BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL,

PRINCIPAL BENCH, NEW DELHI

ORIGINAL APPLICATION NO. 606 OF 2018

IN THE MATTER OF :-

COMPLIANCE OF MUNICIPAL SOLID WASTE MANAGEMENT RULES, 2016 AND OTHER ENVIRONMENTAL ISSUES

NDOH: 20.04.2026

I N D E X

THROUGH

(SHUBHAM BHALLA)
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PLACE: NEW DELHI
DATE: 14.04.2026

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL,
PRINCIPAL BENCH, NEW DELHI

ORIGINAL APPLICATION NO. 606 OF 2018

IN THE MATTER OF :-

COMPLIANCE OF MUNICIPAL SOLID WASTE MANAGEMENT RULES, 2016 AND OTHER ENVIRONMENTAL ISSUES

STATUS REPORT BY WAY OF AFFIDAVIT ON BEHALF OF UT CHANDIGARH.

I, H. Rajesh Prasad, IAS, Chief Secretary, UT Chandigarh, having office at Chandigarh Secretariat, Sector 9, UT Chandigarh, being well conversant with the facts of the case in my official capacity and being competent to swear this Affidavit on behalf of Respondent UT Chandigarh:-

1057
14/3/26

1. That I am the Chief Secretary, UT Chandigarh, and am competent to file the present affidavit. This Affidavit is being filed in compliance with the directions issued by this Hon'ble Tribunal to file regular status reports.

2. That the present affidavit is being filed along with a detailed status report, in compliance with the orders passed by this Hon'ble Tribunal concerning UT Chandigarh.

GOVT OF INDIA
DALIP KUMAR
CHANDIGARH
Regd. No. 5604
Expiry dt. 23-3-2028
NOTARY

Chief Secretary
U.T. Chandigarh

A true copy of the status report of UT Chandigarh is annexed herewith as **Annexure R-1**.

3. That the contents of the present affidavit as well as the accompanying status report are based on the official records made available to the deponent and are true and correct to the best of my knowledge, and nothing material has been concealed therefrom.

DEPONENT

Chief Secretary
U.T. Chandigarh

VERIFICATION:

I, H. Rajesh Prasad, IAS, Chief Secretary, UT Chandigarh, the above-named deponent, do hereby verify that the contents of paragraphs 1 to 3 of the above Affidavit are true and correct to my knowledge and belief, based on official records, and nothing material has been concealed therefrom.

Verified at Chandigarh on this day of April, 2026.

DEPONENT

Chief Secretary
U.T. Chandigarh

NOTARY GOVT OF INDIA DALIP KUMAR CHANDIGARH Regd. No. 5604 Expiry dt. 25-3-2028

Attested as Identified
14 APR 2026
NOTARY CHANDIGARH

COMPLIANCE REPORT

O.A. No. 606/ 2018

(Compliance of Municipal Solid Waste Management Rules, 2016 and other Environmental Issues)

SUBMITTED BY

CHANDIGARH ADMINISTRATION

April, 2026

4.

INDEX

1. Introduction

The O.A. No. 606/2018 (Compliance of Municipal Solid Waste Management Rules, 2016 and other Environmental Issues) in the Hon'ble National Green Tribunal relates to solid and liquid waste management. Progress in this case is being closely monitored by Chandigarh Pollution Control Committee and is being reviewed, on regular basis, by the Chief Secretary U.T. Chandigarh. Last status report in this matter was filed by Chandigarh Administration on 01.09.2025 and the Chief Secretary appeared through video conferencing before the Hon'ble Tribunal during last hearing held on 19.09.2025. In accordance with the directions issued during that hearing, a Supplementary Affidavit was subsequently filed on 25.09.2025 (attached as Annexure A).

Pursuant to the Hon'ble NGT's order dated 19.09.2025, which directed the submission of a fresh action taken report and included specific observations, the status update is provided below:

2. Solid Waste Management

2.1 Observation: "*4[A][III]. We find that 7 TPD of compost, 81 TPD of RDF, and 35 TPD of inerts are produced out of waste processing. The details on utilisation and management should be properly disclosed*".

Response/Status:

i. The response to aforesaid observation is at vi, vii and xv.

ii. The average generation of municipal solid waste is 500 TPD in U.T. Chandigarh. The city currently maintains over 100% treatment capacity across all MSW categories. The solid waste processing facilities along with their capacities are given below.

Director Environment
Chandigarh Administration

Solid Waste Processing Facilities

S. No.	Facility	Capacity
1.	Material Recovery Facilities (MRFs)	03 Nos. (75 tonnes per shift each)
2.	Dry waste processing plant (RDF Plant)	200 TPD
3.	Wet waste processing plant (Compost Plant)	300 TPD
4.	Mixed waste processing plant	100 TPD
5.	Horticulture waste processing plant	(30 TPD of Horticulture Waste Processing Plant) + (32 TPD in parks) + Land composting
6.	Bio-Methanation plant	5 TPD
7.	Coconut Shell shredder	10 TPD
8.	Cloth, mattress shredder	10 TPD

iii. Recently new Solid Waste Management Rules, 2026 have been notified which came into effect from 01.04.2026 wherein there is a mandate for four-stream segregation system. However, in case of Chandigarh, the practice is in place since long and in alignment with the Solid Waste Management Rules, 2026; waste is collected via four-stream segregation viz. wet waste, dry waste, sanitary waste, and domestic hazardous waste (special care waste).

Director Environment
Chandigarh Administration

iv. Collection of waste is being done through 523 Nos. of GPS-enabled, covered, compartmentalized vehicles. The Municipal Corporation Chandigarh (MCC) maintains consistent oversight to ensure comprehensive city-wide coverage, mandating that all vehicles are cleaned daily following their shifts and the

resulting wastewater is then channeled to a nearby Sewage Treatment Plant (STP) for treatment.

v. All the collected waste is sent to three Material Recovery Facilities (MRFs) for secondary segregation and further processing. Recyclable waste approx. 8 TPD is sold to registered/authorized recyclers.

vi. The non-recyclable dry waste (approx. 109 TPD) is sent to RDF plant for processing where it undergoes trommel screening to eliminate inerts, followed by ballistic separation and shredding. This results in production of approx. 82 TPD of Refuse Derived Fuel (RDF), which serves as an alternative energy source for the paper and cement industries. The remaining 2 TPD of inert waste is disposed of at sanitary landfill site. The details are provided in table 1 of Annexure B.

vii. The collected wet waste (approx. 190 TPD) is sent to compost plant where approx. 7 TPD compost is produced through windrow composting method. The produce is being sold to farmers for use as manure. Approx. 17 TPD inert waste is generated which goes to sanitary landfill site. The details are provided in table 1 of Annexure B and the compost quality is attached as Annexure C.

viii. Other than these, some quantum of mixed waste (approx. 70 TPD) is generated which is sent for processing at mixed waste processing plant where machines have been installed to segregate waste which is further sent for processing.

ix. The collected sanitary waste approx. 1 TPD is disposed through incinerator as prescribed in rules.

x. Approx. 0.1 TPD domestic hazardous waste is disposed through authorized TSDF (Treatment Storage and Disposal Facility at Nimbua, Punjab) for its scientific disposal.

Director Environment
Chandigarh Administration

xi. Approximately 96 TPD of horticulture waste is generated and 100% horticulture waste is being processed. Pruned horticulture waste is processed

to manufacture Bio-Briquettes at Horticulture Processing Plant of 30 TPD capacity. Horticulture waste produced in parks and green belts is processed (in situ) for which 104 aerobic compost pits of total capacity 32 TPD have been constructed. The remaining horticulture waste is also processed through land composting and the quality of compost produced is attached as Annexure D. Further, a new 60 TPD horticulture waste plant is also in development.

xii. Mandi waste approx. 1 TPD is processed through bio-methanation plant dedicatedly installed for the purpose.

xiii. There are dedicated facilities for managing coconut shell waste and cloth/seat cover/mattresses waste.

xiv. Additionally, MCC has entered into an agreement with Indian Oil Corporation Limited (IOCL) to establish a Compressed Biogas (CBG) plant in Chandigarh.

xv. In line with the SWM Rules, 2026; the inerts/ rejects (approx. 27 TPD) from the processing are sent for disposal at the sanitary landfill site. The status of municipal solid waste management in Chandigarh is given in table 1 of Annexure B.

2.2 Observation: "*4[A][IV]. We find that segregation of waste at source has not been fully achieved. As a result, 75 TPD of Mixed waste is subjected to segregation at mixed processing site before it is further processed. Such areas should be identified. Segregation of waste to be undertaken*".

Response/Status:

Director Environment
Chandigarh Administration

i. Municipal Corporation Chandigarh (MCC) has intensified efforts to improve source-level four stream waste segregation through regular public education drives. Now the quantum of mixed waste is reduced from 75 TPD to 70 TPD. Field inspections are being conducted by all senior officers of MCC up to the

level of Executive Engineer to ensure effective waste segregation, collection, and prevention of littering. Proper area-wise allocation of responsibility of each officer has been clearly defined, examined, and analyzed for ensuring effective monitoring and accountability on the ground. The field performance is weekly reviewed and necessary directions are issued accordingly. To enforce compliance, penalties are being strictly applied, with a total of 2,869 challans issued over the past three months for failure to properly segregate waste particularly in identified hotspots specially villages viz. Attawa, Khajeri, Faidan, Badheri, Buterla, Palsora, Maloya, Burail and Dadumajra. Details regarding the awareness initiatives undertaken by MCC are provided in Annexure E.

2.3 Observation: "*4[A][V].With regard to legacy waste, the remaining 55,000 MT should be expeditiously remediated and no further legacy waste is should be created. Details of legacy waste, the area covered, the processing method and disposal and the area recovered by removing the legacy waste be provided in the next report*".

Response/Status:

i. In terms of the last Affidavit filed on 01.09.2025 and Supplementary Affidavit filed on 25.09.2025; approx. 55,000 MT of unprocessed waste accumulated during the installation of the mixed waste processing plant and due to other technical challenges was remaining to be bio-remediated. Out of this 55,000 MT waste, 48900 MT has been processed. The biosoil of 40270 MT was used in leveling activities in low lying areas. The RDF (6696 MT) was sold by concessionaire to paper/cement industries and 1934 MT inerts were disposed in sanitary landfill site of 7.41 acres. The remaining 6100 MT of unprocessed waste is likely to be cleared by April, 2026.

Director Environment
Chandigarh Administration

ii. Previously, 13 lakh metric tons (LMT) of legacy waste was successfully bio-remediated across two sites (spread over 20 acres and 8.28 acres), and land has already been reclaimed.

iii. Currently, all municipal waste is being processed on a daily basis and no further legacy waste is being created. The details of legacy waste are provided in table 2 of Annexure B.

2.4 Observation: *"4[A][VI]. Details of land fill site existing and the quantity of waste in such sites to be provided".*

Response/Status:

i. As already submitted vide Supplementary Affidavit dated 25.09.2025, the earlier dumping ground in Chandigarh was spread over 45 acres of land.

ii. Out of the total 45 acres, 20 acres which was previously used for waste dumping has now been cleared and reclaimed. 5 LMT of legacy waste from this has already been bio-remediated. On a part of this 20 acres reclaimed land, a 300 TPD wet waste processing plant and a mixed waste processing plant have been set up.

iii. Out of remaining 25 acres, 16.72 acres have been capped and covered. The balance 8.28 acres site was utilized as a sanitary landfill site for waste dumping. Approximately 8 LMT of legacy waste from this 8.28 acres area has already been bio-remediated. The remaining unprocessed waste to the tune of 6100 MT is currently being bio-remediated and is likely to be cleared by April, 26.

iv. During the bio-remediation of the 8.28 acres sanitary landfill site and considering the ongoing daily dumping of inert waste, a new sanitary landfill site measuring 7.41 acres was developed within the 16.72 acres of land that had been previously capped and covered. This 7.41 acres site is currently being used for dumping of inert material.

Director Environment
Chandigarh Administration

3. Liquid Waste Management

3.1 Observation: *"4[B][I]. Out of 232.0 MLD of sewage generation, treatment capacity of 253.5 MLD has been created and 239.0 MLD is treated as per disclosed figures but, the extent of utilisation of STPs has not been disclosed. Therefore, we direct that details on the existing sewerage network, household connectivity, and areas yet to be sewered, if any, be provided."*

Response/Status:

i. As already submitted vide Supplementary Affidavit dated 25.09.2025; Chandigarh has eight (8) Sewage Treatment Plants (STPs) which are operational with combined treatment capacity of 253.5 MLD against generation of 232 MLD. The utilization of STPs maintained by the log books is given below:

Utilization Capacity of STPs

S. No.	Location of STP	Capacity (MLD)	Utilization (MLD) (As on 09.04.2026)
1.	Diggian	135	119.51
2.	3 BRD	50	48.16
3.	Maloya	22.5	21.46
4.	Dhanas	7.5	6.36
5.	Raipur Kalan – I	22.5	24.36
6.	Raipur Khurd	9.0	8.78
7.	Raipur Kalan – II	5.0	0.9
8.	Kishangarh	2.0	1.09
Total		**253.5 MLD**	**230.62 MLD**

Director Environment
Chandigarh Administration

ii. Chandigarh has separate systems for storm water drainage and sewerage. The storm water flows into Sukhna choe, N-choe, Patiala ki Rao choe and Faidan choe. No sewage is discharged into storm water drains.

iii. There is 100% household connectivity to the sewerage network, ensuring all waste is directed to STPs for scientific disposal. The details on sewage generation, collection network and household connections are given in table 3 and the details on sewage treatment and utilization are provided in table 4 of Annexure B.

3.2 Observation: *"4[B][II].Discharge of sewage into storm water drains (SWD) and whether any SWD carrying sewage or mixed effluents has been intercepted and diverted to any of the STP, be provided."*

Response/Status:

i. As already submitted vide Supplementary Affidavit dated 25.09.2025; no sewage is discharged into storm water drains. Chandigarh has separate systems for storm water drainage and sewerage. The storm water drains connect to Sukhna choe, N-choe, Patiala ki Rao choe and Faidan choe.

ii. Wastewater discharge points into the choes have been intercepted, with routine inspections and repairs conducted as necessary to ensure continued compliance. To date, 17 discharge points for the Sukhna Choe, 19 for the N-Choe, and 6 for the Patiala Ki Rao have been identified and tapped. In case of sewer line breakage, immediate repairs are undertaken. The details of drains are given in table 5 of Annexure B.

iii. All the waste water is being treated in STPs except for approx. 1-2 MLD generated from the Faidan village which is situated on the boundary of Chandigarh and Punjab. To address this, two modular STPs (750 KLD capacity each) were proposed. One of the STPs is currently operational (photograph is attached as Annexure F) and the second will be operational by 30.05.2026.

Director Environment
Chandigarh Administration

3.3 Observation: *"4[B][III]. While going through the performance of eight STPs, we find values of fecal coliform are reported as "BDL" rather than reporting the units as per standard methods. Further, there is no disclosure on the condition and standards stipulated and the mode of disposal of treated sewage. We also find that*

constructing STP of 135 MLD has not been consented and reasons for not granting consent should be disclosed".

Response/Status:

i. As submitted vide earlier Affidavit dated 04.12.2024; the parameters of treated effluent from STPs are being tested as per the procedures given in the Standard Methods for Examination of Water and Wastewater, American Public Health Association (APHA) 24th edition and in accordance with the notification of Ministry of Environment, Forest and Climate Change (MoEFCC) dated 17.06.2005 and Central Pollution Control Board (CPCB) Guidelines for Water Quality Monitoring dated 28.12.2007 (Annexure G). For Fecal Coliform; the procedure for estimation of Total Most Probable Number (MPN) & Fecal Coliform - 9221 is being followed as given in the Standard Methods for Examination of Water and Wastewater (Annexure H). As per the test procedure if no test tube is positive then MPN index is <1.8 MPN/100ml and accordingly as per the direction, the values are now reported as <1.8 MPN/100ml.

ii. All the STPs have been upgraded for meeting with the latest norms as directed by Hon'ble NGT dated 30.04.2019 in the matter of O.A. No. 1069/2018 (Annexure I). All the treated water is of tertiary level and disinfection is carried out through Gas chlorination. Presently approx. 45 MLD treated water is being used in gardening and other purposes.

iii. For utilizing Tertiary Treated (TT) water, distribution lines of 165 km are being laid including in industrial areas so that TT water can be used upto maximum possible extent. The distribution network for TT water is being expanded to cover additional parks, gardens, and green belts. This enhancement also includes schools, colleges, community centers, government offices, and residential properties of one kanal (4,500 sq. ft.) or larger, as well as roundabouts and road berms. New user connections are being provided concurrently with the laying of pipeline. The work is likely to be completed by 30.06.2026. After the completion of work approx. utilization of tertiary water will be 90 MLD.

Director Environment
Chandigarh Administration

14.

iv. The STP Diggian of 135 MLD handling the sewage of Chandigarh is located in Punjab. The STP got Consent to Operate (CTO) earlier. However, the case of renewal is pending with the Punjab Pollution Control Board (PPCB). The consent is expected to be granted soon. The performance of the STP is evidenced by the test reports provided at Annexure J.

4. Ring Fenced Account

4.1 Observation: *"4[C][I]. We have noted that the balanced ring-fenced amount will be utilized for works in hand, like bioremediation of legacy waste, installation of modular STPs, installation of treated water distribution system, etc. It was conveyed during the proceedings that details on ring fenced expenditure along with the response the queries raised will be filed separately."*

Response/Status:

i. The balance amount is being utilized strictly as per the earlier directions of the Hon'ble NGT (dated 12.12.2024) i.e. for the left out activities viz. installation of STP at Faidan village, installation of new leachate treatment plant at landfill site, laying of Tertiary Treated water distribution network etc. The remaining amount will be utilized for further left out activities and restoration measures in the field of Solid Waste Management and Liquid Waste Management as and when required. The ring-fenced account details showing expenditure incurred and plan for utilizing remaining amount are provided in table 6 of Annexure B.

Director Environment
Chandigarh Administration

ANNEXURE - A

15.

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL,

PRINCIPAL BENCH, NEW DELHI

ORIGINAL APPLICATION NO. 606 OF 2018

IN THE MATTER OF:-

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THROUGH

(SHUBHAM BHALLA)
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PLACE: NEW DELHI
DATE: . .2025

16.

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL, PRINCIPAL BENCH, NEW DELHI

ORIGINAL APPLICATION NO. 606 OF 2018

IN THE MATTER OF :-

COMPLIANCE OF MUNICIPAL SOLID WASTE MANAGEMENT RULES, 2016 AND OTHER ENVIRONMENTAL ISSUES

SUPPLEMENTARY AFFIDAVIT ON BEHALF OF UT CHANDIGARH

I, Saurabh Kumar, IFS, Director, Department of Environment, Paryavaran Bhawan, Madhya Marg, Sector 19-B, UT Chandigarh, am duly authorized to file the present affidavit on behalf of the Worthy Chief Secretary. In my official capacity, I am well conversant with the facts of the case and competent to affirm this affidavit on behalf of Respondent UT Chandigarh:

That I am the Director, Department of Environment, UT Chandigarh Administration, am filing this affidavit in the light of queries raised by this Hon'ble Tribunal on the last date of hearing dated 19.09.2025

2. That the submission on the specific queries raised on last date of hearing 19.09.2025 are as under :

GOVT. OF INDIA NOTARY DALIP KUMAR CHANDIGARH Regd. No. 5604 Expiry dt. 25-3-2028

Director
Department of Environment
Chandigarh Administration

(A) Storm Water Drains:

(a) UT Chandigarh has separate systems for storm water drainage and sewerage. The Storm water drains connect to Sukhna Choe, N-Choe, and Patiala ki Rao Choe.

(b) No sewage is discharged into storm water drains.

(c) That currently, all 08 STPs are operational and compliant with standards, ensuring no untreated wastewater enters drains.

(d) In case of sewer line breakage, immediate repairs are undertaken.

(B) Dumping of Inert at Landfill Site:

That only Inert are disposed of in sanitary landfill site, in line with SWM Rules and the inert only account around 7% of the entire MSW.

Actual Utilization of STPs

Location	Capacity (MLD)	Avg. Utilization (MLD)
Dadumajra	135	129.6
3 BRD	50	46.4
Maloya	22.5	18.0
Dhanas	7.5	4.2
Raipur Kalan - I	22.5	21.5

Director
Department of Environment
Chandigarh Administration

18.

Raipur Khurd	9.0	8.2
Raipur Kalan - II	5.0	0.9
Kishangarh	2.0	1.2
TOTAL	**253.5**	**230.0**

4. Landfill Site: -

(a) The dumping ground is spread over 45 acres.

(b) Out of the total 45 acres, 20 acres which was previously used for waste dumping has now been cleared. 5 lakh metric tons (LMT) of legacy waste from this area has already been bio-remediated.

(c) That on a part of this 20 acres reclaimed land a 300 TPD wet waste processing plant and mixed waste processing plant has been set up.

(d) Out of the remaining 25 acres, 16.72 acres have been capped and covered. The balance 8.28 acres was utilized as a sanitary landfill site for waste dumping. Approximately 8 lakh metric tons (LMT) of legacy waste from this 8.28-acre area has already been bio-remediated. While a majority of the site has been cleaned, around 55,000 metric tons (MT) of unprocessed waste accumulated during the installation of the mixed waste processing plant and due to other technical challenges. This residual waste is currently

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Director
Department of Environment
Chandigarh Administration

being bio-remediated on priority and is expected to be fully cleared by November 2025.

(e) During the bioremediation of the 8.28-acre sanitary landfill site considering the ongoing daily dumping of inert waste, a new sanitary landfill site measuring 7.41 acres was developed within the 16.72 acres of land that had been previously capped and covered. This 7.41 acres site is currently being used for dumping of inert material.

(f) A total of 13 lakh metric tons (LMT) of legacy waste has been completely bio-remediated, and currently, all municipal waste is being processed on a daily basis.

5. RDF (Refuse Derived Fuel) Sale :

(a) That Municipal Corporation, Chandigarh has given contract to different companies/agencies for bio-mining of legacy waste, who in turn generate the RDF and sell it to the companies with whom they wish to contract.

(b) The sale of RDF is within the scope of agencies engaged by Municipal Corporation, Chandigarh for bio-mining of Legacy waste. During the period January to August, 2025 a sale of RDF worth Rs.70 Lakhs has been reported by the respective engaged agencies.

GOVT. OF INDIA NOTARY DALIP KUMAR CHANDIGARH Regd. No. 5604 Expiry dt. 25-3-2028

Director
Department of Environment
Chandigarh Administration.

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6. That the contents of the affidavit and the status report are based on the record made available to the Deponent and are true to the knowledge of the Deponent.

DEPONENT
Director
Department of Environment
Chandigarh Administration

VERIFICATION:

I, Saurabh Kumar, IFS the deponent above named do hereby verify and declare that the facts stated in the above paras are true to my knowledge.

Verified at on this day of September, 2025.

DEPONENT
Director
Department of Environment
Chandigarh Administration

Attested as identified
25 SEP 2025
NOTARY CHANDIGARH

NOTARY GOVT. OF INDIA
DALIP KUMAR
CHANDIGARH
Regd. No. 5604
Expiry dt. 25-3-2028

Certified that the Affidavit of A/GHA. R& was read over & Explained to the Deponent / Executant who understand the

ANNEXURE B

21.

Table 1. Solid Waste Management

1) Name of ULB	2) *Waste Generation (TPD)	3) Composition of Waste					4) Waste Collected	5) Waste Transported	6) Final Destination of transported waste
		Biodegradable	Dry/ Recyclable	Dry/Non Recyclable	Mixed Waste	Inerts			
MCC	**500**	286	8	109	70	27	500	500	**Non Recyclable Dry waste** - Dry Waste Processing Plant (RDF) **Biodegradable Waste** – Land Composting (horticulture waste) and Wet Waste Processing Plant **Mandi Waste** – Biomethanation plant

* based on an average of 6 months
Inerts : Wet Waste 17 TPD, Dry Waste 02 TPD, Mixed Waste 8 TPD

7) Waste Processing					
A) Composting					
Intake quantity	Method adopted	Output quantity as Compost	Quality	Residue and Rejects and Management	Utilization of compost
190 TPD wet waste	Windrow Composting	7 TPD	Test results are attached as Annexure C	17 TPD Inerts disposed in Sanitary Landfill	Disposal at the level of concessionaire and used by nearby farmers

Nodal SWM.
MC Chd

Nodal LWM
MC Chd

96 TPD horticulture waste	Land Composting	10 TPD	Test results are attached as Annexure D	-	In Municipal Corporation Green Belts and Parks.

7) Waste Processing				
B) Refuse Derived Fuel				
Capacity of Plant	Sources of waste for making RDF	RDF Produced	Residue / Reject management	Utilization of RDF
200 TPD	109 TPD Dry waste from Households and markets	82 TPD	2 TPD Inerts disposed in Sanitary Landfill	Disposal at the level of concessionaire and used as alternate fuel at Paper Industry ie; Galaxy Papers Private Limited, Muzafarnagar (UP) M/s Tirupatibaalaji Fibers Pvt Ltd, Muzzafarnagar (UP), Krishnanchal Pulp & Paper Pvt Ltd, Muzzafarnagar '(UP)Cement Factory -Ambuja Cement Ltd Darlaghat H.P.

7) Waste Processing					
C)Waste to Energy (Methanation route)					
Plant capacity	Daily inputs of feed	Sources of waste	Output (Energy)	Residue / Rejects Management	Fly ash and Bottom Ash management
5 TPD Bio-methanation Plant	1 TPD	Mandi Waste	3.51 kWh electricity	0.018 Rejects – Mixed waste plant Residues/inerts – Sanitary landfill	NIL

Nodal SWM.
MC Chd

Nodal LWM
MC Chd

Gap in Waste generation and Processing	Time bound plan to fill up the Gap
Nil	NA

Nodal SWM.
MC Chd

Nodal LWM
MC Chd

Table 2. Legacy Waste details

Number of legacy waste dump sites	Quantity of legacy waste reported on 19.09.2025	Present quantity of legacy waste	Daily legacy waste being added as unprocessed waste	Quantification and utilization of out of Bioremediation and bio mining				Gap in legacy waste remediation and time bound plan
				Digested material	Plastics	Rubber	Inerts and others	
01	55000 MT beside Mixed waste processing plant	6100 MT	Nil	40270 MT	6696 MT (RDF)	-	1934 MT	The bioremediation work is in progress and will be completed by end of April 2026
				The biosoil is disposed at the level of concessionaire & generated is used to fill low lying areas in sector 47, 50 and Mullanpur Punjab	The RDF produced is disposed at the level of concessionaire & used as an alternate fuel in Maruti Papers(P) Ltd. Shamli (U.P.), Nikita Papers Ltd. Shamli (UP), Garg Duplex Papers Mills Pvt.Ltd. Muzzafarnagar UP etc	-	The inerts are disposed in Sanitary Landfill	

Nodal SWM.
MC Chd

Nodal LWM
MC Chd

25.

Table 3. Sewage Generation

Name of ULB	Sewage Status Estimation and Measurement	Sewage Conveyance / sewers		
	Total Sewage Generation per day	Targeted Household to be connected to sewers	House-holds connected	Time targets to complete connectivity (gap in connectivity)
Municipal Corporation Chandigarh (MCC)	Approx. 232 MLD	241171	241171	100% Achieved

Table 4. Sewage treatment and Utilisation

Installed treatment capacity of existing STPs (MLD)	Utilisation capacity of existing STPs (MLD)	Gap in sewage generation and treatment (MLD)	Time bound plan to set up and operationalize STPs	Performance of STPs with reference to Standards	Final point of discharge of treated effluent	Level of Utilisation of Treated sewage	Sludge generation and its management
253.5	230.62 MLD	Approx. 1-2 MLD is generated from the Faidan village which is a private land and is situated on the boundary of Chandigarh and Punjab and 02 modular STPs were proposed out of which one STP of 750 KLD has been made operational	One of the two modular STP for Faidan Village, Chd is already operational and second STP will be operational by 30.05.2026.	All 08 STPs are meeting with the prescribed standards except for some instances. Test results are attached as Annexure J.	Sukhna Choe and Patiala ki Rao choe	For utilizing Tertiary Treated (TT) water, distribution lines are being laid all over the city for maximum usage. Further ensured that water requirement for roadside vegetation and dust mitigation measures is met through TT water only. Presently 45 MLD of Tertiary Treated Water is being usedfor irrigating Lawns	58 MT Class A sludge is generated.

Nodal SWM.
MC Chd

Nodal LWM
MC Chd

		and the other STP of same capacity is in progress				Green Belts of Chandigarh. Additional 45 MLD will be available afterlaying of TT water distribution lines in the peripheral areas of Chandigarh including Industrial Areas.	

Table 5. Status of Drains

Sewage and Sullage flowing in open drains (Storm water drains / concretised drains / unlined / katcha drains) (No. of drains)	Flow in each drain (MLD)	Quality / Characteristics of effluent	Quantity of industrial effluent discharged in drain (MLD)	Final point of discharge of drain	Time bound action plan to prevent sewage discharge into drain
04 drains Sukhna choe, N – choe, Patiala ki rao choe and Faidan choe	The entire sewerage network is connected with STPs and there is no discharge of untreated waste water in choes except for Faidan choe.	Test results are attached as Annexure K.	NIL No industry is allowed to operate without proper effluent treatment plant	Patiala Ki Rao choe enters Chandigarh from Punjab and subsequently flows back into Punjab territory. Sukhna Choe originates within Chandigarh and flows into river Ghaggar. Both Faidan Choe and N-Choe originate in Chandigarh. The Faidan Choe merges with the N-Choe, which eventually	Approx. 1-2 MLD flowing into Faidan choe for which remedial measures are underway. This is generated from Faidan village which is situated on the boundary of Chandigarh and Punjab. To address this, two modular STPs (750 KLD capacity each) were proposed. One of the STPs is currently operational and the second will be operational by 30.05.2026.

Nodal SWM.
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				flows into river Ghaggar.	

Nodal SWM.
MC Chd

Nodal LWM
MC Chd

Table 6 . Ring Fence Account details

1) Amount to be ring fenced	2) Whether single dedicated account has been opened	3) Date of opening account	4) Amount utilized	5) Plan of utilization
In compliance with the Hon'ble NGT's order dated 18.05.2023, regarding the ring-fencing of Rs. 282 Cr., the Chandigarh Administration has incurred expenditure of Rs. 189.07 Cr. toward solid and liquid waste management and restoration efforts. The residual amount of Rs. 92.93 Cr. was kept in the ring-fenced account, strictly designated for left out activities and restoration measures.	Yes	04.11.2024	Rs 202.86 Cr.	For SWM activities – Installation of LTP at Dumping Ground, Installation of ETP Maloya.

Nodal SWM.
MC Chd

Nodal LWM
MC Chd

ANNEXURE - C

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29.

Centre for Environment and Food Technology Pvt. Ltd.

An ISO 9001; 2015, ISO 45001; 2018 (OHSAS); ISO/IEC 17025; 2017
NABL Accredited, FSSAI and MoEF/CPCB Recognised Testing Laboratory

TEST REPORT

ISSUED: M/s 300 TPD WET WASTE PROCESSING PLANT,
DADU MAJRA DUMP SITE, MC, CHANDIGARH.

Report No.	**CEFT|2601|105**	**Report Date**	**29.01.2026**
Your Ref. No.	**Nil**	**Type of sample**	**Compost Sample**
Sample Code given by customer	**Nil**	**Quantity**	**2 Kg**
		Date of sampling	**22.01.2026**
Sampling Location	**Compost Plant**	**Date of sample receipt**	**23.01.2026**
Sample Collected By	**Associate Lab person**	**Sample I.D.**	**CEFT|GEN|2601|105**
Sampling procedure	**As per SOP**	**Date of test**	**23.01.2026 to 29.01.2026**

Sr. No.	PARAMETERS	RESULT	Requirement as per FCO 1985-Schedule-VI, Part-A	TEST METHODS
1.	pH (1:2.5) at 25°C	7.31	6.5-7.55	IS 2720 (Part 26)
2.	Cadmium as Cd, mg/kg	4.1	5	USEPA
3.	Chromium as Cr, mg/kg	21.3	50	USEPA
4.	C/N Ratio	18.1	<20	USEPA
5.	Nickel as Ni, mg/kg	19.5	50	USEPA
6.	Copper as Cu, mg/kg	204	300	USEPA
7.	Zinc as Zn, mg/kg	232	1000	USEPA
8.	Arsenic as As, mg/kg	ND	10	USEPA
9.	Mercury as Hg, mg/kg	ND	0.15	USEPA
10.	Lead as Pb, mg/kg	39.8	100	USEPA

End of Report

Authorised Signatory

Note : 1. The test results are related to the sample/ tested as identified.
2. The sample will be discarded after retention time of 7 days unless otherwise specified.
3. Any Discrepancy found in the test report may be communicated within seven days.
4. This report shall not be reproduced, cannot be used as evidence in the court of law and should not be used in any advertising media without written permission of CEO, CEFT Pvt. Ltd.
5. The Court Jurisdiction will be Delhi.
6. Customer complaint register is available at the laboratory.

Regd. Address - Bldg. No. 17, 1st & 2nd Floor, DLF Industrial Area, Moti Nagar, New Delhi - 110015
Ph.: - 011-45012722, Email: info@ceftlab.com, Website : www.ceftlab.in

VISIT OUR WEBSITE-SCAN HERE
WWW.CEFTLAB.IN

ANNEXURE - D

Punjab Biotechnology Incubator

1484

30.

Department of Science, Technology & Environment,
Govt. of Punjab

Notified State Analytical Agency

FSSAI Empanelled | EIC Approved | APEDA Approved | Notified State Water Lab - GoP | Notified Under EPA - GoI

No.PBTI/FA0/030326/007028 /4885 Dated : 18/3/26

TEST REPORT

Sample Registration No. : **PBTI/FA0/030326/007028**

Sample code given by customer : **Compost**

Issued to:

Sub Divisional Engineer,
Hor. Sub Div. No. 3, Municipal Corpn Committee Centre,
Near Govt. School, 2nd Floor, Sec-21,
Chandigarh,
U.T.

SAMPLE PARTICULARS

Your Ref. No.	:	Memo No. SDE(H)-3 MC 2026/66, dt. 03/03/2026
Date of Receipt	:	03/03/2026
Name/Nature of sample	:	**Compost**
Sample code given by customer	:	Compost
Condition of the sample	:	Intact coded sample under ambient condition
Brand name	:	NA
Qty/Pkg.	:	10kg approx packed in poly bag packing
Batch No.:	:	NA
Date of Manufacture :	:	NA/NM
Sampling Method	:	Sample not drawn by PBTI
Test Start Date	:	03/03/2026
Test Completion Date	:	18/03/2026

18/3/2026

Authorized Signatory
Punjab Biotechnology Incubator Lab
Employee Code : Employee Code: 16

Note:
1. The above results pertain only to the sample tested.
2. There is no addition, deviation or exclusion from the method mentioned.
3. The report shall not be used for advertising or any legal purpose without written permission from the Chief Executive Officer, Punjab Biotechnology Incubator.
4. This report cannot be re-produced, except when in full, without the written permission from the Chief Executive Officer, Punjab Biotechnology Incubator.
5. Perishable samples will be destroyed after testing, others after one month from the date of issue of the report, unless otherwise agreed with the customer or as required by the applicable regulations.

Format No : PBTI/F/7.8/02
Issue No & Date : 02 & 03.10.23

31.

Dated :

Sample Registration No. : PBTI/FA0/030326/007028

Sample code given by customer : Compost

Test Results

S.No.	Parameter	Results	Units	Standard / Specification / Method Followed
1	Total Kjeldahl Nitrogen (TKN)	0.69	%	FCO 1985
2	Potassium (K2O)	0.25	%	FCO 1985
3	Lead (as Pb)	10.4	mg/kg	FCO 1985
4	Cadmium (as Cd)	BDL(MDL 0.5)	mg/kg	FCO 1985
5	Chromium (as Cr)	18.9	mg/kg	FCO 1985
6	Nickel (as Ni)	14.3	mg/kg	FCO 1985
7	Total Phosphate	0.13	%	FCO 1985

BDL:Below Detection Limit MDL:Method Detection Limit

18/3/2026

Authorized Signatory

Punjab Biotechnology Incubator Lab

Employee Code : Employee Code: 16

IEC and Enforcement Measures for Effective Waste Segregation by Municipal Corporation Chandigarh

Municipal Corporation Chandigarh conduct regular IEC activity to sensitize the general public on the importance of segregating waste into four categories i.e., wet, dry, sanitary and domestic hazardous waste in order to achieve 100% source segregation within Chandigarh. The awareness drives are conducted by the field supervisory staff in their respective areas along with the sanitation staff/ door-to-door garbage collectors. Apart from this regular challaning drives are also conducted against the violators not segregating the waste. Pamphlets regarding source segregation are also distributed from time to time for mass engagement and sensitization of general public.

For last three months challans related to segregation is as follows:

- January 1076
- February 823
- March 970

IEC awareness activities conducted at different locations in Chandigarh is as below:

1. **Har Ghar Har Dawar, Swachhta Ki Dastak** – To create awareness among the citizens of the city regarding waste segregation, a drive titled *"Har Ghar Har Dawar Swachhta Ki Dastak"* has been initiated under the leadership of the Hon'ble Mayor from Ward No. 12 and is being carried out across the entire city.

Mayor rolls out citizen-led waste management, cleanliness drive

Residents urged to adopt home composting, stick to waste segregation

Tribune News Service

स्वच्छता की दस्तक

Chandigarh Mayor Sarabjit Joshi distributes pamphlets as part of Har Ghar, Har Dawar Swachhta Ki Dastak' in on Monday.

स्वच्छता की दस्तक

Nodal SWM
MC Chd

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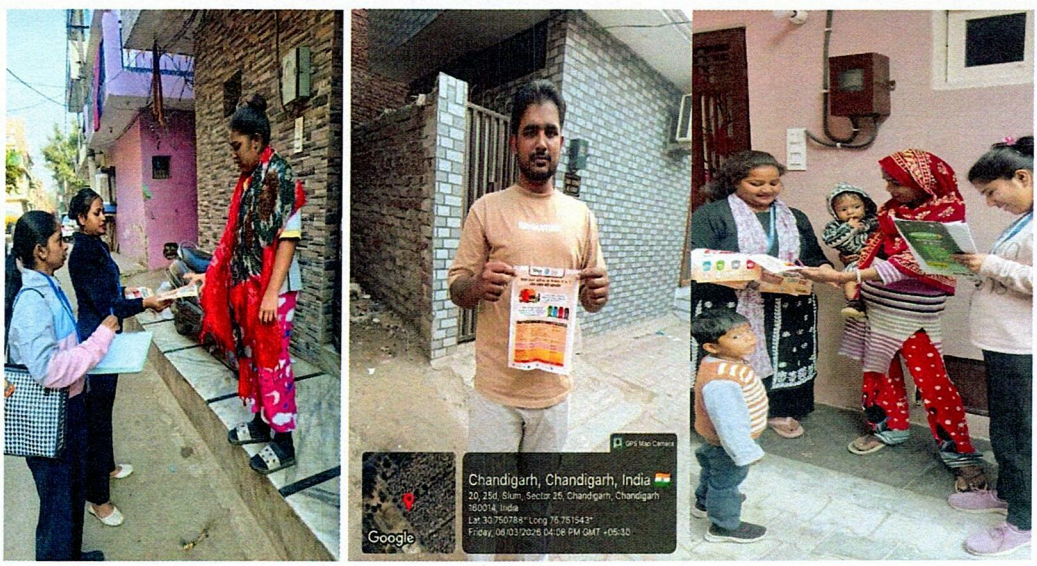
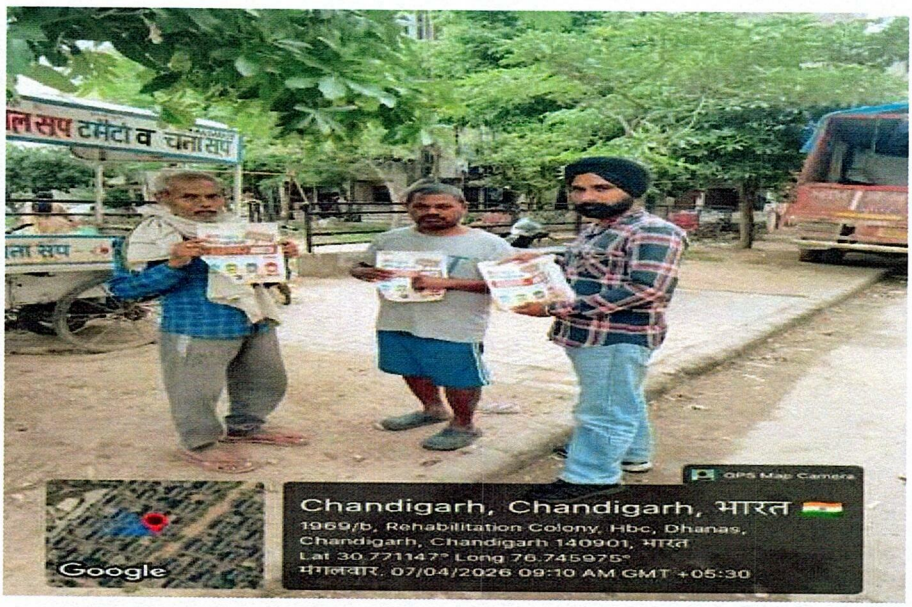
2. **IEC activity in Sector 41-** IEC carried out in Sector 41 to create awareness among residents regarding the segregation of waste into four categories.

3. **Sector 25-** A special drive was carried out in Sector 25 to identify residents who were not handing over waste to the waste collectors and to create awareness regarding proper waste collection and segregation, with the help of Self Help Groups (SHGs).

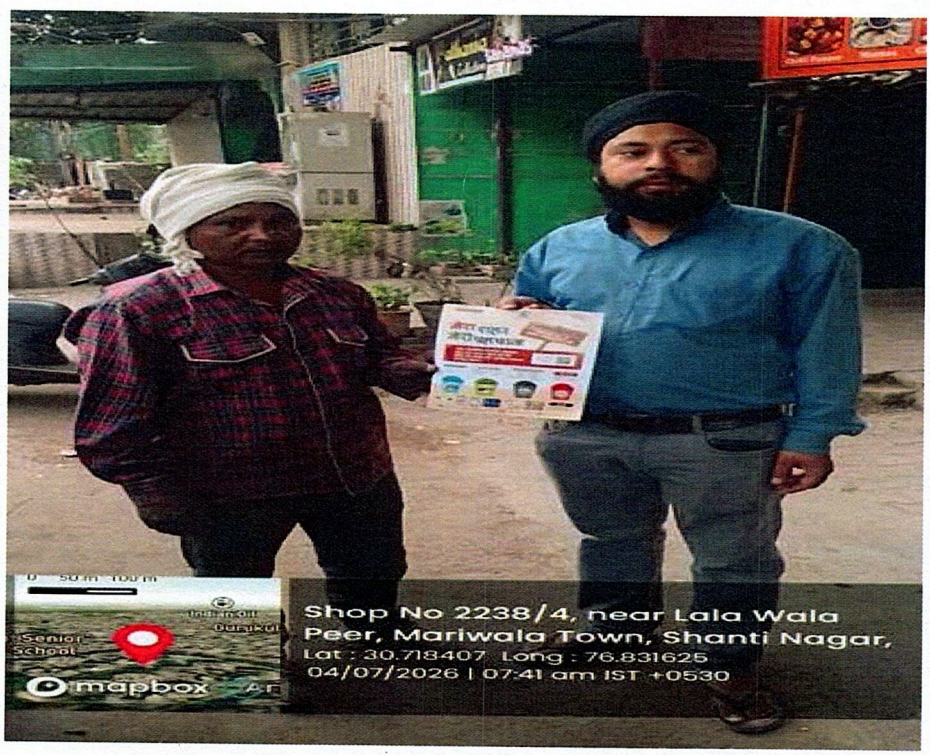


Nodal SWM
MC Chd

4. **EWS colony, Dhanas-** During door-to-door pamphlets distribution and awareness regarding segregation in EWS colony, Dhanas.



5. **Manimajra-** During door-to-door pamphlets distribution and awareness regarding segregation in Manimajra.



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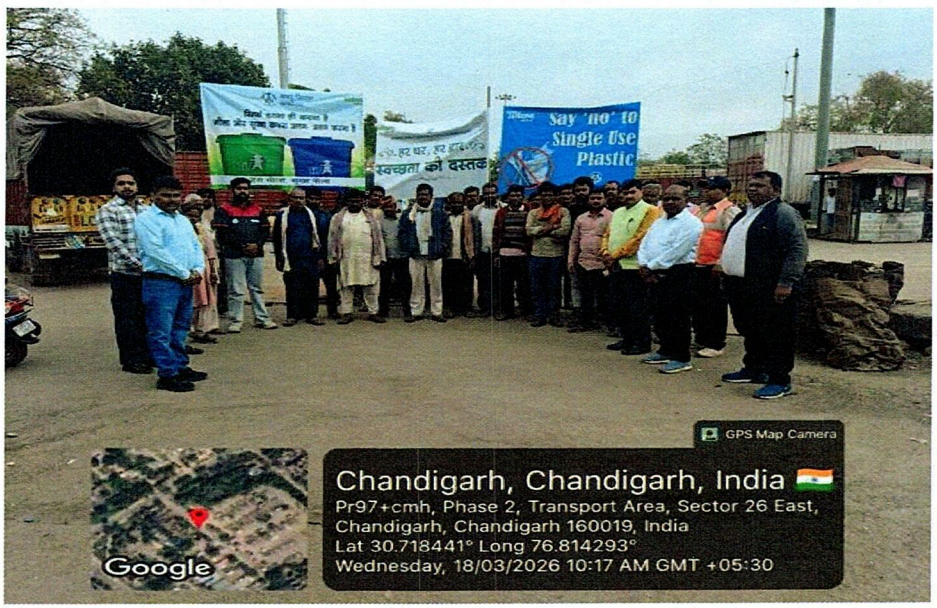
6. **Sector 26 Transport area-** During awareness regarding segregation in Sector 26 Transport area.



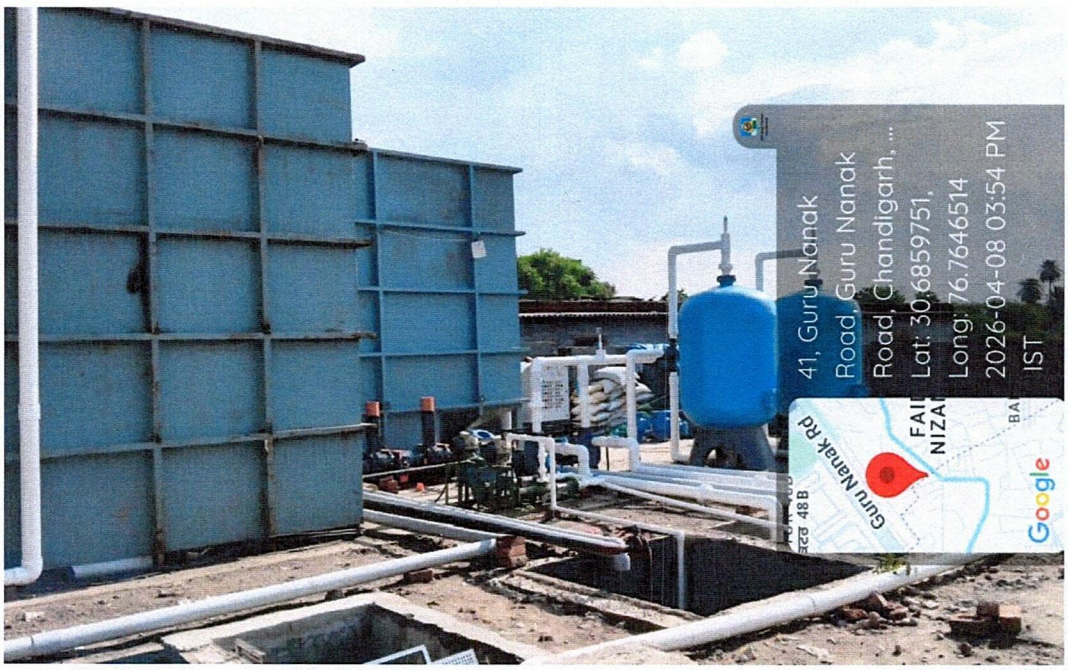
7. **Hallomajra-** During door-to-door pamphlets distribution and awareness regarding segregation in Hallomajra.

Nodal SWM
MC Chd

ANNEXURE - A

36.

1st Modular STP of 750 KLD Operational In Faidan Village



ANNEXURE-9
37.

MINARS/27/2007-08

Guidelines for Water Quality Monitoring

Central Pollution Control Board
Parivesh Bhawan
East Arjun Nagar, Delhi-32

38.

केन्द्रीय प्रदूषण नियंत्रण बोर्ड
(भारत सरकार का संगठन)
पर्यावरण एवं वन मंत्रालय
Central Pollution Control Board
(A Govt. of India Organisation)
Ministry of Environment & Forests
Phone : 22304948 / 22307233

ज. मो. माऊसकर, भा.प्र.से.
अध्यक्ष
J. M. MAUSKAR, IAS
Chairman

Foreword

For drawing up and implementing any water quality management plan, water quality monitoring is essential in identification of water bodies or their part(s) in need of restoration and also nature and magnitude of pollution control required. It also helps in prioritization of pollution control efforts and evaluating trends and effectiveness of such efforts.

Since there are a number of agencies involved in water quality monitoring, in order to optimize and rationalize the monitoring programme, it is important that all these agencies follow the same monitoring protocol. Water Quality Assessment Authority (WQAA) created under Environment (Protection) Act, 1986 has notified a "Protocol for Water Quality Monitoring". In order to effectively implement this Protocol, water quality monitoring Guidelines are necessary. The present Document is an attempt to fulfill this need. The Document brings out major considerations to design water quality monitoring network, procedures for sampling, laboratory analysis, data storage, data analysis, presentation, interpretation, reporting and quality assurance. I hope this Document will be useful to all involved in water quality monitoring.

28/12/2007

(J.M. Mauskar)

'Parivesh Bhawan' C.B.D. - cum-Office Complex, East Arjun Nagar, Delhi-110 032
Fax : 22304948 / 22307078 email : cpcb@alpha.nic.in
Website : http://www.cpcb.nic.in

Contents

40.

1. Introduction

Water is one of the most important and basic natural resources. Water is not only one of the most essential commodities of our day-to-day life, but the development of this natural resource also plays a crucial role in economic and social development processes. While the total amount of water available in the world is constant and is generally said to be adequate to meet all the demands of mankind, its quality and distribution over different regions of the world is uneven and causes problems of scarcity and suitability. It is therefore imperative that man develops, uses and manages this scarce commodity as rationally and efficiently as possible. In order to execute this task, accurate and adequate information must be available about the quality of the this natural resource under constantly changing human pressures and natural forces.

Water quality management is for a great deal controlled by authorization of discharges of dangerous substances for which monitoring of discharges, effluents and influenced surface water is essential. On national and state levels, we have several policies and regulation like Water (Prevention and Control of Pollution) Act, 1974 to regulate pollution discharges and restore water quality of our aquatic resources including the prescription of monitoring activities (Box-1,2 and 3). Under Water Act, 1974, pollution control boards were created, who are responsible for implementation of its provisions. One of the important provision of the Water Act, 1974 is to maintain and restore the 'wholesomeness' of our aquatic resources. To define the level of 'wholesomeness to be maintained or restored a system of water use classification was developed. Under this system water uses are classified in 5 classes (Box-4). If a water body or its part is used for multipurpose, then the use which

Box 1: 'Protection of Environment' Provisions in India's Constitution

The Forty Second Amendment to the Constitution in 1976 underscored the importance of 'green thinking'. Article 48A enjoins the state to protect and improve the environment and safeguard the forests and wildlife in the country. Further, Article 51A(g) states that the "fundamental duty of every citizen is to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

Box 2: Policy Documents on Natural Resource Conservation

Policy Statement for Abatement of Pollution (1992) has suggested developing relevant legislation and regulation, fiscal incentives, voluntary agreements and educational programs and information campaigns. It emphasizes the need for integration by incorporating environmental considerations into decision making at all levels by adopting frameworks namely, pollution prevention at source, application of best practicable solution, ensure polluter pays for control of pollution, focus on heavily polluted areas and river stretches and involve public in decision-making.

The National Conservation Strategy and Policy Statement on Environment and Development, 1992 aimed at "integrating environmental concerns with developmental imperatives.... [to] meet the challenges....by redirecting the thrust of our developmental process so that the basic needs of our people could be fulfilled by making judicious and sustainable use of natural resources." The priorities mentioned in this policy document include the sustainable use of land and water resources, prevention and control of pollution and preservation of biodiversity.

The National Water Policy, 2002 contains provisions for developing, conserving, sustainable utilizing and managing this important water resources and need to be governed by national perspectives. Concern due to water logging, ingress of soil salinity and over–exploitation of groundwater will be addressed on the basis of common policies and strategies. The policy includes improvements in existing strategies, innovation of new techniques to eliminate the pollution of surface and groundwater resources to improve water quality. It has emphasized on water resource planning, development of institutional mechanism, water allocation, groundwater development and participatory approach to water resource management. Regular water quality monitoring programme for both surface and groundwater will be undertaken with particular emphasis on pollution control at source.

demands highest quality of water is designated as 'designated best use' and accordingly water body or its part is designated. Now through regular water quality monitoring existing water quality is assessed and compared with the desired quality as identified under designated best use class and gaps are identified. Based on the identified gaps the water body or its part is identified as polluted.

Water quality monitoring is one of the first steps required in the rational development and management of water resources. In the field of water quality management, there has been a steady evolution in procedures for designing system to obtain information on the changes of water quality. The 'monitoring' comprise all activities to obtain 'information' with respect to the water system.

Water quality monitoring is a complex subject, and the scope of it is both deep and wide. Water quality monitoring has a direct relation with chemistry, biology, statistics and also economics. Its scope is also related to the types of water uses and functions which are manifold and the nature of the sources of water such as surface water (rivers and lakes), sea water groundwater.

Box 3: Indian Laws and Regulation on Water Quality Management

The conservation of water resources expressed in the Constitution is embodied in the following regulations:

The Water (Prevention & Control of Pollution) Act, 1974 as amended deals comprehensively with water issues. It empowers the Government to constitute Pollution Control Boards to maintain the wholesomeness of national water bodies. It enables Central and State Pollution Control Boards to prescribe standards and has provisions for monitoring & compliance and penal provisions against the violators of the Act. It provides the permit system i.e. **"Consent"** procedure to prevent and control of water pollution. The Act empowers State Boards to issue directions to the defaulters.

Water Cess Act, 1977 was adopted to strengthen the Pollution control Boards financially, to promote water conservation. This Act empowers the Central Government to impose a **Cess** on water abstracted from natural resources by industries and local authorities.

Environment (Protection) Act, 1986 has a broad coverage in which 'Environment' includes **water**, air and land and there exists an interrelationship among water, air, land, human beings and other creatures. It empowers to take measures in protecting and improving the quality of the environment through preventing, controlling and abating environmental pollution. The Government is authorized to set national standards for ambient environmental quality and controlling discharges to regulate industrial locations, to prescribe procedure for hazardous substance management and to collect and disseminate information regarding environmental pollution. The Act provides for severe penalties for those who fail to comply with or contravenes any provision of the Act.

The Manufacture, Storage, Import of Hazardous Chemicals Rules, 1989 and its amendments under EPA, 1986 has identified the responsibilities of various stakeholders for management of chemicals and containment of spillage.

The Hazardous Wastes (Management and Handling) Rules, 1989 and its subsequent Amendment 2000 were created to provide 'cradle-to grave' or comprehensive guidance to the generators, transporters and operators of disposal facilities among others, and monitoring norms for State governments.

The Municipal Wastes (Management & Handling) Rules,1999 fix responsibilities to every municipalities responsible for the collection ,segregation, storage, transportation and disposal of municipal wastes. **The Bio-medical waste (Management & Handling) Rules, 1998** are likewise directed at institutions that generate and bio-medical wastes in any form.

The Central Pollution Control Board (CPCB) is an apex body in the field of water quality management in India. For rational planning of any water quality management programme, CPCB needs to know the nature and extent of water quality degradation. Therefore, a sound scientific water quality monitoring programme is prerequisite. Realising this fact, water quality monitoring was started in 1976 by CPCB with 18 stations on the Yamuna river. The programme was gradually extended. Today, there are 1032 monitoring stations in the country spread over all important water bodies.

2. Water Quality

Water quality is a complex subject, which involves physical, chemical, hydrological and biological characteristics of water and their complex and delicate relations. From the user's point of view, the term "water quality" is defined as "those physical, chemical or biological characteristics of water by which the user evaluates the acceptability of water". For example for drinking water should be pure, wholesome, and potable. Similarly, for irrigation dissolved solids and toxicants are important, for outdoor bathing pathogens are important and water quality is controlled accordingly. Textiles, paper, brewing, and dozens of other industries using water, have their specific water quality needs.

Box 4: Designated Best Use Classification of Surface water

Designated best use	Quality Class	Primary Water Quality Criteria
Drinking water source without conventional treatment but with chlorination	A	➢ Total coliform organisms (MPN*/100 ml) shall be 50 or less ➢ pH between 6.5 and 8.5 ➢ Dissolved Oxygen 6 mg/l or more, and ➢ Biochemical Oxygen Demand 2 mg/l or less
Outdoor bathing (organized)	B	➢ Total coliform organisms(MPN/100 ml) shall be 500 or less ➢ pH between 6.5 and 8.5 ➢ Dissolved Oxygen 5 mg/l or more, and ➢ Biochemical Oxygen Demand 3 mg/l or less
Drinking water source with conventional treatment	C	➢ Total coliform organisms(MPN/100 ml) shall be 5000 or less ➢ pH between 6 and 9 ➢ Dissolved Oxygen 4 mg/l or more, and ➢ Biochemical Oxygen Demand 3 mg/l or less
Propagation of wildlife and fisheries	D	➢ pH between 6.5 and 8.5 ➢ Dissolved Oxygen 4 mg/l or more, and ➢ Free ammonia (as N) 1.2 mg/l or less
Irrigation, industrial cooling, and controlled disposal	E	➢ pH between 6.0 and 8.5 ➢ Electrical conductivity less than 2250 micro mhos/cm, ➢ Sodium Aborption Ratio less than 26, and Boron less than 2 mg/l.

*** MPN: Most Probable Number**
(Source: CPCB, 1978)

3. What is monitoring ?

Webster's dictionary defines monitoring as **(1)** to check and sometimes to adjust for quality or fidelity, **(2)** to watch, observe or check, especially for a special purpose, **(3)** to keep track of, regulate or control (as a process for the operation of a machine). Note that both (1) and (3) involve adjustment, regulation, or control, which fit well with the various types of monitoring information. A distiction can be made between different monitoring activities:

Survey: short term observation(s) on water quality (in present context) to fulfil definite objective(s);
Surveillance: a continued programme of surveys systematically undertaken to provide a series of observations in definite time period;
Monitoring: continuous surveillance undertaken to fulfil set of objectives.

4. Monitoring Strategy

Due to economic and practical considerations, monitoring network design, sampling frequencies, choice of variables and frequency of laboratory analysis should be determined on the basis of the information requirements, the hydraulic and hydrologic constraints, variability in water body characteristics, the end-use of water that drains to and from the

water body, the overall objectives of the monitoring programme, and finally of course on costs involved and budgets allocated to the programme. It is also important to optimise the amount of efforts required and information generated and its importance to fulfil the set objectives.

The scoping and designing step is the foundation of the entire water quality monitoring programme. The main objective of the design should be to minimise the cost of monitoring without sacrificing the desired information to the level of precision. Scoping and designing of water quality monitoring programme is based on clear scientific understanding of:

1. issues;
2. relevant background information;
3. monitoring objectives;
4. desired outcomes;
5. appropriate methods;
6. the dynamics and characteristics of water systems

Water quality monitoring involves 8 steps as explained below:

Step-1 Setting Water Quality Monitoring Objectives

↓

Step-2 Assessment of Resources Availability
- Laboratory facilities and competence
- Transport
- Manpower –adequate number and competence

↓

Step-3 Reconnaissance Survey
- Map of the area
- Background information
- Human activities
- Potential polluting sources
- Water abstractions and uses
- Hydrological information
- Water regulation

↓

Step-4 Network Design
- Selection of sampling locations
- Optimum number of locations
- Parameters to be measured
- Frequency of sampling
- Component to be samples – water, sediment or biota

↓

Step-5 Sampling
- Representative sampling
- Field testing
- Sample preservation and transport

↓

Step-6 Laboratory Work
- Laboratory procedures
- Physical, chemical analysis
- Microbiological and biological analysis

↓

Step-7 Data Management
- Storage
- Statistical analysis
- Presentation
- Interpretation
- Reporting

↓

Step-8 Quality Assurance
- Production of reliable data
- Quality control
- Internal AQC
- External AQC

For each of the above steps following guidelines are provided:

5. Step-1 Setting Water Quality Monitoring objectives

Before formulation of any water quality monitoring programme it is very important to have clear understanding on the monitoring objectives. Everybody of the programme team should be fully aware of the objectives, methodology, quality assurance, data validation and other aspects. Clearly environmental monitoring must have a purpose and a function in the process of risk assessment and pollution control. In risk management, monitoring is essential in the stage of problem recognition (indication of water quality deviations), the stage of analysis (with respect to the expected changes) and the stage of management (verification or control of strategy results).
A number of purposes for monitoring can be discerned:

- The **signal or alarm function** for the detection of suddenly occurring (adverse) changes in the environment. Preferably the monitoring system should be designed to immediately enable the tracing of causes;
- The **control function** to assess the general quality of water in relation to adopted water quality requirements or objectives, and for verification on the effectivity of pollution control strategies as well as a check on permitted effluent quality compliance;
- The **trend (recognition) function** based on time series analysis to enable the prediction of future developments;
- The **instrument function** to help in the recognition and clarification of underlying processes.

Water quality monitoring is carried out for various reasons and the objectives of a particular monitoring programme have a direct bearing on the costs of carrying out the programme.

The most important objectives of water and effluent quality monitoring programmes kept in mind by CPCB/SPCBs/PCCs include:

- rational planning of pollution control strategies;
- to identify nature and magnitude of pollution control required;
- to evaluate effectiveness of pollution control efforts already in existence;
- identification of state and trends in water quality, both in terms of concentrations and effects;
- identification of the mass flow of contaminants in surface water and effluents;
- formulation of standards and permit requirements;
- testing of compliance with standards and classifications for waters and effluents;
- early warning and detection of pollution.

In practise, data from routine monitoring programmes are generally used for a variety of purposes in addition to those for which the programmes were designed. Identification of the state and trends in water quality is mainly important for policy and management, while the identification of the mass flow in rivers and waste water discharges is of particular importance at the boundaries between states countries, districts or water systems. Mass flows are subject of international, national or state disputes, negotiations are an input for mass balances for specific substances. Testing of compliance with standards (control) is related to the water quality objectives for surface water as prescribed in both national and international standards. The early warning monitoring programme to signal pollution due to (accidental) spills by industry and ships is especially important if surface water of that particular river or water system is used for public water supply. Finally, data will be used for various projects including research.

Water quality monitoring is an important aspect of overall water quality management and water resources development. A well planned and well managed water quality monitoring system is required to **signal, control** or **predict** changes or trends of changes in the quality of a particular water body, so that curative or preventive measures can be taken to restore and maintain ecological balance in the water body. Monitoring is essential for the successful implementation of environmental legislation: to ensure that standards and criteria set by CPCB/SPCBs/PCCs are maintained on a continuing basis.

6. Step-2 Assessment Resources Availability

Once the monitoring objectives are known, it is important to look into the availability of resources for monitoring. Generally a compromise is made between quality and quantity of data required to fulfil certain objective(s) and resources available. Before planning water quality monitoring programme it is important to ensure that following resources are available:

a. Sampling equipment (as per checklist)
b. Transport for sampling
c. Laboratory facilities
d. Trained Manpower adequate number and competence
e. Equipment/instruments for desired parameters analysis
f. Chemicals/glasswares and other gadgets for analysis of desired parameters

46.

g. Funds for operation and maintenance of laboratory

7. Step-3: Reconnaissance Survey

Most water quality monitoring programs have the objective of defining pollution, and relating it to its sources. After this the reductions in discharges, which are necessary to remedy the problem, can be determined. A few days spent reviewing all available reports and records concerning the water quality of all waste discharges and of the receiving water body may save several days of field work and may prevent the collection of useless data. It is important to make a reconnaissance survey of the river during the planning stage, noting all sources of wastes, all entering tributaries that might contribute a potential pollutant, and all uses and abstractions of the water. This action will also include a survey of background information such as geography, topography, climate and weather, hydrology, hydrogeology, land use, urbanization, industrialization and agriculture, including farming in the riverbed. This information will help in an appropriate siting of sampling locations.

For groundwater quality monitoring network, it is important to conduct survey to identify potential sources of pollution. For groundwater pollution monitoring generally existing structures in the potentially polluted sites are selected. Since variation in groundwater quality is very high and unpredictable, it is practically not possible to cover assessment of groundwater quality of a particular area fully. It is also not practicable to create so many groundwater structures for sampling. Thus, a compromise has to be made between resources available and criticality of information required. It commonly agreed that groundwater quality is generally degraded in the urban, industrial, solid wastes (both municipal and hazardous from industries) dumpsites and agricultural areas. In such areas a reasonable network is adopted for groundwater quality monitoring depending on resources available. Sometimes groundwater structures need to be created in view of the criticality of the information needed for a particular area. Because of the heavy cost involved in sampling and analysis, it is well worth devoting time and effort to careful planning of a monitoring system.

This survey will give an overview of the geographical location of the water body to be monitored, its accessibility all kind of human influences to decide appropriate sampling location and also appropriate number of sampling locations. The survey may include acquisition of following information:

a. Location map
b. Background information on water body
c. Human activities around the water body like mass bathing, melon farming, cattle wading etc
d. Identification of potential polluting sources
e. Water abstraction – quantity and uses
f. Water flow regulation - schedule, quantity etc

The above information will help in proper designing the network and also planning the schedule for sampling.

8. Step-4: Network Design

In designing the sampling network, it is important to consider optimum number of sampling location, sampling frequency and parameters required to fulfil the desired objectives. Under NWMP, CPCB has set certain important criteria for selection of sampling location.

Criteria for Site Selection

The sampling site selection is generally linked with water quality monitoring objectives. For example if the monitoring is carried out for judging suitability of water for drinking water source then the monitoring site should be closer to the intake point whereas for outdoor bathing it should be near bathing ghats.

After understanding the factors affecting water quality thoroughly, it is necessary to select specific reaches or areas of the stream or river to sample. There is no set number of sampling stations that will be sufficient to monitor all the possible types of waste discharges. There is no routine methodology for site selection on a cook book basis. However, there are some basic rules. If these rules are carefully followed, a basically sound sampling design will be the result.

Some general criteria for selecting appropriate sampling sites will be summarized under the following points:

1) Always have a reference station up-stream of all possible discharge points. The usual purpose of a monitoring exercise is to determine the degree of man induced pollution, and the damage that is caused to aquatic life. The reference station serves to assess the situation with respect to background water quality and biological aspects, which may vary locally and regionally.
2) Drinking water intake points, bathing ghats, irrigation canal off-take points should be considered for monitoring.
3) Sampling stations should be located upstream and downstream of significant pollution outfalls like city sewage drains and industrial effluent outfalls.
4) All samples must be representative, which means that the determinants in the sample must have the same value as the water body at the place and time of sampling. In order to achieve this it is important that the sample is collected from well-mixed zone. A homogeneity test must be performed to identify the well-mixed zone.
5) Additional downstream stations are necessary to assess the extent of the influence of an outfall, and locate the point of recovery.
6) In large rivers like Ganga, Yamuna, Narmada, Krishna and Godavari, where mixing is poor and incomplete, the effluent may tend to follow one bank. Stations on both sides downstream are useful to make an estimate of the extent of the mixing zone.
7) In large rivers a balance has to be found between the selection of a few stations giving poor coverage, and the selection of more stations having different substrates and dissimilar fauna, which can not be compared spatially.

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8) In order to enable comparisons among sampling stations, it is essential that all stations be sampled approximately at the same time. Not more than two weeks should elapse between the sampling of the first and last station in a river.
9) Sites for biological sampling should match with sites for chemical sampling.
10) Biological sampling stations need to be selected with proper attention to representative habitats (kind of substrate, depth and flow). All sampling stations in a certain river should preferably be ecologically similar. To increase biological and chemical comparability, they should have similar substrate (sand, gravel, rock, or mud), depth, presence of rifles and pools, stream width, flow velocity, bank cover, human disturbances, etc.
11) The conventional location of macro-invertebrate sampling stations in rivers arises not only from an assumed uniformity of substrate and fauna, but also from the ease with which it may be sampled by means of handnets and stone-lifting or kicking, and from the ease of access.
12) For the estimation of the oxygen exchange rate of the river, a measurement of cross section is required. Any station should be typical with respect to the cross section of the river.
13) The sampling team normally has to carry an appreciable burden of sampling gear and water samples, and the distance they can walk is limited. Easily accessible sites should be selected. The site should also be accessible under all conditions of weather and riverflow. Accessibility is therefore an important consideration.
14) With respect to preservation, samples are taken to perform analysis on three types of parameters: for some parameters, such as heavy metals, the samples need not be preserved. For other parameters, samples can be preserved by cold storage or by the addition of certain preservatives. However, the samples for analysis of parameters like BOD and bacterial counts cannot be preserved and need to reach the laboratory shortly after taking the sample. The need to transport the samples to the laboratory will govern the range of determinations which can be carried out for a particular sampling site. Travel time greater than 24 hours between the site and laboratory is not recommended.
15) The collection of samples can be hazardous at some locations in bad weather (such as high flow). Such sampling sites can better be avoided.
16) There are many disturbing influences in the rivers, especially cattle wading, melon farming, fishing, sand recovery, etc.. These disturbances can drastically influence chemical processes and the nature of the biological community. Dams and barrages provide a different kind of habitat. Such sampling sites should be avoided.
17) Availability of sampling facilities such as bridges, boats, and possibilities for wading are important criteria in the selection of sampling sites.
18) In case of ghroundwater sampling select only wells (tubewell, dug-well, handpump), which are in use.
19) For groundwater pollution monitoring generally existing structures in the potentially polluted sites is selected.

20) Since variation in groundwater quality is very high and unpredictable, it is practically not possible to cover assessment of groundwater quality of a particular area fully.
21) It is also not practicable to create so many groundwater structures for sampling. Thus, a compromise has to be made between resources available and criticality of information required. It commonly agreed that groundwater quality is generally degraded in the urban, industrial, solid wastes (both municipal and hazardous from industries) dumpsites and agricultural areas. In such areas a reasonable network is adopted for groundwater quality monitoring depending on resources available. Sometimes groundwater structures need to be created in view of the criticality of the information needed for a particular area.

Zonation

The occurrence of two general types of zonation in water bodies should be mentioned here because of their significance for the planning and execution of large scale sampling programs.

Cross-sectional zonation. A cross-section of the river and lakes will usually reveal gradients in depth, current velocities and sediment and water characteristics.

Longitudinal zonation. On a large geographical scale rivers may be classified in a number of zones: highland brooks and lowland courses both subdivided in upper and lower reaches.

Sampling frequency

The sampling frequency is governed by the level of variation in water quality of a water body. If variations are large in a short duration of time, a larger frequency is required to cover such variations. On the other hand, if there is no significant variation in water quality, frequent collection of sample is not required. The water quality variations could be of two types i.e. random and cyclic or seasonal. In case of random variations e.g. due to sudden rainfall in the catchment or sudden release of water from the dam etc., increased frequency may not help much as such variations are highly unpredictable. Thus, within the available resources it is not cost effective to cover such variations. In case of the water bodies having cyclic variations more frequently, sampling on monthly basis is justified. But for all those water bodies having stable water quality round the year, monthly sampling is not justified.

Frequency and Parameters

- On routine basis, a combination of general parameters, nutrients, oxygen consuming substances and major ions should be analyzed at all stations. Depending upon the industrial activities and anticipated at the upstream of the sampling station other parameters like micro-pollutants, pesticides or other site specific variables may be included at lower frequency. Such stations need to be identified.

- A list of parameters to be considered for analysis and frequency of sampling is provided in the "Protocol for Water Quality Monitoring" notified by Govt of India. These are provided in Table 1 and 2.
- It was also emphasized that biological monitoring should form an important part of our water quality monitoring programme due to its inherent advantages. The SPCBs/PCCs agreed to initiate such exercise initially at limited stations.
- Sediment needs to be analyzed for micro pollutant in some stretches as most of micro pollutants are associated with sediment. This should form part of monitoring programme.

Table 1: Parameters and frequency of monitoring in surface waters

Type of Station	Frequency	Parameter
Baseline:	**Perennial rivers and Lakes :** Four times a year **Seasonal rivers** : 3-4 times (at equal spacing) during flow period. **Lake**: 4 times a year	**(A) Pre-monsoon**: Once a year Analyse 25 parameters as listed below : **(a)General** : Colour, odour, temp, pH, EC, DO, turbidity, TDS **(b) Nutrients** : NH_3-N, $NO_2 + NO_3$, Total P **(c)Organic Matter** : BOD, COD **(d)Major ions** : K, Na, Ca, Mg, CO_3, HCO_3, Cl, SO_4, **(e)Other inorganics** : F, B and other location-specific parameter, if any **(f)Microbiological** : Total and Faecal Coliforms **(B)Rest of the year** (after the pre-monsoon sampling) at every three months' interval: Analyse 10 parameters: Colour, Odour, Temp., pH, EC, DO, $NO_2 + NO_3$, BOD, Total and Faecal Coliforms.
Trend:	Once every month starting April-May (pre-monsoon), i.e. 12 times a year	**(A)Pre-monsoon**: Analyse 25 parameters as listed for baseline monitoring **(B)Other months** : Analyse 15 parameters as listed below **(a)General** : Colour, Odour, Temp, pH, EC, DO and Turbidity **(b)Nutrients** : NH_3-N, $NO_2 + NO_3$, Total P **(c)Organic Matter** : BOD, COD **(d)Major ions** : Cl **(e)Microbiological** : Total and Faecal coliforms **(C)Micropollutant** :Once in a year in monsoon season **(i)Pesticides**-Alpha BHC, Beta BHC, Gama BHC (Lindane), OP-DDT, PP-DDT, Alpha Endosulphan, Beta Endosulphan, Aldrin, Dieldrin, 2,4-D, Carboryl (Carbamate), Malathian, Methyl Parathian, Anilophos, Chloropyriphos

		(ii)Toxic Metals-As,Cd,Hg,Zn,Cr,Pb,Ni,Fe (Pesticides & Toxic metals may be analysed once a year)

- This does not, however, restrict analysis of more parameters depending upon specific requirements of the analysing agency and its manpower availability.
- For lakes/reservoirs, monitoring of additional parameters, like Total Kjeldhal Nitrogen, Chlorophyll, total plankton count and productivity, are to be included in the list of parameters.
- If bio-monitoring is done in rivers/lakes/reservoirs, additional parameters, like Photosynthesis-Respiration (P/R) ratio, saprobity index and diversity index are to be included.
- The list of pesticides & toxic metals is flexible and should be decided on need basis.

Table 2: Parameters and frequency of monitoring in Groundwaters

Type of Station	Frequency	Parameters
Baseline	Twice a year in Pre & Post monsoon season. The frequency may be reviewed after 3 years of monitoring	**(A)Pre & Post Monsoon season**: Analyse 20 parameters as listed below : **(a)General** : Colour, odour, temp, pH, EC, TDS **(b)Nutrients** : $NO_2 + NO_3$, ortho-phosphate **(c) Organic Matter** : COD **(d)Major ions** : K^+, Na^+, Ca^{++}, Mg^{++}, CO_3, HCO_3, Cl, SO_4, **(e)Other inorganics** : F, B and other location-specific parameter, if any
Trend	Four times every year (once in pre-monsoon, April-May, and thereafter at intervals of 3 months)	**(A)April-May** : Analyse 20 parameters as listed for Baseline monitoring. **(B)Other times**: Analyse 14 parameters as listed below **(a)General** : Colour, odour, temp, EC, pH, TDS **(b)Nutrients** : $NO_2 + NO_3$, ortho-phosphate **(c)Organic Matter** : COD **(d)Major ions** : Cl **(e)Other organics** : F, B **(f)Microbiological** : Total and faecal coliforms **(C) Micropollutant** : **(i)Pesticides**- Alpha BHC, Beta BHC, Gama BHC (Lindane), OP-DDT, PP-DDT, Alpha Endosulphan, Beta Endosulphan, Aldrin, Dieldrin, 2,4-D, Carboryl (Carbamate), Malathian, Methyl Parathian, Anilophos, Chloropyriphos **(ii) Toxic metals**- Fe, Cu, Cr, Ni, Pb, Cd, Zn, Hg, As

- The parameters to be analysed as mentioned above are the minimal requirement. This does not, however, restrict analysis of more parameters depending upon specific requirements of the analysing agency and its man power availability.
- If COD value exceeds 20 mg/l , the sample is to be analysed for BOD also. The list of pesticides & toxic metals is flexible & should be decided on need basis

9. Step-5: Sampling

Planning for Sampling

When planning a sampling programme the number of sampling stations or wells that can be sampled in one day is required. For this is necessary to know the required time needed for sampling, and other actions required, at the site. Since purging is a time consuming activity an estimate of the required purging time is a must to arrive at a fair estimate of the sampling time.

Check list for the field visit

Table 3 contains a list of items which should be checked before starting on a sampling mission. At least one day before sampling, make sure that all the arrangements are made as per the check list. Make sure that you know how to reach sampling site(s). Take help of location map for each site which shows the sample collection point with respect to prominent landmarks in the area. In case there is any deviation in the collection point, record it on the sample identification form giving reason. Note that depending on the local conditions, type of water body, analysis requirements, etc., not all items on the check list may be necessary. Other items, not listed, may sometimes be required. The field operator may make his or her own personal checklist based on Table 3. Decide on the number of each item that would be required depending on the number of samples to be collected. It is always safer to carry a few numbers in excess. If for any reason the laboratory conducting analyses is different from the laboratory preparing sample bottles, ensure that the concerned laboratory is informed of the programme and ready to receive samples, particularly those which would need immediate attention.

Table 3: Checklist for Field Visit

• Itinerary for the trip (route, stations to be covered, start and return time)	• Personnel and sample transport arrangement
• Area map	• Sampling site location map
• Icebox filled with ice or icepacks or ice	• Weighted bottle sampler
• BOD bottles	• Rope
• Special sample containers: bacteriological, heavy metals, etc.	• Sample containers
• Sample preservatives (e.g. acid solutions)	• Thermometer
• Tissue paper	• Other field measurement kit, as required

• Sample identification forms	• Labels for sample containers
• Field notebook	• Pen / pencil / marker
• Soap and towel	• Match box
• Spirit lamp	• Torch
• Drinking water	• Knife
• First-aid box	• Gloves and eye protection
• Dump sampler to check well conditions	• Submersible pump and accessories

General Guidelines for Sampling

- Rinse the sample container three times with the sample before it is filled.
- Leave a small air space in the bottle to allow mixing of sample at the time of analysis.
- Label the sample container properly, preferably by attaching an appropriately inscribed tag or label. The sample code and the sampling date should be clearly marked on the sample container or the tag.
- Complete the sample identification form for each sample.
- The sample identification form should be filled for each sampling occasion at a monitoring station. Note that if more than one bottle is filled at a site, this is to be registered on the same form.
- Sample identification forms should all be kept in a master file at the laboratory where the sample is analysed.

Surface water Sampling

- Samples will be collected from well-mixed section of the river (main stream) 30 cm below the water surface using a weighted bottle or DO sampler.
- Samples from reservoir sites will be collected from the outgoing canal, power channel or water intake structure, in case water is pumped. When there is no discharge in the canal, sample will be collected from the upstream side of the regulator structure, directly from the reservoir.
- DO is determined in a sample collected in a DO bottle using a DO sampler. The DO in the sample must be fixed immediately after collection, using chemical reagents. DO concentration can then be determined either in the field or later, in a level I or level II laboratory.

Groundwater Sampling

- Samples for groundwater quality monitoring would be collected from one of the following three types of wells:
- *Open dug wells* in use for domestic or irrigation water supply,
- *Tube wells* fitted with a hand pump or a power-driven pump for domestic water supply or irrigation
- *Piezometers*, purpose-built for recording of water level and water quality monitoring.

- Open dug wells, which are not in use or have been abandoned, will not be considered as water quality monitoring station. However, such wells could be considered for water level monitoring.
- Use a weighted sample bottle to collect sample from an open well about 30 cm below the surface of the water. Do not use a plastic bucket, which is likely to skim the surface layer only.
- Samples from the production tube wells will be collected after running the well for about 5 minutes.
- Non-production piezometers should be purged using a submersible pump. The purged water volume should equal 4 to 5 times the standing water volume, before sample is collected.
- For bacteriological samples, when collected from tubewells/hand pump, the spout/outlet of the pump should be sterilised under flame by spirit lamp before collection of sample in container.

Sample Labeling

Label the sample container properly, preferably by attaching an appropriately inscribed tag or label. Alternatively, the bottle can be labelled directly with a water-proof marker. Information on the sample container or the tag should include:

- sample code number (identifying location)
- date and time of sampling
- source and type of sample
- pre-treatment or preservation carried out on the sample
- any special notes for the analyst
- sampler's name

Sample Preservation and Transport

Preserve the collected samples as specified in Tables 1. Samples for BOD and bacteriological analyses should be stored at a temperature below 4°C and in the dark as soon as possible after sampling. In the field this usually means placing them in an insulated cool box together with ice or cold packs. Once in the laboratory, samples should be transferred as soon as possible to a refrigerator. If samples collected for chemical oxygen demand (COD) analysis cannot be analysed on the day of collection they should be preserved below pH 2 by addition of concentrated sulphuric acid. This procedure should also be followed for samples for ammoniacal nitrogen, total oxidised nitrogen and phenol analysis. Samples which are to be analysed for the presence of metals, should be acidified to below pH 2 with concentrated nitric acid. Such samples can then be kept up to six months before they need to be analysed; mercury determinations should be carried out within five weeks, however. After labeling and preservation, the samples should be placed in an insulated ice box for transportation. Samples should be transported to concerned laboratory as soon as possible, preferably within 48 hours. Analysis of bacteriological samples should be started and analysed within 24 hours of collection. If samples are being brought to the laboratory they should be transported in less than 24 hours.

The result of any test on the quality of the environment is no better than the result of all efforts that lead to this final result: collection of the samples, the handling and chemical treatment, the method of storage, the chemical analysis, the calculation and interpretation of the data. If any of these steps are carried out with insufficient care, the final result (e.g. the concentration of a given compound) will be no more than a figure without relation to the actual situation in the environment, and therefore be useless: the entire operation has been a waste of energy, time and money.

In a situation where the tasks of sampling (and preservation) and chemical analysis belong to different specialized groups, lack of communication may easily lead to erroneous results. The optimum situation is there, where the entire procedure, from sampling to final analysis, is within the hands of one group of experts. However, this is due to managerial aspects not always possible. Therefore, instead of blaming each other for evident errors in analysis (often without proof), it is essential that both sampling team and chemical analysts work together to optimize the integrated task: the analysis. Both groups are specialized: the sampling party has the knowledge of the actual situation in the field, with the consequential restrictions and possibilities in terms of e.g. logistics (transport, accessability, local condition) and should already in the planning phase be consulted, the analytical party (chemical or biological) is specialized in aspects related to contamination control, sample- and sampling-bottle selection, cleaning and preservation methods etc. The necessity for close cooperation is evident and serves the ultimate goal: reliable analysis that reflect the actual situation in the environment.

Importance of the sampling procedures

It will be obvious that the result of any chemical or biological analysis can be no better than the sample that is offered to the analytical laboratory. Often the quality control aspects are only related to the analytical part, whereas the control procedures for the sampling are neglected. There appears to be a need for a detailed description of the sampling and preservation procedures. It is not possible, however, to specify one detailed description, valid for all parameters of interest, because of varied purposes and specific needs required in the analytical process. Therefore in this report a detailed description is offered per parameter (or set of parameters) in the following sections. The present section deals with general considerations.

The objective of sampling is to collect a portion of material from an environmental compartment (either water, sediment or biota) small enough in volume to be conveniently transported and handled in the laboratory, while still accurately retaining is representativity. This implies that the relative proportions or concentrations of the components of interest should be the same in the samples when they are being analysed , as they were originally in the environment. This requires that the sample will be handled and, if necessary, treated in such a way that no significant changes in composition occur that may hamper proper analysis. In other words, no addition (e.g. contamination), loss (e.g. adsorption to the wall of the sample bottle) or deterioration (e.g. physico-chemical or biological degradation or transformation) can be allowed.

Sampling devices

Many sampling devices have been developed during the last century. Not only became the design more reliable, also new materials were introduced. It goes too far, to give a complete list of the different sampling gear available and their (im)possibilities (Hellawell, 1986; Kramer, 1988; Holme & McIntyre, 1984; Sournia, 1978). The most important sampling devices are the following:

Water
For the compartment water several type of sampling devices are available:

a - Bottle. The same bottle used for storage is used for collection. Only (sub)surface samples can be collected.

b - Sampler. Operated on a line or wire for deep water sampling. Several samplers can be mounted together on one wire. They are closed by messenger (metal weight gliding along the wire) or by electronic means. In this paper the Van Dorn type is mentioned (see the following figure), but also Niskin-, NIO-, Nansen- samplers (and others) are available, and can often be used. A large variation in sizes is available. Specific purposes (sampling for bacteria (thus sterile), trace metals (metal free), pesticides (no plastics)) require specially designed samplers.

c - Pumping. Automatic sampling devices, using pumping systems are available. They usually can be preset to desired volume and/or time of sampling; depending on the collection bottles installed, either a series of spot samples or one composite sample may be collected.

Sediment For sediment sampling one may use one of the following techniques:

d - Coring. A PVC or perspex tube (ca. 1 m x 8 cm φ) is used to extract relatively undisturbed sediment.

e - Grabbing. A larger volume of sediment, disturbed, however, can be collected. Useful also for the collection of organisms.
f - Others. Special types of sediment samplers have been developed, e.g. for use in the deep sea (piston corers), for use in sandy sediments (vibro-corers), for large sections of the sediment (box-corers). They are beyond the scope of this report, however.

Biota Sampling methods for biota may be roughly divided into active and passive methods. Among the passive methods belong:

- methods that extract and separate the organisms from their habitat (which at the same time will be disturbed);
- methods that remove an undisturbed part of the habitat from which the organisms are then extracted.

- Among the active methods belong various artificial experimental designs like:

- colonization substrates from which the biota are collected;

- exposure techniques with different species by which some environmental problems can be studied under conditions that are under control.

Apart from the organisms that are collected in the above mentioned compartments, such as phytoplankton and bacteria in water samples, meiofauna in sediments, a multitude of special sampling gear has been developed for the collection of organisms.
We can summarize to the following types, without even trying to be complete: local conditions and habits often necessitate own adaptations or modifications of existing designs.

g - Nets. Hand nets for macro-invertebrates, plankton nets with various mesh sizes for phyto- and zoo-plankton, fish nets of various designs like fykes, seines or (beam) trawls;

h - Dredges. like naturalists' dredge, rock dredges, anchor dredge

i - Suction samplers

j - Colonization samplers like baskets filled with various substrates (e.g. bricks) or microscope glass slide holders;

k - Exposure cages of various design for different organisms as molluscs, crustaceans or fish;

l - Collection by hand is an easy and valuable technique, especially for sessile organisms (molluscs, water plants) or floating species (e.g. water hyacinth). For deeper water the use of divers should be considered. An advantage of manual picking is that already during sampling one may select special organisms (e.g. in size/age) and one is more able to prevent damage to the organisms than when using a mechanical device.

A variety of sampling equipement is depicted on the following pages. In some cases the method of applying the instruments is also graphically demonstrated.

Types of Samples
Apart from a separation into compartments (water, sediment and biota) different types of samples can be collected:

1) Grab sample (also called spot - or catch samples)
One sample is taken at a given location and time. In case of a flowing river, they are usually taken from the middle of the flowing water (main) stream and in the middle of the water column. When a source is known to vary with time, spot samples collected at suitable time intervals and analyzed separately, can document the extent, frequency and duration of these variations. Sampling intervals are to be chosen on the basis of the expected frequency with which changes occur. This may vary from continuous recording, or sampling every 5 minutes, to several hours or more.

2) composite samples

In most cases, these samples refer to a mixture of spot samples collected at the same sampling site at different times. This method of collection reduces the analytical effort, because variations are middled out in one analysis. It is a useful technique when daily variations occur and seasonal variations are the objective of the programme. If, however, the series of spot samples are not mixed but analyzed individually, also information on the daily variability can be obtained, and afterwards the average can be computed.
Sometimes the indication 'time-composite' is used to distinguish from 'location-composite' sampling. Time-composite sampling representing a 24-hour period is often used. For many determinations, the time interval between sampling events being 1-3 hours. To evaluate the nature of special discharges (e.g. variable in volume or irregular in time), samples should be collected at time intervals representing the period during which such discharges occur. Especially in effluents, one may sample a volume that is proportional to the discharge (flow based composite). This type of sampling is also required to measure the flux of pollution load discharged through a point source.

Biota that is only active during certain periods of the day (e.g. activity during the night) can only be sampled accordingly.

For parameters that will change after collection, and that can not be preserved, in-situ determinations should be applied if possible. If preservatives are to be added, add them to each sample and not in the end to the composite sample.

3) Integrated samples

Sometimes samples are collected at the same location but, due to horizontal or vertical variation in the composition of the river (or in water flow) or lake, they come from different points in the cross-section that are regarded with a different relative importance. To evaluate the average composition, total load or mass balance, integrated samples are collected, often in proportion to the river flow of the areas of sample collection.

4) In-situ measurements

Some determinations are more likely to be affected by sampling and sample storage than others. In several cases the expected changes are so large, that it is impossible to store the sampled material for a correct analysis at a later moment. If possible, these parameters should be analyzed on the sampling site or, even better, in-situ. Most important parameters that should (and can) be analyzed in situ are the pH, dissolved oxygen, temperature, conductivity and sometimes turbidity. For several measurements special portable measuring devices are available.

The estimation on numbers and diversity of organisms is also to be considered as in situ analysis.

Contamination control

Special attention should be given to the minimization of contamination. As said earlier, unintentional additions to the sample of the compound under consideration, will increase the concentration (contamination) and make further analysis quite useless. The levels of

many constituents, especially of pollutants in the water are, although they may be elevated, still very low (µg/l levels are common for dissolved trace metals, while ng/l levels occur in case of organic micropollutants). Therefore, contamination will easily occur: from the sampling equipment, from the sample bottle, from preservatives, from the ambient atmosphere, from the personnel taking the sample etc. Utmost care should therefore be maintained, - and the mind should always be focused on this topic during sampling - in order to prevent contamination.

Often sampling bottles need to be cleaned in a special way, depending on the parameter. To avoid cross-contamination, the same bottles should be used only for identical selected parameters, even when they are cleaned in between. Separate sets of bottles should be used for (low concentration) natural waters and for (high concentration) effluents. To prevent contamination by the hands, plastic (PE) gloves are needed. Atmospheric dust and (exhaust) fumes are readily available to contaminate the sample: minimum contact of the sample with the atmosphere is essential, here. A (portable) laminar flow "clean bench" is of great use for adding preservatives and for filtration under controlled conditions. The person taking a sample (and the analyst) should take care not to touch the inside of bottle and cap. The sampling bottles should be kept clean from dust and dirt. In between cap and bottle dust can accumulate that is not easily washed away. The (cleaned) bottles should therefore leave the analytical laboratory protected by a polythene plastic bag; only on the sampling site this bag should temporarily be removed to allow sampling. Then, after addition of preservative(s) if necessary, the bottles should be stored in the plastic bag again. Pipettes or pipette tips should (in the field and in the laboratory) only be used once. Biota, especially those that are collected for chemical analysis of the concentration of pollutants, require special attention with regard to contamination control. Be aware of the intention of the programme (and the compounds to be analyzed) and take appropriate measures. Prevent the use of metal equipment for the collection or storage of organisms in case of trace metal analyses (no zinc plated steel buckets or storage boxes, no copper mesh sieves). For trace organic analysis, try to stick to glass and stainless steel equipment. Handle the organisms with care, remove excessive sediment or algae, and collect them in clean (plastic or glass) wide mouth bottles. Prevent contact of the collected organisms with the (shore) sediment, effluent water, deck of the ship etc.

Cleaning procedures

The cleaning of samplers, sampling bottles and other labware, that comes into contact with the sample, is essentially a task for the analytical chemical laboratory, not for the sampling team. Depending on the parameter, different cleaning procedures can be applied.

For heavy metals rinsing with:

- 1:1 diluted Nitric acid (supra pure quality) for 1 week is needed, followed by:
- three times washing with double distilled water.

Bottles for trace organic (chlorinated) compounds, like pesticides, should be cleaned with the solvent used for extraction (also of high purity quality).

Samples for the general physical-chemical characterization allow less vigorous methods. Thorough cleaning with water to remove particulates and two times rinsing with distilled water will usually be sufficient.

Organisms that are to be preserved (alcohol, formalin) should be stored in glass bottles. The samples for chemical analysis follow the selection and cleaning procedures for the water and sediment compartments (wide mouth bottles facilitate the entry of the organisms.

All bottles should arrive at the sampling site in a fully cleaned state, protected from accidental contamination.

The last cleaning step is in most cases (NOT all: not for the trace organics, in case a solvent is already present in the bottle, and not for microbiological samples) rinsing 2-3 times with the water to be sampled. This cleaning should be done, one bottle at the time, at the sampling point and both bottle and cap should be cleaned: fill the bottle (1/3), put on the cap, shake and empty. Repeat this procedure 2 times.

Sample Containers

The sample containers needed for a sampling campaign are prepared by the laboratory and given to the person collecting samples. An overview of the types of containers and preservation is given in Table 4. More detailed information on the specific containers needed for each parameter is given in Table 1.

Table 4: Container Types and Volumes Needed for Sampling

	Analysis	Container	Volume	Preservatio
0	On-site analysis	PE bowl or	±200	-
1	General (SS, TDS, major ions	Glass, PE	1000	-
2	COD, NH3, NO2-+NO3-	Glass, PE	500	H_2SO_4, pH
3	o-PO4	Glass	100	-
4	BOD	Glass, PE	1000	4°C, Dark
5	Coliforms	Glass, PE,	300	4°C, Dark
6	Heavy metals (Cd, Zn)	Glass, PE	500	HNO_3, pH
7	Mercury	Glass	1000	HNO_3, pH
8	Pesticides	Glass, Teflon	1000	4°C, Dark

Reagent Solutions

For some of the field analyses, reagent solutions are necessary for the analysis. All necessary reagent solutions should be prepared in the laboratory and brought to the field by the sample collector.In all cases, sample preservatives and DO fixing solutions, if applicable, *must* be brought to the field and added to the samples immediately after collection.

For analysis of pH, buffer solutions are necessary to standardise the pH meter: Buffer solutions should be prepared in the laboratory, or purchased, for pH = 4, 7, and 9.

For analysis of Electrical Conductivity, standard potassium chloride solution, KCl (0.01*M*) is needed to standardise the conductivity meter.
For preservation of certain samples, concentrated nitric acid, concentrated sulfuric acid, ZoBell's solution, etc., are needed.
A supply of distilled water is needed for rinsing equipment.

Instruments
Some instruments and equipment are necessary to make the field analyses. Instruments and equipment must be brought to the field. *Temperature should always be measured in the field*:

- For measurement of Temperature, a (mercury) thermometer or thermistor is needed.
- For analysis of Electrical Conductivity, a conductivity meter is needed.
- For analysis of pH, a pH meter is needed.
- For analysis of Redox Potential, a pH meter (mV scale), reference electrode and oxidation-reduction indicator electrode are needed.

Note: It is possible that instead of separate meters for temperature, pH and conductivity, there is a single instrument with different probes which will measure all three parameters. These are called field monitoring kits.

A supply of batteries and standard spare parts should also be carried along with the field instruments.

Field Analysis
Measurements of colour, odour, temperature, electrical conductivity, pH and dissolved oxygen are considered to be 'Field Determinations' and should be made as soon as possible after collecting a sample.
Measurement of these parameters can be made in the field if field meters are available. This is the best option, as the analyses will be made immediately. If samples are brought to the level II/II^{+} laboratory, the travel time should be *very* short, so that parameter values do not change between the time the sample is collected at the time of analysis.

Colour
Determining the colour in the field is relatively easy. Pour an aliquot of approximately 10mL of sample into a glass test tube and judge the colour observed. Consider one of the following options:
(1) Light brown
(2) Brown
(3) Dark brown
(4) Light green
(5) Green
(6) Dark green
(7) Clear
(8) Other specify

Odour

Determining the odour should always be done in the field, as soon as possible after collecting a sample. After collection, fill a cleaned odourless bottle half-full of sample, insert stopper, shake vigorously for 2-3 seconds and then quickly smell the odour. Alternatively, pour an aliquot of approximately 5mL of sample into a glass test tube and judge the odour. Consider one of the following options:

(1) Odour free
(2) Rotten eggs
(3) Burnt sugar
(4) Soapy
(5) Fishy
(6) Septic
(7) Aromatic
(8) Chlorinous
(9) Alcoholic
(10) Unpleasant

Temperature

Water temperature should be measured in degrees Celsius, using a mercury thermometer or a thermistor. Normally, if temperature is measured electronically using a thermistor this device is built into an instrument which is capable of making other water quality measurements (e.g., pH and EC). Whenever possible, the temperature should be measured by directly dipping the thermometer in the natural body of water being studied. In case it is not possible, collect about 500 mL sample in a plastic or glass container and measure temperature by immersing the thermometer in the sample. Read the temperature after equilibration (no more change in the temperature reading). Report the Temperature on the sample identification form in degrees Celsius with 1 digit after the decimal point e.g. 13.2 °C.

pH

The most accurate method of measuring water pH in the field is by means of a portable purpose designed meter. Such meters are normally capable of measuring pH to the nearest 0.05 of a pH unit by using a 'glass' and a 'reference' electrode (although these are often combined in a single probe). Before measuring pH, it is necessary to calibrate the meter. This should be done at least once per day, before the first pH measurement is attempted. The procedure of this is as follows:

- After removing their protective caps, the electrodes are rinsed in distilled water and carefully blotted dry with soft absorbent paper. *NOTE: Care needs to be exercised here as the electrodes are very fragile.*
- The electrodes are then placed in a fresh buffer solution and after following time for meter stabilisation, the pH reading of the meter is adjusted to the pH the buffer solution (normally pH = 7).
- The electrodes are then rinsed again with distilled water and blotted dry.
- If a pH measurement is not to be taken immediately, the electrodes should be replaced in their protective caps. Normally, the glass electrode cap is filled with distilled water before replacement to prevent the electrode drying out.

- Report the pH on the sample identification form in pH units showing one digit after the decimal point, e.g. 7.6.

Once calibrated, the pH meter can be used to measure the pH directly by placing the electrodes in water sample immediately after it is obtained. Care should be taken to ensure that the electrodes are rinsed with distilled water before and after each determination and that distilled water is placed in to the glass electrode cap for transportation.

Electrical Conductivity (EC)

EC can be measured in the field with a purpose-designed meter, see section 2.3. Before measuring conductivity it is necessary to calibrate the meter. This should be carried out at least once per day, before the first measurement is taken. Calibration is achieved by determining the conductivity of a known, fresh solution of potassium chloride and adjusting the meter accordingly. In order to ensure the conductivity reading is accurate, it is necessary to adjust the conductivity reading to compensate for temperature changes. In most modern meter this is done automatically. Once calibrated, the conductivity of the water can be measured by immersing electrode in a sample of water as soon as it is taken. It is important to remember that conductivity meters often take some minutes to stabilise. The reading must, therefore be taken after this stabilisation has occurred. Report the EC at 25° C preferably in µmhos/cm with no figure after the decimal point, e.g. 1135 µmhos/cm.

Documentation of sampling and analysis

A special form has to be prepared where the details of the sampling event and the in-situ/on site analysis can be filled in. The form ("field data protocol") should at least contain room for the following items:

Field Data protocol

a. Sampling team members
b. Date and time (24 hr method) of collection (time span in case of composite - sampling)
c. Nature of the sample: spot/composite/integrated
d. Results of performed in-situ/on site analyses (water/air temperature, dissolved oxygen, pH (field or lab), conductivity (field or lab), turbidity, macrofauna composition (BMWP score), macrofauna diversity (SCI), and 24 hr oxygen production / respiration ratio)
e. Exact sampling location (location along the river, distance from shore) and depth of collection
f. Definition of sampling intervals and volumes in case of composite sampling
g. Maximum depth of the river, lake and current velocity in case of river (only if actually measured with a current meter)
h. Weather conditions with respect to clouds, precipitation, wind (direction and force)
i. Consistency of sediment (sandy, silty etc.)

j. Comments on smell, colour, discharges etc.
k. Parameter(s) that will be analyzed
l. Sample bottle (number, type, material, volume, and an indication if a preservative is already present)
m. The method of preservation/storage

Especially if a large number of different sample bottles have to be filled for various observations, it is convenient to have a space on the form to tick-off when the sample has been collected. At the end of the sampling event it is then easy to check, if all samples have been collected in the correct number.

Analytical result sheets

When offering the samples to the analytical laboratory, each and every series of replicate sample containers has to be accompanied by a prefilled "result sheet". This sheet is marked with sample specifications identical to the specs marked on the bottle. The individual parameters to be measured in the sample are tabulated, together with the units they should be reported in. The sheet leaves space for the analytical lab to fill in the results of replicate analysis.

10. Step 6: Laboratory Work

Work Assignment and Personnel Register

- The laboratory incharge should maintain a bound register for assignment of work. This register would link the lab. sample number to the analyst who makes specific analyses, such as pH, EC, BOD, etc.
- An estimate of time needed for performing the analyses may also be entered in the register.
- Each laboratory analyst should have his/her own bound register, where all laboratory readings and calculations are to be entered.
- When analysis and calculations are completed, the results must be recorded in a register containing data record sheets described in the next section.

Laboratory Analysis

The laboratory analysis is to be performed by the laboratory staff within stipulated time and precision. It is observed that many laboratories have their own procedures traditionally being followed. Not only that they also use different units to present the results and sometimes many digits after decimal. This create un-necessary problem in integrating the results. In order to make the procedures uniform and also presentation methods uniform a guideline is prepared. The analytical methods are prescribed for each parameter along with measurement unit and significant figure in the following table 5. It is important that all the agencies monitoring water quality and putting the data on website through EDB use the table 5 strictly.

Table 5: Measurement methods, units and significant figures for different paprametrs used in water quality monitoring

Parameters	Unit	Measurement Methods	Significant figures after Decimal

Colour	-	Visual method	
Odour	-	Manual	
Temperature	°C	Thermameter	1
pH	-	pH meter	1
Electrical Conductivity	µS/cm	Conductivity meter	0
Dissolved Oxygen	mg/L	DO Meter or Winkler modified method	1
Turbidity	NTU	Nephelometer	1
Total Dissolved Solids	mg/L	Gravimetry	0
Ammonical Nitrogen (NH_4-N)	mgN/L	Colorimetry	1
Nitrite + Nitrate-N	mgN/L	Colorimetry	1
Total Phosphate	mg/L	Colorimery	4
Orthophosphate	mg/L	Colorimetry	4
Biochemical Oxygen Demand (BOD)	mg/L	DO consumption in 3 days at 27 °C	1
Chemical Oxygen Demand (COD)	mg/L	Potassium dichromate method	1
Sodium	mg/L	Flame photometry	1
Potassium	Mg/L	Flame photometry	1
Calcium	mg$CaCO_3$/ L	EDTA Titrimetric	1
Magnesium	mg $CaCO_3$/L	EDTA Titrimetric	1
Carbonate as CaCo3	mg $CaCO_3$/L	Titrimetric	1
Bicarbonate, as CaCo3	mg $CaCO_3$/L	Titrimetric	1
Chloride	mg/L	Argentometric titration	1
Sulphate	mg/L	Turbidimetry	1
Fluoride	mg/L	Ion meter, Colorimetry	2
Boron	mg/L	Ion meter, curcumin method	2
Total Coliform	No./100mL	MPN or MF method	0
Fecal Coliform	No/100mL	MPN or MF method	0
% Sodium	-	Calculation	2
SAR	-	Calculation	2
1 Specific Parameters			
Arsenic	µg/L	Cold vapour AAS	1
Mercury	µg/L	Cold Vapour AAS	1
All other heavy metals	µg/L	AAS	1

Pesticides and other organics	µg/L	GC, GCMS	1

11. Step 7: Data Management

Data Storage and Validation

- A recommended format for recording data is given in EDB. It includes all parameters, except heavy metals and trace organics, that may be analysed in the water quality monitoring programme currently envisaged. Note that ordinarily a sample would NOT be analysed for all the listed parameters in EDB.
- Record of analyses for heavy metals and trace organics, which would be performed on a limited number of samples, would be kept separately in a similar format.

Data Validation

- Absolute checking/Data entry
- Checking if data is within the detection limits of a particular method
- Checking if the data is within the expected ranges for a parameter
- Checking if there are too many (or too few) significant digits reported
- Checking if data are physically or scientifically possible (general checks)
- Checking correlation of parameters (Some conditional checks like BOD/COD relation, TC/FC relation)
- Checking the correlation between EC and TDS
- Checking cation/anion balance
- Total coliforms must be greater than faecal coliforms
- Total iron must be greater than dissolved iron
- Total phosphorus must be greater than dissolved (ortho-)phosphorus
- Total iron must be greater than dissolved iron

General checks:

Total solids	≥ Total dissolved solids
Total solids	≥ Total settleable solids
COD	> BOD
Total Coli	≥ Faecal Coli
Total Iron	≥ Fe^{+2}, Fe^{+3}
Total P	≥ $PO4^{-3}$
EC (µS/cm)	≥ TDS (mg/l)
Total oxidized nitrogen	≥ Nitrate, nitrite
Total oxidized nitrogen	= Nitrate + nitrite
Total hardness	= Ca hardness + Mg hardness

Conditional Checks

When there are known correlations between one or more water quality parameters these can be used to

Some of the more well known correlations between parameters are:

- Total dissolved solids specific conductance

- pH and carbonate species
- pH and free metal concentrations
- Dissolved oxygen and nitrate
- If pH <8.3 then Carbonate = 0
- If DO = 0, then nitrate = 0
- If DO >0, then nitrate >0
- If DO > 7m, then ferrous ions = 0
- If nitrite >0, then ferrous ions = 0
- If ferrous ions >0, then nitrite = 0

Data Analysis and Presentation

It is often useful to subject data to some simple statistical analysis. It may be, for example, that such an analysis could be used to summarise the data; to transform them to aid understanding or to compare them with a water quality standard that is couched in statistical terms (annual mean, standard deviation, trend, seasonal changes or a percentile for certain parameters). The data can also be summarized in form of index. Statistical analysis like parametric correlation, seasonal fluctuations, seasonal trends over a period of time are also common. The data after analysis can be presented in different format. For a river usually river profiles are commonly presented. For groundwater contours are plotted over a geographical area.

Graphical Presentation

1. Time Series Graphs
2. Histograms
3. Pie Charts
4. Profile Plots (river profiles)
5. Geographical Plots (contours)

Data Interpretation

The data interpretation involves understanding on the water chemistry, biology and hydrology. Normally data analysed and interpreted in terms of chemical quality, quality fluctuations, and their possible effect on different uses and ecosystem. A comparison is made with predefined criteria or standards set for protection of different uses. The quality fluctuation are explained in view of possible sources of pollution and their fates in aquatic environment and their effects.

12. Step 8: Quality Assurance

The QA programme for a laboratory or a group of laboratories should contain a set of operating principles, written down and agreed upon by the organisation, delineating specific functions and responsibilities of each person involved and the chain of command. The following sections describe various aspects of the programmes

Sample control and documentation: Procedures regarding sample collection, labelling, preservation, transport, preparation of its derivatives, where required, and the chain-of-custody.

Standard analytical procedures: Procedures giving detailed analytical method for the analysis of each parameter giving results of acceptable accuracy.

Analyst qualifications: Qualifications and training requirements of the analysts must be specified. The number of repetitive analyses required to obtain result of acceptable accuracy also depends on the experience of the analyst.

Equipment maintenance: For each instrument, a strict preventive maintenance programme should be followed. It will reduce instrument malfunctions, maintain calibration and reduce downtime. Corrective actions to be taken in case of malfunctions should be specified.

Calibration procedures: In analyses where an instrument has to be calibrated, the procedure for preparing a standard curve must be specified, e.g., the minimum number of different dilutions of a standard to be used, method detection limit (MDL), range of calibration, verification of the standard curve during routine analyses, etc.

Data reduction, validation and reporting: Data obtained from analytical procedures, where required, must be corrected for sample size, extraction efficiency, instrument efficiency, and background value. The correction factors as well as validation procedures should be specified. Results should be reported in standard units. A prescribed method should be used for reporting results below MDL.

An important aspect of reporting the results is use of correct number of significant figures. In order to decide the number of significant digits the uncertainty associated with the reading(s) in the procedure should be known. Knowledge of standard deviation will help in rounding off the figures that are not significant. Procedures regarding rounding off must be followed.

Analytical quality control: This includes both *within-laboratory* AQC and *inter-laboratory AQC.*

Under the within-laboratory programme studies may include: recovery of known additions to evaluate matrix effect and suitability of analytical method; analysis of reagent blanks to monitor purity of chemicals and reagent water; analysis of sample blanks to evaluate sample preservation, storage and transportation; analysis of duplicates to asses method precision; and analysis of individual samples or sets of samples (to obtain mean values) from same control standard to check random error. Inter-laboratory programmes are designed to evaluate laboratory bias. It may be added that for various determinands all of the AQC actions listed may not be necessary. Further, these are not one time exercises but rather internal mechanisms for checking performance and protecting laboratory work from errors that may creep in. Laboratories who accept these control checks will find that it results in only about 5 percent extra work.

Within Laboratory Exercise

Shewhart Control Chart

If a set of analytical results is obtained for a control sample under conditions of routine analysis, some variation of the observed values will be evident. The information is said to be statistically uniform and the analytical procedure is said to be under statistical control if this variation arises solely from random variability. The function of a control chart is to identify any deviation from the state of statistical control.

Shewhart control chart is most widely used form of control charts. In its simplest form, results of individual measurements made on a control sample are plotted on a chart in a

time series. The control sample is analysed in the same way as the routine samples at fixed time intervals, once or twice every week, or after 20 to 50 routine samples.

Assuming the results for the control sample follow the Normal frequency distribution, it would be expected that only 0.3% of results would fall outside lines drawn at 3 standard deviations above and below the mean value called upper and lower control limits, UCL and LCL, respectively. Individual results would be expected to fall outside these limit so seldom (3 out of 1000 results), that such an event would justify the assumption that the analytical procedure was no longer in statistical control, i.e., a real change in accuracy has occurred.

The chart is constructed from 20 or more replicate analysis results of a control or standard samples. Two lines are inserted on the chart at 2 standard deviations above and below the mean value called upper and lower warning limits, UWL and LWL, respectively. If the method is under control, approximately 4.5% of results may be expected to fall outside these lines.

This type of chart provides a check on both random and systematic error gauged from the spread of results and their displacement, respectively. Standard Methods lists the following actions that may be taken based on analysis results in comparison to the standard deviation.

Control limit: If one measurement exceeds the limits, repeat the analysis immediately. If the repeated analysis result is within the UCL and LCL, continue analyses; if it exceeds the action limits again, discontinue analyses and correct the problem.

Warning limit: If two out of three successive points exceeds the limits, analyse another sample. If the next point is within the UWL and LWL, continue analyses; if the next point exceeds the warning limits, discontinue analyses and correct the problem.

Standard deviation: If four out of five successive points exceed one standard deviation, or are in increasing or decreasing order, analyse another sample. If the next point is less than one standard deviation away from the mean, or changes the order, continue analyses; otherwise discontinue analyses and correct the problem.

Central line: If six successive points are on one side of the mean line, analyse another sample. If the next point changes the side continue the analyses; otherwise discontinue analyses and correct the problem.

Figure 8.5 to Figure 8.6 illustrate the cases of loss of statistical control for analysis of individual samples based on the above criteria.

Precision: The most important parameter to evaluate in the results is the precision. The statistical term to evaluate precision is standard deviation. The numerical value of the standard deviation depends on the average concentration (standard deviation also has the unit of concentration). Numerical values of standard deviations of low concentration solutions are usually smaller than those of solutions with higher concentrations. Therefore the coefficient of variation, defined earlier, should be used to evaluate precision. This is particularly useful when comparing results of analysis for samples having different concentrations. Before evaluating the results one should answer the question 'what is the desired precision for an analyses?'. In fact this question should be answered by the so called 'data users'. The use of the data determines the required precision, e.g. detection of trends may require more precise results (in order to actually detect small changes with time) than checking water for use, say for irrigation.

Laboratory staff should always ask for the purpose for which they are performing the requested test.

As a minimum goal for precision, however, the precision that can be obtained by correctly and adequately following the method prescribed by the APHA Standard Methods for the examination of water and wastewater may be adopted

Calculating revised limits when continuing the exercise: Warning and control limits should be recalculated periodically. Especially when new techniques are introduced, the precision improves when experience is gained with the technique. A good time for recalculating the control and warning limits is at the time when the control chart is full and a new graph has to be created anyway. At this point, use the 20 most recent data on the old chart for construction of LCL, LWL, average, UWL and UCL.

Errors that cannot be detected by within-laborartory AQC: The within-laboratory AQC exercise focusses mainly on precision. A laboratory on its own cannot detect many sources of bias. A good example to illustrate this is the total hardness method. If the analytical balance in a lab always reads 10% too much all solution prepared will have a 10% higher concentration: the Standard $CaCO_3$ solution, the EDTA titrant and also the control sample containing $CaCO_3$. This error can only be detected by analysing a sample prepared by a laboratory with a correctly functioning balance. The current laboratory will underestimate the concentration of such a inter-laboratory sample by 10% because their EDTA titrant is '10% too strong'. In some cases freshly introduced bias may be detected. For example, if the measurements consistently fall on one side of the previously calculated mean, it indicates a freshly introduced bias.

Inter-Laboratory AQC

CPCB regularly carry out Inter-laboratory AQC involving about 140 laboratories in the country.

The objectives of an *inter*-laboratory AQC programme are:

1 To test for possible bias in measurements in a laboratory.

2 To provide direct evidence of comparability of results among laboratories in a common water quality monitoring programme. Some related objectives and benefits are listed below:

- to assess the status of analytical facilities and capabilities of participating laboratories.
- to identify the serious constraints (random & systematic) in the working environment of laboratories.
- to provide necessary assistance to the concerned laboratories to overcome the short comings in the analytical capabilities.
- to promote the scientific and analytical competence of the concerned laboratories to the level of excellence for better output.
- to enhance the internal and external quality control of the concerned laboratories

Inter-laboratory AQC should form the routine part of monitoring programme. Such exercises will give more confidence on results.

13. Guidelines on Management Aspects

Following important aspects are included:

a. Before planning for any water quality monitoring programme ensure that adequate resources are available as prescribed.

b. Ensure that every body who is involved in monitoring is fully aware of the objectives, procedures, time schedule, quality assurance and importance of this programme.

c. Ensure that people are motivated and working with full interest.

d. Ensure that accountability of every body is fixed.

e. Ensure that there is enough communication among all the groups involved in monitoring.

f. All the field data collected should be properly transferred to the laboratory people.

g. Data should be transferred as soon as acquired through electronic mean (EDB).

h. Adequate funds are available with the field staff and laboratory people to take care of emergency measures.

i. Private transport facility should be available to the sampling team.

j. There should be annual maintenance contract (AMC) for the repair and maintenance of laboratory equipment/instruments.

k. There should be regular AQC exercises both internal and external and the results of these exercises are available to any body.

MINISTRY OF ENVIRONMENT AND FORESTS

NOTIFICATION

New Delhi, the 17 June, 2005

S. O. 2151.— WHEREAS the Water Quality Assessment Authority (WQAA) was constituted by the Central Government vide Order No. S.O. 583 (E) dated the 29th May, 2001 and No. S.O. 635(E) dated the 27th October, 2004 to exercise powers under section 5 of the Environment(Protection) Act, 1986(29 of 1986) for issuing directions and for taking measures with respect to matters referred to in clauses(ix),(xi), (xii) and (xiii) of sub-section(2) of section 3 of the said Act and to standardise method(s) for water quality monitoring and to ensure quality of data generation for utilization thereof and certain other purposes;

AND WHEREAS it is necessary and expedient to evolve water quality assessment and monitoring protocol as directed by the Water Quality Assessment Authority in order to maintain uniformity in the procedure for water quality monitoring mechanism by all monitoring agencies, departments, Pollution Control Boards and such other agencies so that water related action plans may be drawn up on the basis of reliable data;

AND WHEREAS the uniform process on water quality monitoring shall provide frequency of monitoring, procedure for sampling, parameters for analysis, analytical techniques, quality assurance and quality control system, infrastructure requirement for laboratories, procedure for data processing, reporting and dissemination and such other matters as the Central Government deems necessary for the said purpose, both for surface and ground water;

AND WHEREAS due to the deterioration of the river water quality, health and livelihood of the downstream people are being severely affected and concerns are raised time and again;

AND WHEREAS the immediate maintenance and restoration of 'wholesomeness' of the river water quality is the mandate under the Water (Prevention and Control of Pollution) Act, 1974 (6 of 1974) and that of maintenance of the ground water quality by the Central Ground Water Authority constituted under the provisions of the Environment (Protection) Act, 1986;

AND WHEREAS sub-rule(4) of rule 5 of the Environment(Protection) Rules, 1986, provides that whenever it appears to the Central Government that it is in public interest to do so, it may dispense with the requirement of notice under clause(a) of sub-rule(3) of the said rules";

AND WHEREAS the Central Government is of the opinion that it is in public interest to dispense with the requirement of notice under clause(a) of sub-rule(3) of rule 5 of the said rules to issue the Order.

NOW, THEREFORE, in exercise of the powers conferred by section 3 of the Environment (Protection) Act, 1986, the Central Government hereby makes the following order, namely:-

1. **Short title and commencement.-**

(a) This order may be called the Uniform Protocol on Water Quality Monitoring Order, 2005".

(b) It shall come into force on the date of its publication in the Official Gazette.

2. **Application.-** It shall apply to all organizations, agencies and any other body monitoring surface and ground water quality for observance of uniform protocol on water quality monitoring.

3. **Definitions.-**

In this Order, unless the context otherwise requires,-

(1) **"agencies"** means water quality monitoring agencies(government or non-government, local bodies) and other organizations including research and academic institutions involved in water quality monitoring of surface and ground waters;

(2) **"Authority"** means the Water Quality Assessment Authority (WQAA) constituted under sub-sections (1) and (2) of section 3 of the Environment (Protection) Act, 1986;

(3) **"Baseline stations"** means the monitoring location where there is no influence of human activities on water quality;

(4) **"Flux stations or Impact stations"** means the location for measuring the mass of particular pollutant on main river stem for measuring the extent of pollution due to human interference or geological feature at any point of time and is necessary for measuring impact of pollution control measures adopted;

(5) **"monitoring"** means standardised measurements of identified parameters in order to define status and trends of water quality;

(6)**"protocol"** means a system of uniform water quality monitoring mechanism developed by the Water Quality Assessment Authority constituted under sub-sections (1) and (3) of section 3 of the Environment (Protection) Act, 1986;

(7) **"Quality Assurance Programme"** means a programme described in paragraph 12 of this Order.

(8) **"Trend station"** means the monitoring location designed to show how a particular point on a watercourse varies over time due, normally, to the influence of man's activities;

(9) **"water quality monitoring network"** means a systematic planning for collection, preservation and transportation, storage, analysis of water samples and dissemination of data for national water bodies restricted to surface and ground water in the country.

4. **Monitoring station and frequency of sampling.-**

(1) The frequency of sampling in respect of surface water shall be as follows:-

(a) all the stations shall be a combination of Baseline, Trend and Flux or Impact stations.

(b) the Baseline stations shall be monitored four times a year for perennial rivers and lakes and three to four times a year for seasonal rivers. Trend stations shall be monitored with an increased frequency of once in a month i.e. twelve times in a year. Flux or Impact stations shall be monitored twelve to twenty-four times in a year depending upon pollution potential or importance of water use.

(c) all agencies shall follow the sampling frequency and parameters for analysis of surface water as mentioned in the Table-I given below:-

Table-I
Frequencies and parameters for analysis of surface water samples

1 Type of Station	2 Frequency	3 Parameters
Baseline.	Perennial rivers and Lakes: Four times a year (seasonal) Seasonal rivers: 3-4 times (at equal spacing) during flow period. Lake: 4 times a year (seasonal)	(A) Pre-monsoon: Once a year Analyse 25 parameters as listed below : (a)General : Colour, odour, temperature, pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Turbidity, Total Dissolved Solid (TDS) (b) Nutrients: Ammoniacal Nitrogen (NH_4-N), Nitrite & Nitrate Nitrogen ($NO_2 + NO_3$), Total Phosphate (Total P) (c)Demand parameters: Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) (d)Major ions : Sodium (Na), Potassium (K), Calcium (Ca), Magnesium (Mg), Carbonate (CO_3), Bicarbonate (HCO_3), Chloride (Cl), Sulphate (SO_4) (e)Other inorganic: Fluoride (F), Boron (B) and other location specific parameter, if any (f)Microbiological: Total coliform and Faecal Coliform (B)Rest of the year (after the pre-monsoon sampling) at every three months' interval. Analyse 10 parameters: Colour, Odour, Temperature, pH, EC, DO, $NO_2 + NO_3$, BOD, Total coliform and Faecal Coliform.
Trend or Impact or Flux:	Once every month starting April-May (pre-monsoon), i.e. 12 times a year	(A)Pre-monsoon Analyse 25 parameters as listed for baseline monitoring (B)Other months : Analyse 15 parameters as listed below (a)General : Colour, Odour, Temp, pH, EC, DO and Turbidity (b)Nutrients : NH_4-N, $NO_2 + NO_3$, Total P (c)Organic Matter: BOD, COD (d)Major ions : Cl (e)Microbiological : Total and Faecal coliforms (C)Micropollutant : Once in a year / pre monsoon

		(i)Pesticides-Alpha Benzenehexachloride (BHC), Beta BHC, Gama BHC (Lindane), OP-Dichlorodiphenyltrichloroethane (OP-DDT), PP-DDT, Alpha Endosulphan, Beta Endosulphan, Aldrin, Dieldrin, Carbaryl (Carbamate), Malathian, Methyl Parathian, Anilophos, Chloropyriphos (ii)Toxic Metals-Arsenic (As), Cadmium (Cd), Mercury (Hg), Zinc (Zn), Chromium (Cr), Lead (Pb), Nickel (Ni), Iron (Fe) (The parameters may be selected based on local need).

Note: (i) The parameters mentioned in the above Table shall be the minimal requirement. This does not, however, restrict analysis of more parameters depending upon the specific requirements of the analysing agency and its manpower availability.

(ii) For lakes or reservoirs, monitoring of additional parameters, like total Kjeldhal Nitrogen, Chlorophyll, total Plankton count and productivity, shall be included in the list of parameters.

(iii) If biomonitoring is done in river or lakes or reservoirs, additional specific parameters are to be considered.

(2) **Ground Water**

The frequency of sampling in respect of ground water shall be as follows:

(a) all stations shall be classified as Baseline stations.

(b) 20-25 % of Baseline stations shall be classified as Trend stations where there is a perceived problem.

(c) all agencies shall follow the sampling frequency and parameters for analysis of ground water as mentioned in the Table-2 given below:-

Table -2

Frequencies and parameters for analysis of Ground Water samples

1	2	3
Type of Station	**Frequency**	**Parameters**
Baseline	Twice a year (Pre and Post monsoon season)	(A) Pre and Post Monsoon Season: Analyse 20 parameters as listed below:- (a) General: Colour, odour, temperature, pH, EC, TDS (b) Nutrients: NO2 ~ NO3, orthophosphate (c) Demand Parameter: COD (d) Major Ions: Na+, K+, Ca++, Mg++, CO_3^{--}, HCO_3^-, Cl^-, SO_4^{--} %Na & SAR (e) Other inorganics: F, B and other location-specific parameter, if any
Trend	Twice a year (pre and post	(A) April-May: Analyse 20 parameters as listed for Baseline monitoring. (B) Other times: Analyse 14 parameters as listed below:-

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	monsoon)	(f) General: Colour, odour, temp, EC, pH. TDS, %Na & SAR (a) Nutrients: NO2+NO3, orthophosphate (b) Demand parameter: COD (c) Major ions : Cl (d) Other inorganics : F,B (e) Microbiological: Total coliform and faecal coliform (C) Micropollutant (parameters may be selected based on local need) (2) Pesticides – Alpha BHC, Beta, BHC, Gama BHC (Lindane), OP-DDT, PP-DDT, Alpha Endosulphan, Beta Endosulphan, Aldrin, Dieldrin, 2, 4-D, Carbaryl (Carbamate), Malathian, Methyl, Parathian, Anilphos, Chloropyriphos. (3) Toxic Metals-As, Cd, Hg, Zn, Cr, Pb, Ni, Fe (Pesticides and Toxic metals may be analysed once a year in pre monsoon on selected locations).

Note:- (i) The parameters mentioned in the above Table shall be the minimal requirement. This does not, however, restrict analysis of more parameters depending upon the specific requirements of the analysing agency and its manpower availability.

(ii) If Chemcial Oxygen Demand(COD) value exceeds 20 mg/l, the sample shall be analysed for Biochemical Oxygen Demand(BOD) also.

5. Sample Collection.

(1) The procedure for sample collection in respect of surface water shall be as under:

(a) samples for Baseline and Trend stations shall be collected from well-mixed section of the river or main stem 30 cm below the water surface using a Dissolved Oxygen (DO) sampler or weighted bottle.

(b) samples for Impact stations shall be collected from the point of interest, such as bathing ghat, down stream of point discharge, water supply intakes and other sources.

(c) the Dissolved Oxygen (DO) in the sample shall be fixed immediately after collection and Dissolved Oxygen (DO) analysis shall be done either in the field or in laboratory.

(2) The procedure for sample collection in respect of ground water shall be as under:

(a) open dug wells, which are not in use or have been abandoned, shall not be considered as water quality monitoring station. However, such well could be considered for water level monitoring.

(b) weighted sample bottle to collect sample from an open well about 30 cm below the surface of water may be used. The plastic bucket, which is likely to skim the surface layer only, shall not be used.

(c) samples from the production tube wells shall be collected after running the well for about five minutes.

(d) non-production piezometers shall be purged using a submersible pump. The purged water volume shall equal 4 to 5 times the standing water volume, before sample is collected.

(e) for bacteriological samples, when collected from tube wells or hand pump, the spout or outlet of the pump shall be sterilized under flame by spirit lamp before collection of sample in container.

6. Sample preservation and transportation.

(1) The type of containers and sample preservation to be adopted shall be as mentioned in the Table-3 below:

Table-3

1	2	3
Analysis	Container	Preservation
General	Glass, PE	4^0C, dark
BOD	Glass, PE	4^0C, dark
COD, NH_3, NO_2, NO_3	Glass, PE	H_2SO_4, PH<2
Coliform	Glass, PE, Sterilised	4^0C, dark
DO	BOD bottle	DO fixing chemicals
Fluoride	PE	None
P	Glass	None
Pesticides	Glass, Teflon	4^0C, dark
Toxic metals	Glass, PE	HNO3, PH<2

(2) Samples shall be transported to concerned laboratory as soon as possible, preferably within forty-eight hours of collection.

(3) Analysis for coliforms shall be started within twenty-four hours of collection of sample. If time is exceeded, it should be recorded with the result.

(2) Samples containing microgram/l metal level should be stored at 4^0C and analyzed as soon as possible. If the concentration is of mg/l level, it can be stored for up to 6 months, except mercury, for which the limit is 5 weeks.

(5) Sample Identification for the water sample analysis for surface and ground water samples shall be as mentioned in the Form-I and Form-II.

7. Sample records.

(1) Each laboratory shall have a bound register, which shall be used for registering samples as they are received. A format for sample receipt register is annexed as **Form – III.**

(2) The Laboratory Incharge shall maintain a register for assignment of work to specific analyst.

8. Analytical techniques.

Each agency shall follow the analytical techniques prescribed in the Standard Methods for Analysis of Water and Wastewater published by American Public Health Association(Latest Edition) or Bureau of Indian Standards(BIS) Methods for Testing Water and Wastewater-methods of sampling and testing(physical and chemical) (IS:3025)

9. Analysis records and data validation.

A recommended format for recording data including all parameters except toxic metals and trace organics is enclosed as **Form – IV**. Report of heavy metals and trace organics as per Table 2 may be recorded separately. Validation checks should be performed in the laboratory on completion of the analysis. The results of laboratory analyses shall be entered in the format provided in **Form – II** for validation.

10. Manpower requirements in laboratories.

The manpower requirements shall be optimised by the concerned monitoring agencies in order to get the maximum utilization of mandays, for timely completion of analysis.

11. Data Processing, Reporting and Dissemination.

Each monitoring agency shall process the analytical data and report the data after validation to the Data Centre at the Central Pollution Control Board. The Central Pollution Control Board shall store the data and disseminate through website or electronic mail to various users on demand.

12. Quality Assurance and Accreditation of Laboratories.

The Quality Assurance Programme for the laboratories of various agencies shall contain a set of operating principles, written down and agreed upon by the organization, delineating specific functions and responsibilities of each person involved. Each laboratory of water quality monitoring agencies shall follow the guidelines of Quality Assurance Programme prescribed by their respective Central Laboratory or Headquarters and shall participate in Inter Laboratory Quality Assurance Programme like Proficiency Testing (PT) organized by them or any other agency on regular basis. The Water Quality Laboratories shall seek recognition from the Ministry of Environment and Forests, Government of India or accreditation from National Accreditation Board for Testing and Calibration Laboratories (NABL) under the Ministry of Science and Technology, Government of India.

[F. No. 15011/8/2004-NRCD]
M. SENGUPTA, Adviser

FORM-I

Sample identification for surface water samples analysis and record.

Sample code											
Observer	Agency				Project						
Date Time	Station code										
Parameter code	Container				Preservation				Treatment		
	Glass	PVC	PE	Tef-lon	None	Cool	Acid	Other	None	Decant	Filter
(1) General											
(2) Bacteriology											
(3) BOD											
(4) COD, NH_3, NO_3											
(5) Toxic Metals											
(6) Trace Organics											

Source of sample				
Water	Point	Approach	Medium	Matrix
0 River 0 Drain 0 Canal 0Reservoir (lakes/tank/pond)	0 Main current 0 Right bank 0 Left bank	0 Bridge 0 Boat 0 Wading	0 Water 0 Suspended matter 0 Biota 0 Sediment	0 Fresh 0 Brackish 0 Salt 0 Effluent
Sample type	0 Grab 0 Time-comp	0 Flow-comp	0 Depth-integ	0 Width-integ
Sample device	0 weighted bottle	0 Pump	0 Depth sampler	

Field determinations			
Temp °C	PH	EC micromhos/cm	DO mg/l
Odour Code	(1) Odour free (6) Septic (2) Rotten eggs (7) Aromatic (3) Burnt sugar (8) Chlorinous (4) Soapy (9) Alcoholic (5) Fishy (10) Unpleasant	Colour code	(1) Light brown (6) Dark green (2) Brown (7) Clear (3) Dark brown (8) Other (4) Light green (specify) (5) Green

Remarks	
Weather	0 Sunny 0 Cloudy 0 Rainy 0 Windy
Water vel. M/s	0 High (> 0.5) 0 Medium (0.1-0.5) 0 Low (< 0.1) 0 Standing
Water use	0 None 0 Cultivation 0 Bathing & washing 0 Cattle washing 0 Melon/vegetable farming in riverbed. 0 Organised water supply

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FORM-II

Sample identification for ground water samples.

Sample code											
Observer	Agency				Project						
Date	Time			Station code							
Source of sample: 0 Open dug well 0 Hand pump 0 Tube well 0 Piezometer											
Parameter code	Container				Preservation				Treatment		
	Glass	PVC	PE	Tef-lon	None	Cool	Acid	Other	None	Decant	Filter
(1) General											
(2) Bacterlogical											
(3) BOD											
(4) COD, NH_3, NO_3											
(5) Toxic Metals.											
(6) Tr. Organics											

Field determinations			
Temp ^0C	PH	EC micromho/cm	DO mg/l
Odour Code	(1) Odour free (6) Septic (2) Rotten eggs (7) Aromatic (3) Burnt sugar (8) Chlorinous (4) Soapy (9) Alcoholic (5) Fishy (10) Unpleasant	Colour code	(1) Light brown (6) Dark green (2) Brown (7) Clear (3) Dark brown (8) Other (4) Light green (specify) (5) Green

IF WELL IS PURGED, COMPLETE BELOW:-

Office Well Data			
Diameter	Q		cm
Depth	D		m
Static water level (avg)	SWL		m
Water column (D-SWL)	H		m
Initial volume well	V		L
Projected pump discharge	PQ		L/s
Projected time of purging (V/PQ)	PT		min

Field Flow Measurement			
Static water level on arrival	SWL		M
Actual pump setting			m
Purging duration			Min
Pump Discharge before sampling	Q		L/min
Pump Discharge after sampling	Q		L/min
Volume purged	V		L
Dynamic water level	DWL		M

Field Chemical Measurement			
Time at start of sampling started	T (^0C)	EC (micromho/cm)	pH
+10 min			
+20 min			
+30 min			
+40 min			

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FORM-III
Sample Record for Analysis

Date/Time received at lab.	Date/Time collected	Station code	Project	Collecting agency / collector	Pre-servation	Parameter code	Lab. Sample No.
1	2	3	4	5	6	7	8

Sample receipt register

Note:-

- Column 3 gives the station code conventionally followed by the monitoring agency.
- Column (4) gives the project under which the sample is collected.
- Column (7) corresponds to the parameter(s) code given in the sample identification form.
- Column (8) gives the laboratory sample assigned to the sample as it is received in the laboratory. Note that the numbering has two parts separated by a hyphen. The first part is assigned in a sequential manner as samples are received from various stations. If two samples are collected at the same time from a station for different sets of analysis, the first part of the number is the same. The second part corresponds to the parameter code as given in the sample.
- The results of the analyses of all the samples having the same first part of the code would be entered in the data entry system as one sample having the same station code and time of sample collection

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FORM-IV

Data record / Laboratory/organization / Laboratory code

No.	Parameter	Group
1.		
2.		
3.		Date of collection
4.	pH	Field determination
5.	EC, micromohs/cm	
6.	DO, mg/l	
7.	Temp, °C	
8.	Colour, code	
9.	Odour, code	
10.	pH	General
11.	EC, umho/cm	
12.	TDS, mg/l	
13.	TSS, mg/l	
14.	NH_3, mg N/l	Nutrients
15	NO_2, NO_3, mg N/l	
16.	Total, mg/l	
17.	BOD, mg/l	Org matter
18.	COD, mg/l	
19.	Phen, mg C_aCO_3/l	Alkalinity
20.	Total, mg C_aCO_3/l	
21.	Total, mg C_aCO_3/l	Hardness
22.	C_a++, mg C_aCO_3/l	
23.	Ca^{++}, mg/l	Major Ions
24.	Mg^{++}, mg/l	
25.	Na^{+}, mg/L	
26.	K^{+}, mg/l	
27.	Cr, mg/l	
28.	SO_4.mg/L	
29.	CO_3, mg/l	
30.	HCO_3, mg/l	
31.	Si, mg/l	Other inorganics
32.	F, mg/l	
33.	B,mg/l	
34.	Total, MPN/100 ml	Coliforms
35.	Faecal, MPN/100ml	
36.	Chlorophyll-A, mg/l	Biol

Data validation

No.	Parameter	Group
1		Lab sample No.
2		Station code
37	Ca^{++} meq/l	Cations
38	Mg^{++},meq/l	
39	Na^{+}, meq/l	
40	K^{++} meq/l	
41	meq/l Total cations	
42	Cl, meq/l	Anions
43	SO_4, meq/l	
44	CO_3, meq/l	
45	HCO_3, meq/l	
46	NO_2+NO3, meq/l	
47	Total anions meq/l	
48	{(41)-(47)/(41)+(47)} (39) / (42)	Ion balance
49	(12) / (11)	TDS/EC Ratio
50	(17) / (18)	BOD/COD Ratio
51	If (10) < 8.3, is (19)=0?	PH, Vs; Alkalinity Ratio
		CO3. bal
52		
53	(48) (49) (50) (51) (52)	Verification criteria
54		Checked by
55		Remarks

ANNEXURE - 4

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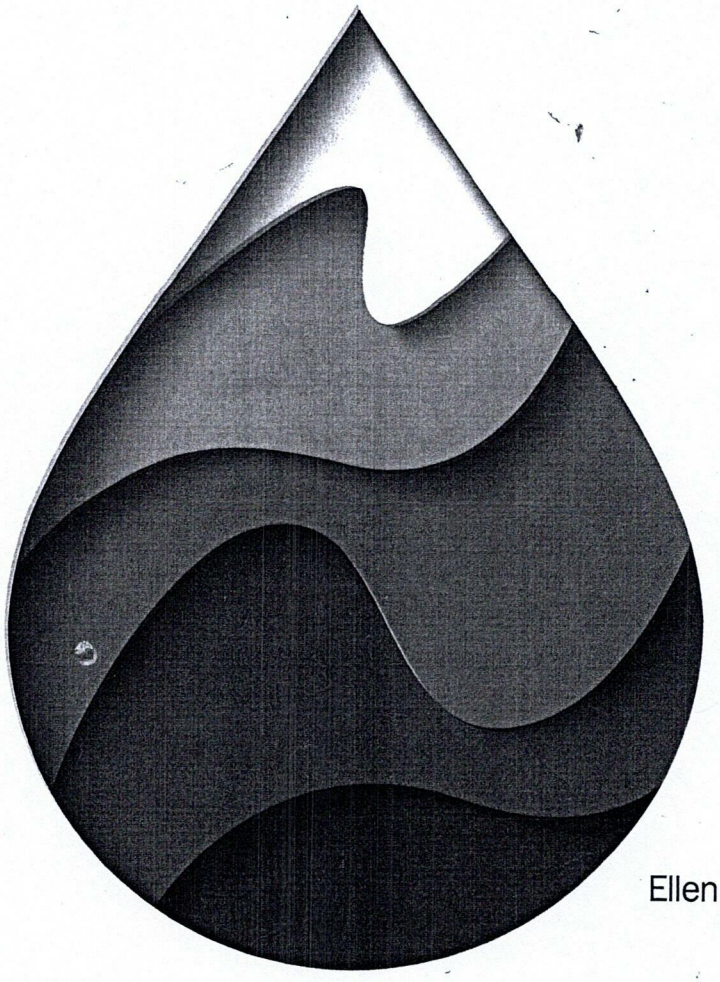
83.

Standard Methods

for the Examination of Water and Wastewater

24TH EDITION



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9221

MULTIPLE-TUBE FERMENTATION TECHNIQUE FOR MEMBERS OF THE COLIFORM GROUP

Approved by Standard Methods Committee, 2014. Joint Task Group: Ellen B. Braun-Howland (chair), Jennifer Best, Robert J. Blodgett, Laura Boczek, Gil Dichter, Clifford H. Johnson.

9221 A. INTRODUCTION

Coliform bacteria have long been used as water-quality indicators based on the premise that, because these organisms are present in the intestines of warm-blooded animals, their presence in water could indicate that recent fecal contamination has occurred. Historically, this group of organisms has been defined by their ability to ferment lactose, rather than through the tenets of systematic bacteriology, so the group consists of bacteria from several genera belonging to the family Enterobacteriaceae.

The methods described in this section use a lactose-based broth medium to detect the metabolic end products of lactose fermentation. The presence of coliforms must be confirmed in a lactose- and bile salt-containing medium [brilliant green lactose bile (BGLB) broth]. Thus, when the fermentation techniques in this section are used, *coliforms* are defined as all facultatively anaerobic, Gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose to produce acid, gas, or both in the presence of bile salts within 48 h at 35 °C.

The standard test for the coliform group may be carried out by the multiple-tube fermentation technique or presence-absence procedure (through the presumptive-confirmed phases or completed test) described herein, the membrane filter (MF) technique (Section 9222), or the enzymatic substrate coliform test (Section 9223). Each technique is applicable within the limitations specified and with due consideration of the purpose of the examination. Production of valid results requires strict adherence to quality control (QC) procedures, which are outlined in Section 9020.

The fermentation technique can be used to detect coliforms in drinking water or quantitate coliforms in potable and nonpotable water. When multiple tubes are used, coliform density is estimated via a most probable number (MPN) table. This number, generated using specific probability formulas, is an estimate of the mean density of coliforms in the sample. Coliform testing results, together with other information obtained from engineering or sanitary surveys, provide the best assessment of water-treatment effectiveness and the sanitary quality of source water.

The fermentation test's precision in estimating coliform density depends on the number of tubes used. The most satisfactory information is obtained when the largest sample inoculum examined shows production of acid or gas in some or all of the tubes; and the smallest sample inoculum shows no acid or gas in any or most of the tubes. Bacterial density can be estimated by the formula given or from the table using the number of positive tubes in the multiple dilutions (9221 C.2). The number of sample portions selected is governed by the desired precision of the result. The MPN tables are based on the assumption of a Poisson distribution (random dispersion). However, if the sample is not adequately shaken before aliquots are removed or if bacterial cells clump, the MPN value will be an underestimate of actual bacterial density.

1. Potable Water

When analyzing drinking water to determine whether its quality meets US EPA standards, a 100-mL sample must be analyzed; use the fermentation technique with 10 replicate tubes each containing 10 mL, 5 replicate tubes each containing 20 mL, or a single bottle containing a 100-mL sample portion. When examining drinking water via the fermentation technique, process all tubes or bottles demonstrating growth—with or without a positive acid or gas reaction—through the confirmed phase (9221 B.4). Drinking water samples that are positive for total coliforms also must be tested for thermotolerant (fecal) coliforms (9221 E) or *Escherichia coli* (9221 F).

For the routine examination of public water supplies, the objective of the total coliform test is to determine the efficiency of treatment plant operations and the integrity of the distribution system. The test is also used to screen for the presence of fecal contamination. Some coliform occurrences in a distribution system may be attributed to coliform growth or survival within bacterial biofilms in the mains rather than treatment failure at the plant or well source, or outside contamination of the distribution system. Because it is difficult to distinguish coliforms entering the distribution system and coliforms already present in the pipe biofilm and sediments, assume that all coliforms originate from a source outside the distribution system.

2. Nonpotable Water

When analyzing nonpotable waters, inoculate a series of tubes with appropriate decimal dilutions of the water (multiples of 10 mL) based on the probable coliform density. Use the presumptive-confirmed phases of the multiple-tube procedure. Use the more labor-intensive completed test (9221 B.5) as a QC measure on 10% (or a set percentage) of coliform-positive nonpotable water samples quarterly. Generally, the objective of analyzing nonpotable water is to estimate bacterial density, determine a pollution source, enforce water quality standards, or trace the survival of microorganisms. The multiple-tube fermentation technique may be used to obtain statistically valid MPN estimates of coliform density. Examine a sufficient number of water samples to yield representative results for the sampling station. Generally, the geometric mean or median value of the results of a number of samples yields a value in which the effect of sample-to-sample variation is minimized.

3. Other Samples

The multiple-tube fermentation technique applies to the analysis of salt or brackish waters, as well as muds, sediments, and sludges. Collect samples as directed in Section 9060 A, using sample containers specified in Section 9030 B.19. Follow the precautions given above on portion sizes and numbers of tubes per dilution.

To prepare solid or semisolid samples, weigh the sample and add diluent to make a 10^{-1} dilution. For example, place 30 g sample in a sterile blender jar, add 270 mL sterile phosphate buffered or 0.1% peptone dilution water, and blend for 1 to 2 min at high speed (8000 rpm). Prepare the appropriate decimal dilutions of the homogenized slurry as quickly as possible to minimize settling.

(9221) B. Standard Total Coliform Fermentation Technique

1. Samples

Collect samples as directed in Section 9060 A, using sample containers specified in Section 9030 B.19. Follow the QC guidelines for sample bottles described in Section 9020 B.5*d*. Ensure that samples meet laboratory acceptance criteria upon receipt.

2. Quality Control

All phases of the fermentation technique (9221 B-G) require adherence to the quality assurance/quality control (QA/QC) guidelines presented in Section 9020, including, but not limited to, analytical QC (Section 9020 B.9), instrumentation/equipment (Sections 9020 B.4 and 9030 B), and supplies (Section 9020 B.5). Refer to Table 9020:1 for key QC procedures. Also, note the sections pertaining to appropriate storage and preparation of dehydrated culture media and water quality (Sections 9050 and 9020 B.5*f*).

Use commercial dehydrated media when possible, and ensure that their formulations match those specified here because commercial formulations may vary. Prepared fermentation media can be stored in tightly capped tubes or bottles for up to 3 months in the dark, if temperatures are between 1 and 30 °C and evaporation is less than 10% of the original volume. If the tubes were refrigerated after sterilization, incubate them overnight at room temperature (20 °C) before use and discard those showing growth or bubbles to avoid false-positive results. To demonstrate acceptable medium performance, positive and negative culture controls must be tested before first use and as otherwise specified (see Table 9020:6). Verify and record sterility, volume per tube, and pH. To demonstrate comparability between batches of media, perform a use test (Section 9020 B.5*f*2).

When switching to the multiple-tube fermentation technique, ideally first conduct parallel tests with the previous method to demonstrate applicability and comparability. The results of many coliform performance studies are available in the literature, and the rates of false-positive and -negative results can differ among various media. Carefully select the medium and procedure that best fits the requirements.

3. Presumptive Phase

Use lauryl tryptose broth in this phase of the multiple-tube test, following the QC guidelines cited in 9221 B.2.

a. Reagents and culture medium:

Lauryl tryptose broth:

Tryptose	20.0 g
Lactose	5.0 g
Dipotassium hydrogen phosphate (K_2HPO_4)	2.75 g
Potassium dihydrogen phosphate (KH_2PO_4)	2.75 g
Sodium chloride (NaCl)	5.0 g
Sodium lauryl sulfate	0.1 g
Reagent-grade water	1 L

Add dehydrated ingredients to water, mix thoroughly, and heat to dissolve. Before sterilization, dispense enough medium into fermentation tubes containing inverted vials (also known as Durham tubes) to cover the inverted vial at least one-half to two-thirds after sterilization. Alternatively, add 0.01 g/L bromocresol purple to lauryl tryptose broth to determine acid production, an indicator of a positive result in this part of the coliform test. Inverted vials are not required if bromocresol purple is added, but their inclusion permits evaluation of both gas and acid production in the sample. Close tubes with metal or heat-resistant plastic caps.

Prepare in accordance with Table 9221:1, making lauryl tryptose broth concentrated enough that adding 100-, 20-, or 10-mL portions of sample to the medium does not reduce ingredient concentrations below those of the standard medium. Autoclave medium at 121 °C for 12 to 15 min. Ensure that inverted vials, if used, are free of air bubbles. The medium pH must be 6.8 ± 0.2 after sterilization.

b. Procedure:

1) Arrange fermentation tubes in rows of 5 or 10 tubes each in a test tube rack. The number of rows and the sample volumes selected depend on the quality and character of the water to be examined. For potable water, 100 mL must be tested. Use five 20-mL portions, ten 10-mL portions, or one 100-mL portion (a single bottle). For nonpotable water, use 5 tubes per dilution (e.g., of 10, 1, 0.1 mL).

When making dilutions and measuring diluted sample volumes, follow the precautions given in Section 9215 B.2. Use Figure 9215:1 as a guide to preparing dilutions. Shake sample and dilutions

Table 9221:1. Preparation of Lauryl Tryptose Broth

Inoculum (mL)	Amount of Medium in Tube (mL)	Volume of Medium + Inoculum (mL)	Dehydrated Lauryl Tryptose Broth Required (g/L)
1	10 or more	11 or more	35.6
10	10	20	71.2
10	20	30	53.4
20	10	30	106.8
100	50	150	106.8
100	35	135	137.1
100	20	120	213.6

vigorously 5 s (about 25 times). Inoculate each tube in a set of 5 with replicate sample volumes in increasing decimal dilutions, if decimal quantities of the sample are used. Mix test portions in the medium by gentle agitation.

2) Promptly incubate inoculated tubes or bottles, any culture controls, and sterility blanks at 35 ± 0.5 °C. After 24 ± 2 h, swirl each tube or bottle gently and examine it for growth, gas, and acidic reaction (shades of yellow color) and, if no gas or acidic reaction is evident, re-incubate and re-examine at the end of 48 ± 3 h. Record the presence or absence of growth, gas, and acid production. If the inner vial is omitted, growth with acidity (yellow color) signifies a presumptive positive reaction.

c. Interpretation: Detection of an acidic reaction (yellow color) or gas in the tubes or bottles within 48 ± 3 h constitutes a presumptive positive reaction. Submit tubes or bottles with a presumptive positive reaction to the confirmed phase (9221 B.4).

The absence of acidic reaction or gas formation at the end of 48 ± 3 h of incubation constitutes a negative test. Submit drinking water samples demonstrating growth without a positive gas or acidic reaction to the confirmed phase (9221 B.4).

4. Confirmed Phase

a. Culture medium: Use BGLB broth fermentation tubes for the confirmed phase, following QC guidelines cited in 9221 B.2.

Brilliant green lactose bile broth:

Peptone	10.0 g
Lactose	10.0 g
Oxgall	20.0 g
Brilliant green	0.0133 g
Reagent-grade water	1 L

Add dehydrated ingredients to water, mix thoroughly, and heat to dissolve. Before sterilization, dispense medium into fermentation tubes with an inverted vial, ensuring sufficient volume of medium to cover the inverted vial at least one-half to two-thirds after sterilization. Close tubes with metal or heat-resistant plastic caps. Autoclave medium at 121 °C for 12 to 15 min. Ensure that inverted vials are free of air bubbles. The medium pH must be 7.2 ± 0.2 after sterilization.

b. Procedure: Promptly submit all presumptive tubes or bottles showing growth, any amount of gas, or acidic reaction within 24 ± 2 h of incubation to the confirmed phase. If additional presumptive tubes or bottles show active fermentation or acidic reaction at the end of a 48 ± 3 h incubation period, promptly submit these to the confirmed phase. To confirm presumptive coliform colonies growing on a solid medium using fermentation media, see Section 9222 B.4*g*.

Gently shake or rotate presumptive tubes or bottles showing gas or acidic growth to resuspend the organisms. With a sterile loop 3.0 to 3.5 mm in diameter, transfer one or more loopfuls of culture to a fermentation tube containing BGLB broth. Alternatively, insert a sterile wooden applicator at least 2.5 cm into the culture, promptly remove, and plunge applicator to the bottom of fermentation tube containing BGLB broth. Remove and discard the applicator. Repeat for all other presumptive positive tubes. Analysts may simultaneously inoculate BGLB broth for total coliforms and EC broth for thermotolerant (fecal) coliforms (see 9221 E) or EC-MUG broth for *Escherichia coli* (see 9221 F). However, if using the same loop or wooden applicator stick to inoculate a culture into more than one medium, inoculate the most inhibitory medium (BGLB broth) last.

Promptly incubate the inoculated BGLB broth tubes at 35 ± 0.5 °C. Any amount of gas formed in the inverted vial of the BGLB broth fermentation tube at any time within 48 ± 3 h constitutes a positive confirmed phase. To estimate the coliform density, calculate the MPN value from the number of positive BGLB tubes as described in 9221 C.

c. Alternative procedure: Use this alternative only for polluted water or wastewater known to produce positive results consistently.

If all presumptive tubes are positive in 2 or more consecutive dilutions within 24 h, then only submit to the confirmed phase the highest-dilution tubes (smallest sample inoculum) in which all tubes are positive, along with any positive tubes in still higher dilutions. Submit to the confirmed phase all tubes in which gas or acidic growth is produced in 24 to 48 h.

5. Completed Phase

The completed test as described here is not required for drinking-water compliance sample analyses. For nonpotable water samples collected under the Clean Water Act, the requirement that 10% of all total-coliform-positive tubes be subjected to the completed test on a seasonal basis no longer exists. The completed test is included here as a QC recommendation and for use when testing results are uncertain. As additional testing for thermotolerant (fecal) coliforms or *E. coli* is required of positive coliform tests, further testing using EC or EC-MUG broths is considered a completed test. For QC purposes, if no positive drinking water samples are received within a quarter, then analyze at least one positive source-water sample to confirm that media respond appropriately.

To verify the presence of coliform bacteria and to provide QC data for nonpotable water sample analysis, use the completed test on at least one positive sample per quarter. If no positive sample occurs within a quarter, perform a QC check using a known positive sample. Analysts may simultaneously inoculate presumptive-positive media into both BGLB broth for confirmation of total coliforms and EC broth for thermotolerant (fecal) coliforms (9221 E) or EC MUG broth for *Escherichia coli* (9221 F) as long as BGLB broth is inoculated last. Positive results from incubation in EC or EC-MUG broths at elevated temperature (44.5 ± 0.2 °C) can be considered a completed test. Parallel positive BGLB broth cultures with negative EC or EC-MUG broth cultures indicate the presence of nonfecal coliforms. Parallel positive EC or EC-MUG tubes and negative BGLB broth cultures indicate the presence of thermotolerant (fecal) coliforms or *E. coli*, respectively. Alternatively, the completed test for positive total coliforms may be performed as follows.

a. Culture media and reagents: Follow the QC guidelines cited in 9221 B.2.

1) *LES Endo agar*—See Section 9222 B.2*a*. Use 100- × 15-mm petri plates.

2) *MacConkey agar:*

Peptone	17 g
Proteose peptone	3 g
Lactose	10 g
Bile salts	1.5 g
Sodium chloride (NaCl)	5 g
Agar	13.5 g
Neutral red	0.03 g
Crystal violet	0.001 g
Reagent-grade water	1 L

Add ingredients to water, mix thoroughly, and heat to boiling to dissolve. Sterilize by autoclaving for 15 min at 121 °C. Temper agar after sterilization and pour into petri plates (100 × 15 mm). Medium pH must be 7.1 ± 0.2 after sterilization.

3) *Nutrient agar:*

Peptone	5.0 g
Beef extract	3.0g
Agar	15.0 g
Reagent-grade water	1 L

Add ingredients to water, mix thoroughly, and heat to dissolve. Before sterilization, dispense in screw-capped tubes. Autoclave at 121 °C for 15 min. The medium's pH must be 6.8 ± 0.2 after sterilization. After sterilization, immediately place tubes in an inclined position so the agar solidifies with a sloped surface. Tighten screw caps after cooling and store in a protected, cool storage area.

4) *Gram-stain reagents*—Reagents are commercially available as prepared solutions.

a) *Ammonium oxalate-crystal violet (Hucker's)*—Dissolve 2 g crystal violet (90% dye content) in 20 mL 95% ethyl alcohol. **Caution: Flammable.** Dissolve 0.8 g $(NH_4)_2C_2O_4 \cdot H_2O$ in 80 mL reagent-grade water. Mix the 2 solutions and age for 24 h before use. Filter through paper into a staining bottle.

b) *Lugols solution, Gram's modification*—Grind 1 g iodine crystals and 2 g KI in a mortar. Add reagent-grade water, a few milliliters at a time, and grind thoroughly after each addition until solution is complete. Rinse solution into an amber glass bottle with the remaining water, using a total of 300 mL.

c) *Counterstain*—Dissolve 2.5 g safranin dye in 100 mL 95% ethyl alcohol. Add 10 mL to 100 mL reagent-grade water. **Caution: Flammable**.

d) *Acetone alcohol*—Mix equal volumes of ethyl alcohol (95%) with acetone. **Caution: Flammable**.

b. Procedure:

1) Using aseptic technique, streak one LES Endo agar (Section 9222 B.2*a*) or MacConkey agar plate from each presumptive positive tube of BGLB broth as soon as possible after gas is observed. Streak plates in a manner to ensure the presence of some discrete colonies separated by at least 0.5 cm. To obtain a high proportion of successful isolations if coliform organisms are present, use the following approach:

a) Use a sterile 3-mm-diam loop or an inoculating needle slightly curved at the tip;

b) tap and incline the fermentation tube to avoid picking up any membrane or scum on the needle;

c) insert the end of the loop or needle into the liquid in the tube to a depth of approximately 0.5 cm; and

d) streak a plate for isolation with the curved section of the needle in contact with the agar to avoid a scratched or torn surface. Flame the loop between the second and third quadrants to improve colony isolation.

Incubate plates, inverted, at 35 ± 0.5 °C for 24 ± 2 h.

2) The colonies developing on LES Endo agar are defined as *typical* (pink to dark red with a green metallic surface sheen) or *atypical* (pink, red, white, or colorless colonies without sheen) after 24 h incubation. Typical lactose-fermenting colonies developing on MacConkey agar are red and may be surrounded by an opaque zone of precipitated bile. From each plate, pick one or more typical, well-isolated coliform colonies or, if no typical colonies are present, pick 2 or more colonies considered most likely to be coliforms. Transfer the growth from each isolate to a single-strength lauryl tryptose broth fermentation tube and onto a nutrient agar slant.

If needed, use a colony-magnifying device to provide optimum magnification when colonies are picked from the LES Endo or MacConkey agar plates. When transferring colonies, choose well-isolated ones and barely touch the colony surface with a flame-sterilized, air-cooled transfer needle to minimize the danger of transferring a mixed culture.

Incubate secondary broth tubes (lauryl tryptose broth with inverted fermentation vials) at 35 ± 0.5 °C for 24 ± 2 h; if gas is not produced within 24 ± 2 h, reincubate and examine again at 48 ± 3 h. Microscopically examine Gram-stained preparations from those 24-h nutrient agar slant cultures corresponding to the secondary tubes that show gas.

3) Gram-stain technique—The Gram stain may be omitted from the completed test for potable-water samples only because Gram-positive bacteria and spore-forming organisms in drinking water rarely survive this selective screening procedure.

Various modifications of the Gram-stain technique exist. Use Hucker's modification (as follows) for staining smears of pure cultures; include a Gram-positive and a Gram-negative culture as controls.

On one slide, prepare separate light emulsions of the test bacterial growth and positive and negative control cultures using drops of reagent-grade water on the slide. Air-dry, fix by passing slide through a flame, and stain for 1 min with ammonium oxalate-crystal violet solution. Rinse the slide in tap water and drain off the excess; apply Lugols solution for 1 min.

Rinse the stained slide in tap water. Decolorize for approximately 15 to 30 s with acetone alcohol by holding the slide between the fingers and letting acetone alcohol flow across the stained smear until the solvent flows colorlessly from the slide. Do not overdecolorize. Counterstain with safranin for 15 s, rinse with tap water, blot dry with absorbent paper or air dry, and examine microscopically. Gram-positive organisms are blue; Gram-negative organisms are red. Results are acceptable only when controls have given proper reactions.

c. Interpretation: Formation of gas in the secondary tube of lauryl tryptose broth within 48 ± 3 h and demonstration of Gram-negative, nonspore-forming, rod-shaped bacteria from the agar culture constitute a positive result for the completed test, demonstrating that a member of the coliform group is present.

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9221 C. Estimation of Bacterial Density

1. Precision of the Multiple-Tube Fermentation Test

The multiple-tube fermentation test is not very precise unless many sample portions are examined, so use caution when interpreting the sanitary significance of any single coliform result. Precision improves greatly when several samples from a given sampling point are estimated separately and their geometric mean is calculated.

Although most probable number (MPN) tables and calculations are described for use in the coliform test, they also can be used to determine the MPN of any organism so long as suitable test media are available. Online MPN calculators are available, but until a calculator's accuracy has been verified, confirm its results using an MPN table in this section.

2. Use of Tables to Determine MPN

Record the coliform concentration as MPN/100 mL. The MPN values for a variety of positive and negative tube combinations are given in Table 9221:2, Table 9221:3 and Table 9221:4. The sample volumes indicated in Tables 9221:2 and 3 are chosen especially for drinking water examinations. Table 9221:4 illustrates MPN values for combinations of positive and negative results when five 10-mL, five 1.0-mL, and five 0.1-mL sample-portion volumes of nonpotable water are tested. If the sample-portion volumes tested are identical to those found in the tables, then report the value corresponding to the appropriate combination of positive and negative results as the MPN/100 mL. However, if the series of decimal dilutions is different, then select the MPN value in Table 9221:4 that corresponds to the combination of positive results and calculate the actual MPN using the following formula:

$$\text{MPN/100 mL} = (\text{Table MPN/100 mL}) \times 10/V$$

where:

V = volume of sample portion at the lowest selected dilution.

If the decimal series[1] includes more than 3 dilutions, use the following guidelines to select the 3 most appropriate dilutions and then use Table 9221:4 and the equation above to calculate the MPN. See Table 9221:5, which provides several examples (A-G) of combinations of positives. First, remove the highest dilution (smallest sample volume) if it has all negative tubes and at least one remaining dilution has a negative tube. Next, remove the lowest dilution (largest sample volume) if it has all positive tubes and at least one remaining dilution has a positive tube. According to these guidelines, the 3 dilutions in Example A are selected by removal of the highest (0.001-mL) and the lowest (10-mL) dilutions.

If the lowest dilution does not have all positive tubes, and several of the highest dilutions have all negative tubes, then remove the highest negative dilutions (Example B).

More than 3 dilutions may remain after removal of the lowest dilution with all positive tubes and high dilutions with all negative tubes. In this case, if the highest dilution with *all* positive tubes is within 2 dilutions of the highest dilution with *any* positive tubes, then use the highest dilution with *any* positive tubes and the 2 immediately lower dilutions. In Example C, the highest dilution with all positive tubes is 0.1 mL, which is within 2 dilutions of 0.001 mL, which has 1 positive tube. In Example D, the highest

Table 9221:2. MPN Index and 95% Confidence Limits for All Combinations of Positive and Negative Results When Five 20-mL Portions Are Used

No. of Tubes Giving Positive Reaction Out of 5 (20 mL Each)	MPN Index/ 100 mL	95% Confidence Limits (Exact)	
		Lower	Upper
0	<1.1	–	3.5
1	1.1	0.051	5.4
2	2.6	0.40	8.4
3	4.6	1.0	13
4	8.0	2.1	23
5	>8.0	3.4	–

Table 9221:3. MPN Index and 95% Confidence Limits for All Combinations of Positive and Negative Results When Ten 10-mL Portions Are Used

No. of Tubes Giving Positive Reaction Out of 10 (10 mL Each)	MPN index/ 100 mL	95% Confidence Limits (Exact)	
		Lower	Upper
0	<1.1	–	3.4
1	1.1	0.051	5.9
2	2.2	0.37	8.2
3	3.6	0.91	9.7
4	5.1	1.6	13
5	6.9	2.5	15
6	9.2	3.3	19
7	12	4.8	24
8	16	5.8	34
9	23	8.1	53
10	>23	13	–

Table 9221:4. MPN Index and 95% Confidence Limits for Various Combinations of Positive Results When Five Tubes Are Used per Dilution (10 mL, 1.0 mL, 0.1 mL)[a]

Combination of Positives	MPN Index/ 100 mL	Confidence Limits		Combination of Positives	MPN Index/ 100 mL	Confidence Limits	
		Low	High			Low	High
0-0-0	<1.8	–	6.8	4-0-3	25	9.8	70
0-0-1	1.8	0.090	6.8	4-1-0	17	6.0	40
0-1-0	1.8	0.090	6.9	4-1-1	21	6.8	42
0-1-1	3.6	0.70	10	4-1-2	26	9.8	70
0-2-0	3.7	0.70	10	4-1-3	31	10	70
0-2-1	5.5	1.8	15	4-2-0	22	6.8	50
0-3-0	5.6	1.8	15	4-2-1	26	9.8	70
1-0-0	2.0	0.10	10	4-2-2	32	10	70
1-0-1	4.0	0.70	10	4-2-3	38	14	100
1-0-2	6.0	1.8	15	4-3-0	27	9.9	70
1-1-0	4.0	0.71	12	4-3-1	33	10	70
1-1-1	6.1	1.8	15	4-3-2	39	14	100
1-1-2	8.1	3.4	22	4-4-0	34	14	100
1-2-0	6.1	1.8	15	4-4-1	40	14	100
1-2-1	8.2	3.4	22	4-4-2	47	15	120
1-3-0	8.3	3.4	22	4-5-0	41	14	100
1-3-1	10	3.5	22	4-5-1	48	15	120
1-4-0	11	3.5	22	5-0-0	23	6.8	70
2-0-0	4.5	0.79	15	5-0-1	31	10	70
2-0-1	6.8	1.8	15	5-0-2	43	14	100
2-0-2	9.1	3.4	22	5-0-3	58	22	150
2-1-0	6.8	1.8	17	5-1-0	33	10	100
2-1-1	9.2	3.4	22	5-1-1	46	14	120
2-1-2	12	4.1	26	5-1-2	63	22	150
2-2-0	9.3	3.4	22	5-1-3	84	34	220
2-2-1	12	4.1	26	5-2-0	49	15	150
2-2-2	14	5.9	36	5-2-1	70	22	170
2-3-0	12	4.1	26	5-2-2	94	34	230
2-3-1	14	5.9	36	5-2-3	120	36	250
2-4-0	15	5.9	36	5-2-4	150	58	400
3-0-0	7.8	2.1	22	5-3-0	79	22	220
3-0-1	11	3.5	23	5-3-1	110	34	250
3-0-2	13	5.6	35	5-3-2	140	52	400
3-1-0	11	3.5	26	5-3-3	170	70	400
3-1-1	14	5.6	36	5-3-4	210	70	400
3-1-2	17	6.0	36	5-4-0	130	36	400
3-2-0	14	5.7	36	5-4-1	170	58	400
3-2-1	17	6.8	40	5-4-2	220	70	440
3-2-2	20	6.8	40	5-4-3	280	100	710
3-3-0	17	6.8	40	5-4-4	350	100	710
3-3-1	21	6.8	40	5-4-5	430	150	1100
3-3-2	24	9.8	70	5-5-0	240	70	710
3-4-0	21	6.8	40	5-5-1	350	100	1100
3-4-1	24	9.8	70	5-5-2	540	150	1700
3-5-0	25	9.8	70	5-5-3	920	220	2600
4-0-0	13	4.1	35	5-5-4	1600	400	4600
4-0-1	17	5.9	36	5-5-5	>1600	700	–
4-0-2	21	6.8	40				

[a] Results to 2 significant figures.

dilution with all positive tubes is 0.01 mL, which is within 2 decimal dilutions of 0.001 mL, to yield a combination of 4-5-1.

If, after removal of the lowest dilution with all positive tubes, no dilution with all positive reactions remains, then select the lowest 2 dilutions and assign the sum of any remaining dilutions to the third dilution. In Example E, the highest dilution with all positive tubes contains 10 mL; this dilution was removed in the second step. Four dilutions, none of which have all positive tubes, remain. Under these circumstances, select the 2 lowest remaining dilutions corresponding to 1 and 0.1 mL of sample. For the third dilution, add the number of positive tubes in all higher dilutions (0.01 and 0.001 mL of sample), to yield a final combination of 4-4-1.

If no dilution has all positive tubes (Example F), select the lowest 2 dilutions, corresponding to 10 and 1 mL of sample. For the third dilution, add the number of positive tubes in the remaining dilutions (0.1, 0.01, and 0.001 mL of sample), to yield a final combination of 4-3-2. If the third dilution is assigned more than 5 positive tubes, then the selected combination will not be in Table 9221:4.

If the 3 dilutions selected are not found in Table 9221:4, then something in the serial dilution was unusual. In this case, the usual methods for calculating the MPN, presented here, may not apply. If a new sample cannot be collected and an MPN value is still desired, use the highest dilution with at least 1 positive tube and the 2 dilutions immediately lower as the 3 selected dilutions. In Example G, the first selection, 4-3-6 (the outcome from the highest 3 dilutions), is not in Table 9221:4 because 6 is greater than 5. The second selection, according to the above guidelines, would be 3-2-1. If this second set of selected dilutions is not in Table 9221:4, then use the following formula to calculate the MPN:

$$-\frac{230.3}{z_s}\log_{10}\left(1-\frac{x_s z_s}{\sum_{j=s}^{K} n_j z_j}\right)$$

where:

z_s = the amount of the original sample inoculated into each tube of the sth dilution,
x_s = the number of positive tubes in the sth dilution,
K = the number of dilutions,
j = a dilution,
s = the highest dilution with at least one positive tube,
n_j = the number of tubes in the jth dilution, and
z_j = the amount of the original sample inoculated into each tube in the j^{th} dilution.

For example, in the series x-x-3-0-0, where the third dilution level (z_s) equals 0.1 mL, $x_s z_s = 0.3$, and $\Sigma n_j z_j = 0.555$. Thus, the calculated MPN = 780/100 mL.

This formula also applies to serial dilutions having all positive tubes in a single dilution, and can serve as an approximation for outcomes like 5-5-5-0-0-0, where 5 tubes are used per dilution, by using just the last 4 dilutions.

Table 9221:4 shows all but the improbable positive tube combinations for a 3-dilution series. In testing 10 samples, there is a 99% chance of finding all the results among these 95 outcomes. If untabulated combinations occur with a frequency greater than 1%, it indicates that the technique is faulty or that the statistical assumptions underlying the MPN estimate are not being fulfilled (e.g., growth inhibition at low dilutions).

The MPN for combinations not appearing in the table, or for other combinations of tubes or dilutions, may be *estimated* as follows: First, select the lowest dilution that does not have all positive results. Second, select the highest dilution with at least 1 positive result. Finally, select all the dilutions between them. For example, from (10/10, 10/10, 4/10, 1/10, 0/10) use only (–, –, 4/10, 1/10, –), corresponding to 4/10 at 0.1 mL sample/ tube and 1/10 at 0.01 mL sample/tube. Likewise, from (10/10, 10/10, 10/10, 0/10, 0/10), select only (–, –, 10/10, 0/10, –), corresponding to 10/10 at 0.1 mL sample/ tube and 0/10 at 0.01 mL sample/tube. Use only the selected dilutions in the following formula of Thomas:[1]

$$\text{MPN/100 mL (approx.)} = 100 \times P/(N \times T)^{1/2}$$

where:

P = number of positive results,
N = volume of sample in all the negative portions combined (mL), and
T = total volume of sample in the selected dilutions (mL).

That is, $N = \Sigma(n_j - x_j)z_j$, $P = \Sigma x_j$, and $T = \Sigma n_j z_j$, where the summations are over the dilutions selected, and x_j = the number of positive tubes in the j^{th} dilution.

In the first example above,

$$\text{MPN/100 mL (approx.)} = 100 \times 5/(0.69 \times 1.1)^{1/2}$$
$$= 500/0.87 = 570/100 \text{ mL}$$

In the second example above,

$$\text{MPN/100 mL (approx.)} = 100 \times 10/(0.1 \times 1.1)^{1/2}$$
$$= 1000/0.332 = 3000/100 \text{ mL}$$

The 2 examples compare well with the true MPNs, 590/100 mL and 2400/100 mL, respectively. The second example is a special case for which an exact solution can be calculated directly for the 2 selected dilutions.

When summarizing the results from several samples with a single MPN value, use the geometric mean or the median. The geometric mean is calculated by averaging the logarithmic values; for example, the geometric mean of A, B, and C is 10^L where:

Table 9221:5. Examples for Choice of 3 Combinations of Positives from 5 Dilutions

Example	Volume (mL)					Combination of Positives	MPN Index (No./100 mL)
	10	1	0.1	0.01	0.001		
A	5	**5**	**1**	**0**	0	x-5-1-0-x	330
B	**4**	**5**	**1**	0	0	4-5-1-x-x	48
C	5	2	**5**	**2**	**1**	x-x-5-2-1	7000
D	4	5	**4**	**5**	**1**	x-x-4-5-1	4800
E	5	**4**	**4**	**0**	**1**	x-4-4-1-x	400
F	**4**	**3**	**0**	**1**	**1**	4-3-2-x-x	39
G	4	3	**3**	**2**	**1**	x-x-3-2-1	1700

$$L = (\log_{10} A + \log_{10} B + \log_{10} C)/3$$

Mean values are reported as the antilog of L.

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(9221) D. Presence-Absence (P-A) Coliform Test

The presence-absence (P-A) test for the coliform group is a simple modification of the multiple-tube procedure that is intended for use on routine samples collected from distribution systems or water treatment plants. This simplification using one large test portion (100 mL) in a single culture bottle to determine qualitatively whether coliforms are present or absent is justified on the theory that no coliforms are present in 100 mL of a drinking water sample. Also, it enables analysts to examine more samples in a given time period compared to quantitative methods. Comparative studies with the membrane-filter procedure indicate that the P-A test may maximize coliform detection in samples containing many organisms that could overgrow coliform colonies and cause detection problems.

The P-A broth contains lactose and a pH indicator to detect the presence of acid production. Analysts observe the culture bottles for gas and acid production—the metabolic end products of lactose fermentation. Presumptive positive coliform results obtained from P-A broth must be confirmed using BGLB broth.

1. Samples

Collect samples as directed in Section 9060, using sample containers specified in Section 9030 B.19. Follow the QC guidelines for sample bottles described in Section 9020 B.5*d*. Ensure that samples meet laboratory acceptance criteria upon receipt.

2. Presumptive Phase

a. Culture medium:

P-A broth: Follow QC guidelines cited in 9221 B.2.

Beef extract	3.0 g
Peptone	5.0 g
Lactose	7.46 g
Tryptose	9.83 g
Dipotassium hydrogen phosphate (K_2HPO_4)	1.35 g
Potassium dihydrogen phosphate (KH_2PO_4)	1.35 g
Sodium chloride (NaCl)	2.46 g
Sodium lauryl sulfate	0.05 g
Bromocresol purple	0.0085 g
Reagent-grade water	1 L

Make this formulation triple strength (3×) when examining 100-mL samples. Dissolve P-A medium in water by stirring (do not use heat). Dispense 50 mL prepared medium into screw-capped 250-mL milk dilution bottles or equivalent containers. A fermentation vial insert is unnecessary. Autoclave for 12 min at 121 °C; limit the total time in the autoclave to 30 min or less. Medium pH must be 6.8 ± 0.2 after sterilization.

If sterilized via filtration, a 6× strength P-A medium may be used. Aseptically dispense 20 mL of the 6× medium into a sterile 250-mL dilution bottle or equivalent container.

b. Procedure: Shake sample vigorously for 5 s (approximately 25 times) and inoculate 100 mL into a P-A culture bottle. Mix thoroughly by inverting the bottle once or twice to evenly distribute the sample throughout the medium. Incubate at 35 ± 0.5 °C and inspect after 24 ± 2 h and 48 ± 3 h for acid reactions.

c. Interpretation: If acidic conditions exist after lactose fermentation, a distinct yellow color forms in the medium. If gas also is being produced, then foaming will occur when the bottle is gently shaken. Any amount of gas or acid constitutes a presumptive positive test that requires confirmation.

ANNEXURE-I

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Item No. 04 Court No.1

BEFORE THE NATIONAL GREEN TRIBUNAL
PRINCIPAL BENCH, NEW DELHI

Original Application No. 1069/2018
(M.A. No. 1792/2018, M.A. No. 1793/2018, I.A. No. 150/2019 & I.A. No. 151/2019)

Nitin Shankar Deshpande Applicant(s)

Versus

Union of India &Ors. Respondent(s)

Date of hearing: 30.04.2019

CORAM: **HON'BLE MR. JUSTICE ADARSH KUMAR GOEL, CHAIRPERSON**
HON'BLE MR. JUSTICE K. RAMAKRISHNAN, JUDICIAL MEMBER
HON'BLE DR. NAGIN NANDA, EXPERT MEMBER

For Applicant(s): Ms. Ekta Sikri and Ms. K. Gayatri, Advocates

For Respondent (s): Mr. Rajkumar, Advocate for CPCB
Mr. Gigi C. George, Advocate for MoEF&CC
Mr. Dhruv Mehta, Sr. Advocate with Mr. Ashish Wad and Mr. Sidharth Mahajan, Advocates

NATIONAL GREEN TRIBUNAL, PRINCIPAL BENCH

ORDER

1. The issue for consideration is effluent discharge standards for STPs as laid down vide Notification dated 13.10.2017 by way of Environment (Protection) Amendment Rules, 2017 against Serial No. 105 of Schedule-I to the Environment (Protection) Rules, 1986.

2. Vide order dated 21.12.2018, this Tribunal noted that untreated or partially treated sewage is a major source of pollution in the country.

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The Hon'ble Supreme Court in the case of *Paryavaran Suraksha Samiti & Anr. Vs. Union of India & Ors.*[1] directed taking of steps so that huge gap in sewage generated and treated is bridged.

3. The Tribunal also noted that the proposed standards as per Draft Notification dated 24.11.2015 issued by Ministry of Environment, Forest & Climate Change (MoEF & CC) are sought to be diluted by the impugned Notification as follows:

Sr. No.	Parameters	Old Norms 1986	Draft Norms Nov., 15	MoEF& CC Notification October 2017
1.	Biochemical Oxygen Demand (BOD) (mg/l)	<30	<10	<30 and <20 (metro cities)
2.	Chemical Oxygen Demand (COD) (mg/l)	<250	50	No limit
3.	Total Suspended Solids (TSS) (mg/l)	<100	<20	<100 and <50 (metro cities)
4.	Total Nitrogen (mg/l)	<100	<10	No limit
5.	Ammonical Nitrogen (mg/l)	<50	<5	No limit
6.	Total Phosphorus (mg/l)	No limit	No limit	No limit
7.	Fecal Coliform MPN/100 ml	No limit	<100	<1000

4. The Tribunal also noted that the relaxed standards will deteriorate the water quality and degrade the environment and be a retrograde

[1](2017) 5 SCC 326

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step. The dilution will also affect the human life and the water quality of the rivers.

5. Accordingly, the Tribunal constituted an Expert Committee comprising the nominees from IIT Kanpur, IIT Roorkee, NEERI and CPCB which was to give its report after examining the best available technologies and best practices and after referring to the Experts study on the subject particularly CPCB Report on "River Stretches for Restoration of Water Quality, 2014-15" and the order of this Tribunal on the subject of polluted river stretches dated 20.09.2018 in Original Application No. 673/2018 in the matter of News item published in *"The Hindu" authored by Shri Jacob Koshy titled "More river stretches are now critically polluted : CPCB"*. The Tribunal also directed stay of operation of the impugned Notification and application of pre-revised standards till further orders.

6. Accordingly, report has been received from CPCB vide e-mail dated 30.04.2019 forwarding the Expert Committee report. The report noted the current status of water quality of rivers which flows in India and the fact that 351 river stretches out of 323 rivers were polluted. There was need for revised standards for BOD and COD with a view to protect the water quality of the rivers/streams. There was also a need for revised standards for TSS, for Nitrogen (Ammonia & Nitrates) and Phosphorus and for Fecal Coliform.

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7. The Committee while discussing the need for revised the Standards for BOD and COD observed that:

"Inclusion of COD in sewage discharge certainly offers advantages in terms of early diagnosis on functioning of STPs and thus helps in resorting immediate measures/corrective actions. This is because analysis of COD is completed within 5 Hours as against 5 days at 20°c or 3 days at 27°C for BOD (Sawyer & Mccarty, V. Edition). Moreover, if Government wishes to regulate STPs across the county through online monitoring system in future, inclusion of COD in Discharge Standards will prove beneficial for the reason that COD sensors are quite reliable and readily available in Indian market, however the same is not the case with BOD sensors. Thus, from regulatory point of view also, COD is an important parameter and needs to be included in sewage Discharge Standards."

While discussing the need for revised standards for TSS the Committee has observed that:

" The Microbial quality of wastewater could be linked with the TSS concentration. The larger the Suspended solids, the larger shall be the presence of bacteria, protozoa and viruses. High TSS wastewater cannot be easily disinfected, as the suspended particles "hide" these microorganisms and also react with chemical disinfectants."

Further the committee observed:

"A well designed and operated conventional sewage treatment system such as activated sludge process can meet 20 mg/L effluent TSS discharge standards. Many STPs bases on secondary wastewater treatment all over the globe are able to achieve 10-20mg/L. TSS without any tertiary treatment."

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Further with regard to the need for revised standard for Nitrogen (Ammonia & Nitrates) and Phosphorus it has been elaborated by Committee that:

"Nitrogen and phosphorus in all forms are major rate limiting elements essential for the growth of alage and other vegetation in water bodies leading to a state called eutorphication. The greenish color water with large vegetation growth is common sight for not only lakes and ponds but also slow moving rivers.

Eutrophication arises from the oversupply of nutrients (N & P), which leads to overgrowth of plants and alage. Degradation of dead alage and plants by microbes consumes dissoloved oxygen in the water, thereby creating the state of hypoxie.

Eutrophication leads to many problems related to water quality:

- *Large Dissolved oxygen variation leads to fish kills.*
- *Filling the water body with dead algae and other vegetation.*
- *Decomposition of dead algae and vegetation at the bottom causing oxygen depletion and further release of nutrient.*
- *Release of algal toxins and odors causing substances make the water unsuitable for human and animal consumption."*

The Committee has also observed that:

Due to the absence of dilution and worsening of our rivers and lakes, it is necessary to move towards nutrients (nitrogen and phosphorus) regulations in water bodies.

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The Committee while discussing the revised standards for Fecal Coliforms observed:

"As per "Houses and Household Amenities, Latrine Facility, Census of India - 2011, Registrar General and Commissioner, India" available at http://censusindia.gov.in/ 2011census/hlo/ Data sheet/ India / Latrine. Pdf; Out of 7.9 Crores Urban Households (UHH), nearly 1.7 Crores UHH (i.e. 20 %) lacks adequate sanitation. At the same time more than 5 lakhs villages in the country are now open defecation free (ODF) (https:// sbm.gov.in/sbmdashboard / ODF.aspx.) Although rural parts are covered through sanitary toilets, effluent from septic tanks from newly built 9.2 crores toilets across the country is unavoidable. This may pose very high health risk owing to the fact that "Sanitation" including collection, conveyance and treatment is either absent or inadequate in such areas. ***Relaxing FC pose risk to downstream cities/town/villages that rely on drinking water source on same water body in case of rivers. It appears quite reasonable to say that FC Standards be prescribed to 100 MPN/100 ml. considering its impact on human health in general and readiness of Indian wastewater sector to handle the same (Recommended value of FC in CPHEEO Manual, 2013 is MPS230/100 ml.),*** *(emphasis added)*

Hence, CPHEEO 2013 recommended the following guidelines for treated sewage discharge into surface water which after some travel may join a ***drinking water source to be used as source of supply for drinking water as given in following Table 5.20***

Table 5.20 Recommended Guidelines for Treated Sewage if Discharged into Surface Water to be used as source of Drinking Water.

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Parameter	*MoEF Standards (A)*	*Recommended Values*
BOD, mg/L	*30*	*Less than 10*
SS, mg/L	*100*	*Less than 10*
TN, mg/L	*100*	*Less than 10*
Dissolved P, mg/L	*5*	*Less than 2*
Faecal Coliforms, MPN/100 mL	*Not specified*	*Less than 230*

(A) .General Standards, Environmental Protection Rule, 1986 & as authorized by PCB

"In order to achieve the above values, the treatment process would need to be designed for nutrient removal in addition to the conventional BOD and SS removal. It has also been reported that if the nutrients were removed to the levels mentioned in Table 3.20, then the amount of chlorine required for disinfection would be less at about 5 mg/ l.

Considering aforementioned analysis, the Chairman CPCB directed all State Pollution Control Boards to make it mandatory for local bodies to set up sewerage systems for treatment and disposal of sewage to meet the prescribed standards ie., pH 6.5-9, BOD (mg/L): Not more than 10, COD (mg/L): Not more than 50, TSS (mg/L) : Not more than 20, NH_4-N (mg/L): Not more than 5, N-total (mg/L) Not more than 10 ,Fecal Coliforms (MPN/100 ml) Less than 230. The details are provided in Annexure 1."

8. The report further mentions that the stringent standards in terms of Draft Notification dated 24.11.2015 are not only economically viable

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and technically feasible, the cost will not be significantly high. In this regard, it was observed:

"7.0 ECONOMIC VIABILITY & RESOURCE POSITION

1. For Nitrification (Conversion of ammonia to nitrate), 20-30% larger aeration tanks are required with additional 40-50 % aeration demand. The Total capital and O&M cost of the system increases by 10-20 & 5-10 % respectively.

2. For further removal of nitrate from wastewater, denitrification (conversion of nitrate to Nitrogen gas) is needed by additional anoxic tank in the system. The capital cost further increases by 5-10 %. Nevertheless, denitrification gives 25 % oxygen credit which reduces 25 % aeration requirement.

3. Finally, overall capital and operational cost implications for achieving standards for metropolitan and class-I cities shall be 20-30 %.

4. Typical total unit costs for wastewater treatment based on experience gained in Western Europe and the USA is presented in Figure XX (WHO/ UNEP 1997). The total unit cost for secondary treatment (BOD < 20-30 mg/L & TSS < 50-100 mg/L) varies between 1.5-2.0 US$/m3, while for tertiary treatment (BOD, TSS & TN < 10 mg/L) it is 2.0-2.5 US$/m3. The additional burden is approximately 25-33 % which matches with Indian experience as well.

5. In recent years, many STPs are constructed based on effluent BOD, TSS & TN < 10 mg/L) and all the well operated and maintained STPs are providing the desired effluent quality. Some of these STPs are monitored by IIT Roorkee in recent years under several research projects and NGT reports. The performance evaluation results for 20 MGD Nilothi STP, 20 MLD Pappan Kalan STP, 15 MLD Delhi Gate STP and 5 MGD Kapashera STP of Delhi submitted to NGT alongwith 3.0 MID

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STP, Rishikesh, 1 MGD STP, Delhi, 27 MGD STP, Haridwar etc., monitored under various research projects is attached as Annexure 3.

6. CPCB has also conducted study on technological achievability of proposed standards. Delhi Jal Board has installed and commissioned 04 STPs on advanced treatment technology along with coliform reduction facilities.

7. In addition, the following STPs all over India are producing the desired quality: 1.5 MLD STP, Cubbon Park, Bangalore, 2.0 MLD STP, Pahalgam, 3.5 MLD STP, Tapovan, Rishikesh, 4.0 MLD STP, IIT' Madras, 12.5 MLD STP, Tonca, Goa, 15.0 MLD STP, Gorakhpur, 17.3 MLD STP, Zirakpur, Punjab, 18 MLD STP, Sarai, Haridwar, 20.0 MLD STP, Hyderabad, 20.0 MLD Sangvi, Pune, 30 MLD STP, Hyderabad, 37.5 MLD STP, UP Housing Board, Lucknow, 40.0 MLD Kharadi, Pune, 40.0 MLD STP, Hubbali, Karnataka, 45 MLD STP, Mundhwa, Pune, 50 MLD STP Kalamboli, Navi Mumbai, 54 MLD STP, Noida, 55.0 MLD, Singanpure, Surat, 56 MLD STP, Indirapuram, Ghaziabad, 68.0 MLD STP, Dehradun, 100 MLD STP, Vashi Navi Mumbai, 130 MLD STP, Nagpur, 137 MLD STP, Greater Noida, 245 MLD STP Indore, etc.

8. In practical experience with actual tendered cost, the experience has been quite differing. Many tenders based on old and less stringent quality standards have been awarded at much higher per MLD cost as compared to STPs having more stringent standards. Plus on a long term basis, new technologies have lower life cycle costs. Other factors which are encouraging most corporations and contractors to adopt new technologies are more compact designs, less land requirement, less construction time, better material of construction, less maintenance cost, automation and less dependency on expensive trained manpower to operate plants in remote locations."

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9. Accordingly, the Committee further observed that:

"• *The new stringent standards are devised considering the deterioration condition of water bodies and unavailability of adequate dilution water in our water bodies. If not stringent quality standards are not implemented then in the coming future with more population burden on rivers, situation will further deteriorate.*

- *The greatest benefit of these standards is to achieve all purpose non-portable reuse quality effluent. Each STP is to be treated as a source of water for reuse and recycling, helping in mitigating drought/climate change in the country. It will also reduce exploitation of groundwater reserves and dependency on rainfall which has become quite unpredictable in the past few years. Climate change is a reality that should be addressed and adopted for in the coming future. It will go a long way in reducing agricultural dependency on bore well water.*
- *If treatment of wastewater is not carried out with intention of reuse and recycle, expenditure on conveyance/long distance transport of water/sewage will be much higher. Even as on toady in many cities cost of conveyance of water is much higher than the treatment of sewage to make it fit for most uses including domestic uses. For example the cost of transporting water from Narmada to fulfil water supply needs of Indore city (approximately @ Rs. 20/cum) is much higher than the cost of treating sewage to tertiary level."*

In view of above and severity of depletion of aquatic resources vis-a-vis the financial aspects related to conveyance and treatment of water/sewage the committee recommended that the effluent discharge for STPs to be as follows:

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"

Sl. No.	Industry	Parameters	Standards (Applicable to all mode of disposal)			
1	2	3	4			
	Sewage Treatment Plants (STPs)		Mega and Metropolitan Cities	Class I Cities	Others	Deep Marine Outfall
		pH	5.5-9.0	5.5-9.0	5.5-9.0	5.5-9.0
		Bio-Chemical Oxygen Demand (BOD)	10	20	30	30
		Total Suspended Solids (TSS)	20	30	50	50
		Chemical Oxygen Demand (COD)	50	100	150	150
		Nitrogen-Total	10	15	-	-
		Phosphorus-Total(For Discharge into Ponds, Lakes)	1.0	1.0	1.0	
		Fecal Coliform (FC) (Most Probable	Desireable-100 Permissible-	Desireable-230 Permissi	Desireable-1000 Permissible-	Desirable-1000 Permissibl

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		Number per 100 mililiter, MPN/100 ml	*230*	*ble-1000*	*10,000*	*e-10,000*

Note:

(i) *Mega-Metropolitan Cities have population more than 1 crore, Metropolitan Cities-Population more than 10 Lakhs and Class-1 Population more than 1 Lakh.*

(ii) *All value in mg/l except for pH and Fecal Coliform.*

(iii) *These standards will be applicable for discharge into water bodies as well as for land disposal/applications.*

(iv) *These Standards shall apply to all new STPs for which construction is yet to be initiated.*

(v) *The existing/under construction STPs shall achieve these standards within 07 years from the date of notification.*

(vi) *In case where the marine outfall provides a minimum initial dilution of 150 times at the point of discharge and a minimum dilution of 1500 times at a point 100m away from discharge point, then norms for deep sea marine discharge shall be applied.*

(vii) *Reuse/Recycling of treated effluent shall be encouraged.*

(viii) *State Pollution Control Boards/Pollution Control Committees may make these norms more stringent taking into account the local conditions.*

"

10. We have heard Learned Counsel for the parties.

11. Learned Counsel for the applicant submits that while the Expert Committee is fully justified in suggesting parameters as per its report for Mega-Metropolitan Cities, there is no justification for different and diluted standards for Class-I cities, Other cities or Deep Marine Outfall and to that extent the report of the Expert Committee fall short of the required scientific logic and database. While

recommending the diluted standards for Class-I cities, Other cities or Deep Marine Outfall the Committee has not given any explanation with regard to the existing pollution load in these areas, the available systems in place, the efficacy of the systems in terms of meeting of norms, the population impacted by deteriorating water quality and likely consequences on health of people if these diluted norms are permitted. There is no scientific justification offered for diluting the norms for these areas in which the majority of country's population resides. Also such standards we feel must apply not only to new STPs but also to the existing ones. Further, there is no justification for non-application of such standards for seven years for existing STPs.

12. Learned Counsel for CPCB and interveners are unable to justify dilution of standards for areas other than Mega Metropolitan Cities or for existing STPs.

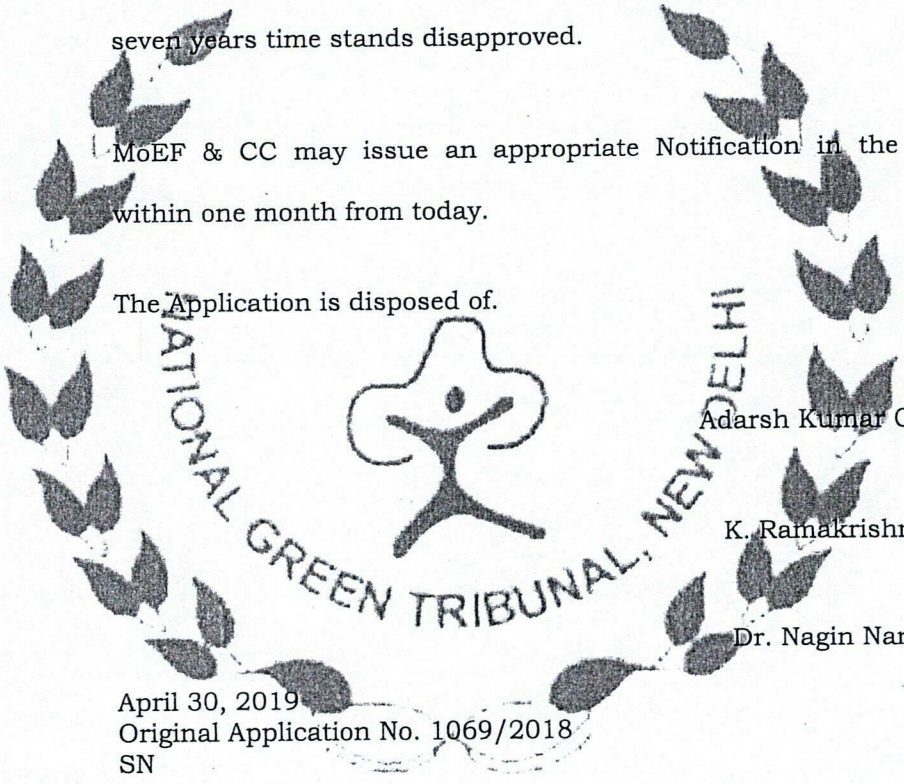
13. We find that there is no justification for diluted standards for areas other than Mega and Metropolitan Cities. The water quality standards are required to be same for the population of major cities or other cities. No justification has been shown for different standards for persons living in cities other than Mega and Metropolitan Cities. Major population of this country will be affected by diluted standards and only persons in Mega and Metropolitan Cities will have comparatively better standards without any valid reason or distinction. We may note that filters, UV filters etc. are facilities

mainly available in major cities and not in smaller cities or villages where the standards are proposed to be diluted.

14. Accordingly, we accept the report of the Expert Committee with the modification that the standards recommended for Mega and Metropolitan Cities will also apply to rest of the country. We also direct that the standards will apply not only for new STPs but also for existing/under construction STPs without any delay and giving of seven years time stands disapproved.

MoEF & CC may issue an appropriate Notification in the matter within one month from today.

The Application is disposed of.



Adarsh Kumar Goel, CP

K. Ramakrishnan, JM

Dr. Nagin Nanda, EM

April 30, 2019
Original Application No. 1069/2018
SN

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ANNEXURE - I

SIX MONTHLY DATA (STPs)

STP DIGGIAN

S.N.	Parameters	Unit	Stds.	Oct (2025)	Nov (2025)	Dec (2025)	Jan (2026)	Feb (2026)	Mar (2026)
1	pH	-	6.5-9.0	6.6	6.9	6.7	7	6.3	6.7
2	DO	mg/l	...	7.1	8.9	10	4.2	9.6	7
3	COD	mg/l	50	16	26	31	36	35	45
4	BOD	mg/l	10	2.7	BDL	3.4	3.2	BDL	BDL
5	TSS	mg/l	20	BDL	8	10	BDL	BDL	13
6	NH_3-N	mg/l	5	BDL	3	BDL	0.90	0.5	9.2
7	TKN-N	mg/l	...	BDL	3	BDL	0.90	0.5	9.2
8	NO_2-N	mg/l	...	0.002	0.32	0.02	1.1	BDL	0.15
9	NO_3-N	mg/l	...	1.2	4.4	8	6.9	9.2	12.6
10	Total Nitrogen	mg/l	10	1.2	7.7	8	8.9	9.7	22
11	Fecal Coliform	MPN/100ml	<100	<1.8	<1.8	<1.8	110	<1.8	<1.8

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STP 3 BRD

S.N.	Parameters	Unit	Stds.	Oct (2025)	Nov (2025)	Dec (2025)	Jan (2026)	Feb (2026)	Mar (2026)
1	pH	-	6.5-9.0	6.6	6.8	7.2	6.6	6.8	6.7
2	DO	mg/l	...	11.8	7.8	8.3	...	...	...
3	COD	mg/l	50	9	33	38	29	13	33
4	BOD	mg/l	10	2.4	BDL	3.2	2.9	BDL	BDL
5	TSS	mg/l	20	BDL	BDL	BDL	7.5	BDL	9.0
6	NH_3-N	mg/l	5	BDL	BDL	BDL	BDL	BDL	1.7
7	TKN-N	mg/l	...	BDL	BDL	BDL	BDL	BDL	1.7
8	NO_2-N	mg/l	...	0.009	BDL	BDL	0.03	0.04	0.02
9	NO_3-N	mg/l	...	9.8	7.3	7.9	7.1	9.0	17
10	Total Nitrogen	mg/l	10	9.8	7.3	7.9	7.1	9.0	19
11	Fecal Coliform	MPN/100ml	<100	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8

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1562 108

STP MALOYA

S.N.	Parameters	Unit	Stds.	Oct (2025)	Nov (2025)	Dec (2025)	Jan (2026)	Feb (2026)	Mar (2026)
1	pH	-	6.5-9.0	7.4	7.3	7.4	7.3	7.3	7.1
2	DO	mg/l	...	4.8	3.2	3.9	5.6	3.4	4.4
3	COD	mg/l	50	47	31	41	40	33	44
4	BOD	mg/l	10	2.8	BDL	7.7	BDL	2.8	2.4
5	TSS	mg/l	20	BDL	BDL	12	8	BDL	7.0
6	NH_3-N	mg/l	5	BDL	3.3	1.1	6.6	16	6.8
7	TKN-N	mg/l	...	BDL	3.3	1.1	6.6	16	6.8
8	NO_2-N	mg/l	...	0.009	0.28	0.02	0.49	0.75	0.44
9	NO_3-N	mg/l	...	2.6	2	2.5	1.7	2.3	2.5
10	Total Nitrogen	mg/l	10	2.6	5.6	3.6	8.8	19	9.7
11	Fecal Coliform	MPN/ 100ml	<100	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8

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STP DHANAS

S.N.	Parameters	Unit	Stds.	Oct (2025)	Nov (2025)	Dec (2025)	Jan (2026)	Feb (2026)	Mar (2026)
1	pH	-	6.5-9.0	7	7.3	7.3	7.3	7.0	7.1
2	DO	mg/l	...	7.9	9.2	5.4	5.4	8.0	8.0
3	COD	mg/l	50	47	24	46	45	42	39
4	BOD	mg/l	10	3.3	BDL	4.5	5.6	2.1	3
5	TSS	mg/l	20	BDL	9.0	10	6.0	BDL	9.0
6	NH_3-N	mg/l	5	BDL	BDL	3	2.4	3.3	6.3
7	TKN-N	mg/l	...	BDL	BDL	3	2.4	3.3	6.3
8	NO_2-N	mg/l	...	0.007	BDL	1	1.3	0.77	0.07
9	NO_3-N	mg/l	...	4.9	6.2	3.8	3.3	4.5	6.0
10	Total Nitrogen	mg/l	10	4.9	6.2	7.8	7.0	8.6	12
11	Fecal Coliform	MPN/100ml	<100	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8

STP RAIPUR KALAN-I

S.N.	Parameters	Unit	Stds.	Oct (2025)	Nov (2025)	Dec (2025)	Jan (2026)	Feb (2026)	Mar (2026)
1	pH	-	6.5 - 9.0	7.2	7.3	7.2	7.3	7.4	7.3
2	DO	mg/l	...	6.8	7.3	8.1	7.5	6.9	8.3
3	COD	mg/l	50	29	20	32	41	43	36
4	BOD	mg/l	10	4.3	2.9	3.3	4.3	6.3	4.6
5	TSS	mg/l	20	BDL	BDL	9	7	7	11
6	NH_3-N	mg/l	5	BDL	BDL	2.3	BDL	0.90	5.3
7	TKN-N	mg/l	...	BDL	BDL	2.3	BDL	0.90	5.3
8	NO_2-N	mg/l	...	0.10	0.02	0.32	0.18	0.17	0.84
9	NO_3-N	mg/l	...	9.7	3.9	2.6	9.3	6.7	9.5
10	Total Nitrogen	mg/l	10	9.8	3.9	5.2	9.5	7.8	15.6
11	Fecal Coliform	MPN/100ml	<100	<1.8	<1.8	<1.8	220	94	<1.8

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STP RAIPUR KHURD

S.N.	Parameters	Unit	Stds.	Oct (2025)	Nov (2025)	Dec (2025)	Jan (2026)	Feb (2026)	Mar (2026)
1	pH	-	6.5-9.0	7.7	7.7	7.2	7.7	7.7	7.8
2	DO	mg/l	...	5.8	7.4	4.7	5.9	7.0	7.2
3	COD	mg/l	50	47	37	48	46	48	46
4	BOD	mg/l	10	10	4.6	4	7.4	2.6	7.8
5	TSS	mg/l	20	13	BDL	10	BDL	13	11
6	NH_3-N	mg/l	5	3.3	1.3	7.2	0.94	14	18
7	TKN-N	mg/l	...	3.3	1.3	7.2	0.94	14	18
8	NO_2-N	mg/l	...	0.009	3.9	0.51	1.4	6.9	0.81
9	NO_3-N	mg/l	...	6.2	1.7	1.7	5.5	5.1	2.3
10	Total Nitrogen	mg/l	10	9.5	6.9	9.4	7.8	26	21
11	Fecal Coliform	MPN/100ml	<100	11	<1.8	<1.8	94	<1.8	<1.8

STP RAIPUR KALAN-II

S.N.	Parameters	Unit	Stds.	Oct (2025)	Nov (2025)	Dec (2025)	Jan (2026)	Feb (2026)	Mar (2026)
1	pH	-	6.5 - 9.0	7.5	7.5	7.2	7.3	7.2	7.4
2	DO	mg/l	...	6.9	8.4	5.3	6.7	5.4	5.9
3	COD	mg/l	50	31	25	36	49	40	47
4	BOD	mg/l	10	4.5	6.0	3.7	3.4	4.9	7.8
5	TSS	mg/l	20	BDL	BDL	18	7	15	10
6	NH_3-N	mg/l	5	BDL	BDL	8.4	BDL	0.59	0.69
7	TKN-N	mg/l	...	BDL	BDL	8.4	BDL	0.59	0.69
8	NO_2-N	mg/l	...	0.04	0.02	0.28	0.26	0.06	0.04
9	NO_3-N	mg/l	...	7.9	3.8	1.2	4.7	11	5.5
10	Total Nitrogen	mg/l	10	7.9	3.8	9.9	5	12	6.2
11	Fecal Coliform	MPN/100ml	<100	7.8	<1.8	<1.8	11	<1.8	<1.8

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STP KISHANGARH

Sr.No.	Parameters	Unit	Stds.	Oct (2025)	Nov (2025)	Dec (2025)	Jan (2026)	Feb (2026)	Mar (2026)
1	pH	-	6.5-9.0	...	...	8.2	7.9	7.3	7.6
2	DO	mg/l	...	...	...	7.7	8.8	9.5	8.5
3	COD	mg/l	50	...	...	28	28	29	21
4	BOD	mg/l	10	...	...	3.5	2.8	BDL	BDL
5	TSS	mg/l	20	...	...	9	BDL	BDL	5.4
6	NH_3-N	mg/l	5	...	...	0.73	BDL	BDL	BDL
7	TKN-N	mg/l	...	...	...	0.73	BDL	BDL	BDL
8	NO_2-N	mg/l	...	...	...	0.23	0.01	BDL	BDL
9	NO_3-N	mg/l	...	...	...	5	9.6	4.3	7.2
10	Total Nitrogen	mg/l	10	...	...	6	9.6	4.3	7.2
11	Fecal Coliform	MPN/100ml	<100	...	...	280	<1.8	<1.8	<1.8

ANNEXURE - K

SIX MONTHLY DATA (DRAINS)
SUKHNA CHOE

Sr. No.	Parameters	Unit	Oct (2025)	Nov (2025)	Dec (2025)	Jan (2026)	Feb (2026)	Mar (2026)
1.	pH	-	7.8	8	7.8	7.9	7.6	7.9
2.	Conductivity	µs/cm	821	880	1012	955	1014	1012
3.	DO	mg/l	BDL	BDL	BDL	2.5	4.3	4.4
4.	COD	mg/l	233	452	443	155	106	235
5.	BOD	mg/l	143	286	239	85	44	97
6.	NO_3-N	mg/l	2.0	1.0	4.2	2.8	2.20	3.6
7.	Total Coliform	MPN/ 100 ml	5.4×10^6	2.4×10^6	9.2×10^7	1.6×10^7	2.4×10^7	9.2×10^7
8.	Faecal Coliform	MPN/ 100 ml	3.3×10^5	7.9×10^5	2.2×10^5	3.5×10^4	1.7×10^5	3.5×10^5
9.	Turbidity	NTU	120	350	362	58	22	64
10.	P-Alkalinity	mg/l	Nil	Nil	Nil	Nil	Nil	Nil
11.	Total alkalinity	mg/l	360	385	421	323	320	342
12.	Chloride	mg/l	59	63	70	49	66	65
13.	NH_3-N	mg/l	14	12	31	21	11	19.0
14.	TH as $CaCO_3$	mg/l	218	250	288	238	272	264
15.	Ca as $CaCO_3$	mg/l	150	172	188	162	178	198
16.	Mg	mg/l	68	78	100	76	94	66
17.	Sulphate	mg/l	25	15	32	30	34	24
18.	Sodium	mg/l	44	61	62	25	68	76
19.	TDS	mg/l	472	548	630	456	498	560
20.	TFS	mg/l	372	423	452	376	364	488
21.	TSS	mg/l	101	324	321	55	38	64
22.	Phosphate	mg/l	0.54	1.4	3.6	2.8	2.2	1.7
23.	Boron(B)	mg/l	...	...	...	BDL	BDL	BDL
24.	Potassium	mg/l	7.8	25	18	4.8	29	19
25.	Fluoride	mg/l	BDL	BDL	BDL	BDL	BDL	BDL

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N-CHOE

Sr.No.	Parameters	Unit	Oct (2025)	Nov (2025)	Dec (2025)	Jan (2026)	Feb (2026)	Mar (2026)
1.	pH	-	7.6	7.9	7.7	7.8	7.4	7.2
2.	Conductivity	µs/cm	701	706	678	766	684	697
3.	DO	mg/l	4.5	8.3	8.5	5.7	4.8	5.2
4.	COD	mg/l	33	20	40	51	95	60
5.	BOD	mg/l	4.2	BDL	14	6.5	12	25
6.	NO_3-N	mg/l	4.5	1.9	1.9	0.93	1.3	1.3
7.	Total Coliform	MPN/100 ml	1.7×10^5	9.2×10^4	2.7×10^4	2.2×10^4	2.8×10^5	5.4×10^5
8.	Faecal Coliform	MPN/100 ml	2.2×10^4	9.4×10^3	1.7×10^4	920	9.4×10^3	3.5×10^3
9.	Turbidity	NTU	9	3	11	4	24	5
10.	P-Alkalinity	mg/l	Nil	Nil	Nil	Nil	Nil	Nil
11.	Total alkalinity	mg/l	272	270	263	268	222	290
12.	Chloride	mg/l	30	31	30	29	30	31
13.	NH_3-N	mg/l	0.66	1.2	5.0	1.2	7.9	11
14.	TH as $CaCO_3$	mg/l	294	282	310	290	228	264
15.	Ca as $CaCO_3$	mg/l	204	216	212	214	178	214
16.	Mg as $CaCO_3$	mg/l	90	66	98	76	50	50
17.	Sulphate	mg/l	50	55	56	67	71	71
18.	Sodium	mg/l	37	65	42	19	47	54
19.	TDS	mg/l	470	474	468	406	356	478
20.	TFS	mg/l	356	460	372	298	276	428
21.	TSS	mg/l	8	BDL	12	10	26	16
22.	Phosphate	mg/l	0.13	0.67	0.37	0.27	1.0	0.76
23.	Boron(B)	mg/l	...	...	...	BDL	BDL	BDL
24.	Potassium	mg/l	7.7	14	7	7.4	15	10
25.	Fluoride	mg/l	BDL	0.22	BDL	BDL	BDL	BDL

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PATIALA KI RAO

Sr. No.	Parameters	Unit	Oct (2025)	Nov (2025)	Dec (2025)	Jan (2026)	Feb (2026)	Mar (2026)
1.	pH	-	7.8	7.9	7.7	7.2	7.6	7.5
2.	Conductivity	µs/cm	682	731	694	999	858	843
3.	DO	mg/l	BDL	BDL	BDL	0.91	Nil	Nil
4.	COD	mg/l	146	194	291	423	338	339
5.	BOD	mg/l	74	111	201	255	197	204
6.	NO_3-N	mg/l	1.8	0.80	1.3	0.78	2.4	1.2
7.	Total Coliform	MPN/ 100 ml	2.8×10^6	2.2×10^6	5.4×10^7	9.2×10^7	5.4×10^7	1.6×10^7
8.	Faecal Coliform	MPN/ 100 ml	2.6×10^5	1.7×10^5	4.6×10^5	5.4×10^4	2.8×10^4	1.5×10^5
9.	Turbidity	NTU	161	71	299	217	161	253
10.	P-Alkalinity	mg/l	Nil	Nil	Nil	Nil	Nil	Nil
11.	Total alkalinity	mg/l	291	299	273	320	310	275
12.	Chloride	mg/l	38	38	44	54	45	25
13.	NH_3-N	mg/l	11	15	10	16	14	14
14.	TH as $CaCO_3$	mg/l	214	216	196	234	222	225
15.	Ca as $CaCO_3$	mg/l	162	144	138	154	174	190
16.	Mg	mg/l	52	72	58	80	48	35
17.	Sulphate	mg/l	26	22	25	66	62	59
18.	Sodium	mg/l	52	73	48	52	54	65
19.	TDS	mg/l	392	474	454	672	372	494
20.	TFS	mg/l	222	440	432	474	348	379
21.	TSS	mg/l	241	108	293	494	190	217
22.	Phosphate	mg/l	0.58	1.1	1.4	3.2	3.7	2.7
23.	Boron(B)	mg/l	...	...	...	BDL	BDL	BDL
24.	Potassium	mg/l	14	20	11	18	19	32.0
25.	Fluoride	mg/l	BDL	BDL	BDL	BDL	BDL	BDL

FAIDA CHOE

Sr.No.	Parameters	Unit	Nov (2025)	Feb (2026)
1	pH	-	BDL	7.0
2	DO	mg/l	422	Nil
3	COD	mg/l	227	327
4	BOD	mg/l	105	251
5	TSS	mg/l	14	253
6	NH_3-N	mg/l	1.0	11
7	Phosphate	mg/l	7.4	0.53