

**BEFORE THE NATIONAL GREEN TRIBUNAL**

**SOUTHERN ZONE BENCH AT CHENNAI**

**APPEAL NO. 15 OF 2020(SZ)**

**IN THE MATTER OF:**

THE CONSERVATION ACTION TRUST & ANR.

... APPELLANTS

VERSUS

UNION OF INDIA & ORS.

...RESPONDENTS

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**THROUGH**

4/07

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CHENNAI/ DELHI

DATE: 04-02-2021

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**REJOINDER TO THE REPLY OF RESPONDENT NOS. 1 AND 4**

**MOST RESPECTFULLY SHOWETH:**

1. The Appellant above-named is filing the present the rejoinder to the replies of Respondent Nos. 1 and 4 in the above-said appeal. The abovementioned Appeal has been filed against the Environment Clearance dated 29th June 2017 granted by the Ministry of Environment, Forest and Climate Change to M/s. Telangana State Power Generation Corporation ("the project proponent") for the development of a 5x800 MW Super Critical coal based Yadadri Thermal Power Station ("Yadadri TPS") at Veerlapalem Village, Dameracheral Mandal, Nalgonda District, Telangana State ("the impugned EC").
2. That in the reply filed by the Respondent Nos. 1 and 4 the main contentions are as follows :-
  - (i) NGT has advised MOEF to revise siting guidelines in line with the current scenarios since the existing guidelines were promulgated in 1987
  - (ii) The Hon'ble Chief Minister, Telengana state has also visited the same site and satisfied with the selection and given his approval for setting up of the said thermal power plant.

- (iii) Cumulative Impact Assessment has been done
- (iv) The Project has Forest Clearance
- (v) There will be no impact on Tiger Reserve
- (vi) Minimum flow from upstream reservoir would ensure sustenance of downstream ecology of the River Krishna
- (vii) The analysis of Mercury in the coal been done
- (viii) The NGT Judgment in Krishi Vigyan Sansad nowhere states that the Project Proponent need to undertake detailed studies on radioactivity before environmental clearance is given
- (ix) Detailed Water Balance and wastewater balance has been furnished in the Revised EIA
- (x) Project Proponent has applied to ministry of Coal for allocation of a long term coal linkage
- (xi) On the issue of Ash Dyke, HPDE liner HPDE liner and clay lining, all issues have been considered and addressed
- (xii) On the issue of Fly Ash disposal, the disposal issue has been addressed
- (xiii) EIA of the project has extensively dealt with the Hydrology of the site
- (xiv) Public Health impacts have been addressed

3. The Appellant states that all the above contentions of Respondent Nos. 1 and 4 in their respective replies are false, misleading and hence denied except those which are a matter of record. It is also stated that Respondent Nos.1 and 4 have provided little or no new information on a number of material issues in their respective Reply.

4. **That in Rejoinder to the Contention No. (i)** that NGT has advised MOEF to revise siting guidelines in line with the current scenarios since the guidelines were promulgated in 1987 it is stated that the ***T. Mohana Rao vs. The Director, Ministry of Environment & Forests*** and other related Appeals were decided by this Hon'ble Tribunal by its Order dated 23.05.2012 wherein on the issue of siting guidelines for setting up Thermal Power Plants it has been observed as follows:-

*"25. In course of hearing we called upon Ms. Rathore, Learned Counsel for the appellant to produce a copy of the environmental guidelines and / or siting criteria framed by the MoEF for setting up of a Thermal Power Plant. In response Ms. Rathore produced a set of guidelines framed by the MoEF way back in the year 1987. According to the said guidelines, the location of the Thermal Power Plant should be avoided within 25 km. of outer peripheries of metropolitan cities, national parks and wildlife sanctuaries, ecological sensitive areas like tropical forests, bio-sphere reserves, national parks and sanctuaries, important lakes and coastal areas rich in coral formation etc. The guidelines does not create any embargo with regard to setting up Coal Based Power Plant in / or around Wetland.*

**26. After going through the guidelines, we feel that the same are not exhaustive nor has taken care of many factors affecting environment and ecology prevailing as on date. It is pertinent to note that the siting criteria produced before us, were framed 25 years ago (1987).** *By afflux of time number of further studies have been undertaken, new concept and theories in the field of environment and ecology have developed. The changed scenario, scientific developments and change in technology mandates that the siting criteria as well as guidelines for setting up Thermal Power Stations (TPPs) should be revised to bring it in par with the modern techniques to suit the present environmental condition and to protect the ecologically sensitive areas. All these eventualities have not been kept in mind by the MoEF, which is still guided by the siting criteria formulated way back in the year 1987. We, therefore, direct the MoEF to take cognizance of the present day scenario and revise the siting criteria, guidelines for setting up of Thermal Power Projects to match with the present day requirements as early as possible so as to avoid future*

*controversies. In course of hearing, this Tribunal was informed that an exercise in this respect was initiated in the year 2009 but then till date MoEF has not arrived at a logical conclusion. It should be kept in mind that the updated guidelines for setting up TPPs would not only avoid unnecessary litigation but would also go a long way in providing proper selection of environmentally compatible sites. Further, the principles of sustainable development and precautionary principles mandate that the guidelines should clearly spell out "GO" and "NO GO" areas for locating Thermal Power Plant so that the environmental issues can be internalised right from the beginning of project formation stage. We, therefore, direct the MoEF to frame new guidelines and siting criteria with the observations made in this paragraph for TPPs and file a copy thereof before this Tribunal within a period of three months hence.*

**However, it is made clear that the proposal of the present Project Proponent has rightly been dealt with in view of the siting criteria guidelines which were prevailing at the relevant time."**

(Emphasis supplied)

5. Even though the siting guidelines in issue in this case were issued in 1987, it was observed by this Hon'ble Tribunal that the proposal of the present Project Proponent has rightly been dealt with in view of the siting criteria guidelines which were prevailing at the relevant time. Secondly, it is important to point out that the siting guidelines relied upon by the Appellant in this Appeal are the siting guidelines prepared by IL&FS for Respondent No.1 in terms of Notification No. CEA/TETD/MP/R/01/2010 issued under Section 177 of the Electricity Act, 2003. Siting Guidelines of 2010 state:-

*"4.2.4 Siting Guidelines*

*Areas preferably be avoided*

*While siting industries, care should be taken to minimize the adverse impact of the industries on immediate neighborhood as well as distant places. Some of the natural life sustaining systems and some specific land uses are sensitive to industrial impacts because of the nature and extent of fragility. With a view to protect such sites, the industries may maintain the following distances as far as possible, from the areas listed:*

- *Ecologically and/or otherwise sensitive areas: Preferably 5 km; depending on the geoclimatic conditions the requisite distance may be decided appropriate by the agency.*
- *Coastal Areas: Preferably half-a-kilometre away from high tide line (HTL).*
- *Flood Plain of the Riverine System: Preferably half-a-kilometre away from flood plain or modified flood plain affected by dam in the upstream or by flood control systems.*

.....

*Guidelines for site selection of coal-based thermal power stations set by the MoEF*

- *Locations of thermal power stations are avoided within 25 km of the outer periphery of the following:*
  - *metropolitan cities;*
  - *National park and wildlife sanctuaries;*
  - *Ecologically sensitive areas like tropical forest, biosphere reserve, important lake and coastal areas rich in coral formation;*
- .....
- *Those sites should be chosen which are at least 500 m away from the flood plain of river system;*
- .....
- *Forest or prime agriculture lands are avoided for setting up of thermal power houses or ash disposal*

It thus seems that both sets of Guidelines are applicable though in the Appeal the Appellant has specifically relied upon siting guidelines mentioned in EIA Guidance Manual for Thermal Power Plants prepared for the MoEF, Government of India, by IL&FS Ecosmart Ltd. of August, 2010. The use of Forest Land for setting up power plants or ash disposal are to be avoided. The site should also be at least 500 metres away from the flood plain of river system. Further the site is within 25 Km

of Amrabad Tiger Reserve and as per MoEF's siting guidelines it is in an area which needs to be avoided for setting up of a Thermal Power Plant.

Copy of the Relevant pages of siting guidelines mentioned in EIA Guidance Manual for Thermal Power Plants prepared for the MoEF, Government of India, by IL&FS Ecosmart Ltd. of August, 2010 pertaining to Thermal Power Plants is annexed herewith as **ANNEXURE-A28.**

6. **That in Rejoinder to the Contention No. (ii)** that the Hon'ble Chief Minister, Telengana state has also carried out an aerial survey of the site and has satisfied himself with the selection and given his approval for setting up of the said thermal power plant, it is stated that an aerial survey cannot be considered to be an adequate means of assessment of the project site, particularly in view of the *prima facie* unsuitability of site-1 and site-2. It is also respectfully submitted that once the Hon'ble Chief Minister takes a decision in this manner, it is not possible for any Government Agency at the State Level to reverse or modify this decision. It is respectfully submitted that the procedure followed in this case by the Chief Minister goes on to violate the site selection procedure of the Respondent No.1 in 2010. It is stated that the site selection exercise was not carried out as prescribed and the site was predetermined prior to the Chief Minister's aerial survey.
7. **That in Rejoinder to the Contention No. (iii)** that Cumulative Impact Assessment has been done it is stated that the same is wrong and denied. It is stated that no Cumulative Impact Assessment was done in this case, despite the mandatory requirement under Paragraph 9.4 of Form-1 of Appendix 1 of the EIA Notification, 2006.
8. That as per the Additional ToR No. (xi) Cumulative Impact Assessment of air, water, soil, transportation and social-economics needed to be carried out in view of a number of cement plants already established/operating in the vicinity of the proposed Plant.

9. That a perusal of EIA section on emissions from industries located within 15 km and Table no.- 4.3 of the EIA shows estimation of cumulative ground level concentrations of operating and proposed industries within 15 km radius. There is nothing on record to show how these GLCs have been compiled and combined. Secondly, only some of the air emissions have been purportedly taken into account in this case to assess part of the requirements of the Cumulative Impact Assessment. It is well settled by a number of Judgments, that for a Cumulative Impact Assessment, the total impact resulting from the impacts of the proposed project with other project activities around it- past, present and those to come up in the future- need to be assessed.

10. That this Hon'ble Tribunal observed the meaning and scope of the term Cumulative Impact Assessment Study in its Judgment dated 10th November, 2014 in ***Appeal no. 50 of 2012 in T. Muruganandam & Ors. vs. Ministry of Environment & Forest & Ors.*** as follows:-

*"41...Thus, the Cumulative Impact as the term indicates is not the impact of any project in isolation but it is a total impact resulting from the interaction of the project with other project activities around it- past, present and those to come up in future. It is a comprehensive view of the impacts resulting from all the projects- past, present or planned ones on the environment. Cumulative Impact may be same or different and those arising out of individual activities and tend to be larger, long lasting and spread over a greater area within the individual impact. Such studies are therefore commonly expected to:*

- 1. Assess effects over a larger area that may cross jurisdiction boundaries;*
- 2. Assess effects during a longer period of time into the past and future;*
- 3. Consider effects on other eco-system components due to interactions with other actions, and not just the effect of the single action under review ;*

4. *Include other past, existing and future (reasonably foreseeable) action; and*

5. *Evaluate significant effect in consideration of other than just local and direct effects."*

11. This Hon'ble Tribunal in ***Vimal Bhai & Anr. v. Union of India & Ors., 2012***

**SCC OnLine NGT 77** which was an Appeal filed against the forest clearance granted for diversion 80.507 ha of forest land for the construction of a 65m dam across the river Alakhnanda in Uttarakhand, the Hon'ble NGT delved into detail as to what cumulative effects would entail. It has stated that cumulative effects are those that –

- " (i) are caused by the aggregate of past, present, and future actions;
- (ii) are the total effect, including both direct and indirect effects, on a given resource, ecosystem, and human community of all actions taken, no matter who has taken the actions;
- (iii) need to be analysed in terms of the specific resource, ecosystem, and human community being affected;
- (iv) cannot be practically analysed beyond a reasonable boundary; the list of environmental effects must focus on those that are meaningful;
- (v) rarely correspond to political or administrative boundaries;
- (vi) may result from the accumulation of similar effects or the synergistic interaction of different effects;
- (vii) may last for many years beyond the life of the project that caused the effects; and
- (viii) should be assessed in terms of the capacity of the affected resource, ecosystem, and/or human community to accommodate additional *effects."*

12. At this juncture, it is pertinent to note the contents of the EIA Guidance Manual for Thermal Power Plants prepared for the MoEF, Government of India, by IL&FS

Ecosmart Ltd. In the said Guidance Manual for thermal power plants Cumulative Impacts have been defined as follows:

*"2. 8.3 Cumulative Impact*

*Cumulative impact consists of an impact that is created as a result of the combination of the project evaluated in the EIA together with other project in the same vicinity causing related impacts. These impacts occur when the incremental impact of the project is combined with the cumulative effects of other past, present and reasonably foreseeable future projects."*

13. That in this context it is important to look at the judgment of this Hon'ble Tribunal in dated 12.09.2011 in ***Sarpanch, Grampanchayat Tiroda v. The Ministry of Environment and Forests (Appeal No. 3 of 2011)***. This case involved the grant of an EC to the project proponent for conducting mining operations at Tiroda. Here the cumulative effect of four proposed projects was not properly considered. The Hon'ble Tribunal expressed the importance of a Cumulative Impact assessment as follows:

*"Unfortunately, the cumulative effect of these four proposed project was not considered to be of significant in causing environmental pollution in a small area. It appears an impression is sought to be created that there was only one application of Tiroda mine and at that time the Redi mine was not in operation. When number of mines are sought to be considered in a small area of Sawantwadi Taluk, the EAC was expected to examine various aspects such as the cumulative impact of Air, Water, Noise Flora, Fauna and Socio economic aspect in view of large number of transport vehicles, plants and machinery, etc. that would be operating in the area. It would have been appropriate, if a cumulative impact study was undertaken to take care of all existing/proposed mines within 10 km of the present project site apart from Redi mine, if any. Therefore, we are of the opinion that these aspect were not property assessed and examined scientifically and therefore the 'EIA report requires to be re-examined*

*afresh' Thus' the EIA report suffers from incorrect and insufficient data which pertains to a period much prior to grant of TOR, therefore the EIA report cannot be said to be sufficient for the purpose of recommending grant of EC."*

14. The importance of a cumulative impact assessment was also reiterated by the Hon'ble Supreme Court in the case of ***Alaknanda Hydro Power Company Ltd. v. Anuj Joshi and Orc. reported in (2014) 1 SCC 769 para 50.*** The aforementioned judgments indicate that the obligation to conduct cumulative impact assessments is a well-established precept of Indian environmental and conservation jurisprudence. Given that the Cumulative Impact Assessment study was not carried out adhering to universally accepted scientific parameters, and the same was accepted by the EAC without any application of mind, vitiates the grant of the EC by the MoEF&CC. Therefore, in view of the settled case law on the issue of Cumulative Impact Assessment by the Hon'ble Supreme Court in ***Alaknanda Hydro Power Company Ltd. vs. Anuj Joshi and Orc. reported in (2014) 1 SCC 769*** and NGT's larger bench Judgment in ***Appeal no. 50 of 2012 in T. Muruganandam & Ors. vs. Ministry of Environment & Forest & Ors.*** and other Judgments ***Sarpanch, Grampanchayat Tiroda vs. The Ministry of Environment and Forests (Appeal No. 3 of 2011) Vimal Bhai & Anr. vs. Union of India & Ors., 2012 SCC OnLine NGT 77***, it is clear that the no Cumulative Impact Assessment that is required was actually carried out.
15. In view of the already high levels of pollution, several cement units and thermal power plants, already existing in the region, Cumulative Impact Assessment Study needed to be done in terms of and as per the abovementioned Judgements which has still not been done.
16. **That in Rejoinder to the Contention No. (iv)** that the project has Forest Clearance it is stated that the same is wrong and denied. It is admitted by the Respondent No.4 in its Reply that the Project only has stage-2 Forest Clearance for 1892.35 Ha. The Project Proponent has not produced the final Section 2 order permitting

Forest Clearance under Forest (Conservation) Act, 1980 issued by the State Government. It is stated that it is well settled that without the final forest clearance order no forest land can be utilised by the project proponent for non-forest purpose. In this case it would be appropriate if this Hon'ble Tribunal seeks a report as to how much of the Forest land has been broken into by this Project without section 2 final forest Clearance.

17. That as per the law laid down by this Hon'ble Tribunal in ***Vimal Bhai & Anr v. Union of India & Ors. 2012 SCC Online NGT 77*** and ***Prafulla Samantara v. Union of India & Orc., 2014 SCC Online NGT 892*** it has been clarified to the effect that No Non-forest activity can be carried out before granting of the final state government Order under Section 2 of the Forest (Conservation) Act, 1980 and that both Stage I (in principle) and Stage II are not Forest Clearances as required under the law. Non Forest use of forest land can be permitted only after an order is issued by the State Government under Section 2 of the FC Act, 1980.
18. This Hon'ble Tribunal in ***Vimal Bhai and Ors. v. MoEF and Ors., 2011 SC OnLine NGT 16*** that:-

*"30. However, a party cannot be remediless, a person who is aggrieved by the Approval/Clearance granted by the Central Government has to avail an opportunity to assail the same. In the aforesaid scenario it can safely be concluded that after receiving a Stage - I and/or Stage - II Clearance, thereby granting a consent to permit use of forest land for non-forest purposes, from the Central Government, it is incumbent upon the State Government to pass a reasoned order transferring and/or allowing the land in question for being used for non forest purpose. **It is needless to be said that bereft or such order no forest lands can be put to use for non-forest purpose. Further, all activities done without such orders would be ab initio void.** An Appeal can be filed against the said order of the State Government under Section 2(A) of FC Act and/or under Section 16(e) of the NGT Act. In the event such an Appeal is filed it would be open for the person aggrieved, to assail the order/Clearances granted by the Central Government under Section 2 of the Act which forms an integral part and sole basis of the order passed by the State Government."*

(Emphasis supplied)

19. This Hon'ble Tribunal in ***Prafulla Samantara v. Union of India & Ors. 2014*** ***SCC Online NGT 892*** has clarified that no non-forest activity can be carried out before the final State Government order-

**"This question also came for consideration before a Bench of this Tribunal in the case of Vimal Bhai v. Union of India in Appeal No. 7 of 2012 dated 7th November, 2012.**

**In addition to the aforesaid-we do concur with the judgment of Bench of this Tribunal in Vimal Bhai v. Union of India (supra) to the extent that the State Government is obliged to pass an Order then alone non forest activity can be carried on in the forest area in terms of section 2 of the Act of 1980.**

*The Learned Counsel appearing for the parties have also brought to our notice a reply in the form of information to a RTI query raised under Right to Information Act, 2005. In this it is recorded that the State Government does not pass any order under Section 2 of the Act of 1980. This reply is contrary to the requirements of law and we, therefore, specifically set-aside such view and direct that all State Governments shall pass an appropriate order in accordance with law in terms of Section 2 of the Act of 1980.*

*Having answered the above question, nothing survives in this application and accordingly Original Application No. 123 of 2013 is disposed of. The Respondent No. 3 (Project Proponent) is at liberty to approach the State Government for appropriate Orders in accordance with law.*

*Till such Order is passed by the Competent Authority, Respondent No. 9 would not carry on tree cutting/felling in the forest area."*

(Emphasis supplied)

20. **That in Rejoinder to the Contention No. (v)** that there will be no impact on Amrabad Tiger Reserve is wrong and denied. The new standard for SO<sub>2</sub> and NO<sub>x</sub>

permits 100 mg/Nm<sup>3</sup> each of these gases in the flue gas leaving the stack. That is not exceptionally low by any standard. Incremental concentration for these gases as predicted and presented in the revised EIA table 4.6 range between <5 – 18 mg/Nm<sup>3</sup> for SO<sub>2</sub> and <5 – 20 mg/Nm<sup>3</sup> for NO<sub>x</sub> and these are not exceptionally low. The NAAQS of USEPA permits just 75 ppb of sulphur dioxide for 1 hour as primary standard and 0.5 ppm for 3 hours to be exceeded only once in a year. Similarly for NO<sub>x</sub> the primary standard is 100 ppb and a primary and secondary standard of 53 ppb for 1 year.

Copy of the NAAQS Standard table as per USEPA mentioned at <https://www.epa.gov/criteria-air-pollutants/naaqs-tables> annexed as

### **ANNEXURE-A29**

21. That it is stated that the air pollution dispersion modeling was done with dry stack of 275 m height while the wet stack to be used with FGD unit in place with a height of about 150 m and larger in diameter will change the GLCs. As the stack outlet concentration for both SO<sub>2</sub> and NO<sub>x</sub> remaining same at 100 mg/Nm<sup>3</sup> the GLC will be much higher. The very premise of meeting the NAAQS could change. It is stated that the Respondent No.4 has failed to substantiate the statement that "there will be no impact on the Tiger Reserve" with published scientific evidence which shows that SO<sub>2</sub> can harm trees at levels below 1 ppm.

Copy of Research Article "Assessment of the Tolerance of Trees to High Concentration Sulfur Dioxide published in Research Gate is annexed herewith as

### **ANNEXURE-A30**

22. That it is re-iterated that according to the MoEF's 2010 siting guidelines area 25 Kms from a Wildlife Sanctuary or National Park should be avoided for setting up of a Thermal Power Plant.

23. That the impact of the transportation of coal, fly ash, etc. would also impact the wildlife in and around the Amrabad Tiger Reserve and the tiger corridors.

24. **That in Rejoinder to the Contention No. (vi)** that minimum flow from upstream reservoir would ensure sustenance of down stream ecology of the River Krishna is wrong and denied. Respondent No.4 submits that the Thermal Power

Plant would only withdraw 0.03% of the average flow of the River Krishna. (EIA § 4.2.3.9).

25. However, it is important to understand that the flow in the River Krishna varies dramatically through the year, and sufficient flow must be maintained year round to sustain aquatic ecosystems. If the Thermal Power Plant withdraws 0.24 million m<sup>3</sup>/day during the lowest flow period when the river flows at just 4.34 million m<sup>3</sup>/day, the Thermal Power Plant would be diverting 5.5% of the entire river flow. This diverted proportion is then 183 times greater than the proportion (0.3%) Respondent No.4 has based its conclusion on.

26. That various studies show that in most years, the Krishna river water has not been joining the sea due to the complete extraction of water, mainly for agriculture. The International Water Management Institute (IWMI), a CGIAR institution, has clearly documented in its 121st Report that the Lower Krishna Basin has become a closed basin, i.e., there is no outflow to the sea in number of years. The Report, J.P. Venot et al, Shifting Waterscapes: Explaining basin closure in the Lower Krishna Basin, South India (IWMI, Colombo, 2007), says:

“The Krishna Basin has seen an increasing mobilization of its water resources and a dramatic development of irrigation, with little regard to the limits of available water resources. This progressively led to closure of the basin (zero or minimal discharge to the ocean): by 2001-2004, surface water resources were almost entirely committed to human consumptive uses, increasing groundwater abstraction contributed to the decrease in surface water base flows and the discharge to the ocean was almost zero...”

...

“By 1996-2000, 77% of the Lower Krishna Basin net inflow was depleted and discharge to the ocean amounted to 17.9 BCM/yr, defining a moderately modified ecosystem. During the drought of 2001-2004, likely to forecast the future waterscape of the Lower Krishna Basin, all indicators pointed to a fully committed situation, with depletion amounting to 98.8% of the net inflow, a lack of discharge to the ocean, a dramatic overdraft of the aquifers and the shrinkage of surface irrigated agriculture.”

Copy of the relevant page of the 121st Report of International Water Management Institute (IWMI) is annexed as **ANNEXURE-A31**

27. That though it is stated 15 % of minimum flow is considered as minimum ecological flow required as observed by this Hon'ble Tribunal vide it's Order dated

09.08.2017 in ***Pushp Saini Vs. Ministry of Environment, Forest & Climate Change & Ors., Original Application No. 498 of 2015***, this minimum flow is not being maintained even today even before this project is constructed.

Copy of the Order dated 09.08.2017 in Pushp Saini vs. Ministry of Environment, Forest & Climate Change & Ors. is annexed herewith as **ANNEXURE-A32**

28. That **in Rejoinder to the Contention No. (vii)** that the analysis of Mercury in the coal has been done it is stated that Respondent No.4 does not address the issue in the appeal that the EC was granted without proper evaluation of the mercury content of the source coal for the project. Without complete data, the EC application could not be properly evaluated and the EC never should have been issued without all required data.

29. Respondent's inability to provide data on the mercury content of source coal, it is impossible to evaluate the potential damage from mercury emissions from the proposed Thermal Power Plant. Efficiency of mercury removal by air pollution controls varies widely depending on source coal as well as the particular controls employed and the manner in which they are operated. Respondent's failure to provide details regarding these critical factors makes it impossible to evaluate the potential for mercury contamination in nearby waterways. Studies have shown that at least 10%, and possibly as much as 70%, of the total mercury emitted into the air by Thermal Power Plant's falls to the surface within 25 km of the smoke stack.

Copy of the study titled Mercury Emissions from Coal Fired Power Plants Local Impacts on Human Health Risk, at p 51 (2005) by T. M. Sullivan, et. al, Brookhaven Nat'l Laboratory is annexed herewith as **ANNEXURE-A33**

30. That **in Rejoinder to the Contention No. (viii)** that the NGT Judgment in Krishi Vigyan Sanshamn nowhere states that the Project Proponent need to undertake detailed studies on radioactivity before clearance is given it is stated that the same is wrong and denied.

31. That in the ***Appeal No.07 of 2011 (Krishi Vigyan Arogya Sanstha & Ors. Vs. The Ministry of Environment & Forests & Ors.) dated 20.09.2011***

wherein this Hon'ble Tribunal had disposed of the appeal with the following directions:-

**"Conclusion:**

*10. Taking all the above into consideration, we are of the considered opinion that this appeal requires to be disposed of with the following directions keeping in view the principles of sustainable development and precautionary principle.*

*a) The first respondent, Ministry of Environment and Forests is directed to look into the matter as to long term impacts caused by nuclear radiation from the thermal power projects, by instituting a scientific long term study involving Bhabha Atomic Research Agency or any such other recognized scientific institution dealing with nuclear radiation with reference to the coal ash generated by thermal power project (Respondent No. 3) particularly the cumulative effect of a number of thermal power project located in the area on human habitation and environment and ecology. The study shall also take into consideration the health profile of the residents within the area in which the pollutants are expected to spread from the thermal power project.*

*b) The Ministry of Environment and Forests shall direct the proponent to synchronize the commissioning of the project with that of the Sewage Wastewater Treatment plant, treated water from which is proposed to be used for the operation of the project. Until, there is such synchronization, no Consent to Operate shall be issued by the Maharashtra State Pollution Control Board and the Board shall monitor the mitigating measures suggested in the Environmental Clearance.*

**c) The Ministry of Environment and Forests shall include in the Terms of Reference of all the future projects asking the proponent to furnish details of possible nuclear radioactivity levels of the coal proposed to be used for the thermal power plant.**

*d) The Ministry of Environment and Forests shall get the national standards prescribed, if not already available, from the Department of Atomic Energy, Govt. of India within a period of one year from*

*the date of receipt of this order, as to permissible levels of nuclear radiation in residential, industrial and ecologically sensitive areas of the country.*

*e) If any of these directions are not carried out, the appellant is at liberty to take appropriate steps as required under the law.*

*With the above directions, the Appeal stands disposed of."*

**(Emphasis supplied)**

32. That it is stated therefore it is apparent from a mere reading of the above directions that the much before the EC is granted i.e. from the stage of grant of Terms of Reference, all the future projects need to furnish details of possible nuclear radioactivity levels of the coal proposed to be used for the thermal power plant. This view has been further reiterated by this Hon'ble Tribunal in ***Appeal No. 105 of 2016 (SZ) titled Dr. Lenin Dhanisetty vs Union of India and Ors.*** where this Hon'ble Tribunal vide it's Order dated 21<sup>st</sup> January, 2021 has issued the following direction:-

*"26. (iv) The MoEF&CC is directed to comply with the directions issued by the Principal Bench of National Green Tribunal, New Delhi in **Appeal No.07 of 2011 (Krishi Vigyan Arogya Sanstha & Ors. Vs. The Ministry of Environment & Forests & Ors.) dated, 20.09.2011** while issuing Terms of Reference (ToR) in respect of thermal power plant in its letter and spirit."*

33. That Respondent No.4 does not deny that it had failed to evaluate the levels and impacts of radiation in the source coal for the proposed Thermal Power Plant and the resultant coal ash. Radiation is a known environmental and human health danger associated with coal, and the failure to evaluate these risks for the project constitute a serious deficiency in the EIA.

34. That **in Rejoinder to the Contention No. (ix)** that Detailed Water Balance and wastewater balance has been furnished in the Revised EIA is wrong and denied. it is stated that the Respondent's claim that it provided a "detailed water balance

and wastewater balance has been furnished in the Revised EIA Report at Para 2.10.3 and Fig. 2.11 on Page 44," is false and misleading. This paragraph of the EIA merely describes the theoretical components of the proposed ash handling system and contains no mention whatsoever of the volume of wastewater the proposed Thermal Power Plant will generate, making it impossible to evaluate whether the proposed system is adequate. Figure 2.11 in the EIA does not depict a "detailed waste water balance," at all; as the title of the diagram indicates, it is simply a "flow diagram of ash water recovery system." The key distinction between a water balance diagram and a flow diagram is that the former includes volumes of water flowing into and out of various parts of the system (*i.e.*, the *balance* of inflow and outflow), while a flow diagram only depicts the various components of the system (and in this case, the maximum capacity of some of the pumps and tanks). The Respondent No.4's failure to provide any data about the amount of ash slurry that will be piped to the ash dyke is a gross deficiency in the EIA, which renders it impossible to determine whether the proposed treatment systems will be adequate to treat the huge volume of heavily contaminated water the proposed Thermal Power Plant will generate. Respondent No.4 also fails to explain how the treatment system can be evaluated at the EC stage when the system itself has not even been designed yet. Further, Respondent No.4 avoids responding to the Appellant's contention that the Respondent No.4 also failed to account for the effects of monsoon inflow to the system.

35. That **in Rejoinder to the Contention No. (x)** that Project Proponent has applied to Ministry of Coal for allocation of a long term coal linkage, it is stated that as per the Table 5.1 of EIA the Coal sources have been mentioned as M/s Singareni Coal Collieries for domestic and M/s MSTC for imported coal. Also, merely naming three possible ports, and not specifying the specific sources of coal or the various permissions needed to set up the rail/handling infrastructure does not provide adequate information by which to assess and evaluate the environmental impacts. It is stated that the Respondent has failed to assess the physio-chemical properties of the coal it intends to burn in the proposed Thermal

Power Plant. It has merely stated that some of the coal would likely come from mines that do not even exist yet and may never exist, and "in case there is delay then SCCL will provide coal from other sources." This provides no basis upon which the actual impacts of the project can be evaluated, such as the levels of air pollution emissions and amount of ash to be generated, as the source of coal is yet to be confirmed.

36. It is respectfully submitted that the ToRs clearly require the identification of fuel linkage, analysis for radioactivity and heavy metals in the source coal, and additional fuel analyses, including ash content. Since the Project Proponent did not identify the source coal, the following Standard Terms of Reference are violated:

(i) The Project Proponent has violated ToR No. 42 by failing to conduct the required analyses and include the laboratory reports in the EIA. Further the sole analysis contained in the EIA of domestic coals is deficient and is used by the Project Proponent in a misleading manner to make a patently false claim as mentioned in the below-mentioned paras.

(ii) Standard ToR 43 requires: "Fuel analysis shall be provided."

(iii) The Project Proponent violates ToR 43 by failing to provide an analysis of a specific source of coal. The Project Proponent admits in the reply to the representation of Shri N. Harinder that a specific source of imported coal has not been fixed and states that the coal may be from any country from which MSTC imports coal.

(iv) Standard ToR 44 requires: "Quantity of fuel required, its source and characteristics and documentary evidence to substantiate confirmed fuel linkage shall be furnished. The Ministry's Notification dates 02.01.2014 regarding ash content in coal shall be complied."

(v) The Project Proponent has violated ToR 44 by failing to substantiate confirmed coal linkage of imported coal. The Project

Proponent failed to supply the source, characteristics or documentary evidence regarding the same.

- 37. That in Rejoinder to the Contention No. (xi)** with respect to the issue of Ash Dyke, HPDE liner and clay lining it is stated that Respondent No.4 has admitted that it has not even conducted geotechnical investigations to determine whether it is even possible to construct an ash pond in the proposed location, nor has it offered any explanation of how it will proceed should it eventually discover that the proposed land is not suitable for ash dyke construction. Similarly, Respondent No.4 has not demonstrated that its HDPE liner will be adequate to prevent leaching, because Respondent has not designed the ash dyke or the liner, including the clay layer that must underlie an HDPE liner.
38. With regards to the proposed ash dyke, Respondent No.4 provides the most cursory, vague description of the structure, stating it will be "400 acres with 15 m height (max)." Seven words is hardly sufficient to describe and evaluate a massive structure that will be filled with millions of cubic metres of toxic waste, with the potential to bury entire villages, rivers and hundreds of acres of farmland should there be a breach in the dyke. Complete engineering specifications must be provided, including details such as materials to be used to construct the dyke, analysis of underlying soil stability, seismic activity in the area, slope factors of safety, etc. Numerous ash dyke breaches have wreaked havoc across India in recent years, and the Respondent No.4 has failed to demonstrate that it is taking sufficient steps to ensure the proposed ash dyke will not cause yet another disaster.
39. That Respondent No.4 admits that it has failed to take into account the design of the ash dyke, or even the suitability of the proposed land area for ash dyke construction when it performed the EIA. The environmental impacts of the proposed project cannot be evaluated without these critical details.

40. Respondent No.4 does not deny the allegation in Para 95 of the Appeal, that though the Respondent listed "breach of ash dyke" as a potential hazard in the EIA, yet it failed to develop or describe any emergency preparedness plan.
41. The Appellant acknowledges the obvious fact the US EPA requirements are not legally binding in India - however the US requirements are merely referenced to demonstrate what has been determined to be necessary to protect the surrounding environment from leachate from a coal ash impoundment. The Respondent No.4 has failed to offer any evidence that its proposed 100-micron liner will be sufficient to prevent leakage. The additional verbiage included by the Respondent No.4 is merely a vague and speculative list of factors it may consider when it constructs its ash dyke, but does nothing to demonstrate the environment will actually be protected from the vast amounts of toxic waste the project would create.
42. The US EPA has determined that "even the best liner and leachate collection system will eventually fail due to natural deterioration." It should be noted that Respondent No.4 is currently proposing a thinner liner that is less protective for its ash dyke than what US EPA requires for landfills in the US. Moreover, Respondent No.4 again acknowledges that it has not even conducted geotechnical investigations to determine whether it is even possible to construct an ash pond in the proposed location, nor has it offered any explanation of how it will proceed should it eventually discover that the proposed land is not suitable for ash dyke construction.
43. Appellant cites US EPA monitoring requirements for coal ash dykes because in 2015, since the US EPA has implemented the most comprehensive set of environmental rules in the world that apply specifically to coal ash. India has only general groundwater regulations that do not take into account the specific set of chemicals and environmental hazards associated with coal ash. The EPA rules were written based on extensive scientific research as well as input from

the regulated industry. Thus, the US EPA rules serve as a guidepost for monitoring ash dykes anywhere in the world.

**44. That in Rejoinder to the Contention No. (xii)** on the issue of Fly Ash disposal it is stated that Respondent No.4 acknowledges that the combined capacity of area cement plants to accept fly ash from the proposed Thermal Power Plant is only 0.875 million tonnes (MT) per annum, while the Thermal Power Plant would generate 2.2 MT per annum. Even assuming Respondent No.4 is able to offload the entire 0.875 MT to cement plants (with whom it has no firm agreements), that leaves 1.325 MTPA to be disposed in the ash pond. Over 25 years, that would amount to 33.125 MT of ash that must be disposed in the ash pond, exceeding the ash pond's 30 MT capacity. Respondent No.4 claims that it will achieve 25%, 50%, 75%, and finally 100% utilization over the first five years of operation, however it does not explain exactly how this will be accomplished, and the fact remains that it does not even have firm agreements with the cement plants that could help achieve some, but not all, of the utilization goals. The proposed disposal and storage of fly ash by the project proponent would be in violation of the provisions of the Fly Ash notifications issued by the MoEF.

**45. That in Rejoinder to the Contention No. (xiii)** that EIA of the project has extensively dealt with the Hydrology of the site is wrong and denied. Respondent No.4 has failed to provide hydrogeological evaluation, as required by the ToR. The EIA contains cursory statements characterizing a study, but fails to provide the study itself. Thus, the findings cannot be adequately evaluated. The EAC should not have recommended the grant of EC without such information.

46. Respondent No.4 does not address the issue raised in Para 79 of the Appeal that Respondent No.4 did not provide details of how drainage features that contribute to the flow of the Tungapahad Vagu will be diverted. Figure 4.21 (A) in the EIA depicts the project footprint overlaying six distinct tributary streams,

and Figure (B) is the exact same image, except the stream segments lying within the project boundaries have been deleted. It would not be possible to simply eliminate sections of the streams within the project boundary, while leaving upstream segments of the same streams that lie outside the project boundary. Even if it were possible to delete sections of streams in the manner shown, this would reduce flows to the Tungapahad Vagu, causing ecological damage.

47. The ToR requires distance of 500 m between ash dyke and all streams on site, not just the Tungapahad vagu. Respondent proposes to construct the ash dyke over two existing streams, claiming, without providing any detail, that the streams will be diverted. Will Respondent divert the existing streams more than 500 meters away from the ash dyke? This appears impossible to do, and Respondent has provided no details about where the streams will be diverted.

48. Respondent's replies to Shri N. Harinder were vague, incomplete, and in at least one instance, demonstrably false. Respondent No.4 made the outrageous false claim that "the sides of the vagu is completely rocky terrain and there is no possibility of seepage of any water from the ash pond into the vagu area." Rocks are not impermeable substrate on earth, and the rocky terrain Respondent referred to will not prevent contaminated groundwater from entering the vagu through its banks and bed.

49. Respondent No.4 plans to destroy six tributaries of the Tungapahadu stream, which will alter the flow and ecology of the stream, which will violate EC condition (xxxiii). Though the Respondent now claims that the tributaries will be diverted to discharge into the vagu, there is no description of how this will be accomplished or where the tributaries will be diverted to in the EIA reports, thus making it impossible to evaluate the feasibility and impacts of this endeavour.

50. That Ground water levels often shift dramatically during pre-monsoon and monsoon seasons. The Respondent No.4 has failed to include temporal

distinctions in the cursory information it has provided about groundwater levels, making it impossible to evaluate the suitability of the site for the project.

51. The Respondent again concedes that it has not even designed the storm water management system for the proposed project, and that it will be designed later, during the "engineering phase." The so-called "detailed storm water management" the Respondent claims to have furnished amounts to six sentences that provide little detail about how storm water will be dealt with. What few details are provided give rise to serious concerns about off-site pollution from contaminated runoff. For example, the EIA (at pages 265, 268) states:

*"Storm water drain in the northern direction of the ash pond at the outer periphery will be laid to collect the rainwater from the upstream. This drain will prevent wash off of the ash dyke and contamination. This drain will be connected to the streamlets on the downstream of ash point for draining into the Tungapahad Vagu."*

52. This description raises many questions and concerns. What kind of storm water drain and what will be its capacity? Where is "the northern direction of the ash pond"? The drain will be laid at the outer periphery of what? How will this drain prevent washoff of the ash dyke? How does the drain prevent contamination if it simply connects to the Tungapahad Vagu, which then connects to the Krishna River? The information in the EIA is grossly inadequate to explain how storm water runoff will be mitigated at the project.

53. The Respondent contends "that the rainfall cannot infiltrate to the groundwater table and recharge contaminated water due to precipitation," demonstrating an astonishing lack of understanding of the most elementary concepts of the hydrological cycle. Any Thermal Power Plant will have various sources of contamination (e.g. coal pile, ash dust, etc.) that will be exposed to rainwater around the site. It is basic knowledge that water that falls as precipitation must either evaporate, run off to a stream, or percolate into the ground.

54. **That in Rejoinder to the Contention No. (xiv)** that Public Health impacts have been addressed. it is stated that Respondent No.4 is trying to divert the issue by raising a confusion between public and occupational health. The answer given about measures taken to reduce impacts on public health is mere implementation of new emission norms that were to be implemented by December 2017. Even now most of the plants of TSGENCO have not implemented the air pollution norms for SO<sub>2</sub> and NO<sub>x</sub>. There is plenty of peer reviewed literature on public health impacts from plants that have already implemented FGD and DeNoX units in other countries. Paul R. Epstein et al., Full cost accounting for the life cycle of coal, Ann. N.Y. Acad. Sci. 1219 (2011) 73–98] states:-

*"The true ecological and health costs of coal are thus far greater than the numbers suggest. Accounting for the many external costs over the life cycle for coal-derived electricity conservatively doubles to triples the price of coal per kWh of electricity generated."*

55. Physicians for Social Responsibility lead by Dr Alan H. Lockwood produced a white paper "Coal's Assault on Human Health" in November 2009. Dr Alan also wrote a book "The Silent Epidemic: Coal and the Hidden Threat to Health" published by MIT Press in 2012. These present the health effects of coal on respiratory, cardiovascular and nervous systems at pollution levels below those at Indian coal fired power plants.

56. National Academies of USA produced a study "HIDDEN HEALTH AND ENVIRONMENTAL COSTS OF ENERGY PRODUCTION AND CONSUMPTION IN U.S." in 2009. This study states "In 2005 the total annual external damages from sulfur dioxide, nitrogen oxides, and particulate matter created by burning coal at 406 coal-fired power plants, which produce 95 percent of the nation's coal-generated electricity, were about \$62 billion; these non climate damages average about 3.2 cents for every kilowatt-hour (kWh) of energy produced."

Pass any other orders as the Hon'ble Tribunal may deem fit and proper in facts and circumstances of the case.

*Debi Goenka*

**APPELLANT No.1**

THROUGH

*gms*

**RITWICK DUTTA SAURABH SHARMA G.STANLY HEBZON SINGH  
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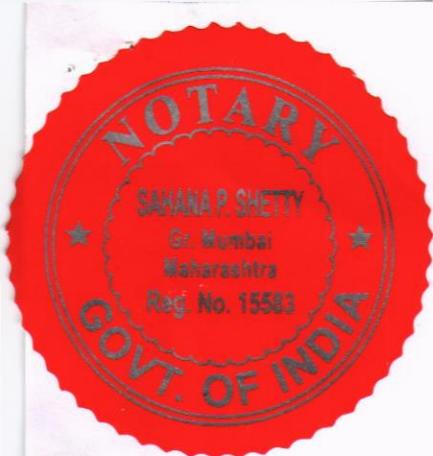
Date: *04-02-2021*

**VERIFICATION**

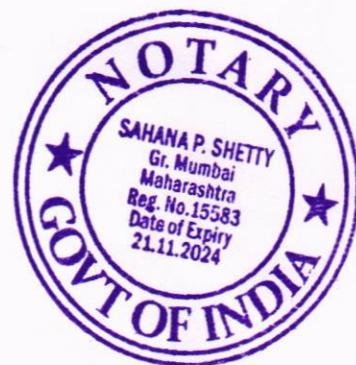
I, Debi Goenka, S/o Shri Nandlall Goenka, aged about 64 years, R/o B-502, Glengate, Hiranandani Gardens, Powai, Mumbai-400076 do hereby verify that the contents of the Paras 1 to 56 are true to my personal knowledge and that I have not suppressed any material fact.

*Debi Goenka*

**APPELLANT No.1**



**BEFORE THE NATIONAL GREEN TRIBUNAL  
SOUTHERN ZONE BENCH AT CHENNAI  
APPEAL NO. 15 OF 2020(SZ)**



**IN THE MATTER OF:**

The Conservation Action Trust & Anr.

...Appellants

Versus

Union of India & Ors.

...Respondents

**AFFIDAVIT**

Debi Goenka, S/o Shri Nandlall Goenka, aged about 64 years,  
B-502, Glengate, Hiranandani Gardens, Powai, Mumbai-400076, Executive  
Trustee and Authorized Representative of Appellant No. 1, do hereby solemnly  
affirm and state as under:

That I am presently the Executive Trustee and Authorized Representative  
of Appellant No. 1 Organization and am well conversant with the facts and  
circumstances in the abovementioned Appeal and as such, I am competent  
to swear this affidavit.

2. That the contents of the accompanying Rejoinder are true and correct and  
nothing material has been concealed therefrom.

*Debi Goenka*

**DEPONENT**

**VERIFICATION**

Verified on this 28<sup>th</sup> Day of January 2021 that the contents of the above mentioned affidavit are  
true and correct and nothing material has been concealed therefrom and no part of it  
is false.

**ATTESTED BY ME**

*S. Shetty*  
*Debi Goenka*

**SAHANA P SHETTY**  
**NOTARY GOVT. OF INDIA**  
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Powai, Mumbai-400076.  
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**DEPONENT**

28 JAN 2021

|              |              |
|--------------|--------------|
| REGISTER No. | Date 28/1/21 |
| SR No. 149   |              |



# TECHNICAL EIA GUIDANCE MANUAL FOR THERMAL POWER PLANTS

Prepared for  
**The Ministry of Environment and Forests**  
Government of India



by  
**IL&FS Ecosmart Limited**  
Hyderabad

August 2010

determined based on whether or not the project or activity requires further environmental studies for preparation of an EIA for its appraisal prior to the grant of environmental clearance. The necessity of which will be decided, depending upon the nature and location specificity of the project, by SEAC after scrutiny of the applications seeking environmental clearance for Category B projects or activities.

The projects requiring an EIA report shall be included in Category B1 and remaining projects will fall under Category B2 and will not require an EIA report and public consultation.

#### 4.2.3 Application for prior environmental clearance

- The project proponent, after identifying the site and conducting the pre-feasibility study, is required to apply for the prior environmental clearance by filling and submitting the Form I given in **Annexure VII**. The proponent has to submit the filled in Form I along with the pre-feasibility report and draft ToR for EIA studies to the concerned Authority *i.e.*, MoEF, Government of India for Category A projects and the SEIAA/UTEIAA in case of Category B projects. Please refer subsequent sections for the information on how to fill the Form I, contents of pre-feasibility report and draft ToR for Thermal power plant.
- Prior environmental clearance is required before starting any construction work, or preparation of land on the identified site/project/activity by the project management, except for securing the land.
- If the application is made for a specific developmental activity, which has an inherent area development component as a part of its project proposal and the same project also attracts the construction and area development provisions under 8a and 8b of the Schedule, then the project will be seen as a developmental activity other than 8a and 8b of the Schedule.

#### 4.2.4 Siting guidelines

These are the guidelines, stake holders may consider while siting the developmental projects, to minimize the associated possible environmental impacts. In some situations, adhering to these guidelines is difficult and unwarranted. Therefore these guidelines may be kept in the background, as far as possible, while taking the decisions.

##### Areas preferably be avoided

While siting industries, care should be taken to minimize the adverse impact of the industries on immediate neighborhood as well as distant places. Some of the natural life sustaining systems and some specific landuses are sensitive to industrial impacts because of the nature and extent of fragility. With a view to protect such sites, the industries may maintain the following distances as far as possible, from the areas listed:

- Ecologically and/or otherwise sensitive areas: Preferably 5 km; depending on the geo-climatic conditions the requisite distance may be decided appropriate by the agency.
- Coastal Areas: Preferably half-a-kilometre away from high tide line (HTL).
- Flood Plain of the Riverine System: Preferably half-a-kilometre away from flood plain or modified flood plain affected by dam in the upstream or by flood control systems.



### Operational Aspects of an EIA

- Transport/Communication System: Preferably half-a-kilometre away from highway and railway line.
- Major Settlements (3,00,000 population): Distance from settlements is difficult to maintain because of urban sprawl. At the time of siting of the industry, if the notified limit of any major settlement is located within 50 km, the spatial direction of growth of the settlement for at least a decade must be assessed and the industry shall be sited at least 25 km away from the projected growth boundary of the settlement.
- Critically polluted areas are identified by MoEF from time-to-time. Current list of critically polluted areas is given in **Annexure VIII**.

Note:

*Ecological and/or otherwise sensitive areas include (i) Religious and Historic Places; (ii) Archaeological Monuments (e.g. identified zone around Taj Mahal); (iii) Scenic Areas; (iv) Hill Resorts; (v) Beach Resorts; (vi) Health Resorts; (vii) Coastal Areas rich in Corals, Mangroves, Breeding Grounds of Specific Species; (viii) Estuaries rich in Mangroves, Breeding grounds of Specific Species; (ix) Gulf Areas; (x) Biosphere Reserves; (xi) National Parks and Sanctuaries; (xii) Natural lakes, Swamps; (xiii) Seismic Zones; (xiv) Tribal Settlements; (xv) Areas of Scientific and Geological Interest; (xvi) Defence Installations, specially those of security importance and sensitive to pollution; (xvii) Border Areas (International) and (xviii) Air Ports.*

*Pre-requisite: State and Central Governments are required to identify such areas on a priority basis.*

### General sitting factors

In any particular selected site, the following factors must also be recognized.

- No forest land shall be used for non-forest activity for the sustenance of the industry (Ref: Forest Conversation Act, 1980).
- No prime agricultural land shall be converted into industrial site.
- Land acquired shall be sufficiently large to provide space for appropriate green cover including greenbelt, around the battery limit of the industry.
- Layout and form of the industry that may come up in the area must conform to the landscape of the area, without affecting the scenic features of that place.
- Associated township of the industry may be created at a space having physiographic barrier between the industry and the township.

### Guidelines of central electricity authority [CEA], government of India, for site selection of coal-based thermal power stations

- The choice of location is based on the following:
  - Nearness to coal source;
  - Accessibility by road and rail;
  - Availability of land, water and coal for the final installation capacity;
  - Coal transportation logistics;
  - Power evacuation facilities;
  - Availability of construction material, power and water;
  - Preliminary environmental feasibility including rehabilitation and resettlement requirements, if any;

- Land requirement for large capacity power plant is about 0.2 km<sup>2</sup> per 100 MW for the main power house only excluding land for water reservoir (required if any).
- The land for housing is taken as 0.4 km<sup>2</sup> per project.
- Land requirement for ash pond is about 0.2 km<sup>2</sup> per 100 MW considering 50% of ash utilization. Land for ash pond is considered near the main plant area (say 5 to 10 km away). In case of non-availability of low lying ash pond area at one place, the possibility of having two areas in close proximity is considered.
- Water requirement is about 40 cusecs per 1000 MW.
- First priority is given to the sites those are free from forest, habitation and irrigated/agricultural land. Second priority is given to those sites that are barren, *i.e.*, wasteland, intermixed with any other land type, which amounts to 20% of the total land identified for the purpose.
- Location of thermal power station is avoided in the coal-bearing area.
- Coal transportation is preferred by dedicated marry-go-round (MGR) rail system. The availability of corridor for the MGR need to be addressed while selecting the sites.

#### **Guidelines for site selection of coal-based thermal power stations set by the MoEF**

- Locations of thermal power stations are avoided within 25 km of the outer periphery of the following:
  - metropolitan cities;
  - National park and wildlife sanctuaries;
  - Ecologically sensitive areas like tropical forest, biosphere reserve, important lake and coastal areas rich in coral formation;
- The sites should be chosen in such a way that chimneys of the power plants does not fall within the approach funnel of the runway of the nearest airport;
- Those sites should be chosen which are at least 500 m away from the flood plain of river system;
- Location of the sites are avoided in the vicinity (say 10 km) of places of archaeological, historical, cultural/religious/tourist importance and defense installations;
- Forest or prime agriculture lands are avoided for setting up of thermal power houses or ash disposal

### **4.3 Scoping for EIA Studies**

Scoping exercise is taken up soon after the project contours are defined. The primary purpose of scoping is to identify concerns and issues which may affect the project decisions. Besides, scoping defines the requirements and boundaries of an EIA study.

Scoping refers to the process by which EAC, in case of Category 'A' projects or activities, and SEAC in case of Category 'B1' projects, including applications for expansion and/or modernization of existing projects, determines ToR for EIA studies addressing all relevant environmental concerns for preparation of an EIA Report for a particular project.

2/3/2021

NAAQS Table | Criteria Air Pollutants | US EPA

An official website of the United States government.



### NAAQS Table

The Clean Air Act, which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards (40 CFR part 50) for pollutants considered harmful to public health and the environment. The Clean Air Act identifies two types of national ambient air quality standards. **Primary standards** provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. **Secondary standards** provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

The EPA has set National Ambient Air Quality Standards for six principal pollutants, which are called "criteria" air pollutants. Periodically, the standards are reviewed and may be revised. The current standards are listed below. Units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb) by volume, and micrograms per cubic meter of air ( $\mu\text{g}/\text{m}^3$ ).

| Pollutant<br>[links to historical tables of<br>NAAQS reviews] | Primary/<br>Secondary       | Averaging<br>Time           | Level  | Form  |  |
|---|-----------------------------|-----------------------------|--|---|--|
| <u>Carbon Monoxide (CO)</u>                                   | primary                     | 8 hours                     | 9 ppm  | Not to be exceeded more than once per year                                      |  |
|   |                             | 1 hour                      | 35 ppm                                       |   |  |
| <u>Lead (Pb)</u>  | primary<br>and<br>secondary | Rolling 3<br>month average  | 0.15 $\mu\text{g}/\text{m}^3$ <sup>(1)</sup> | Not to be exceeded  |  |
| <u>Nitrogen Dioxide (NO<sub>2</sub>)</u>                      | primary                     | 1 hour                      | 100 ppb                                      | 98th percentile of 1-hour daily maximum concentrations, averaged over 3 years   |  |
|   | primary<br>and<br>secondary | 1 year                      | 53 ppb <sup>(2)</sup>                        | Annual Mean   |  |
| <u>Ozone (O<sub>3</sub>)</u>                                  | primary<br>and<br>secondary | 8 hours                     | 0.070 ppm <sup>(3)</sup>                     | Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years |  |
| <u>Particle Pollution (PM)</u>                                | PM <sub>2.5</sub>           | primary                     | 1 year                                       | 12.0 $\mu\text{g}/\text{m}^3$   | annual mean, averaged over 3 years                                 |
|   |                             | secondary                   | 1 year                                       | 15.0 $\mu\text{g}/\text{m}^3$   | annual mean, averaged over 3 years                                 |
|   |                             | primary<br>and<br>secondary | 24 hours                                     | 35 $\mu\text{g}/\text{m}^3$   | 98th percentile, averaged over 3 years                             |
|   | PM <sub>10</sub>            | primary<br>and<br>secondary | 24 hours                                     | 150 $\mu\text{g}/\text{m}^3$  | Not to be exceeded more than once per year on average over 3 years |
| <u>Sulfur Dioxide (SO<sub>2</sub>)</u>                        | primary                     | 1 hour                      | 75 ppb <sup>(1)</sup>                        | 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years   |  |
|   | secondary                   | 3 hours                     | 0.5 ppm                                      | Not to be exceeded more than once per year                                      |  |

(1) In areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5  $\mu\text{g}/\text{m}^3$  as a calendar quarter average) also remain in effect.

(2) The level of the annual NO<sub>2</sub> standard is 0.053 ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.

(3) Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O<sub>3</sub> standards additionally remain in effect in some areas. Revocation of the previous (2008) O<sub>3</sub> standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.

2/3/2021

## NAAQS Table | Criteria Air Pollutants | US EPA

(4) The previous SO<sub>2</sub> standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2) any area for which an implementation plan providing for attainment of the current (2010) standard has not been submitted and approved and which is designated nonattainment under the previous SO<sub>2</sub> standards or is not meeting the requirements of a SIP call under the previous SO<sub>2</sub> standards (40 CFR 50.4(3)). A SIP call is an EPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the required NAAQS.

**Menu of Control Measures for NAAQS Implementation**

The Menu of Control Measures (MCM) provides state, local and tribal air agencies with the existing emission reduction measures as well as relevant information concerning the efficiency and cost effectiveness of the measures. State, local and tribal agencies will be able to use this information in developing emission reduction strategies, plans and programs to assure they attain and maintain the National Ambient Air Quality Standards (NAAQS). The MCM is a living document that can be updated with newly available or more current data as it becomes available.

- [Menu of Control Measures](#)

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## Assessment of the Tolerance of Trees to High Concentration Sulfur Dioxide

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**Keywords:** Tolerance; tree; Sulfur dioxide; Fumigation.

**Abstract.** This research utilized a custom-made air fumigation equipment to evaluate the tolerance of 10 species of side-walk trees with 600, 1000 and 2000 ppb Sulfur Dioxide (SO<sub>2</sub>) for 48 hours. The tolerance of tested trees toward SO<sub>2</sub> pollution was analyzed. Results showed that these plants influenced by high concentration SO<sub>2</sub> gas with physiology properties changes and the decrease of photosynthetic rates and the stomata conductance than before fumigation. The net photosynthetic rate and stomata conductance of tested trees was linearly correlated to each tested tree species. Among tested tree, the *Quercus glauca* had the highest tolerance in exposure with high concentration of SO<sub>2</sub> pollutant. While the *Camellia axillaries* was the least.

### Introduction

Plants are capable of absorb the air pollutant [1-3], so the information of their capacity and efficiency to clean the air pollution is important measurement to improve the air quality in our environment [4-5]. To achieve better air quality in the urban area the planted trees must have high tolerance to most known air pollutants. In this research, the SO<sub>2</sub> concentration of the experiment was 600, 1000 and 2000 ppb and the fumigation period was continually for 48 hours. The results of this research could let us understand the tolerance of plants with SO<sub>2</sub> more closely and accurately. The aims of this research were to evaluate the common side-walk trees tolerance ability to SO<sub>2</sub>, using as an indicator of air quality, by utilized custom-made fumigation equipment. The collected experimental data was used the ordered method to sort the tolerance ability toward SO<sub>2</sub> of 10 tested trees species.

### Materials and Methods

**Tested Plants.** In this study, 10 common sidewalk tree species were chosen for tested which shown in Table 1. The chamber capacities were 20 pots of plants per experiment, and there were 4 pots for each tested tree species using identical soil in each pot for all tested tree samples. The potting soil was composed of 73.4% sand, 11.3% silt and 15.3% clay. The pots were covered with aluminum foil to reduce water evaporation and to prevent SO<sub>2</sub> gas from being absorbed by the potting soil during fumigation. The height of each tested tree was in the range of 60 ~ 70 cm. All trees were cultivated for 2 months prior to the experimental period and watered twice daily.

Table 1. Tested Trees.

| Species                       | Family name    | Abbreviation |
|-------------------------------|----------------|--------------|
| <i>Acacia confusa</i>         | Leguminosae    | A. c.        |
| <i>Camellia axillaries</i>    | Theaceae       | C. a.        |
| <i>Hibiscus taiwanensis</i>   | Malvaceae      | H. ta.       |
| <i>Hibiscus tiliaceus</i>     | Malvaceae      | H. ti.       |
| <i>Leea indica</i>            | Leeaceae       | L. i.        |
| <i>Neolitsea parvigemma</i>   | Lauraceae      | N. p.        |
| <i>Palaquium formosanum</i>   | Sapotaceae     | P. f.        |
| <i>Podocarpus costalis</i>    | Podocarpaceae  | P. c.        |
| <i>Quercus glauca</i>         | Fagaceae       | Q. g.        |
| <i>Viburnum odoratissimum</i> | Caprifoliaceae | V. o.        |

**Fumigation System.** The tested trees were put into a custom-made fumigation chamber under natural sunlight. The chamber was made of clear 8 mm thick acrylic with the following dimensions: 1.5 m (L) x 1.5 m (W) x 2.0 m (H). It was then sealed with epoxy adhesive, as shown in Fig. 1. The SO<sub>2</sub> gas was supplied from the top of the chamber by a calibrated flow meter to control the fumigation of the SO<sub>2</sub> gas in the chamber. There was a fan attached to the chamber ceiling in order to mix the SO<sub>2</sub> to achieve a uniform environment in the chamber. The system utilized an air conditioner to control the temperature between 25 to 30°C during the fumigation experiment. An SO<sub>2</sub> gas detector (K50206 Pulsed Fluorescence, Philips, U.S.A.) was used to measure the concentration of SO<sub>2</sub> and to keep the gas concentration constant in the chamber during the experiment. The tree leaf physiological responses were examined before the after fumigation. The measurements of plant leaf physiological responses, including the net photosynthetic rate and stomata conductance, were tested using a Mini-Photosynthesis Meter (Walz, Germany).

**Fumigation Gas Concentration Monitoring.** In order to achieve constant gas concentration in the chamber during the fumigation experiment, a tube was connected between the chamber and a gas detector (see Fig. 1). SO<sub>2</sub> detection was achieved with a chemical luminescence spectrometer using the ultraviolet/fluorescence method. The ultraviolet exciting/emission wavelength was set at 190/230 nm, and the intensity of fluorescence was measured.

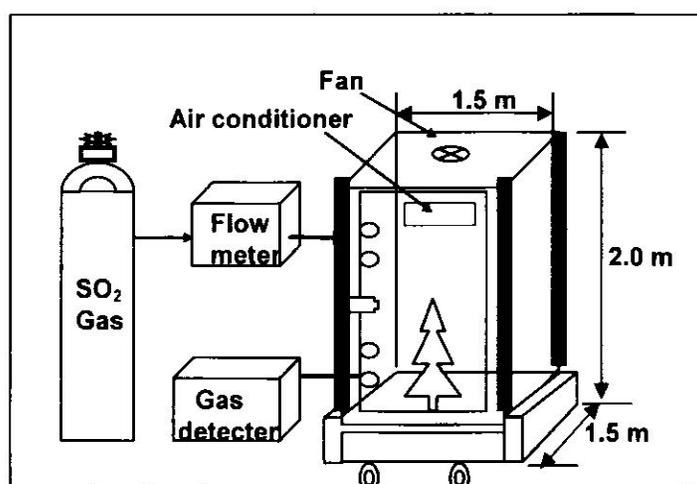


Fig. 1. Fumigation system.

**Fumigation Tests.** A total of four custom-made fumigation chambers were built. The first step of the experiment was to fill the chamber with SO<sub>2</sub>. After the gas concentration reached equilibrium, the plants were put into the chamber for 48 hrs. The plants absorbed the SO<sub>2</sub> gas, so the concentration in the chamber decreased during the experiment. The SO<sub>2</sub> concentration was adjusted to the target concentration by refilling during the fumigation period. The physiology of the plants was measured before and after fumigation.

**The physiological properties of tested plant.** The physiological properties of tested plant leaves were measured before and after fumigation. A portable photosynthetic analyzer (LI-6400, LI-COR, USA) was used to measure the photosynthetic and stomata conductance. This measuring box can control the light intensity to the tested leaves and measure the CO<sub>2</sub> concentration, leaves temperature, environment temperature, and relative humidity. The light intensity was controlled at 1,000  $\mu\text{mol photon/m}^2\text{s}$  for shady plants and 1,500  $\mu\text{mol photon/m}^2\text{s}$  for shined plants, respectively. The plants physiology measurement environmental factors were controlled as follows: CO<sub>2</sub> concentration was 380  $\mu\text{L/L}$ , leaves temperature was 28°C, and relative humidity was 60 ~ 80%.

## Results and Discussion

**SO<sub>2</sub> Concentration Stability and Distribution Test in the Fumigation Chamber.** The SO<sub>2</sub> gas was injected into the chamber by a calibrated flow meter with the target concentration. The injected SO<sub>2</sub> gas was filled in the chamber and the total tested duration was 9 hrs and the gas concentration in the chamber during the tested period was recorded every 5 minutes. The SO<sub>2</sub> concentration increased after gas flew into the chamber continually; it could reach to a steady state of the target concentration in 90 to 120 minutes (Fig. 2). The concentration distribution test will be held when the SO<sub>2</sub> gas reached stable. There were 9 sampling points distributed in 3 equally divided vertical layers of the chamber with 50 cm gaps between each layer. There were 8 sampling points on layer I and III (4 points on each layer) and 1 point on layer II. The maximum and minimum SO<sub>2</sub> concentrations of these sampling points were 45 and 38 ppb, respectively. The average concentrations of layer I, II, III were 39, 42 and 43 ppb in sequence. The mean value of whole chamber was 41 ppb. The results showed that the SO<sub>2</sub> concentration in the chamber could reach uniformly distribution.

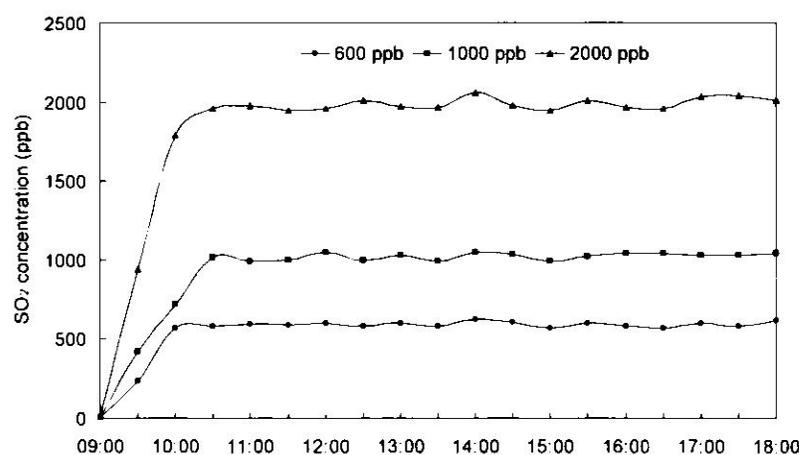


Fig. 2. SO<sub>2</sub> concentration in the chamber during fumigation stability test period.

**The net photosynthetic rate of tested trees.** Photosynthesis is the process in which the energy of sunlight is used by plant to grow. It is the most important physiological function of plant. The net photosynthetic rate was used as indicator of the health of plant. The plant living environment condition will change the net photosynthetic rate. The tested trees showed net photosynthetic rate decrease in compare with before fumigation.

Table 2 displays the net photosynthetic rate of tested trees reduction after fumigation. The relative net photosynthetic rate of tested trees before and after fumigation was showed in Fig. 3. These plants influenced by high concentration SO<sub>2</sub> gas with significant physiological properties changes and the lower photosynthetic rates than before fumigation. After 48 hours fumigation with 600 ppb SO<sub>2</sub>, the net photosynthetic rate of *Viburnum odoratissimum* had the maximum exchanges of all tested trees with 16% reduction after fumigation. The *Acacia confuse*'s net photosynthetic rates was maintain at 98% of the values before fumigation. As the fumigation concentration rose to 1000 ppb, the net

photosynthetic rates of tested trees influenced by the gas were more significantly. The values of *Palaquium formosanum*, *Hibiscus taiwanensis*, *Leea indica*, *Acacia confus* and *Antidesma barbatum* reduced more than 50% compared with the values before fumigation. After 48 hours fumigation experiment with 2000 ppb SO<sub>2</sub> of the tested plants, the *Hibiscus tiliaceus* and *Viburnum odoratissimum* showed symptom of withered and fallen leaves. The *Neolitsea parvigemma* had the lowest net photosynthetic rate value 0.68  $\mu\text{molCO}_2/\text{m}^2\text{sec}$  and the *Palaquium formosanum* had the lowest relatively percentage than before fumigation with the value 8%. Other tested trees' net photosynthetic rate were 46% lower of the values before fumigation except *Acacia confus* and *Quercus glauca* could retain 75%. The results showed that under the high concentration SO<sub>2</sub> gas environment, the physiology changes of the tested trees would damage and impact their health and growth.

Table 2. The net photosynthetic rate of tested plants before and after fumigation with 600, 1000 and 2000ppb SO<sub>2</sub>.

| Species       | 600 ppb    |            | 1000 ppb   |            | 2000 ppb   |            |
|---------------|------------|------------|------------|------------|------------|------------|
|               | Before     | After      | Before     | After      | Before     | After      |
| <i>A. c.</i>  | 8.75±0.25  | 8.60±0.79  | 8.31±1.02  | 1.85±0.73* | 18.85±1.07 | 14.70±2.28 |
| <i>C. a.</i>  | 6.42±0.49  | 3.02±2.36* | 8.30±0.70  | ---        | 6.09±0.49  | ---        |
| <i>H. ta.</i> | 13.52±0.68 | 8.69±4.08* | 10.59±1.15 | 3.74±3.68* | 22.29±2.23 | ---        |
| <i>H. ti.</i> | 19.95±0.79 | 4.73±3.73* | 11.93±1.51 | 11.75±1.96 | 16.08±0.79 | ---        |
| <i>L. i.</i>  | 11.57±0.67 | 9.61±3.84  | 12.0±1.43  | 5.83±0.29* | 9.98±0.66  | 1.64±0.66* |
| <i>N. p.</i>  | 7.53±1.14  | 3.07±0.84* | 5.6±0.55   | 5.27±0.57  | 4.40±0.36  | 0.68±0.00* |
| <i>P. f.</i>  | 6.90±0.51  | 6.39±1.12  | 7.13±0.73  | 4.36±1.44* | 9.68±0.64  | 0.81±0.35* |
| <i>P. c.</i>  | 10.03±0.56 | 7.84±2.12* | 6.72±0.29  | 6.01±1.03  | 4.41±0.23  | 1.48±0.22* |
| <i>Q. g.</i>  | 6.81±0.47  | 6.12±1.58  | 7.66±0.27  | 7.12±0.41  | 6.98±0.39  | 5.51±0.49* |
| <i>V. o.</i>  | 11.25±0.58 | 8.90±2.21* | 8.25±1.11  | 4.81±1.21* | 10.67±0.37 | ---        |

a. unit:  $\mu\text{molCO}_2/\text{m}^2\text{sec}$ . b. ---: The leaves could not be measured. c. \*: Indicated a significant difference ( $p^* < 0.05$ ).

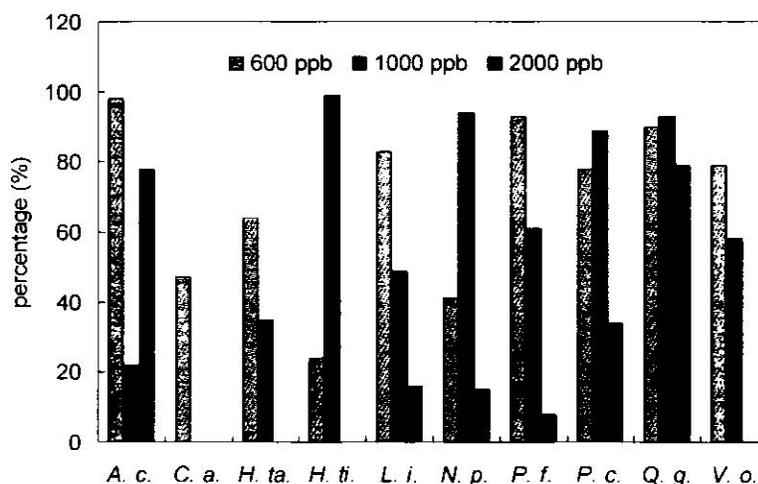


Fig. 3. The relative net photosynthetic rate of tested plants before and after fumigation with 600, 1000 and 2000 ppb SO<sub>2</sub>.

**The stomata conductance variation after fumigation of tested trees.** The stomata were the channel of plants exchanged the gas from tree body to outside [6]. The needed CO<sub>2</sub> gas was flow into plants body from these channels. When the plants were influenced by environment, especially the air pollutants, the stomata would close up to prevent injures. So the stomata status could display the healthy status of plants [7].

Table 3 displays the stomata conductance of tested trees reduction after fumigation. The relative stomata conductance of tested trees before and after fumigation was showed in Fig. 4. It showed that the similarly trend with the net photosynthetic rate. The stomata conductance of all tested plants was reduced after fumigation. After 600 ppb SO<sub>2</sub> fumigation for 48 hours continually, the lowest stomata conductance of the tested trees was *Neolitsea parvigemma* with 9.7 mmol/m<sup>2</sup>sec. and also had the most variation which was 14% of the value before fumigation. The stomata conductance changes of other tested trees were 21% to 92% after fumigation. As the fumigation gas concentration rose to 1000 ppb, the *Acacia confuse* and *Hibiscus taiwanensis* showed more damaged than other tested trees which only had 7% and 15% decrease of the stomata conductance value before fumigation. While the tested trees fumigated with 2000 ppb SO<sub>2</sub>, the stomata conductance of all tested trees were under 59% before fumigation especially the *Palaquium formosanum* and *Leea indica* which only remained 4% and 11% of the values before fumigation.

Table 3. The stomata conductance of tested plants before and after fumigation with 600, 1000 and 2000ppb SO<sub>2</sub>.

| Species       | 600 ppb    |            | 1000 ppb   |            | 2000 ppb   |            |
|---------------|------------|------------|------------|------------|------------|------------|
|               | Before     | After      | Before     | After      | Before     | After      |
| <i>A. c.</i>  | 83.6±7.5   | 76.8±8.1   | 60.5±9.9   | 4.3±0.4*   | 186.3±18.9 | 168.7±12.4 |
| <i>C. a.</i>  | 51.8±12.9  | 13.7±8.6*  | 234.5±46.5 | ---        | 49.7±8.8   | ---        |
| <i>H. ta.</i> | 196.8±48.4 | 129.0±28.2 | 184.3±24.8 | 27.4±7.3*  | 356.9±60.7 | ---        |
| <i>H. ti.</i> | 296.7±34.0 | 62.2±44.4* | 103.7±6.6  | 100.4±9.8  | 174.0±11.1 | ---        |
| <i>L. i.</i>  | 170.3±20.5 | 151.4±70.5 | 164.3±29.1 | 72.9±13.7* | 130.5±24.9 | 14.2±5.1*  |
| <i>N. p.</i>  | 71.2±11.0  | 9.7±3.9*   | 55.0±12.4  | 53.0±3.0   | 28.1±2.4   | 13.9±0.0*  |
| <i>P. f.</i>  | 71.2±17.8  | 65.6±24.8  | 232.8±47.0 | 39.9±22.8* | 172.8±25.4 | 7.4±1.5*   |
| <i>P. c.</i>  | 105.9±22.3 | 54.2±20.2* | 55.7±11.9  | 52.4±16.3  | 24.1±3.9   | 5.8±0.7*   |
| <i>Q. g.</i>  | 68.4±20.5  | 51.5±7.2   | 83.6±10.7  | 80.0±5.8   | 93.4±8.8   | 65.2±3.0*  |
| <i>V. o.</i>  | 138.7±13.3 | 106.0±26*  | 88.2±6.3   | 78.5±37.5  | 114.9±17.9 | ---        |

a. unit: mmol/m<sup>2</sup>sec. b. ---: The leaves could not be measured. c. \*: Indicated a significant difference (p\* $<$ 0.05).

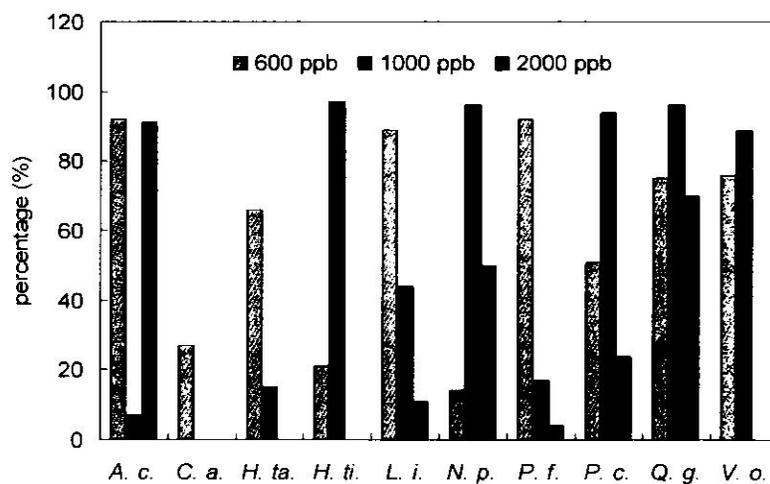


Fig. 4. The relative stomata conductance of tested plants before and after fumigation with 600, 1000 and 2000 ppb SO<sub>2</sub>.

**Tolerance ranking of tested trees with Sulfur dioxide.** The order method was used to rank the tolerance efficiency toward SO<sub>2</sub> of tested trees in this research. The relative percentage after and before fumigation of the net photosynthetic rate and stomata conductance were listed in series from high to low which ordered as 1 to 10, respectively. The lower order number meant the better tolerance toward SO<sub>2</sub> gas. The tolerance index was combined both the stomata conductance order and net

photosynthetic rate tolerant order. The combined numbers tolerance index displayed the better tolerance to SO<sub>2</sub> with lower values. Table 4 showed the values of tolerance rank of tested trees. Among all tested tree species, the *Quercus glauca* had the highest tolerance toward exposure with SO<sub>2</sub> and the *Camellia axillaries* was the least.

Table 4. The tolerance of tested plants to SO<sub>2</sub>.

| Species       | Tolerance Score |         | Tolerance Index | Tolerance Rank |
|---------------|-----------------|---------|-----------------|----------------|
|               | Net             | Stomata |                 |                |
| <i>A. c.</i>  | 2               | 2       | 4               | 2              |
| <i>C. a.</i>  | 10              | 10      | 20              | 10             |
| <i>H. ta.</i> | 9               | 9       | 18              | 9              |
| <i>H. ti.</i> | 7               | 8       | 15              | 8              |
| <i>L. i.</i>  | 5               | 4       | 9               | 4              |
| <i>N. p.</i>  | 6               | 3       | 9               | 4              |
| <i>P. f.</i>  | 3               | 7       | 10              | 6              |
| <i>P. c.</i>  | 4               | 4       | 8               | 3              |
| <i>Q. g.</i>  | 1               | 1       | 2               | 1              |
| <i>V. o.</i>  | 8               | 6       | 14              | 7              |

### Summary

In this research, customized air fumigation equipment was used to evaluate the purifying efficiency of 10 species of common side-walk trees with 600, 1000 and 2000 ppb SO<sub>2</sub>, respectively. These plants influenced by high concentration SO<sub>2</sub> gas with physiological properties changes and the lower photosynthetic rates than before fumigation. As the fumigation concentration rose, the damage to the tested trees was more significant and some of the tested trees appeared the fallen leaves phenomenon. Most of the tested trees could not survive under this SO<sub>2</sub> environment. The stomata conductance of tested trees showed that the similarly trend with the net photosynthetic rate. The stomata conductance and net photosynthetic of tested trees were shown a linear correlation to each other. Among tested tree, the *Quercus glauca* had the highest tolerance in exposure with high concentration of SO<sub>2</sub> pollution. While the *Camellia axillaries* was the least.

### Acknowledgements

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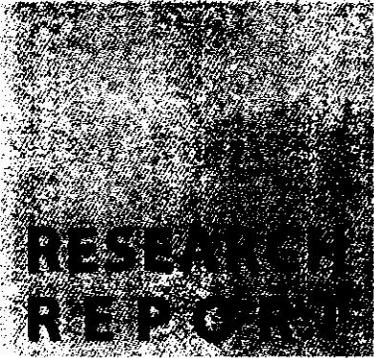
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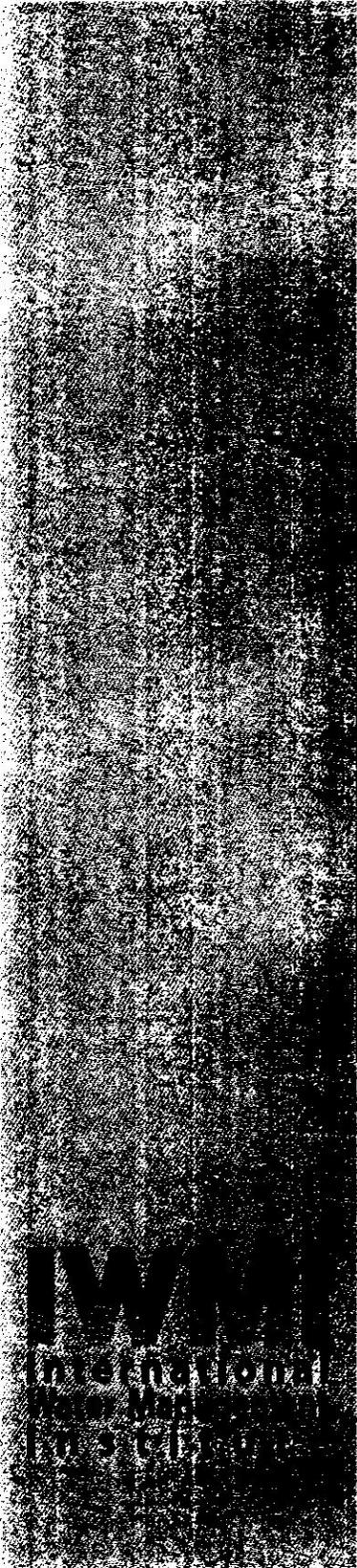
**Assessment of the Tolerance of Trees to High Concentration Sulfur Dioxide**

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RESEARCH  
REPORT

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# Shifting Waterscapes: Explaining Basin Closure in the Lower Krishna Basin, South India

Jean-Philippe Venot, Hugh Turrall, Madar Samad and François Molle



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## Summary

The Krishna River Basin in South India crosses the semi-arid Deccan Plateau from west to east. Since the 1850s, the Krishna Basin has seen an increasing mobilization of its water resources and a dramatic development of irrigation, with little regard to the limits of available water resources. This progressively led to closure of the basin (zero or minimal discharge to the ocean): by 2001-2004, surface water resources were almost entirely committed to human consumptive uses, increasing groundwater abstraction contributed to the decrease in surface water baseflows and the discharge to the ocean was almost zero. Despite evidence of basin closure, the three states that share the Krishna waters continue to strongly promote their agriculture and irrigation sectors. This development path can no longer be sustained without impinging on existing water use and affecting the security of supply for existing users.

The downstream areas of the Krishna Basin largely depend on the actions of upstream water users. The Lower Krishna Basin is one of the first regions to be adversely affected by any hydrological changes that take place elsewhere in the basin and to witness both severe water shortages and a spatial redistribution or re-appropriation of water during times of drought. Taking place on the basis of current political, institutional and geographical forces, this re-appropriation of water raises sociopolitical questions of sectoral and regional water apportionment within the Lower Krishna Basin, and may be at the origin of conflicts between water users.

This paper identifies the main changes that have affected the waterscape of the Lower Krishna Basin during the last fifty years: (i) a decrease by more than half of the surface water inflow into the lower basin (~25.8 billion cubic meters (BCM) a year in 1996-2000) due to water development in the upper basin; and (ii) an uncontrolled irrigation development in excess of existing formal allocation procedures in the Lower Krishna Basin itself. Irrigation depletion has increased almost four fold in

50 years and accounted for a fourth of all water depleted in the Lower Krishna Basin in 1996-2000. This local overcommitment of water resources in the Lower Krishna Basin is due to the uncontrolled development of private groundwater abstraction and the introduction of several biases, both at the farmer and command area levels, in the way *protective irrigation* has been practiced in that region. At the local scale, farmers take some liberties vis-à-vis a highly controlled management of water: they generally want to intensify their production and therefore require an optimal and flexible water supply, which they often obtain at the expense of their less well-placed peers and by always increasing the amount of water they use compared to what they are entitled to. At the irrigation project level (notably in Nagarjuna Sagar), governmental decisions and recommendations of the World Bank have led to changes in the design and practices of *protective irrigation* that have resulted in increased water use. By 1996-2000, 77% of the Lower Krishna Basin net inflow was depleted and discharge to the ocean amounted to 17.9 BCM/yr, defining a moderately modified ecosystem. During the drought of 2001-2004, likely to forecast the future waterscape of the Lower Krishna Basin, all indicators pointed to a fully committed situation, with depletion amounting to 98.8% of the net inflow, a lack of discharge to the ocean, a dramatic overdraft of the aquifers and the shrinkage of surface irrigated agriculture.

This paper shows that, while total water available in the Lower Krishna Basin is decreasing, changes in the waterscape of the basin are being shaped, to a large extent, by local users. This study underlines that it is not only the availability of the physical resource that is crucial in explaining the evolution of water use but, as water has become a disputed and highly politicized object, waterscapes are also strongly shaped by the social and political conditions of a region (a state for example), the boundaries of which often exceed the area where water is effectively used. In the Lower

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**Pushp Saini Vs. Ministry of Environment, Forest & Climate Change & Ors.**

**CORAM : HON'BLE MR. JUSTICE SWATANTER KUMAR, CHAIRPERSON  
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| <p><b>Present:</b></p> <p><b>Applicant:</b></p> <p><b>Respondent No. 1 :</b></p> <p><b>Respondent Nos. 15&amp;26:</b></p> <p><b>Respondent No. 19:</b></p> <p><b>Respondent No. 22:</b></p> <p><b>Respondent No. 37:</b></p> | <p><b>Ms. Shibani Ghosh, Adv. for Intervenor</b></p> <p><b>Mr. Divya Prakash Pande , Adv.</b></p> <p><b>Mr. Mukesh Verma, Adv.</b></p> <p><b>Mr. Nishe Rajen Shonker and Ms. Anu K. Joy, Advs. for State of Kerala</b></p> <p><b>Ms. K. Enatoli Sema, Adv. For Nagaland SPCB and Mr. Amith J, Adv.,</b></p> <p><b>Mr. Shiv Mangal Sharma, AAG, Mr. Saurabh Rajpal, Adv., and Mr. Adhiraj Singh, Adv. for State of Rajasthan</b></p> <p><b>Respondent Nos. 28&amp;29: Mr. Nikhil Nayyar, Adv., Mr. Smriti Shah, Advs. for APPCB &amp; TSPCB</b></p> <p><b>Mr. G.M. Kawoosa, Adv. and Ms. Palak Mittal, Adv. for State of J&amp;K</b></p> <p><b>Mr. Guntur Prabhakar, Mr. Pramod Kumar and Mr. Gautam Prabhakar, Advs. for State of AP</b></p> <p><b>Mr. Devraj Ashok, Adv. for State of Karnataka</b></p> <p><b>Mr. A.K. Panda and Mr. M. Paikaray, Advs. for SPCB, Odisha</b></p> <p><b>Mr. Atul Jha, Adv. For State of Chhattisgarh</b></p> <p><b>Mr. Ranjan Mukherjee and Ms. Aprajita Mukherjee, Advs. For State of Meghalaya</b></p> <p><b>Mr. Raja Chatterjee and Mr. Chanchal Kumar Ganguly, Advs., Mr. Piyush Sachdev, Adv. for State of WB</b></p> <p><b>Mr. Aruna Mathura, Mr. Avneesh Arputham, Ms. Simran Jeet and Ms. Anuradha Arputham, Advs. For State of Sikkim</b></p> <p><b>Mr. Edward Belho, Mr. K. Luikang Michael and Mr. Hoinethiam, Advs. for State of Nagaland</b></p> <p><b>Ms. Sujaya Agnihotra, Adv. for CECB</b></p> <p><b>Ms. Priyanka Sinha, Adv. for State of Jharkhand</b></p> <p><b>Mr. Anil Shrivastav, Mr. Rituraj Biswas and Ms. Sujaya Bardhan, Advs. for State of Arunachal Pradesh</b></p> <p><b>Mr. Tayenjam Momo Singh, Adv. for Meghalaya SPCB</b></p> <p><b>Mr. Sapam Biswajit Meitei and Mr. Naresh Kumar Gaur, Advs. for MPCB</b></p> <p><b>Mr. Gopal Singh, Mr. Rituraj Biswas, Advs. for State of Tripura</b></p> <p><b>Mr. Dhruv Pal and Mr. Himanshu Pal, Advs. for State of Gujarat &amp; GSPCB</b></p> <p><b>Mr. Ajay Marwah, Adv. for HPSPCB</b></p> <p><b>Mr. Gautam Singh, Adv. for Mr. Shoeab Alam, Adv. for State of Bihar</b></p> <p><b>Mr. R. Rakesh Sharma, Adv. For State of Tamil Nadu &amp; TN Pollution Control Board</b></p> <p><b>Mr. Rajul Shrivastav, Adv. for MPPCB</b></p> <p><b>Mr. V.K. Shukla, Adv. and Ms. Vijay Laxmi, Adv. for State of MP</b></p> <p><b>Mr. Amrit Agarwal and Ms. Asha N. Basu, Advs. for WBPCB</b></p> |
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Mr. Ravin Dubey, Adv.  
 Mr. Utkarsh Sharma, Adv. for State of UP  
 Mr. Gaurav M. Liberhan, AAG, State of Punjab  
 Mr. Jogy Scaria, Adv., Mr. Reegan S. Bal and Ms. Beena Victor, Advs. for Kerala State Pollution Control Board  
 Mr. Shuvodeep Roy, Adv. and Mr. Sayooj Mohandas M., Adv. for State of Assam and ASPCB  
 Mr. Rajkumar, Adv. for Central Pollution Control Board  
 Mr. Anil Grover, AAG, Mr. Rahul Khurana, Mr. Sandeep Yadav and Mr. Mishal Vij, Advs. for HSPCB  
 Mr. Naginder Benipal, Adv. for PPCB  
 Mr. B.V. Niren, Adv. and Mr. Vinayak Gupta, Adv.

|  | Date and Remarks                               | Orders of the Tribunal   |
|--|--|--|
|  | <p>Item No.<br/>21<br/>August 09,<br/>2017</p> | <p>The Learned Counsel appearing for Ministry of Environment, Forest and Climate Change submits that the Ministry has already completed river basin study of 6 river basins i.e. Siang River Basin, Twang River Basin, Bichom River Basin, Subansiri River Basin, Dibang River Basin and Lohit River Basin and upon study the Ministry has recommended the minimum flow of the river to be 18% of the average of lean season flow of the river. However, in some of the cases, it has stated to be even 20%.</p> <p>The Tribunal in the recent Judgment pronounced on river Ganga had directed 20% minimum environment flow to be maintained from Haridwar onwards on the basis of the average lean season flow. In light of the above and the clear stand being taken by the Ministry, we direct that all the rivers in the Country shall maintain minimum 15 % to 20% of the average lean season flow of that river. However, whichever State is unable to adhere to this average percentage, in that event we grant liberty to that State Government to move the Secretary, Ministry of Environment, Forest and Climate Change who shall in</p> |

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| <p><b>Item No.</b><br/><b>21</b></p> <p><b>August 09,</b><br/><b>2017</b></p> <p><b>sn</b></p> | <p>consultation with the Ministry of Water Resources examine such a representation and if it is desirable to fix any lower percentage than the percentage aforesaid, then it will pass appropriate order. The order should be reasoned and thereafter it would be left to the discretion of the State concerned to follow the directions of the Ministry in accordance with law.</p> <p>We also grant liberty to the Applicant to move the Ministry of Environment, Forest and Climate Change if it has material with them in respect of any river of the country, which should have minimum environment flow in excess of 20%. If such representation is moved the same shall be disposed of by the Committee headed by Secretary in the Ministry of Environment, Forest and Climate Change in accordance with law.</p> <p>With the above direction, Original Application No. 498 of 2015 stands disposed of without any order as to cost.</p> <p><del>M.A. No. 628 of 2016</del></p> <p>This Application does not survive for consideration as the main Application it stands disposed of.</p> <p>Thus, M.A. No. 628 of 2016 stands disposed of accordingly.</p> <p>.....,CP<br/>(Swatanter Kumar)</p> <p>.....JM<br/>(Raghuvendra S. Rathore)</p> <p>.....EM<br/>(Bikram Singh Sajwan)</p> |
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**MERCURY EMISSIONS FROM COAL FIRED POWER  
PLANTS LOCAL IMPACTS ON HUMAN HEALTH RISK**

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December 2005

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## 1. Introduction

### 1.1 Background

Mercury is a neurotoxin that accumulates in the food chain and is therefore a health concern. Concentrations of mercury in the air are of little direct health concern. However, mercury in the air falls onto the Earth's surface through dry and wet deposition processes. This mercury can enter water bodies where a small percentage (< 10%) is transformed to methyl mercury. This chemical form of mercury readily enters the food chain and bioaccumulates. Upper trophic level fish can have mercury concentrations several orders of magnitude greater than that found in the water or sediment. As mercury accumulates in these organisms, ecological risks occur and potentially human health risks may occur through fish consumption.

On December 15, 2003, EPA signed its first ever proposal to substantially cut mercury emissions from coal-fired power plants. The Utility Mercury Reductions proposal would cut mercury emissions by nearly 70 percent when fully implemented. The Utility Mercury Reductions rule would permanently cap emissions from coal-fired power plants and provide companies with flexibility to achieve early reductions of mercury. EPA proposed two alternatives for controlling mercury.

- Require power plants to install controls known as "maximum achievable control technology (MACT) under section 112 of the Clean Air Act. If implemented, this proposal would reduce nationwide mercury by 14 tons or about 30 percent by early 2008.
- Or, EPA proposed a market-based "cap and trade" program that, if implemented, would reduce nationwide utility emissions of mercury in two phases. When fully implemented mercury emissions would be reduced by 33 tons (nearly 70 percent).

On February 24, 2004, EPA signed a proposed cap-and trade rule that supplements its December 15, 2003 proposal to cost effectively reduce mercury emissions from power plants. States may choose to adopt the cap-and-trade program to achieve and maintain the necessary emission budgets. Public comments were accepted until June 29, 2004. In all over 1 million comments were received. EPA is currently reviewing and addressing the comments in order to finalize the rule by March 15, 2005.

Although a Cap and Trade approach is being considered, there are technical doubts pertaining to local deposition of mercury leading to "hot spots" that would make a Cap and Trade approach unacceptable to many. This has received widespread attention in the literature (ES&T, 2004). The following are selected quotes from public health officials in the past year.

- "Unlike most pollutants, mercury is highly toxic and does not disperse easily, creating "hot spots" of contamination." (Kathleen McGinty, Director of Pennsylvania Department of Environmental Protection, July 2, 2004 (<http://www.dep.state.pa.us/newsletter/default.asp?NewsletterArticleID=8850&SubjectID=>)
- "Specifically, we are concerned that local "hot spots" of elevated mercury may result or worsen, especially if the required reduction levels are not sufficiently strict." (Renee Cipriano, Director of Illinois Environmental Protection Agency, February 26, 2004

(Testimony to the U.S. EPA regarding the U.S. Environmental Protection Agency's Proposal to Control Emissions of Hazardous Air Pollutants from Utilities (January 30, 2004, 69 Federal Register 4652) Docket ID No. OAR 2002-0056.

- “We generally support market-based approaches such as cap and trade schemes, yet we have an equally strong objection to the exclusive use of cap and trade schemes where local emissions “hot spots” are a concern. While mercury pollution and emissions are widespread, indeed a global problem, we share the concerns of many states that EPA’s proposed rule understates the needs for local controls as well”, letter from Stephen Mahfood, Director Missouri Department of Natural Resources to Michael Leavitt, Director U.S. EPA.
- “Sulfur dioxide is light, and travels long distances; power plants in the Midwest can cause acid rain in Maine. So a cap on total national emissions makes sense. Mercury is heavy; much of it precipitates to the ground near the source. As a result, coal-fired power plants in states like Pennsylvania and Michigan create “hot spots” – chemical Chernobyls – where the risks of mercury poisoning are severe. ... That probably means thousands of children will be born with preventable neurological problems.” Paul Krugman, New York Times, p. A-23, April 6, 2004.

## 1.2 Defining a “Hot Spot.”

Although the term “hot spot” appears frequently in the health and environmental literature, precise definitions do not. A “hot spot” is a spatial anomaly, i.e., a location whose properties exceed those generally expected in the area. In statistical terms, a hotspot is an outlier whose properties exceed more than about 2 or 3 standard deviations above the relevant mean. Some authors have simply defined “hotspots” as the highest observed values: for example, Worm et al. (2003) found a range of diversities in ocean predator species of less than one order of magnitude, among which the highest groups were termed “hotspots”. Lebret et al. (2000) used the term to refer to locations where the ambient air quality standard for NO<sub>2</sub> is routinely exceeded; in the two locations studied, the ranges of ambient values were less than a factor of 3. These two examples of “hot spots” would not meet the statistical definition.

However, the expected ranges of environmental concentrations depend heavily on the “natural” or background values and on the length of the measurement period (i.e., the averaging time). In many cases, environmental concentrations are log-normally distributed (skewed towards high values), so that the distribution is best described by  $\exp(\text{mean logarithm})$  and  $\exp(\text{standard deviations of the logarithms})$ . These statistics are referred as the log-mean and the geometric standard deviation (GSD). As an example, Lu et al. (2005) studied the distribution of the polycyclic aromatic hydrocarbon naphthalene in Southern California and found a large range of values, in part because there is little or no natural background. The log-mean and GSD for 13 one- to two-month averages were 227 ng/m<sup>3</sup> and 1.57, leading to an expected range (GSD<sup>4</sup>) of a factor of 6. However, for 16 four-day averages in other locations, these values were 269 ng/m<sup>3</sup> and 3.12, leading to an expected range of a factor of 94. In both of these distributions, the top 3 or 4 values appear to be outliers and thus bona fide “hot spots”, since deleting them reduces the range of the distribution by about a factor of 2. This would not have been the case in the presence of a substantial natural background.

While small-scale transient hot spots may be a valid concern for inhalation exposures, the situation with mercury is quite different. The exposure pathway is through diet, and the relevant human exposure times relate to the development of the fetus and are of the order of months. Although a large point source of Hg indeed constitutes an emission “hot spot”, it does not constitute a fetal exposure hot spot. In addition to the substantial global background in Hg air concentrations and deposition, the following processes act to smooth out spatial anomalies:

- Atmospheric variability, including winds and precipitation.
- Re-emission of mercury from vegetation.
- Terrestrial leaching and washout in transferring watershed deposits into water bodies.
- Aquatic mixing within water bodies.
- Spatial and temporal variability in biomagnification processes.
- Variability among fish species.

Only atmospheric variability is included in the models that may be used to define deposition “hotspots.” The other processes involve spatial variability, especially with regard to mixing within the receiving waters, for which the size of the water body may be key. In order for a local Hg deposit to pose a risk to a developing fetus, its mother must routinely consume high-Hg fish from an affected water body for several months, probably at the rate of 2 or 3 meals per day. While this scenario is unlikely in any event, it also requires a substantial body of water, say of the order of tens of square km.

### 1.3 Statistical Methods.

Many empirical findings concerning Hg are subject to experimental error, which may be considerable in some cases. Accordingly, statistical methods may be required to gain an understanding of the data. They include averaging, correlation, and linear regression, using established relationships to try to reduce experimental variability. In all cases, “statistical significance” implies a 95% probability that the finding is not due to chance alone, denoted as “ $p < 0.05$ ”.

### 1.4 Contents of the Report.

This report examines the possibility that coal-fired power plants act as local sources leading to mercury “hot spots”, using a three-tiered approach. First, the worldwide literature was searched for reports of deposition around mercury sources, including coal-fired power plants. Second, soil samples from around two mid-sized U.S. coal-fired power plants were collected and analyzed for evidence of “hot spots” and for correlation with model predictions of deposition. Third, a risk assessment construct was developed that demonstrates a possible approach for examining human-health risks that might be associated with local deposition of mercury emitted from coal-fired power plants. Based on this work, conclusions about the impacts of “hot-spots” are made.

The health impacts of mercury arising from coal-fired power plants comprise a complicated issue with many active areas of research. To provide context for the current studies and to keep current with the latest findings, the literature on mercury deposition, transformation and bioaccumulation in the food chain, on fish consumption, and on health effects has been followed closely. Appendix B presents a review of some of the latest findings from the literature on fish consumption, levels of mercury in fish, and modeled deposition under various regulatory control

scenarios. Appendix C presents an annotated literature review of findings on the studies of health impacts of mercury, exposures to mercury through fish consumption, atmospheric modeling of mercury transport and deposition, measured mercury data, and reviews, editorials, and opinions that have been published recently.