Heavy Metals from Fly Ash

This short-term leaching study was carried out in the presence of strong acids to provide the available concentration levels of trace/heavy elements in the fly ash samples [21]. A direct acid digestion method was carried out for the determination of heavy metals. About 0.5 g of dry fly ash was roundly selected from composite samples and weighed. They were digested with 10 ml nitric acid and 5 ml perchloric acid. The digested material was filtered through Whatmann No. 42 filter paper and diluted to 100 ml with distilled water. Aliquots were taken for heavy metal determination [19]. Metals like Zn, Ni, Cu, Fe, Pb, Mn, Mg, and Cd were analyzed by AAS.

Heavy Metal Analysis in Water Samples

The water samples were collected from the surface as well as ground water sources in the vicinity of ash disposal sites and analyzed for heavy metal concentrations on AAS.

The results obtained were compared for the maximum permissible limit of various heavy metals in drinking water (IS: 10,500 and WHO limits).

Table 1. Heavy metal concentrations leached as a result of batch leach test (n=3).

Metal	FA-1	FA-2	FA-3	FA-4	FA-5
Zn	ND	ND	0.14	0.02	ND
Ni	ND	ND	ND	ND	ND
Cu	0.18	0.13	0.04	0.20	0.21
Fe	ND	ND	ND	0.02	0.13
Pb	0.18	ND	ND	0.30	ND
Mn	0.04	0.02	ND	ND	0.01
Mg	11.30	8.95	3.00	2.90	6.60
Cd	ND	ND	ND	ND	ND

Concentrations in mg/kg ash, ND – Not Detected, FA-1– fly ash, FA-2 – bottom ash, FA-3 – cement sample, FA-4 – brick sample, and FA-5 – dumping site ash.

Results

Leaching studies of heavy metals from fly ash are important in predicting the environmental impacts associated with the disposal of fly ash into ponds. In these studies, the leachability of heavy metals from fine fly ash, bottom ash, dumping site ash taken from the ash pond, cement sample and brick samples in the area of Bhusawal Power Plant were compared. During these studies, leaching behaviors of various heavy metals like Zn, Ni, Cu, Fe, Pb, Mn, Mg, and Cd from fly ash and its admixtures was studied.

Discussion of Results

Batch Leach Test

The concentrations of the heavy metals that were leached out with deionized water as a result of the batch leaching test are shown in Table 1. Ni and Cd did not leach from the fly ash samples. Mg and Cu show solubility with deionized water and leached in higher concentration in all samples of fly ash and its admixtures. The leached Cu con-

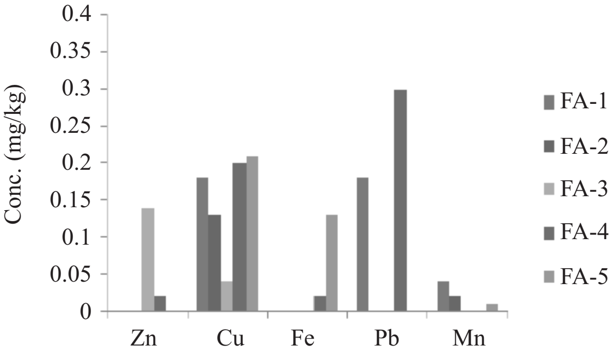

Fig. 1. Comparison of heavy metal concentrations leached as a result of batch leach test.

Table 2. Heavy metal concentrations leached as a result of TCLP test (n=3).

Metal	FA-1	FA-2	FA-3	FA-4	FA-5
Zn	1.45	1.93	2.43	1.28	0.58
Ni	0.33	0.53	2.18	1.05	0.43
Cu	7.75	5.25	11.75	23.25	8.75
Fe	1.95	2.23	2.33	2.03	1.15
Pb	0.88	ND	ND	1.48	ND
Mn	58.25	154.75	180.25	86.25	28.25
Mg	239.25	184.75	396.50	320.25	164.48
Cd	ND	ND	ND	ND	ND

Concentrations in mg/kg ash, ND – Not Detected, FA-1– fly ash, FA-2 – bottom ash, FA-3 – cement sample, FA-4 – brick sample, and FA-5 – dumping site ash.

Table 3. Heavy metal concentrations as a result of acid digestion (n=3).

Metal	FA-1	FA-2	FA-3	FA-4	FA-5
Zn	0.039	0.052	0.056	0.038	0.011
Ni	0.011	0.014	0.032	0.018	0.003
Cu	0.014	0.009	0.018	0.072	0.008
Fe	0.500	0.552	0.570	0.530	0.462
Pb	0.004	0.002	0.042	0.007	ND
Mn	0.066	0.257	0.263	0.121	0.051
Mg	0.262	0.202	0.544	0.481	0.183
Cd	0.004	ND	0.008	0.002	ND

Concentrations in %, ND – Not Detected, FA-1– fly ash, FA-2 – bottom ash, FA-3 – cement sample, FA-4 – brick sample, and FA-5 – dumping site ash.

centrations were low in comparison with Mg, this is probably because Cu is precipitated as their insoluble hydroxides. The Pb is leached out in only fly ash and brick samples to a similar extent, but below permissible limits. Mn is leached in fly ash samples but shows very low concentration. Zn did not leach from fly ash samples, but leached in trace amounts from cement and brick samples. Iron oxides have a lower solubility in deionized water. Iron leached from pond ash is probably precipitated as hydroxides due to the alkaline nature of fly ash.

During the leaching studies, the resulting high pH in the leachates led to a limited removal of Pb and Fe from fly ash, which was even less than Cu and Mn. The leachability of trace elements will depend more or less on the leachability of iron [23]. Choi et al. (2002) have suggested that the elements in the ash particles were mainly associated with the surface, and these surface-associated fractions might dominate the leachate chemistry at the early stages of fly-ash disposal in contact with water [7]. However, the elements incorporated within the interior of the fly ash dissolved at a slower rate compared with the readily leachable surface-associated elements.

TCLP Test

The heavy metal concentrations as a result of TCLP are shown in Table 2. In this procedure sodium acetate buffer was used at pH 4.99. Mg, Mn, and Cu show solubility in weakly acidic medium and were leached at higher amounts in all samples. Cd was insoluble and does not leach out from these samples. Zn, Ni, Fe, and Pb also leached but at very low concentrations.

The concentration of metals in TCLP was higher than the concentration of metals found in batch leach test. This is because metal solubility generally decreases with increasing pH [24]. TCLP involved leaching in slightly acidic buffered conditions (4.99), and in batch leach test the pH was around 7.2. This is due to the precipitation of metal ions as insoluble hydroxides at high pH values.

For all metals, the lowest solubility was found in water extracts. Trace metal concentrations in fly ash and its admixture were well within the Indian standards for disposal of effluents. A similar comparison of TCLP and batch leach test indicates that all metals were well within specified limits.

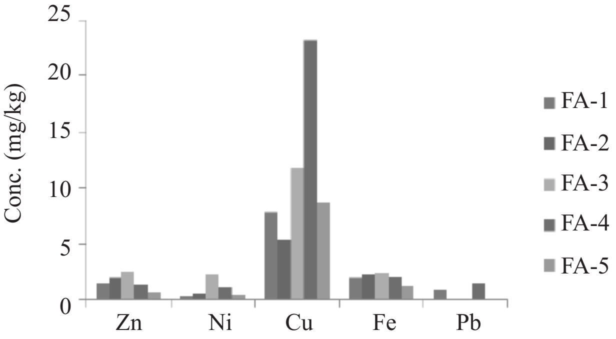

Fig. 2. Comparison of heavy metal concentrations leached as a result of TCLP test.

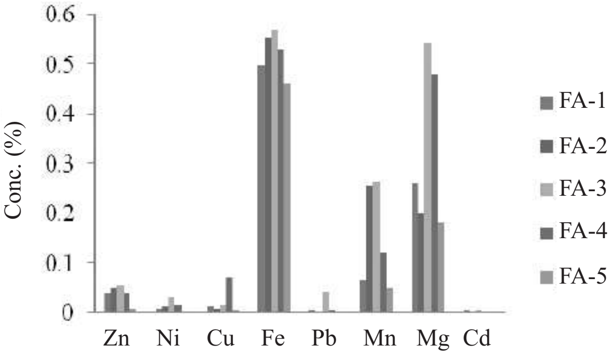

Fig. 3. Comparison of heavy metal concentrations as a result of acid digestion.

Table 4. Comparison of heavy metal concentrations observed in groundwater samples with drinking water standards (n=16).

Metal	Pond water	Stream water	Wells near ash pond	Tube wells in nearby villages	WHO limits for drinking water	IS:10500-1991
Zn	0.024	ND	0.091	0.075	3.0	5.0
Ni	ND	ND	0.054	0.040	0.02	-
Cu	0.068	0.030	0.052	0.057	2.0	0.05
Fe	0.021	ND	0.037	ND	0.3	0.3
Pb	ND	0.037	ND	ND	0.01	0.1
Mn	ND	0.002	0.024	0.019	0.1	-
Mg	3.45	10.80	19.69	14.93	-	30.0
Cd	ND	ND	ND	ND	-	0.01

Concentrations in mg/l, ND – Not Detected

Acid Digestion

Acid digestion data provides the total available concentration levels of trace elements in fly ash and its admixture, which is shown in Table 3. The results obtained from acid digestion test was found to be significantly higher in composition to the above shake test, i.e. batch leaching test and TCLP. Mg and Fe were extracted to a large extent. Zn and Mn were extracted to medium level while Ni, Cu, Pb, and Cd were extracted to lower level in comparison with other heavy metals.

Heavy Metal Analysis in Water Samples

After study of the comparative evaluation of short-term leaching (shake) tests (i.e. batch leach test and TCLP in the laboratory) it is essential to evaluate the actual field condition for environmental escape of heavy metals from fly ash and its admixtures. For this reason ground water analysis was performed on the water samples collected from the wells and bore wells from different locations in the area of the fly ash dumpsite.

Details of the concentration of heavy metals in the groundwater samples near the ash ponds and at the surrounding villages are given in Table 4. pH of the water samples ranged from 7.02 to 8.70, indicating the alkaline nature of the water. The elements found in highest concentration in the tube well waters were Mg followed by Zn and Ni. Mg and Zn are present in higher amounts in the tube well waters in the villages than those near the ash pond. A comparison of data is also made between the concentrations of the trace elements in the waters of the tube wells near the ash pond and those of the tube wells in the villages. The concentration of Cu and Mn is lower and nearly similar in the water samples in all locations, while Pb and Cd are absent in all water samples.

Conclusions

On the basis of the study of the leaching of heavy metals from coal ashes, the following conclusions can be drawn:

- The concentrations of all the heavy metals under study in the leachates were invariably well below the permissible limits for discharge of effluents as per the Indian standards.
- Comparison of water samples near the ash ponds and at the surrounding villages shows that the concentration of

Table 5. Harmful effects of heavy metals on human health.

Metal	Effect on human health
Zn	Gastroenteritis and stomach cramps
Ni	Heart attack and respiratory diseases
Cu	Liver cancer, kidney, and intestinal disorders
Fe	Nausea, vomiting, and liver failure
Pb	Cardiovascular, reproductive, gastrointestinal, and renal disorders
Mn	Mental disorders
Mg	Diarrhea and abdominal cramping
Cd	Pulmonary cancer

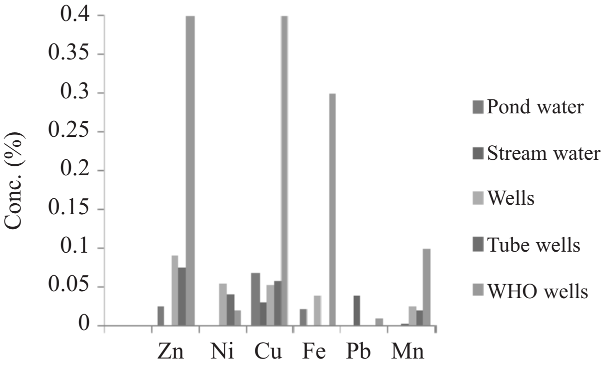

Fig. 4. Comparison of heavy metal concentrations observed in groundwater samples with WHO permissible limits for drinking water.

heavy metals is within the permissible limits of Indian standard IS: 10500 and WHO limits for drinking water quality.

- From the leaching study of heavy metals from cement and bricks it can be concluded that utilization of fly ash in cement and brick manufacturing is safe from an environmental point of view as it does not impart any hazardous effect of heavy metal leaching.
- The fly ash samples from Bhusawal Thermal Power Plant were found to be environmentally safe for disposal and can be engineered for their bulk utilization in industry and agriculture.

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ANNEXURE A-9

IS 15464 : 2022

भारतीय मानक

Indian Standard

मोटर गैसोलीन में सम्मिश्रण घटक के रूप में उपयोग के लिए निर्जल इथेनॉल — विशिष्टि

(पहला पुनरीक्षण)

Anhydrous Ethanol for Use as Blending Component in Motor Gasoline — Specification

(First Revision)

ICS 71.080.80

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली – 110002
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February 2022 Price Group 10

Petroleum and their Related Products of Synthesis or Biological Origin Sectional Committee, PCD 03

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Petroleum and their Related Products of Synthesis or Biological Origin Sectional Committee was approved by the Petroleum, Coal and Related Products Division Council.

Ethyl alcohol (ethanol) is considered as an alternative fuel source that possesses environment friendly characteristics associated with its use. The term anhydrous ethanol is applied to ethyl alcohol after the first addition of a denaturant.

An attempt has been made in this standard to confine the name anhydrous alcohol to the denatured ethyl alcohol only and to keep it distinct from the blends that may be produced by admixture of this anhydrous alcohol with automobile fuel.

It has to be ensured that vehicles running on ethanol blended motor gasoline have no adverse effects on fuel system materials, emission, on-board diagnostics (OBD) systems, or drivability. Original Equipment Manufacturers (OEMs) need to identify such vehicles with proper identifications to indicate the vehicle capability to handle such blended fuels. The engine control unit adjusts engine fueling with respect to the oxygen content and the reduced energy content of Ethanol blended fuels in order to maintain the proper air-fuel ratio under the various engine operating loads and conditions. The vaporization characteristics of ethanol blended fuels tend to be different from normal motor gasoline and therefore the engine fueling strategies under engine cold-start and warm-up conditions need to be addressed for this fuel. Blended fuel when used in conventional vehicles, fuel system materials and components may be affected over time and which in turn-may lead to leaks. Drivability, performance and emissions may also vary. Since it is to be used in spark ignition engine vehicles, with relevant modification, the fuel properties of ethanol blended fuel should be very similar to motor gasoline.

Ethanol till recently was being produced only through molasses. In order to increase usage of alternate fuels in the country, National Biofuel Policy 2018 included various routes for producing ethanol. Bioethanol [1st Generation (1G) Ethanol] is produced from biological sources, such as sugar containing materials like sugar cane, sugar beet, sweet sorghum etc.; starch containing materials, such as corn, cassava, rotten potatoes, etc.; as well, and from damaged food grains like wheat, broken rice etc. which are unfit for human consumption. Food grains during surplus phase and algal feedstock and cultivation of sea weeds were identified as potential feedstock for ethanol production from 1G technology. Ethanol produced through cellulosic materials, such as bagasse, wood waste, agricultural and forestry residues or other renewable resources like industrial waste, and ‘Advanced biofuels’ that are produced from lignocellulosic feedstocks (that is, agricultural and forestry residues, for example, rice and wheat straw/corn cobs and stover, bagasse, woody biomass), non-food crops (that is, grasses, algae), or industrial waste and residue streams and having low CO_2 emission or high GHG reduction and do not compete with food crops for land use are categorized as second generation (2G) ethanol. The large volume of waste gas produced at industrial facilities, such as refineries cannot be stored or transported; rather it must be combusted to make power locally and emitted as carbon dioxide (CO_2). These refinery off-gases formed often contain components, such as olefins, hydrogen, CO_2, CO, hydrocarbons, H_2S, etc. Ethanol production through fermentation of gas mixtures containing CO, CO_2 and H_2 has just started operating at commercial scale and process is known as Off Gas Fermentation (OGF). Instead of sugars and yeast, the fermentation process uses a biological catalysts to ferment waste gas emissions to ethanol.

In this (first revision, the committee noted that the same specification cannot be used for fuel ethanol as such fuel. For using ethanol only as a fuel, addition of a few specialty chemicals/additives are required. Hence, it was decided that a separate specification for anhydrous ethanol as a fuel for automotive applications, IS 17821 ‘Ethanol as a fuel for use in positive ignition engine powered vehicles — Specification’ is prepared and this standard will continue to be applicable only for blending purposes. Specifications for 2G ethanol are also included. Further, the scope is limited to the blending with gasoline only as there is no global reference or specification available for mixing ethanol with diesel.

Properties like purity, methanol content, higher alcohols content, contaminants like chloride, moisture are important to define the quality of ethanol produced through various technologies and raw materials mentioned in National Biofuel Policy, 2018 and hence included. Considerable assistance has been taken for finalizing the requirements of these parameters from the specifications of other countries namely, USA, Brazil, China like ASTM D4806, ANP #19 and GB 18350 respectively.

(*Continued on third cover*)

Indian Standard

ANHYDROUS ETHANOL FOR USE AS BLENDING COMPONENT IN MOTOR GASOLINE — SPECIFICATION

(First Revision)

1 SCOPE

This standard specifies requirements, methods of sampling and test methods for anhydrous ethanol to be used as blending component with gasoline for automotive fuel in positive ignition engine vehicles.

2 REFERENCES

The following standards contain provisions, which through reference in this text constitute the provisions of the standards. At the time of publication, the editions indicated were valid. All the standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standard indicated below:

IS No.	*Title*
196 : 1966	Atmospheric conditions for testing (*revised*)
264 : 2005	Nitric acid (*third revision*)
265 : 2021	Hydrochloric Acid — Specification (*fifth revision*)
321 : 1964	Specification for absolute alcohol (*revised*)
323 : 2009	Rectified Spirit for industrial use — Specification (*second revision*)
1070 : 1992	Reagent grade water — Specification (*third revision*)
1447 (Part 1) : 2021	Methods of sampling of Petroleum and its products Part 1: Manual sampling (*second revision*)
1448	Methods of test for petroleum products
(Part 160) : 2017/ ISO 20846 : 2011	Determination of sulfur content of automotive fuels — Ultraviolet fluorescence method
(Part 180) : 2020/ ISO 16591 : 2010	Determination of sulphur content — Oxidative microcoulometry method
2302 : 1989	Table for alcoholometry by hydrometer method (*first revision*)
2362 : 1993	Determination of water by Karl Fischer method — Test method (*second revision*)
4117 : 2008	Alcohol Denaturants — Specification (*second revision*)
17342 : 2020	Determination of ethyl alcohol concentration by digital densitometer

3 TERMINOLOGY

3.1 Ethanol — Ethanol is a pure organic chemical, otherwise known as hydroxy-ethane, corresponding to the constitution CH_3CH_2OH and molecular formula C_2H_5OH.

3.2 Ethyl Alcohol (Absolute Alcohol) — Ethyl alcohol (absolute alcohol) is a clear, colourless, and homogeneous liquid, consisting essentially of ethanol containing not more than 0.5 percent by volume of water.

3.3 Anhydrous Ethanol — Anhydrous ethanol is essentially ethyl alcohol, which is minimum 99.5 percent purity and having a boiling point of 78.5 °C without any denaturant. In this standard anhydrous ethanol refers to the ethyl alcohol which is denatured, meant for use in automotive gasoline blending.

3.4 Denaturant — Denaturant is a substance, prescribed by law, completely miscible in ethyl alcohol and of such a character that while its addition makes the material or any aqueous dilution of it unpleasant and unwholesome for potable purposes, its presence does not render anhydrous ethanol, either as such or blended with gasoline, unsuitable for use in automobile engines. The denaturants cannot be removed from alcohol except by complex and costly process.

4 REQUIREMENTS

4.1 Description

Anhydrous ethanol for use in automotive gasoline fuel shall be a clear, colorless, and homogeneous liquid, free from any suspended matters.

4.2 Denaturant

The denaturant to be admixed with ethyl alcohol and the proportion in which it is to be used is specified in IS 4117.

4.2.1 *Prohibited Denaturants*

Specific mention must be made of some materials that have extremely adverse effects on fuel stability, automotive engines and fuel systems. These materials shall not be used as denaturants, for anhydrous ethanol for use in automobile fuels, under any circumstances. They are, methanol, pyrroles, turpentine, ketones and tars (high- molecular weight pyrolysis products of fossil or non-fossil vegetable matter). Unless a denaturant, such as a higher aliphatic alcohol or ether, is known to have no adverse effect on a gasoline-ethanol blend or on automotive engines or fuel systems, it shall not be used.

4.2.2 Subject to the effect of the added denaturant, anhydrous ethanol shall comply with the requirements for general purposes prescribed for ethyl alcohol.

4.3 Acidity

The material shall be neutral or acidic in reaction to phenolphthalein and when tested as prescribed in Annex D. The acidity, other than due to dissolved carbon dioxide shall not exceed the value given in Table 1, Sl No. viii).

4.4 The material shall also comply with the requirements given in Table 1 when tested in accordance with appropriate methods prescribed under parts of IS 1448 or other suitable test methods, reference to which is given in col **5** of Table 1.

5 PACKING AND MARKING

5.1 Packing

5.1.1 The material shall be packed in such containers and packages as agreed to between the purchaser and the vendor, subject to the provisions of law in force from time to time.

5.1.2 All containers in which the material is packed shall be dry, clean, free from substances soluble in anhydrous ethanol, and leak-proof.

5.1.3 Necessary safeguards against the risk arising from the storage and handling of large volume of flammable liquids shall be provided and all due precautions shall be taken at all times to prevent accidents or explosions.

5.1.4 Except when they are opened for the purpose of cleaning and rendering them free from alcohol vapour, all empty tanks or other containers shall be kept securely closed unless they have been thoroughly cleansed and freed from alcohol vapour.

5.2 Marking

5.2.1 Each container shall be marked legibly and indelibly with the following information:

a) Name of the material;
b) Source of the material (1G/2G/OGF);
c) Manufacturer's name;
d) Volume of the contents, in litres;
e) Recognized trade-mark, if any;
f) Date of packing;
g) Only for automotive use;
h) Highly flammable;
j) Hazardous chemical and injurious to health; and
k) Any other statutory requirements.

5.2.2 *BIS Certification Marking*

The product confirming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the rules and regulations framed thereunder. The product may be marked with the Standard Mark.

6 SAMPLING

Representative samples of the material shall be drawn as prescribed in IS 1447 (Part 1).

7 TEST METHODS

7.1 Tests shall be conducted as prescribed in col 5 of Table 1.

7.2 Quality of Reagents

Unless specified otherwise, pure chemicals and distilled water (see IS 1070) shall be employed in tests.

NOTE — "Pure chemicals" shall mean chemicals that do not contain impurities, which affect the results of analysis (Laboratory or Analytical Reagent grade).

Table 1 Requirements of Anhydrous Ethanol for Use as Blending component in Motor Gasoline

(*Cl* 4.3, 4.4 *and* 7.1)

Sl No.	Characteristics	Requirements		Reference to the Test Method Annex/IS/ASTM/EN/ Parts of IS 1448
		1 G	2G/OGF	
(1)	(2)	(3)	(4)	(5)
i)	Appearance	Clear, bright, and free from any sediments	Clear, bright, and free from any sediments	Visual observation
ii)	Relative density at 15.6/15.6 °C, *Max*.	0.7961	0.7965	Annex A
iii)	Ethanol, percent, *v*/*v*, *Min*[1]. (excluding denaturant)	99.5	98[1]	Annex B[3]/IS 17342/ASTM D 5501
iv)	Methanol, percent, *v*/*v*, *Max.*	0.5	0.5	ASTM D 5501/EN 15721/ ASTM D 4815[3]
v)	Higher saturated alcohols (C3-C5), percent, *v*/*v*, *Max.*	–	1.5	EN 15721
vi)	Boiling point, °C, *Min*.	–	To report	ASTM D 1078
vii)	Residue on evaporation, percent by mass, *Max.*	0.005	0.005	Annex C
viii)	Acidity (as CH_3COOH), mg/kg, *Max.*	30	30	Annex D[3]/ASTM D 7795/ EN 15491
ix)	Alkalinity, mg/kg, *Max.*	NIL	NIL	Annex D
x)	Aldehyde (as CH_3CHO) content, mg/l, *Max.*	60	60	Annex E
xi)	Electrical conductivity, µS/m, *Max.*	300	500	Annex F
xii)	Copper, mg/kg, *Max.*	0.1	0.1	Annex G[3]/EN 15837/ EN 15488
xiii)	*p*He	–	6.5 – 8.0	ASTM D6423
xiv)	Inorganic chloride, mg/kg, *Max.*	–	3.0	ASTM D7319[3]/EN 15492
xv)	Sulfur content, mg/kg, *Max.*	10	10	(Part 180) /(Part 160) ASTM D7039/EN 15485/ EN 15486/ASTM D 5453[3]
xvi)	Sulphate content, mg/kg *Max*.	–	4	ASTM D7318[3]/D7319/ D7328/EN 15492
xvii)	Water content, percent *v*/*v*, *Max.*	To Report (Note 2)	0.3	ASTM D7923[3]/ASTM E1064
xviii)	Hydrocarbons, percent *v*/*v*	–	To report	Annex H
xix)	Miscibility with water	Miscible	Miscible	Annex J

NOTES

[1] In case of 2G/OGF technology process, total alcohol content shall be minimum 99.5 percent, as per Annex B.

[2] To be reported by 1G manufacturer during release of product.

[3] In case of disputes, this method shall be the referee method.

ANNEX A

[*Table* 1, *Sl No* ii)]

DETERMINATION OF RELATIVE DENSITY

A-1 GENERAL

Two methods have been prescribed for determination of specific gravity in anhydrous ethanol for use as automotive fuel. Both the methods can be used for the determination of specific gravity on routine basis. However, in the event of any dispute, Method 2 shall be treated as a referee method.

A-2 METHOD 1 - SPECIFIC GRAVITY BOTTLE METHOD

Determine the specific gravity of anhydrous ethanol using IS 323.

A-3 METHOD 2 - OSCILLATING SAMPLE TUBE METHOD – (DIGITAL DENSITOMETER)

A-3.1 Summary of Test Method

A small volume (approximately 0.7 ml) of liquid sample is introduced into an oscillating sample tube and the change in oscillating frequency caused by the change in the mass of the tube is used in conjunction with calibration data to determine the density of the sample.

A-3.2 Apparatus

A-3.2.1 *Digital Density Analyzer* — Consisting of a U-shaped, oscillating sample tube and a system for electronic excitation, frequency counting, and display. The analyzer must accommodate the accurate measurement of the sample temperature during measurement or must control the sample temperature as described in **A-3.2.2**. The instrument shall be capable of meeting the precision requirements described in this test method.

A-3.2.2 *Circulating Constant-Temperature Bath,*— Optional capable of maintaining the temperature of the circulating liquid constant to ± 0.05 °C in the desired range. Temperature control can be maintained as part of the density analyzer instrument package.

A-3.2.3 *Syringes* — At least 2 ml in volume with a tip or an adapter tip that will fit the opening of the oscillating tube.

A-3.2.4 *Flow-Through or Pressure Adapter* — For use as an alternative means of introducing the sample into the density analyzer either by a pump or by vacuum.

A-3.2.5 *Thermometer* — Calibrated and graduated to 0.1 °C, and a thermometer holder that can be attached to the instrument for setting and observing the test temperature. In calibrating the thermometer, the ice point and bore connections should be estimated to the nearest 0.05 °C.

A-3.3 Reagents and Materials

A-3.3.1 *Purity of Water* — Water, redistilled, fleshly boiled and cooled reagent water for use as a primary calibration standard.

A-3.3.2 *Petroleum Naphtha* — For flushing viscous petroleum samples from the sample tube.

Warning — Extremely flammable.

A-3.3.3 *Acetone* — For flushing and drying the sample tube.

Warning — Extremely flammable.

A-3.3.4 *Dry Air* — for blowing the oscillator tube.

A-3.4 Preparation of Apparatus

Set up the density analyzer and constant temperature bath following the manufacturer's instructions. Adjust the bath or internal temperature control so that the desired test temperature is established and maintained in the sample compartment of the analyzer. Calibrate the instrument at the same temperature at which the density of the sample is to be measured.

CAUTION — Precise setting and control of the test temperature in the sample tube is extremely important. An error of 0.1 °C can result in a change in density of one in the fourth decimal.

A-3.5 Calibration of Apparatus

A-3.5.1 Calibrate the instrument when first set up and whenever the test temperature is changed. Thereafter, conduct calibration checks at weekly intervals during routine operation.

A-3.5.2 Initial calibration, or calibration after a change in test temperature, necessitates calculation of the values of the constants A and B from the periods of oscillation (T) observed when the sample cell contains air and redistilled, freshly boiled and cooled reagent water. Other calibrating materials, such as n-nonane, n-tridecane, cyclohexane, and n-hexadecane (for high temperature applications) can also be used as appropriate.

A-3.5.2.1 While monitoring the oscillator period, T, flush the sample tube with petroleum naphtha, followed with an acetone flush and dry with dry air. Contaminated or humid air can affect the calibration. When these conditions exist in the laboratory, pass the air used for calibration through a suitable purification and drying train. In addition, the inlet and outlet ports for the U-tube must be plugged during measurement of the calibration air to prevent ingress of moist air.

A-3.5.2.2 Allow the dry air in the U-tube to come to thermal equilibrium with the test temperature and record the *T*-value for air.

A-3.5.2.3 Introduce a small volume (about 0.7 ml) of redistilled, freshly-boiled and cooled reagent water into the sample tube from the bottom opening using a suitable syringe. The test portion must be homogeneous and free of even the smallest air or gas bubbles. The sample tube does not have to be completely full as long as the liquid meniscus is beyond the suspension point. Allow the display to reach a steady reading and record the *T*-value for water.

A-3.5.2.4 Calculate the density of air at the temperature of test using the following equation:

$$d_m\text{, g/ml} = 0.001293[273.15/T]\ [P/760] \quad \ldots (1)$$

where

T = temperature, K, and

P = barometric pressure, Torr.

A-3.5.2.5 Determine the density of water at the temperature of test by reference to Table 2.

A-3.5.2.6 Using the observed *T*-values and the reference values for water and air, calculate the values of the constants *A* and *B* using the following equations:

$$A = [T_W^2 - T_a^2]/[d_W - d_a] \quad \ldots(2)$$

$$B = T_a^2 - (A \times d_a) \quad \ldots(3)$$

where

T_w = observed period of oscillation for cell containing water,

T_a = observed period of oscillation for cell containing air,

d_W = density of water at test temperature, and

d_a = density of air at test temperature.

Alternatively, use *T* and *d* values for the other reference liquid, if one is used.

A-3.5.2.7 If the instrument is equipped to calculate density from the constants *A* and *B* and the observed *T*-value from the sample, then enter the constants in the instrument memory in accordance with the manufacturer's instructions.

A-3.5.2.8 Check the calibration and adjust, if needed by performing the routine calibration check described in **A-5.3**.

A-3.5.2.9 To calibrate the instrument to display relative density, that is, the density of the sample at a given temperature referred to the density of water at the same temperature, follow sections **A-3.5.2.1** through **A-3.5.2.7**, but substitute 1.000 for d_W in performing the calculations described in **A-3.5.2.6.**

A-3.5.3 Weekly calibration adjustments to constants, *A* and *B* can be made if required, without repeating the calculation procedure.

NOTE — The need for a change in calibration is generally attributable to deposits in the sample tube that are not removed by the routine flushing procedure. Although this condition can be compensated for by adjusting *A* and *B,* it is good practice to clean the tube with warm chromic acid solution, whenever a major adjustment is required. Chromic acid solution is the most effective cleaning agent; however, surfactant cleaning fluids have also been used successfully.

Warning — Causes severe bums. A recognized carcinogen.

A-3.5.3.1 Flush and dry the sample tube as described in **A-3.5.2.1** and allow the display to reach a steady reading. If the display does not exhibit the correct density for air at the temperature of test, repeat the cleaning procedure or adjust the value of constant *B* commencing with the last decimal place until the correct density is displayed.

A-3.5.3.2 If adjustment to constant *B* was necessary in **A-3.5.3.1** then continue the recalibration by introducing redistilled, freshly boiled and cooled reagent water into the sample tube as described in **A-3.5.2.3** and allow the display to reach a steady reading. If the instrument has been calibrated to display the density, adjust the reading to the correct value for water at the test temperature (*see* Table 2) by changing the value of constant *A,* commencing with the last decimal place. If the instrument has been calibrated to display the relative density, adjust the reading to the value 1.0000.

NOTE — In applying this weekly calibration procedure, it can be found that more than one value each for *A* and B, differing in the fourth decimal place, will yield the correct density reading for the density of air and water. The setting chosen would then be dependent upon whether it was approached from a higher or lower value. The setting selected by this method could have the effect of altering the fourth place of the reading obtained for a sample.

A-3.5.4 Some analyzer models are designed to display the measured period of oscillation only (*T*-values) and their calibration requires the determination of an instrument constant *K,* which must be used to calculate the density or relative density from the observed data.

A-3.5.4.1 Flush and dry the sample tube as described in **A-3.5.2.1** and allow the display to reach a steady reading. Record the *T*-value for air.

A-3.5.4.2 Introduce redistilled, freshly boiled and cooled reagent water into the sample tube as described in **A-3.5.2.3**, allow the display to reach a steady reading and record the *T*-value for water.

A-3.5.4.3 Using the observed *T*-values and the reference values for water and air (**A-3.5.2.4** and **A-3.5.2.5**), calculate the instrument constant *K* using the following equations:

$$K = [1.0000 - d_a]/[T_W^2 - T_a^2] \quad ....(4)$$

where

T_w = observed period of oscillation for cell containing water,

T_a = observed period of oscillation for cell containing air, and

d_a = density of air at test temperature.

A-3.6 Procedure

A-3.6.1 Introduce a small amount (about 0.7 ml) of sample into the clean, dry sample-tube of the instrument using a suitable syringe.

A-3.6.2 The sample can also, be introduced by siphoning. Plug the external TFE-fluorocarbon capillary tube into the lower entry port of the sample tube. Immerse the other end of the capillary in the sample and apply suction to the upper entry port using a syringe or vacuum line until the sample tube is properly filled.

A-3.6.3 Turn on the illumination light and examine the sample tube carefully. Make sure that no bubbles are trapped in the tube, and that it is filled to just beyond the suspension point on the right-hand side. The sample must be homogeneous and free of even the smallest bubbles.

A-3.6.4 Turn the illumination light off immediately after sample introduction, because the heat generated can affect the measurement temperature.

A-3.6.5 After the instrument displays a steady reading to four significant figures for density and five for *T*-values, indicating that temperature equilibrium has been reached, record the density or *T*-value.

A-3.7 Calculation

A-3.7.1 *Calculating Density Analyzers*

The recorded is the final result, as relative density.

A-3.7.2 *Non-calculating Density Analyzers*

Using the observed *T*-value for the sample and the *T*-value for water and appropriate instrument constant, *K,* determined in **A-3.5.4.3**, calculate the density or relative density using Equation 5. Carry out all calculations to six significant figures and round the final results to four.

$$\text{Relative density, t/t} = 1 + K (T_s^2 - T_W^2) \ ... (5)$$

where

T_W = observed period of oscillation for cell containing water,

T_s = observed period of oscillation for cell containing sample,

K = instrument constant, and

t = temperature of test, °C.

Table 2 Density of Water

(*Clauses* A-3.5.2.5 *and* A-3.5.3.2)

Temperature *°C* (1)	Density *g/ml* (2)
0.0	0.999990
3.0	0.999984
4.0	0.999972
5.0	0.999964
10.0	0.999899
15.0	0.999699
15.56	0.999612
16.0	0.998943
17.0	0.998774
18.0	0.998595
19.0	0.998404
20.0	0.998203
21.0	0.997991
22.0	0,997709
23.0	0.997537
24.0	0.997295
25.0	0.997043
26.0	0.996702
27.0	0.996511
28.0	0.99623 I
29.0	0.995943
30.0	0.995043
35.0	0.994029
37.7	0.993042
40.0	0.992212
45.0	0.990200
50.0	0.990030
55.0	0.985600
60.0	0.983191
65.0	0.980546
70.0	0.977759
75.0	0.974837
80.0	0.971705
85.0	0.966606
90.0	0.965305
100	0.958345

A-4 Ethanol content calculation using Table 1 of IS 2302, followed by conversion to specific gravity by using Appendix B of IS 321.

ANNEX B

[*Table* 1, *Sl No.* iii)]

DETERMINATION OF ETHANOL CONTENT

B-1 GENERAL

Two methods have been prescribed for determination of ethanol content in anhydrous ethanol for use as automotive fuel. Both the methods can be used for determination of ethanol content on routine basis. However, in the event of any dispute, Method 2 shall be treated as a referee method.

B-2 METHOD 1 - ALCOHOLOMETRIC METHOD USING HYDROMETER

Determine the ethanol content in the anhydrous ethanol using method given in IS 2302 using alcohol meter and Table 1 of IS 2302. Report in percent by volume.

IS 2302 is for rectified spirit and its applicability to anhydrous ethanol meeting this specification need to be assessed.

B-3 METHOD 2 - GAS CHROMATOGRAPHIC METHOD

B-3.1 General

B-3.1.1 This test method covers the determination of the ethanol content of denatured fuel ethanol by gas chromatography.

B -3.1.2 Water cannot be determined by this test method and shall be measured by a procedure as given in 1S 2362 and the result used to correct the chromatographic values.

B-3.1.3 This test method is inappropriate for impurities that boil at temperatures higher than 225 °C or for impurities that cause poor or no response in a flame ionization detector, such as water.

B-3.2 Summary of Test Method

A representative aliquot of the fuel ethanol sample is introduced into a gas chromatography equipped with a methyl silicone bonded phase fused silica capillary column. Helium carrier gas transports the vaporized aliquot through the column where the components are separated by the chromatographic process. Components are sensed by a flame ionization detector as they elute from the column. The detector signal is processed by an electronic data acquisition system. The ethanol and methanol components are identified by comparing their retention, times to the ones identified by analyzing standards under identical conditions. The concentration of all components are determined in mass percent area by normalization of the peak areas.

B-3.3 Apparatus

B-3.3.1 *Gas Chromatography* – Capable of operating at the conditions listed in Table 3. A heated flash vaporizing injector designed to provide a linear sample spilt injection (for example, 200 : 1) is required for proper sample introduction. Carrier gas controls shall be of adequate precision to provide reproducible column flows and split ratios in order to maintain analytical integrity. Pressure control devices and gauges shall be designed to attain the linear velocity required in the column used. A hydrogen flame ionization detector with associated gas controls and electronics, designed for optimum response with open tabular columns, is required.

B-3.3.2 *Sample Introduction* – Manual or automatic liquid syringe sample injection to the splitting injector is employed. Devices capable of 0.1 to 0.5 PI injections are suitable. It should be noted that inadequate splitter design, poor injection technique, and overloading the column can result in poor resolution. Avoid overloading, particularly of the ethanol peak and eliminate this condition during analysis.

B-3.3.3 *Column – This* test method utilizes a fused silica open tubular column with non-polar methyl silicone bonded (cross-linked) phase internal coating. Any column with equivalent or better chromatographic efficiency and selectivity to those described in **B-3.3.3.1** can be used.

B-3.3.3.1 Open tubular column with anon-polar methyl silicone bonded (cross-linked) phase internal coating, either 150 m by 0.25 mm with a 1.0 µm film thickness, or 100 m by 0.25 mm with a 0.5 µm film thickness is required.

B-3.3.4 *Electronic Data Acquisition System*

Any data acquisition and integration device used for quantification of these analyses must meet or exceed these minimum requirements:

a) Capacity for at least 80 peaks/analysis,
b) Normalized area percent calculation with response factors,
c) Identification of individual components based on retention time,
d) Noise and spike rejection capability,
e) Sampling rate for fast (<1 sP) peaks,
f) Positive and negative sloping baseline correction,
g) and broad peaks, and
h) Non-resolved peaks separated by perpendicular drop or tangential skimming as needed.

B-3.3.5 *Containers*

B-3.3.5.1 *Vial* – Glass, threaded neck, approximately 22 ml capacity, short style.

Table 3 Typical Operating Conditions

(*Clauses* B-3.3.1, B-3.6.3 *and* B-3.8.1)

Column Temperature Program		
Column length	100m	150m
Initial temperature	15 °C	60 °C
Initial hold time	12 min	15 min
Program rate	30 °C/min	30 °C/min
Final temperature	250 °C	250 °C
Final hold time	19 min	23 min

Injector		Detector	
Temperature	300 °C	Type	Flame ionization
Split ratio	200 : 1	Temperature	300 °C
Sample size	0.1 to 0.5 µl	Fuel gas	Hydrogen (~30ml/min)
		Oxidizing gas	Air (~300 ml/min)
		Make-up gas	Nitrogen (~30 ml/min)

Carrier Gas	
Type	Helium
Average linear velocity	21-24 cm/s

B-3.3.5.2 *Bottle cap* – Molded plastic with polyethylene conical liner.

B-3.3.5.3 Bottle *cap* – Molded plastic with tin-foil liner. Tin foil liners are preferred to other metal liners because they are better.

B-3.4 Reagents and Materials

B-3.4.1 *Carrier Gas* – Helium, with a minimum purity of 99.95 mol percent. Oxygen removal systems and gas purifiers should be used.

Warning — Helium, compressed gas under high pressure.

B-3.4.2 *Detector Gases* – Hydrogen, air and nitrogen. The minimum purity of the gases used should be 99.95 percent for the hydrogen and nitrogen. The air should be hydrocarbon-free grade. Gas purifiers are recommended for the detector gases.

a) **Warning** — Hydrogen, extremely inflammable gas under high pressure.
b) **Warning** — Air and nitrogen, compressed gases under pressure.

B-3.4.3 *Standards for Calibration and Identification,*

Standards of all components to be analyzed are required for establishing identification by retention time as well as calibration for quantitative measurements. These materials shall be of known purity and free of the other components to be analyzed.

B-3.4.3.1 *Ethanol*

a) **Warning** — Two grades of ethanol are available. Only absolute ethanol 99.5 percent, *Min* meets the requirement of this test method.
b) **Warning** — These materials are flammable and may be harmful or fatal, if ingested or inhaled.

B-3.4.3.2 *Methanol*

Warning — These materials are flammable and may be harmful or fatal, if ingested or inhaled.

B-3.4.3.3 *Heptane*

Warning — These materials are flammable and may be harmful or fatal, if ingested or inhaled.

B-3.5 Sampling

B-3.5.1 Denatured ethanol can be sampled into an open container since a vapor pressure of less than 21 kPa is expected.

B-3.5.2 Transfer an aliquot of the sample into a septum vial and seal. Obtain the test sample for analysis directly from the sealed septum vial, for either manual or automatic syringe injection.

B-3.6 Preparation of Apparatus

B-3.6.1 Install and condition column in accordance with manufacturer's or supplier's instructions. After conditioning, attach column outlet to flame ionization detector inlet and check for leaks throughout the system. When leaks are found, tighten or replace fittings before proceeding.

B-3.6.2 Adjust the carrier gas flow rate so that the average linear gas velocity, at the initial temperature of the run, is between 21 and 24 cm/s, as determined by the following equation:

$$\mu = L/t_m \qquad \text{...(6)}$$

where

μ = average linear gas velocity in cm/s,
L = column length in cm, and
t_m = retention time of methane.

Flow rate adjustment is made by raising or lowering the carrier gas pressure (head pressure) to the injector.

B-3.6.3 Adjust the operating conditions of the gas chromatography (*see* Table 3) and allow the system to equilibrate.

B-3.6.4 *Linearity*

The linearity of the gas chromatography system shall be established prior to the analysis of samples.

B-3.6.4.1 The split ratio used is dependent upon the split linearity characteristics of the particular injector and the sample capacity of the column. The capacity of a particular column for a sample component is proportional to the amount of liquid phase (loading or film thickness) and the ratio of the column temperature to the component boiling point (vapour pressure). Overloading of the column may cause loss of resolution for some components and since overloaded peaks are skewed, variance in retention times. This can lead to erroneous component identification. During column evaluations and split linearity studies, be aware of any peaks that may appear front skewed, indicating column overload. Note the component size and avoid conditions leading to this problem during actual analysis.

B-3.6.4.2 Splitting injector linearity must be established to determine proper quantitative parameters and limits. Use a standard mixture of known mass percentages of ethanol, methanol and 10 to 20 pure hydrocarbons, covering the boiling range of this test method. The determined mass percent for such component shall match the gravimetric known concentration within ± 3 percent relative.

B-3.6.4.3 The linearity of the flame ionization detector (FID) should be checked. A plot of the peak areas versus ethanol concentration for prepared standards in the concentration range of interest should be linear. If the plot is not linear, either the split ratio shall be increased or the detector range must be made less sensitive.

B-3.7 Calibration and Standardization

B-3.7.1 *Identification*

Determine the retention time of ethanol and methanol. By injecting amounts of each, either separately or in known mixtures, in proportions expected in the final blend using n-heptane as the solvent.

B-3.7.2 *Calibration*

Typical mass relative response factors for the components of interest are found in Table 4. These response factors shall be determined by analyzing a standard that has been blended according to **B-3.7.2.1**. This standard is comprised of the proportions of ethanol and methanol expected in the sample using n-heptane in place of the denaturant. A typical standard blend would be 96 percent ethanol, 0.1 percent methanol and 3.9 percent n-heptane. Calculate the mass relative response factor according to **B-3.7.3**.

B-3.7.2.1 *Preparation of blend*

B-3.7.2.1.1 Pre-blending calculations

In order to make blends of components at specific levels, it is necessary to calculate beforehand the mass of each component required to achieve these levels. Calculate masses as follows:

$$W_N = \frac{A \times T}{100} \qquad \text{...(7)}$$

where

W_N = mass of component N to be added, g;
A = desired percentage in the final blend; and
T = desired mass of typical final blend, g.

B-3.7.2.1.2 Procedure

B-3.7.2.1.2.1 Examine the vial and cap to verify that a leak-free closure is obtained. The rim at the top of the vial should be smooth and flat and the cap should fit snugly.

B-3.7.2.1.2.2 Plastic caps with tin foil liners provide a good seal unless blend components react with the tin. Polyethylene-lined caps usually provide a good closure but are not to be used for aromatic hydrocarbons and similar compound since these materials will, with-time, diffuse through the liner.

B-3.7.2.1.2.3 Weigh the vial and cap to the nearest 0.1 mg. Remove cap and add the first component to the vial, being careful not to allow the component to contact the rim of the vial, which could produce losses. Place the cap on the vial and re-weigh to the nearest 0.1 mg. Repeat this procedure with each additional component always being careful not to allow the content of the vial to contact the cap. After all components have been added and the final weighing completed, thoroughly shake the vial to mix the solution.

B-3.7.2.1.3 Calculations

Calculate the mass percent composition as follows:

$$\text{N, mass percent} = \frac{W_N \times 100}{\sum \left(W_N + W_O + W_P, ... \right)} \qquad \text{...(8)}$$

where

W_Y, W_o, W_P= mass of components N, O, *P*, etc, g.

B-3.7.3 *Calculation of Mass Relative Response Factor*

B-3.7.3.1 Calculate the response factor for each component on a mass (weight) basis as follows:

$$R_M = M/A \qquad \text{...(9)}$$

where

R_M = mass (weight) response factor for a specific component g/unit;
M = mass (weight) of a specific component in the blend, g; and
A = area or peak height of the specific component peak, units.

B-3.7.3.1.1 Calculate the mass relative response factors as follows:

$$RR_M(C_N) = R_M(C_N)/R_M(C_7) \quad ...(10)$$

where

$RR_M(C_N)$ = mass (weight) relative response factor for a component, N, g/unit;

$R_M(C_N)$ = mass (weight) response factor for specific component, N, determined in **B-3.7.3.1**, g/unit; and

$R_M(C_7)$ = mass (weight) response factor for n-heptane, determined in **B-3.7.3.1**, g/unit.

NOTE — For purposes of this model calculation n-heptane has been chosen as the standard reference compound.

B-3.8 Gas Chromatographic Analysis Procedure

B-3.8.1 Set the instrument operating variables to the values specified in Table 3.

B-3.8.2 Set instrumental sensitivity such that any component of at least 0.002 mass percent can be detected and integrated.

B-3.8.3 Inject 0.1 to 0.5 µl of sample into the injection port and start the analysis. Obtain a chromatogram and peak integration report. A sample chromatogram is shown in Fig. 1.

B-3.8.4 The ethanol peak will require tangential skimming to be correctly integrated, if components of the denaturant elute on the ethanol peaks tail.

B-3.9 Calculation

B-3.9.1 Multiply the area of each identified peak by the appropriate mass relative response factor. Use those factors determined for individual compounds and use a factor of 1.000 for unknowns.

B-3.9.2 Determine the relative mass percent of the individual alcohols by using the following equation:

$$RM_i = \frac{AR_i \times 100}{AR_t} \quad ...(11)$$

where

RM_i = relative mass percent of the individual alcohols,

AR_i = area of the individual alcohol peak corrected by the appropriate mass relative response factor (*see* **B-3.8.1**), and

AR_t = total area of all detected peaks corrected by their appropriate mass relative response factors (*see* **B-3.8.1**).

B-3.9.3 Obtain the mass percent of water in the sample. Test method IS 2362, or equivalent, can be used.

B-3.9.4 Determine the mass percent of the alcohols of interest by using the following equation:

$$M_i = \frac{RM_i \times (100 - \text{mass percent water in sample})}{100} \quad ...(12)$$

where

M_i = mass percent of the individual alcohol being determined, and

RM_i, = relative mass percent of the individual alcohol from **B-3.9.2**.

Table 4 Pertinent Physical Constants

(*Clauses* B-3.7.2 *and* B-3.9.5)

Component	**Typical Mass Response Factors** [1]	**Relative Density at 15.56 °C**
(1)	(2)	(3)
Methanol	3.20	0.796
Ethanol	2.06	0.794

[1] When n-heptane = 1.

B-3.9.5 For the volumetric concentration of the alcohol, calculate as follows:

$$V_i = \frac{M_i \times D_s}{D_i} \quad ... \quad (13)$$

where

V_i = volume percent of component *i,*

M_i = mass percent of component, *i,* from **B-3.9.4**,

D_i = relative density at 15.56 °C (60 °F) of component, *i,* as found in Table 4, and

D_s = relative density of sample under study as determined in Annex A.

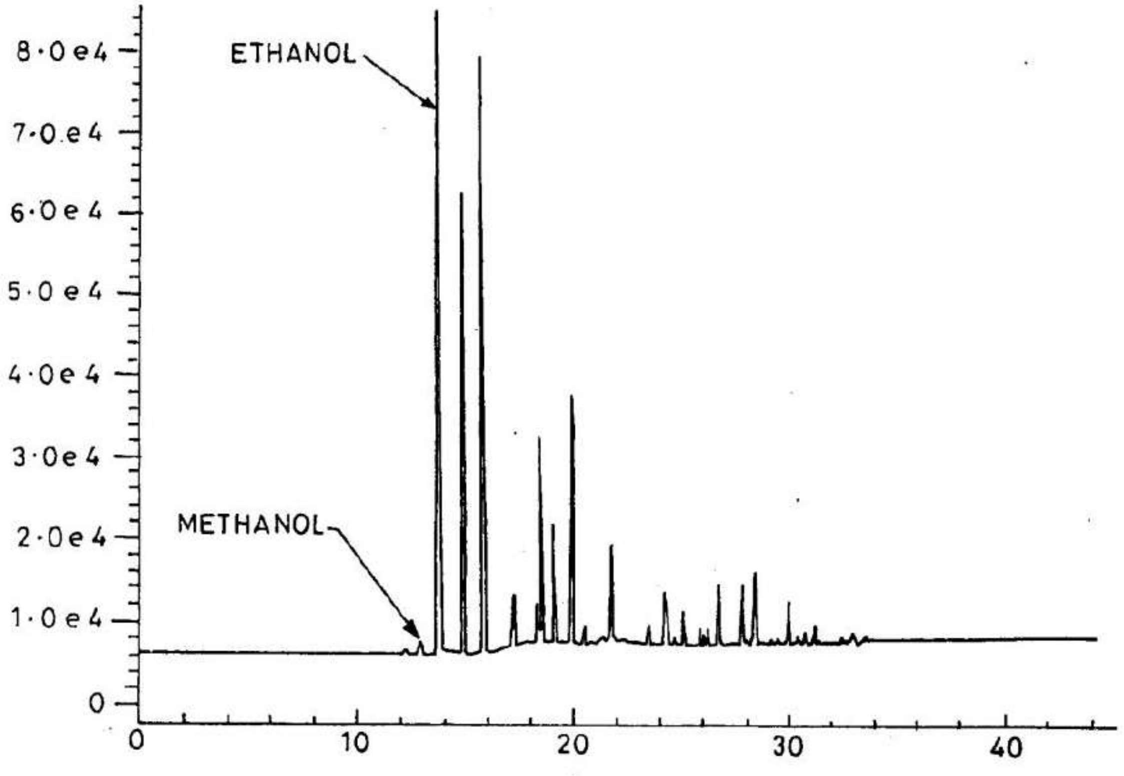


FIG. 1 SAMPLE CHROMATOGRAM

ANNEX C

[*Table* 1, *Sl No.* (vii)]

DETERMINATION OF RESIDUE ON EVAPORATION

C-1 PROCEDURE

Evaporate on a water bath, 100 ml or more of the material to dryness in a weighed, clean, dry platinum, silica or resistance glass dish. Dry the residue for 30 min in an oven at a temperature of 100 ± 2 °C. Cool in a desiccator and weigh.

C-2 CALCULATION

Residue on evaporation, percentage by mass =

$$= \frac{(B-A)\times 100}{V\times S}$$

where

B = weight of dish after evaporation, drying, in g;
A = weight of empty dish, in g;
V = Volume of material taken for tests, in ml; and
S = Specific gravity of material determined at room temperature.

ANNEX D

[*Table* 1, *Sl No* (viii) *and* (ix)]

TEST FOR ALKALINITY AND DETERMINATION OF ACIDITY

D-1 GENERAL

D-1.1 Acidity

It is defined as a quality, state or degree of being acid. Very dilute aqueous solutions of low molecular weight organic acids (acetic acid) may be present in the anhydrous ethanol and are highly corrosive to many metals in vehicle operation when used as fuel or blending component with gasoline. It is therefore necessary to measure and keep such acids at a very low level in the anhydrous ethanol.

D-1.2 This test method estimates the amount of acid by titrating with alkali (NaOH) and report as acetic acid (CH_3COOH) mg/l.

D-2 REAGENTS

D-2.1 Standard Sodium Hydroxide Solution 0.l N

D-2.2 Phenolphthalein Indicator

Dissolve 0.5 g of phenolphthalein in 100 ml of anhydrous ethanol and carefully add standard sodium hydroxide solution till the colour is rendered faintly pink.

D-3 PROCEDURE

Place 100 ml of water and a few pieces of clean porous pot in a 500 ml conical flask of resistance glass, and boil gently for 5 min to eliminate carbon dioxide. Cool slightly and add 100 ml of the material. Boil gently for a further period of 5 min. At the end of this period, close the neck of the flask with a stopper carrying a soda-lime guard tube, and allow to cool. When cool, examine for alkalinity; if not alkaline, titrate with standard sodium hydroxide solution using a micro-burette.

D-4 CALCULATION AND REPORTING

D-4.1 Report whether the material is alkaline or acidic.

D-4.2 Calculate the acidity, if any, in terms of acetic acid and express it, in mg/l (as CH_3COOH) of the material taken for the test:

$$\text{Acidity (as } CH_3COOH\text{), mg/1} = 600\,VN$$

where

V = volume in ml, of standard sodium hydroxide solution required for the titration; and

N = normality of standard sodium hydroxide solution.

ANNEX E

[*Table* 1, *Sl No.* x)]

DETERMINTION OF ALDEHYDE CONTENT

E-1 METHODS

E-1.1 For Low Aldehyde Content

A suitable colour reaction is available when the aldehyde content (as CH_3CHO) is expected not to exceed 60 mg/1 of the material. This is based on the resinification that takes place and the yellow colour that results on treatment of acetaldehyde with sodium hydroxide. The procedure described under **E-4.1** provides a satisfactory qualitative limit test, but in case of dispute, the quantitative procedure described under **E-4.2** shall be adopted in the qualitative procedure, acetals are also included as aldehydes.

E-1.2 For Higher Aldehyde Content

For materials containing 0.05 to 0.5 percent of aldehydes, only the quantitative procedure described under **E-4.2** shall be adopted.

E-2 APPARATUS

E-2.1 Stoppered Flasks

Two, each of 250 ml capacity and identical in shape, size and colour.

E-3 REAGENTS

E-3.1 Sodium Hydroxide Solution

Dissolve 20 g of sodium hydroxide in water and dilute to 100 ml with water.

E-3.2 Stock Solution of Hydroxylamine Hydrochloride

Dissolve 20 g of hydroxylamine hydrochloride in 100 ml of water.

E-3.3 Meta-phenylenediamine Hydrochloride

E-3.4 Aldehyde Free Alcohol

Re-distil rectified spirit over solid caustic soda or caustic potash, add 2 to 3 g of meta-phenylenediamine hydrochloride per liter of rectified spirit, digest at ordinary temperature for several days or under a reflux condenser on a stream bath for several hours and distil slowly, rejecting the first 100 ml and the last 200 ml of the distillate.

E-3.5 Standard Sodium Hydroxide Solution, 0.1N

E-3.6 Bromophenol Blue Solution

Dissolve 0.1 g of bromophenol blue in 1.5 ml of standard sodium hydroxide solution of hydroxylamine hydrochloride with 100 ml of aldehyde-free alcohol, add 2 ml of bromophenol blue solution and then add standard sodium hydroxide solution till the characteristic dichroic yellowish green colour is obtained.

E-4 PROCEDURE

E-4.1 Qualitative Test

E-4.1.1 Mix 10 ml of the material with 5 ml of sodium hydroxide solution and set aside for 5 min.

E-4.1.2 The limit prescribed for aldehyde content (0.006 g/100 ml) shall be taken as not have exceeded, if no yellowish colour is produced in 5 min.

E-4.2 Quantitative Test

E-4.2.1 Take 50 ml of the material in a flask, add 25 ml of hydroxylamine reagent and 25 ml of distilled water. Allow to stand for 15 min. Meanwhile prepare a blank in a similar flask by using 25 ml of hydroxylamine reagent and 75 ml of distilled water. Titrate this solution with standard sodium hydroxide solution until the characteristic dichroic yellowish green colour appears. Titrate the sample solution with standard sodium hydroxide solution until the colour matches with that of the blank solution.

E-4.2.2 *Calculation*

$$\text{Aldehyde content (as } CH_3CHO\text{), mg/1} = 880 \times (V - v) \times N$$

where

V = volume of standard sodium hydroxide solution required for the titration, in ml;

v = volume of standard sodium hydroxide solution required, if any, in the blank, in ml; and

N = normality of standard sodium hydroxide solution.

ANNEX F

[*Table* 1, *Sl No.* (xi)]

DETERMINATION OF ELECTRICAL CONDUCTIVITY

F-1 GENERAL

This test method is applicable to field and routine laboratory measurements of the electrical conductivity using static samples. This test method utilizes dip-type or pipet-type conductivity cells for testing static samples. Temperature control and correction methods are also provided.

F-2 DETERMINATION OF CELL CONSTANT

F-2.1 For the purposes of this test method, the cell constant of the conductivity cell used shall be known within ±1 percent. The manufacturer's certification of the cell constant within this accuracy is generally considered satisfactory but the user is advised that damage could occur in shipment and it is best to re-check the cell constant when received. If the conductivity cell has been in service for a period subsequent to this certification, it shall be re-checked by the manufacturer, or in the laboratory.

F-2.2 Rinse the conductivity cell several times with water, then at least twice with the KCl reference solution that has conductivity nearest to that of the sample under test. Measure the resistance of the cell. Repeat the measurement on additional portions of the KC1 reference solution until the value obtained remains constant.

F-2.3 For instruments reading measured conductance in Siemens, calculate the cell constant:

$$J = 10^{-6} \times (K_1 + K_2/K_X)$$

where

J = cell constant, cm^{-1};

K_1 = conductivity of the KC1 in the reference solution at the temperature of measurement, µS/cm;

K_2 = conductivity of the water used to prepare the reference solution, at the same temperature of measurement, µS/cm; and

K_X = measured resistance, ohm.

NOTE — Since the conductivities of a mixture of two solutions are not exactly additive, use of $K_1 + K_2$ is only an approximation and requires that K_2 be much smaller than K_1.

F-3 PROCEDURE

F-3.1 Precision Method Using Temperature Control

Use a dip-type or pipet-type cell. Rinse the cell, container, and thermometer thoroughly several times with water and then two or three times with the sample. Adjust the temperature to 15.6 ± 1 °C. Allow sufficient time for equalization of temperatures. Read the conductance. Calculate conductivity according to **F-4** using Q = 1, since temperature correction is required.

F-3.2 Routine Method Using Temperature Correction

Use a dip-type or pipet-type cell. Rinse the conductivity cell thoroughly several times with water and then two or more times with the sample. Measure the resistance and the temperature (to the nearest 0.1 °C), on successive portions of the sample until a constant value is obtained. If the measuring instrument is provided with a manual temperature compensator, adjust this to the sample temperature value before reading the instrument. If an automatic temperature compensator is provided, no adjustment is necessary, but sufficient time must be allowed to permit equalization of temperature. If instrument temperature compensation is used, calculate conductivity according to **F-4** using Q = l.

F-4 CALCULATION

For instruments reading measured conductance in Siemens, calculate the conductivity of the sample:

$$K = \frac{10^6 \times J \times K_X}{Q}$$

where

K = conductivity at 25 °C, µS/cm;

J = cell constant, cm^{-1};

K_X = measured resistance, ohm; and

Q = temperature correction factor.

ANNEX G

[*Table* 1, *Sl No.* (xii)]

DETERMINATION OF COPPER CONTENT IN ETHANOL

G-1 GENERAL

Copper is a very active catalyst for the low-temperature oxidation of hydrocarbons. Experimental work has shown that copper concentrations higher than 0.012 mg/kg in ethanol or ethanol blended gasoline can significantly increase the rate of gum formation. Hence, it is necessary to control and measure the copper presence in the anhydrous ethanol

Three methods have been prescribed for determination of copper content in anhydrous ethanol to be used in blending of automotive gasoline fuel. All the methods can be used for determination of copper content on routine basis. However, in the event of any dispute, Method 3 should be treated as a referee method.

G-2 METHOD 1 AND 2 - CHEMICAL METHODS

Determine the copper content of anhydrous ethanol using methods given in Appendix J of IS 323.

G-3 METHOD 3 ATOMIC ABSORPTION METHOD

G -3.1 General

G-3.1.1 This test method covers the determination of copper by atomic absorption spectrophotometry. This test method is applicable in the range from 0.05 to 5 mg/1 of copper. The range may be extended to concentrations greater than 5 mg/1 by dilution of the sample.

G-3.2 The sample shall be filtered through 0.45 µm membrane filler, if there is any suspended particle otherwise filtration is not necessary.

G-3.3 Summary of Test Method

Copper is determined by atomic absorption spectrophotometry. Copper sample is aspirated directly with no pretreatment.

G-3.4 Interferences

The lower concentration of the element as mentioned below:

> Sodium, potassium, sulphate, and chloride (8 000 mg/l each), calcium and magnesium (5 000 mg/l each), nitrate (2 000 mg/1), iron (1 000 mg/1) and cadmium, lead, nickel, zinc, cobalt, manganese, and chromium (10 mg/l each) do not interfere in the analysis of copper.
>
> NOTE — Instrument manufacturer's instructions for use of specific correction technique should be followed.

G-3.5 Apparatus

G-3.5.1 *Atomic Absorption Spectrophotometer,* for use at 324.7 nm.

> NOTE — The manufacturer's instructions should be followed for all instrumental parameters. A wavelength other than 324.7 nm may be used if it has been determined to be equally suitable.

G-3.5.1.1 *Copper Hollow-Cathode Lamp* — Multi-element hollow-cathode lamps are available and have been found satisfactory.

G-3.5.2 *Pressure-Reducing Valves* — The supplies of fuel and oxidant shall be maintained at pressures somewhat higher than the controlled operating pressure of the instrument by suitable valves which are operated manually or automatically through computer.

G-3.6 Reagents and Materials

G-3.6.1 *Copper Solution, Stock* (1.0 *ml* = 1.0 *mg* Cu)

Dissolve 1.000 g of electrolytic copper contained in a 250 ml beaker in a mixture of 15 ml of HNO_3 (sp gr 1.42) and 15 ml of water. Slowly add 4 ml of H_2SO_4 (1 + 1) and heat until SO_3 fumes evolve. Cool, wash down the beaker with water, and dilute to 1 litre with water or used commercially available SRM.

G-3.6.2 *Copper Solutions Standard* (1.0 ml = 0.1 mg Cu), dilute 100.0 ml of copper stock solution to 1 litre with ethanol.

G-3.6.3 *Nitric Acid (sp gr 1.42), concentrated*

> NOTE — If a high reagent blank is obtained, distill the $HN0_3$ or use a spectro grade acid.

G-3.6.4 *Oxidant*

G-3.6.4.1 *Air*

which has been passed through a suitable filter to remove oil, water, and other foreign substances, is the usual oxidant.

G-3.6.5 *Fuel*

G-3.6.5.1 *Acetylene,* standard, commercially available acetylene is the usual fuel. Acetone, always present in acetylene cylinders, can affect analytical results. The cylinder should be replaced at 345 kPa.

> *CAUTION* — 'Purified' grade acetylene containing a special proprietary solvent rather than acetone should not be used with polyvinyl chloride tubing as weakening of the tubing walls can cause potentially hazardous situation.

G-3.7 Standardization

G-3.7.1 Prepare 100 ml each of a blank and at least four standard solutions to bracket the expected copper concentration range of the samples to be analyzed by diluting the standard copper solution with ethanol. Prepare the standards each time the test is to be performed.

G-3.7.2 Aspirate the blank and standards and record the instrument readings.

G-3.7.3 Prepare an analytical curve by plotting on linear paper the absorbance *versus* standard concentration for each standard. Alternatively, read directly in concentration, if this capability is provided with the instrument.

G-3.8 Procedure

Aspirate each sample and determine its absorbance or Concentration at 324.7 nm.

G-3.9 Calculation

Calculate the concentration of copper in each sample, in milligrams per liter, using an analytical curve or alternatively, read directly in concentration (*see* **G-3.7.3)**.

ANNEX H

[*Table* 1, *Sl No.* xix)]

TEST METHOD FOR HYDROCARBON DETERMINATION IN FUEL ETHANOL BLENDS

H-1 One of the following test procedures can be utilized for hydrocarbon determination in ethanol.

H-2 METHOD A-STANDARD TEST METHOD FOR ETHANOL AND HYDROCARBON DETERMINATION IN FUEL ETHANOL AND GASOLINE BLENDS BY VOLUMETRIC TEST METHOD

H-2.1 Principle

This method is based on phase separation promoted by water (sodium chloride solution) addition to determinate the hydrocarbon (organic phase) content as the volume fraction. Other compounds, such as methanol, higher alcohols, ethers and other oxygenates, are miscible in the aqueous or organic phase and are quantified as ethanol or hydrocarbon content.

NOTE — Volume fraction of hydrocarbons is represented in percentage.

H-2.2 Reagents

H-2.2.1 *Sodium Chloride Solution* (*NaCl*), 100 *g/l*

A solution prepared in accordance with the following or a commercially available sodium chloride solution with equivalent concentration. In order to prepare NaCl 100 g/l, transfer 100 g of NaCl to a 1 000 ml volumetric flask, complete the volume to 1 000 ml with water and homogenize the solution.

H-2.3 Apparatus

H-2.3.1 100 *ml Glass Measuring Cylinder with Stopper* — As shown in Fig. 2, calibrated at 3 points between 95 to 100 ml , and then full range as per the requirement.

NOTE —The measuring cylinder should be also calibrated at other points also, as required.

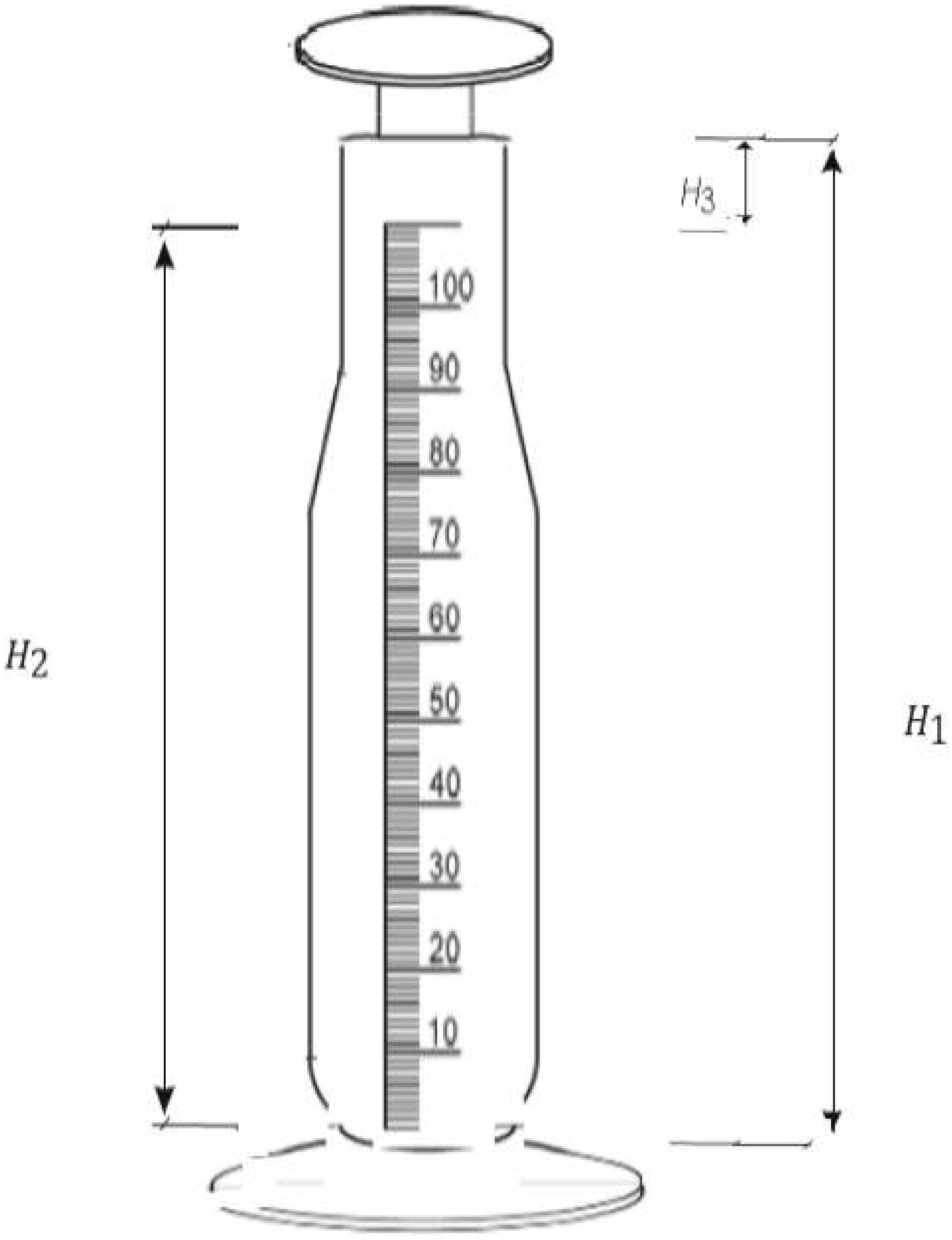
H-2.4 Procedure

H-2.4.1 The sample and the NaCl solution shall be at the room temperature.

H-2.4.2 Place 50 ml of the sample in the clean, defatted and dried measuring cylinder. Add the NaCl solution to complete the measuring cylinder to 100 ml. Place the stopper in the measuring cylinder. Turn the measuring cylinder slowly upside down ten times to extract the ethanol phase without forming an emulsion and preventing excessive pressure. Loosen the stopper to relieve the internal pressure of the measuring cylinder. Replace the stopper. Place the measuring cylinder on a leveled surface. Allow up to 10 min to permit complete separation of the aqueous and organic phase. Read the volume, in ml, of the organic phase by measuring the upper phase and subtracting the measure of the bottom phase. Read the lowest part of the both phases meniscus, as shown in Fig. 3. Record the organic phase volume to the nearest 0.5 ml.

H-2.5 Calculation

H-2.5.1 Calculate the hydrocarbon content in the sample using Table 5.



where

H_1 is the total high (maximum 260 mm);
H_2 is the internal height of the nominal range of indications (minimum 170 mm); and
H_3 is the distance between the upper scale and the top of the cylinder (minimum 35 mm).

FIG. 2 MEASURING CYLINDER DESCRIPTION

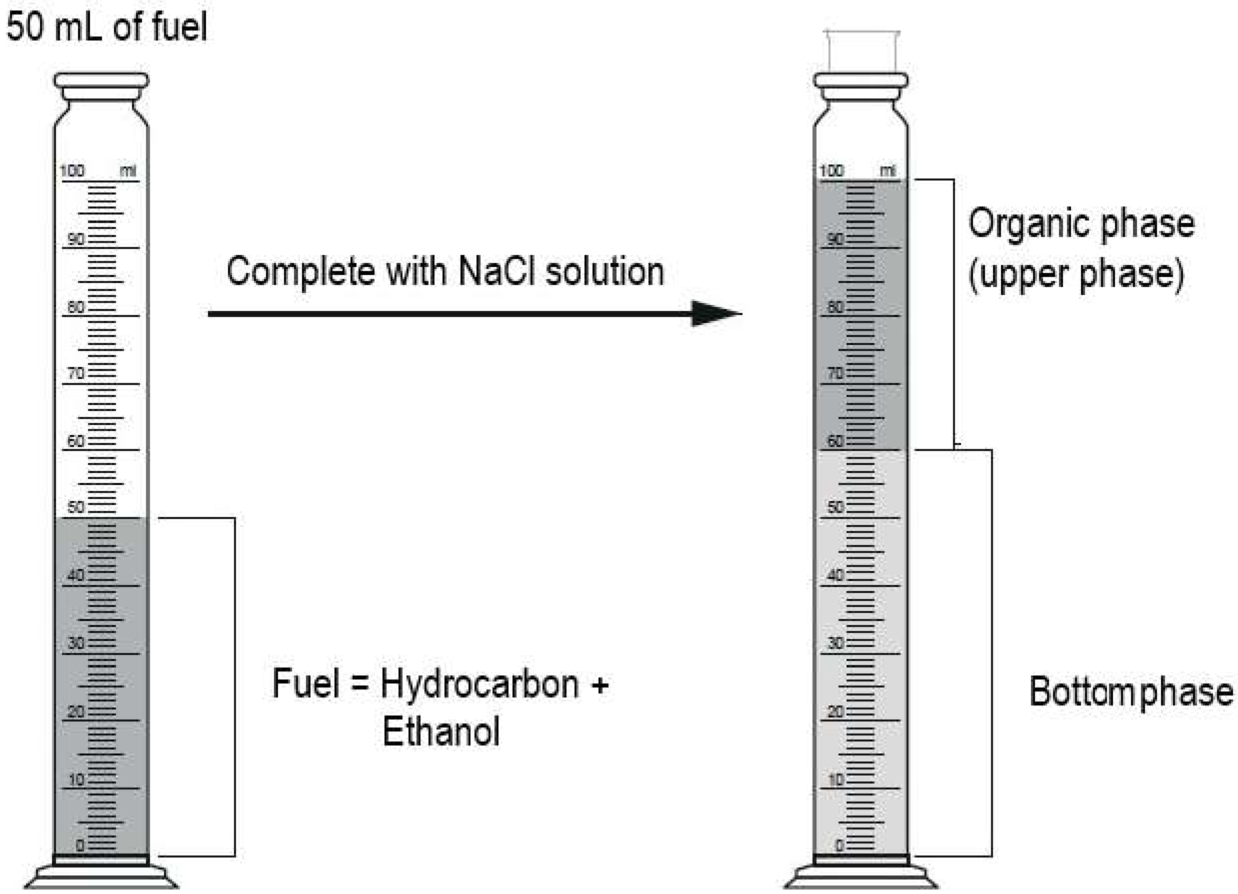


FIG. 3 LECTURE PROCEDURE OF UPPER AND BOTTOM PHASE

Table 5 Hydrocarbon Content in Fuel Sample

(*Clause* H-2.5.1)

V, ml	*H*, percent
Not detected [1]	Not detected [1]
< 0.5	< 2
≥ 0.5	(V × 2)

[1] Record the hydrocarbon content as “not detected”, if a volume of organic phase is not visually identified

where,

V = the volume of organic phase, in milliliters; and

H = the volume fraction of hydrocarbon content.

H-2.6 Report

Express the hydrocarbon content (V, percent) in Anhydrous Ethanol sample as integer number.

H-3 METHOD B — STANDARD TEST METHOD FOR HYDROCARBON DETERMINATION IN FUEL ETHANOL AND GASOLINE BLENDS BY USING GAS CHROMATOGRAPHY

H-3.1 General

H-3.1.1 This test method includes determination of paraffins, olefins, naphthenes, aromatics and unknowns (P.O.N.A.U.) in automotive gasolines and denatured ethanol using gas chromatography and flame ionization detection (GC/FID). The samples having a boiling point more than 225 °C and components such as water cannot be determined.

H-3.1.2 The separation of individual hydrocarbons and oxygenated compounds may result in some peaks that represent coeluting components. Due to this possibility of coeluting peaks, caution is to be taken while interpreting the data.

NOTES

1 Toluene and 2,3,3-trimethylpentane may coelute. If isooctane (2,2,4-trimethylpentane) and 2,3,4-trimethylpentane are present in the gasoline sample, it is probable that the sample contains 2,3,3-trimethylpentane. The concentration of 2,3,3-trimethylpentane is almost certain to be less than the concentration of 2,3,4-trimethylpentane. When determining the concentration of toluene and 2,3,3-trimethylpentane, it is essential that the gas chromatographic integrator has individual peak processing capabilities including peak expansion and perpendicular drop. To detect 2,3,3-trimethylpentane and toluene, it is essential for these components to be within a 5 : 1 ratio of each other with either component having the greater concentration. If these components are present in a greater than 5 : 1 ratio, toluene and 2,3,3-trimethylpentane may appear as a coeluted peak, thus causing the component in the smallest concentration to be integrated with the more concentrated component.

2 Components of automotive gasoline like toluene, 2-methylhexane, methylcyclopentane and n-hexane form coeluted peaks in this method.

The number of coeluting peaks depends on the total number of individual components and olefinic components present in the sample. The possibility of coeluting components increases with the increase of components detected after n-octane.

H-3.2 Summary of Test Method

A sample is introduced into a gas chromatograph equipped with a fused silica, open tubular capillary column coated with a bonded methyl silicone liquid phase. The sample passes through the column and is separated into its individual components. The eluted components are detected using a flame ionization detector and recorded using an integrator or an integrating computer.

H-3.3 Apparatus

H-3.3.1 *Gas Chromatograph*

Any chromatographic instrument capable of the temperature program ranging from 0 °C to at least 300 °C. For sample introduction, the instrument should be equipped with a capillary inlet system designed to provide a linear split of the sample injected. A hydrogen flame ionization detector designed for capillary use is required.

H-3.3.2 *Column*

A fused silica, open tubular column, 100 m in length and 0.25 mm inside diameter, coated with a 0.5 µm thick film of bonded methyl silicone.

H-3.3.3 *Signal Integrator*

An electronic integrating device or computer capable of measuring peak areas and retention times. The integrating device shall be capable of processing a minimum of five hundred peaks using a corrected area normalization technique. The integrating device should be capable of measuring peaks eluting as fast as 0.04 s width at half height and have the capability of peak processing parameters tailored to individual peaks. The electronic ranges of the integrating device shall be within the linear range of the detector/electrometer systems used. Common ranges are 1 V or 10 V.

H-3.3.4 *Sample Introduction*

Any method of sample introduction capable of delivering 0.1 to 0.5 µl to the split injector. Micro syringes, automatic liquid samplers, or valves may be used, if the injection produces a linear split of the sample.

H-3.4 Materials

H-3.4.1 *Carrier Gas* — Helium, 99.999 percent, pure.

H-3.4.2 *Air* — 99.999 percent, pure.

H-3.4.3 *Hydrogen* — 99.999 percent, pure.

NOTE — Hydrogen carrier may change the elution order of some components. Hydrogen carrier will require method optimization and demonstration of equivalency to helium carrier gas.

H-3.4.4 *Make-up Gas (Helium or Nitrogen) m* — 99.999 percent, pure.

H-3.4.5 *Reference Standards* — Hydrocarbons and oxygenated components of known purity.

H-3.5 Procedure

H-3.5.1 *Preparation of Apparatus and Establishment of Conditions*

Install the column in the gas chromatograph oven and condition the column according to the manufacturer's instructions. Adjust the gas chromatograph parameters as mentioned in Table6. These parameters will elute all components up to and including pentadecane (*n* C15).

Instrument parameters can be marginally changed to optimize for sample types and to optimize each gas chromatograph system.

H-3.5.2 Determine the carrier gas flow rate by injection of methane or natural gas. Calculate the linear gas velocity in cm/s using the following equation.

$$linear\ gas\ velocity = \frac{column\ length, cm}{retension\ time\ of\ methane, s}$$

A retention time of 6.51 min for methane at an oven temperature of 0 °C, yielding a linear velocity of 25.6 cm/s, was found to be satisfactory.

H-3.5.3 Calculate and adjust the split ratio using the following equation.

$$split\ ratio = \frac{split\ vent\ flow\ rate \times coloumn\ flow\ rate}{coloumn\ flow\ rate}$$

H-3.5.4 Measure the volumetric flow rate at the column outlet. Alternatively, the volumetric flow rate through a capillary column can be calculated as follows.

$$F = \left[60\,\pi r^2\right]\left[T_{ref}/T\right]\left[2\left(p_i^3 - p_o^3\right)/3p_{ref}\left(p_i^2 - p_o^2\right)\bar{\mu}\right]$$

where

F = calculated column flow rate at standard temperature and pressure, in ml/min;

R = column radius, in cm;

p_i = inlet pressure (absolute), in dyne/cm^2;

p_o = outlet pressure (absolute), in dyne/cm^2;

p_{ref} = reference pressure, typically 1 atm (1.03 × 10^6 dyne/cm^2);

T = column temperature, in K;

T_{ref} = reference temperature, typically 298 K (25 °C);

$\bar{\mu}$ = average linear velocity, in cm/s; and

60 = to convert s to min.

Table 6 Recommended Instrument Parameters

(*Clause* H-3.5.1)

Detector type temperature, °C	Hydrogen flame ionization, 300
Inlet system type temperature, °C	Split 275
Column	
Length, m	100
Internal diameter, mm	0.25
Film thickness, µm	0.5
Stationary phase	Bonded methyl silicone
Temperature program	
Initial temperature, °C	0
Initial hold time, min	15
First program rate, °C/min	1
Final temperature, °C	50
Hold time, min	0
Second program rate, °C/min	2
Final temperature, °C	130
Hold time, min	0
Third program rate, °C/min	4
Final temperature, °C	270
Carrier gas	
Gas type	Helium
Linear velocity at 0°C, cm/s	25.6
Column head pressure, kPa (psi)	270 (35 to 50)
Split ratio	270:1
Sample size, µl	0.1 to 0.5
Total run time, min	142
NOTE — The use of constant flow is recommended.	

H-3.5.5 Make a blank baseline run to ensure that no stray peaks are detected and that the baseline signal at the upper temperature limit is steady and similar to that of the initial signal. The baseline rise at the end of the chromatographic temperature program should not exceed 1 percent of full scale. Further conditioning of the column may be required.

H-3.5.6 *Initial Evaluation and Performance of the Column*

H-3.5.6.1 The column shall meet the resolution requirements value for:

a) Benzene and 1-methyl-1-cyclopentene peaks. The resolution (*R*) value for these two peaks should have a value greater than 1.0.

b) *m*-Xylene and *p*-xylene peaks. The resolution (*R*) value for these two peaks should have a value greater than 0.40.

H-3.5.6.2 Calculate resolution (*R*) by using the following equation:

$$R = \frac{2\left(tR_2 - tR_1\right)}{1.699\,(Wh_2 + Wh_1)}$$

where

tR_1 = retention time of the first peak, seconds;

tR_2 = retention time of the second peak, seconds;

Wh_1 = peak width at half height for the first peak, seconds; and

Wh_2 = peak width at half height for the second peak, seconds.

NOTE — It is recommended that the resolution of the column be checked every 200 samples or a minimum of three times a year to assure column performance.

H-3.5.6.3 Measure the sensitivity of the system by analyzing a 100 mg/kg (0.010 mass percent) heptane standard. The heptane content measured should be 0.010 ± 0.002 mass percent.

H-3.5.6.4 Calculate the percent separation of m-xylene and p-xylene. Measure the distance from the valley between the two peaks to the apex of the m-xylene peak (a). Divide this value by the height of the m-xylene peak (b), and multiply by 100. The separation for gasoline is typically greater than 75 percent.

NOTE — The identification of components is based on retention times. To verify the system performance, it is recommended that the reference gasoline be run at six-month intervals, or when there is a change with the instrument. The purpose is to ensure that retention time drift has not resulted in misidentifications of the components and that the analytical system is continuing to produce accurate peak identifications.

H-3.5.6.5 A quality control (QC) sample shall be representative of samples being analyzed and run at regular intervals. The QC sample should contain oxygenated components at concentrations similar to the oxygenated components in the test samples.An interval of once per week or after every 15 samples is suggested. The quantitation results for benzene can be tracked by statistical quality control charts. Other components of interest in the reference sample can be tracked in a similar manner. By monitoring these components over an extended period of time, the performance of the column and chromatographic system can be determined.

H-3.6 Identification and Standardization

H-3.6.1 *Identification*

Create a reference table similar to that of Table 7 by running the reference gasoline and/or calibration standards and adjusting the retention time or Kovats indices. Pay special attention to peak patterns as retention times for different columns, head pressure, etc., will vary from instrument to instrument.

H-3.6.2 It is recommended that the retention times for all oxygenated components be determined by analyzing calibration standards. Determine the retention times for ethanol and methanol by running concentrations expected in the test sample of both (either together or separately).

The split vent ratio may need to be adjusted in order to minimize ethanol peak tailing at high concentration but still be able to detect the ethanol peak at low concentration.

H-3.6.3 *Standardization*

H-3.6.3.1 The response factors for all components, except oxygenated components, are theoretical response factors and have been calculated using the following equation. All response factors may also be determined by analyzing standards.

$$F_i = \frac{\dfrac{\left[\left(C_{aw} \times C_n\right) + \left(H_{aw} \times H_n\right)\right]}{C_n} \times 0.7487}{C_{aw}}$$

where

F_i = relative response factor for a hydrocarbon type group of a particular carbon number;

C_{aw} = relative atomic mass of carbon;

C_n = number of carbon atoms in the group;

H_{aw} = relative atomic mass of hydrogen; and

H_n = number of hydrogen atoms in the group 0.7487 corrects the response of methane to unity.

In this case, methane will be considered to have a unity (1) response factor.

H-3.6.3.2 It is recommended that the response factors for all oxygenated components, other than ethanol and methanol, be determined by analyzing calibration standards.

H-3.6.3.3 The response factors for ethanol and methanol shall be determined by performing a single point calibration at concentrations dependent on the fuel being analyzed. The calibration standard methanol concentration (mass percent) for the response factor determination shall be within ± 20 percent of the test sample methanol concentration (mass percent).

H-3.6.3.4 The calibration standard ethanol concentration for the response factor determination when analyzing denatured ethanol (shall be in the range of 90 to 99 percent), preferably within ± 2 percent of the test sample ethanol concentration (mass percent).

H-3.6.3.5 The calibration standard ethanol concentration for the response factor determination when analyzing automotive ethanol fuel, E50-E85 shall be within ± 20 percent of the test sample ethanol concentration.

H-3.6.3.6 The calibration standard ethanol concentration for the response factor determination when analyzing oxygenated automotive gasoline containing ethanol, E1-E10, shall be within ± 20 percent of the test sample ethanol concentration, as given in Table 7.

Table 7 Suggested Calibration Standards for Ethanol and Methanol, in Mass Percent

(*Clause* H-3.6.1 *and* H-3.6.3.6)

Calibration Standard Methanol Concentration	Lowest Sample Methanol Concentration	Highest Sample Methanol Concentration
0.05	0.04	0.06
0.1	0.08	0.12
0.2	0.16	0.24
0.3	0.24	0.36
0.4	0.32	0.48
0.5	0.40	0.60
0.6	0.48	0.72
Calibration Standard Ethanol Concentration	**Lowest Sample Ethanol Concentration**	**Highest Sample Ethanol Concentration**
1	0.8	1.2
5	4	6
10	8	12
20	16	24
50	40	60
75	60	90
95	93	97

H-3.6.3.7 Prepare a standard containing ethanol and/or methanol, gravimetrically, at the concentration expected in the test sample and a known concentration of n-heptane using n-octane or iso-octane as the diluent. Correct for impurities and water content in the oxygenate stocks before preparing standards. Where available, certified reference materials may be used. Analyze the standard and calculate the RRF relative to n-heptane. Convert the RRF from relative to n-heptane to relative to methane using the factor 0.892. Methane will be considered to have a unity (1) response factor.

$$RF(n-heptane)=\frac{mass\ percent}{area}$$

$$RF(ethanol)=\frac{mass\ percent}{area}$$

$$RRF(ethanol)=\frac{RF(ethanol)\times 0.892}{RF\ (n-heptane)}$$

H-3.6.4 *Analysis*

H-3.6.4.1 Obtain a representative sample. Precaution should be taken wherever possible to minimize the loss of light ends from volatile samples in automotive gasolines. Obtain sample aliquot, prior to analysis. Cool the sample to less than + 4 °C prior to taking a sample aliquot or prior to filling autosampler vials. The sample aliquot or autosampler vial should be maintained at less than + 4 °C until ready for analysis or autosampler loading. The syringe can be cooled with the sample when using a manual injection technique.

H-3.6.4.2 Introduce a representative sample into the injection port and start the analysis. Obtain a chromatogram and a data report from the integrator. Retention times may differ because of slight variations in oven temperature and column flow rate. Retention times may also differ because of peak size, that is, column overload. Allow for differences in retention times of sample peaks with retention times of the reference peaks in the peak table. A computing integrator may be used for automatic peak identification; however, the chromatogram and report shall be carefully examined to ensure proper identification of the components.

H-3.6.4.3 When toluene and 2, 3, 3-trimethylpentane coelute and integration using perpendicular drop cannot be performed, the amount of each component may be estimated. The amount of 2, 3, 3-trimethylpentane can be estimated based on a fixed ratio to 2 ,3, 4-trimethylpentane. The ratio of 2, 3, 3-trimethylpentane to 2, 3, 4-trimethylpentane in alkylated gasoline is approximately 0.75. Analyze the sample as mentioned in **H-3.6.4.1**. Multiply the concentration of 2, 3, 4-trimethylpentane (mass, volume and mole percent) by 0.75 and subtract this amount from the toluene concentration. Alternatively, analyze the alkylate stream and experimentally determine the exact 2, 3, 4-trimethylpentane to 2, 3, 3-trimethylpentane ratio. Use the calculated ratio for the toluene correction. Subtract the amount of toluene determined from either of these methods from the coeluted toluene/ 2, 3, 3-trimethylpentane peak to obtain corrected values for these components. Report the concentration of toluene and 2, 3, 3-trimethylpentane as “corrected” and state the correction method.

H-3.6.5 *Calculation*

H-3.6.5.1 Calculate the normalized mass percentage of individual components using the following equation:

$$i,\ percent\ by\ mass=\frac{area\ (i)\times rf\ \times 100}{\sum\left[area(i)\times rf\,(i)\times area(k)\times rf\,(k)+...\right]}$$

where,

area (i), area (j), area (k) = area of component i, j, k, etc.

rf (i), rf (j), rf (k) = mass relative response factor for components i, j, k, etc.determined experimentally for the component of interest

H-3.6.5.2 Calculate the normalized volume percentage of individual components using the following equation:

$$i,\ percent\ by\ volume=\frac{\left(\dfrac{C_i}{D_i}\right)\times 100}{\sum\left[\left(\dfrac{C_i}{D_i}\right)+\left(\dfrac{C_k}{D_k}\right)+...\right]}$$

where

C_i, C_j, C_k = percent by mass of components i, j, k, etc.; and

D_i, D_j, D_k = relative density of components i, j, k, etc., all determined at the same temperature.

H-3.6.5.3 Calculate the normalized mole percentage of individual components using the following equation:

$$i,\ percent\ by\ mole=\frac{\left(\dfrac{C_i}{M_i}\right)\times 100}{\sum\left[\left(\dfrac{C_i}{M_i}\right)+\left(\dfrac{C_k}{M_k}\right)+...\right]}$$

Where:

C_i, C_j, C_k = percent by mass of components i, j, k, etc.

M_i, M_j, M_k = relative molecular mass of components i, j, k, etc.

H-3.7 Report

Report the total concentration of paraffins, olefins, naphthenes, aromatics and unknowns on an absolute basis as percent by mass to two significant figures.

ANNEX J

[*Table* 1, *Sl No.* (xix)]

TEST FOR MISCIBILITY WITH WATER

J-1 PROCEDURE

J-1.1 Mix 10 ml of the material with 190 ml of water in a suitable glass vine and allow standing at ambient temperature for atleast 10 min. Compare the clarity of the mixture with that of an equal volume of water.

J-1.2 The material shall be taken to comply with the specified requirement, if there is no noticeable difference in clarity between the mixture and water.

ANNEX K

ADDITIONAL/ALTERNATE TEST METHODS

Parameters	**Alternate Test Method**
Water content	ASTM E1064
Acidity	ASTM D 7795/EN 15491
pHe	D6423
Inorganic chloride	D7319/D7328/EN 15492
Copper	D1688-Method-A/EN 15837/EN 15488
Ethanol content	ASTM D 5501
Methanol content	ASTM D 5501/EN 15721
Sulfur	D2622, D3120, D7039, EN 15485/EN 15486
Sulfate	D7318, D7319, D7328, EN 15492

ANNEX L

(*Foreword*)

COMMITTEE COMPOSITION

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Shrimati Nagamani. T
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Panel for Anhydrous Ethanol Specification-For use as Automotive Fuel and Blending in Motor Gasoline

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(*Continued from second cover*)

Denaturants as prescribed by Central/State Excise departments are applicable, apart from those mentioned in IS 4117.

The alternate test methods are provided in Annex J for the characteristics stated and in case of dispute the referee method shown in the Table 1 shall be followed. Reference to the overseas standards like ISO, ASTM, etc., has been given for the characteristics for which presently there are no Indian Standard available. Once the Indian Standards are formulated, the standard will be updated accordingly.

The composition of the Panel responsible for the formulation of this draft revision is given in Annex L.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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Review of Indian Standards

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This Indian Standard has been developed from Doc No.: PCD 03 (17741).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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ANNEXURE A-10

IS 323 : 2009

(Reaffirmed 2014)
(Reaffirmed 2019)

भारतीय मानक

औद्योगिक प्रयोग के लिए रेक्टीफाइड स्प्रिट — विशिष्टि

(दूसरा पुनरीक्षण)

Indian Standard

RECTIFIED SPIRIT FOR INDUSTRIAL USE — SPECIFICATION

(Second Revision)

ICS 71.100.80

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

March 2009 Price Group 6

Organic Chemicals, Alcohols and Allied Products and Dye Intermediate Sectional Committee, PCD 9

FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Organic Chemicals, Alcohols and Allied Products and Dye Intermediate Sectional Committee had been approved by the Petroleum, Coal and Related Products Division Council.

This standard was first published in 1952. At that time, the minimum ethanol content of rectified spirit had been left to the option of the purchaser and the vendor subject to a minimum of 91.27 percent by volume [60° Overproof (OP)].

The first revision of this standard was carried out in 1959 to upgrade ethanol content and also to modify acidity, residue on evaporation, besides, potassium ferro-cyanide method was prescribed as an alternate method for the determination of copper. This standard covered two grades, Grade 1 suitable for use as a reagent for pharmaceutical/medicinal purposes and for the production of alcoholic beverages and Grade 2 was intended for other industrial purposes. Besides, additional requirement to Grade 1 were laid down to cater to the needs of the acetone industry. The computation of strength of aqueous solutions containing ethanol was made from specific gravity figures at 15.6°C (60°F) and the strength was expressed in terms of percent by volume or of proof spirit in line with prevailing practices in the country.

In this standard, grade relevant for pharmaceutical, medicinal and production of alcoholic beverages has been deleted. A separate standard for potable applications is under formulation. The rectified spirit intended for industrial purpose only is being retained in this revision. The Committee responsible for the formulation of this standard, however, felt that it would be advisable to retain the proof spirit method of expressing strength of alcoholic solutions and its co-relation with specific gravity and percentage of alcohol by volume as well as weight at 20°C as routine method for ease of testing. In this revision, GC method has also been included for determination of ethanol, methyl alcohol, *n*-propanol and *iso*-amyl alcohol. Instrumental methods have been included for determination of specific gravity as an alternative to specific gravity bottle method in this standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

RECTIFIED SPIRIT FOR INDUSTRIAL USE — SPECIFICATION

(Second Revision)

1 SCOPE

This standard prescribes the requirements and the methods of sampling and test for rectified spirit. The material is intended for industrial applications only.

2 REFERENCES

The following standards contain provisions, which through reference in this text constitute provisions of the standards. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the latest edition of the standards indicated below:

IS No.	*Title*
266 : 1993	Sulphuric acid (*third revision*)
1070 : 1992	Reagent grade water (*third revision*)
2302 : 1989	Tables for alcoholometry by hydrometer method (*first revision*)
2362 : 1993	Determination of water by Karl Fischer method — Test method (*second revision*)
6749 : 1972	Glossary of terms relating to alcohol (ethyl) industry and trade
15464 : 2004	Anhydrous ethanol for use in automotive fuel — Specification

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply. Besides, IS 6749 may also be referred for other definitions.

3.1 Ethyl Alcohol — Ethyl alcohol (CAS No. 64-17-5) also referred to as ethanol, alcohol or grain alcohol is a flammable colourless liquid with a characteristic odour having a molecular formula as C_2H_5OH.

3.2 Rectified Spirit — Spirit purified by distillation to achieve strength of not less than 95 percent by volume of ethyl alcohol is a mixture of ethyl alcohol and water.

3.3 Proof Spirit — A measure of the absolute alcohol content of a mixture of ethanol and water, which shall, at a temperature of 10.6°C (or 51°F), weigh exactly 12/13th part of an equal volume of distilled water at the same temperature. It has a density of 0.915 5 at 20°C and contains 49.28 percent by weight of alcohol or 57.10 percent of alcohol by volume at 20°C.

3.4 Overproof Spirit (OP) — Mixture of ethanol and water containing a greater percentage of ethanol than is contained in proof spirit, especially containing more than 50 percent alcohol by volume. If an overproof strength is added to 100, the sum represents the volumes of spirit at proof strength which 100 volumes of spirit of that particular overproof strength would yield when diluted with water. For example, 100 volume of 60° OP spirit would yield 160 volumes of proof spirit.

4 REQUIREMENTS

4.1 Description

The material shall be a clear, colourless, homogenous liquid free from suspended matter and consist essentially of ethyl alcohol admixed with water.

4.2 The material shall also comply with the requirements prescribed in Table 1.

5 PACKING AND MARKING

5.1 Packing

5.1.1 The material shall be packed in such containers as agreed to between the purchaser and the vendor under provisions of law in force from time-to-time.

5.1.2 All containers, in which the material is packed, shall be dry, clean, and leak-free.

5.1.3 Necessary safeguards against the risk arising from the storage and handling of large volume of flammable liquids shall be provided, and all due precautions shall be taken at all times to prevent accident by fire or explosion.

Table 1 Requirements for Rectified Spirit for Industrial Use

(*Clause* 4.2)

Sl No.	Characteristics	Requirement	Method of Test, Ref to	
			IS No.	Annex
(1)	(2)	(3)	(4)	(5)
i)	Specific gravity at 20°C, *Max*	0.812 6	IS 15464	A
ii)	Ethanol content:			
	a) Percent by volume at 20°C, *Min*	95.0	IS 2302	B
	b) Degree overproof, *Min*	66		
iii)	Miscibility with water	Miscible	—	C
iv)	Alkalinity	Nil	—	D
v)	Total acidity (as CH_3COOH), mg/l, *Max*	100	—	D
vi)	Residue on evaporation percent by mass, *Max*	0.01	—	E
vii)	Aldehyde content (as CH_3CHO), mg/l, *Max*	100	—	F
viii)	Ester content (as $CH_3COOC_2H_5$), mg/l, *Max*	200	—	G
ix)	Methyl alcohol, mg/l, *Max*	100	—	H
x)	*n*-Propanol, mg/l, *Max*	1 000	—	B
xi)	*Iso*-amyl alcohol mg/l, *Max*	300	—	B

5.1.4 Except when they are opened for the purpose of cleaning and rendering them free from alcohol vapour, all empty tanks or other containers shall be kept securely closed unless they have been thoroughly cleansed and freed from alcohol vapour.

5.2 Marking

All containers in which the material is stored or transported shall be marked as prescribed by law in force from time-to-time. The labels shall be legible and indelible with the following information:

a) Name of the material;
b) Manufacturer's name;
c) Net gross and tare weight;
d) Recognized trade-mark, if any;
e) Date of packing;
f) Highly flammable; and
g) Hazardous chemical and injurious to health.

5.2.1 *BIS Certification Marking*

The container may also be marked with the Standard Mark.

5.2.1.1 The use of the Standard Mark is governed by the provisions of *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

6 SAMPLING

Representative samples of the material shall be drawn as prescribed in Annex J.

7 TEST METHODS

7.1 Tests shall be conducted as prescribed in col 4 and 5 of Table 1.

7.2 Quality of Reagents

Unless specified otherwise, pure chemicals and distilled water (*see* IS 1070) shall be employed in tests.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities, which affect the results of analysis.

ANNEX A

[*Table* 1, *Sl No.* (i)]

DETERMINATION OF SPECIFIC GRAVITY

A-1 DEFINITION

For the purpose of this standard, the specific gravity of a material shall mean the ratio of the weight of a given volume of the material at a specified temperature to the weight of an equal volume of distilled water at the same temperature.

A-2 METHOD 1 — SPECIFIC GRAVITY BOTTLE METHOD

A-2.1 The specific gravity may be determined by means of a pyknometer or a specific gravity bottle, or a special hydrometer. Specific gravity bottle method is referee method.

A-2.1.1 *Apparatus*

For determination of specific gravity, two alternate specific gravity bottles shown in Fig.1A and Fig.1B are prescribed. In case of a dispute, the vacuum jacketed specific gravity bottles shown in Fig.1A shall be used.

A-2.1.2 *Procedure*

Clean the specific gravity bottle, its stopper and dry it in an oven. Cool the bottle, its stopper under a desiccator to 20° C and record the initial weight (B) Fill the specific gravity bottle with the material to over-flowing ensuring no entrapment of air bubbles. Insert the stopper, immerse the bottle in the water bath maintained at 20 ± 0.2°C and hold for 30 min. Remove the specific gravity bottle from the bath and clean and dry it thoroughly and weigh (A). Repeat the experiment with distilled water (C)

A-2.1.3 *Calculation*

$$\text{Specific gravity, at } 20^\circ\text{C} = \frac{A-B}{C-B}$$

where

A = weight of the specific gravity bottle with the material at 20°C, in g;

B = weight of empty specific gravity bottle, in g; and

C = weight of the specific gravity bottle with water at 20°C, in g.

A-3 METHOD 2 — OSCILLATING SAMPLE TUBE METHOD

Determine the specific gravity of rectified spirit using Method 2 (*see* A-3 of IS 15464 or any other instrumental method such as PAAR Density Meter, etc, provided the method has been validated).

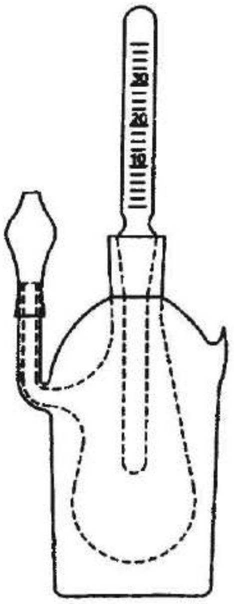

FIG. 1A VACUUM JACKETED SPECIFIC GRAVITY BOTTLE

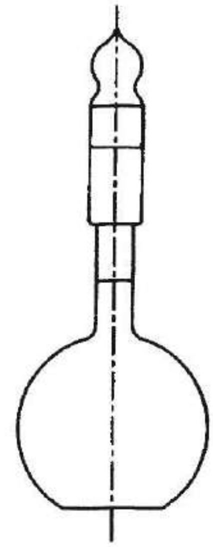

FIG. 1B REGNAULT'S SPECIFIC GRAVITY BOTTLE

ANNEX B

[*Table* 1, *Sl No.* (ii), (x) *and* (xi)]

DETERMINATION OF ETHANOL CONTENT

B-1 GENERAL

Two methods have been prescribed for determination of ethanol content in rectified spirit. Both the methods can be used for determination of ethanol content on routine basis. However, in the event of any dispute, Method 2 should be treated as a referee method.

B-2 METHOD 1 — ALCOHOLOMETRIC METHOD USING HYDROMETER

Determine the ethanol content of anhydrous ethanol using method given in IS 2302.

B-3 METHOD 2 — GAS CHROMATOGRAPHIC METHOD

B-3.1 General

This test method covers the determination of the ethanol content and other components such as aldehyde, ester (as ethyl acetate), methyl alcohol, *n*-propanol and *iso*-amyl alcohol of denatured rectified spirit by gas chromatography.

B-3.1.1 The chromatographic analysis given here is for information and guidance only.

B-3.1.2 Water cannot be determined by this test method and shall be measured by a procedure as given in IS 2362 and the result used to correct the chromatographic values.

B-3.1.3 This test method is inappropriate for impurities that boil at temperatures higher than 225°C or for impurities that cause poor or no response in a flame ionization detector, such as water.

B-3.2 Summary of Test Method

B-3.2.1 A representative aliquot of the ethanol sample is introduced into a gas chromatograph equipped with a methyl silicone bonded phase fused silica capillary column. Suitable carrier gas transports the vapourized aliquot through the column where the components are separated by the chromatographic process. Components are sensed by a flame ionization detector as they elute from the column. The detector signal is processed by an electronic data acquisition system. The ethanol, methanol and other components are identified by comparing their retention, times to the ones identified by analyzing standards under identical conditions. The concentration of all components are determined in mass percent area by normalization of the peak areas.

B-3.3 Apparatus

B-3.3.1 *Gas Chromatograph*, capable of operating at the conditions listed below. A heated flash vaporizing injector designed to provide a linear sample spilt injection (for example, 2:1) is required for proper sample introduction. Carrier gas controls shall be of adequate precision to provide reproducible column flows and split ratios in order to maintain analytical integrity. Pressure control devices and gauges shall be designed to attain the linear velocity required in the column used. A hydrogen flame ionization detector with associated gas controls and electronics, designed for optimum response with open tabular columns, is required.

B-3.3.2 *Sample Introduction* — Manual or automatic liquid syringe sample injection to the splitting injector is employed. Devices capable of 0.1 to 0.5 µl injections are suitable. It should be noted that inadequate splitter design, poor injection technique, and overloading the column can result in poor resolution. Avoid overloading, particularly of the ethanol peak and eliminate this condition during analysis.

B-3.3.3 *Column* — This test method utilizes a fused silica open tubular column with non-polar methyl silicone bonded (cross-linked) phase internal coating. Any column with equivalent or better chromatographic efficiency and selectivity to those described in **B-3.3.3.1** can be used.

B-3.3.3.1 *Column temperature programme*

Column Capillary column coated with 6 percent cyanopropylphenyl, 94 percent dimethylpoly-siloxane

Column length : 30 m
Internal diameter : 0.53 mm
Film thickness : 3 µm
Initial temperature : 40°C
Initial hold time : 5 min
Programme rate : 30°C/min
Final temperature : 230°C
Final hold time : 2 min

Injector

Temperature : 140°C
Split ratio : 2:1
Sample size : 0.1 to 0.5 µl

Detector

Type : Flame ionization
Temperature : 240°C
Carrier gas : Nitrogen (3 ml/min)

B-3.4 Approximate Retention Time

Sl No.	*Name of the Component*	*Retention Times* min
i)	Acetaldehyde	3.96
ii)	Methyl alcohol	4.20
iii)	Ethyl alcohol	5.65
iv)	*n*-Propanol	9.12
v)	Ethyl acetate	10.53
vi)	*iso*-Butanol	12.75
vii)	Benzene	13.46
viii)	Crotonaldehyde	14.83
ix)	*n*-Butanol	15.50
x)	Acetal	17.78
xi)	*Iso*-amyl alcohol	20.88

NOTE — Retention time may change slightly as per actual GC conditions.

B-3.5 Procedure

Separately inject 0.5 µl each of standard and sample and record the chromatogram. Calculate the acetaldehyde, methanol, ethyl acetate, *n*-propanol and *iso*-amyl alcohol in the sample by area normalisation method. Reference may be made to IS 15464 for detailed analysis. A typical gas chromotogram using FID showing retention time is given in Fig. 2.

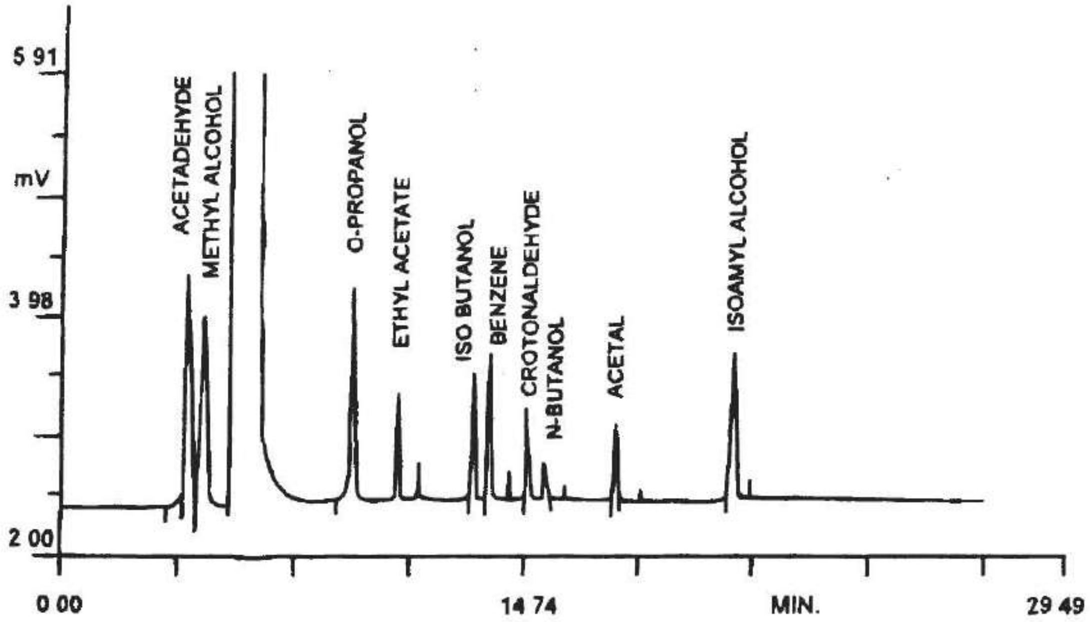

FIG. 2 TYPICAL CHROMATOGRAM FOR RECTIFIED SPIRIT

ANNEX C

[*Table* 1, *Sl No.* (iii)]

TEST FOR MISCIBILITY WITH WATER

C-1 PROCEDURE

C-1.1 Mix 10 ml of the material with 190 ml of water in a suitable glass vine and allow to stand at ambient temperature for minimum 10 min. Compare the clarity of the mixture with that of an equal volume of water.

C-1.1.1 The material shall be taken to comply with the specified requirement, if there is no noticeable difference in clarity between the mixture and water.

ANNEX D

[*Table* 1, *Sl No.*(iv) *and* (v)]

TEST FOR ALKALINITY AND DETERMINATION OF ACIDITY

D-1 REAGENTS

D-1.1 Standard Sodium Hydroxide Solution — 0.1N.

D-1.2 Phenolphthalein Indicator — Dissolve 0.5g of phenolphthalein in 100 ml of rectified spirit and carefully add standard sodium hydroxide solution till the colour is rendered faintly pink.

D-2 PROCEDURE

D-2.1 Place 100 ml of water and a few pieces of clean porous pot in a 500 ml conical flask of resistance glass, and boil gently for 5 min to eliminate carbon dioxide. Cool slightly and add 100 ml of the material. Boil gently for a further period of 5 min. At the end of this period, close the neck of the flask with a stopper carrying a soda-lime guard tube, and allow to cool. When cool, examine for alkalinity; if not alkaline, titrate with standard sodium hydroxide solution using a micro-burette.

D-2.2 Determine the specific gravity of the material at room temperature using a specific gravity bottle or a pyknometer or a suitable hydrometer.

D-3 CALCULATION AND REPORT

D-3.1 Report whether the material is alkaline or acidic.

D-3.2 Calculate the acidity, if any, in terms of acetic acid and express as percentage by weight of the material taken for the test:

$$\text{Acidity (as } CH_3COOH\text{), mg/litre} = 600\ VN$$

where

V = volume of standard sodium hydroxide solution required for the titration , in ml; and

N = normality of standard sodium hydroxide solution.

ANNEX E

[*Table* 1, *Sl No.* (vi)]

DETERMINATION OF RESIDUE ON EVAPORATION

E-1 PROCEDURE

Evaporate, on a water bath, 100 ml or more of the material to dryness in a weighed, clean, dry platinum, silica or resistance glass dish. Dry the residue for 30 min in an oven at a temperature of 100 ± 2°C. Cool in a desiccator and weigh.

E-2 CALCULATION

$$\text{Residue on evaporation, percent by mass} = \frac{B-A}{VS} \times 100$$

where

B = weight of dish after evaporation, drying and cooling, in g;

A = weight of empty dish, in g;

V = volume of the material taken for the test, in ml; and

S = specific gravity of the material determined at room temperature (*see* **D-2**).

ANNEX F

[*Table* 1, *Sl No.* (vii)]

DETERMINATION OF ALDEHYDE CONTENT

F-1 METHODS

F-1.1 For Low Aldehyde Content

A suitable colour reaction is available when the aldehyde content (as CH_3CHO) is expected not to exceed 60 mg per litre of the material. This is based on the resinification that takes place and the yellow colour that results on treatment of acetaldehyde with sodium hydroxide. The procedure described under **F-4.1** provides as satisfactory qualitative limit test, but in case of dispute, the quantitative procedure described under **F-4.2** shall be adopted in the qualitative procedure, acetals are also included as aldehydes.

F-1.2 For Higher Aldehyde Content

For materials containing 0.05 to 0.5 percent of aldehydes, only the quantitative procedure described under F-4.2 shall be adopted.

F-2 APPARATUS

F-2.1 Stoppered Flasks — Two, each of 250 ml capacity and identical in shape, size and colour.

F-3 REAGENTS

F-3.1 Sodium Hydroxide Solution – Dissolve 20 g of sodium hydroxide in water and dilute to 100 ml with water.

F-3.2 Stock Solution of Hydroxylamine Hydrochloride — Dissolve 20 g of hydroxylamine hydrochloride in 100 ml of water.

F-3.3 Metaphenylenediamine Hydrochloride

F-3.4 Aldehyde Free Alcohol — Re-distill rectified spirit over solid caustic soda or caustic potash, add 2 to 3 g of metaphenylenediamine hydrochloride per litre of rectified spirit, digest at ordinary temperature for several days or under a reflux condenser on a stream bath for several hours and distil slowly, rejecting the first 100 ml and the last 200 ml of the distillate.

F-3.5 Standard Sodium Hydroxide Solution — 0.1N.

F-3.6 Bromophenol Blue Solution — Dissolve 0.1 g of bromophenol blue in 1.5 ml of standard sodium hydroxide solution and dilute with water to 250 ml.

F-3.7 Hydroxylamine Reagent (Neutral Alcohol Solution of Hydroxylamine) — Dilute 10 ml of the stock solution of hydroxylamine hydrochloride with 100 ml of aldehyde-free alcohol, add 2 ml of bromophenol blue solution, and then add standard hydroxide solution till the characteristic dichloric yellowish green colour is obtained.

F-4 PROCEDURE

F-4.1 Qualitative Test

F-4.1.1 Mix 10 ml of the material with 5 ml of sodium hydroxide solution and set aside for 5 min.

F-4.1.2 The limit prescribed for aldehyde content (0.006 g per 100 ml) shall be taken as not have exceeded, if no yellowish colour is produced in 5 min.

F-4.2 Quantitative Test

F-4.2.1 Take 50 ml of the material in a flask, add 25 ml of hydroxylamine reagent and 25 ml of distilled water. Allow to stand for 15 min. Meanwhile prepare a blank in a similar flask by using 25 ml of hydroxylamine reagent and 75 ml of distilled water. Titrate this solution with standard sodium hydroxide solution until the characteristic dichromic yellowish green colour appears. Titrate the sample solution with standard sodium hydroxide solution until the colour matches with that of the blank solution.

F-4.2.2 *Calculation*

Aldehyde content (as CH_3CHO), $= 880\ (V - v)\ N$ mg/litre

where

V = volume of standard sodium hydroxide solution required for the titration, in ml;

v = volume of standard sodium hydroxide solution required, if any, in the blank, in ml; and

N = normality of standard sodium hydroxide solution.

ANNEX G

[*Table* 1, *Sl No.* (viii)]

DETERMINATION OF ESTER CONTENT (AS ETHYL ACETATE)

G-1 REAGENTS

G-1.1 Standard Potassium Hydroxide Solutions — Two, 0.1 N and 0.5 N.

G-1.2 Standard Sulphuric Acid (*see* IS 266) — 0.1 N.

G-1.3 Phenolphthalein Indicator — Dissolve 0.5 g of phenolphthalein in 100 ml of rectified spirit and carefully add standard potassium hydroxide solution (0.1 N) till the colour is rendered faintly pink.

G-2 PROCEDURE

G-2.1 Transfer exactly 100 ml of the material into a heat resistant flask of about 200-ml capacity, add a few drops of phenolphthalein indicator and neutralize, in the cold (temperature below 10°C), the free acid, if present, with standard potassium hydroxide solution (0.1 N). Add 2 ml of standard potassium hydroxide solution (0.5 N) attach the flask to a reflux condenser provided with a soda-lime guard tube and reflux the contents on a water bath for at least one hour. Cool the contents (temperature below 10°C), pour into another flask, wash the original flask with 100 ml of freshly distilled water, add the washings to the original liquor and then titrate with standard sulphuric acid adding a few drops of phenolphthalein indicator.

G-2.2 Carry out a blank, using 100 ml of water in place of the neutralized material.

G-3 CALCULATION

Calculate the percentage of esters (as ethyl acetate) as follows:

$$\text{Esters as ethyl acetate } (CH_2COOC_2H_2)\ \text{g}/100\ \text{litre} = 880\,(V_2 - V_1)\,N$$

where

V_1 = volume of standard sulphuric acid required in the blank, in ml;
V_2 = volume of standard sulphuric acid required with the material, in ml; and
N = Normality of standard sulphuric acid.

ANNEX H

[*Table* 1, *Sl No.* (ix)]

DETERMINATION OF METHYL ALCOHOL

H-0 Two methods, namely, spectrophotometric method and gas chromatography methods are employed. The spectrophotometric method is sufficiently sensitive for routine type of analysis. The gas chromatography method is more sensitive and shall serve as a reference method.

H-1 SPECTROPHOTOMETRIC METHOD

H-1.1 Apparatus

H-1.1.1 *Spectrophotometer*, of any make with wavelength range from 350 to 700 nm and a maximum band width of 5 nm.

H-1.2 Reagents

H-1.2.1 *Sodium Bisulphite*, AR grade.

H-1.2.2 *Potassium Permanganate Solution* — Dissolve 3.0 gm of potassium permanganate and 15 ml of phosphoric acid in 100 ml distilled water. The solution shall be prepared monthly.

H-1.2.3 Sodium salt of chromotropic acid solution (Sodium 1, 8-dihydoxy naphthalene - 3, 6 -disulphonate), 5 percent Aqueous solution (*m/v*)

a) Prepare fresh solution every week of either acid or salt and filter, if not clear.

b) If necessary, prepare purified chromotropic acid by dissolving 10 g of chromotropic acid or its sodium salt in 25 ml water (add 2 ml sulphuric acid to aqueous solution of salt to convert it to free acid). Add 50 ml of methyl alcohol heat just to boiling and filter. Add 100 ml *iso*-propyl alcohol to precipitate free acid–chromotropic acid. Add more *iso*-propyl alcohol to complete precipitation of acid.

H-1.2.4 *Methanol Stock Solution* — Dilute 1 g of methanol [99.9 percent (*v/v*)] to 100 ml with 40 percent (*v/v*) ethanol (methanol free). Dilute 10 ml of this solution to 100 ml with 40 percent ethanol (methanol free).

H-1.2.5 *Methanol Standard Solutions* — Dilute appropriate volume of methanol stock solution (*see* **H-2.4**) to 100 ml volumetric flask with 40 percent (*v/v*) ethanol (methanol free) to get final concentration 20, 40, 60, 80, 100 ppm of methanol.

H-1.3 Procedure

Take 50 ml of sample in a distillation flask and distil, collecting about 40 ml of distillate. Dilute 1 ml of distillate to 5 ml with distilled water and shake well. Take 1ml of this solution, 1 ml of distilled water (for blank) and 1 ml of methanol standard solution in to 50 ml stoppered test tubes and keep them in an ice cold water bath. Add to each test tube 2 ml of potassium permanganate reagent and keep aside for 30 min. Decolorize the solution by adding a little sodium bisulphite and add 1 ml of chromotropic acid solution. Mix well and 15 ml of sulphuric acid slowly with swirling and place in hot water bath maintained at 80°C for 20 min. Observe the colour development from violet to red. Cool the reaction mixture to 20°C and measure the absorbance at 575 nm using 1 cm path length cell.

H-1.4 Calculation

Calculate methanol content in g/100 litre of absolute ethanol as follows:

$$\text{Methanol content} = \frac{A_2 \times C \times D \times 1\,000 \times 100 \times 100}{A_1 \times S}$$

where

A_2 = absorbance for sample standard solution;
C = concentration of methanol standard solution, in g/ml;
D = dilution factor for sample solution;
A_1 = absorbance for methanol standard solution; and
S = ethanol content in sample, in percent (*v/v*).

H-2 GAS CHROMATOGRAPHIC METHOD

This test method is related to determination of methyl alcohol content by gas chromatography.

H-2.1 Apparatus

Gas Chromatograph — Any gas liquid chromatograph equipped with FID or TCD detector can be used with following accessories and operating conditions:

Column *Chromosorb* 101

Mesh size : 80/100

Column length : 3 m

I.D. : 3 mm

Column tubing material : Stainless steel (tubing must be non-reactive with substrate, sample and carrier gas)

Carrier gas : Hydrogen for TCD and Helium or Argon or Nitrogen for FID (Purity — 99.99 mole percent, *Min*)

Syringe : 10 ml

Sample size : 0.2 ml

Electronic integration : For computation of results

H-2.1.1 *Instrument Condition*

Detector : TCD or FID

Oven temperature : 110°C

Injector, temperature : 280°C

Detector, temperature : 200°C

Carrier gas flow rate : 30 ml/min

NOTE — The above gas chromatographic conditions are suggestive. However, any GC with different column may be used provided standardization/calibration are done after setting up chromatographic conditions for the required resolution.

H-2.1.2 *Identification, Calibration and Standardization*

Install the column in the chromatograph. Set the conditions given above, of column temperature and carrier gas flow that gives the necessary resolution of the components in the sample being analyzed. Set the conditions as such which gives a minimum 10 percent recorder deflection for a 0.1 percent concentration at the most sensitive setting of instrument. Allow sufficient time for the instrument to reach equilibrium as indicated by stable base line. Adjust carrier gas flow rate to a constant value.

H-2.1.2.1 *Identification*

Determine the retention time of each component by injecting small amount either separately or in known mixture.

H-2.1.2.2 *Calibration and standardization*

The response of any given detector varies from one chemical to another. Therefore, calibration is must. Calibration allows the computation of response factor which express the relative response of different components to the detector.

Calibration standard is prepared containing the impurities present in anhydrous alcohol. During standard preparation the exact amounts of all the components is noted. Inject 0.2 µl of calibration standard in the chromatographic column in accordance with the specified conditions.

Calculate response factor to four decimal places for all components relative to anhydrous alcohol using following equation:

$$Rf_x = \frac{W_x \times AM}{A_x \times WM}$$

where

Rf_x = response factor for component x relative to acetone,

W_x = weight of component x, in the calibration standard,

A_x = area of component x, in the calibration run,

WM = weight of acetone in the calibration standard, and

AM = area of acetone in the calibration standard run which is selected as reference component.

The component which is unknown in the sample is assigned the relative response factor 1.000 0. It is advisable that the determination of response factors be made on the basis of duplicate analysis.

Response factor should be re-checked after any perceptible change in column or instruments performance.

H-3 PROCEDURE

Inject 0.2 µl of sample into the chromatographic column, using the same conditions as for components identification and standardization. Record and integrate the chromatogram using appropriate attenuation setting that provide optimum peak heights. Measure the area of all the peaks.

H-4 CALCULATION

Calculate the concentrations of sample components using the following equation:

$$C_x, \text{ percent} = \frac{f_x \times R_x}{R_x \times f_x} \times 100$$

where

C_x = component x, mass percent,

R_x = peak response of component x,

f_x = relative response factor of componen x, and

$(R_x) \times (f_x)$ = sum of the individual component peak responses (R_x) multiplied by their relative response factors (f_x).

ANNEX J

(*Clause* 6)

SAMPLING OF RECTIFIED SPIRIT

J-1 GENERAL REQUIREMENTS

J-1.0 In drawing, preparing, storing and handling test samples, the following precautions and directions shall be observed.

J-1.1 Samples shall not be taken in an exposed place.

J-1.2 The sampling instrument shall be clean and dry when used.

J-1.3 The samples, the material being sampled, the sampling instrument and the containers for samples shall be protected from adventitious contaminations.

J-1.4 To draw a representative sample, the contents of each container selected for sampling shall be mixed as thoroughly as possible by shaking or stirring or both by suitable means, or by rolling so as to bring all portions into uniform distribution.

J-1.5 The samples shall be placed in suitable, clean, dry and air-tight metal or glass containers, on which the material has no action.

J-1.6 The sample containers shall be of such a size that they are almost but not completely, filled by the sample.

J-1.7 Each sample containers shall be sealed air-tight with a glass stopper after filling, and marked with full details of sampling, the date of sampling, and the year of manufacture of the material.

J-1.8 Samples shall be stored in such a manner that the temperature of the material does not vary unduly from the normal temperature.

J-1.9 Samples shall be protected from light as far as possible.

J-2 SAMPLING INSTRUMENTS

J-2.0 The following forms of sampling instruments may be used:

a) Sampling bottle or can for taking samples from various depths in large tanks, and
b) Sampling tube for sampling homogeneous materials.

J-2.1 Sampling bottle or can consists of a weighed bottle or metal container with removable stopper or top, to which is attached a light chain. The bottle or can is fastened to a suitable pole. For taking a sample, it is lowered in the tank to the required depth, and the stopper or top is removed by means of the chain for filling the container.

J-2.2 Sampling tube for homogeneous liquids is made of metal or thick glass, of 20 to 40 mm diameter and 400 to 800 mm length. The upper and lower ends are conical and reach 5 to 10 mm diameter at the narrow ends. Handling is facilitated by two rings at the upper end. For taking a sample, the apparatus is first closed at the top with the thumb or a stopper and lowered until the desired depth is reached. It is then opened for a short time to admit the material and finally closed and withdrawn.

J-2.2.1 For small containers, the size of the sampling tube may be altered suitably.

J-3 SCALE OF SAMPLING

J-3.1 From a Tank

Take two sets of samples, one from the top and another from the bottom, and test them separately.

J-3.2 Material from a Single Run

Select one container at random and sample as described under **J-4.2**.

J-3.2.1 If the single sample fails to comply with the requirements of the standard, procedure for sampling of material from mixed batches, described under **J-3.3**, may be followed for re-test, if so agreed.

J-3.3 Material from Mixed Batches

J-3.3.1 *Lot*

All the containers in single consignment of material drawn from a single batch of manufacture shall constitute the lot. If a consignment is declared to consist of different batches of manufacture, the batches shall be marked separately and the groups of containers in each batch shall constitute separate lots.

J-3.3.2 *Gross Sample*

A number of containers shall be selected at random from a lot for the purpose of drawing samples for test. This number of containers shall constitute the gross sample. Size of the gross sample in relation to the size of the lot, or the scale of sampling, shall be subject to agreement between the purchaser and the vendor.

J-3.3.3 *Suggested Scales of Sampling*

In the absence of an agreement as to the scale of sampling and a guide to such an agreement, two scales are suggested, namely the normal scale and the low scale, as given in Table 2. The normal scale is to be used wherever possible and the low scale wherever the cost of the tests (including cost of material) is likely to be relatively high.

Table 2 Minimum Number of Containers to be Selected for Sampling from Various Sizes of Lots

Sl No.	Size or Lot	Size of Gross Sample	
		Normal Scale	Low Scale
(1)	(2)	(3)	(4)
i)	Under 25	10	5
ii)	25 to 49	15	5
iii)	50 to 99	20	10
iv)	100 to 199	30	15
v)	200 to 299	40	20
vi)	300 to 499	55	30
vii)	500 to 799	75	40
viii)	800 to 1299	115	55
ix)	1300 to 3199	150	75
x)	3200 to 8000	225	115

NOTE — The two scales of sampling suggested are based on statistical consideration. By using one of these scales, the risk of accepting a defective lot or rejecting a good lot, as judged by the inspection of the number of containers in the gross sample, remains the same, irrespective of the lot size. These risks, however, are different for the two scales of sampling. All sampling plans requiring a given percentage of the lot to be chosen as a sample are considered basically unsound for they invariably lead to relatively higher risks in case of smaller lots. These risks progressively decrease as the size of the lot increases. Furthermore, in the case of very big lots, the percentage sampling plans become uneconomical because of the unnecessarily large size of sample.

J-4 PROCEDURE

J-4.1 Sampling from a Tank

With the help of a sampling bottle or can, draw a sufficient number of samples from the top and the bottom. Keep, the top samples separate from the bottom samples, but mix each of these thoroughly and draw from each three test samples, each not less than 750 ml in volume.

J-4.2 Sampling from Containers

J-4.2.1 The procedure varies according to the size of the containers, namely whether the material is supplied in large containers of 180 litre and more, or in smaller containers.

J-4.2.2 *Mixing Contents of Containers*

Before drawing the test sample, thoroughly mix the contents of all containers in a gross sample, whether they are drums, bottles, cans or others, by shaking or stirring or both by suitable means, or by rolling so as to bring all portions into uniform distribution.

J-4.2.3 *Drawing of Samples*

Draw by inserting the sampling instrument through the bung hole or any other convenient opening, small portions of the material from different parts of each container in the gross sample.

J-4.2.4 *Reduced Samples*

Separately mix the samples drawn from each container obtain a composite sample for the container which shall be not less than 3 litre. Divide this composite sample in to the required number of reduced samples of not less than 750 ml in dried bottles or other containers, seal air-tight and label with all the particulars of sampling given under **J-1.7**.

J-4.2.5 *Test Samples*

The set of samples consisting of one each of the reduced samples, representatives of each of the containers in the gross sample, shall constitute the test sample.

J-4.2.6 *Referee Samples*

One of the test samples, bearing the seals of the purchaser and the vendor, shall constitute the referee sample, to be used in case of dispute between the purchaser and the vendor. It shall be kept at a place agreed between the purchaser and the vendor.

J-5 TESTS FOR ACCEPTANCE

J-5.1 Examination and Tests

The purchaser may examine and test each of the reduced samples constituting a test sample separately for compliance with the requirements of this standard, or he may prepare, for the purpose of such examination and at any stage of the progress of the examination, a composite sample representative of the whole lot, by mixing all the reduced samples constituting the test sample.

J-5.2 Criteria for Judgment

When the individual reduced samples in a test sample are separately examined and the results vary from one reduced sample to another, the criterion for judging the quality of the lot for the purpose of acceptance on the basis of the result obtained shall be as given below, unless otherwise previously agreed between the purchaser and the vendor:

Test Results	*Mean*	*Range*	*Criterion for Acceptance*
1, 2, ……… *n*	$\bar{x}$	*R*	($\bar{x} - 0.6R$) shall be not less than 94.85 percent by volume at 20°C or 66° OP.

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ANNEXURE A-11

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पेट्रोलियम और प्राकृतिक गैस मंत्रालय

अधिसूचना

नई दिल्ली, 4 जून, 2018

मिसिल सं.-पी-13032(16)/18/2017-सीसी.—दिनांक 4 अगस्त, 2017 की सां. आ. सं.2492 (ई) द्वारा भारत के राजपत्र में प्रकाशित भारत सरकार (कारोबार का आबंटन) तीन सौ पैंतीसवें संशोधन नियम, 2017 के तहत प्रदत्त शक्तियों का प्रयोग करते हुए केन्द्र सरकार वर्ष 2009 में नवीन और नवीकरणीय ऊर्जा मंत्रालय के जरिए लागू की गई राष्ट्रीय जैव ईंधन नीति के अधिक्रमण में एक संशोधित जैव ईंधन नीति एतद्वारा बनाती है, नामत:-

1. (1) इस नीति को राष्ट्रीय जैव ईंधन नीति-2018 कहा जाएगा।
   (2) यह नीति मंत्रिमंडल द्वारा अनुमोदन की तारीख अर्थात 16.5.2018 से प्रभावी होगी।

2. इस नीति का पाठ संलग्न है।

राष्ट्रीय जैव ईंधन नीति-2018

1.0 प्रस्तावना

संख्या पी-13032)16)18/2017-सीसी -- 1.1 भारत दुनिया की सबसे तेजी से बढ़ती अर्थव्यवस्थाओं में से एक है और आगामी कुछ दशकों तक जनसांख्यिकीय लाभ भी इसे मिलता रहेगा। विकास का उद्देश्य समावेश पर केंद्रित है, समावेश अर्थात राष्ट्रीय विकास, प्रौद्योगिकी उन्नयन एवं क्षमता निर्माण, आर्थिक विकास, इक्विटी और मानव कल्याण का साझा विजन। नागरिकों के जीवन स्तर के स्तर को बढ़ाने के लिए ऊर्जा एक महत्वपूर्ण इनपुट है। देश की ऊर्जा नीति का उद्देश्य ऊर्जा क्षेत्र में सरकार की हालिया महत्वाकांक्षी घोषणाओं को पूरा करना है, जैसे 2019 तक सभी सेन्सस (जनगणना) गांवों का विद्युतीकरण, 2022 तक 24x7 बिजली और 175 जीडब्ल्यू की नवीकरणीय ऊर्जा क्षमता, 2030 तक 33% -35% तक ऊर्जा

उत्सर्जन की तीव्रता में कमी और वर्ष 2030 तक बिजली मिश्रण में गैर-जीवाश्म ईंधन आधारित क्षमता की 40% से अधिक साझेदारी का उद्देश्य है। भले ही आने वाले दशक में तेल, गैस, कोयला, नवीकरणीय संसाधनों, परमाणु और हाइड्रो ऊर्जा के योगदान में संभावित विस्तार हो, ऊर्जा भंडार में जीवाश्म ईंधन की एक खासी हिस्सेदारी जारी रहेगी। हालांकि, परंपरागत या जीवाश्म ईंधन संसाधन सीमित, गैर- नवीकरणीय और प्रदूषणकारी हैं, इसलिए इनका समझदारी से उपयोग किए जाने की आवश्यकता है । जबकि दूसरी ओर, नवीकरणीय ऊर्जा संसाधन स्वदेशी, गैर प्रदूषणकारी और वास्तव में अक्षय हैं। भारत प्रचुर नवीकरणीय ऊर्जा संसाधनों से संपन्न है। इसलिए, हर संभव तरीके से इनका उपयोग प्रोत्साहित किया जाना चाहिए। राष्ट्रीय जैव ईंधन नीति – 2018, जैव ईंधन पर पहले की राष्ट्रीय नीति की उपलब्धियों पर आधारित है और नवीकरणीय क्षेत्र में उभरती हुई विकास की पुन: परिभाषित भूमिका के अनुरूप नए एजेंडे का निर्माण करती है।

1.2 विश्व बाजार में कच्चे तेल की कीमत में उतार-चढ़ाव होता रहा है। इस तरह के उतार-चढ़ाव दुनिया भर की विभिन्न अर्थव्यवस्थाओं में, विशेष रूप से, विकासशील देशों पर दबाव डाल रहे हैं। सड़क परिवहन क्षेत्र भारत के सकल घरेलू उत्पाद (जीडीपी) का 6.7% है। वर्तमान में, परिवहन ईंधन की 72% अनुमानित मांग केवल डीजल और इसके बाद पेट्रोल 23% मांग और शेष अन्य ईंधन जैसे सीएनजी, एलपीजी इत्यादि पूरी करते हैं जिसकी मांग लगातार बढ़ रही है। अस्थायी अनुमानों ने संकेत दिया है कि वित्त वर्ष 2017-18 में पेट्रोलियम उत्पादों के स्वदेशी उपभोग के लिए 210 एमएमटी कच्चा तेल आवश्यक है। घरेलू कच्चे तेल का उत्पादन केवल 17.9% मांग को पूरा करने में सक्षम है, जबकि शेष आयातित कच्चे तेल से पूरा होता है। जब तक स्वदेशी तौर पर उत्पादित नवीकरणीय फीडस्टॉक के आधार पर पेट्रो आधारित ईंधन का विकल्प/पूरक वैकल्पिक ईंधन का विकास नहीं होता तब तक भारत की ऊर्जा सुरक्षा कमजोर रहेगी। इन चिंताओं को दूर करने के लिए, सरकार ने 2022 तक आयात निर्भरता को 10 प्रतिशत तक कम करने का लक्ष्य रखा है।"

1.3 सरकार ने पांच आयामी नीति अपनाकर, जिसमें घरेलू उत्पादन बढ़ाना, जैव ईंधन और नवीकरण, ऊर्जा दक्षता मानदंड अपनाना, रिफाइनरी प्रक्रियाओं में सुधार और मांग प्रतिस्थापन शामिल करके तेल और गैस क्षेत्र में आयात निर्भरता को कम करने के लिए एक रोड मैप तैयार किया है। इसमें भारतीय ऊर्जा बास्केट में जैव ईंधन के लिए एक रणनीतिक भूमिका की परिकल्पना की गई है।

1.4 जैव ईंधन नवीकरणीय बायोमास संसाधनों और अपशिष्ट पदार्थों जैसे प्लास्टिक, नगरपालिका ठोस अपशिष्ट (एमएसडब्लू), अपशिष्ट गैसों आदि से प्राप्त किया जाता है और इसलिए पारंपरिक ऊर्जा संसाधनों की आपूर्ति द्वारा पर्यावरण के अनुकूल संपोषणीय तरीके से, आयातित जीवाश्म ईंधन पर निर्भरता कम करने और भारत की शहरी और विशाल ग्रामीण आबादी की ऊर्जा आवश्यकताओं को पूरा करने के लिए उच्च स्तर की राष्ट्रीय ऊर्जा सुरक्षा प्रदान करने की आवश्यकता है।

1.5 ऊर्जा सुरक्षा और पर्यावरण संबंधी मुददों के कारण वैश्विक स्तर पर जैव ईंधन को महत्वपूर्ण माना गया है। जैव ईंधन के उपयोग को प्रोत्साहित करने के लिए कई देशों ने अपनी घरेलू आवश्यकताओं को पूरा करने हेतु विभिन्न कार्यप्रणालियों, प्रोत्साहन और सब्सिडी के माध्यम को अपनाया है। ग्रामीण विकास और रोजगार सृजन के लिए एक प्रभावी उपकरण के रूप में, एक प्रथम उपाय के रूप में भारत में जैव ईंधन में स्वदेशी फीडस्टॉक के उत्पादन को बढ़ावा देना होगा।

1.6 पिछले दशक में, सरकार ने एथेनॉल मिश्रित पेट्रोल कार्यक्रम, राष्ट्रीय बायो डीजल मिशन, बायोडीजल अपमिश्रण कार्यक्रम जैसे सुव्यवस्थित कार्यक्रमों के माध्यम से देश में जैव ईंधन को बढ़ावा देने के लिए कई प्रयास किए हैं। पिछले अनुभवों और मांग आपूर्ति की स्थिति के आधार पर, सरकार ने मूल्य निर्धारण, प्रोत्साहन, इथेनॉल उत्पादन के लिए वैकल्पिक मार्ग खोलकर, थोक और खुदरा ग्राहकों को बायोडीजल की बिक्री, अनुसंधान एवं विकास आदि पर ध्यान केंद्रित करके इन कार्यक्रमों में सुधार किया है। इन उपायों से देश में जैव ईंधन कार्यक्रम में सकारात्मक प्रभाव पड़ा है।

1.7 भारत में जैव ईंधन का कार्यनीतिक महत्व है, क्योंकि इससे सरकार द्वारा चलाए जा रहे मेक इन इंडिया और स्वच्छ भारत अभियान जैसे प्रयासों में अच्छे परिणाम प्राप्त हो रहे हैं और यह किसानों की आय को दुगुना करने, आयात में कमी करने, रोजगार सृजन करने, अपशिष्ट से सम्पदा का निर्माण करने के महत्वाकांक्षी लक्ष्यों के साथ एकीकृत करने के लिए शानदार अवसर प्रदान करता है। इसके साथ ही, देश की मौजूदा जैव विविधता को स्थानीय आबादी के लिए सम्पदा सृजन

करने के लिए सुदूर इलाकों का उपयोग करके और स्थायी विकास के लिए योगदान करके इसका अधिकतम उपयोग किया जा सकता है।

1.8 विश्व स्तर पर, जैव ईंधन ने पिछले दशक में ध्यान आकर्षित किया है और जैव ईंधन के क्षेत्र में हुए विकास की गति के साथ तालमेल बनाए रखना जरूरी है। अंतरराष्ट्रीय परिप्रेक्ष्य और राष्ट्रीय परिदृश्य के संदर्भ में इस नीति का उद्देश्य जैव ईंधन के उत्पादन के लिए स्वदेशी फीडस्टॉक्स के प्रयोग से नए सिरे से ध्यान देना है। यह नीति नई फीडस्टॉक्स पर आधारित अगली पीढ़ी के जैवईंधन की रूपांतरण तकनीक के विकास और देश की जैव विविधता का उपयोग करके घरेलू स्तर पर उपलब्ध फीडस्टॉक को बढ़ावा देने पर भी निर्भर है। भारत में जैव ईंधन के विकास के लिए दृष्टि, लक्ष्य, रणनीति और अवधारणा का निर्धारण तकनीकी रूपरेखा, वित्तीय, संस्थागत हस्तक्षेप और सक्षम तंत्र के माध्यम से किया गया है।

2.0 विजन और लक्ष्य

2.1 इस नीति का उद्देश्य आने वाले दशक के दौरान देश के ऊर्जा और परिवहन क्षेत्रों में जैव ईंधन के उपयोग को बढ़ावा देना है। नीति का उद्देश्य घरेलू फीडस्टॉक को बढ़ावा देना और जैव ईंधन के उत्पादन के लिए इसकी उपयोगिता के साथ-साथ एक स्थायी तरीके से नए रोजगार के अवसर पैदा करने के अलावा राष्ट्रीय ऊर्जा सुरक्षा, जलवायु परिवर्तन के अल्पीकरण में योगदान करते हुए जीवाश्म ईंधन का तेजी से विकल्प बनाना है। साथ ही, यह नीति जैव ईंधन बनाने के लिए अग्रिम तकनीकों के आवेदन को प्रोत्साहित करेगी।

2.2 पॉलिसी का लक्ष्य बाजार में जैव ईंधन की उपलब्धता को सुगम बनाना है जिससे उसके मिश्रण प्रतिशत में वृद्धि होगी। वर्तमान में पेट्रोल में इथेनॉल का सम्मिश्रण प्रतिशत लगभग 2.0% है और डीजल में बायोडीजल मिश्रण प्रतिशत 0.1% से कम है। 2030 तक पेट्रोल में इथेनॉल के 20% मिश्रण और डीजल में बायोडीजल का 5% मिश्रण का प्रस्ताव है। यह लक्ष्य निम्नलिखित के माध्यम से हासिल किए जाएंगे:

क) घरेलू उत्पादन में वृद्धि के द्वारा की जा रही इथेनॉल / बायोडीजल आपूर्ति को बढ़ाना

ख) द्वितीय पीढ़ी (2 जी) बायो रिफाइनरीज की स्थापना

सी) जैव ईंधन के लिए नए फीडस्टॉक का विकास

घ) जैव ईंधन में परिवर्तित करने वाली नई प्रौद्योगिकियों का विकास

ई) जैव ईंधन के लिए उपयुक्त वातावरण बनाना और मुख्य ईंधन इसे एकीकृत करना

3.0 परिभाषाएं और कार्यक्षेत्र

3.1 इस नीति के उद्देश्य के लिए जैव ईंधन की निम्नलिखित परिभाषाएं लागू होंगी:

i 'जैव ईंधन' नवीकरणीय संसाधनों से उत्पादित ईंधन हैं और परिवहन, स्टेशनरी, पोर्टेबल और अन्य अनुप्रयोगों के लिए डीजल, पेट्रोल या अन्य जीवाश्म ईंधन के स्थान पर अथवा उसके साथ मिश्रण में इसका प्रयोग किया जाता है;

ii नवीकरणीय संसाधन कृषि, वानिकी, वृक्ष आधारित तेल, अन्य गैर-खाद्य तेलों और संबंधित उद्योगों के साथ-साथ औद्योगिक और नगरपालिका अपशिष्टों के बायोडिग्रेडेबल अंशों के उत्पादों, अपशिष्टों और अवशेषों के बायोडिग्रेडेबल अंश हैं।

3.2 नीति के अंतर्गत "जैव ईंधन" के रूप में ईंधन की निम्नलिखित श्रेणियां शामिल है जिसे परिवहन ईंधन के रूप में या स्टेशनरी अनुप्रयोगों में इस्तेमाल किया जा सकता है: -

i. 'बायोएथेनॉल': बायोमास से उत्पन्न इथेनॉल जैसे कि चीनी युक्त सामग्री, जैसे गन्ना, चुकंदर, मीठे चारा आदि; स्टार्च युक्त मकई, कसावा, पके आलू, शैवाल आदि; और, सेल्यूलोजिक सामग्रियों जैसे कि बगैस, लकड़ी का कचरा, कृषि और वन अवशेष या औद्योगिक अपशिष्ट जैसे अन्य नवीकरणीय संसाधन;

ii. 'बायोडीजल': गैर-खाद्य वनस्पति तेलों, एसिड तेल, खाना पकाने के तेल या पशु वसा और जैव-तेल से बने फैटी एसिड के मिथाइल या एथिल एस्टर;

iii. 'उन्नत जैव ईंधन': (1) लिगोनोसेलुलोजिक फीडस्टॉक्स (जैसे कृषि और वनों के अवशेष, जैसे चावल और गेहूं के भूसे / मकई सीओएस और स्टेवर / बैगेस, वुडी बायोमास), गैर-खाद्य फसलों (यानी घास, शैवाल) से उत्पन्न ईंधन या औद्योगिक कचरे और अवशेष प्रवाह, (2) कम सीओ$_2$ उत्सर्जन या उच्च जीएचजी में कमी और भूमि उपयोग के लिए खाद्य फसलों के साथ प्रतिस्पर्धा नहीं करते। द्वितीय पीढ़ी (2 जी) एथेनॉल, ड्रॉप-इन ईंधन, शैवाल आधारित 3 जी जैव ईंधन, जैव-सीएनजी, जैव-मेथनॉल, जैव-मेथनॉल से उत्सृजित दि मिथाइल ईथर (डीएमई) जैव-हाइड्रोजन, एमएसडब्ल्यू के साथ ईंधन में गिरावट जैसे ईंधन स्रोत/ फीडस्टॉक सामग्री "उन्नत जैव ईंधन" के रूप में मान्य होंगे।

iv. 'ड्रॉप-इन ईंधन': बायोमास, कृषि अपशिष्टों, निगम ठोस अपशिष्ट (एमएसडब्ल्यू), प्लास्टिक अपशिष्ट, औद्योगिक अपशिष्ट आदि से उत्पादित तरल ईंधन, जो कि एमएस, एचएसडी और जेट ईंधन के लिए भारतीय मानकों पर खरा उतरता है और जो यथावत या मिश्रित रूप में बाद में, इंजन सिस्टम में किसी भी संशोधन के बिना वाहनों में उपयोग किया जाता है और वर्तमान पेट्रोलियम वितरण प्रणाली का उपयोग कर सकता हैं।

v. 'जैव-सीएनजी': जैव-गैस का शुद्ध रूप जिसकी संरचना और ऊर्जा क्षमता जीवाश्म आधारित प्राकृतिक गैस के समान है और इसे कृषि अवशेषों, पशुओं के गोबर, खाद्य अपशिष्ट, एमएसडब्ल्यू और सीवेज पानी से उत्पन्न किया जाता है।

4.0 रणनीति और दृष्टिकोण

4.1 सरकार जैव ईंधन के उपयोग को बढ़ावा देने एवं प्रोत्साहन हेतु बहु-आयामी दृष्टिकोण को इस प्रकार अपना रही है:

o एथेनॉल मिश्रित पेट्रोल (ईबीपी) प्रोग्राम के माध्यम से कई फीडस्टॉक्स से प्राप्त एथेनॉल का उपयोग करके पेट्रोलियम में एथेनॉल का सम्मिश्रण ।

o सेकंड जनरेशन (2जी) एथेनॉल प्रौद्योगिकियों का विकास और इसका व्यावसायीकरण।

o स्टेशनरी, कम आरपीएम इंजनों में सीधे वनस्पति तेल के इस्तेमाल सहित कई फीडस्टॉक की खोज करके बायोडीजल ब्लेंडिंग कार्यक्रम के माध्यम से डीजल में बायोडीजल को सम्मिश्रित करना ।

o एमएसडब्ल्यू, औद्योगिक अपशिष्ट, बायोमास आदि से बने ड्रॉप-इन ईंधन पर विशेष ध्यान।

o जैव-सीएनजी, जैव-मेथनॉल, डीएमई, जैव-हाइड्रोजन, जैव-जेट इंधन आदि सहित उन्नत जैव ईंधनों पर विशेष ध्यान ।

4.2 इस नीति का मुख्य बल स्वदेशी फीडस्टॉक से जैव ईंधन की उपलब्धता सुनिश्चित करना है। इस दिशा में कदम बढ़ाते हुए, देश भर में बायोमास के मूल्यांकन के लिए राष्ट्रीय बायोमास भंडार तैयार किया जाएगा।

4.3 जैव ईंधन की मांग और आपूर्ति के दरम्यान पुनः संतुलन बनाने के प्रयास तहत, सरकार का उद्देश्य जैव ईंधन के घरेलू उत्पादन, भंडारण और वितरण के संबंध में जब भी आवश्यकता पड़े सभी हितधारकों को शामिल करते हुए परामर्शी अवधारणा अपनाकर जरूरी अंतर- हस्तक्षेप करना है।

4.4 इस कार्यनीति के अंतर्गत समय-समय पर ऐसे उपयुक्त वित्तीय एवं राजकोषीय उपाय किए जाएंगे जिससे जैव ईंधन के विकास और संवर्धन को समर्थन मिले ताकि विभिन्न क्षेत्रों में इनका उपयोग बढ़े।

4.5 विभिन्न अंतिम-उपयोग अनुप्रयोगों के लिए फीडस्टॉक उत्पादन और जैव ईंधन प्रसंस्करण के सभी पहलुओं तक पहुँच के लिए अनुसंधान, विकास और प्रतिपादन का समर्थन किया जाएगा। उन्नत जैव ईंधन और अन्य नए फीडस्टॉक के विकास के लिए जोर दिया जाएगा।

5.0 अंतर- हस्तक्षेप एवं समुचित प्रक्रियाएँ

क. फीडस्टॉक की उपलब्धता एवं इसका विकास

5.1 भारत में, बायोएथेनॉल कई स्रोतों से उत्पन्न किया जा सकता है जैसे कि शर्करा युक्त सामग्री, स्टार्च युक्त सामग्री, सेल्यूलोज और पेट्रोरसायनिक मार्ग सहित लिगोनोसेलुलोज सामग्री। लेकिन, इथनॉल मिश्रित पेट्रोलियम (ईबीपी) कार्यक्रम की मौजूदा नीति गैर-खाद्य फीडस्टॉक जैसे शीरा, सेलूलोज़ और पेट्रोकेमिकल रूट सहित लिगोनोसेल्ज सामग्री से बायोएथेनॉल की खरीद की अनुमति देती है I इसी तरह, किसी भी खाद्य / गैर खाद्य तेल से बायोडीजल का उत्पादन किया जा सकता है। हालांकि, सम्मिश्रण कार्यक्रम के लिए उपयोग क्ये जाने वाला बायोडीजल वर्तमान में आयातित स्रोतों जैसे पाम स्टीयरिन से निर्मित किया जा रहा है।

5.2 देश में जैव ईंधन के उत्पादन के लिए संभावित घरेलू कच्चे माल के रूप निम्न पदार्थ उपलब्ध हैं,

एथेनॉल उत्पादन के लिए :	बी-शीरा, गन्ने का रस, घास के रूप में बायोमास, कृषि अवशेष (चावल का पुआल, कपास की डंठल, मकई के कोष, लकड़ी का बुरादा, खोई इत्यादि), शक्कर युक्त सामग्री, जैसे चुकंदर, चारा इत्यादि और स्टार्च युक्त सामग्री जैसे मकई, कसावा, सड़ा हुआ आलू आदि, अनाज जैसे गेहूं, चावल इत्यादि के खराब दाने जो कि खाने योग्य नहीं हों, आधिक्य के समय अनाज के कण I शैवाल युक्त फीडस्टॉक और समुद्री शैवाल की खेती भी एथेनॉल उत्पादन के लिए एक संभावित फीडस्टॉक हो सकती है।
बायोडीजल उत्पादन के लिए:	अखाद्य तिलहन, इस्तेमाल किया हुआ खाना पकाने का तेल (UCO), पशुओं की चर्बी, एसिड आयल, शैवाल फीडस्टॉक इत्यादि।
उन्नत जैव ईंधन के लिए :	बायोमास, एमएसडब्लू, औद्योगिक अपशिष्ट, प्लास्टिक अपशिष्ट आदि I

5.3 ईबीपी कार्यक्रम के तहत एथेनॉल की खरीद के लिए कच्चे माल का दायरा बढ़ाया जाएगा। इस नीति में बी-शीरे और सीधे गन्ने के रस से एथेनॉल के उत्पादन की अनुमति होगी। इस नीति में मानव उपभोग हेतु अयोग्य खराब खाद्यानो जैसे गेहूं, टूटे चावल आदि से एथेनॉल का उत्पादन करने की भी अनुमति होगी। एक कृषि फसल वर्ष के दौरान जब कृषि और किसान कल्याण मंत्रालय द्वारा यह अनुमान लगाया जाए कि खाद्यान्न की पैदावार आपूर्ति से काफी अधिक होगी तो इस नीति के तहत प्रस्तावित राष्ट्रीय जैव ईंधन समन्वय समिति के अनुमोदन के आधार पर, इस अतिरिक्त खाद्यान्न की मात्रा को एथेनॉल में परिवर्तित करने की अनुमति होगी। एथेनॉल उत्पादन के लिए इस मार्ग के खुलने से न केवल खाद्यान्न आधारित डिस्टिलरीज की स्थापित क्षमता का उपयोग करने में मदद मिलेगी, अपितु न्यूनतम निवेश के साथ पूरी तरह से विकसित 1जी तकनीक का इस्तेमाल करके इसमें उन सभी कच्चे सामग्रियों को भी शामिल किया जा सकेगा, जिनसे एथेनॉल का उत्पादन किया जा सकता है।

5.4 औद्योगिक स्थापना को बढ़ावा देने के लिए अतिरिक्त उपलब्ध बायोमास वाले स्थानों की पहचान और ऊर्जा घास और बेकार जमीन पर छोटी अवधि की फसलों का उपयोग जैसे फीडस्टॉक का उत्पादन इस दिशा में निर्णायक होगा। देश में अधिशेष बायोमास वाले स्थानों की पहचान करने पर विशेष बल दिया जाएगा।

5.5 जैव ईंधन उत्पादन के लिए स्वदेशी फीडस्टॉक की आपूर्ति बढ़ाने में ग्राम पंचायत और समुदाय महत्वपूर्ण भूमिका निभाएंगे। फीडस्टॉक पीढ़ी के लिए बंजर भूमि के उपयोग से संबंधित मामलों में, ग्राम पंचायत/तालुकों के स्थानीय समुदायों को पौधों के लिए गैर-खाद्य तिलहन/फसलों जैसे पोंगामिया पिन्नता (करंज), मेलिया अजादिरचट्टा (नीम), एरंड, जाट्रोपा केरकस, कॉलोफिलम इनोफिलम, सिमरोबा ग्लॉका, हिबिस्कस कैनबिनस आदि के पौधारोपण के लिए प्रेरित किया जा सकता है। पूरे देश में बायोएथेनॉल के उत्पादन के लिए अतिरिक्त फीडस्टॉक बनाने के लिए लघु रोटेशन फसल जैसे कि मीठे ज्वार और ऊर्जा घास जैसे मिसकेनथुस जाईगंटम, स्विचग्रास (पैनिकम विग्राटम), विशालकाय रीड (अरुंडो डोनाक्स) इत्यादि को बंजर भूमि में लगाया जा सकता है।

5.6 जहाँ वर्षा निर्भर परिस्थितियों के चलते केवल एक ही फसल में उगाई जाती है, वहाँ के किसानों को तिलहन के साथ ही अपनी सीमान्त भूमि पर अलग-अलग बायोमास की विविध प्रजातियों को अंतर फसल एवं दूसरी फसल के रूप में लगाने के लिए प्रोत्साहित किया जाएगा।

5.7 स्थानीय निकायों, राज्यों और संबंधित हितधारकों के साथ बेहतर तालमेल रखकर सम्बद्ध समुदायों के लिए समुचित आपूर्ति श्रृंखला तंत्र, फीडस्टॉक कलेक्शन केंद्र और उचित मूल्य तंत्र विकसित किए जाएंगे।

5.8 एमएसडब्लू, औद्योगिक अपशिष्ट, प्लास्टिक कचरा आदि जैसे कचरे की पर्याप्त मात्रा देश भर में उपलब्ध संग्रह तंत्र के साथ उपलब्ध है। यह जैव-सीएनजी, ड्रॉप-इन ईंधन, जैव-मेथनॉल, डीएमई, जैव-हाइड्रोजन आदि जैसे जैव ईंधन पैदा करने के लिए फीडस्टॉक के रूप में कार्य करेगा।

ख. सम्मिश्रण और बायोरिफाइनरी कार्यक्रम

5.9. एथेनॉल मिश्रित पेट्रोल कार्यक्रम

5.9.1 वर्तमान में, ईबीपी कार्यक्रम के लिए एथेनॉल चीनी उद्योग के उप-उत्पाद के रूप में शीरा उत्पाद से आ रहा है। गन्ना और चीनी उत्पादन के वर्तमान स्तर (क्रमशः 350 एमएमटी और 26-28 एमएमटी प्रति वर्ष) में उपलब्ध अधिकतम शीरा लगभग 13 एमएमटी है, जो लगभग 300 करोड़ लीटर अल्कोहल / एथेनॉल का उत्पादन करने के लिए पर्याप्त है। वर्तमान में, शराब / एथेनॉल का उत्पादन करने के लिए सी-भारी शीरा का इस्तेमाल किया जा रहा है।

5.9.2 चीनी की उपलब्धता के अनुसार एथेनॉल उत्पादन के लिए बी-भारी शीरा रूट को अपनाने के लिए प्रोत्साहित किया जाएगा। एक एमएमटी शुगर के उत्सर्ग पर 60 करोड़ लीटर इथनॉल का उत्पादन किया जा सकता है। इस विकल्प का उपयोग करने से एथेनॉल उत्पादन में सहयोगी डिस्टिलरीज़ में सुधार हो सकेगा। मिश्रण प्रतिशत को बढ़ाने के लिए सीधे गन्ने के रस से एथेनॉल उत्पादित किए जाने की अनुमति होगी।

5.9.3 एथेनॉल के उत्पादन के लिए अन्य वैकल्पिक कच्ची सामग्रियां जैसे कि शुगर युक्त सामग्री- चुकन्दर, ज्वार, आदि तथा स्टार्च युक्त जैसे - मकई, कसावा, सड़ा हुआ आलू आदि जैसे सामग्रियों का पहली पीढ़ी की पूर्णरूपेण विकसित प्रौद्योगिकियों का उपयोग करके किया जाएगा। राष्ट्रीय जैव-ईंधन समन्वय समिति के निर्णय के अनुसार खाद्यान की अधिशेष उपलब्धता होने पर खाद्यानों जैसे मक्का आदि से एथेनॉल उत्पादित किए जाने की अनुमति होगी।

5.10 दूसरी पीढ़ी (2 जी) एथेनॉल

5.10.1 शीरे के माध्यम से एथेनॉल उत्पादन की अपनी सीमाएं हैं और मद्यपान और केमिकल उद्योगों में इसका प्रतिस्पर्धात्मक उपयोग होने से ईबीपी कार्यक्रम के लिए यह उपलब्ध हो पाएगा, इसकी संभावना में संदेह है। यह वारंट पारंपरिक शीरा रूट और गन्ना रस रूट से अलग एथेनॉल के अन्य स्रोतों की तलाश करता है।

5.10.2 भारत में किए गए कुछ अध्ययनों में प्रति वर्ष **120 -160** एमएमटी की अतिरिक्त बायोमास उपलब्धता का संकेत दिया गया है**,** जिसे परिवर्तित करने पर प्रति वर्ष **3000** करोड़ लीटर एथेनॉल प्राप्त किया जा सकता है। अतिरिक्त बायोमास / कृषि अपशिष्ट जो सेल्यूलोसिक और लिग्नोसेल्लोसिक किस्म की सामग्री है**,** इसको दूसरी पीढ़ी (**2** जी) की प्रौद्योगिकियों का उपयोग करके एथेनॉल में परिवर्तित किया जा सकता है। भारत सरकार ने ग्रामीण अर्थव्यवस्था और ईबीपी कार्यक्रम को आगे बढ़ाने में बायोमास की भूमिका को मान्यता दी है और शीरे के अलावा पेट्रोकेमिकल मार्ग सहित अन्य गैर-खाद्य फीडस्टॉक जैसे सेल्यूलोजिक और लिग्नॉसेल्यूलोजी सामग्री से उत्पादित एथेनॉल की खरीद की अनुमति दी है बशर्ते कि संबंधित बीआईएस मानकों का अनुपालन होता हों। इस नीति के तहत कार्रवाई के लिए निम्नलिखित क्षेत्रों की परिकल्पना की गई है:

5.10.3 प्रोत्साहन: वैश्विक रूप से, 2 जी इथेनॉल उद्योग प्रोत्साहनों के माध्यम से संचालित किया जाता है क्योंकि अभी इस प्रौद्योगिकी को व्यावसायिक पैमाने पर सिद्ध होना है और इस प्रकार उत्पादित एथनॉल अधिक पर्यावरण सापेक्ष है। यह 2 जी एथनॉल बायो रिफाइनरीज के बुनियादी ढांचागत विकास को संचालित करने में एक प्रमुख साधन होगा।

5.10.4 ऑफटेक आश्वासन: सार्वजनिक क्षेत्र की तेल विपणन कंपनियाँ निजी हितधारकों को आश्वस्त बाजार प्रदान करने और 2 जी एथनॉल अभ्युपायों में सहायता देने के लिए 15 वर्ष की अवधि के लिए 2 जी एथनॉल आपूरकों के साथ एथनॉल खरीद समझौते (ईपीए) पर हस्ताक्षर करने के लिए सहमत हो गई हैं। सार्वजनिक क्षेत्र की गैस विपणन कंपनियों द्वारा जैव-सीएनजी को 2जी इथनॉल बायो रिफाइनरीज में प्रमुख उप-उत्पाद और परिवहन ईंधन होने के कारण ऑफटेक आश्वासन के तहत लाया जाएगा।

5.11. बायोडीजल सम्मिश्रण कार्यक्रम

5.11.1 फीडस्टॉक उपलब्धता से संबंधित बाधाओं के कारण देश में डीजल में बायोडीजल का समग्र सम्मिश्रण 0.5 प्रतिशत से कम रहा है। इसके अलावा, सम्मिश्रण कार्यक्रम के लिए जो भी बायोडीजल आ रहा है वह आयातित स्रोतों से तैयार होता है। इस कार्यक्रम की दीर्घकालिक सफलता के लिए इस प्रकार के बायोडीजल उत्पादन के लिए घरेलू कच्चे माल का सुनिश्चय करना अत्यावश्यक है।

5.11.2 घरेलू उत्पादित/अपशिष्ट कूकिंग ऑयल (यूसीओ/डब्ल्यूसीओ) में बायोडीजल उत्पादन के स्रोत होने की संभावना है। लेकिन विभिन्न छोटे भोजनालयों/विक्रेताओं और व्यापारियों के माध्यम से खाद्य स्ट्रीम के लिए यूसीओ के उपयोग के तौर तरीके में बदलाव लाना है। खाद्य प्रवाह में यूसीओ के प्रवेश को रोकने और बायोडीजल उत्पादन के लिए इसकी आपूर्ति बढ़ाने के लिए उपयुक्त संग्रहण तंत्र विकसित करने के लिए कड़े मानदंड बनाने पर फोकस किया जाएगा।

5.12 अन्य जैव ईंधन (ड्रॉप-इन-ईंधन, जैव-सीएनजी, जैव-हाइड्रोजन,जैव-मेथनॉल, डीएमई,आदि)

5.12.1 नीति आयोग द्वारा बनाए गए अपशिष्ट से ऊर्जा कार्यदल ने अनुमान लगाया है कि भारत में हर वर्ष 62 एमएमटी नगरीय ठोस अपशिष्ट (एमएसडब्लू) होता है। रिफ्यूज्ड उत्सर्जित ईंधन, बायो गैस/बिजली और कृषि में सहायता के लिए इस अपशिष्ट में खाद सहित ड्रॉप-इन-ईंधन तैयार करने और बिजली उत्पन्न करने की भारी क्षमता है।

5.12.2 विश्वभर में, कचरे को ड्राप-इन-ईंधन, जैव-सीएनजी, जैव-हाइड्रोजन आदि जैसे जैव ईंधनों में परिवर्तित करने के लिए उपलब्ध प्रौद्योगिकियां नवप्रवर्तनशील चरण में हैं और इन्हें व्यावसायिक स्तर पर साबित होने की जरूरत है। ऐसे कचरे का जैव-सीएनजी में रूपांतरण एक मॉडल है जिसे ग्रामीण इलाकों में ऊर्जा की मांग को पूरा करने और पर्यावरण संबंधी मसलों को करने के लिए प्रोत्साहित किया जाएगा। इस नीति के अनुरूप प्रति यूनिट संसाधित अपशिष्ट से बायो-सीएनजी का अधिक उत्पादन करने वाली प्रोद्योगिकियां प्रोत्साहित की जाएंगी। विभिन्न प्रोत्साहनों और ऑफटेक आश्वासन के माध्यम से उन्नत ईंधनों के उत्पादन के लिए ऐसे संयंत्र लगाने में भी वृद्धि की जाएगी। इसी तरह, रिफाइनरियों सहित कई उद्योगों में हाइड्रोजन का उपयोग सबसे महंगे ईंधन के रूप में पता लगाया गया है। बायोमास और अपशिष्ट से उत्पादित बायो-हाइड्रोजन, अन्वेषण करने के लिए दिलचस्प प्रस्ताव होगा।

5.12.3 विश्वभर में, परिवहन ईंधन के रूप में मोटर स्प्रिट के साथ सम्मिश्रण में मेथनॉल के उपयोग का पता लगाया गया है। इसी प्रकार कृषि अपशिष्टों, प्राकृतिक गैस, उच्च राख कोयला आदि सहित विभिन्न स्रोतों से ही इसका उत्पादन किया

जा सकता है। इस समय भारत मेथनॉल का विशेष आयातक है। अतिरिक्त बायोमास उपलब्धता में जैव-मेथनॉल और बायो-बॉटियनॉल के उत्पादन की संभावना है और भारतीय परिवहन व्यवस्था में उसके अनुप्रयोग का पता लगाया जाएगा।

5.12.4 डाय-मिथाइल ईथर (डीएमई) मेथनॉल के 2 अणुओं से पानी के 1 अणु को निकालकर प्राप्त किया जाता है, जो एक रासायनिक प्रक्रिया है, जो आमतौर पर उत्प्रेरक की सहायता से प्राप्त होती है। आरएंडडी संस्थानों द्वारा प्रोपेन के विकल्प के रूप में घरेलू एलपीजी में (डीएमई) का उपयोग किया जा रहा है। डीएमई धीमे आरपीएम डीजल इंजनों में डीजल के लिए एक विकल्प भी हो सकता है और इसलिए व्यापक उपयोग, औद्योगिक अनुप्रयोग और संभावित ईंधन के रूप में डीएमई की स्वीकृति मेथनॉल के औद्योगिक उत्पादन को बढ़ावा देने के लिए उचित है।

5.12.5 उच्च तेल घटक, सीमित अपशिष्ट स्ट्रीम और न्यूनतम भूमि आवश्यकताओं (बायोमास की तुलना में), उत्पादन मार्ग पर निर्भरता की दृष्टि से शैवाल (3 जी) से जैव ईंधन के उत्पादन की काफी अच्छी संभावनाएँ हैं। वर्तमान में, इस तरह के ईंधन का उत्पादन अपने प्रारंभिक चरण में है और वाणिज्यिक व्यवहार्यता के संबंध में आगे की परीक्षण की आवश्यकता है। तकनीकी-व्यावसायिक व्यवहार्यता प्राप्त करने के लिए शैवाल आधारित जैव ईंधन और इस विषय पर अपेक्षित आर एंड डी को प्रोत्साहित किया जाएगा।

ग. वित्त व्यवस्था

5.13 सरकार वित्तीय संस्थानों द्वारा उधार देने के उद्देश्य से प्राथमिक क्षेत्र के तौर पर जैव ईंधनों के बायोडीजल के उत्पादन व भंडारण और वितरण के बुनियादी ढांचे के लिए तेल निष्कासन/निष्कर्षण और प्रसंस्करण इकाइयों की घोषणा करने पर विचार करेगी।

5.14 कार्बन वित्तपोषण के अवसरों सहित जैव ईंधन विकास के लिए बहु-पक्षीय और द्विपक्षीय वित्त पोषण के स्रोतीकरण को प्रोत्साहित किया जाएगा।

5.15 जैव ईंधन क्षेत्र में संयुक्त उद्यम और निवेश को प्रोत्साहित किया जाएगा। जैव ईंधन प्रौद्योगिकियों में 100% विदेशी प्रत्यक्ष निवेश (एफडीआई) को स्वचालित अनुमोदन मार्ग के माध्यम से प्रोत्साहित किया जाएगा, बशर्ते कि इस प्रकार उत्पादित जैव ईंधन घरेलू उपयोग के लिए ही हो।

घ. वित्तीय और राजकोषीय प्रोत्साहन

5.16 सरकार जैव ईंधन के लिए व्यवहार्यता अंतरण वित्तपोषण, सब्सिडी और अनुदान सहित वित्तीय प्रोत्साहनों का विस्तार करने पर विचार करेगी। सरकार उन्नत जैव ईंधन के रूप में द्वितीय पीढ़ी (2 जी) इथनॉल, ड्रॉप-इन ईंधन, बायो-सीएनजी, शैवाल आधारित 3 जी जैव ईंधन, जैव-मेथनॉल, डीएमई, जैव-हाइड्रोजन आदि का वर्गीकरण करेगी। वित्तीय प्रोत्साहन देने के लिए एक राष्ट्रीय जैव ईंधन फंड पर विचार किया जा सकता है।

5.17 2जी इथनॉल बायो रिफाइनरीज स्थापित करने के लिए स्टेकहोल्डर्स को प्रोत्साहित करने के लिए इस पॉलिसी में टैक्स क्रेडिट, संयंत्र खर्च पर अग्रिम मूल्यह्रास, 1 जी इथनॉल के साथ-साथ अंतर मूल्य निर्धारण, व्यवहार्यता गैप फंडिंग (वीजीएफ) आदि के रूप में वित्तीय प्रोत्साहन के साथ प्रारंभिक "उन्नत बायो ईंधन" उद्योग को प्रोत्साहित करने पर विचार करना है। "उन्नत जैव ईंधन" कार्यक्रम को आगे बढ़ाने के लिए योजनाएं शुरू की जाएंगी।

5.18 जैव ईंधन फीडस्टॉक के निर्माण और शुद्ध या मिश्रित रूप में जैव ईंधन के उपयोग पर सीओ 2 उत्सर्जन की बचत के लिए कार्बन क्रेडिट पैदा करने के अवसरों का पता लगाया जाएगा।

5.19 नाबार्ड और अन्य सार्वजनिक क्षेत्र के बैंकों को वित्त पोषण, साफ्ट ऋण आदि के माध्यम से वित्तीय सहायता प्रदान करने के लिए प्रोत्साहित किया जाएगा।

ड. अनुसंधान एवं विकास और प्रदर्शन

5.20 दूसरी पीढ़ी के विकास और घरेलू फीडस्टॉक का उपयोग करने वाले उन्नत जैव ईंधनों के लिए मजबूत प्रौद्योगिकी फोकस आवश्यक है। यह पॉलिसी इनोवेशन को प्रोत्साहित करती है और अनुसंधान एवं विकास गतिविधियां करते समय विकसित / उभरती प्रौद्योगिकियों का उपयोग करते हुए जैव ईंधनों के क्षेत्र में अनुसंधान एवं विकास (आर एंड डी) और

प्रदर्शन पर बल देती है। अनुसंधान और विकास गतिविधियां जैव ईंधन उत्पादन, बागान, प्रसंस्करण और रूपांतरण प्रौद्योगिकियों के लिए नए कच्चे माल के विकास के क्षेत्र में होंगे। विभिन्न अंत-उपयोग अनुप्रयोगों और उप-उत्पादों के उपयोग की क्षमता बढ़ाने के लिए दक्षता सुधार और नवाचार को प्रोत्साहित किया जाएगा। स्थानीय फीडस्टॉक्स के आधार पर स्वदेशी अनुसंधान एवं विकास तथा प्रौद्योगिकी विकास को उच्च प्राथमिकता दी जाएगी। जहां संभव हो पेटेंट पंजीकृत किए जाएंगे। स्पष्ट रूप से परिभाषित लक्ष्य और उपलब्धियों के साथ बहु संस्थानों को शामिल करते हुए बायोईंधनों के क्षेत्र में अनुसंधान कार्यक्रम में सहयोग किया जाएगा।

5.21 गहन अनुसंधान एवं विकास कार्य के अभिज्ञात क्षेत्रों में शामिल है.

(क): बायो ईंधन फीडस्टाक उत्पादन

(ख): अभिज्ञात फीडस्टॉक से उन्नत अंतरण प्रोद्योगिकियां

(ग): बायो ईंधनों के आशोधनों सहित अन्त्य प्रयोक्ता अनुप्रयोगों की प्रोद्योगिकियां

(घ): बायो ईंधनों के उप उत्पादों का उपयोग

5.22 जैव ईंधन उत्पादन के लिए प्रायोगिक/ प्रदर्शन परियोजनाएं स्थापित की जाएंगी। अनुसंधान संगठनों, आर एंड डी के लिए संस्थानों और प्रदर्शन परियोजनाओं की स्थापना, उच्च प्रौद्योगिकी वाले क्षेत्रों में विशेष केंद्रों के लिए अनुदान प्रदान किया जाएगा। मौजूदा अनुसंधान एवं विकास केन्द्रों को मजबूत किया जाएगा और व्यापक उपयोग/अनुप्रयोग के लिए अनुसंधान संगठन, संस्थाओं और उद्योगों के बीच संबंध स्थापित किए जाएंगे। सरकार अनुसंधान एवं विकास तथा प्रौद्योगिकी के क्षेत्र में उद्योग की भागीदारी को प्रोत्साहित करेगी, जिसमें उद्योग को सुविधा प्रदान करने के बारे में जानकारी प्रदान की जाएगी।

5.23 कम से कम जीएचजी उत्सर्जन के लिए अंतरराष्ट्रीय मंचों पर हमारी प्रतिबद्धताओं को देखते हुए जैव ईंधन क्षेत्र में उभरती हुई प्रौद्योगिकी के जीवन चक्र विश्लेषण (एलसीए) महत्वपूर्ण है। प्रोत्साहित कार्य निष्पादन एलसीए रिपोर्ट का वादा और जलवायु परिवर्तन पर हमारी प्रतिबद्धताओं के अनुसार, प्रदर्शन/ व्यावसायिक स्तर पर परवर्ती तैनाती के लिए प्रायोगिक चरण में प्रौद्योगिकियों को स्वच्छ प्रौद्योगिकी के रूप में प्रोत्साहित किया जाएगा।

5.24 राष्ट्रीय, द्विपक्षीय और बहुपक्षीय अनुसंधान कार्यक्रमों के माध्यम से ज्ञान को जोड़ने के लिए संबंधित मंत्रालयों के साथ-साथ अकादमिक और उद्योग के प्रतिनिधियों वाले जैव ईंधन के क्षेत्रों में अनुसंधान और विकास को बढ़ावा देने के लिए एक संकेंद्रित समूह का गठन किया जा सकता है।

च. गुणवत्ता मानक

5.25 विभिन्न जैव ईंधन और अंत उपयोग अनुप्रयोगों के लिए मानकों और प्रमाणीकरण की शुरुआत के साथ-साथ परीक्षण विधियों, प्रक्रियाओं और प्रोटोकॉल का विकास प्राथमिकता पर किया जाएगा। भारतीय मानक ब्यूरो (बीआईएस) ने पहले से ही स्वैच्छिक और मिश्रित रूप अनुप्रयोगों के लिए बायोएथनॉल, बायोडीजल के मानकों का विकास किया है। उच्च सम्मिश्रण स्तर के लिए विनिर्देशों का विकास चल रहा है।

5.26 भारतीय मानक ब्यूरो (बीआईएस) मौजूदा मानकों की समीक्षा करेगा और उन्हें अपडेट करेगा, साथ ही विभिन्न अंत-उपयोग अनुप्रयोगों के लिए उपकरणों और प्रणालियों के नए मानकों को विकसित करेगा। उत्पाद के प्रदर्शन और विश्वसनीयता के लिए दिशा-निर्देश सभी प्रासंगिक हितधारकों के परामर्श से भी विकसित और संस्थागत होंगे

5.27 यह नीति आवश्यक कौशल सेटों के विकास को प्रोत्साहित करेगी ताकि जैव ईंधन उद्योग की नई मांगों के अनुकूल होने के लिए प्रशिक्षित और कुशल जनशक्ति उपलब्ध हो।

छ. जैव ईंधनों का वितरण एवं विपणन

5.28 तेल विपणन कंपनियां जैव ईंधनों का भंडारण, वितरण और विपणन जारी रखेंगे। जैव ईंधनों की आवश्यकताओं को पूरा करने के लिए वे भंडारण, वितरण और विपणन बुनियादी ढांचे को बनाए रखने और सुधारने के लिए मुख्य रूप से जिम्मेदार

होंगे। सरकार गुणवत्ता मानक सुनिश्चित करने, सम्मिश्रण प्रतिशतता के बारे में उपभोक्ता जागरूकता, वारंटी की आवश्यकता आदि जैसे घटकों के आधार पर जैव ईंधनों के वितरण और विपणन के लिए अन्य कंपनियों को अनुमति देने पर भी विचार कर सकती है।

ज. जैव ईंधनों का मूल्य निर्धारण

5.29 इस उद्देश्य के लिए गठित एक समिति की सिफारिश के आधार पर वर्तमान में ईबीपी कार्यक्रम के लिए पहली पीढ़ी के एथनॉल आधारित शीरे की कीमत का निर्धारण सरकार द्वारा निर्धारित किया जा रहा है। डीजल में मिश्रण के लिए बायोडीजल की खरीद के लिए ओएमसी द्वारा मूल्य निर्धारित किया जा रहा है। बाजार की स्थितियों, घरेलू बाजार में जैव ईंधन की उपलब्धता, आयात प्रतिस्थापन आवश्यकता आदि सहित विभिन्न कारकों के आधार पर सरकार प्रशासित कीमतों या बाजार निर्धारित कीमतों से पहली पीढ़ी के जैव ईंधन को प्रोत्साहित करना जारी रखेगी। उन्नत जैव ईंधनों को और प्रोत्साहित करने के लिए एक अंतर मूल्य दिया जाएगा। उन्नत जैव ईंधन के लिए अंतर मूल्य निर्धारण के लिए तंत्र का निर्णय राष्ट्रीय जैव ईंधन समन्वय समिति द्वारा किया जाएगा।

6.0 जैव ईंधनों का आयात एवं निर्यात

6.1 जैव ईंधन का देशी उत्पादन व्यावहारिक और युक्तियुक्त प्रोत्साहनों के एक सेट से प्रोत्साहित किया जाएगा। जैव ईंधनों का आयात काफी हद तक हतोत्साहित होगा। जैव ईंधन के आयात की अनुमति देने का निर्णय देश में जैव ईंधनों की उपलब्धता, अंतरराष्ट्रीय कीमतों और अन्य कारकों के आधार पर राष्ट्रीय जैव ईंधन समन्वय समिति द्वारा लिया जाएगा।

6.2 इस नीति ने फीडस्टॉक उत्पादन के लिए बंजर भूमि का उपयोग करते हुए जैव ईंधन के लिए स्वदेशी फीडस्टॉक की आपूर्तियों को बढ़ाने के लिए प्रोत्साहित किया है। तथापित, घरेलू फीडस्टॉक की उपलब्धता और सम्मिश्रण की आवश्यकता के आधार पर, जैव डीजल के उत्पादन के लिए फीडस्टॉक के आयात को आवश्यकता की सीमा तक अनुमति होगी। प्रस्तावित इस नीति के तहत राष्ट्रीय जैव ईंधन समन्वय समिति द्वारा फीडस्टॉक आयात की आवश्यकताओं का निर्णय लिया जाएगा।

6.3 चूंकि घरेलू जैव-ईंधनों की उपलब्धता देश की आवश्यकता से बहुत कम है इसलिए जैव-ईंधनों के निर्यात की अनुमति नहीं होगी।

7.0 स्टेक धारकों की भूमिका

7.1 सभी हितधारकों अर्थात मंत्रालयों / विभागों, राज्य सरकारों, किसानों, व्यवसाय और उद्योग और व्यावसायिकों की निम्नलिखित क्षेत्रों में सक्रिय भागीदारी सुनिश्चित की जाएगी:

i) बंजर भूमि पर टिकाऊ तरीके से फीडस्टॉक का उत्पादन
ii) किसानों को अपने सीमांत भूमि पर फीड स्टॉक की किस्मों को विकसित करने के लिए प्रोत्साहन
iii) फीडस्टॉक के लिए उपयुक्त आपूर्ति श्रृंखला की स्थापना
iv) फीडस्टॉक स्टोरेज इंफ्रास्ट्रक्चर
v) एकल खिड़की की मंजूरी और शीघ्र स्वीकृति
vi) जैव ईंधन संयंत्रों के लिए कर प्रोत्साहन, सब्सिडी वाली बिजली, पानी की आपूर्ति, एक्सेस सड़कों इत्यादि जैसे प्रोत्साहन

क. राज्यों की भूमिका

7.2 जैव ईंधन कार्यक्रम का सफलतापूर्वक कार्यान्वयन राज्यों की सक्रिय भागीदारी पर काफी हद तक निर्भर करता है। जिन राज्यों ने अपने यहां जैव ईंधन बोर्ड स्थापित किए हैं उनके अनुभवों को उपयोग करके अन्य राज्यों में जैव ईंधन बोर्ड स्थापित किए जाएंगें तथा राज्य सरकारों को अपने यहां जैव ईंधन के विकास एवं बढ़ावे के लिए इन एजेंसियों/बोर्डों को उपयुक्त रूप से सशक्त बनाने के लिए प्रोत्साहित किया जाएगा। अन्य स्टेक धारकों को भी कार्यक्रम हेतु नामांकित किया जाएगा।

7.3 राज्य सरकारें को अखाद्य तिलहन पौधों की रोपण या जैव ईंधन के अन्य फीडस्टॉक्स हेतु भूमि के प्रयोग तथा इस प्रकार के पौधों को उगाने के लिए परती तथा खाली पड़ी सरकारी भूमि के आवंटन पर भी निर्णय लेने की आवश्यकता होगी। समस्त मूल्य श्रृंखला में जैव ईंधन परियोजनाओं को सहारा देने के लिए आवश्यक बुनियादी ढांचे का भी निर्माण करना होगा।

7.4 जैव ईंधन पौधों को लगाने के लिए एकल खिड़की की मंजूरी देने हेतु राज्यों को भी प्रोत्साहित किया जाएगा। राज्य सरकारें राजकोषीय प्रोत्साहनों, कर छूट, सब्सिडी वाली बिजली की आपूर्ति, प्राथमिकता से सब्सिडी दरों पर भूमि आवंटन के साथ शुरुआती कुछ जैव ईंधन संयंत्रों को सहारा देने के लिए प्रतिबद्ध रहेंगी।

ख. मंत्रालयों/विभागों की भूमिका

7.5 देश में जैव ईंधन कार्यक्रम के प्रभावी कार्यान्वयन हेतु विभिन्न मंत्रालयों और विभागों की भूमिका को निम्न सारणीबद्ध किया गया है :

मंत्रालय/विभाग	भूमिका
पेट्रोलियम एवं प्राकृतिक गैस मंत्रालय	• जैव ईंधन के विकास के हेतु समग्र समन्वय मंत्रालय • राष्ट्रीय जैव ईंधन नीति और इसका कार्यान्वयन • जैव ईंधन के आवेदन पर अनुसंधान, विकास और प्रदर्शन • जैव ईंधन का विपणन और वितरण • जैव ईंधन के मिश्रण का स्तर • मूल्य निर्धारण और खरीद नीति का विकास और कार्यान्वयन • विवाद निवारण • उन्नत जैव ईंधन अनुसंधान और क्षमता निर्माण के लिए अंतरराष्ट्रीय सहयोग को बढ़ावा देना • परिवहन ईंधन के लिए एमएसडब्लू
ग्रामीण विकास मंत्रालय	ग्रामीण आजीविका कार्यक्रमों मनरेगा आदि के साथ बागवानी, आपूर्ति श्रृंखला गतिविधियां ।
कृषि और सहयोग विभाग (कृषि और परिवार कल्याण मंत्रालय)	अन्य मंत्रालयों के साथ समन्वय करके जैव ईंधन के लिए वृक्षारोपण और नर्सरी के जरिए संयंत्र सामग्री का उत्पादन।
पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय (एमईईएफ और सीसी)	• वन भूमि पर जैवईंधन वृक्षारोपण और जैव ईंधन से संबंधित पर्यावरण संबंधी मुद्दे • बागानों और आपूर्ति श्रृंखला के रखरखाव में समुदायों की भागीदारी
विज्ञान और प्रौद्योगिकी मंत्रालय (जैवप्रौद्योगिकी विभाग तथा विज्ञान एवं प्रौद्योगिकी विभाग)	• विविध फीडस्टॉक्स पर अनुसंधान एवं विकास और जैव ईंधन विकास के लिए प्रौद्योगिकियों में सुधार। • जैव ईंधन (बायोफ्यूल) क्षेत्र में नवाचार और अत्याधुनिक अनुसंधान को बढ़ावा देना। • बायोरिफ़ाइनरी और वैल्यू वर्धित उत्पादों के लिए प्रौद्योगिकियों का विकास।
सड़क परिवहन और राजमार्ग मंत्रालय	• परिवहन क्षेत्र में जैव ईंधन के उपभोग / उपयोग को बढ़ावा दें।
रेल मंत्रालय	• जैव ईंधन की खपत / उपयोग को प्रोत्साहन ।
उपभोक्ता मामलों के विभाग (एम ओ सीए, एफ व पी डी)	• अनांतिम उपयोग हेतु जैव ईंधन की गुणवत्ता नियंत्रण को सुनिश्चित करने के लिए विनिर्देशों, मानकों और कोडों को निर्धारित करना ।
भारी उद्योग और सार्वजनिक उद्यम मंत्रालय	• बाजार में उपलब्ध जैव ईंधन के अनुकूल बनाने के लिए उपस्कर निर्माताओं को सलाह देना।
नवीन और नवीकरणीय ऊर्जा मंत्रालय	• बायोमास / शहरी, औद्योगिक और कृषि कचरे से बायोगैस के माध्यम से ऊर्जा उत्पन्न / उत्पन्न करना।
आवास और शहरी गरीबी उन्मूलन मंत्रालय	• एमएसडब्लू की उपलब्धता हेतु नगर निकायों और राज्यों के साथ समन्वय करना। यह शहरी क्षेत्रों में पालिकाओं के ठोस अपशिष्ट सहित जैवईंधन हेतु आवश्यक फीड स्टॉक है, जिसके लिए इस मंत्रालय द्वारा नीतियों को जारी किया जा रहा है।
उपभोक्ता, खाद्य एवं सार्वजनिक वितरण मंत्रालय, खाद्य और सार्वजनिक वितरण विभाग	• एथेनॉल डिस्टिलरीज स्थापित करने के लिए चीनी क्षेत्र में उपयुक्त वित्तीय प्रोत्साहन देने के लिए डीएफपीडी

8.0 अंतरराष्ट्रीय सहयोग

8.1 जैव ईंधन के क्षेत्र में नए सिरे से ध्यान देने के कारण, राष्ट्रीय प्राथमिक के अनुसार अंतरराष्ट्रीय स्तर पर वैज्ञानिक और तकनीकी सहयोग स्थापित किए जाएंगे । इसमें अनुसंधान एवं विकास संस्थानों और उद्योगों से जुड़े संयुक्त अनुसंधान और प्रौद्योगिकी विकास, क्षेत्रीय अध्ययन, पायलट पैमाने के संयंत्र और प्रदर्शन परियोजनाओं में सहयोग शामिल होगा। प्रौद्योगिकियों को साझा करने और वित्तपोषण के लिए उपयुक्त द्विपक्षीय और बहु-पार्श्व सहयोग कार्यक्रम विकसित किए जाएंगे।

9.0 संस्थागत तंत्र

क. केंद्र में जैव ईंधन नीति संस्थागत तंत्र

9.1 व्यावसायिक नियमों के आवंटन के तहत, देश में जैव ईंधन के विकास और उन्नयन के विभिन्न पहलुओं के साथ व्यवहार करते हुए विविध मंत्रालयों को जिम्मेदारी सौंपी जा रही है। शामिल व्यापक दृष्टिकोण / कार्य क्षेत्र के कारण विभिन्न विभागों और एजेंसियों के बीच तालमेल आवश्यक है। यह जैव ईंधन विकास, उन्नयन और उपयोग के विभिन्न पहलुओं पर नीति मार्गदर्शन और प्रारंभिक समीक्षा के लिए एक सशक्त समिति की अपेक्षा है।

9.2 पेट्रोलियम और प्राकृतिक गैस मंत्री की अध्यक्षता वाली राष्ट्रीय जैव ईंधन समन्वय समिति (एनबीसीसी) स्थापित करने की परिकल्पना की गई है। संबंधित मंत्रालयों के प्रतिनिधि इस समिति के सदस्य होंगे। समग्र समन्वयन, प्रभावी अंत-से-अंत के कार्यान्वयन तथा जैव ईंधन कार्यक्रमों की निगरानी प्रदान करने हेतु समिति समय-समय पर बैठक आयोजित करेगी। राष्ट्रीय जैव ईंधन समन्वय समिति की निम्न प्रकार संरचना होगी:

अध्यक्ष : पेट्रोलियम और प्राकृतिक गैस मंत्री

सदस्य:

i. सचिव, पेट्रोलियम और प्राकृतिक गैस मंत्रालय

ii. सचिव, ग्रामीण विकास विभाग, ग्रामीण विकास मंत्रालय

iii. सचिव, कृषि, सहयोग और किसान कल्याण, कृषि और किसान कल्याण मंत्रालय

iv. सचिव, पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय

v. सचिव, विज्ञान और प्रौद्योगिकी विभाग, विज्ञान और प्रौद्योगिकी मंत्रालय

vi. सचिव, व्यय विभाग, वित्त मंत्रालय

vii. सचिव, सड़क परिवहन और राजमार्ग मंत्रालय

viii. अध्यक्ष, रेलवे बोर्ड

ix. सचिव, खाद्य और सार्वजनिक वितरण विभाग, उपभोक्ता, खाद्य और सार्वजनिक वितरण मंत्रालय

x. सचिव, भारी उद्योग विभाग, भारी उद्योग और सार्वजनिक उद्यम मंत्रालय

xi. सचिव, जैव प्रौद्योगिकी विभाग, विज्ञान और प्रौद्योगिकी मंत्रालय

xii. सचिव, नवीन और नवीकरणीय ऊर्जा मंत्रालय

xiii. सचिव, आवास और शहरी गरीबी उन्मूलन मंत्रालय

xiv. मुख्य कार्यकारी अधिकारी, नीति आयोग

xv. संयुक्त सचिव (रिफाइनरी), पेट्रोलियम और प्राकृतिक गैस मंत्रालय - सदस्य सचिव सचिव, पेट्रोलियम और प्राकृतिक गैस मंत्रालय

9.3 जैव ईंधन के कार्य समूह– जैव ईंधन कार्यक्रम के कार्यान्वियन के मोनीटरन हेतु एक कार्य समूह गठित किया जाएगा। इस कार्य समूह की रचना निम्न प्रकार होगी—

अध्यक्ष: संयुक्त सचिव (रिफाइनरी), पेट्रोलियम और प्राकृतिक गैस मंत्रालय

सदस्य :

i) एमओपीएंडएनजी द्वारा नामांकित जैव ईंधनों के क्षेत्र में प्रख्यात विशेषज्ञ

ii) जैव ईंधनों के क्षेत्र में अनुसंधान और शैक्षणिक संस्थानों के तकनीकी विशेषज्ञ

iii) उपर्युक्त 9.2 में उल्लेखित प्रासंगिक मंत्रालयों / विभागों के प्रतिनिधि

iv) ओएमसी के प्रतिनिधि

v) पीसीआरए के प्रतिनिधि

vi) उद्योग, सीएसआईआर लैब, राष्ट्रीय शर्करा संस्थान और जैव ईंधन संघ से विशेषज्ञ/ प्रतिनिधि

ख. राज्य स्तर पर जैव ईंधन संस्थागत तंत्र

9.4 राष्ट्रीय जैवईंधन नीति के प्रावधानों और रूप रेखा के अनुरूप राज्य स्तरीय जैव ईंधन विकास बोर्ड की स्थापना को यह नीति प्रोत्साहित करती है। छत्तीसगढ़, उत्तरप्रदेश, कर्नाटक, राजस्थान और उत्तराखंड जैसे पांच राज्यों में इस प्रकार के बोर्ड कार्य कर रहे हैं। राज्य सरकारें इन बोर्डों को अनुदान देती हैं जो इनके कार्य के लिए पूर्णत: जवाबदेह है। जैव ईंधन पर राष्ट्रीय नीति के व्यापक उद्देश्यों के अनुसार अन्य राज्यों को अपने यहां जैव ईंधन को बढ़ावा देने के लिए इसी प्रकार के बोर्ड स्थापित करने के लिए प्रोत्साहित किया जाएगा। मौजूदा बोर्डों को सहयोगात्मक गतिविधियों को बढ़ावा देने हेतु प्रोत्साहित किया जाएगा ताकि जैव ईंधन कार्यक्रम में अधिक से अधिक राज्य भाग ले सकें।

संदीप पौण्डरीक, संयुक्त सचिव

MINISTRY OF PETROLEUM AND NATURAL GAS

NOTIFICATION

New Delhi, the 4th June, 2018

F. No.P-13032(16)/18/2017-**CC.—**In exercise of the powers conferred under Government of India (Allocation of Business) Three Hundred and Thirty Fifth Amendment Rules, 2017 published in the Gazette of India vide S.O. No.2492 *(*E) dated the 4th August, 2017, the Central Government, through Ministry of Petroleum & Natural Gas, in supersession of National Policy on Biofuels, promulgated through the Ministry of New & Renewable Energy, in 2009, hereby makes a revised policy on biofuels, namely: **—**

1. **(1)** This policy may be called National Policy on Biofuels,- 2018.

(2) This policy shall be effective from the date of approval by the Cabinet i.e. 16-05-2018.

2. The Text of the policy is annexed.

National Policy on Biofuels - 2018

1.0 PREAMBLE

1.1 India is one of the fastest growing economies in the world and will continue to enjoy the demographic dividend for few decades. The Development Objectives focus on Samavesh – Inclusion, shared vision of National development, technology upgradation & capacity building, economic growth, equity and human well-being. Energy is a critical input towards raising the standard of living of citizens. The energy strategy of country aims to chart the way forward to meet the Government's recent ambitious announcements in the energy domain such as electrification of all census villages by 2019, 24x7 electricity & 175 GW of renewable energy capacity by 2022, reduction in energy emissions intensity by 33%-35% by 2030 and share of non-fossil fuel based capacity in the electricity mix is aimed at above 40% by 2030. Even if there is likely expansion in the energy contribution of oil, gas, coal, renewable resources, nuclear and hydro in the coming decade, fossil fuels will continue to occupy a significant share in the energy basket. However, conventional or fossil fuel resources are limited, non-renewable, polluting and, therefore, need to be used prudently. On the other hand, renewable energy resources are indigenous, non-polluting and virtually inexhaustible. India is endowed with abundant renewable energy resources. Therefore, their use should be encouraged in every possible way. This National Policy on Biofuels - 2018 builds on the achievements of the earlier National Policy on Biofuels and sets the new agenda consistent with the redefined role of emerging developments in the Renewable Sector.

1.2 The crude oil price has been fluctuating in the world market. Such fluctuations are straining various economies the world over, particularly those of the developing countries. Road transport sector accounts for 6.7% of India's Gross Domestic Product (GDP). Currently, diesel alone meets an estimated 72% of transportation fuel demand followed by petrol at 23% and balance by other fuels such as CNG, LPG etc. for which the demand has been steadily rising. Provisional estimates have indicated that crude oil required for indigenous consumption of petroleum products in FY 2017-18 is about 210 MMT. The domestic crude oil production is able to meet only about 17.9% of the demand, while the rest is met from imported crude. India's energy security will remain vulnerable until alternative fuels to substitute/supplement petro-based fuels are developed based on indigenously produced renewable feedstock. To address these concerns, Government has set a target to reduce the import dependency by 10 per cent by 2022."

1.3 Government has prepared a road map to reduce the import dependency in Oil & Gas sector by adopting a five pronged strategy which includes, Increasing Domestic Production, Adopting biofuels & Renewables, Energy Efficiency Norms, Improvement in Refinery Processes and Demand Substitution. This envisages a strategic role for biofuels in the Indian Energy basket.

1.4 Biofuels are derived from renewable biomass resources and wastes such as Plastic, Municipal Solid Waste (MSW), waste gases etc. and therefore seek to provide a higher degree of national energy security in an environmentally friendly and sustainable manner by supplementing conventional energy resources, reducing dependence on imported fossil fuels and meeting the energy needs of India's urban and vast rural population.

1.5 Globally, biofuels assume importance due to growing energy security and environmental concerns. To encourage use of biofuels several countries have put forth different mechanisms, incentives and subsidies suiting to their domestic requirements. As an effective tool for rural development and generating employment, the primary approach for biofuels in India is to promote indigenous feedstock production.

1.6 Over the last decade, Government has undertaken multiple interventions to promote biofuels in the Country through structured programmes like Ethanol Blended Petrol Programme, National Biodiesel Mission, Biodiesel Blending Programme. Learning from the past experiences and demand supply status, Government has revamped these programmes by taking steps on pricing, incentives, opening alternate route for ethanol production, sale of biodiesel to bulk and retail customers, focus on R&D etc. These steps have impacted the biofuels programme in the Country positively.

1.7 Biofuels in India is of strategic importance as it augers well with the ongoing initiatives of the Government such as Make in India & Swachh Bharat Abhiyan and offers great opportunity to integrate with the ambitious targets of doubling of Farmers Income, Import Reduction, Employment Generation, Waste to Wealth Creation. Simultaneously, the existing biodiversity of the Country can be put to optimum use by utilizing drylands for generating wealth for the local populous and in turn contribute to the sustainable development.

1.8 Globally, biofuels have caught the attention in last decade and it is imperative to keep up with the pace of developments in the field of biofuels. This policy aims to bring in renewed focus taking into context the international perspectives and National scenario primarily by utilization of indigenous feedstocks for production of biofuels. The

Policy also dwells on the development of the next generation biofuel conversion technologies based on new feedstocks and promote domestically available feedstock exploring, utilizing the Country's biodiversity. Vision, Goals, Strategy and Approach to the development of biofuels in India is set out through technological framework, financial, institutional interventions and enabling mechanisms.

2.0 THE VISION AND GOALS

2.1 The Policy aims to increase usage of biofuels in the energy and transportation sectors of the country during the coming decade. The Policy aims to utilize, develop and promote domestic feedstock and its utilization for production of biofuels thereby increasingly substitute fossil fuels while contributing to National Energy Security, Climate Change mitigation, apart from creating new employment opportunities in a sustainable way. Simultaneously, the policy will also encourage the application of advance technologies for generation of biofuels.

2.2 The Goal of the Policy is to enable availability of biofuels in the market thereby increasing its blending percentage. Currently the ethanol blending percentage in petrol is around 2.0% and biodiesel blending percentage in diesel is less than 0.1%. An indicative target of 20% blending of ethanol in petrol and 5% blending of biodiesel in diesel is proposed by 2030. This goal is to be achieved by

(a) reinforcing ongoing ethanol/biodiesel supplies through increasing domestic production

(b) setting up Second Generation (2G) bio refineries

(c) development of new feedstock for biofuels

(d) development of new technologies for conversion to biofuels.

(e) creating suitable environment for biofuels and its integration with the main fuels.

3.0 DEFINITIONS AND SCOPE

3.1 The following definitions of biofuels shall apply for the purpose of this Policy:

i. 'Biofuels' are fuels produced from renewable resources and used in place of or in blend with, diesel, petrol or other fossil fuels for transport, stationary, portable and other applications;

ii. Renewable resources are the biodegradable fraction of products, wastes and residues from agriculture, forestry, tree based oil other non-edible oils and related industries as well as the biodegradable fraction of industrial and municipal wastes.

3.2 The scope of the Policy encompasses following categories of fuels as "Biofuels" which can be used as transportation fuel or in stationery applications:—

i. 'bioethanol': ethanol produced from biomass such as sugar containing materials, like sugar cane, sugar beet, sweet sorghum etc.; starch containing materials such as corn, cassava, rotten potatoes, algae etc.; and, cellulosic materials such as bagasse, wood waste, agricultural and forestry residues or other renewable resources like industrial waste;

ii. 'biodiesel': a methyl or ethyl ester of fatty acids produced from non-edible vegetable oils, acid oil, used cooking oil or animal fat and bio-oil;

iii. 'Advanced biofuels': Fuels which are (1) produced from lignocellulosic feedstocks (i.e. agricultural and forestry residues, e.g. rice & wheat straw/corn cobs & stover/bagasse, woody biomass), non-food crops (i.e. grasses, algae), or industrial waste and residue streams, (2) having low CO_2 emission or high GHG reduction and do not compete with food crops for land use. Fuels such as Second Generation (2G) Ethanol, Drop-in fuels, algae based 3G biofuels, bio-CNG, bio-methanol, Di Methyl Ether (DME) derived from bio-methanol, bio-hydrogen, drop in fuels with MSW as the source / feedstock material will qualify as "Advanced Biofuels".

iv. 'drop-in fuels': Any liquid fuel produced from Biomass, agri-residues, wastes such as Municipal Solid Wastes (MSW), Plastic wastes, Industrial wastes etc. which meets the Indian standards for MS, HSD and Jet fuel, in pure or blended form, for its subsequent utilization in vehicles without any modifications in the engine systems and can utilize existing petroleum distribution system.

v. 'bio-CNG': Purified form of bio-Gas whose composition & energy potential is similar to that of fossil based natural gas and is produced from agricultural residues, animal dung, food waste, MSW and Sewage water.

4.0 STRATEGY AND APPROACH

4.1 Government is adopting a multi-pronged approach to promote and encourage use of biofuels by

- Blending ethanol in petrol through Ethanol Blended Petrol (EBP) Programme using ethanol derived from multiple feedstocks
- Development of Second Generation (2G) ethanol technologies and its commercialization
- Blending biodiesel in diesel through Biodiesel Blending Programme exploring multiple feedstocks including straight vegetable oil in stationery, low RPM engines
- Focus on drop-in fuels produced from MSW, industrial wastes, biomass etc.
- Focus on advanced biofuels including bio-CNG, bio-methanol, DME, bio-hydrogen, bio-jet fuel etc.

4.2 The major thrust of this policy is to ensure availability of biofuels from indigenous feedstock. As a step in this direction, a National Biomass Repository will be created by conducting appraisal of biomass across the Country.

4.3 While attempt will be made to rebalance the biofuel demand and supply side, Government aims to undertake necessary interventions as and when required with respect to domestic production, storage and distribution of biofuels adopting a consultative approach by involving all stakeholders.

4.4 Strategy will include adopting appropriate financial and fiscal measures periodically to support development and promotion of biofuels thereby enlarging their utilization in different sectors.

4.5 Research, development and demonstration will be supported to cover all aspects from feedstock production and biofuels processing for various end-use applications. Thrust will also be given to development of advanced biofuels and other new feedstocks.

5.0 INTERVENTIONS AND ENABLING MECHANISMS

A. Feedstock Availability & its Development

5.1 In India, Bioethanol can be produced from multiple sources like sugar containing materials, starch containing materials, celluloses and lignocelluloses material including petrochemical route. However, the present policy of Ethanol Blended Petrol (EBP) Programme allows bioethanol to be procured from non-food feed stock like molasses, celluloses and lignocelluloses material including petrochemical route. Similarly, biodiesel can be produced from any edible/non edible oil. However, biodiesel coming for the blending programme is presently being manufactured from imported sources like palm stearin.

5.2 Potential domestic raw materials for production of biofuels in the Country are,

For Ethanol Production : B-Molasses, Sugarcane juice, biomass in form of grasses, agriculture residues (Rice straw, cotton stalk, corn cobs, saw dust, bagasse etc.) , sugar containing materials like sugar beet, sweet sorghum, etc. and starch containing materials such as corn, cassava, rotten potatoes etc., Damaged food grains like wheat, broken rice etc. which are unfit for human consumption, Food grains during surplus phase. Algal feedstock and cultivation of sea weeds can also be a potential feedstock for ethanol production

For Biodiesel Production : Non- edible Oilseeds, Used Cooking Oil (UCO), Animal tallow, Acid Oil, Algal feedstock etc.

For Advanced Biofuels : Biomass, MSW, Industrial waste, Plastic waste etc.

5.3 The scope of raw material for procurement of ethanol under EBP Programme will be increased. The policy will allow production of ethanol from B Molasses as well as directly from sugarcane juice. The policy will also allow production of ethanol from damaged food grains like wheat, broken rice etc. which are unfit for human consumption. During an agriculture crop year when there is projected over supply of food grains as anticipated by the Ministry of Agriculture & Farmers Welfare, the policy will allow conversion of these surplus quantities of food grains to ethanol, based on the approval of National Biofuel Coordination Committee proposed under this Policy. Opening of this route for ethanol production will not only help in utilizing the installed capacities of grain based distilleries but also cover all the raw materials from which ethanol can be produced harnessing fully developed 1G technologies with minimum investment.

5.4 Identification of locations with surplus available biomass and generation of feedstock such as energy grasses and short gestation crops by utilizing wastelands will be pivotal for promoting Industrial set up. Focus shall be laid on identifying surplus biomass pockets in the country.

5.5 Village Panchayat and communities will play crucial role in augmenting indigenous feedstock supplies for biofuel production. In cases relating to usage of wastelands for feedstock generation, local communities from Gram Panchayats/ talukas will be encouraged for plantations non-edible oil seeds bearing trees/ crops such as Pongamia pinnata (Karanja), Melia azadirachta (Neem), castor, Jatropa Carcus, Callophylum Innophylum, Simarouba glauca, Hibiscus cannabbinus etc. Short Rotation Crops such as sweet sorghum and energy grasses e.g. *Miscanthus gigantum*, switchgrass (*Panicum vigratum*), giant reed (*Arundo donax*) etc. will also be planted in wastelands for generating additional feedstock for bioethanol production across country.

5.6 Farmers will be encouraged to grow variety of different biomass as well as oil seeds on their marginal lands, as inter crop and as second crop wherever only one crop is raised by them under rain fed conditions.

5.7 Suitable supply chain mechanisms, feedstock collection centres and fair price mechanisms for the engaged community will be developed in coordination with Local Bodies, States and concerned stakeholders.

5.8 Ample quantity of wastes such as MSW, Industrial waste, Plastic waste etc. is available across country with established collection mechanism. This will serve as a feedstock for generating biofuels such as bio-CNG, drop-in fuels, bio-methanol, DME, bio-hydrogen etc.

B. Blending & Bio-refinery Programme

5.9. Ethanol Blended Petrol Programme

5.9.1 Currently, ethanol for EBP programme is coming from molasses route as a by-product of sugar Industry. At the present levels of cane and sugar production (about 350 MMT & 26-28 MMT per annum respectively), the maximum quantity of molasses available is about 13 MMT, which is sufficient to produce about 300 crore litres of alcohol/ethanol. Currently, C- Heavy Molasses is being used to produce alcohol/ethanol.

5.9.2 Adoption of B- heavy Molasses route for ethanol production will be encouraged as per availability of sugar. One MMT of Sugar sacrificed can produce 60 crore litres of ethanol. By utilizing this option participation by distilleries for ethanol production would improve. Ethanol will also be allowed to be produced directly from sugarcane juice to increase blending percentage.

5.9.3 Other alternate raw materials for production of ethanol such as sugar containing materials like sugar beet, sweet sorghum, etc. and starch containing materials such as corn, cassava, rotten potatoes etc. using first generation fully developed technologies will be promoted. During surplus availabilty of foodgrains, ethanol will also be allowed to ve produced from foodgrains like corn etc, as per decision of National Bio Fuel Coordination Commiittee.

5.10 Second Generation (2G) Ethanol

5.10.1 Ethanol production through Molasses route has limitations and its competitive usage in Potable liquor & Chemical industries leaves little scope to enhance its availability for EBP Programme in a big way. This warrants exploring other sources of ethanol, apart from conventional molasses and sugarcane juice route.

5.10.2 Few studies undertaken in India have indicated a surplus biomass availability to the tune of 120 -160 MMT annually which, if converted, has the potential to yield 3000 crore litres of ethanol annually. Surplus biomass / agricultural waste which has cellulosic and lignocellulosic content, can be converted to ethanol using second generation (2G) technologies. Government of India recognized the role of biomass in taking the rural economy & EBP programme forward and has allowed procurement of ethanol produced from other non-food feedstock besides molasses, like cellulosic and lignocelluloses materials including petrochemical route, subject to meeting the relevant BIS standards. Following areas for action have been envisaged under the policy:

5.10.3 Incentives**:** Globally, 2G ethanol industry is driven by incentives as the technology is yet to be proven at commercial scale and the ethanol so produced is more environment friendly. This will be a major instrument in driving the infrastructural growth of 2G Ethanol Bio refineries.

5.10.4 Offtake Assurance: Public Sector Oil Marketing Companies have agreed to sign Ethanol Purchase Agreements (EPAs) with 2G Ethanol suppliers for period of 15 years to provide assured market to Private stakeholders and support 2G Ethanol initiatives. Bio-CNG, being one of the major by-product in 2G Ethanol Biorefineries and transport fuel, will be brought under offtake assurance by the Public sector Gas marketing companies.

5.11. Biodiesel Blending Programme

5.11.1 The overall blending percentage of biodiesel in diesel has been less than 0.5 percent in the country due to constraints pertaining to feedstock availability. Moreover, whatever biodiesel is coming for the blending programme is manufactured from imported sources. Thus ensuring domestic raw material for biodiesel production is integral for long term success of this programme.

5.11.2 In-house produced Used/Waste cooking oil (UCO/WCO) offers potential to be a source of biodiesel production. However, the same is marred by diversion of UCO to edible stream through various small eateries/vendors & traders. Focus will be laid upon laying down the stringent norms for avoiding the entry of UCO in food stream and developing a suitable collection mechanism to augment its supply for biodiesel production.

5.12 Other Biofuels (Drop-in-fuels, Bio-CNG, Bio-Hydrogen, Bio-methanol, DME, etc.)

5.12.1 Task force on Waste to Energy created by NITI Aayog has estimated generation of 62 MMT of Municipal Solid Waste (MSW) annually in India. This waste has a huge potential of producing drop-in fuels and generate power including Refused Derived fuel, biogas/electricity and compost to support agriculture.

5.12.2 World over, technologies available for converting wastes into Biofuels such as drop-in fuels, bio-CNG, bio-Hydrogen etc. are in nascent stage and need to be proven on commercial scale. Conversion of such wastes into bio-CNG is a model which will be promoted for meeting the energy demand in rural areas and address the environmental issues. Technologies providing higher yield of bio-CNG per unit of waste processed will be promoted in line with the policy. Setting up of such plants for production of advanced fuels will also be promoted through various incentives and offtake assurance. Similarly, Hydrogen, one of the costliest fuel, has found its use in many industries including Refineries. bio-hydrogen, produced from biomass and wastes, will be interesting proposition to explore.

5.12.3 World over, methanol has found its use as transport fuel in blended form with motor spirit. The same can be produced from various sources including agriculture residues, natural gas, high ash coal etc. Presently, India is a net importer of methanol. Surplus biomass availability offers potential for production of bio-methanol & bio-butanol and their application in Indian transport system will be explored.

5.12.4 Di-Methyl Ether (DME) is obtained by removing 1 molecule of water from 2 molecules of methanol, which is a chemical process, usually aided by catalyst. Use of (DME) in domestic LPG as a substitute of Propane is being explored by the R& D institutions. DME can also be a substitute for diesel in slow RPM diesel engines and hence promotion of industrial production of methanol is pertinent for widespread usage, industrial application & acceptance of DME as potential fuel.

5.12.5 Production of biofuels from Algae (3G) has promising potential in terms of high oil content, limited waste streams and minimal land requirements (compared to biomass), depending on the production pathway. Presently, the production of such fuels is at its nascent stage and need further examination with respect to commercial viability. Algae based biofuels & requisite R&D on the subject will also be promoted to attain techno-commercial viability.

C. Financing

5.13 Government will consider declaring oil expelling/extraction and processing units for production of biodiesel and storage and distribution infrastructure for biofuels as a priority sector for the purpose of lending by financial institutions.

5.14 Sourcing of multi-lateral and bi-lateral funding would be encouraged for biofuel development including carbon financing opportunities.

5.15 Joint ventures and investments in the biofuel sector would be encouraged. 100% Foreign Direct Investment (FDI) in biofuel technologies would be encouraged through automatic approval route provided biofuel so produced is for domestic use only.

D. Financial and Fiscal Incentives

5.16 Government will consider extending financial incentives including viability gap funding, subsidies and grant for biofuels. Government will classify Second Generation (2G) Ethanol, drop-in fuels, bio-CNG, algae based 3G biofuels, bio-methanol, DME, bio-hydrogen etc." as "Advanced Biofuels". A National Biofuel Fund may be considered for providing financial incentives.

5.17 The policy envisages incentivizing the nascent "Advanced Biofuel" industry with fiscal incentives in the form of tax credits, advance depreciation on plant expenditure, differential pricing vis-à-vis 1G Ethanol, Viability Gap Funding (VGF) etc. for encouraging stakeholders to set up 2G Ethanol Bio refineries. Schemes will be launched to take the "Advanced Biofuel" programme forward.

5.18 Opportunities of generating carbon credits for the savings on CO_2 emissions on the account of biofuel feedstock generation and use of biofuels, in pure or blended form, will be explored.

5.19 NABARD and other Public Sector Banks will be encouraged to provide funding, financial assistance through soft loans etc.

E. Research & Development and Demonstration

5.20 Strong technology focus is imperative for the development of second generation and advanced biofuels utilizing domestic feedstock. The Policy would encourage Innovation and provide thrust to Research & Development (R&D) and Demonstration in the field of biofuels by utilizing developed / emerging technologies while undertaking R&D activities. The R&D activities will be in the areas of developing new raw material for biofuel production, plantations, processing and conversion technologies. Efficiency Improvement and Innovation for maximizing efficiencies of different end-use applications and utilization of by-products will be encouraged. High priority will be accorded to indigenous R&D and technology development based on local feedstocks. Patents would be registered wherever possible. Research programme in the field of biofuels involving multiple institutions with clearly defined goals and milestones would be supported.

5.21 Identified areas of intensive R&D work include

(a): Biofuel feedstock production

(b): Advanced conversion technologies from identified feedstock

(c): Technologies for end use applications including modifications for biofuels

(d): Utilization of bi-products of biofuels

5.22 Pilot/ Demonstration projects will be set up for biofuel production. Grants would be provided to Research Organizations, Institutions for undertaking R&D and setting up demonstration projects, specialized centers in high technology areas. Existing R&D centres would be strengthened and linkages would be established between the research organization, institutions and industry for wider usage/application. Government will encourage participation of the Industry in R&D and technology development including transfer of know-how would be facilitated to the Industry.

5.23 Life Cycle Analysis (LCA) of emerging Technologies in biofuel sector is crucial keeping in view our commitments at international forums for reduced GHG emissions. Technologies at pilot stage with encouraging performance, promising LCA reports and in accordance to our commitments on Climate change, will be promoted as Clean Technology for subsequent deployment at demonstration / commercial scale.

5.24 A focused group may be constituted to promote Research and Development in the areas of biofuels having representatives of academic and industry besides relevant Ministries to provide knowledge connect through national, bilateral and multilateral research programmes.

F. Quality Standards

5.25 Development of test methods, procedures and protocols would be taken up on priority along with introduction of standards and certification for different biofuels and end use applications. The Bureau of Indian Standards (BIS) has already evolved standards for bioethanol, biodiesel for standalone and blended form applications. Development of specifications for higher blending levels are underway.

5.26 The Bureau of Indian Standards (BIS) would review and update the existing standards, as well as develop new standards for devices and systems for various end-use applications. Guidelines for product performance and reliability would also be developed and institutionalized in consultation with all relevant stakeholders.

5.27 The policy will encourage development of required skill sets so that trained and skilled manpower is available for adapting to the new demands of the biofuel industry.

G. Distribution & Marketing of Biofuels

5.28 Oil Marketing Companies will continue to store, distribute and market biofuels. They will be primarily responsible for maintaining and improving the storage, distribution and marketing infrastructure to meet the requirements of biofuels. Government may also consider to allow other players to distribute and market biofuels depending upon factors like ensuring quality standards, consumer awareness about blending percentages, warranty requirements etc.

H. Pricing of Biofuels

5.29 At present, the price of first generation molasses based ethanol for EBP Programme is being determined by the Government based on the recommendation of a Committee constituted for this purpose. For procurement of biodiesel for blending in diesel, the price is being determined by OMCs. The Government will continue to incentivise first generation biofuels by administered prices or market determined prices depending upon various factors including market conditions, availability of biofuels in domestic market, import substitution requirement, etc. The advanced biofuels will be given a differential pricing to further incentivise them. The mechanism for differential pricing for advanced biofuels will be decided by the National Biofuel Coordination Committee.

6.0 IMPORT & EXPORT OF BIOFUELS

6.1 Indigenous production of biofuels would be encouraged by a set of practical and judicious incentives. The Policy emphasizes development of domestic Biofuel Industry and Feedstock. Allowing import will adversely affect domestic biofuels and hence import of biofuels will not be allowed.

6.2 The policy encourages augmenting indigenous feedstock supplies for biofuel production utilizing the wastelands for feedstock generation. However, depending upon availability of domestic feedstock and blending requirement, import of feedstock for production of bio diesel would be permitted to the extent necessary. Feedstock import requirements will be decided by the National Biofuel Coordination Committee proposed under this Policy.

6.3 As the domestic biofuels availability is much lower than the Country's requirement, export of biofuels will not be allowed.

7.0 ROLE OF STAKE HOLDERS

7.1 Active participation of all stakeholders viz. Ministries/Departments, the State Governments Farmers, Business & Industry and Professionals will be ensured in following areas:

(i) Generation of feedstock in sustainable manner on wastelands.

(ii) Encourage farmers to grow varieties of feed stock on their marginal lands

(iii) Establishment of suitable supply chain for feedstock.

(iv) Feedstock storage infrastructure.

(v) Single window clearances & expeditious approvals.

(vi) Incentives such as tax incentives, subsidized power, water supply, access roads etc. to biofuel Plants

A Role of States

7.2 The successful implementation of biofuel programme largely depends on the active participation of the States. The learning experiences of the States who have set up Biofuel Development Boards will be utilized for setting up Biofuel Boards in other States and the State Governments would be encouraged to suitably empower these agencies/boards for development and promotion of biofuels in their respective States. Other Stake holders will also be enrolled for the programme.

7.3 State Governments would also be required to decide on land use for plantation of non-edible oilseed bearing plants or other feedstocks of biofuels and on allotment of Government wasteland, degraded land for raising such plantations. Creation of necessary infrastructure would also have to be facilitated to support biofuel projects across the entire value chain.

7.4 States will also be encouraged for granting single window clearances in setting up biofuel plants. State Governments will also be pursued for supporting initial few Biofuel plants with fiscal incentives, tax rebates, supply of subsidized power, land allocation on priority at subsidized rates.

B. Role of Ministries/Departments

7.5 The role of different Ministries and Departments for effective implementation of biofuels programme in the Country is tabulated below:

Ministry/Department	**Role**
Ministry of Petroleum & Natural Gas	• Overall Coordinating Ministry for development of biofuels • National Biofuel policy & its implementation • Research, Development & Demonstration on applications of biofuels • Marketing and Distribution of biofuels • Blending levels of biofuels • Development & Implementation of Pricing & Procurement Policy • Dispute redressal • Foster international collaboration for advance Biofuel research and Capacity Building • MSW to transportation fuels
Ministry of Rural Development	• Plantation, Supply Chain activities along with Rural livelihood programmes, MGNREGA etc.
Department of Agriculture & Cooperation (Ministry of Agriculture & FW)	• Production of plant materials through Nurseries and plantations for biofuels in coordination with other Ministries
Ministry of Environment, forest and Climate Change (MoEF&CC)	• Biofuel plantations in forest lands and environmental issues concerning biofuels • Involvement of communities in maintenance of plantations and supply chain
Ministry of Science and Technology (Department of Biotechnology and Department of Science & Technology)	• R&D&D on various feedstocks and improvement of technologies for Biofuel development. • Promote innovation and cutting edge research in Biofuel area. • Development of technologies for bio-refinery and value added products.
Ministry of Road Transport and Highways	• Encourage consumption/usage of Biofuels in transport sector
Ministry of Railways	• Encourage consumption/usage of Biofuels
Department of Consumer Affairs (Ministry of CA, F&PD)	• Laying down specifications, standards and codes for ensuring quality control of biofuels for end uses
Ministry of Heavy Industries and Public Enterprises	• To advise Manufacturers of Equipment for making them compatible with biofuels available in the market
Ministry of New & Renewable	• To generate/produce energy through biogas including enriched biogas,

Energy	bio-CNG and bio-power etc. from biomass/urban, industrial and agricultural waste.
Ministry of Housing & Urban Poverty Alleviation	• To coordinate with States and ULBs for the availability of MSW as an important feed stock for biofuels including municipal solid waste in urban areas for which the policies are being enunciated by this Ministry
Ministry of Consumer Affairs, Food & Public Distribution, Department of Food & Public Distribution	• DFPD to provide suitable financial incentives to the sugar sector for setting up of ethanol distilleries

8.0 INTERNATIONAL COOPERATION

8.1 Owing to renewed focus in the field of biofuels, scientific and technical cooperation will be established internationally in accordance with national priorities. This will include cooperation in joint research and technology development, field studies, pilot scale plants and demonstration projects involving R&D institutes and industry. Appropriate bilateral and multi-lateral cooperation programmes for sharing of technologies and funding would be developed.

9.0 INSTITUTIONAL MECHANISMS

A. Biofuel Policy Institutional Mechanism at the Centre

9.1 Under the Allocation of Business Rules, responsibilities have also been allocated to various Ministries to deal with different aspects of biofuel development and promotion in the country. Synergy is required between various departments and agencies due to the broader outlook/scope of work involved. This calls for an empowered Committee for policy guidance and early review on different aspects of biofuel development, promotion and utilization.

9.2 It is envisaged to set up a National Biofuel Coordination Committee (NBCC) headed by the Minister, Petroleum and Natural Gas and representatives of concerned Ministries would be the Members of this Committee. The Committee would meet periodically to provide overall coordination, effective end-to-end implementation and monitoring of biofuel programmes. The National Biofuel Coordination Committee will have the following composition:

Chairman: Minister of Petroleum & Natural Gas

Members:

i. Secretary, Ministry of Petroleum & Natural Gas

ii. Secretary, Department of Rural Development, Ministry of Rural Development

iii. Secretary, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare

iv. Secretary, Ministry of Environment, Forest & Climate Change

v. Secretary, Department of Science & Technology, Ministry of Science & Technology

vi. Secretary, Department of Expenditure, Ministry of Finance

vii. Secretary, Ministry of Road Transport and Highways

viii. Chairman Railway Board

ix. Secretary, Department of Food & Public Distribution, Ministry of Consumer Affairs, Food & Public Distribution

x. Secretary, Department of Heavy Industry, Ministry of Heavy Industries and Public Enterprises

xi. Secretary, Department of Bio-Technology, Ministry of Science & Technology

xii. Secretary, Ministry of New & Renewable Energy

xiii. Secretary, Ministry of Housing & Urban Poverty Alleviation

xiv. CEO, NITI Aayog

xv. Joint Secretary (Refinery), Ministry of Petroleum & Natural Gas – Member Secretary

9.3 Working Group on Biofuels - In order to monitor the implementation of biofuel programme, a Working Group will be setup. This Working Group will have the following composition:—

Chairman: Joint Secretary (Refinery), Ministry of Petroleum & Natural Gas

Members:

(i) Eminent experts in the field of biofuels nominated by MoP&NG

(ii) Technical experts from research and academic institutions in the field of biofuels

(iii) Representatives from relevant Ministries/Departments as mentioned in 9.2 above

(iv) Representatives of OMCs

(v) Representative of PCRA

(vi) Representatives/ Experts from the Industry, CSIR Lab, National Sugar Institute & Biofuel Associations

B. Biofuel Institutional Mechanism at the States Level

9.4 The policy encourages setting up of State Level Biofuel Development Boards in line with the broad contours and provisions of this National Policy on Biofuels. Five such Boards are functional in the States of Chattisgarh, Uttar Pradesh, Karnataka, Rajasthan and Uttarakhand. The State Governments aid these Boards and are entirely responsible for their functioning. Other States will be encouraged to set up similar boards to promote biofuels in their respective States in line with the broader objectives of this National Policy on Biofuels. The existing boards will be encouraged to undertake handholding activities so that more and more States participate in the biofuel programme.

SANDEEP POUNDRIK, Jt. Secy.

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ANNEXURE A-12

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EXTRAORDINARY

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PART II—Section 3—Sub-section (ii)

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अधिसूचना

नई दिल्ली, 24 जुलाई, 2025

का.आ. 3401(अ).— विषाक्त और परिसंकटमय पदार्थों से संदूषित क्षेत्र मानव स्वास्थ्य और पर्यावरण के लिए जोखिम पैदा करते हैं;

तथा : प्रारूप नियम, अर्थात् संदूषित स्थलों का उपचार नियम, 2024, भारत सरकार के पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय द्वारा भारत के राजपत्र, असाधारण, भाग 2, खंड 3, उप-खंड (ii) में अधिसूचना संख्या का.आ. 3550 (अ), तारीख 21 अगस्त , 2024 द्वारा प्रकाशित किए गए थे, जिसमें उन सभी व्यक्तियों, जिनके इससे प्रभावित होने की संभावना थी, से उक्त अधिसूचना को अंतर्विष्ट करने वाले राजपत्र की प्रतियां जनता के लिए उपलब्ध कराए जाने की तारीख से साठ दिनों की अवधि के अवसान से पूर्व आपत्तियां और सुझाव आमंत्रित किए गए थे;

तथा : उक्त अधिसूचना को अंतर्विष्ट करने वाली राजपत्र की प्रतियां 21 अगस्त, 2024 को जनता के लिए उपलब्ध करा दी गई थीं ;

तथा : उक्त प्रारूप अधिसूचना के संबंध में उक्त अवधि के भीतर जनता से प्राप्त आपत्तियों और सुझावों पर केन्द्रीय सरकार द्वारा सम्यक् रूप से विचार किया गया है;

अत: अब, पर्यावरण (संरक्षण) अधिनियम, 1986 (1986 का 29) की धारा 3, धारा 6, धारा 8 और धारा 25 द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए, केन्द्रीय सरकार निम्नलिखित नियम बनाती है, अर्थात:-

1. संक्षिप्त नाम और प्रारंभ.- (1) इन नियमों का संक्षिप्त नाम पर्यावरण संरक्षण (संदूषित स्थलों का प्रबंधन) नियम, 2025 है।

(2) ये राजपत्र में उनके प्रकाशन की तारीख से प्रवृत्त होंगे।

2. लागू होना .- (1) ये नियम निम्नलिखित से प्रभावित किसी संदूषित स्थल पर लागू नहीं होंगे-

(क) परमाणु ऊर्जा (रेडीओऐक्टिव अपशिष्टों का सुरक्षित निपटान) नियम, 1987 के नियम 2 के खंड (xxii) के अधीन यथा परिभाषित रेडीओऐक्टिव अपशिष्ट;

(ख) खान और खनिज (विकास और विनियमन) अधिनियम, 1957 (1957 का 67) की धारा 3 के खंड (घ) के अधीन यथा परिभाषित खनन संक्रियाएं;

(ग) मर्चेंट शिपिंग अधिनियम, 1958 और मर्चेंट शिपिंग (तेल द्वारा समुद्र प्रदूषण निवारण) नियम, 1974 द्वारा यथा शासित तेल या तैलीय पदार्थ द्वारा समुद्र का प्रदूषण;

(घ) ठोस अपशिष्ट प्रबंधन नियम, 2016 नियम 3 के उपनियम (1) के खंड 20 के अधीन यथा परिभाषित डंप साइट से ठोस अपशिष्ट।

(2) उप-नियम (1) में किसी बात के होते हुए भी, यदि किसी स्थल का संदूषण रेडियोधर्मी अपशिष्ट या खनन प्रचालन या तेल रिसाव या डंप साइट से विक्रय अपशिष्ट के साथ मिश्रित संदूषक के कारण है, और यदि संदूषक के कारण स्थल का संदूषण इन नियमों में विनिर्दिष्ट अनुक्रिया स्तर की सीमा से अधिक होता है, तो उस स्थल का उपचार इन नियमों के अधीन शामिल किया जाएगा।

3. परिभाषाएं.- (1) इन नियमों में, जब तक कि संदर्भ से अन्यथा अपेक्षित न हो, -

(क) "अधिनियम" से पर्यावरण (संरक्षण) अधिनियम, 1986 (1986 का 29) अभिप्रेत है;

(ख) "समिति" से 'नियम 10 (1) और 10 (2) के अधीन केन्द्रीय सरकार द्वारा गठित केन्द्रीय उपचार समिति' अभिप्रेत है;

(ग) "केन्द्रीय बोर्ड" से 'जल (प्रदूषण निवारण और नियंत्रण) अधिनियम, 1974 (1974 का 6) की धारा 3 की उपधारा (1) के अधीन गठित केन्द्रीय प्रदूषण नियंत्रण बोर्ड' अभिप्रेत है;

(घ) "केन्द्रीकृत ऑनलाइन पोर्टल" से 'नियम 9 के अधीन ऑनलाइन पोर्टल' अभिप्रेत है;

(ङ) "प्रदूषक" से 'पर्यावरण (संरक्षण) अधिनियम, 1986 (1986 का 29) की धारा 2 के खंड (ङ) में यथा परिभाषित परिसंकटमय पदार्थ की मौजूदगी' निर्देशित है, जो अनुसूची I में निर्धारित अनुक्रिया स्तरों से अधिक हो;

(च) "संदूषित स्थल" से 'संदूषक पदार्थों से प्रभावित कोई क्षेत्र या स्थल अभिप्रेत है और जिसे नियम 4 के उप-नियम (9) के तहत संदूषित स्थल घोषित किया गया है, अभिप्रेत है;

(छ) "पर्यावरण राहत निधि" से लोक दायित्व बीमा अधिनियम, 1991 (1991 का 6) की धारा 7क के अंतर्गत स्थापित निधि से है;

(ज) " संदिग्ध स्थल" से ऐसे स्थल से है, जहां प्रारंभिक निर्धारण या विस्तृत निर्धारण के आधार पर, संदूषक स्क्रीनिंग स्तर या प्रतिक्रिया स्तर से नीचे मौजूद हैं;

(झ) "भूमि उपयोग" से 'आवासीय, कृषि, औद्योगिक, वाणिज्यिक या लोक प्रयोजन के लिए भूमि का उपयोग' अभिप्रेत है;

(ञ) "स्थानीय निकाय" से 'किसी नगर पालिका या पंचायत अभिप्रेत है और इसमें तत्समय प्रवृत किसी विधि द्वारा या उसके अधीन स्थापित विकास प्राधिकरण शामिल है'

(ट) "परित्यक्त स्थल" से 'कोई संदूषित स्थल जहां जिम्मेदार व्यक्ति का पता नहीं लगाया जा सकता है, अभिप्रेत है;

(ठ) "व्यक्ति" के अंतर्गत कोई व्यष्टि, न्यायिक व्यक्ति या संस्था, कंपनी, फर्म, व्यक्तियों का संगम या व्यष्टि निकाय, चाहे निगमित हो या नहीं, या कोई न्यासी या कोई न्यास' आते हैं;

(ड) "संभावित संदूषित स्थल" वह क्षेत्र है, चाहे उसे चिन्हित किया गया हो या नहीं, जहां किसी स्थल को संदिग्ध संदूषित स्थल के रूप में चिह्नित किए जाने के बाद प्रारंभिक निर्धारण के आधार पर संदूषकों की उपस्थिति देखी जाती है;

(ढ) "निर्देश संगठन" से 'नियम 7 के अधीन निर्देश संगठन अभिप्रेत है;

(ण) ''अनुक्रिया स्तर'' अनुसूची I में विनिर्दिष्ट सीमाओं पर या उससे उपर मिट्टी और तलछट में परिसंकटमय पदार्थों की सांद्रता है जो मानव स्वास्थ्य या पर्यावरण के लिए आसन्न खतरा हो सकता है;

(त) "जिम्मेदार व्यक्ति" से नियम 5 के उप-नियम (2) के अधीन राज्य बोर्ड द्वारा पहचाने गए किसी भी व्यक्ति अभिप्रत है, जिस पर संदूषित स्थल के लिए दायित्व सौंपा गया है;

(थ) "स्क्रीनिंग स्तर" मिट्टी और तलछट, तथा भूजल और सतही जल में परिसंकटमय पदार्थों की सांद्रता है जो अनुसूची I में विनिर्दिष्ट, या इससे ऊपर मानव स्वास्थ्य या पर्यावरण के लिए संभावित खतरा हो सकता है;

(द) "स्थल-विनिर्दिष्ट उपचार स्तर" से चिंताजनक परिसंकटमय पदार्थों या रसायन को कम करके संदूषित स्थलों को उपचारित करने के लिए जोखिम आधारित लक्ष्य स्तर अभिप्रेत है;

(ध) "राज्य बोर्ड" से 'राज्य प्रदूषण नियंत्रण बोर्ड या जल (प्रदूषण निवारण और नियंत्रण) अधिनियम, 1974 (1974 का 6) की धारा 4 की उपधारा (1) और (4) के अधीन गठित प्रदूषण नियंत्रण समिति' अभिप्रेत है;

(न) "संदिग्ध संदूषित स्थल" वह क्षेत्र है जिसके संदूषित होने का संदिग्ध है और जिसे स्थानीय निकाय या जिला प्रशासन और राज्य बोर्ड द्वारा नियम 4 के उपनियम (1) और उपनियम (4) के अधीन पहचाना गया है;

(2) इन नियमों में प्रयुक्त और अपरिभाषित, किन्तु अधिनियम या इसके अधीन बनाए गए नियमों में परिभाषित, शब्दों और अभिव्यक्तियों के वही अर्थ होंगे, जो अधिनियम या नियमों में उन्हें दिया गया है।

4. संदूषित स्थलों की पहचान.- (1) स्थानीय निकाय या जिला प्रशासन, स्वत: संज्ञान लेकर या जनता से शिकायत प्राप्त होने पर संदूषकों से प्रभावित क्षेत्र की पहचान करेगा तथा अपनी अधिकारिक क्षेत्र में संदिग्ध संदूषित स्थलों के रूप में ऐसे सभी क्षेत्रों को केन्द्रीकृत ऑनलाइन पोर्टल पर सूचीबद्ध करेगा।

(2) उपनियम (1) के अधीन किसी क्षेत्र की पहचान करते समय स्थानीय निकाय या जिला प्रशासन निम्नलिखित सूचना को ध्यान में रखेगा,-

(क) परिसंकटमय और अन्य अपशिष्ट (प्रबंधन और सीमापार संचलन) नियम, 2016 के कार्यान्वियन के माध्यम से उपलब्ध कोई भी सूचना और वायु (प्रदूषण निवारण और नियंत्रण) अधिनियम, 1981 और जल (प्रदूषण निवारण और नियंत्रण) अधिनियम, 1974 के अधीन सहमति के प्रबंधन के माध्यम से उपलब्ध सूचना;

(ख) सरकारी अभिकरणों द्वारा किए गए कोई अध्ययन या अन्वेषण;

(ग) अवस्थान कारकों के माध्यम से उपलब्ध सूचना जो संदूषण के जोखिम को बढ़ाती है, जैसे कि आस-पास में पहले से संदूषित स्थल का होना और रसायनों का भूमिगत भंडारण ;

(घ) विगत समय से चल रहा औद्योगिक या कोई मानवजनित क्रियाकलाप जिसके कारण स्थल पर चिंताजनक परिसंकटमय पदार्थों या रसायनों से उस स्थल का संदूषण हुआ हो; या

(ङ) ऐसे अन्य कारक, जिन्हें वह उचित समझे।

(3) स्थानीय निकाय या जिला प्रशासन संदिग्ध संदूषित स्थलों की सूची राज्य बोर्ड को आवधिक तौर पर अर्धवार्षिक आधार पर, केन्द्रीकृत ऑनलाइन पोर्टल पर प्ररूप 1 में उपलब्ध कराएगा।

(4) राज्य बोर्ड जल (प्रदूषण निवारण एवं नियंत्रण) अधिनियम, 1974 और वायु (प्रदूषण निवारण एवं नियंत्रण) अधिनियम, 1981 के अंतर्गत उपलब्ध सहमति निगरानी तंत्र के माध्यम से उद्योगों या औद्योगिक परिसरों में स्थित संदिग्ध संदूषित स्थलों की पहचान करेगा।

(5) संदिग्ध संदूषित स्थलों की सूची प्राप्त होने पर, राज्य बोर्ड, स्वत: या निर्देश संगठन के माध्यम से, ऐसी सूची की प्राप्ति की तारीख से नब्बे दिन के भीतर, संदिग्ध संदूषित स्थल के नमूनाकरण और विश्लेषण द्वारा संदिग्ध संदूषित स्थल का प्रारंभिक स्थल निर्धारण करेगा।

(6) प्रारंभिक स्थल निर्धारण के पूरा होने पर, राज्य बोर्ड संदिग्ध संदूषित स्थल को संभावित संदूषित स्थल के रूप में सूचीबद्ध कर सकता है, यदि संदूषक स्क्रीनिंग स्तर से ऊपर पाया जाता है या यदि संदूषक स्क्रीनिंग स्तर से नीचे पाया जाता है तो स्थल को संदिग्ध स्थल के रूप में सूची से हटा सकता है।

(7) राज्य बोर्ड, प्रारंभिक स्थल निर्धारण के पूरा होने की तारीख से तीस दिन के भीतर, संभावित संदूषित स्थलों और संदिग्ध स्थलों की ऐसी सूची केन्द्रीकृत ऑनलाइन पोर्टल पर, केन्द्रीय बोर्ड को उपलब्ध कराएगा।

(8) तत्पश्चात्, राज्य बोर्ड स्वयं या किसी निर्देश संगठन के माध्यम से, ऐसे स्थल की सूची तैयार करने की तारीख से तीन मास के भीतर, संभावित संदूषित स्थल के संपूर्ण भौगोलिक क्षेत्र को कवर करते हुए विस्तृत नमूनाकरण और विश्लेषण द्वारा संभावित संदूषित स्थल का विस्तृत स्थल निर्धारण करेगा।

(9) राज्य बोर्ड, विस्तृत स्थल निर्धारण के पूरा होने के पश्चात्, यदि संदूषक की मात्रा अनुक्रिया स्तर से अधिक पाई जाती है, तो आगे की कार्रवाई के लिए उस स्थल को संदूषित स्थल के रूप में सूचीबद्ध कर सकता है।

(10) राज्य बोर्ड, विस्तृत स्थल निर्धारण के पूरा होने के पश्चात्, यदि संदूषक की मात्रा अनुक्रिया स्तर से कम पाया जाता है तो उस स्थल को संदिग्ध स्थल के रूप में सूची से हटा सकता है।

(11) राज्य बोर्ड, मानव स्वास्थ्य और पर्यावरण के लिए अंतर्वलित जोखिमों को ध्यान में रखते हुए, संदिग्ध या संभावित संदूषित स्थलों के क्रमशः प्रारंभिक या विस्तृत निर्धारण के दौरान किसी भी क्रियाकलाप को राज्य सरकार में संबंधित प्राधिकारी को सूचित करते हुए निर्बंधित या प्रतिषिद्ध करने के लिए सार्वजनिक नोटिस जारी करेगा।

(12) राज्य बोर्ड, संदूषित स्थलों की सूची केन्द्रीकृत ऑनलाइन पोर्टल पर प्रकाशित करेगा तथा ऐसे प्रकाशन के साठ दिन के भीतर प्रभावित होने वाले पणधारियों से टिप्पणियां और सुझाव आमंत्रित करेगा।

(13) पणधारियों से टिप्पणियां और सुझाव प्राप्त होने पर, राज्य बोर्ड केंद्रीकृत ऑनलाइन पोर्टल पर संदूषित स्थलों की अंतिम सूची प्रकाशित करेगा तथा और इस संबंध में बरती जाने वाली सावधानी का भी संकेत देते हुए जन साधारण की सूचना के लिए उस क्षेत्र में प्रसारित होने वाले दो स्थानीय समाचार पत्रों में इस संबंध में नोटिस भी प्रकाशित करेगा।

5. **संदूषित स्थलों का उपचार . -** (1) राज्य बोर्ड, इन नियमों के नियम 4 के उपनियम (13) के अधीन संदूषित स्थलों की सूची के प्रकाशन की तारीख से नब्बे दिन के भीतर एक निर्देश संगठन का चयन करेगा तथा और उपचार योजना की तैयारी आरंभ करेगा और उपचार क्रियाकलापों निष्पादित करेगा।

(2) राज्य बोर्ड, नियम 4 के उप-नियम (13) के अधीन संदूषित स्थल का प्रकाशन होने पर, जांच के पश्चात संदूषण वाले स्थल को संदूषित करने के लिए जिम्मेदार व्यक्ति की 90 दिनों की अवधि के भीतर पहचान करेगा।

(3) यदि संदूषित स्थल को संदूषण फैलाने वाले व्यक्ति (हस्तांतरक) द्वारा किसी अन्य व्यक्ति (हस्तांतरिती) को हस्तांतरित कर दिया गया है, तो राज्य बोर्ड जिम्मेदार व्यक्ति को अन्य व्यक्ति (हस्तांतरिती) के रूप में निर्धारित करेगा।

(4) निर्धारण और उपचार के दौरान संदूषकों का संचालन और प्रबंधन केन्द्रीय बोर्ड द्वारा जारी मानक संचालन प्रक्रिया के अनुसार किया जाएगा।

(5) जिम्मेदार व्यक्ति की पहचान हो जाने पर राज्य बोर्ड, जिम्मेदार व्यक्ति को उपचार संबंधी योजना तैयार करने तथा राज्य बोर्ड द्वारा यथा चयनित निर्देश संगठन के माध्यम से उपचार कार्य आरंभ करने और इस पर होने वाले व्यय का वहन करने का निदेश देगा।

(6) जिम्मेदार व्यक्ति, राज्य बोर्ड के निदेशों पर, उप-नियम (5) के अधीन निदेशों की प्राप्ति की तारीख से छह मास के भीतर उपचार संबंधी योजना तैयार करेगा और इसे राज्य बोर्ड को अनुमोदन हेतु प्रस्तुत करेगा।

(7) उपचार संबंधी योजना में, स्थल-विनिर्दिष्ट उपचार स्तर, जोखिम निर्धारण की पद्धति, संदूषित स्थल के उपचार या विसंदूषण या सफाई पद्धति, उपचार कार्य आरंभ करने के लिए अपेक्षित वित्तीय संसाधन और अपेक्षित समय-सीमा के साथ-साथ उपचार कार्य के दौरान पर्यावरणीय और रक्षोपाय, उपचार-पश्च मॉनीटरी और निर्धारण संबंधी क्रियाकलाप तथा व्यावसायिक स्वास्थ्य, सुरक्षा और आपातकालीन अनुक्रिया अधिकथित की जाएगी।

(8) राज्य बोर्ड, जिम्मेदार व्यक्ति द्वारा उपचार संबंधी योजना प्रस्तुत किए जाने की तारीख से तीन मास के भीतर उपचार योजना प्रस्तुत करने की तिथि से इसकी समीक्षा और अनुमोदन करेगा तथा उसकी एक प्रति केन्द्रीय बोर्ड को सूचनार्थ अग्रेषित करेगा।

(9) उपचार योजना के विकास, सत्यापन और उसके अनुमोदन के लिए मानदंड केन्द्रीय बोर्ड द्वारा जारी दिशा-निर्देशों के अनुसार किया जाना है।

(10) राज्य बोर्ड द्वारा उपचार संबंधी योजना के अनुमोदन के पश्चात् जिम्मेदार व्यक्ति, उपचार संबंधी योजना के अनुसार संदूषित स्थल का उपचार कार्य आरंभ करेगा तथा उपचार कार्य पूर्ण होने तक राज्य बोर्ड अर्धवार्षिक प्रगति रिपोर्ट को प्ररूप 2 में प्रस्तुत करेगा केन्द्रीय बोर्ड को सूचना देते हुए।

(11) उपचार योजना के अनुमोदन के आधार पर, राज्य बोर्ड उपचार क्रियाकलाप को आगे बढ़ाने के लिए संदूषित स्थलों से लोगों के पुनर्वास के लिए आदेश जारी करने हेतु राज्य सरकार को सिफारिश करेगा।

(12) राज्य बोर्ड, मानव स्वास्थ्य और पर्यावरण में अंतर्वलित जोखिमों को ध्यान में रखकर, संदूषित स्थल के उपचार के दौरान भूमि उपयोग में परिवर्तन और भूमि या भूमि पर भवन या किसी सुविधा के स्वामित्व के हस्तांतरण या परिवर्तन सहित किसी भी क्रियाकलाप को निर्बंधित या प्रतिषिद्ध करते हुए एक सार्वजनिक सूचना जारी करेगा।

(13) जिम्मेदार व्यक्ति की पहचान न होने दशा में राज्य बोर्ड, संदूषित स्थल में उपचार कार्य करने के लिए इन नियमों के नियम 4 के उपनियम (13) के अधीन संदूषित स्थल के प्रकाशन की तारीख से छह माह के भीतर स्वयं या निर्देश संगठन के माध्यम से उपचार संबंधी योजना तैयार करेगा, जो या तो अपने संसाधनों से अथवा राज्य सरकार अथवा दोनों और नियम 8 के अधीन निर्धारित अनुपात के अनुसार केन्द्रीय सरकार के संसाधनों से सहायता के माध्यम से की जाएगी तथा उपचार योजना को अंतिम रूप दिए जाने के नब्बे दिन के भीतर निर्देश संगठन के माध्यम से उपचार आरंभ करेगा।

(14) किसी संदूषित स्थल का उपचार कार्य, अनुक्रिया स्तर को स्थल-विनिर्दिष्ट उपचार स्तर तक लाने के लिए किया जाएगा।

(15) राज्य बोर्ड, उपचार कार्य पूरा होने के पश्चात, उपचार किए गए स्थल में कतिपय क्रियाकलापों के लिए उपयुक्त भूमि उपयोग को विनिर्दिष्ट या किसी ऐसे क्रियाकलाप को निर्बंधित करते हुए उक्त स्थल को अधिसूचित करेगा और केन्द्रीय बोर्ड को रिपोर्ट प्रस्तुत करेगा।

(16) संदिग्ध संदूषित स्थल या संभावित संदूषित स्थल के, किसी उद्योग या अधिसूचित औद्योगिक क्षेत्र के परिसर में अवस्थित होने की दशा में राज्य बोर्ड, संबद्ध औद्योगिक विकास प्राधिकरण या संबद्ध उद्योग को किसी निर्देश संगठन के माध्यम से, यथा स्थिति प्रारंभिक या विस्तृत स्थल निर्धारण करने और इसके पूर्ण होने तक राज्य बोर्ड को रिपोर्ट प्रस्तुत

करने का निदेश देगा तथा ऐसे स्थलों का उपचार कार्य करने के लिए नियम 4 और नियम 5 के उपबंध यथा संभव लागू होंगे।

6. उपचार कार्य का सत्यापन - (1) राज्य बोर्ड, उपचार कार्य पूर्ण होने के पश्चात् केन्द्रीय बोर्ड को अपनी रिपोर्ट प्रस्तुत करेगा।

(2) केन्द्रीय बोर्ड, उपचार क्रियाकलापों के पूर्ण होने संबंधी सत्यापन करने हेतु किसी निर्देश संगठन को नियुक्त कर सकता है।

(3) राज्य बोर्ड की रिपोर्ट को निर्देश संगठन की रिपोर्ट के साथ समिति के समक्ष, उसके पुनर्विलोकन समीक्षा और सिफारिश हेतु प्रस्तुत किया जाएगा।

(4) समिति, अपने पुनर्विलोकन के दौरान अतिरिक्त या अनुपूरक उपचार संबंधी क्रियाकलापों, यदि आवश्यक हों, की सिफारिश कर सकती है।

(5) समिति की सिफारिशें प्राप्त होने पर केन्द्रीय बोर्ड, उपचार कार्य पूर्ण होने संबंधी आदेश जारी करने के लिए राज्य बोर्ड को संसूचित करेगा।

(6) राज्य बोर्ड, उपचार पश्च मॉनीटरी संबंधी क्रियाकलापों के साथ-साथ उपचार कार्य पूर्ण होने संबंधी आदेश जारी करेगा।

(7) जिम्मेदार व्यक्ति, ऐसे स्थलों के संदूषण के कारण, पर्यावरण और मानव स्वास्थ्य या तीसरे पक्षकार को होने वाली सभी प्रकार की क्षतियों के लिए दायी होगा।

(8) जिम्मेदार व्यक्ति को निम्नलिखित कारणों से अपने दायित्व से छूट प्राप्त नहीं होगी या छूट प्राप्त नहीं माना जाएगा –

(क) यदि संदूषण करने वाली क्रियाकलापों और संदूषण के प्रभाव, इन नियमों के लागू होने से पूर्व हुई हो;

(ख) यदि स्थल अन्वेषण की अपेक्षा न हो तो अनिवार्य हो और ना ही सामान्य कारोबार पद्धति के भाग के रूप में प्रत्याशित हो और व्यक्ति से ऐसी अन्वेषण या परीक्षण करना प्रत्याशित नहीं की जा सकता;

(ग) यदि संदूषकों को अधिसूचित किया गया हो या न ही परिसंकटमय पदार्थों के रूप में अधिसूचित किया गया हो।

(9) किसी संदूषित स्थल या संदूषित स्थल पर अवस्थित सुविधा में या स्थल से या स्थल में किसी सामग्री के परिवहन के दौरान कोई दुर्घटना होती है तो, उक्त स्वामी या अधिभोगी या जिम्मेदार व्यक्ति या परिवाहक, दुर्घटना के बारे में राज्य बोर्ड को टेलीफोन और ई-मेल के माध्यम से तत्काल सूचित करेगा तथा तत्पश्चात प्ररूप 3 में रिपोर्ट प्रेषित करेगा और उसे केन्द्रीयकृत ऑनलाइन पोर्टल पर प्रकाशित करेगा।

7. निर्देश संगठन – (1) अनुसूची 2 में दी गई अर्हताएं और अनुभव रखने वाला कोई संगठन, निर्देश संगठन के रूप में पैनल में रखने के लिए केन्द्रीय बोर्ड को प्ररूप 4 में आवेदन कर सकता है।

(2) केन्द्रीय बोर्ड, आवेदन प्राप्त होने पर, अनुसूची 2 में विहित मानदंडों के अनुसार निर्देश संगठन के प्रत्यय-पत्रों का मूल्यांकन करेगा और उक्त संगठन को निर्देश संगठन के पैनल में रखने के संबंध में या कारणों सहित आवेदन को अस्वीकार करने के संबंध में साठ दिन के भीतर संसूचित करेगा।

(3) निर्देश संगठन का पैनल में रखा जाना, केन्द्रीय बोर्ड द्वारा इसे रद्द किए जाने तक वैध रहेगा या जब तक संगठन का अस्तित्व समाप्त नहीं हो जाता या वह संदूषित स्थलों के निर्धारण और उपचार के क्षेत्र में अपनी क्रियाकलापों को बंद नहीं कर देता।

(4) केन्द्रीय बोर्ड, निर्देश संगठन के पैलन में रखा जाने को, गलत सूचना प्रस्तुत करने, कपटपूर्ण क्रियाकलापों को करने, आंकड़ों का दुरुपयोग करने तथा निर्धारण, उपचार संबंधी योजना तैयार करने और उपचार कार्य करने संबंधी संविदा या कार्य आदेश के अनुसरण में कार्यकलाप न करने के आधार पर, रद्द कर सकता है।

(5) केन्द्रीय बोर्ड अपनी वेबसाइट पर पैनल में रखे गए निर्देश संगठन की सूची प्रकाशित करेगा और इस सूची को त्रैमासिक आधार पर अद्यतित करेगा।

8. संदूषित स्थलों के निर्धारण और उपचार हेतु वित्तीय तंत्र - (1) सभी मामलों में, संदिग्ध संदूषित स्थल और संभावित संदूषित स्थल के लिए क्रमशः प्रारंभिक निर्धारण और विस्तृत निर्धारण करने के लिए निधियों, जहां तक संभव हो, प्रारम्भ में केन्द्रीय सरकार द्वारा लोक दायित्व बीमा अधिनियम, 1991 की धारा 7 की उपधारा (9) के अधीन पर्यावरण राहत निधि से पूर्णतः या आंशिक रूप से तथा राज्य सरकार द्वारा भी की जा सकेगी।

(2) निधियों को केन्द्रीय सरकार और राज्य सरकार के बीच निम्नलिखित अनुपात में सहभाजित किया जाएगा -

(क) क्षेत्र के, पूर्वोत्तर और हिमालयी राज्यों में होने की दशा में, केन्द्रीय सरकार से नब्बे प्रतिशत निधियां और राज्य सरकार से दस प्रतिशत निधियां;

(ख) क्षेत्र के, अन्य राज्यों में होने की दशा में, केन्द्रीय सरकार से साठ प्रतिशत निधियां तथा राज्य सरकार से चालीस प्रतिशत निधियां;

(ग) क्षेत्र के, संघ राज्य क्षेत्रों में होने की दशा में, केन्द्रीय सरकार से शत-प्रतिशत निधियां।

(3) राज्य सरकार अपने हिस्से के लिए पर्यावरण (संरक्षण) अधिनियम, 1986 की धारा 16(1) और 16(5) के अंतर्गत पर्यावरण संरक्षण निधि से आवंटित धनराशि और/या राज्य बोर्ड द्वारा एकत्रित पर्यावरण क्षतिपूर्ति से प्राप्त धनराशि का उपयोग कर सकती है।

(4) राज्य सरकार, यथास्थिति, केन्द्रीय बोर्ड या राज्य बोर्ड, , द्वारा संदूषित स्थलों की संसूचना दिए जाने की तारीख से साठ दिनों के भीतर प्रारंभिक और विस्तृत स्थल निर्धारण के लिए निधियों के सहभाजन करने के लिए सहमति प्रदान करेगी:

परंतु यह कि जब केन्द्रीय सरकार उपचार संबंधी क्रियाकलापों को तत्काल आरंभ करना आवश्यक और समीचीन समझती है, तो वह राज्य सरकार के अनुमोदन को लंबित रख सकती है, ऐसे उपचार संबंधी क्रियाकलापों को करने के लिए राज्य सरकार के हिस्से की समतुल्य निधियां प्रदान कर सकती है और तत्पश्चात राज्य सरकार से उक्त धनराशि वसूल सकती है।

(5) जिम्मेदार व्यक्ति की पहचान हो जाने की दशा में, केंद्र सरकार और राज्य सरकार द्वारा प्रारंभिक और विस्तृत स्थल निर्धारण पर किए गए व्यय की, जिम्मेदार व्यक्ति से तीन मास के भीतर वसूली की जाएगी।

(6) केन्द्रीय सरकार या राज्य सरकार केन्द्रीय बोर्ड या राज्य बोर्ड द्वारा प्रारंभिक निर्धारण, विस्तृत निर्धारण, उपचार संबंधी योजना तैयार करने और उपचार संबंधी क्रियाकलाप करने के लिए निधियां उपलब्ध कराने की दशा में जिम्मेदार व्यक्ति, राज्य बोर्ड द्वारा यथा निदेशित रीति से ब्याज सहित उक्त व्यय का संदाय करने के लिए दायी होगा:

परंतु यह कि स्थल की संदूषित स्थल के रूप में पुष्टि न होने की दशा में जिम्मेदार व्यक्ति, प्रारंभिक निर्धारण और विस्तृत निर्धारण पर होने वाले व्यय का संदाय करने के लिए दायी नहीं होगा।

(7) परित्यक्त स्थलों की दशाओ में, क्रमशः संदिग्ध संदूषित स्थलों, संभावित संदूषित स्थलों और संदूषित स्थलों के लिए में प्रारंभिक निर्धारण, विस्तृत निर्धारण और उपचार संबंधी योजना तैयार करने तथा उपचार कार्य करने पर होने वाला व्यय, उप-नियम (2) में दिए गए अनुपात में पूरा किया जाएगा।

(8) बैंकों के अस्थायी कब्जे वाले या न्यायिक कार्यवाही के अधीरन आने वाले ऐसे स्थलों जैसे अन्य सभी मामलों में समिति की सिफारिशों के आधार पर, प्रारंभिक निर्धारण, विस्तृत निर्धारण, उपचार योजना तैयार करने और उपचार संबंधी क्रियाकलाप करने के लिए निधियां, उप-नियम (2) में दिए गए अनुपात में पूरी की जाएंगी।

9. केंद्रीयकृत ऑनलाइन पोर्टल - (1) केन्द्रीय बोर्ड इन नियमों के अधीन संदिग्ध संदूषित स्थलों, संभावित संदूषित स्थलों और संदूषित स्थलों की रिपोर्टिंग तथा संदूषण के निर्धारण की की मानीटरी और संदूषित स्थलों के उपचार के प्रयोजन के लिए केंद्रीकृत ऑनलाइन पोर्टल विकसित करेगा।

(2) राज्य बोर्ड संभावित और संदूषित स्थलों की सूची और उनकी जियोटैगिंग या जियो-फेंसिंग, रिमोट सेंसिंग और सैटेलाइट इमेजरी, उपचार योजना की तैयारी की स्थिति, उपचार क्रियाकलापों और जिम्मेदार व्यक्तियों की सूची, उपचार कार्य पूर्ण होने संबंधी आदेश और उपचार कार्य के बाद की निगरानी क्रियाकलापों को अपलोड करने सहित अपने सभी क्रियाकलापों को केंद्रीकृत ऑनलाइन पोर्टल पर अपडेट करेगा।

(3) केन्द्रीय बोर्ड सभी संदूषित स्थलों की सूची, उनकी प्रस्थिति और इस संबंध में समिति की सिफारिशों को अपलोड करेगा।

10. उपचार समिति- (1) केन्द्रीय सरकार, इन नियमों के अधीन उपचार क्रियाकलापों का पुनर्विलोकन करने तथा इन नियमों के कार्यान्वयन की निगरानी के लिए केन्द्रीय उपचार समिति का गठन करेगी।

(2) केंद्रीय उपचार समिति में निम्नलिखित सदस्य शामिल होंगे, अर्थात्:-

(क) अध्यक्ष, केंद्रीय प्रदूषण नियंत्रण बोर्ड - अध्यक्ष;

(ख) सदस्य के रूप में निम्नलिखित मंत्रालयों या विभागों में से प्रत्येक का एक प्रतिनिधि, -

(i) आवासन और शहरी कार्य मंत्रालय;

(ii) उद्योग संवर्धन और आंतरिक व्यापार विभाग, वाणिज्य और उद्योग मंत्रालय;

(iii) रसायन और पेट्रोरसायन विभाग, रसायन एवं उर्वरक मंत्रालय

(iv) विज्ञान एवं प्रौद्योगिकी मंत्रालय

(V) स्वास्थ्य एवं परिवार कल्याण मंत्रालय

(ग) संदूषित स्थलों के व्यौहार में अनुभव रखने वाले राज्य बोर्डों के दो प्रतिनिधि, जिन्हें केंद्रीय सरकार द्वारा चक्रानुक्रम के आधार पर नामनिर्दिष्ट किया जाएगा - सदस्य;

(घ) संबंधित राज्य सरकार का एक प्रतिनिधि - सदस्य;

(ण) पर्यावरण, भू-तकनीकी और औद्योगिक अपशिष्ट प्रबंधन के क्षेत्र से दो तकनीकी विशेषज्ञ, जिन्हें केंद्रीय सरकार द्वारा नामनिर्दिष्ट किया जाएगा - सदस्य;

(च) सदस्य सचिव, केन्द्रीय बोर्ड या उनके द्वारा नामित - सदस्य संयोजक।

(3) समिति, इन नियमों के उपबंधों के कार्यान्वयन का पुनर्विलोकन और मानीटरी करेगी तथा केन्द्रीय सरकार या केन्द्रीय बोर्ड द्वारा उसे निर्दिष्ट गए किसी मामले के संबंध में सिफारिशें कर सकती है।

(4) समिति छह मास में कम से कम एक बार बैठक करेगी और वार्षिक आधार पर केन्द्रीय सरकार को अपनी रिपोर्ट प्रस्तुत करेगी।

(5) समिति संदिग्ध संदूषित स्थलों, संभावित संदूषित स्थलों और संदूषित स्थलों की सूची और इन नियमों के अधीन क्रियाकलापों के ब्यौरों का वार्षिक पुनर्विलोकन करेगी।

(6) राज्य सरकार या संघ राज्य क्षेत्र प्रशासन इन नियमों के प्रकाशन की तारीख से तीन मास के भीतर, पर्यावरण विभाग के प्रभारी अपर मुख्य सचिव या प्रधान सचिव की अध्यक्षता में, तथा नगर प्रशासन और शहरी विकास विभाग, पंचायती राज विभाग, औद्योगिक विभाग के सचिवों और राज्य बोर्ड के प्रतिनिधि को सदस्यों के रूप में सम्मिलित करते हुए एक राज्य स्तरीय समिति का गठन करेगी, जो समयबद्ध रीति में इन नियमों और उनके अधीन क्रियाकलापों के कार्यान्वयन की निगरानी करेगी।

11. केन्द्रीय बोर्ड के कृत्य- (1) केन्द्रीय बोर्ड, इन नियमों के अधीन उपबंधों की मॉनीटरी और रिपोर्टिंग के लिए केंद्रीकृत ऑनलाइन पोर्टल विकसित करेगा।

(2) केन्द्रीय बोर्ड प्ररूप 5 में संदूषित स्थलों के प्रबंधन पर एक समेकित पुनर्विलोकन रिपोर्ट तैयार करेगा तथा उसे प्रत्येक वर्ष में एक बार 30 सितम्बर से पहले अपनी सिफारिशों के साथ केंद्रीय सरकार को अग्रेषित करेगा तथा उसे केंद्रीकृत ऑनलाइन पोर्टल पर प्रकाशित करेगा।

(3) केन्द्रीय बोर्ड सभी प्रासंगिक सुसंगत केंद्रीकृत ऑनलाइन पोर्टल पर प्रकाशित करेगा।

(4) केन्द्रीय बोर्ड इन नियमों के अधीन निधियों के उपयोग तथा व्यय के हिस्सेदारी के लिए केंद्र सरकार से अनुरोध प्रस्तुत कर सकता है।

(5) केन्द्रीय बोर्ड इन नियमों के कार्यान्वयन के प्रयोजन से दिशानिर्देश जारी कर सकेगा:

परंतु यह कि पर्यावरणीय क्षतिपूर्ति के संबंध में दिशानिर्देश केंद्रीय सरकार की पूर्व अनुमोदन से ही जारी किए जा सकेंगे।

12. स्वैच्छिक उपचार - (1) स्वैच्छिक उपचार किसी भी स्थल के लिए उपयुक्त हो सकता है.-

(क) जिसकी पहचान संभावित संदूषित स्थल या संदूषित स्थल के रूप में नहीं की गई है; या

(ख) जिसकी इन नियमों के अधीन संदूषित स्थल के रूप में पहचान के लिए जांच नहीं की गई है; और

(ग) जहां स्वैच्छिक उपचार का प्रस्ताव करने वाला व्यक्ति उपचार तथा संबंधित पर्यावरण और सामाजिक पहलुओं और स्थानीय समुदाय की अपेक्षाओं के प्रबंधन या प्रापण के लिए सक्षम है।

(2) कोई व्यक्ति स्वैच्छिक उपचार के लिए समिति के समक्ष पुनर्विलोकन के लिए आवेदन प्रस्तुत कर सकता है, जिसके साथ प्रारंभिक निर्धारण रिपोर्ट, सभी मालिकों और अधिभोगियों के बीच स्वैच्छिक करार, उपचार के लिए संदाय करने की पर्याप्त क्षमता का साक्ष्य और उपचार के दौरान समिति के निदेशों का अनुपालन करने की वचनबद्धता भी लेनी चाहिए।

(3) समिति स्वैच्छिक उपचार प्रस्ताव को मंजूरी देने के लिए केन्द्रीय सरकार को सिफारिश कर सकती है, यदि यह समाधान हो जाता है कि -

(क) यह उप-नियम (1) में निर्धारित मानदंडों को पूरा करता है;

(ख) स्वैच्छिक प्रस्ताव पर सभी स्थल स्वामियों और अधिभोगियों द्वारा सहमति व्यक्त की गई है और उसे स्वीकार किया गया है;

(ग) सभी व्यक्तियों ने मिलकर यह प्रदर्शित किया है कि उनके पास उपचार लागत का संदाय करने की पर्याप्त क्षमता है और उपचार के लिए संदाय करने के लिए सार्वजनिक निधि की कोई अपेक्षा नहीं है;

(घ) सभी व्यक्ति समिति द्वारा जारी आदेशों, निदेशों और नोटिसों का पालन करने के लिए सहमत हैं;

(ङ) यह इन नियमों के उपबंधों का अनुपालन करता है।

(4) यदि किसी भी प्रक्रम पर स्वैच्छिक उपचार करने वाला व्यक्ति केन्द्रीय बोर्ड अनुसरण या राज्य बोर्ड या केन्द्रीय सरकार या राज्य सरकार के किसी आदेश या निदेशों या नोटिस का अनुपालन नहीं करता है या इन उपबंधों के प्रावधानों का उल्लंघन करता है, तो उस व्यक्ति द्वारा पहले से किए गए किसी भी लागत के व्यय का कोई प्रतिदाय नहीं होगा और समिति, केन्द्रीय बोर्ड या केन्द्रीय सरकार को आदेशों के प्रवर्तन के लिए कदम उठाने की सिफारिश कर सकती है, जैसे कि कोई स्वैच्छिक उपचार प्रस्ताव नहीं थी ।

(5) स्वैच्छिक उपचार के अनुमोदन से पर्यावरण को होने वाली क्षति या हानि के अधिरोपण या अन्यथा और किसी अन्य नियम, इन नियमों के उपबंधों या इसके अधीन जारी आदेशों या निदेशों का अनुपालन करने में विफलता या उल्लंघन के दायित्व को रोका नहीं जा सकेगा।

13. पर्यावरणीय क्षतिपूर्ति - (1) राज्य बोर्ड किसी भी जिम्मेदार व्यक्ति पर पर्यावरणीय क्षतिपूर्ति अधिरोपित कर सकता है जो उपचार करने में इन नियमों के उपबंधों का अनुपालन नहीं करता है या किसी संदूषित स्थल के संबंध में इन नियमों के अधीन उपाय नहीं करता है और मानव जीवन और पर्यावरण के लिए जोखिम पैदा करता है, जिससे पर्यावरण या मानव स्वास्थ्य को नुकसान, क्षति या चोट पहुंचती है।

(2) यदि राज्य बोर्ड उपनियम (1) के अंतर्गत साठ दिनों के भीतर पर्यावरणीय क्षतिपूर्ति लगाने के संबंध में कार्रवाई नहीं करता है, तो केन्द्रीय बोर्ड ऐसे किसी भी व्यक्ति पर पर्यावरणीय क्षतिपूर्ति लगा सकता है जो उपचार करने में इन नियमों के प्रावधानों का पालन नहीं करता है या किसी संदूषित स्थल के संबंध में इन नियमों के अंतर्गत उपचार नहीं करता है और मानव जीवन तथा पर्यावरण के लिए जोखिम उत्पन्न करता है, जिससे पर्यावरण या मानव स्वास्थ्य को हानि, क्षति या नुकसान पहुँचता है।

(3) उपर्युक्त के होते हुए भी, केन्द्रीय बोर्ड या राज्य बोर्ड पर्यावरण (संरक्षण) अधिनियम, 1986, जल (प्रदूषण निवारण एवं नियंत्रण) अधिनियम, 1974, वायु (प्रदूषण निवारण एवं नियंत्रण) अधिनियम, 1981, जैसी भी स्थिति हो, के अंतर्गत उचित कार्रवाई कर सकता है।

(4) पर्यावरणीय क्षतिपूर्ति का भुगतान जिम्मेदार व्यक्तियों को लगाए गए उपचार लागत के भुगतान से मुक्त नहीं करेगा।

(5) इन नियमों के अंतर्गत पर्यावरणीय क्षतिपूर्ति की राशि, लोक दायित्व बीमा अधिनियम, 1991 (1991 का 6) की धारा 7क के अंतर्गत स्थापित पर्यावरण राहत निधि में जमा की जाएगी और एक पृथक खाते में रखी जाएगी।

(6) इन नियमों के अंतर्गत एकत्रित पर्यावरणीय क्षतिपूर्ति का उपयोग संदूषण के निर्धारण और संदूषित स्थलों के उपचार के माध्यम से पर्यावरण या लोक स्वास्थ्य को होने वाली हानि, क्षति या क्षति की प्रतिपूर्ति हेतु तथा इन नियमों के उपबंधों के कार्यान्वयन के प्रयोजनार्थ किया जाएगा।

(7) केन्द्रीय बोर्ड, उप-नियम (6) के अंतर्गत विनिर्दिष्ट प्रयोजनों के लिए पर्यावरणीय क्षतिपूर्ति के अंतर्गत एकत्रित निधियों के उपयोग हेतु लागत के अनुमान सहित एक योजना, केंद्रीय सरकार को प्रस्तुत करेगा।

(8) केंद्र सरकार, उप-नियम (7) के अंतर्गत प्रस्तुत योजना और अनुमान से संतुष्ट होने पर, केन्द्रीय बोर्ड को राशि के संवितरण हेतु आदेश जारी कर सकेगी।

(9) राज्य बोर्ड, उप-नियम (6) के अंतर्गत विनिर्दिष्ट प्रयोजनों के लिए निधियों की प्राप्ति हेतु केन्द्रीय बोर्ड के माध्यम से केंद्र सरकार को योजना प्रस्तुत करेगा।

(10) केन्द्रीय बोर्ड, उप-नियम (9) के अंतर्गत राज्य बोर्ड से योजना प्राप्त होने पर, राज्य बोर्ड से योजना प्राप्त होने की तिथि से 30 दिनों के भीतर योजना पर अपनी सिफारिश केंद्र सरकार को भेजेगा।

(11) केन्द्रीय सरकार, उप-नियम (9) के अधीन प्रस्तुत योजना से संतुष्ट होने पर, केन्द्रीय बोर्ड को राशि के संवितरण के लिए आदेश जारी कर सकेगी, जो बदले में संबंधित राज्य बोर्ड को निधि का संवितरण करेगा।

[फा. सं. 12/4/2024 -एचएसएम]

नीलेश कुमार साह, संयुक्त सचिव

अनुसूची I
[नियम 3 (ड.) (ण) और (थ) देखिए]

परिसंकटमय पदार्थों की अनुक्रिया और स्क्रीनिंग स्तर

क्र. सं.	रासायनिक नाम	रासायनिक समूह	मिट्टी/तलछट					भूजल गुणवत्ता (स्क्रीनिंग स्तर) (मिलीग्राम/लीटर में)	सतही जल गुणवत्ता (स्क्रीनग स्तर) (µg/L में)
			अनुक्रिया स्तर (आरएल) (मिलीग्राम/किलोग्राम में)	स्क्रीनिंग स्तर (एसएल) (मिलीग्राम/किग्रा में)					
				कृषि	आवासीय	वाणिज्यिक	औद्योगिक		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1.	1,1,1-ट्राइक्लोरोइथेन (टीसीए)	हैलोजेनेटेड एलिफैटिक यौगिक	50	0.1	5	**50**	**50**	-	-
2.	1,1,2,2- टेट्राक्लोरोइथीन (पीसीई)	हैलोजेनेटेड एलिफैटिक यौगिक	8.8	0.1	0.2	0.5	0.6	0.03	110
3.	1,1,2,2-टेट्राक्लोरेथेन	हैलोजेनेटेड एलिफैटिक यौगिक	50	0.1	5	50	50	-	-
4.	1,1,2-ट्राइक्लोरोइथेन	हैलोजेनेटेड एलिफैटिक यौगिक	50	0.1	5	**50**	**50**	-	-
5.	1,1,2-ट्राइक्लोरोइथीन (टीसीई)	हैलोजेनेटेड एलिफैटिक यौगिक	2.5	0.01	0.01	0.01	0.01	0.005	21
6.	1,1-डाइक्लोरोइथेन	हैलोजेनेटेड एलिफैटिक यौगिक	50	0.1	5	**50**	**50**	-	-
7.	1,1-डाइक्लोरोइथीन	हैलोजेनेटेड एलिफैटिक यौगिक	50	0.1	**5**	**50**	**50**	0.014	-
8.	1,2,3,4-टेट्राक्लोरोबेंज़ीन	हैलोजनयुक्त सुगंधित यौगिक	10	0.05	2	**10**	**10**	-	1.8
9.	1,2,3,5-टेट्राक्लोरोबेंज़ीन	हैलोजनयुक्त सुगंधित यौगिक	10	0.05	2	**10**	**10**	-	-
10.	1,2,3-ट्राइक्लोरोबेंजीन	हैलोजनयुक्त सुगंधित यौगिक	11	0.05	2	10	10	-	8
11.	1,2,4,5-टेट्राक्लोरोबेंज़ीन	हैलोजनयुक्त सुगंधित यौगिक	10	0.05	2	**10**	**10**	-	-
12.	1,2,4-ट्राइक्लोरोबेंजीन	हैलोजनयुक्त सुगंधित यौगिक	11	0.05	2	10	10	-	24
13.	1,2-डाइक्लोरोबेंज़ीन	हैलोजनयुक्त सुगंधित	19	0.1	1	10	10	0.005	0.7

		यौगिक							
14.	1,2-डाइक्लोरोइथेन	हैलोजेनेटेड एलिफैटिक यौगिक	50	0.1	5	**50**	**50**	0.005	100
15.	1,2-डाइक्लोरोइथीन	हैलोजेनेटेड एलिफैटिक यौगिक	50	0.1	**5**	**50**	**50**	0.05	-
16.	1,2-डाइक्लोरोप्रोपेन	हैलोजेनेटेड एलिफैटिक यौगिक	50	0.1	**5**	**50**	**50**	-	-
17.	1,2-डाइक्लोरोप्रोपीन (सिस और ट्रांस)	हैलोजेनेटेड एलिफैटिक यौगिक	50	0.1	5	50	50	-	-
18.	1,3,5-ट्राइक्लोरोबेंजीन	हैलोजनयुक्त सुगंधित यौगिक	11	0.05	2	10	10	-	-
19.	1,3-डाइक्लोरोबेंज़ीन	हैलोजनयुक्त सुगंधित यौगिक	19	0.1	1	10	10	-	150
20.	1,4-डाइक्लोरोबेंज़ीन	हैलोजनयुक्त सुगंधित यौगिक	19	0.1	1	10	10	0.005	26
21.	1,4-डाइऑक्सेन	विषमचक्रीय कार्बनिक यौगिक	-	-	-	-	-	0.05	-
22.	2,3,4,6-टेट्राक्लोरोफेनॉल	हैलोजनयुक्त सुगंधित यौगिक	21	0.05	0.5	5	5	0.1	-
23.	2,4,6-ट्राइक्लोरोफेनॉल	हैलोजनयुक्त सुगंधित यौगिक	22	0.05	0.5	5	5	0.005	-
24.	2,4-डाइक्लोरोफेनॉल	हैलोजनयुक्त सुगंधित यौगिक	5	0.05	0.5	5	5	0.9	-
25.	2,4-डाइक्लोरोफेनोक्सीएसिटिक एसिड (2,4-डी)	कीटनाशक (फेनोक्सी शाकनाशी)	-	-	-	-	-	0.1	-
26.	3-आयोडो-2-प्रोपिनिल ब्यूटाइल कार्बामेट	कीटनाशक, कार्बामेट	-	-	-	-	-	-	1.9
27.	एसेनाफ्थीन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	5.8
28.	एसेनाफ्थिलीन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	-
29.	एक्रिडीन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	4.4
30.	एल्डीकार्ब	कीटनाशक, कार्बामेट	-	-	-	-	-	0.009	1
31.	एल्ड्रिन	कीटनाशक, ऑर्गेनोक्लोरीन	0.32	-	-	-	-	0.0007	0.004
32.	एलिफैटिक्स नॉनक्लोरीनेटेड (प्रत्येक)	गैर-हैलोजनयुक्त ऐलिफैटिक यौगिक	0.3	0.3	-	-	-	-	-
33.	अल्युमीनियम	धातु		-	-	-	-	2.9	-
34.	अमोनिया (कुल)	अकार्बनिक	-	-	-	-	-	0.5	-
35.	अमोनिया (अन-आयनीकृत)	अकार्बनिक	-	-	-	-	-	-	19
36.	रंगों का रासायनिक आधार	जैविक	-	-	-	-	-	-	2.2

37.	अंगारिन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	0.012
38.	एंटीमनी (धात्विक)	अकार्बनिक	40	20	20	**40**	**40**	0.006	-
39.	हरताल	धातु	76	12	12	12	12	0.01	5
40.	अदह		100					-	-
41.	एटेराजिन	कीटनाशक, ट्राइएज़ीन	0.71					0.005	1.8
42.	बेरियम	अकार्बनिक	2000	750	500	2000	2000	2	-
43.	बेंजीन	मोनोसाइक्लिक सुगंधित यौगिक	5	0.05	0.5	**5**	**5**	0.005	370
44.	बेंज़ो(ए) एन्थ्रेसेन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	0.018
45.	बेंज़ो(ए) पाइरीन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	0.00004	0.015
46.	बेंज़ो(बी) फ्लोराएन्थीन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	-
47.	बेंज़ो(के) फ्लोराएन्थीन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	-
48.	फीरोज़ा	अकार्बनिक	8	4	4	8	8	-	-
49.	बोरान	अकार्बनिक	2	2	-	-	-	5	0.0015
50.	ब्रोमेसिल	कीटनाशकों	-	-	-	-	-	-	5
51.	ब्रोमोक्सिनिल	कीटनाशक, बेंज़ोनाइट्राइल		-	-	-	-	0.03	5
52.	कैडमियम	धातु	22	1.4	10	**22**	**22**	0.007	-
53.	कैल्शियम	अकार्बनिक	-	-	-	-	-	75	-
54.	कैप्टन	कीटनाशकों	-	-	-	-	-	-	1.3
55.	कार्बेरिल	कीटनाशक, कार्बामेट	0.45					-	0.2
56.	carbofuran	कीटनाशक, कार्बामेट	0.017					0.09	1.8
57.	क्लोरडेन	कीटनाशक, ऑर्गेनोक्लोरीन	4					0.0002	0.006
58.	क्लोराइड	अकार्बनिक	-	-	-	-	-	250	120000
59.	क्लोरोइंथेनोल	कीटनाशकों	-	-	-	-	-	-	0.18
60.	कलोरोफिस	कीटनाशक, ऑर्गनोफॉस्फोरस	-	-	-	-	-	0.09	0.002
61.	क्रोमियम (कुल)	धातु	87	64	64	87	87	0.05	-
62.	क्रोमियम, हेक्सावेलेन्ट	धातु	78	0.4	0.4	1.4	1.4	-	1

	(Cr(VI))								
63.	क्रोमियम, त्रिसंयोजक (Cr(III))	धातु	180					-	8.9
64.	क्रिसेन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	-
65.	कोबाल्ट	अकार्बनिक	300	40	50	**300**	**300**	-	-
66.	कोलीफॉर्म, मल (एस्चेरिचिया कोली)	जैविक	-	-	-	-	-	किसी भी 100 मिलीलीटर नमूने में पता लगाने योग्य नहीं होगा	-
67.	कोलीफॉर्म, कुल	जैविक	-	-	-	-	-	-	-
68.	रंग	भौतिक	-	-	-	-	-	5 हेज़न यूनिट (आईएस)	-
69.	प्रवाहकत्त्व	भौतिक	4 डी एस /मी	2 डी एस /मी	2 डी एस /मी	4 डी एस /मी	4 डी एस /मी	-	-
70.	ताँबा	धातु	190	63	63	91	91	2	
71.	सायनाज़ीन	कीटनाशक, ट्राइएज़ीन	-	-	-	-	-	0.01	2
72.	साइनाइड	अकार्बनिक	50	0.9	0.9	8	8	0.2	5
73.	सायनोबैक्टीरियल विष	जैविक	-	-	-	-	-	0.0015	-
74.	डीडीडी (डाइक्लोरोडाइफेनिलडाइक्लोरोइथेन,2,2-बिस (पी- क्लोरोफेनिल)-1, 1-डाइक्लोरोइथेन)	कीटनाशक, ऑर्गेनोक्लोरीन	34					-	-
75.	डीडीई (डाइक्लोरोडाइफेनिल एथिलीन,1,1-डाइक्लोरो-2,2-बिस (पी- क्लोरोफेनिल) -एथीन)	कीटनाशक, ऑर्गेनोक्लोरीन	2.3					-	-
76.	डीडीटी (डाइक्लोरोडाइफेनिलट्राइक्लोरोइथेन;2, 2-बिस(पी-क्लोरोफेनिल)-1,1,1-ट्राइक्लोरोइथेन)	कीटनाशक, ऑर्गेनोक्लोरीन	1.7					1	-
77.	डीडीटी कुल (डाइक्लोरो डाइफेनिल ट्राइक्लोरोइथेन ; 2,2-बिस (पी-क्लोरोफेनिल) -1,1,1-ट्राइक्लोरोइथेन)	कीटनाशक, ऑर्गेनोक्लोरीन	12	0.7	0.7	**12**	**12**	-	0.001
78.	डेल्टामेथ्रिन	कीटनाशकों	-	-	-	-	-	-	0.000

									4
79.	डाइ(2-एथिलहेक्सिल) फ़थैलेट	फ़थैलेट एस्टर	-	-	-	-	-	-	16
80.	डाइबेन्ज़ (ए,एच)एन्थ्रासीन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	-
81.	डाइब्रोमोक्लोरोमेथेन	हैलोजनयुक्त मीथेन	-	-	-	-	-	0.1	-
82.	डिकैम्बा	कीटनाशक, एरोमैटिक कार्बोक्सिलिक एसिड	-	-	-	-	-	0.11	10
83.	डाइक्लोरोब्रोमोमेथेन	हैलोजनयुक्त मीथेन	-	-	-	-	-	-	-
84.	डाइक्लोरोमेथेन (मेथिलीन क्लोराइड)	हैलोजेनेटेड एलिफैटिक यौगिक	50	0.1	**5**	**50**	**50**	0.05	98.1
85.	डाइक्लोरोफेनोल्स	क्लोरीनयुक्त फिनोल	22	0.05	0.5	5	5	0.9	0.2
86.	डिक्लोफॉप -मिथाइल	कीटनाशकों	-	-	-	-	-	-	6.1
87.	डाइडेसिलडाइमेथिलैमोनियम क्लोराइड	कीटनाशकों	-	-	-	-	-	-	1.5
88.	डिसोपरोपोलामाईन	जैविक	180	180	180	180	180	-	1600
89.	डाइमेथोएट	कीटनाशक, ऑर्गनोफॉस्फोरस	-	-	-	-	-	0.02	6.2
90.	डाइ-एन-ब्यूटाइल फ़थैलेट	फ़थैलेट एस्टर	-	-	-	-	-	-	19
91.	डाइनोसेब	कीटनाशकों	-	-	-	-	-	0.01	0.05
92.	एंडोसल्फान	कीटनाशक, ऑर्गेनोक्लोरीन	4					0.4	0.003
93.	एन्ड्रिन	कीटनाशक, ऑर्गेनोक्लोरीन	-	-	-	-	-	0.0006	0.0023
94.	एथिलबेन्ज़ीन	मोनोसाइक्लिक सुगंधित यौगिक	110	0.1	5	50	50	0.14	90
95.	इथाईलीन ग्लाइकॉल	ग्लाइकॉल्स	960	960	960	960	960	-	192000
96.	विनिमय योग्य सोडियम प्रतिशत (ईएसपी)		15	10				-	
97.	फ्लोराएन्थीन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	0.04
98.	फ्लोरीन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	3
99.	फ्लोराइड	अकार्बनिक	2000	200	400	2000	2000	1.5	120
100.	ग्लाइफोसेट	कीटनाशक, ऑर्गनोफॉस्फोरस	-	-	-	-	-	0.28	800
101.	हेप्टाक्लोर	कीटनाशक, ऑर्गेनोक्लोरीन	4					-	0.01
102.	हेक्साक्लोरोबेंज़ीन	हैलोजनयुक्त सुगंधित यौगिक	10	0.05	2	**10**	**10**	-	-
103.	हेक्साक्लोरोब्यूटाडीन	हैलोजेनेटेड एलिफैटिक यौगिक	-	-	-	-	-	0.0006	1.3

104.	हेक्साक्लोरोसाइक्लोहेक्सेन (अल्फा एचसीएच)	कीटनाशक, ऑर्गेनोक्लोरीन	17	17	17	17	17	0.01	-
105.	हेक्साक्लोरोसाइक्लोहेक्सेन (डेल्टा एचसीएच)	कीटनाशक, ऑर्गेनोक्लोरीन	-	-	-	-	-	0.04	-
106.	हेक्साक्लोरोसाइक्लोहेक्सेन (HCH)	कीटनाशक, ऑर्गेनोक्लोरीन	0.01	0.01	-	-	-	-	0.01
107.	हेक्साक्लोरोसाइक्लोहेक्सेन (बीटा HCH)	कीटनाशक, ऑर्गेनोक्लोरीन	1.6					0.04	-
108.	imidacloprid		-	-	-	-	-	0.23	-
109.	इंडेनो (1,2,3-सी,डी) पाइरीन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	-
110.	लोहा	अकार्बनिक	-	-	-	-	-	0.3	300
111.	नेतृत्व करना	धातु	600	70	140	260	**600**	0.005	-
112.	लिंडेन (गामा एचसीएच)	कीटनाशक, ऑर्गेनोक्लोरीन	1.2					0.002	-
113.	लिनुरोन	कीटनाशकों	-	-	-	-	-	-	7
114.	लिथियम	अकार्बनिक	-	-	-	-	-	-	-
115.	मैगनीशियम	अकार्बनिक	-	-	-		-	30	-
116.	मैलाथियोन	कीटनाशक, ऑर्गेनोफॉस्फोरस	-	-	-	-	-	0.29	-
117.	मैंगनीज	अकार्बनिक		-	-	-	-	0.12	-
118.	एमसीपीए (मिथाइलक्लोरोफेनोक्सीएसिटिक एसिड (4-क्लोरो-2-मिथाइलफेनोक्सीएसिटिक एसिड;2-मिथाइल-4-क्लोरोफेनोक्सीएसिटिक एसिड)	कीटनाशकों	4					0.1	2.6
119.	पारा (अकार्बनिक)	धातु	50	6.6	6.6	24	**50**	0.001	0.026
120.	मेथोप्रीन		-	-	-	-	-	1	-
121.	मिथाइलमर्करी	जैविक	4	-	-	-	-	-	0.004
122.	मिथाइलटरशियरी -ब्यूटाइल ईथर (एमटीबीई)	एलिफैटिकेथर	-	-	-	-	-	-	10000
123.	मेटोलाक्लोर	कीटनाशक, ऑर्गेनोफॉस्फोरस	-	-	-	-	-	0.05	7.8
124.	मेट्रिब्युज़िन	कीटनाशक, ट्राइएज़ीन	-	-	-	-	-	0.08	1
125.	मोलिब्डेनम	अकार्बनिक	190	5	10	40	40	0.07	73
126.	मोनोक्लोरोबेंज़ीन	हैलोजनयुक्त सुगंधित यौगिक	15	0.1	1	10	10	0.08	1.3
127.	मोनोक्लोरोफेनोल्स	क्लोरीनेटेडफिनोल	5.4	0.05	0.5	5	5	-	7
128.	नेफ़थलीन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	1.1
129.	एन-हेक्सेन	एलिफैटिक	21	6.5	6.5	21	21	-	-

		हाइड्रोकार्बन						
130.	निकल	धातु	100	45	45	50	89	0.02	-
131.	नाइट्रेट	अकार्बनिक नाइट्रोजन यौगिक	-	-	-	-	-	45	13मिग्रा/ली
132.	नाइट्राट	अकार्बनिक नाइट्रोजन यौगिक	-	-	-	-	-	-	60
133.	नॉनाइलफेनोलैंडिट्स इथोक्सिलेट्स	नोनीलफेनोल और इसके इथोक्सिलेट्स	14	5.7	5.7	14	14	-	1
134.	पीसीबी (पॉलीक्लोरीनेटेड बाइफिनाइल्स)	पॉलीक्लोरिनेटेड बाइफिनाइल्स	33	0.5	**1.3**	**33**	**33**	-	0.001
135.	पेंटाक्लोरोबेंज़ीन	हैलोजनयुक्त सुगंधित यौगिक	10	0.05	2	**10**	**10**	-	6
136.	पेंटाक्लोरोफेनॉल	हैलोजनयुक्त सुगंधित यौगिक	12	7.6	7.6	7.6	7.6	0.06	0.5
137.	पर्मेथ्रिन	कीटनाशक, ऑर्गेनोक्लोरीन यौगिक	-	-	-	-	-	-	0.004
138.	पीएच	अकार्बनिक अम्लता, क्षारीयता और पीएच	6 से 8	6 से 8	6 से 8	6 से 8	6 से 8	6.5-8.5	6.5 से 9.0
139.	फेनेंथ्रीन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	0.4
140.	फेनोलिक यौगिक ($C6H5OH$ के रूप में)	यौगिक	14	0.1	1	10	10	0.001	-
141.	फिनोल (मोनो- और डाइहाइड्रिक)	सुगंधित हाइड्रॉक्सिल यौगिक	3.8	3.6	3.8	3.8	3.8	-	4
142.	फेनोक्सी शाकनाशी	कीटनाशकों	-	-	-	-	-	-	4
143.	थैलिका एसिड एस्टर (प्रत्येक)	फथैलेटेस्टर्स	30	30	-	-	-	-	-
144.	पिक्लोरम	कीटनाशकों	-	-	-	-	-	-	29
145.	पॉली क्लोरीनेटेड डाइबेंजो -पी-डाइऑक्सिन/डाइबेंजोफ्यूरान	पॉलीक्लोरीनेटेड डाइऑक्सिन और फ्यूरान	4 एनजीटीईक्यू.किग्रा $^{-1}$	4 एनजीटीई क्यू.किग्रा $^{-1}$	4 एनजीटीई क्यू.किग्रा $^{-1}$	4 एनजीटीई क्यू.किग्रा $^{-1}$	4 एनजीटीई क्यू.किग्रा $^{-1}$	-	-
146.	पॉलीसाइक्लिक हाइड्रोकार्बन (पीएएच)	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	40					0.0001	-
147.	प्रोपलीन ग्लाइकोल	ग्लाइकॉल्स	-	-	-	-	-	-	500000
148.	पाइरीन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	0.025
149.	क्विनोलिन	पॉलीसाइक्लिक एरोमैटिक हाइड्रोकार्बन (पीएएच)	10	0.1	1	10	10	-	3.4
150.	प्रतिक्रियाशील क्लोरीन प्रजातियाँ	अकार्बनिक प्रतिक्रियाशील क्लोरीन यौगिक	-	-	-	-	-	-	0.5
151.	सेलेनियम	अकार्बनिक	2.9	1	1	2.9	2.9	0.05	1

152.	चाँदी	अकार्बनिक	40	20	20	40	40	0.1	0,1
153.	सिमाज़ीन	कीटनाशक, ट्राइएज़ीन	-	-	-	-	-	0.01	10
154.	सोडियम	अकार्बनिक	-	-	-		-	50	-
155.	सोडियम अवशोषण अनुपात (एसएआर)		12	5	5	**12**	**12**	-	-
156.	स्टाइरीन	मोनोसाइक्लिक सुगंधित यौगिक	86	0.1	5	50	50	0.02 (सी)	72
157.	sulfolane	कार्बनिक सल्फर यौगिक	0.8	0.8	0.8	0.8	0.8	-	50000
158.	सल्फेट	अकार्बनिक सल्फर यौगिक	-	-	-	-	-	200	-
159.	सल्फर(तत्व)	अकार्बनिक सल्फर यौगिक	500	500	-	-	-	-	-
160.	टेबुथियूरोन	कीटनाशकों	-	-	-	-	-	-	1.6
161.	टेट्राक्लोरोमेथेन	हैलोजेनेटेड एलिफैटिक यौगिक	50	0.1	**5**	**50**	**50**	-	13.3
162.	टेट्राक्लोरोफेनोल्स	हैलोजनयुक्त सुगंधित यौगिक	21	0.05	0.5	5	5	0.1	1
163.	थालियम	अकार्बनिक	1	1	1	1	1	-	0.8
164.	थियोफीन	विविध कार्बनिक यौगिक	0.1	0.1	-	-	-	-	-
165.	टिन (अकार्बनिक)	अकार्बनिक	300	5	50	300	300	-	-
166.	टोल्यूनि	मोनोसाइक्लिक सुगंधित यौगिक	32	0.1	3	30	30	0.06	2
167.	कुल घुलित ठोस (टीडीएस)	एसएनएफ	-	-	-	-	-	500	-
168.	कुल हाइड्रोकार्बन (टीपीएच) (खनिज तेल)	सुगंधित हाइड्रोकार्बन	5000					0.01	-
169.	टोक्साफीन	कीटनाशक, ऑर्गेनोक्लोरीन	-	-	-	-	-	-	0.008
170.	ट्रायलेट	कीटनाशक, कार्बामेट	-	-	-	-	-	-	0.24
171.	ट्राइब्रोमोमेथेन	हैलोजेनेटेड एलिफैटिक यौगिक	75					-	-
172.	ट्राइब्यूटिलटिन	ऑर्गेनोटिन यौगिक	-	-	-	-	-	-	0.008
173.	ट्राइक्लोरोफॉन		-	-	-	-	-	-	0.009
174.	ट्राइक्लोरोमेथेन (क्लोरोफॉर्म)	हैलोजेनेटेड एलिफैटिक यौगिक	50	0.1	**5**	**50**	**50**	0.3	1.8
175.	ट्राइक्लोरोफेनोल्स	हैलोजनयुक्त सुगंधित यौगिक	22	0.05	0.5	5	5	0.005	18
176.	ट्राइसाइक्लोहेक्सिलटिन	ऑर्गेनोटिन यौगिक	-	-	-	-	-	-	-
177.	ट्राइफ्लुरालिन	कीटनाशक, डाइनाइट्रोएनिलिन	-	-	-	-	-	0.02	0.2
178.	ट्राइफेनिलटिन	ऑर्गेनोटिन यौगिक	-	-	-	-	-	-	0.022
179.	गंदगी	ठोस कुल कणिकीय	-	-	-	-	-	0.1-	-

		पदार्थ					1.0एनटीयू	
180.	यूरेनियम	अकार्बनिक	300	23	23	33	300	0.02	15
181.	वैनेडियम	अकार्बनिक	130	130	130	130	130	-	-
182.	विनाइलक्लोराइड	हैलोजेनेटेड एलिफैटिक यौगिक	0.1					0.002	-
183.	ज़ाइलीन	मोनोसाइक्लिक सुगंधित यौगिक	17	2.4	2.4	2.4	2.4	0.09	-
184.	जस्ता	धातु	720	250	250	360	410	5	30
185.	एचएफपीओ-डीए (सामान्यतः जेनएक्स केमिकल्स के नाम से जाना जाता है)	ऑर्गेनोफ्लोरीन यौगिक						0.000004	
186.	पीएफएचएक्सएस	ऑर्गेनोफ्लोरीन यौगिक						0.000001	
187.	पीएफएनए	ऑर्गेनोफ्लोरीन यौगिक						0.000001	
188.	पीएफओए	ऑर्गेनोफ्लोरीन यौगिक						0.000001	
189.	प्फोस	ऑर्गेनोफ्लोरीन यौगिक						1	

अनुसूची 2

[नियम 7(1) देखिए]

निर्देश संगठनों के चयन के मानदंड

संदूषित स्थलों का प्रारंभिक निर्धारण, विस्तृत निर्धारण और उपचार योजना तैयार करने के लिए:

क) निर्देश संगठन को परिसंकटमय पदार्थों तथा रसायनों के संदूषण के निर्धारण में और उपचार योजना तैयार करने में न्यूनतम 5 वर्ष का अनुभव होना चाहिए।

ख) निर्देश संगठन को परिसंकटमय पदार्थों तथा रसायनों के संदूषण के निर्धारण और उपचार योजना तैयार करने के संबंध में कम से कम 3 परियोजनाएं निश्चित रूप से किया होना चाहिए और जिनमें से 1 परियोजना उपचार योजना की होगी।

ग) निर्देश संगठन में निम्नलिखित अर्हताएं और अनुभव रखने वाले कम से कम 10 कार्मिक कार्यरत होंगे:

i. कम से कम 5 व्यक्तियों के पास पर्यावरण इंजीनियरी/सिविल इंजीनियरी/केमिकल इंजीनियरी/जियोटेक्निकल इंजीनियरी में एम.टेक या पर्यावरण विज्ञान/रसायन विज्ञान/जल विज्ञान/भूविज्ञान/भूभौतिकी में एम.एससी. डिग्री हो, साथ ही कम से कम 5 वर्ष का सुसंगत प्रासंगिक कार्य अनुभव हो, जिसमें परियोजना प्रबंधक के पास कम से कम 10 वर्ष का प्रासंगिक कार्य अनुभव होना चाहिए।

ii. कम से कम 4 व्यक्ति जिनके पास पर्यावरण इंजीनियरी/सिविल इंजीनियरी/केमिकल इंजीनियरी/जियोटेक्निकल इंजीनियरी में बी.टेक या पर्यावरण विज्ञान/रसायन विज्ञान /हाइड्रोलॉजी/भूविज्ञान/भूभौतिकी में बी.एससी. हो, साथ ही कम से कम 3 वर्ष का सुसंगत कार्य अनुभव हो।

iii. उपचार योजना तैयार करने के मामले में, सामाजिक विज्ञान में स्नातकोत्तर डिग्री के साथ कम से कम 3 वर्ष का प्रासंगिक कार्य अनुभव रखने वाले सामाजिक विज्ञान के कम से कम एक विशेषज्ञ

को नियुक्त किया जा सकता है।

घ) निर्देश संगठन के पास संदूषण की सीमा का आकलन और पता लगाना की क्षमताओं और अनुभव होगा तथा इस संबंध में मॉडलिंग सॉफ्टवेयर का स्वामित्व प्रदर्शित करना होगा।

ङ) निर्देश संगठन का पर्यावरण संरक्षण अधिनियम, 1986 की धारा 12 के तहत मान्यता प्राप्त प्रयोगशाला के साथ गठजोड़ होना चाहिए।

उपचार योजना के अनुसार उपचार गतिविधियों के कार्यान्वयन के लिए:

क) निर्देश संगठन के पास उपचार योजना तैयार करने, अपशिष्ट प्रसंस्करण, शोधन और निपटान सुविधाओं के डिजाइन और कार्यान्वयन करने तथा उपचार क्रियाकलापों को करने में न्यूनतम 5 वर्ष का अनुभव होना चाहिए।

ख) निर्देश संगठन ने उपचार योजना तैयार करने या अपशिष्ट प्रसंस्करण, शोधन और निपटान सुविधाओं की डिजाइनिंग और कार्यान्वयन करने और उपचार क्रियाकलापों करने के संबंध में कम से कम 3 परियोजनाएं निश्चित रूप से किया होना चाहिए और जिनमें से 1 परियोजना उपचार क्रियाकलापों की होगी।

ग) निर्देश संगठन में निम्नलिखित अर्हताएं और अनुभव रखने वाले कम से कम 15 कार्मिक कार्यरत होंगे:

i. कम से कम 5 व्यक्तियों के पास पर्यावरण इंजीनियरी/सिविल इंजीनियरी/केमिकल इंजीनियरी/जियोटेक्निकल इंजीनियरी में एम.टेक या पर्यावरण विज्ञान/रसायन विज्ञान/जल विज्ञान/भूविज्ञान/भूभौतिकी में एम.एससी. डिग्री हो, साथ ही कम से कम 5 वर्ष का सुसंगत प्रासंगिक कार्य अनुभव हो, जिसमें परियोजना प्रबंधक के पास कम से कम 10 वर्ष का प्रासंगिक कार्य अनुभव होना चाहिए।

ii. कम से कम 4 व्यक्ति जिनके पास पर्यावरण इंजीनियरी/सिविल इंजीनियरी/केमिकल इंजीनियरी/जियोटेक्निकल इंजीनियरी में बी.टेक या पर्यावरण विज्ञान/रसायन विज्ञान /हाइड्रोलॉजी/भूविज्ञान/भूभौतिकी में बी.एससी. हो, साथ ही कम से कम 3 वर्ष का सुसंगत कार्य अनुभव हो।

iii. यांत्रिकी, इलेक्ट्रिकल, सर्वेक्षण, इंस्ट्रूमेंटेशन, फिटर और वेल्डर में सुसंगत व्यवसायिक अर्हताऐं रखने वाले कम से कम 5 तकनीशियन

iv. कम से कम एक व्यक्ति के पास व्यावसायिक स्वास्थ्य एवं सुरक्षा में स्नातकोत्तर डिग्री के साथ कम से कम 3 वर्ष का सुसंगत कार्य अनुभव हो

घ) निर्देश संगठन के पास संदूषण की सीमा का आकलन और पता लगाना की क्षमताओं और अनुभव होगा तथा इस संबंध में मॉडलिंग सॉफ्टवेयर का स्वामित्व प्रदर्शित करना होगा।

ङ) निर्देश संगठन का पर्यावरण संरक्षण अधिनियम, 1986 की धारा 12 के तहत मान्यता प्राप्त प्रयोगशाला के साथ गठजोड़ होना चाहिए।

प्ररूप 1

[नियम 4(3) देखिए]

राज्य बोर्ड को संदिग्ध संदूषित स्थलों की अर्धवार्षिक सूची प्रस्तुत करने का रूपविधान

सेवा में,

अध्यक्ष,
राज्य प्रदूषण नियंत्रण बोर्ड,
…………………
जिले का नाम:
संभावित संदूषित स्थलों की संख्या:

जिलेवार संदिग्ध संदूषित स्थलों की सूची

क्र. सं.	संभावित संदूषित स्थल का नाम	भू-निर्देशांक और स्थान
1.		
2.		

नीचे दिए गए रूपविधान के अनुसार प्रत्येक संभावित संदूषित स्थल के लिए अलग पेपर संलग्न करें:

क्र. सं.	**विशिष्टयां**	**ब्यौरा**
1.	राज्य और जिला	
2.	क्रम संख्या	
3.	स्थल आईडी	(राज्य-जिला-xx) उदाहरण: उत्तर प्रदेश (यूपी), गाजियाबाद (जीजेड) यूपी-जीजेड-01- पहला स्थल यूपी-जीजेड-02 – दूसरा स्थल
4.	स्थल का नाम	
5.	स्थल मालिक का नाम	
6.	अनुमानित क्षेत्रफल	
7.	पता (गली, गली संख्या, पिन कोड)	
8.	जीपीएस निर्देशांक/और ऊंचाई (अक्षांश और देशांतर)	
9.	भूमि उपयोग (वर्तमान)	
10.	संदिग्ध संदूषित स्थल के निकटतम उद्योग का ब्यौरा	
11.	संदूषण का प्रकार (यदि ज्ञात हो)	
12.	संदूषण का संदिग्ध कारण (कोई औद्योगिक प्रक्रिया या कोई अन्य क्रियाकलाप जिसके कारण संदूषण हुआ)	
13.	चिंतायुक्त संदूषक (यदि ज्ञात हो)	
14.	प्रारंभिक स्थल निरीक्षण रिपोर्ट	यदि हां, तो रिपोर्ट की एक प्रति संलग्न करें
15.	क्या पहले कोई पर्यावरण क्षतिपूर्ति अधिरोपित की गई है, यदि	

	हां, तो उसका ब्यौरा दिया जाए।	
16.	यदि कोई न्यायालय/न्यायालय मामला हो, तो उसका ब्यौरा दिया जाए।	

स्थान:
तारीख:

(स्थानीय निकाय या जिला प्रशासन का नाम)

प्ररूप-2

[नियम 5(10) देखिए]

संदूषित स्थलों के उपचार की अर्धवार्षिक प्रगति रिपोर्ट के लिए प्ररूप, जिसे जिम्मेदार व्यक्ति द्वारा राज्य बोर्ड को प्रस्तुत किया जाना है केन्द्रीय बोर्ड को सूचना देते हुए

सेवा में,
अध्यक्ष
राज्य प्रदूषण नियंत्रण बोर्ड

1	संदूषित स्थल का नाम	:	
2	अधिभोगी का नाम और पता टेलीफोन नंबर फैक्स नंबर ई-मेल	:	
3	संदूषित स्थल के उपचार कार्य से संबंधित प्रभारी व्यक्ति का नाम और संपर्क ब्यौरा, साथ ही उपचार अभिकरण/ठेकेदार का ब्यौरा	:	
4	कार्य योजना के संबंध में संदूषित स्थलों के उपचार की भौतिक प्रगति	:	
5	कार्य योजना के संबंध में संदूषित स्थलों के उपचार की वित्तीय प्रगति	:	

स्थान: ________________

तारीख: _______________

(प्राधिकृत हस्ताक्षरकर्ता)
नाम:
पदनाम:

प्रतिलिपि-

सदस्य सचिव

केंद्रीय प्रदूषण नियंत्रण बोर्ड

प्ररूप-3

[नियम 6(9) देखिए]

दुर्घटना की सूचना देने का रूपविधान

[जिम्मेदार व्यक्ति या परिवाहक द्वारा राज्य बोर्ड को प्रस्तुत किया जाना है]

सेवा में,

अध्यक्ष,
राज्य प्रदूषण नियंत्रण बोर्ड, ………………………………………………………………………………

1. दुर्घटना की तारीख और समय :
2. दुर्घटना का कारण होने वाली घटनाओं का क्रम:
3. दुर्घटना में शामिल परिसंकटमय पदार्थों का ब्यौरा:
4. दुर्घटना के कारण स्वास्थ्य और पर्यावरण पर पड़ने वाले प्रभावों का निर्धारण करने की तारीख:
5. किए गए आपातकालीन उपाय:
6. दुर्घटनाओं के प्रभाव को कम करने के लिए उठाए गए कदम:
7. ऐसी दुर्घटना की पुनरावृत्ति रोकने के लिए उठाए गए कदम:

तारीख:
स्थान: हस्ताक्षर:

प्राधिकृत व्यक्ति के हस्ताक्षर

प्रतिलिपि-
संबंधित जिला मजिस्ट्रेट

प्ररूप-4

[नियम 7(1) देखें]

निर्देश संगठन के पैनल में रखे जाने के लिए आवेदन

सेवा में,

सदस्य सचिव
केंद्रीय प्रदूषण नियंत्रण बोर्ड
भारत सरकार, 'परिवेश भवन', ईस्ट अर्जुन नगर,
दिल्ली- 110 032

1.	संगठन का नाम	:	
2.	कंपनी अधिनियम, 2013 के अधीन जारी निगमन प्रमाणपत्र		

	(क) कॉर्पोरेट पहचान संख्या: (ख) वैधता: (ग) एक प्रति संलग्न करें		
3.	रजिस्ट्रीकृत पता टेलीफोन नंबर ई-मेल	:	
4.	प्रभारी व्यक्ति का नाम और संपर्क विवरण	:	
5.	जीएसटी नंबर	:	
6.	संगठनात्मक अनुभव; i. संदूषण के निर्धारण के लिए शुरू की गई परियोजनाओं की संख्या ii. अपशिष्ट प्रसंस्करण, शोधन और निपटान सुविधाओं के डिजाइन के लिए शुरू की गई परियोजनाओं की संख्या iii. उपचार योजना की तैयारी के लिए शुरू की गई परियोजनाओं की संख्या iv. सुधारात्मक कार्यकलापों के लिए शुरू की गई परियोजनाओं की संख्या केवल पूर्ण हो चुकी परियोजनाओं पर ही मूल्यांकन हेतु विचार किया जाएगा कृपया प्रत्येक परियोजना का ब्यौरा, परियोजना का मूल्य, परियोजना की अवधि तथा कार्य देने वाली कंपनी द्वारा जारी किया गया पूर्णता प्रमाण-पत्र संलग्न करें।		
7.	i. विशेषज्ञों की कुल संख्या: ii. एम.टेक डिग्री रखने वाले विशेषज्ञों की संख्या : क. पर्यावरणीय इंजीनियरी ख. सिविल इंजीनियरी: ग. रसायन इंजीनियरी: घ. भू-तकनीकी इंजीनियरी iii. एम.एस.सी. करने वाले विशेषज्ञों की संख्या: क. पर्यावरण विज्ञान: ख. रसायन विज्ञान: ग. जल विज्ञान: घ. भूगर्भ शास्त्र: ङ. भूभौतिकी: iv. बी.टेक. करने वाले विशेषज्ञों की संख्या : क. पर्यावरणीय इंजीनियरी ख. सिविल इंजीनियरी: ग. रसायन इंजीनियरी:		

	घ. भू-तकनीकी इंजीनियरी v. बी.एस.सी. करने वाले विशेषज्ञों की संख्या: क. पर्यावरण विज्ञान: ख. रसायन विज्ञान : ग. जल विज्ञान: घ. भूगर्भ शास्त्र: ङ. भूभौतिकी-: vi. तकनीशियनों की संख्या: क. यांत्रिक: ख. विद्युत: ग. सर्वेक्षक: घ. उपकरण: ङ. फिटर और वेल्डर: vii. व्यावसायिक स्वास्थ्य और सुरक्षा विशेषज्ञों की संख्या: (कालानुक्रमिक क्रम में अनुभव के ब्यौरों के साथ बायोडेटा संलग्न करें)		
8.	प्रयोगशाला का ब्यौरा जिसके माध्यम से गठजोड़ किया गया है : i. प्रयोगशाला का नाम: ii. पर्यावरण संरक्षण अधिनियम, 1986 के अधीन जारी वैध रजिस्ट्रीकरण प्रमाणपत्र संख्या और वैधता (प्रति संलग्न करें): iii. कृपया प्रयोगशाला के साथ गठजोड़ के संबंध में दस्तावेजी प्रमाण संलग्न करें		
9.	संदूषण के निर्धारण और उपचार के लिए मॉडलिंग सॉफ्टवेयर का ब्यौरा		

स्थान: ________________

तारीख: _______________

प्राधिकृत हस्ताक्षरकर्ता

नाम:

पद का नाम:

प्ररूप-5

[नियम 11(2) देखिए]

केन्द्रीय बोर्ड द्वारा केंद्र सरकार को प्रस्तुत की जाने वाली संदूषित स्थलों के प्रबंधन पर वार्षिक समेकित पुनर्विलोकन रिपोर्ट के लिए प्रपत्र

सेवा में,

सचिव
पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय, भारत सरकार,
इंदिरा पर्यावरण भवन,
जोरबाग रोड, अलीगंज,
नई दिल्ली -110003

1.	संदिग्ध संदूषित स्थलों की राज्यवार वार्षिक सूची	:	ब्यौरा संलग्न करें
2.	संभावित संदूषित स्थलों की राज्यवार वार्षिक सूची	:	ब्यौरा संलग्न करें
3.	संदूषित स्थलों की राज्यवार वार्षिक सूची	:	ब्यौरा संलग्न करें
4.	संदूषित स्थलों की राज्यवार वार्षिक सूची	:	ब्यौरा संलग्न करें
5.	साइट निर्धारण रिपोर्ट और उपचार योजना की तैयारी की प्रास्थिति	:	ब्यौरा संलग्न करें
6.	कार्य योजना के संबंध में संदूषित स्थलों के उपचार की भौतिक और वित्तीय प्रगति	:	ब्यौरा संलग्न करें
7.	संदूषित स्थल स्वामी और जिम्मेदार व्यक्ति की राज्यवार सूची	:	ब्यौरा संलग्न करें

स्थान: ________________

तारीख: _______________

सदस्य सचिव
केंद्रीय प्रदूषण नियंत्रण बोर्ड

MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

NOTIFICATION

New Delhi, the 24th July, 2025

S.O. 3401(E).—WHEREAS areas contaminated by toxic and hazardous substances pose a risk to human health and environment;

AND WHEREAS the draft rules, namely the Remediation of Contaminated Sites, 2024 were published by the Government of India in the Ministry of Environment, Forest and Climate Change, vide notification number S.O.3550 (E), dated the 21st August, 2024 in the Gazette of India, Extraordinary, Part II, Section 3, sub-section (ii) inviting objections and suggestions from all persons likely to be affected thereby, before the expiry of the period of sixty days from the date on which copies of the Gazette containing the said notification were made available to the public;

AND WHEREAS the copies of the Gazette containing the said notification were made available to the public on the 21st day of August, 2024;

AND WHEREAS the objections and suggestions received from the public in respect of the said draft notification within the said period have been duly considered by the Central Government;

NOW, THEREFORE, in exercise of the powers conferred by section 3, 6, 8 and 25 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government hereby makes the following rules, namely:-

1. Short title and commencement. - (1) These rules may be called the Environment Protection (Management of Contaminated Sites) Rules, 2025.

(2) They shall come into force from the date of their publication in the Official Gazette.

2. Application. - (1) These Rules shall not apply to a contaminated site affected by –

(a) radioactive waste as defined under clause (xxii) of rule 2 of the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987;

(b) mining operations as defined under clause (d) of section 3 of the Mines and Minerals (Development and Regulation) Act, 1957 (67 of 1957);

(c) pollution of the sea by oil or oily substance as governed by the Merchant Shipping Act of 1958 and the Merchant Shipping (Prevention of Pollution of the Sea by Oil) Rules, 1974;

(d) solid waste from dump site as defined under clause 20 of sub-rule (1) of rule 3 of Solid Waste Management Rules, 2016.

(2) Notwithstanding anything in sub-rule (1), if the contamination of a site is due to a contaminant mixed with radioactive waste or mining operations or oil spill or solid waste from dump site, and if the contamination of the site due to the contaminant exceeds the limit of response level specified in these rules, then remediation of the site would be covered under these rules.

3. Definitions. - (1) In these rules, unless the context otherwise requires. –

a. "Act" means the Environment (Protection) Act, 1986 (29 of 1986);

b. "Committee" means Central Remediation Committee constituted by the Central Government under rules 10(1) and 10(2);

c. "Central Board" means the Central Pollution Control Board constituted under sub-section (1) of section 3 of the Water (Prevention and Control of Pollution) Act, 1974 (6 of 1974);

d. "centralised online portal" means the online portal under rule 9;

e. "contaminant" refers to the presence of hazardous substance as defined in clause (e) of section 2 of the Environment (Protection) Act, 1986 (29 of 1986) above the response levels set out in Schedule I ;

f. "contaminated site" means an area or a site affected with contaminants and declared as contaminated site under sub-rule (9) of rule 4;

g. "Environmental Relief Fund" means a fund as established under section 7A of the Public Liability Insurance Act, 1991 (6 of 1991);

h. "investigated site" means a site wherein on the basis of preliminary assessment or detailed assessment, the contaminants exist below screening levels or response levels;

i. "land use" means use of land for residential, agricultural, industrial, commercial or public purpose;

j. "local body" means a municipality or a panchayat and includes a development authority established by or under any law for the time being in force;

k. "orphan site" means a contaminated site where responsible person cannot be traced;

l. "person" includes an individual, juridical person or entity, a company, a firm, an association of persons or a body of individuals, whether incorporated or not, or a trustee or a trust;

m. "probable contaminated site" is an area, whether or not delineated, where the presence of contaminants is observed on the basis of preliminary assessment after a site has been recognised as suspected contaminated site;

n. "reference organisation'' means the reference organisation under rule 7;

o. "response level" are concentrations of hazardous substances in soil and sediments at or above the limits specified in the Schedule I which there may be an imminent threat to human health or the environment;

p. "responsible person" means any person(s) identified by State Board under sub-rule (2) of rule 5 on whom liability has been assigned for the contaminated site;

q. "screening level" are concentrations of hazardous substances in soil and sediments, ground water and surface water as specified in the Schedule I, at or above which there may be a likely threat to human health or the environment;

r. "site-specific remediation level" means risk based target level for remediating the contaminated sites by reducing levels of hazardous substances and chemicals of concern;

s. "State Board" means the State Pollution Control Board or the Pollution Control Committee constituted under sub-section (1) and (4) of section 4 of the Water (Prevention and Control of Pollution) Act, 1974 (6 of 1974);

t. "suspected contaminated site" means the area that is suspected to be contaminated and identified by local body or District Administration and State Board under sub-rule (1) and sub-rule (4) of rule 4;

(2) Words and expressions used in these rules and not defined, but defined in the Act or the rules made thereunder shall have the meanings assigned to them in the Act or the rules.

4. Identification of contaminated sites.- (1) The local body or District Administration, on its own or on receipt of a complaint from public, shall identify an area affected with contaminants and list all such areas as suspected contaminated sites in its jurisdiction on centralised online portal.

(2) While identifying an area under sub-rule (1), the local body or District Administration may take into account the following information, –

a. any information available through implementation of the Hazardous and Other Wastes (Management and Transboundary Movement) Rules 2016 and information available through management of consents under the Air (Prevention and Control of Pollution) Act, 1981 and the Water (Prevention and Control of Pollution) Act, 1974;

b. any studies or investigations done by Government agencies;

c. information available through location factors that increase the risk of contamination such as vicinity of a previously contaminated site and underground storage of chemicals**;**

d. historic industrial or any anthropogenic activity that may have caused contamination of site with hazardous substances or chemicals of concern at the site; or

e. such other factors as it considers appropriate.

(3) The local body or District Administration shall furnish the list of suspected contaminated sites to the State Board periodically on half-yearly basis, in Form 1 on the centralised online portal.

(4) The State Board shall identify suspected contaminated sites located in the industries or industrial premises through Consent monitoring mechanism available under the Water (Prevention and Control of Pollution) Act, 1974 and the Air (Prevention and Control of Pollution) Act, 1981.

(5) On receipt of a list of suspected contaminated sites, the State Board, on its own or through a reference organisation, undertake preliminary site assessment of the suspected contaminated site by sampling and analysis of the suspected contaminated site, within ninety days from the date of receipt of such list.

(6) On completion of the preliminary site assessment, the State Board may list the suspected contaminated site as probable contaminated site if the contaminant is found to be above the screening level or delist the site as investigated site if the contaminant is found to be below the screening level.

(7) The State Board shall furnish such list of probable contaminated sites and investigated sites to the Central Board on the centralised online portal, within thirty days from the date of completion of the preliminary site assessment.

(8) Thereafter, the State Board shall, on its own or through a reference organisation, undertake a detailed site assessment of a probable contaminated site by detailed sampling and analysis covering the entire geographical area of the probable contaminated site, within three months from the date of listing of such site.

(9) The State Board, after completion of the detailed site assessment, may list the site as contaminated site for further action if the contaminant is found to be above the response level.

(10) The State Board, after completion of the detailed site assessment, may delist the site as investigated site if contaminant is found to be below response level.

(11) The State Board shall issue a public notice restricting or prohibiting any activity during the preliminary or detailed assessment of the suspected or probable contaminated site, respectively, keeping in view the risks involved to human health and the environment, under intimation to relevant authorities in the State Government.

(12) The State Board shall publish the list of contaminated sites on the centralised online portal inviting comments and suggestions from the stakeholders likely to be affected, within sixty days of such publication.

(13) Upon receipt of the comments and suggestions from the stakeholders, the State Board shall publish the final list of contaminated sites on the centralised online portal and also publish a notice in this regard in two local newspaper having circulation in the area for the information of the general public and also indicating the precaution to be taken in this regard.

5. Remediation of the contaminated sites. – (1) The State Board shall select a reference organisation, within three months from the date of publication of the list of the contaminated sites under sub-rule (13) of rule 4 of these rules, and initiate preparation of remediation plan and execute remediation activities.

(2) The State Board, upon publication of the contaminated site under sub-rule (13) of rule 4 shall, after an inquiry, identify the person who is responsible for causing the contamination of the site within a period of ninety days.

(3) In case, the contaminated site has been transferred by the person (transferor) causing the contamination to other person (transferee), the State Board shall determine responsible person as the other person (transferee).

(4) Handling and management of contaminants during assessment and remediation shall be carried out in accordance with the Standard Operating Procedure issued by Central Board.

(5) Where the responsible person is identified, the State Board shall direct the responsible person to prepare a remediation plan and undertake remediation through a reference organisation as selected by the State Board and bear the expenses towards it.

(6) Upon directions from the State Board, the responsible person shall prepare the remediation plan within six months from the date of directions under sub-rule (5) and submit it to the State Board for its approval.

(7) The remediation plan shall lay down the site-specific remediation level, the method of risk assessment, the method of remediation or decontamination or cleaning up of the contaminated site, the financial resources required and the timeframe required for undertaking remediation along with environmental and safety safeguards during remediation, post-remediation monitoring and assessment activities, and occupational health, safety and emergency response.

(8) The State Board shall review and approve the remediation plan submitted by responsible person within three months from the date of submission of remediation plan, and forward a copy thereof to the Central Board for information.

(9) Criteria for development of remediation plan, verification and its approval is to be done in accordance with the guidelines issued by Central Board.

(10) After approval of the remediation plan by State Board, responsible person shall initiate the remediation of the contaminated site as per the remediation plan and furnish half-yearly progress report to the State Board with intimation to the Central Board till the completion of the remediation, in Form 2.

(11) Based on the approval of the remediation plan, the State Board shall recommend to the State Government for issuing orders for rehabilitation of people from contaminated sites to take forward the remediation activities.

(12) The State Board shall, keeping in view the risks involved in human health and the environment, issue a public notice restricting or prohibiting any activities during the time of remediation of the contaminated site which may include change in land use and transfer or change in ownership of land, or building or any facility on the land.

(13) Where the responsible person is not identified, the State Board shall, on its own or through the reference organisation, prepare a remediation plan within six months from the date of publication of the contaminated site under sub-rule (13) of rule 4 of these rules, for undertaking remediation of the contaminated site either out of its own resources or through support from State Government or both and resources of Central Government as per the ratio prescribed under rule 8 and shall initiate remediation through the reference organisation, within ninety days from the finalisation of the remediation plan.

(14) The remediation of a contaminated site shall be undertaken for bringing down the response level to the site-specific remediation level.

(15) The State Board, after completion of the remediation, shall notify the remediated site specifying the land use fit for carrying out certain activities or restrict any such activity on such site and furnish a report to the Central Board.

(16) In case the suspected contaminated site or the probable contaminated site is located in the premises of an industry or a notified industrial area, the State Board shall direct the Industrial Development Authority concerned or the industry concerned to carry out preliminary or detailed site assessment, as the case may be, through a reference organisation and furnish a report to State Board till its completion and the provisions of rules 4 and 5 shall in so far as may apply for undertaking remediation of such sites.

6. Verification of remediation. – (1) After completion of remediation, the State Board shall submit its report to the Central Board.

(2) The Central Board may appoint any reference organisation to verify the completion of remediation activities.

(3) The report of State Board along with the report of reference organisation shall be placed before the Committee for its review and recommendation.

(4) The Committee may recommend additional or supplementary remediation activities, if needed, during its review.

(5) Upon receipt of recommendations of the Committee, the Central Board shall communicate to the State Board for issuing the Remediation Completion Order.

(6) The State Board shall issue the Remediation Completion Order along with post –remediation monitoring activities.

(7) The responsible person shall be liable for all damages caused to the environment and human health or third party due to contamination of such sites.

(8) The responsible person shall not be deemed to be exempted from its liability on account of the following cases –

a. in case the activity causing contamination and effects of contamination occurred prior to commencement of these rules;

b. in case the requirement of a site investigation was neither mandatory nor expected as part of normal business practice and the person cannot be expected to carry out such investigations or examinations;

c. in case the contaminants were notified or not as hazardous substances.

(9) Where an accident occurs at the contaminated site or the facility on the contaminated site or during transport of any material to or from the site, the owner or occupier or responsible person or the transporter shall immediately intimate the State Board through telephone, e-mail about the accident and subsequently send a report in Form 3 and publish it on the centralised online portal.

7. Reference organisation. – (1) An organisation having the qualifications and experience given in Schedule II may make an application to the Central Board, in Form 4, for empanelment as a reference organisation.

(2) The Central Board, upon receipt of the application, shall evaluate the credentials of the reference organisation as per the criteria prescribed in Schedule II, and communicate to such organisation regarding the empanelment of reference organisation or reject the application with reasons, within sixty days.

(3) The empanelment of the reference organisation is valid until it is cancelled by the Central Board, or till the time the organisation ceases to exist or stops its activities in the area of assessment and remediation of contaminated sites.

(4) The Central Board may cancel the empanelment of a reference organisation on the grounds of furnishing incorrect information, carrying out fraudulent activities, misuse of data and not carrying out activities in accordance with the contract or work order for assessment, preparation of remediation plan and carrying out remediation.

(5) The Central Board shall publish the list of empanelled reference organisations on its website and update the list on quarterly basis.

8. Financial mechanism for assessment and remediation of contaminated sites. – (1) In all cases, funds for conducting preliminary assessment and detailed assessment for suspected contaminated site and probable contaminated site, respectively, may, to the extent feasible, be initially met in whole or part by the Central Government from the Environmental Relief Fund under sub-section (9) of section 7 of the Public Liability Insurance Act, 1991 and also by the State Government.

(2) The funds shall be shared between Central Government and State Government in the following ratio. –

a. in case of an area in the North Eastern and Himalayan States, ninety percent funds from the Central Government and ten percent funds from the State Government;

b. in case of an area in the other States, sixty percent funds from the Central Government and forty percent funds from the State Government;

c. in case of an area in the Union territories, hundred percent funds from the Central Government.

(3) The State Government may utilise the funds allocated to it from Environmental Protection Fund under Sections 16 (1) and 16 (5) of the Environment (Protection) Act, 1986 and/or funds from Environmental Compensation collected by State Board, for its share.

(4) The State Government shall provide the concurrence for sharing of funds for preliminary and detailed site assessment within sixty days from the date of communication of the contaminated sites by the Central Board or the State Board, as the case may be:

Provided that where the Central Government considers it necessary and expedient to take up the remediation activities immediately, it may, pending the approval of the State Government, provide the funds equivalent to the share of the State Government for undertaking such remediation activities and may recover the amount from the State Government subsequently.

(5) In case the responsible person is identified, the expenditure made by the Central Government and State Government for preliminary and detailed site assessment shall be recovered from the responsible person within three months.

(6) In case funds have been provided by the Central Government or the State Government or Central Board or State Board for carrying out preliminary assessment, detailed assessment, preparation of remediation plan and carrying out remediation activities, the responsible person shall be liable to pay such expenditure, along with interest, in such manner as may be directed by the State Board:

Provided that the responsible person is not liable for payment towards expenditure on preliminary assessment and detailed assessment in case the site is not confirmed as contaminated site.

(7) In cases of orphan sites, the expenditure for conducting preliminary assessment, detailed assessment and preparation of remediation plan for suspected contaminated sites, probable contaminated sites and contaminated sites, respectively, and for carrying out the remediation shall be met in the ratio as per the sub-rule (2).

(8) In all other cases such as sites under temporary possession of banks or judicial proceedings, based on the recommendations of Committee, the funds for conducting preliminary assessment, detailed assessment, preparation of remediation plan and carrying out the remediation activities shall be met in the ratio as given in sub-rule (2).

9. Centralised online portal. – (1) The Central Board shall develop the centralised online portal for the purpose of reporting of suspected contaminated sites, probable contaminated sites and contaminated sites, and monitoring of assessment of contamination and remediation of contaminated sites under these rules.

(2) The State Board shall update all its activities including listing of probable contaminated sites and contaminated sites and its geotagging or geo-fencing, remote sensing and satellite imagery; status of preparation of the remediation plan; remediation activities; the list of responsible persons; uploading Remediation Completion Order and post-remediation monitoring activities; on the centralised online portal.

(3) The Central Board shall upload the list of all contaminated sites along with their status and the recommendations of the Committee in this regard.

10. Remediation Committee. - (1) The Central Government shall constitute Central Remediation Committee to review the remediation activities under these rules and to oversee the implementation of these rules.

(2) The Central Remediation Committee shall consist of the following members, namely:–

(a) Chairman, Central Board – Chairperson;

(b) a representative from each of the following Ministries or Departments as a member, –

(i) the Ministry of Housing and Urban Affairs;

(ii) the Department for Promotion of Industry and Internal Trade (DPIIT), Ministry of Commerce and Industry;

(iii) the Department of Chemicals and Petrochemicals, Ministry of Chemicals and Fertilizers;

(iv) the Ministry of Science and Technology;

(v) the Ministry of Health and Family Welfare;

(c) two representatives of State Boards having experience in dealing with contaminated sites to be nominated by the Central Government on rotation basis - Member;

(d) a representative from the concerned State Government - Member;

(e) two technical experts from the field of environment, geotechnical and industrial waste management to be nominated by the Central Government- Member;

(f) Member Secretary, Central Board or his/her nominee – Member Convener.

(3) The Committee shall review and monitor the implementation of provisions of these rules and may make recommendations in relation to any matter referred to it by the Central Government or the Central Board.

(4) The Committee shall meet at least once in six months and furnish its report to the Central Government on a yearly basis.

(5) The Committee shall annually review the list of suspected contaminated sites, probable contaminated sites and contaminated sites and the details of activities under these rules.

(6) The State Government or Union territory Administration shall constitute a State Level Committee within three months from the date of publication of these rules under the chairmanship of Additional Chief Secretary or Principal Secretary in-charge of the Environment Department, and Secretaries of the Municipal Administration and Urban Development Department, Department of Panchayati Raj, Industrial Department and representative of the State Board as its members to oversee the implementation of these rules and activities thereunder in a timely manner.

11. Functions of Central Board. – (1) The Central Board shall develop centralised online portal for monitoring and reporting of the provisions under the rules.

(2) The Central Board shall prepare a consolidated review report on management of contaminated sites in Form 5 and forward it to the Central Government, along with its recommendations, before the 30th day of September once in every year and publish it on the centralised online portal.

(3) The Central Board shall publish all relevant information on the centralised online portal.

(4) The Central Board may submit the request to the Central Government for utilisation of funds and sharing of expenditure under these rules.

(5) The Central Board may issue guidelines for the purpose of implementation of these rules:

Provided that the guidelines in regard to environmental compensation may be issued with the prior approval of the Central Government.

12. Voluntary remediation. - (1) A voluntary remediation may be suitable for any site.-

a. that is not identified as probable contaminated sites or contaminated sites; or
b. that is not under investigation under these rules for identification as contaminated site; and
c. where the person proposing voluntary remediation is competent to manage or procure management of remediation and related environment and social aspects and local community requirements.

(2) A person may submit an application for voluntary remediation for review by the Committee accompanied with preliminary assessment report, voluntary agreement between all owners and occupiers, evidence of sufficient capacity to pay for remediation and an undertaking to comply with directions of the Committee during remediation.

(3) The Committee may recommend to the Central Government to approve the voluntary remediation proposal if it is satisfied that –

a. it meets the criteria set out in sub-rule (1);
b. the voluntary proposal has been agreed and accepted by all site owners and occupiers;
c. all persons together have demonstrated that they have sufficient capacity to pay the remediation cost and there is no requirement of public funding to pay for remediation;
d. all persons agree to abide by the orders, directions and notices issued by the Committee;
e. it is in compliance of the provisions of these rules.

(4) If at any stage, the person undertaking voluntary remediation does not follow any order or directive or notice of the Central Board or State Board or the Central Government or State Government or contravenes the provisions of these rules, there shall be no refund of any costs already incurred by the person and the Committee may recommend to the Central Board or Central Government to take steps to enforce the orders as if there was no voluntary remediation proposal.

(5) Approval of voluntary remediation shall not preclude the imposition or otherwise of damages or loss to environment and liability for failure to comply with or contravention of any other rules, provisions of these rules or orders or directions issued thereunder.

13. Environmental Compensation.- (1) The State Board may impose environmental compensation on any responsible person who does not comply to the provisions of these rules in undertaking the remediation or does not undertake the remediation under these rules in respect of a contaminated site and poses risks to human life and the environment contributing thereby to loss, damage or injury to environment or human health.

(2) In case, the State Board does not take action regarding imposition of environmental compensation in sixty days under sub-rule (1), the Central Board may impose environmental compensation on any person who does not comply to the provisions of these rules in undertaking the remediation or does not undertake the remediation under these rules in respect of a contaminated site and poses risks to human life and the environment contributing thereby to loss, damage or injury to environment or human health.

(3) Notwithstanding above, Central Board or State Board may take appropriate action under the Environment (Protection) Act, 1986, the Water (Prevention and Control of Pollution) Act, 1974, the Air (Prevention and Control of Pollution) Act, 1981, as the case may be.

(4) The payment of environmental compensation shall not absolve the responsible persons from payment of remediation cost that has been levied.

(5) The amount of environmental compensation under these rules, shall be credited to the Environmental Relief Fund established under section 7A of the Public Liability Insurance Act, 1991 (6 of 1991) and shall be kept in a separate account.

(6) The environmental compensation collected under these rules shall be utilised for restoration of loss, damage or injury to environment or public health through assessment of contamination and remediation of contaminated sites, and for the purpose of implementation of the provisions of these rules.

(7) The Central Board shall submit a plan, with the estimation of the cost, for utilisation of funds collected under environmental compensation for the purposes specified under sub-rule (6), to the Central Government.

(8) The Central Government on being satisfied with the plan and the estimation submitted under sub-rule (7), may issue an order for disbursement of amount to the Central Board.

(9) The State Board shall submit a plan for purposes specified under sub-rule (6), to the Central Government through Central Board for seeking funds.

(10) The Central Board, on receipt of the plan from the State Board under sub-rule (9), shall forward its recommendation on the plan to the Central Government within 30 days from the date of receipt of the plan from State Board.

(11) The Central Government on being satisfied with the plan submitted under sub-rule (9), may issue an order for disbursement of amount to the Central Board which in turn will disburse the fund to the concerned State Board.

[F. No. 12/4/2024 -HSM]

NEELESH KUMAR SAH, Jt. Secy.

Schedule I
[see rules 3 (e) (o) and (q)]

Response and Screening Levels of Hazardous Substances

S. No.	Chemical Name	Chemical Groups	Soil/Sediment					Ground water quality (Screening levels) (in mg/L)	Surface water quality (Screening levels) (in µg/L)
			Response levels (RL) (in mg/kg)	Screening Levels (SL) (in mg/kg)					
				Agricultural	Residential	Commercial	Industrial		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1.	1,1,1-Trichloroethane (TCA)	Halogenated aliphatic compounds	50	0.1	5	50	50	-	-
2.	1,1,2,2- Tetrachloroethene (PCE)	Halogenated aliphatic compounds	8.8	0.1	0.2	0.5	0.6	0.03	110
3.	1,1,2,2-Tetrachlorethane	Halogenated aliphatic compounds	50	0.1	5	50	50	-	-
4.	1,1,2-Trichloroethane	Halogenated aliphatic compounds	50	0.1	5	50	50	-	-
5.	1,1,2-Trichloroethene (TCE)	Halogenated aliphatic compounds	2.5	0.01	0.01	0.01	0.01	0.005	21
6.	1,1-Dichloroethane	Halogenated aliphatic compounds	50	0.1	5	50	50	-	-
7.	1,1-Dichloroethene	Halogenated aliphatic compounds	50	0.1	5	50	50	0.014	-
8.	1,2,3,4-Tetrachlorobenzene	Halogenated aromatic compounds	10	0.05	2	10	10	-	1.8
9.	1,2,3,5-Tetrachlorobenzene	Halogenated aromatic compounds	10	0.05	2	10	10	-	-
10.	1,2,3-Trichlorobenzene	Halogenated aromatic compounds	11	0.05	2	10	10	-	8
11.	1,2,4,5-Tetrachlorobenzene	Halogenated aromatic compounds	10	0.05	2	10	10	-	-
12.	1,2,4-Trichlorobenzene	Halogenated aromatic compounds	11	0.05	2	10	10	-	24
13.	1,2-Dichlorobenzene	Halogenated aromatic compounds	19	0.1	1	10	10	0.005	0.7
14.	1,2-Dichloroethane	Halogenated aliphatic compounds	50	0.1	5	50	50	0.005	100
15.	1,2-Dichloroethene	Halogenated aliphatic compounds	50	0.1	5	50	50	0.05	-
16.	1,2-Dichloropropane	Halogenated aliphatic compounds	50	0.1	5	50	50	-	-
17.	1,2-Dichloropropene (cis a	Halogenated aliphatic	50	0.1	5	50	50	-	-

	nd trans)	compounds						
18.	1,3,5-Trichlorobenzene	Halogenated aromatic compounds	11	0.05	2	10	10	-	-
19.	1,3-Dichlorobenzene	Halogenated aromatic compounds	19	0.1	1	10	10	-	150
20.	1,4-Dichlorobenzene	Halogenated aromatic compounds	19	0.1	1	10	10	0.005	26
21.	1,4-Dioxane	Heterocyclic organic compound	-	-	-	-	-	0.05	-
22.	2,3,4,6-Tetrachlorophenol	Halogenated aromatic compounds	21	0.05	0.5	5	5	0.1	-
23.	2,4,6-Trichlorophenol	Halogenated aromatic compounds	22	0.05	0.5	5	5	0.005	-
24.	2,4-Dichlorophenol	Halogenated aromatic compounds	5	0.05	0.5	5	5	0.9	-
25.	2,4-Dichlorophenoxyacetic acid (2,4-D)	Pesticides (Phenoxy herbicide)	-	-	-	-	-	0.1	-
26.	3-Iodo-2-propynyl butyl carbamate	Pesticides, Carbamate	-	-	-	-	-	-	1.9
27.	Acenaphthene	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	5.8
28.	Acenaphthylene	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	-
29.	Acridine	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	4.4
30.	Aldicarb	Pesticides, Carbamate	-	-	-	-	-	0.009	1
31.	Aldrin	Pesticides, Organochlorine	0.32	-	-	-	-	0.0007	0.004
32.	Aliphaticsnonchlorinated (each)	Non-halogenated aliphatic compounds	0.3	0.3	-	-	-	-	-
33.	Aluminium	Metal		-	-	-	-	2.9	-
34.	Ammonia (total)	Inorganic	-	-	-	-	-	0.5	-
35.	Ammonia (un-ionized)	Inorganic	-	-	-	-	-	-	19
36.	Aniline	Organic	-	-	-	-	-	-	2.2
37.	Anthracene	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	0.012
38.	Antimony (metallic)	Inorganic	40	20	20	40	40	0.006	-
39.	Arsenic	Metal	76	12	12	12	12	0.01	5
40.	Asbestos		100					-	-
41.	Atrazine	Pesticides, Triazine	0.71					0.005	1.8
42.	Barium	Inorganic	2000	750	500	2000	2000	2	-
43.	Benzene	Monocyclic aromatic compounds	5	0.05	0.5	5	5	0.005	370
44.	Benzo(a) anthracen	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	0.018
45.	Benzo(a) pyrene	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	0.00004	0.015
46.	Benzo(b) fluoranthene	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	-
47.	Benzo(k)fluoranthene	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	-
48.	Beryllium	Inorganic	8	4	4	8	8	-	-
49.	Boron	Inorganic	2	2	-	-	-	5	0.0015
50.	Bromacil	Pesticides	-	-	-	-	-	-	5
51.	Bromoxynil	Pesticides, Benzonitrile		-	-	-	-	0.03	5
52.	Cadmium	Metal	22	1.4	10	22	22	0.007	-
53.	Calcium	Inorganic	-	-	-	-	-	75	-
54.	Captan	Pesticides	-	-	-	-	-	-	1.3
55.	Carbaryl	Pesticides, Carbamate	0.45					-	0.2
56.	Carbofuran	Pesticides, Carbamate	0.017					0.09	1.8

57.	Chlordane	Pesticides, Organochlorine	4					0.0002	0.006
58.	Chloride	Inorganic	-	-	-	-	-	250	120000
59.	Chlorothalonil	Pesticides	-	-	-	-	-	-	0.18
60.	Chlorpyrifos	Pesticides, Organophosphorus	-	-	-	-	-	0.09	0.002
61.	Chromium (total)	Metal	87	64	64	87	87	0.05	-
62.	Chromium, hexavalent (Cr(VI))	Metal	78	0.4	0.4	1.4	1.4	-	1
63.	Chromium, trivalent (Cr(III))	Metal	180					-	8.9
64.	Chrysene	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	-
65.	Cobalt	Inorganic	300	40	50	300	300	-	-
66.	Coliforms, fecal (Escherichia coli)	Biological	-	-	-	-	-	Shall not be detectable in any 100 ml sample	-
67.	Coliforms, total	Biological	-	-	-	-	-	-	-
68.	Colour	Physical	-	-	-	-	-	5 Hazen Units (IS)	-
69.	Conductivity	Physical	4 dS/m	2 dS/m	2 dS/m	4 dS/m	4 dS/m	-	-
70.	Copper	Metal	190	63	63	91	91	2	
71.	Cyanazine	Pesticides, Triazine	-	-	-	-	-	0.01	2
72.	Cyanide	Inorganic	50	0.9	0.9	8	8	0.2	5
73.	Cyanobacterial Toxins	Biological	-	-	-	-	-	0.0015	-
74.	DDD (Dichlorodiphenyldichloroethane,2,2-Bis (p-chlorophenyl)-1,1-dichloroethane)	Pesticides, Organochlorine	34					-	-
75.	DDE (Dichlorodiphenyl ethylene,1,1-Dichloro-2,2-bis(p-chlorophenyl)-ethene)	Pesticides, Organochlorine	2.3					-	-
76.	DDT (Dichlorodiphenyltrichloroethane;2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane)	Pesticides, Organochlorine	1.7					1	-
77.	DDT Total (Dichloro diphenyl trichloroethane; 2,2-Bis(p- chlorophenyl)-1,1,1-trichloroethane)	Pesticides, Organochlorine	12	0.7	0.7	12	12	-	0.001
78.	Deltamethrin	Pesticides	-	-	-	-	-	-	0.0004
79.	Di(2-ethylhexyl) phthalate	Phthalate esters	-	-	-	-	-	-	16
80.	Dibenz(a,h)anthracene	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	-
81.	Dibromochloromethane	Halogenated methanes	-	-	-	-	-	0.1	-
82.	Dicamba	Pesticides, Aromatic Carboxylic Acid	-	-	-	-	-	0.11	10
83.	Dichlorobromomethane	Halogenated methanes	-	-	-	-	-	-	-
84.	Dichloromethane (Methylene chloride)	Halogenated aliphatic compounds	50	0.1	5	50	50	0.05	98.1
85.	Dichlorophenols	Chlorinated phenols	22	0.05	0.5	5	5	0.9	0.2
86.	Diclofop-methyl	Pesticides	-	-	-	-	-	-	6.1
87.	Didecyldimethylammoniumchloride	Pesticides	-	-	-	-	-	-	1.5
88.	Diisopropanolamine	Organic	180	180	180	180	180	-	1600
89.	Dimethoate	Pesticides, Organophosphorus	-	-	-	-	-	0.02	6.2
90.	Di-n-butyl phthalate	Phthalate esters	-	-	-	-	-	-	19
91.	Dinoseb	Pesticides	-	-	-	-	-	0.01	0.05
92.	Endosulfan	Pesticides, Organochlo	4					0.4	0.003

		rine							
93.	Endrin	Pesticides, Organochlorine	-	-	-	-	-	0.0006	0.0023
94.	Ethylbenzene	Monocyclic aromatic compounds	110	0.1	5	50	50	0.14	90
95.	Ethylene glycol	Glycols	960	960	960	960	960	-	192000
96.	Exchangeable Sodium Percentage (ESP)		15	10				-	
97.	Fluoranthene	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	0.04
98.	Fluorene	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	3
99.	Fluoride	Inorganic	2000	200	400	2000	2000	1.5	120
100.	Glyphosate	Pesticides, Organophosphorus	-	-	-	-	-	0.28	800
101.	Heptachlor	Pesticides, Organochlorine	4					-	0.01
102.	Hexachlorobenzene	Halogenated aromatic compounds	10	0.05	2	10	10	-	-
103.	Hexachlorobutadiene	Halogenated aliphatic compounds	-	-	-	-	-	0.0006	1.3
104.	Hexachlorocyclohexane (alfa HCH)	Pesticides, Organochlorine	17	17	17	17	17	0.01	-
105.	Hexachlorocyclohexane (delta HCH)	Pesticides, Organochlorine	-	-	-	-	-	0.04	-
106.	Hexachlorocyclohexane (HCH)	Pesticides, Organochlorine	0.01	0.01	-	-	-	-	0.01
107.	Hexachlorocyclohexane (beta HCH)	Pesticides, Organochlorine	1.6					0.04	-
108.	Imidacloprid		-	-	-	-	-	0.23	-
109.	Indeno(1,2,3-c,d)pyrene	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	-
110.	Iron	Inorganic	-	-	-	-	-	0.3	300
111.	Lead	Metal	600	70	140	260	600	0.005	-
112.	Lindane (gamma HCH)	Pesticides, Organochlorine	1.2					0.002	-
113.	Linuron	Pesticides	-	-	-	-	-	-	7
114.	Lithium	Inorganic	-	-	-	-	-	-	-
115.	Magnesium	Inorganic	-	-	-		-	30	-
116.	Malathione	Pesticide, Organophosphorus	-	-	-	-	-	0.29	-
117.	Manganese	Inorganic		-	-	-	-	0.12	-
118.	MCPA (Methylchlorophenoxyaceticacid(4-Chloro-2-methylphenoxyaceticacid;2-Methyl-4-chlorophenoxyaceticacid)	Pesticides	4					0.1	2.6
119.	Mercury (inorganic)	Metal	50	6.6	6.6	24	50	0.001	0.026
120.	Methoprene		-	-	-	-	-	1	-
121.	Methylmercury	Organic	4	-	-	-	-	-	0.004
122.	Methyltertiary-butyl ether (MTBE)	Aliphaticether	-	-	-	-	-	-	10000
123.	Metolachlor	Pesticide, Organophosphorus	-	-	-	-	-	0.05	7.8
124.	Metribuzin	Pesticides, Triazine	-	-	-	-	-	0.08	1
125.	Molybdenum	Inorganic	190	5	10	40	40	0.07	73
126.	Monochlorobenzene	Halogenated aromatic compounds	15	0.1	1	10	10	0.08	1.3
127.	Monochlorophenols	Chlorinatedphenols	5.4	0.05	0.5	5	5	-	7
128.	Naphthalene	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	1.1
129.	n-hexane	Aliphatichydrocarbon	21	6.5	6.5	21	21	-	-

130.	Nickel	Metal	100	45	45	50	89	0.02	-
131.	Nitrate	Inorganic nitrogen compounds	-	-	-	-	-	45	13mg/L
132.	Nitrite	Inorganic nitrogen compounds	-	-	-	-	-	-	60
133.	Nonylphenolandits ethoxylates	Nonylphenol and its ethoxylates	14	5.7	5.7	14	14	-	1
134.	PCBs (Polychlorinatedbiphenyls)	Polychlorinated biphenyls	33	0.5	1.3	33	33	-	0.001
135.	Pentachlorobenzene	Halogenated aromatic compounds	10	0.05	2	10	10	-	6
136.	Pentachlorophenol	Halogenated aromatic compounds	12	7.6	7.6	7.6	7.6	0.06	0.5
137.	Permethrin	Pesticides, Organochlorine compounds	-	-	-	-	-	-	0.004
138.	pH	Inorganic Acidity, alkalinity and pH	6 to 8	6 to 8	6 to 8	6 to 8	6 to 8	6.5-8.5	6.5to 9.0
139.	Phenanthrene	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	0.4
140.	Phenolic compounds (as C6H5OH)	compounds	14	0.1	1	10	10	0.001	-
141.	Phenols (mono-& dihydric)	Aromatic hydroxyl compounds	3.8	3.6	3.8	3.8	3.8	-	4
142.	Phenoxy herbicides	Pesticides	-	-	-	-	-	-	4
143.	Phthalicacid esters (each)	Phthalateesters	30	30	-	-	-	-	-
144.	Picloram	Pesticides	-	-	-	-	-	-	29
145.	Poly chlorinated dibenzo-p-dioxins/dibenzofurans	Polychlorinated dioxins and furans	4 ngTEQ.kg^{-1}	4 ngTEQ.kg^{-1}	4 ngTEQ.kg^{-1}	4 ngTEQ.kg^{-1}	4 ngTEQ.kg^{-1}	-	-
146.	Polycyclic Hydrocarbon (PAH)	Polycyclic aromatic hydrocarbons (PAH)	40					0.0001	-
147.	Propylene glycol	Glycols	-	-	-	-	-	-	500000
148.	Pyrene	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	0.025
149.	Quinoline	Polycyclic aromatic hydrocarbons (PAH)	10	0.1	1	10	10	-	3.4
150.	Reactive Chlorine Species	Inorganic Reactive chlorine compounds	-	-	-	-	-	-	0.5
151.	Selenium	Inorganic	2.9	1	1	2.9	2.9	0.05	1
152.	Silver	Inorganic	40	20	20	40	40	0.1	0,1
153.	Simazine	Pesticides, Triazine	-	-	-	-	-	0.01	10
154.	Sodium	Inorganic	-	-	-		-	50	-
155.	Sodium adsorption ratio (SAR)		12	5	5	12	12	-	-
156.	Styrene	Monocyclic aromatic compounds	86	0.1	5	50	50	0.02 (C)	72
157.	Sulfolane	Organic sulphur compound	0.8	0.8	0.8	0.8	0.8	-	50000
158.	Sulphate	Inorganic sulphur compounds	-	-	-	-	-	200	-
159.	Sulphur(elemental)	Inorganic sulphur compounds	500	500	-	-	-	-	-
160.	Tebuthiuron	Pesticides	-	-	-	-	-	-	1.6
161.	Tetrachloromethane	Halogenated aliphatic compounds	50	0.1	5	50	50	-	13.3
162.	Tetrachlorophenols	Halogenated aromatic compounds	21	0.05	0.5	5	5	0.1	1
163.	Thallium	Inorganic	1	1	1	1	1	-	0.8
164.	Thiophene	Miscellaneous organic compound	0.1	0.1	-	-	-	-	-
165.	Tin (inorganic)	Inorganic	300	5	50	300	300	-	-
166.	Toluene	Monocyclic aromatic compounds	32	0.1	3	30	30	0.06	2
167.	Total dissolved solids (TD	solids	-	-	-	-	-	500	-

	S)								
168.	Total hydrocarbons (TPH) (mineral oil)	Aromatic Hydrocarbons	5000					0.01	-
169.	Toxaphene	Pesticides, Organochlorine	-	-	-	-	-	-	0.008
170.	Triallate	Pesticides, Carbamate	-	-	-	-	-	-	0.24
171.	Tribromomethane	Halogenated aliphatic compounds	75					-	-
172.	Tributyltin	Organotin compounds	-	-	-	-	-	-	0.008
173.	Trichlorfon		-	-	-	-	-	-	0.009
174.	Trichloromethane (chloroform)	Halogenated aliphatic compounds	50	0.1	5	50	50	0.3	1.8
175.	Trichlorophenols	Halogenated aromatic compounds	22	0.05	0.5	5	5	0.005	18
176.	Tricyclohexyltin	Organotin compounds	-	-	-	-	-	-	-
177.	Trifluralin	Pesticides, Dinitroaniline	-	-	-	-	-	0.02	0.2
178.	Triphenyltin	Organotin compounds	-	-	-	-	-	-	0.022
179.	Turbidity	solids total particulate matter	-	-	-	-	-	0.1-1.0NTU	-
180.	Uranium	Inorganic	300	23	23	33	300	0.02	15
181.	Vanadium	Inorganic	130	130	130	130	130	-	-
182.	Vinylchloride	Halogenated aliphatic compounds	0.1					0.002	-
183.	Xylene	Monocyclic aromatic compounds	17	2.4	2.4	2.4	2.4	0.09	-
184.	Zinc	Metal	720	250	250	360	410	5	30
185.	HFPO-DA (commonly known as Gen X Chemicals)	Organofluorine compounds						0.000004	
186.	PFHxS	Organofluorine compounds						0.000001	
187.	PFNA	Organofluorine compounds						0.000001	
188.	PFOA	Organofluorine compounds						0.000001	
189.	PFOS	Organofluorine compounds						1	

Schedule II
[see rule 7(1)]
Criteria for Selection of Reference Organisations

For carrying out preliminary assessment detailed assessment and preparation of remediation plan of contaminated sites:

a. The Reference Organisation should have minimum of 5 years of experience in assessment of contamination of hazardous substances and chemicals and preparation of remediation plan.

b. The Reference Organisation must have undertaken at least 3 projects in regard to assessment of contamination of hazardous substances or chemicals and preparation of remediation plan, out of which 1 project in preparation of remediation plan.

c. The Reference Organisation shall have employed at least 10 personnel having the following qualifications and experience:

   - At least 5 persons having M.Tech in Environmental Engineering /Civil Engineering /Chemical Engineering/ Geotechnical Engineering or M.Sc. in Environmental Science/ Chemistry / Hydrogeology/ Geology/ Geophysics, with at least 5 years of relevant work experience, of which the project manager shall have at least 10 years of relevant work experience

- At least 4 persons having B.Tech in Environmental Engineering /Civil Engineering /Chemical Engineering/ Geotechnical Engineering or B.Sc. in Environmental Science/ Chemistry / Hydrogeology/ Geology/ Geophysics, with at least 3 years of relevant work experience
- At least one expert in social sciences having post-graduate degree in Social Sciences with at least 3 years of relevant work experience may be engaged, in case of preparation of remediation plan.

d. The Reference Organisation shall have capabilities and experience in assessment and ascertaining the extent of contamination and shall demonstrate the possession of modelling softwares in this regard.

e. The Reference Organisation should have a tie-up with a laboratory recognized under section 12 of the Environment Protection Act, 1986.

For implementation of remediation activities as per the remediation plan:

a. The Reference Organisation should have minimum of 5 years of experience in preparing remediation plan, designing and implementation of waste processing, treatment and disposal facilities, and carrying out the remediation activities.

b. The Reference Organisation must have undertaken at least 3 projects in regard to preparation of remediation plan or designing and implementation of waste processing, treatment and disposal facilities and carrying out remediation activities, out of which 1 project in carrying out remediation activities.

c. The Reference Organisation shall have employed at least 15 personnel having the following qualifications and experience:

- At least 5 persons having M.Tech in Environmental Engineering /Civil Engineering /Chemical Engineering/ Geotechnical Engineering or M.Sc. in Environmental Science/ Chemistry / Hydrogeology/ Geology/ Geophysics, with at least 5 years of relevant work experience, of which the project manager shall have at least 10 years of relevant work experience
- At least 4 persons having B.Tech in Environmental Engineering /Civil Engineering /Chemical Engineering/ Geotechnical Engineering or B.Sc. in Environmental Science/ Chemistry / Hydrogeology/ Geology/ Geophysics, with at least 3 years of relevant work experience
- At least 5 technicians having relevant trade qualifications in Mechanical, Electrical, Surveyor, Instrumentation, Fitter and Welder
- At least one person having post-graduate degree on Occupational Health & Safety with at least 3 years of relevant work experience

d. The Reference Organisation shall have capabilities and experience in assessment and ascertaining the extent of contamination and shall demonstrate the possession of modeling softwares in this regard.

e. The Reference Organisation should have a tie-up with a laboratory recognized under section 12 of the Environment Protection Act, 1986.

Form 1

[see rule 4(3)]

FORMAT FOR SUBMISSION OF HALF-YEARLY INVENTORY OF SUSPECTED CONTAMINATED SITES TO STATE BOARD

To,

Chairman,
State Pollution Control Board,
…………………

Name of District:
No. of Suspected Contaminated Sites:

List of District Wise Suspected Contaminated Sites

S. No.	Name of suspected contaminated site	Geo-coordinates and Location
1.		
2.		

Attach separate sheet for each of suspected contaminated site as per the format below:

SI No.	**Particulars**	**Details**
1.	State & District	
2.	Serial number	
3.	Site ID	(State-district-xx) Example: Uttar Pradesh (UP), Ghaziabad (GZ) UP-GZ-01- 1st Site UP-GZ-02 – 2nd Site
4.	Site Name	
5.	Name of the site owner	
6.	Approximate area	
7.	Address (Street, Street number, postal code)	
8.	GPS coordinates /and elevation (latitude and longitude)	
9.	Land use (current)	
10.	Details of nearest industry to the suspected contaminated site	
11.	Type of contamination (if known)	
12.	Suspected cause of contamination (any industrial processes or any other activity which caused the contamination)	
13.	Contaminants of concern (if known)	
14.	Any study done on the site	If yes, a copy of the report to be attached
15.	Any Environmental Compensation imposed earlier, if yes, details to be provided	
16.	Any Court/ Tribunal case, if yes, details to be provided	

Place:
Date:

(Name of the local body or District Administration)

Form 2

[see rule 5(10)]

FORM FOR HALF-YEARLY PROGRESS REPORT OF CONTAMINATED SITES REMEDIATION TO BE SUBMITTED BY RESPONSIBLE PERSON TO THE STATE BOARD WITH INTIMATION TO CENTRAL BOARD

To,
Chairman,
State Pollution Control Board,
…………………………
…………………………
…………………………

1	Name of contaminated site	:	
2	Name and address of occupier Telephone number Fax number	:	

	E-mail		
3	Name and contact details of person in-charge dealing with the remediation of the contaminated site along with details of Remediation agency/contractor	:	
4	Physical progress of the remediation of contaminated site with regard to action plan	:	
5	Financial progress of the remediation of contaminated site with regard to action plan	:	

Place: _________________
Date: ________________

(Authorised Signatory)
Name:
Designation:

Copy to :-
Member Secretary,
Central Pollution Control Board,
………………………

FORM 3

[see rule 6(9)]

FORMAT FOR REPORTING ACCIDENT

[To be submitted by the responsible person or transporter to the State Board]

To,
Chairman,
State Pollution Control Board,
…………………………
…………………………
…………………………

1. The date and time of the accident :
2. Sequence of events leading to accident :
3. Details of hazardous substances involved in accident :
4. The date for assessing the effects of the accident on health or the environment :
5. The emergency measures taken :
6. The steps taken to alleviate the effects of accidents :
7. The steps taken to prevent the recurrence of such an accident :

Date:
Place: Signature:

Signature of the authorised person

Copy to:
Concerned District Magistrate

Form 4

[see rule 7(1)]

APPLICATION FOR EMPANELMENT OF REFERENCE ORGANISATION

To,

Member Secretary
Central Pollution Control Board
Government of India, 'Parivesh Bhawan', East Arjun Nagar,
Delhi- 110 032

1.	Name of the Organisation	:	
2.	Certificate of Incorporation issued under the Companies Act, 2013 (a) Corporate Identity Number: (b) Validity: (c) Enclose a copy	:	
3.	Registered Address Telephone number E-mail	:	
4.	Name and contact details of person in-charge	:	
5.	GST number	:	
6.	Organisational experience; i. No. of projects undertaken for assessment of contamination ii. No. of projects undertaken for designing waste processing, treatment and disposal facilities iii. No of projects undertaken for preparation of remediation plan iv. No. of projects undertaken for carrying out remediation activities Only completed projects shall be considered for evaluation Please enclose the details of each project along with the value of the project , duration of the project and completion certificate issued by the company which has awarded work		
7.	i. Total number of experts: ii. No. of experts having M.Tech in: a. Environmental Engineering b. Civil Engineering: c. Chemical Engineering: d. Geotechnical Engineering iii. No. of experts having M.Sc. in: a. Environmental Science: b. Chemistry: c. Hydrogeology: d. Geology: e. Geophysics: iv. No. of experts having B.Tech in: a. Environmental Engineering: b. Civil Engineering: c. Chemical Engineering: d. Geotechnical Engineering: v. No. of experts having B.Sc. in: a. Environmental Science: b. Chemistry : c. Hydrogeology:		

	d. Geology: e. Geophysics: vi. No. of technicians: a. Mechanical: b. Electrical: c. Surveyor: d. Instrumentation: e. Fitter and Welder: vii. No. of Occupational Health & Safety expert: (Enclose the bio-data with details of experience in chronological order)		
8.	Details of the laboratory through which tie-up has been made: i. Name of the laboratory: ii. Valid registration certificate number and validity issued under the Environmental Protection Act, 1986 (Enclose the copy): iii. Please enclose a documentary proof regarding tie-up with the laboratory	:	
9.	Details of modelling software for assessment and remediation of contamination	:	

Place: _________________
Date: ________________

Authorized Signatory
Name:
Designation:

Form 5
[see rule 11(2)]

FORM FOR ANNUAL CONSOLIDATED REVIEW REPORT ON MANAGEMENT OF CONTAMINATED SITES TO BE SUBMITTED BY THE CENTRAL BOARD TO THE CENTRAL GOVERNMENT

To,

Secretary
Ministry of Environment, Forest and Climate Change
Government of India,
Indira Paryavaran Bhawan,
Jor Bagh Road, Aliganj,
New Delhi -110003

1.	State-wise annual inventory of suspected contaminated sites	:	Attach details
2.	State-wise annual inventory of probable contaminated sites	:	Attach details
3.	State-wise annual inventory of contaminated sites	:	Attach details
4.	State-wise annual inventory of contaminated sites remediated	:	Attach details
5.	Status of preparation of site assessment report and remediation plan	:	Attach details
6.	Physical and financial progress of the remediation of contaminated sites with regard to action plan	:	Attach details
7.	State-wise inventory of contaminated site owner and responsible person	:	Attach details

Place: _________________
Date: _________________

Member Secretary
Central Pollution Control Board

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ANNEXURE A-13

GROUND WATER RESOURCES OF PUNJAB STATE

(As on 31st March, 2024)

CENTRAL GROUND WATER BOARD
NORTHWESTERN REGION
CHANDIGARH.

GROUND WATER MANAGEMENT CIRCLE
WATER RESOURCES DEPARTMENT, PUNJAB
S.A.S NAGAR.

DECEMBER , 2024

GROUND WATER RESOURCES OF PUNJAB STATE
(As on 31st March, 2024)

Prepared by

GROUND WATER MANAGEMENT CIRCLE
WATER RESOURCES DEPARTMENT, PUNJAB
S.A.S NAGAR.

and

CENTRAL GROUND WATER BOARD
NORTHWESTERN REGION CHANDIGARH.

DECEMBER, 2024

FOREWORD

Water is a scarce resource, and it is essential for all forms of life. Conservation and preservation of water is of utmost importance. Demand of ground water is increasing due to committed surface water resources and further rise of demand for irrigation, drinking & industry sectors. To keep pace with its growing demand, regular monitoring and periodic assessment apart from its efficient use is a dire necessity. Assessment, Utilization and Monitoring of Natural Resources lead the path for their sustainability.

The present Ground Water Assessment Report has been computed by the officers & officials of the Ground Water Management Circle, Department of Water Resources Punjab, along with Department of Agriculture & Farmer's Welfare on the basis of latest guidelines by the Ground Water Resource Estimation Committee (GEC 2015), Government of India. The report gives details on total annual recharge of ground water, its present draft and scope for future block-wise development.

The present ground water development in the state is 156.87% as of March 2024. Out of total 153 Blocks taken for study, 115 Blocks are “Over-Exploited”, 4 Blocks are “Critical”, 12 Blocks are “Semi-Critical”, and 22 Blocks are in “Safe” category. There is urgent need to recharge ground water in the over-exploited blocks and develop available shallow ground water in the safe blocks to avoid water logging in the foreseeable future. The irrigation policy also needs review vis-a-vis prevailing hydrogeological scenario.

I would like to appreciate the efforts regarding excellent data collection by the officers/officials of Ground Water Management Circle, Mohali through their superb network and skilled manpower, which is the main support for this whole exercise especially Mrs. Salvi, Executive Engineer, Sh. Bhupinder Singh, SDO, Dr. Gurvinder Singh, Senior Technical Assistant, Sh. Guriqbal Singh, Senior Technical Assistant, Harmanender Singh, Senior Technical Assistant and Ms. Priya Rani, Senior Technical Assistant under the able guidance of Sh. Manoj Bansal, Superintending Engineer, to complete the task in the most comprehensive and logical manner in a very short span of time.

I would like to place on record the commendable efforts of Sh. Rakesh Rana, Scientist 'D' of the Central Ground Water Board, for their contribution in preparation of this report.

I personally feel that this report will be of immense use to the Planners, Administrators and Agencies engaged in the development and regulation of ground water resources of the state.

December 2024

Er. Sher Singh
Chief Engineer, Canal
Water Resources Department
Government of Punjab

क्षेत्रीय निदेशक
जल शक्ति मंत्रालय
भारत सरकार

केन्द्रीय भूमि जल बोर्ड
उत्तर पश्चिमी क्षेत्र
चण्डीगढ़

Regional Director (I/C)
Ministry of Jal Shakti
Government of India

Central Ground Water Board
North Western Region
Chandigarh

PREFACE

Punjab a granary state of India, comprising 1.5% of the total geographical area of the country has been contributing two third of the wheat and half of the rice to the central pool. Ground water is being used is being used for irrigating 71% of the total area of the state. This has led to over exploitation of ground water resources as surface water falls short of Irrigation needs of the state. Punjab model of Irrigation is characterized by excess demand of irrigation coupled with unconstrained mining of ground water for meeting the food bowl requirement of country.

Ground water being a replenish-able resource requires realistic assessment for its proper management and economic development on sustainable basis. The complexities of the process governing occurrence and movement of ground water make the process of ground water assessment somewhat difficult not only because of enormous data that are to be analyzed but also a multi disciplinary approach that is adopted for computation of parameters regarding extraction and recharge. Moreover, the presence of saline aquifers in south western part of the state makes the estimation more complicated. The estimation of ground water resources based on the recent methodology le GEC-2015 has been carried out with all precessions by the Water resources and Environment Directorate (WRED) Punjab in collaboration with Central Ground Water Board (CGWB) is highly praiseworthy All the computations for the assessment of ground water resources have been carried out through a web based application namely "INDIA GROUND WATER RESOURCE ESTIMATION SYSTEM (IN-GRES) developed jointly by CGWB and IIT Hyderabad. The estimation has brought out the situation regarding ground water resources scenario in Punjab state which needs to be developed in more scientific and sustainable model. The large scale ground water conservation recharge measures like on farm water management techniques, village pond revival for recharging of ground water, construction of check dams in Siwaliks and water harvesting in urban areas is also required to be promoted and encouraged in the state to arrest the over exploitation of precious ground water resources. I place on records my appreciation for sincere efforts made by the officers of CGWB and WRED Punjab in bringing out this report at a very short span of time.

(Vidya Nand Negi)
Regional Director (I/C)

भूजल भवन, प्लाट नं. 3बी, सैक्टर. 27ए, मध्य मार्ग, चण्डीगढ़ 160019
Bhujal Bhawan, Plot No. 3B, Sector - 27 A, Madhya Marg, Chandigarh - 160019
Tel : 0172-2619500-01, E-mail : rdnwr-cgwb@nic.in

Annexure I

S.No	DISTRICT	BLOCK	Recharge Worthy Area (ha)			Hilly Area	Total	Annual Ground water Recharge (ham)								Environmental Flows (ham)	Annual Extractable Ground water Resource (ham)			Ground Water Extraction for all uses (ha.m)								Stage of Ground Water Extrac(%)	Categorization of Assessment Unit
								Rainfall Recharge	Canals	Surface Water Irrigation	Ground Water Irrigation	Tanks and Ponds	Water Conservation Structure	Base Flow	Total					Domestic	Industrial	Irrigation			C	PQ	Total		
			C	PQ	Total			Total	Total	Total	Total	Total	Total	Total		Total	C	NC	Total	Total	Total	C	PQ	Total				Total	Total
1	Fazilka	Abohar	40979	45740	86719	0	86719	2740.67	9335.04	9816.06	549.95	142.86		0	22584.58	2258.46	20326.1	0	20326.12	1778.2472	10.32114	1589.46	9557.41	11146.9	3378.03	9557.41	12935.4	16.619158	safe
2	Jalandhar	Adampur	21823	0	21823	0	21823	3063.65	395.27	290.04	4411.1	16.26		0	8176.32	817.63	7358.69	0	7358.69	410.94255	12.80052	16560.4		16560.4	16984.2		16984.2	230.80426	over_exploited
3	Amritsar	Ajnala	45610	0	45610	0	45610	5569.78	7066.68	1404.58	12591.21	30.42		147.77	26810.44	2666.26	24292	0	24291.95	948.6934	7.55346	36899.7		36899.7	37855.9		37855.9	155.8373	over_exploited
4	Fatehgarh Sahib	Amloh	25765	0	25765	0	25765	3180.48	1436.83	541.58	1828.75	26.97		0	7014.61	701.46	6313.15	0	6313.15	858.46905	1786.691	13960.8		13960.8	16605.9		16605.9	263.03731	over_exploited
5	Amritsar	Amritsar Urban	8664	0	8664	0	8664	606.86		0	0	0		0	606.86	60.69	546.17	0	546.17	0	181.4368	1590		1590	1771.44		1771.44	324.33858	over_exploited
6	Rupnagar	Anandpur Sahib	32031	0	32031	0	32031	5887.34	525.25	465	1512.9	22.61		0	8413.1	841.31	7571.79	0	7571.79	725.9339	132.61	5079.81		5079.81	5938.35		5938.35	78.427294	semi_critical
7	Sangrur	Andana	32794	0	32794	0	32794	2833.93	2348.28	837.74	2450.26	64.84		29.46	8564.51	853.5	7740.47	0	7740.47	541.21105	29.30281	19623.8		19623.8	20194.3		20194.3	260.89204	over_exploited
8	Fazilka	Arniwala Sheikh Subanpur	23813	9024	32837	0	32837	1305.95		3535.6	1232.44	23.54		0	6097.53	609.75	5487.78	0	5487.78	631.0704	0	3542.4	13741.9	17284.3	4173.49	13741.9	17915.4	76.050607	semi_critical
9	Amritsar	Attari	25434	0	25434	0	25434	3275.82	2076.73	650.89	3952.73	34.86		0	9991.03	999.1	8991.93	0	8991.93	608.8784	25.51455	16117.9		16117.9	16752.3		16752.3	186.30372	over_exploited
10	SBS Nagar	Aur	23037	0	23037	0	23037	2980.07	96.22	11241	7900.07	32.13		258.9	22508.39	2224.95	20542.3	0	20542.34	384.26105	0	21706.6		21706.6	22090.8		22090.8	107.53804	over_exploited
11	Moga	Bagha Purana	55866	0	55866	0	55866	4787.9	10538.29	2722.86	6095.8	51.56		0	24196.41	2419.64	21776.8	0	21776.77	941.0722	25.62987	43568.8		43568.8	44535.5		44535.5	204.5093	over_exploited
12	SBS Nagar	Balachaur	32464	0	32464	0	32464	5414.13	3891.61	287.5	2192.93	16.32	1297.74	0	13100.23	1310.03	10622.2	1167.96	11790.2	529.5639	227.1612	9640.23		9640.23	10397		10397	88.183067	semi_critical
13	Pathankot	Bamial	4641	0	4641	0	4641	1033.94		234.39	405.29	0.79		0	1674.41	167.44	1506.97	0	1506.97	183.51105	5.55458	1117.06		1117.06	1306.13		1306.13	86.672595	semi_critical
14	SBS Nagar	Banga	26066	0	26066	0	26066	2835.15	120.13	888.63	2079.42	33.2		0	5956.53	595.65	5360.88	0	5360.88	562.51245	0	12345.8		12345.8	12908.4		12908.4	240.78827	over_exploited
15	Barnala	Barnala	68824.6	146.4	68971	0	68971	7731.81	3227.86	2616.37	6906.67	82.5		0	20565.21	2056.52	18508.7	0	18508.69	1428.4348	43.93692	55020.5	0	55020.5	56492.9	0	56492.9	305.22338	over_exploited
16	Fatehgarh Sahib	Bassi Pathanan	18098	0	18098	0	18098	2638.5	552.35	223.78	1332.63	24.69		0	4771.95	477.2	4294.75	0	4294.75	334.10275	188.2407	10793.2		10793.2	11315.5		11315.5	263.47378	over_exploited
17	Gurdaspur	Batala	25611	0	25611	0	25611	3933.5	4116.31	1081.06	10018.38	28.98		0	19178.23	1917.82	17260.4	0	17260.41	1507.5632	7.55346	28718.8		28718.8	30233.9		30233.9	175.16334	over_exploited
18	Bathinda	Bathinda	34593	9966	44559	0	44559	2447.53	1103.82	7097.59	3648.21	39.06		0	14336.21	1433.62	12902.6	0	12902.59	1413.6815	216.8016	10438.8	3698.38	14137.2	12069.3	3698.37	15767.7	93.541839	critical
19	Bathinda	Bhagta Bhai Ka	26696	0	26696	0	26696	1855.91	399.75	432.18	1545.37	54.53		0	4287.74	428.77	3858.97	0	3858.97	204.4073	2.26796	12432.3		12432.3	12639		12639	327.52185	over_exploited
20	Sangrur	Bhawanigarh	33158	0	33158	0	33158	3775.33	601.86	1168.77	3481.56	39.46		0	9066.98	906.7	8160.28	0	8160.28	490.78265	115.3008	27793.2		27793.2	28399.2		28399.2	348.01796	over_exploited
21	Mansa	Bhikhi	32618	4216	36834	0	36834	2976.45	1457.46	1872.96	3685.41	45.21		0	10037.49	1003.75	9033.74	0	9033.74	416.5818	7.32226	16168.1	0	16168.1	16592	0	16592	183.66657	over_exploited
22	Tarn Taran	Bhikhiwind	32937	0	32937	0	32937	3664.52	622.4	157.61	4717.03	40.87		0	9202.43	920.24	8282.19	0	8282.19	514.7741	5.6699	18068.6		18068.6	18589		18589	224.44547	over_exploited
23	Jalandhar	Bhogpur	18255	0	18255	0	18255	2821.71	3670.77	481.95	3081.31	4.76		0	10060.5	1006.05	9054.45	0	9054.45	294.1316	9.60039	18432.4		18432.4	18736.1		18736.1	206.9272	over_exploited
24	Patiala	Bhunarheri	36316	0	36316	0	36316	4646.7	766.33	208.82	2559.84	38.28		0	8219.97	821.99	7397.98	0	7397.98	514.6573	0	20338.9		20338.9	20853.6		20853.6	281.88222	over_exploited
25	Hoshiarpur	Bhunga	54759	0	54759	0	54759	8123.23		687.74	996.57	19.65	795.432	0	10622.63	538.08	9959.71	124.84	10084.55	573.64495	0	6725.32		6725.32	7298.98		7298.98	72.377845	semi_critical
26	Mansa	Budhlada	45640	26950	72590	0	72590	3301.41	1345.49	15753.1	3852.18	168.56		0	24420.76	2442.08	21978.7	0	21978.68	1061.7449	12.95428	16487.1	11992.6	28479.7	17561.8	11992.6	29554.4	79.903752	semi_critical
27	Rupnagar	Chamkaur Sahib	19223	0	19223	0	19223	3103.2	3453.21	1371.31	4538.28	21.22		258.9	12746.12	1248.72	11756.3	0	11756.3	499.14115	155.2399	13204		13204	13858.3		13858.3	117.88003	over_exploited
28	Amritsar	Chogawan	42030	0	42030	0	42030	5188.63	4735.87	5463.36	11008.1	37.72		0	26433.68	2643.37	23790.3	0	23790.31	900.747	0	33407.8		33407.8	34308.6		34308.6	144.21241	over_exploited
29	Tarn Taran	Chohla Sahib	28817	0	28817	0	28817	3313.28	374.81	562.05	2672.48	20.58		870.51	7813.71	694.32	7989.9	0	7989.9	501.04645	0	15468.4		15468.4	15969.5		15969.5	199.87096	over_exploited
30	Hoshiarpur	Dasuya	32398	0	32398	0	32398	6341.67		1044.33	4040.5	19.9		62.33	11508.73	1144.64	10426.4	0	10426.42	726.0653	7.311288	14103		14103	14836.3		14836.3	142.29563	over_exploited
31	Ludhiana	Dehlon	14040	0	14040	0	14040	1753.94	1674.49	447.8	2370.97	34.25		0	6281.45	628.15	5653.3	0	5653.3	576.12695	194.9485	12073.3		12073.3	12844.4		12844.4	227.20146	over_exploited
32	Gurdaspur	Dera Baba Nanak	28954	0	28954	0	28954	4406.42	1433.34	924.3	8001.72	50.37		147.77	14963.92	1481.61	13630.1	0	13630.08	552.1501	0	22946.8		22946.8	23499		23499	172.4053	over_exploited
33	SAS Nagar	Derabassi	36826	2218	39044	0	39044	5876.02	101.06	760.16	2999.65	21.91	22	29.46	9810.26	978.08	8861.64	0	8861.64	1814.7399	2469.462	11920.6	0	11920.6	16204.8	0	16204.8	182.86446	over_exploited
34	Pathankot	Dhar Kalan	12058	0	12058	16941	28999	2772.25	519.78	1136.77	725.7	6.63	2136.288	0	7297.41	447.2	5368.45	1481.76	6850.21	446.4607	0	1945.18		1945.18	2391.64		2391.64	34.913382	safe
35	Gurdaspur	Dhariwal	23414	0	23414	0	23414	3942.74	3080.78	808.95	8729.31	32.54		0	16594.32	1659.43	14934.9	0	14934.89	550.60615	16.83672	25250.7		25250.7	25818.1		25818.1	172.87124	over_exploited
36	Kapurthala	Dhilwan	27232	0	27232	0	27232	3791.13		1572.9	10687.85	14.73		1550.19	17616.8	1606.66	17560.3	0	17560.33	468.43005	69.6725	30514.6		30514.6	31052.8		31052.8	176.83466	over_exploited
37	Sangrur	Dhuri	23337	0	23337	0	23337	2192.69	296.16	2029.96	2778.17	25.19		0	7322.17	732.22	6589.95	0	6589.95	632.3406	255.9412	22199.4		22199.4	23087.7		23087.7	350.34666	over_exploited
38	Gurdaspur	Dina Nagar	19734	0	19734	0	19734	2772.81	4017.88	443.01	1827.21	18.16		62.33	9141.4	907.91	8295.82	0	8295.82	456.78655	12.493	5159.89		5159.89	5629.18		5629.18	67.855619	safe
39	Sangrur	Dirba	30716	0	30716	0	30716	3211.71	641.18	94.37	2373.52	30.14		0	6350.92	635.09	5715.83	0	5715.83	418.4214	109.0927	19028.7		19028.7	19556.2		19556.2	342.14086	over_exploited
40	Ludhiana	Doraha	20269	0	20269	0	20269	2673.1	9627.13	56.14	8180.8	26.45		0	20563.62	2056.37	18507.3	0	18507.25	549.14615	191.854	28248.4		28248.4	28989.4		28989.4	156.63802	over_exploited
41	Gurdaspur	Dorangala	10920	0	10920	0	10920	2001.59	528.14	74.4	835.52	9.87		147.77	3597.29	344.95	3400.11	0	3400.11	218.1897	0	2398.21		2398.21	2616.4		2616.4	76.950452	semi_critical
42	Faridkot	Faridkot	64389	8364	72753	0	72753	5354.31	8720.82	9244.9	11474.94	36.42		0	34831.39	3483.14	31348.3	0	31348.25	1928.1782	25.5626	32820	20769.6	53589.6	34773.8	20769.6	55543.4	110.92724	over_exploited
43	Gurdaspur	Fatehgarh Churian	23070	0	23070	0	23070	3273.53	3975.66	871.57	9667.75	23.89		0	17812.4	1781.24	16031.2	0	16031.16	461.56075	2.51782	27669.8		27669.8	28133.8		28133.8	175.4946	over_exploited
44	Fazilka	Fazilka	37072.5	537.5	37610	0	37610	2264.09	7126.43	4228.61	1148.44	23.72		3345.29	18136.58	1479.13	20002.7	0	20002.74	771.3034	109.3234	3291.16	13741.9	17033.1	4171.79	13741.9	17913.7	20.856093	safe
45	Firozpur	Firozpur	45410	0	45410	0	45410	4011.06	15758.35	1938.47	10117.45	16.36		1129.41	32971.1	3184.17	30916.3	0	30916.34	1335.2613	62.2728	28691.9		28691.9	30089.4		30089.4	97.32533	critical
46	Tarn Taran	Gandiwind Tatla	20990	0	20990	0	20990	2520.03	3176.43	738.75	2664.51	20.68		0	9120.4	912.04	8208.36	0	8208.36	312.8926	0	9553.64		9553.64	9866.53		9866.53	120.20099	over_exploited
47	Hoshiarpur	Garh Shankar	38858	0	38858	0	38858	5956.26	636.49	495.08	2974.51	20.73		0	10083.07	1008.31	9074.76	0	9074.76	783.071	12.59871	14132		14132	14927.7		14927.7	164.49713	over_exploited
48	Firozpur	Ghall Khurd	42052	9788	51840	0	51840	3699.83	7998.61	11028.9	17206.81	41.3		0	39975.4	3997.54	35977.9	0	35977.86	509.6787	9.34092	49548.4	0	49548.4	50067.4	0	50067.4	139.16178	over_exploited
49	Patiala	Ghanaur	24174	0	24174	0	24174	3229.26	1190.59	1056.75	1976.96	49.84		29.46	7532.86	750.34	6811.98	0	6811.98	308.69145	136.7791	7675.18		7675.18	8120.64		8120.64	119.21115	over_exploited
50	Pathankot	Gharota	11638	0	11638	0	11638	2677.32	120.96	871.28	760.23	2.97	15.096	0	4447.86	444.8	3994.32	8.74	4003.06	469.94115	0	2128.01		2128.01	2597.94		2597.94	64.898852	safe
51	Bathinda	Goniana Mandi	28257	3720	31977	0	31977	1929.61	24.43	113.34	2726.1	28.51		0	4821.99	482.2	4339.79	0	4339.79	942.45555	28.90688	9268.7	0	9268.7	10240.1	0	10240.1	235.95773	over_exploited
52	Gurdaspur	Gurdaspur	28902	0	28902	0	28902	5049.62	5537.26	999.16	5294.69	23.19		62.33	16966.25	1690.39	15338.2	0	15338.19	1514.907	34.63444	15149.4		15149.4	16699		16699	108.87184	over_exploited
53	Firozpur	Guruhar Sahai	44298	2755	47053	0	47053	3596.89	11524.72	3529.16	6924.54	21.58		3345.29	28942.18	2559.69	29727.8	0	29727.78	387.4475	12.7813	19737.6	5743.92	25481.6	20137.9	5743.92	25881.8	67.740914	safe
54	Hoshiarpur	Hajipur	17944	0	17944	0	17944	3724.16	450.53	2441.83	1489.77	15.31		0	8121.6	812.16	7309.44	0	7309.44	350.84165	0	5497.9		5497.9	5848.75		5848.75	80.01639	semi_critical
55	Amritsar	Harsha Chhina	23162	0	23162	0	23162	2844.59	2940.89	659.19	6456.11	17.75		0	12918.53	1291.85	11626.7	0	11626.68	440.628	19.84465	20911.1		20911.1	21371.6		21371.6	183.81524	over_exploited
56	Hoshiarpur	Hoshiarpur-1	35411	0	35411	0	35411	5337.97	89.59	441.31	656.05	22.98		0	6547.9	327.4	6220.5	0	6220.5	1460.3833	50.39484	8338.57		8338.57	9849.35		9849.35	158.33695	over_exploited
57	Hoshiarpur	Hoshiarpur-2	43591	0	43591	0	43591	6418.6		206.99	908.81	29.16	525.338	0	8088.9	808.9	7120.98	159.04	7280.02	634.2094	51.47116	5686.99		5686.99	6372.67		6372.67	87.536435	semi_critical
58	Ludhiana	Jagraon	37126	0	37126	0	37126	3410.84	12023.87	897.15	3248.08	34.56		0	19614.5	1961.45	17653.1	0	17653.05	978.39345	73.95856	27141.5		27141.5	28193.8		28193.8	159.7107	over_exploited
59	Faridkot	Jaiton	42490	0	42490	0	42490	2968.86	981.37	2762.42	4812.32	29.34		0	11554.31	1155.43	10398.9	0	10398.88	353.0207	2.55626	17576.9		17576.9	17932.4		17932.4	172.44569	over_exploited
60	Fazilka	Jalalabad	43293	4514	47807	0	47807	3338.89	3495.02	3116.73	11277.02	15.8		3345.29	24588.75	2124.35	25809.7	0	25809.69	1250.5922	133.6174	32335.8	2263.73	34599.5	33720	2263.74	35983.7	130.64861	over_exploited

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131	Bathinda	Sangat	48201	0	48201	0	48201	3588.47	269.98	13895.9	4431.1	46.8		0	22232.23	2223.22	20009	0	20009.01	531.91085	14.45344	12672.6		12672.6	13219		13219	66.065188	safe
132	Sangrur	Sangrur	47418	0	47418	0	47418	4669.97	3165.97	1273.78	3815.79	41.04		0	12966.55	1296.66	11669.9	0	11669.89	1143.5414	548.8579	30580.2		30580.2	32272.6		32272.6	276.54554	over_exploited
133	Mansa	Sardulgarh	30855	4805	35660	0	35660	2188.49	1793.57	2663.27	691.52	83.29		29.46	7449.6	742.02	6737.04	0	6737.04	470.13825	4.16113	3720.23	7781.93	11502.2	4194.53	7781.93	11976.5	62.260726	safe
134	SBS Nagar	Saroya	16802	0	16802	0	16802	2386.42		371.79	190.9	12.87		0	2961.98	296.2	2665.78	0	2665.78	266.24925	0	1570.68		1570.68	1836.92		1836.92	68.907412	safe
135	Barnala	Sehna	42055	0	42055	0	42055	3966.19	9535.18	1210.56	4469	36.75		0	19217.68	1921.77	17295.9	0	17295.91	497.7286	0	35784.4		35784.4	36282.2		36282.2	209.77306	over_exploited
136	Jalandhar	Shahkot	22414	0	22414	0	22414	2559.72	36.7	75.22	1604.49	11.94		258.9	4546.97	428.81	4377.06	0	4377.06	1034.2677	173.2077	12721.3		12721.3	13928.8		13928.8	318.22228	over_exploited
137	Patiala	Shambu Kalan	22749.9	595.1	23345	0	23345	3672.05	165.58	174.95	1530.52	29.7		0	5572.8	557.28	5015.52	0	5015.52	631.3405	0	12176.3	0	12176.3	12807.6	0	12807.6	255.35956	over_exploited
138	Sangrur	Sher Pur	28584	0	28584	0	28584	3802.64	226.61	511.27	2410.66	22.61		0	6973.79	697.38	6276.41	0	6276.41	475.8578	46.83626	19285.3		19285.3	19808		19808	315.5949	over_exploited
139	Ludhiana	Sidhwan Bet	44370	0	44370	0	44370	5063.44	580.13	616.95	7626.82	17.65		258.9	14163.89	1390.5	13032.3	0	13032.29	292.63875	80.4357	31219.1		31219.1	31592.2		31592.2	242.41465	over_exploited
140	Fatehgarh Sahib	Sirhind	30501	0	30501	0	30501	4415.46	3977.71	714.46	3763.27	30.94		0	12901.84	1290.18	11611.7	0	11611.66	648.8167	405.196	20342		20342	21396		21396	184.26297	over_exploited
141	Gurdaspur	Sri Hargobindpur	27488	0	27488	0	27488	4462.95	10154.81	1297.9	5566.84	37.44		62.33	21582.27	2151.99	19492.6	0	19492.61	498.7506	0	18441.3		18441.3	18940		18940	97.165233	critical
142	Ludhiana	Sudhar	14060	0	14060	0	14060	1743.2	1932.26	609.96	1439.79	38.16		0	5763.37	576.34	5187.03	0	5187.03	527.72065	17.06736	11769.2		11769.2	12314		12314	237.40021	over_exploited
143	Pathankot	Sujanpur	15720	0	15720	0	15720	2885.34	11429.34	1234.11	1801.61	2.61	23.28	0	17376.29	1737.63	15623.5	15.12	15638.66	626.58455	13.88645	5006.01		5006.01	5646.49		5646.49	36.105971	safe
144	Kapurthala	Sultanpur Lodhi	44464	0	44464	0	44464	5296.22	31.71	2101.51	12989.13	26.2		870.51	21315.28	2044.48	20141.3	0	20141.31	517.6138	162.1373	48967.1		48967.1	49646.9		49646.9	246.49266	over_exploited
145	Sangrur	Sunam	48981	0	48981	0	48981	4524.55	447.84	1495.7	4121.42	47.79		0	10637.3	1063.74	9573.56	0	9573.56	627.62845	433.0304	33021.3		33021.3	34081.9		34081.9	356.00069	over_exploited
146	Bathinda	Talwandi Sabo	52684	4689	57373	0	57373	3940.77	4468.85	8230.43	3561.84	43.82		0	20245.71	2024.57	18221.1	0	18221.14	922.4353	27.21552	10194	186.818	10380.8	11143.7	186.82	11330.5	61.157974	safe
147	Hoshiarpur	Talwara	22573	0	22573	0	22573	4550.5	26.03	357.82	591.11	20.21	1636.6	0	7182.27	718.23	4991.1	1472.94	6464.04	335.52625	4.19957	1724.06		1724.06	2063.79		2063.79	31.927247	safe
148	Hoshiarpur	Tanda	27371	0	27371	0	27371	4890.88		1011.79	5976.81	21.42		62.33	11963.23	1190.09	10835.5	0	10835.47	467.56135	1.579884	18789.6		18789.6	19258.8		19258.8	177.73821	over_exploited
149	Tarn Taran	Tarn Taran	36094	0	36094	0	36094	3846.62	2290.38	701.69	2360.12	63.68		0	9262.49	926.25	8336.24	0	8336.24	1096.617	68.0388	19436.3		19436.3	20601		20601	247.12568	over_exploited
150	Amritsar	Tarsikka	23578	0	23578	0	23578	3425.8	3404.94	505.59	6997.35	46.92		0	14380.6	1438.06	12942.5	0	12942.54	637.95795	0	27076.4		27076.4	27714.3		27714.3	214.13347	over_exploited
151	Tarn Taran	Valtoha	37614	0	37614	0	37614	3791.64	330.97	1261.08	4692.56	40.61		1129.41	11246.27	1011.69	11364	0	11363.99	420.33765	0	14687.9		14687.9	15108.2		15108.2	132.94811	over_exploited
152	Amritsar	Verka	17566	0	17566	0	17566	2412.23	2680.58	412.61	3450.05	9.62		0	8965.09	896.51	8068.58	0	8068.58	569.0788	87.88345	18799.6		18799.6	19456.6		19456.6	241.13995	over_exploited
153	Firozpur	Zira	41154.8	49.22	41204	0	41204	3822.44	4427.73	894.41	3840.29	28.79		0	13013.66	1301.37	11712.3	0	11712.29	670.18745	43.59096	30610	0	30610	31323.8	0	31323.8	267.4436	over_exploited
Total			4767339	250188	5017527	16941	5034468	550706.39	453878.36	283215	587944.04	4776.72	7545.876	31380	1919446.9	187450.14	1758870	4506.9	1763376.75	117552.19	24562.88	2624037	129842	2753880	2766152	129842	2895995	156.86679	

Annexure II

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024

PUNJAB

S.NO	Name of District	Ground Water Recharge					Total Natural Discharges	Annual Extractable Ground Water Resource	Current Annual Ground Water Extraction				Annual GW Allocation for Domestic use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction(%)
		Monsoon Season		Non-Monsoon Season		Total Annual Ground Water Recharge									
		Recharge from rainfall	Recharge from other Sources	Recharge from Rainfall	Recharge from other Sources				Irrigation	Industrial	Domestic	Total			
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	**Amritsar**	29515.8	82671.79	5345.17	30811.4	148554.26	14834.4	133929.96	230370	438.41	6391.82	237200.1	6453.15	0	177.11
2	**Barnala**	13419.43	25795.05	1267.8	16138.89	56621.17	5662.11	50959.06	108962	43.94	2515.47	111521.1	2539.61	0	218.84
3	**Bathinda**	17708.15	64376.11	3125.99	35907.55	121117.8	12111.79	109006.01	112186	347.69	5858.76	118392.9	5914.99	18363.87	108.61
4	**Faridkot**	9819.89	35685.13	1160.18	16942.02	63607.22	6360.72	57246.5	67327	66.46	2607.06	70000.54	2632.08	0	122.28
5	**Fatehgarh Sahib**	14525.56	14446.92	1670.85	8118.72	38762.05	3876.21	34885.84	67117.8	2588.59	2530.31	72236.72	2554.58	0	207.07
6	**Fazilka**	11232.43	45176.88	1490.88	23280.99	87871.76	8118.12	86444.22	48438.8	256.7	5069.54	53765.1	5118.18	40552.78	62.2
7	**Firozpur**	18259.72	82916.59	2465.89	41525.3	156332.78	14516.75	152981.31	165856	134.21	3480.64	169471.1	3514.03	21373.46	110.78
8	**Gurdaspur**	36564.83	89272.74	6344.47	35669.86	168606.86	16785.18	152576.64	200933	110.52	7070.63	208114.5	7138.48	3991.66	136.4
9	**Hoshiarpur**	47326.84	24745.2	7725.46	9448.12	89432.61	8073.01	81546.61	87984.1	131.51	6677	94792.59	6741.08	9548.71	116.24

Table III

CATEGORIZATION OF BLOCKS OF PUNJAB STATE (BLOCK WISE)

				2023		**2024**	
S.No	**STATE**	**DISTRICT**	**BLOCK**	**Categorization of Assessment Unit**		**Categorization of Assessment Unit**	
		Amritsar		**Stage of Ground Water Extraction (%)**		**Stage of Ground Water Extraction (%)**	**Category**
1	PUNJAB	Amritsar	Ajnala	157.76	over_exploited	155.83	over_exploited
2	PUNJAB	Amritsar	Amritsar Urban	324.31	over_exploited	324.33	over_exploited
3	PUNJAB	Amritsar	Attari	186.3	over_exploited	186.3	over_exploited
4	PUNJAB	Amritsar	Chogawan	144.21	over_exploited	144.22	over_exploited
5	PUNJAB	Amritsar	Harsha Chhina	183.82	over_exploited	183.82	over_exploited
6	PUNJAB	Amritsar	Jandiala Guru	220.45	over_exploited	214.46	over_exploited
7	PUNJAB	Amritsar	Majitha	166.42	over_exploited	166.42	over_exploited
8	PUNJAB	Amritsar	Rayya	176.67	over_exploited	170.42	over_exploited
9	PUNJAB	Amritsar	Tarsikka	214.13	over_exploited	214.13	over_exploited
10	PUNJAB	Amritsar	Verka	236.04	over_exploited	241.14	over_exploited
		BARNALA					
11	PUNJAB	Barnala	Barnala	324.16	over_exploited	305.22	over_exploited
12	PUNJAB	Barnala	Mahal Kalan	123.7	over_exploited	123.7	over_exploited
13	PUNJAB	Barnala	Sehna	209.77	over_exploited	209.77	over_exploited
		BATHINDA					
14	PUNJAB	Bathinda	Bathinda	94.97	critical	93.54	Critical
15	PUNJAB	Bathinda	Bhagta Bhai Ka	327.52	over_exploited	327.54	over_exploited
16	PUNJAB	Bathinda	Goniana Mandi	224.15	over_exploited	235.95	over_exploited
17	PUNJAB	Bathinda	Maur	172.36	over_exploited	182.28	over_exploited
18	PUNJAB	Bathinda	Nathana	117.23	over_exploited	117.25	over_exploited
19	PUNJAB	Bathinda	Phul	135.98	over_exploited	135.98	over_exploited
20	PUNJAB	Bathinda	Rampura	75.56	semi_critical	78.95	over_exploited
21	PUNJAB	Bathinda	Sangat	61.14	Safe	66.07	over_exploited
22	PUNJAB	Bathinda	Talwandi Sabo	48.58	Safe	61.15	over_exploited
		FARIDKOT					
23	PUNJAB	Faridkot	Faridkot	116.69	over_exploited	110.94	over_exploited

24	PUNJAB	Faridkot	Jaiton	170.21	over_exploited	172.45	over_exploited
25	PUNJAB	Faridkot	Kot Kapura	124.23	over_exploited	111.59	over_exploited
		FATEHGARH SAHIB					
26	PUNJAB	Fatehgarh Sahib	Amloh	299.95	over_exploited	263.07	over_exploited
27	PUNJAB	Fatehgarh Sahib	Bassi Pathanan	263.38	over_exploited	263.49	over_exploited
28	PUNJAB	Fatehgarh Sahib	Khamanon	176.21	over_exploited	176.23	over_exploited
29	PUNJAB	Fatehgarh Sahib	Khera	194.56	over_exploited	187.79	over_exploited
30	PUNJAB	Fatehgarh Sahib	Sirhind	184.26	over_exploited	184.28	over_exploited
		FAZILKA					
31	PUNJAB	Fazilka	Abohar	17.78	safe	16.61	Safe
32	PUNJAB	Fazilka	Arniwala Sheikh Subanpur	71.11	semi_critical	76.08	semi_critical
33	PUNJAB	Fazilka	Fazilka	31.16	safe	20.85	Safe
34	PUNJAB	Fazilka	Jalalabad	178.28	over_exploited	130.64	over_exploited
35	PUNJAB	Fazilka	Khuian Sarwar	61.81	safe	56.17	Safe
		FEROZEPUR					
36	PUNJAB	Firozpur	Firozpur	113.98	over_exploited	97.32	over_exploited
37	PUNJAB	Firozpur	Ghall Khurd	136.23	over_exploited	139.17	over_exploited
38	PUNJAB	Firozpur	Guruhar Sahai	89.75	semi_critical	67.74	semi_critical
39	PUNJAB	Firozpur	Makhu	78.2	semi_critical	58.33	semi_critical
40	PUNJAB	Firozpur	Mamdot	198	over_exploited	122.84	over_exploited
41	PUNJAB	Firozpur	Zira	267.35	over_exploited	267.46	over_exploited
		GURDASPUR					
42	PUNJAB	Gurdaspur	Batala	175.16	over_exploited	175.16	over_exploited
43	PUNJAB	Gurdaspur	Dera Baba Nanak	182.72	over_exploited	172.4	over_exploited
44	PUNJAB	Gurdaspur	Dhariwal	175.67	over_exploited	172.88	over_exploited
45	PUNJAB	Gurdaspur	Dina Nagar	53.96	Safe	67.85	Safe
46	PUNJAB	Gurdaspur	Dorangala	81.91	semi_critical	76.95	semi_critical
47	PUNJAB	Gurdaspur	Fatehgarh Churian	175.49	over_exploited	175.5	over_exploited
48	PUNJAB	Gurdaspur	Gurdaspur	109.68	over_exploited	108.87	over_exploited
49	PUNJAB	Gurdaspur	Kahnuwan	146.25	over_exploited	125.25	over_exploited
50	PUNJAB	Gurdaspur	Kalanaur	186.4	over_exploited	172.56	over_exploited
51	PUNJAB	Gurdaspur	Qadian	104.4	over_exploited	103.72	over_exploited
52	PUNJAB	Gurdaspur	Sri Hargobindpur	100.7	over_exploited	97.16	Critical
		HOSHIARPUR					

PUBLIC ACTION COMMITTEE
PAC Sutlej, Mattewara, Buddha Dariya
Group of Environment NGOs of Punjab since July 2020
Head Office: # 561-L, Model Town, Ludhiana 141002 (Pb.)
Contact: 9815781629, 9855544433 mattewarasutlejpac@gmail.com

PETITION TO THE MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE (MoEFCC)

REQUEST FOR CANCELLATION OF ENVIRONMENTAL CLEARANCE GRANTED TO MALBROS DISTILLERY, ZIRA

Date: 17 November 2025

To
The Secretary
Ministry of Environment, Forest and Climate Change (MoEFCC)
Government of India
Indira Paryavaran Bhawan
Jor Bagh Road
New Delhi – 110003

Subject: Request for cancellation of Environmental Clearance granted to Malbros Distillery and Ethanol Plants, Mansoorwal, Zira, District Ferozepur, Punjab

Respected Sir/Madam,

We, the members of Public Action Committee Mattewara, respectfully submit this petition seeking cancellation of the Environmental Clearance (EC) granted on 15 January 2018 to M/s Malbros International Pvt. Ltd. for its distillery located at Village Mansoorwal, Tehsil Zira.

This request is based on documented findings that the project proponent has caused severe groundwater contamination, air pollution, and widespread environmental harm, and has failed to comply with several essential and mandatory conditions of the Environmental Clearance besides manufacturing products beyond the scope of the EC.

A substantial number of the conditions contained in the EC dated 15 January 2018 stand violated, including those relating to Zero Liquid Discharge, handling of fly ash, groundwater extraction, green-belt development, online monitoring, hazardous waste management, worker health surveillance, and social responsibility.

The clause-wise matrix of EC violations is enclosed as Annexure B.
The evidentiary material relied upon, including videos, photographs, statutory orders, and the CPCB Joint Committee Inspection Report dated 13 April 2023, is enclosed as Annexures A1 – A9.

In addition to the violations, we draw attention to the ambiguity in the Environmental Clearance regarding the products permitted. The EC uses the generic term "ethanol" alongside "rectified spirit," "ENA," and "industrial alcohol." The project proponent has unilaterally interpreted this wording to include anhydrous ethanol or fuel ethanol, although the project was never appraised or approved for fuel-grade ethanol production. The 2006 EC did not include ethanol as a product, and the 2018 EC inserted this term despite being an expansion EC limited to increasing capacity from 100 to 600 KLD. The use of this vague term has enabled activities beyond the scope of appraisal and environmental impact assessment.

We respectfully request that the Ministry exercise its powers under the Environment (Protection) Act, 1986, including its powers under Sections 3(1) and 3(2)(v), and in view of binding non-compliance clauses contained in the Environmental Clearance itself." and cancel the Environmental Clearance granted to the project. We further request appropriate regulatory action regarding the environmental damage caused, and immediate directions for remediation of contaminated soil and groundwater.

With utmost respect,
Sincerely,

Jaskirat Singh	Dr Amandeep Singh Bains
Kapil Dev	Kuldeep Singh Khara

Submitted electronically. No physical signature required.

ANNEXURE B — CONDITION–VIOLATION MATRIX

EC Clause / Condition	Category / Purpose	Violation / Finding	Evidence / Source
(d) Zero Liquid Discharge (ZLD)	Water pollution control	Untreated effluent discharged into groundwater through reverse boring; factory borewells identified as epicentre of contamination.	CPCB Inspection Report 13.04.2023; Chief Secretary Committee Report 26.03.2023
(g) Freshwater abstraction limits & flow meters	Groundwater governance	Ten borewells operated despite permission for four; no flow-meter records or monitoring data submitted.	Appellate Authority Order 05.09.2023; PPCB Consent Withdrawal 30.06.2023
(n) 33% green belt development	Air pollution buffer / ecological safeguard	Required green belt not developed; boundary areas barren and without plantation.	Google Earth imagery; Appellate Authority Order p.125
(k) Disposal of sludge / evaporation salt to TSDF / cement plants	Hazardous waste management	Sludge mixed with fly ash and dumped within factory premises; no record of authorised TSDF or cement-plant disposal.	Appellate Authority Order p.125; Chief Secretary Committee Report 26.03.2023
(v) Covered storage of coal and fly ash	Air pollution control	Fly ash stored and dumped openly in unlined pits; fugitive dust impacting villages.	Video evidence; CPCB field observations
(t) Online monitoring systems (CEMS, cameras, flow meters)	Compliance transparency	No online CEMS feed; no real-time flow-meter data; no online monitoring transmitted to PPCB.	PPCB inspection; Appellate Authority findings
(p) Enterprise Social Commitment (2.5% of project cost)	Social responsibility	Only ₹6.51 lakh spent; no time-bound ESC implementation plan submitted.	Appellate Authority Order p.125
(s) Health surveillance of workers	Occupational safety	No regular medical check-ups; certificates found to be tampered or inadequate.	Appellate Authority Order p.125
(x) Boiler fuel specification (biofuel/agri-waste only)	Emission standard compliance	Ash composition inconsistent with permitted fuel mix; presence of coal combustion indicators.	CPCB ash analysis (2023)
12.1 (i–ii) Compliance with PPCB directions	Legal compliance	PPCB withdrew Consent to Operate on 30.06.2023 due to major violations; Appellate Authority upheld withdrawal on 05.09.2023.	PPCB Consent Withdrawal 30.06.2023; Appellate Authority Order 05.09.2023

Gmail PAC MattewaraSutlej <mattewarasutlejpac@gmail.com>

Petition for Cancellation of Environmental Clearance – Malbros Distillery, Zira (EC dated 15.01.2018)

1 message

PAC MattewaraSutlej <mattewarasutlejpac@gmail.com> Mon, Nov 17, 2025 at 1:04 AM
To: monitoring-ec@nic.in
Cc: secy-moef@nic.in, asag-moefcc@gov.in, jsia-moefcc@gov.in, ms-cpcb@gov.in, js.ia-moefcc@gov.in, vinay.rana@gov.in

Respected Sir/Madam,

Please find enclosed a petition requesting cancellation of the Environmental Clearance dated 15 January 2018 issued to M/s Malbros International Pvt. Ltd., Mansoorwal, Zira, District Ferozepur, Punjab, due to extensive violations and non-compliance with statutory conditions and vague product descriptions.

Independent findings by the CPCB Joint Committee dated 13 April 2023, the Punjab Chief Secretary Committee dated 26 March 2023, and actions of the Punjab Pollution Control Board confirm the following:

- discharge of untreated effluent into groundwater through reverse boring,
- contamination of borewells inside and around the factory,
- illegal open dumping and airborne dispersal of fly ash,
- failure to maintain Zero Liquid Discharge,
- non-compliance with hazardous waste, green-belt, online monitoring and CSR conditions, and
- withdrawal of consent by PPCB and rejection of appeal by the Appellate Authority.

These constitute material violations of several core conditions of the Environmental Clearance and attract action under Paragraph 13 of the EIA Notification, 2006.

We respectfully request appropriate action by the Ministry.

Attachments and Annexures:

Attached PDFs:

1. Petition
2. Annexure B – Clause-wise Matrix of EC Violations

Annexure A is enclosed as individual Google Drive links for the following items:
A-1: Video of CPCB sampling of contaminated borewell water
A-2: Video showing airborne fly ash dispersion
A-3: CPCB Joint Committee Inspection Report
A-4: Passbook photo showing compensation for cattle deaths
A-5: Google Earth image of fly-ash dump inside premises
A-6: PPCB withdrawal of Consent to Operate dated 30 June 2023
A-7: PPCB refusal of Consent under the Air Act
A-8: Appellate Authority Order dated 05 September 2023
A-9: Media report on ED raid in July 2024

Thank you for your attention.

Sincerely,
Jaskirat Singh

Kapil Dev
Dr Amandeep Singh Bains
Kuldeep Singh Khara

A-1 Malbros water sampling CPCB A1.mp4

A-2 Roman Malbros Flyash Zira.mp4

A-3 CPCB Report in NGT 606 of 2022 PAC & ors. vs. …

A-4 ngt passbook.jpg

A-5 malbrosillustration.png

A-6 REPORT BY PPCB IN APPEAL NO. 33 of 2023 …

A-7 ppcb air act.pdf

A-8 Pb Govt.pdf

A-9 Press Release JLZO Ms Malbros international Pvt…

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2 attachments

Annexure B.pdf
40K

petition.pdf
100K

Deepak Singh <deepak.singh@hrln.org>

Response of the Applicant to the oral application of the company seeking approval from this Hon’ble NGT for continuing of the fuel ethanol plant in OA 606 of 2022 by the APPLICANT Dated 21.11.2025

1 message

Deepak Singh <deepak.singh@hrln.org> Fri, Nov 21, 2025 at 5:56 PM
To: chairman.ptl.ppcb@punjab.gov.in, chairmanppcb@yahoo.co.in, seezobti@gmail.com, zldmalbros@oasisgrp.in, rdchandigarh.cpcb@gov.in, gurnamsingh.cpcb@nic.in, msppcb@punjab.gov.in, mattewarasutlejpac@gmail.com, ccb.cpcb@nic.in, narendersharma.cpcb@gov.in, mscb.cpcb@nic.in, ppcbfdk@yahoo.com, cs@punjab.gov.in, "naginder.benipal@gmail.com" <naginder.benipal@gmail.com>, "officeofbalendu@gmail.com" <officeofbalendu@gmail.com>, artakkar@artlo.in, rahul@artlo.in, ENVIRO LEGAL DEFENCE FIRM <eldflegal@gmail.com>

Dear Sir/Madam,
Please find the Response of the Applicant to the oral application of the company seeking approval from this Hon’ble NGT for continuing of the fuel ethanol plant in O.A. 606 of 2022 by the APPLICANT dated 21.11.2025 on behalf of the Original Applicant, listed before the Hon'ble NGT, Principal Bench, Delhi. Please consider it as proof of advance service.
Thank you,
Regards,
On Behalf of the Applicant
Kawalpreet Kaur & Deepak Kumar Singh,
Advocates for the Applicant
OA 606 of 2022

Response Submissions on Fuel ethanol by Applicant OA 606 of 2022.pdf

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Response Submissions on Fuel ethanol by Applicant OA 606 of 2022_compressed (1).pdf
23732K