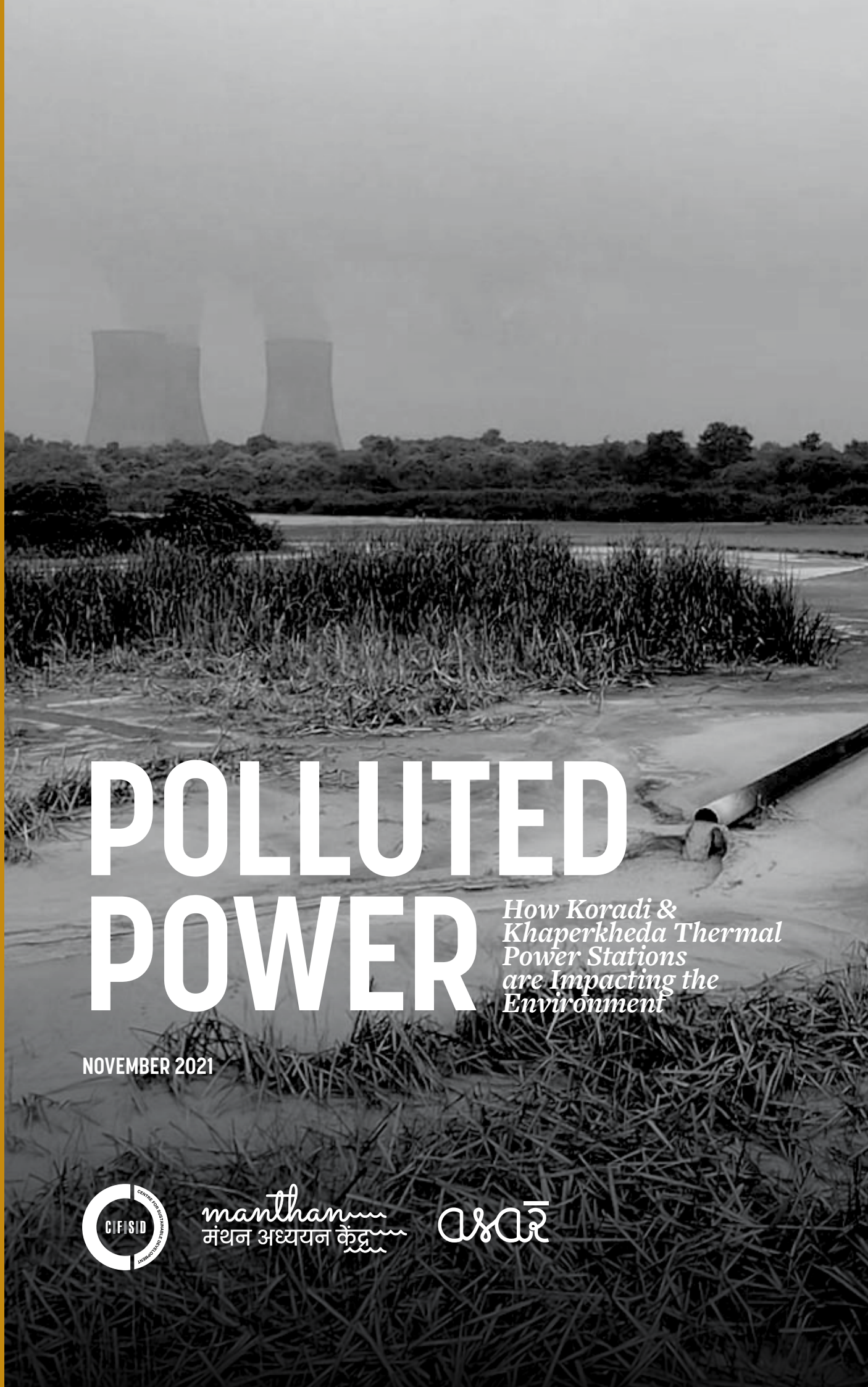


POLLUTED POWER

How Koradi & Khaperkheda Thermal Power Stations are Impacting the Environment

NOVEMBER 2021

CFISD
CENTRE FOR SUSTAINABLE DEVELOPMENT

manthan
मंथन अध्ययन केंद्र

asar

AUTHORS & ACKNOWLEDGEMENTS

AUTHORS

In alphabetical order

Ashish Sinha, *Manthan Adhyayan Kendra*

Leena Buddhe, *Centre for Sustainable Development*

Nisha Sahare, *Centre for Sustainable Development*

Rachel Pearlin, *Asar Social Impact Advisors Pvt. Ltd.*

Rajani Gaurkhede, *Centre for Sustainable Development*

Shripad Dharmadhikary, *Manthan Adhyayan Kendra*

Shubhangi Padole, *Centre for Sustainable Development*

COPY EDITOR

Kavitha Muralidharan, *Senior journalist*

MAPS

Ashish Sinha, *Manthan Adhyayan Kendra*

PHOTOGRAPHER

Atim Neware

DRONE PHOTOGRAPHER

Manish Haridas Patil

DESIGNER

Pallavi Baasri

PUBLISHERS

Centre for Sustainable Development

Asar Social Impact Advisors Pvt. Ltd.

Manthan Adhyayan Kendra

November 2021

SUGGESTED CITATION

Centre for Sustainable Development, Asar, Manthan Adhyayan Kendra: Polluted Power: How Koradi and Khaperkheda Thermal Power Stations are Impacting the Environment, *November 2021*.

CONTACT FOR PUBLISHERS & AUTHORS

Leena Buddhe, *Founder and director*
Centre for Sustainable Development, 56A/2, Pandey Layout, Khamla, Nagpur 440 025 | Email: cfsdindia@gmail.com | Phone: +91 93723 91202

Shripad Dharmadhikary
Email: manthan.shripad@gmail.com
Phone: +91 9552526472

ACKNOWLEDGEMENTS

REVIEWERS

Ashish Fernandes, *Climate Risk Horizons*
Nandikesh Sivalingam, *Centre for Research on Energy and Clean Air*
Sunil Dahiya, *Centre for Research on Energy and Clean Air*
Sehr Raheja, *Manthan Adhyayan Kendra*

CARTOGRAPHY

Raj Bhagat, *Earth Observation Expert*
For providing valuable inputs for better presentation of data and information on the maps

Aslam Sheikh, *Manthan Adhyayan Kendra*
For support in preparing the maps and cross checking data

WATER & FLY ASH SAMPLE COLLECTION AND TESTING

Qualichem Laboratories, Nagpur

SPECIAL THANKS TO

SARPANCHS

The authors would like to thank Sarpanchs from across the villages around Nagpur affected by the impact of water, air and land pollution and by fly ash from thermal power plants on their farmlands, crops, sharing valuable information on the history of such impacts, pollution from coal dust, information on land acquisition in these areas, sampling of the fly ash from ash bund in all the three seasons, and allowing us to collect water samples from across villages for the analysis.

Sharad Makade, Sarpanch, Mhasala & Kawatha; Moreshwar Kapse, Sarpanch, Khairi; Ravindra Pardhi, Sarpanch, New Khasala; kamlakar Bangare, Sarpanch, Waregaon; Sunil Dudhpachare, Sarpanch, Sureadevi; Ravindra Chikale, Sarpanch, Bhanegaon; Pavan Dhurvey, Sarpanch, Pota Chankapur;

Purushottam Chandankhede, Sarpanch, Chicholi; Sachin Shete, Sarpanch, Bailwada; Ganesh Thakare, Sarpanch, Gumthi; Sushila Jamgade, Sarpanch, Gumthada; Anita Gudhadhe, Sarpanch, Lonara; Anita Pandit, Sarpanch, Bokhara; Sonali Warkhade, Sarpanch, Nandgaon; Sevak Thakur, Up Sarpanch, Nandgaon; Naresh Dhone, Sarpanch, Bakhari; Sonali Warkhade, Sarpanch, Nandgaon;; Krishna Kanojiya, Up Sarpanch, Suradevi; Vishwajeet Singh, Up Sarpanch, Pota Chankapur; Nitesh Mankar, Sarpanch office, Khairi; Vijay Tawale, Gram panchayat clerk, Waregaon; & Sanjay Nagpure, New Khasala GP karmachari.

DOCTORS

The authors would also like to express their gratitude to doctors, health authorities, and veterinarians who contributed to the study by giving critical information on the health consequences of fly ash on villages, women, children, and livestock.

Dr Shraddha Wasnik, Veterinary Doctor, Koradi; Dr. Shyama Naz, Doctor, New Khasala/Mhasala/Kawatha; & Dr Petkar, Doctor, Public Health Centre (PHC).

FARMERS

The study would not have been possible without the help of local farmers, who detailed the agricultural impact of fly ash as well as the financial burden imposed by the environmental issue.

Subhash Bhoyar, Farmer, New Khasala; Gulab Korde, Farmer, Khairi; Udayram Patil, Farmer, Suradevi, & Vaibhav Irkhede, Farmer, Kawtha.

SHG PRESIDENTS

Important information on how different communities were dealing with water contamination, how it constituted a danger to their livelihood, the use of water ATMs, and daily expenditure on buying water, were all gathered with the aid of self-help groups (SHGs).

Kiran Zodape, President SHG, Mhasala; Durga Mankar, President SHG, Suradevi; Pinky Mehra, President SHG, Khairi; Kalpana Chankapure, President SHG, Waregaon; & Vaishali Gadekar, President SHG, New Khasala.

LOCAL VILLAGE RESIDENTS

Owing to the cooperation of local citizens, assistance in terms of information, communication, identifying areas, and general permits may be available. We appreciate their help in ensuring that crucial aspects of the study were highlighted.

Avinash Khandate, Resident, Juni Kamptee; Ranjana Bhoyar, Resident, New Khasala; Ambadas Patil, Resident, Waregaon; Sanjay Nagpure, Resident, Khasala; Shalu Bharkar, Resident, Waregaon; Rajashree Gajbhiye, Resident, Pota Chankapur; Sagar Shelare, Resident, Pota Chankapur; Shital Patil, Resident, Bhanegaon; Mr Hussain, Resident, Mhasala; & Mahadev Dudhpachare, Resident, Suradevi.

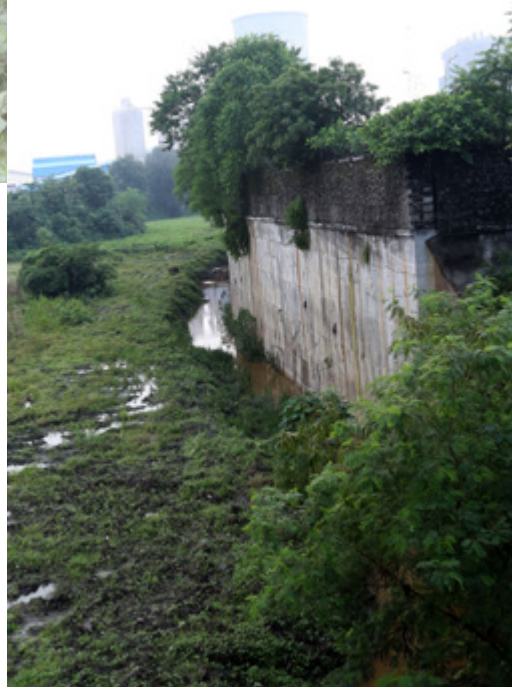
TABLE OF CONTENTS

08
List of abbreviations

09
List of figures
List of tables

10
Executive summary

14
Introduction and background



17
Brief history of pollution from Koradi and Khaparkheda TPS

22
Objectives, structure and approach of the study

28
Key findings: Massive pollution, serious impacts

41
Health impacts of the pollution

43
Thermal power plants responsible for pollution

49
Failure of monitoring and regulatory agencies

52
Conclusions and recommendations

56
Annexure A: Compilation of potential impacts of exposure to metals on human and animal health

67
Citations and endnotes

List of abbreviations

ABBR.	EXPANDED FORM
µg/L	Microgram Per Liter
ATSDR	Agency for Toxic Substances and Disease Registry
CAC	Consent Appraisal Committee
CAG	Comptroller and Auditor General
CCR	Coal Combustion Residuals
CFSD	Centre for Sustainable Development
CPCB	Central Pollution Control Board
CSR	Corporate Social Responsibility
CWC	Central Water Commission
DHHS	Department of Health and Human Services
EAC	Expert Appraisal Committee
EIA	Environment Impact Assessment
EKG	Electrocardiogram

ABBR.	EXPANDED FORM
ESP	Electro Static Precipitator
FGD	Flue Gas Desulphurisation
HDPE	High Density Poly Ethylene
IARC	International Agency for Research on Cancer
JVS	Joint Visit Sampling
KhTPS	Khaparkheda Thermal Power Station
KTPS	Koradi Thermal Power Station
MAHAGENCO	Maharashtra State Power Generation Company
MoEF	Ministry of Environment and Forests
MoEF&CC	Ministry of Environment, Forests & Climate Change
MOIL	Manganese Ore India Limited
MPCB	Manganese Ore India Limited
MTPA	Maharashtra Pollution Control Board
MW	Mega Watt
NGO	Non-Governmental Organisation
NMC	Nagpur Municipal Corporation
OC	Open Cast
SPCB	State Pollution Control Board
SPM	Suspended Particulate Matter
TDS	Total Dissolved Solids
TOI	Times of India
UG	Underground
US-EPA	United States Environment Protection Agency
USGS	United States Geological Survey
WHO	World Health Organisation
WTP	Water Treatment Plant

List of figures and tables

NO.	FIGURE	PAGE NO.
FIG. 1	Map showing Koradi and Khaparkheda Thermal Power Plants and other important features in the area	16
FIG. 2	Ash laden water in Nala flowing out of Khaparkheda ash pond boundary, and fly ash deposited at bottom of Nala. Year 2019	20
FIG. 3	Photograph from the Visit Report of the EAC Sub-Committee of MoEFCC of pollution from the Koradi TPS with their original captions	21
FIG. 4	Map showing water sample collection locations as well as the villages and Nagpur wards where questionnaire based surveys were carried out	25
FIG. 5	Water sample being collected for testing from the stream near Khairi Village. Year 2021	27
FIG. 6	Map showing water sampling locations. R refers to river locations, V refers to village locations	30
FIG. 7	Stream near Khairi village showing cattle bathing in the water. The water from here is used for many different uses. Our sampling showed water here to be highly polluted. Sampling in progress can also be seen. Photo 2021	32
FIG. 8	Map showing locations and names of villages surveyed	38
FIG. 9	Fly ash deposition on water stored in a drum in a house, in village Waregaon. Year 2021	38
FIG. 10	Map showing areas impacted by fly ash from among the surveyed villages and Nagpur city areas	39
FIG. 11	Fly ash deposition on cotton crop of a local farmer. Year 2021	39
FIG. 12	A farmer in his field in village New Khasala where fly ash has been deposited extensively. Year 2021	40
FIG. 13	Farmer from village New Khasala showing skin ailment. Year 2021	42
FIG. 14	Dried section of Khaparkheda ash pond and ash being blown by the wind. Year 2019	44
FIG. 15	Photo showing fly ash laden water being discharged into a channel from the Khaparkheda ash pond. This channel is unlined and water will seep to ground water from this channel and also possibly contaminate other surface water bodies. Year 2021.	45
FIG. 16	Fly ash laden water being discharged from Waregaon Ash Dam into local water body. Year 2021	46
FIG. 17	Kolar River at Suradevi village. Ash from the Khaparkheda TPS deposited on the river bed can be seen in the picture on the river bank. Photo 2021	51

NO.	TABLE	PAGE NO.
TABLE 1	Details of existing units at Koradi and Khaparkheda thermal power plants	15
TABLE 2	Season wise details of locations of water samples collected	29
TABLE 3	Season wise, locations wise results of water sample testing showing contaminants exceeding standards and usage of water at all locations	36
TABLE 4	Comparison of concentrations of select toxic metals in fly ash from various thermal power plants	47

Executive summary

KORADI AND KHAPARKHEDA THERMAL POWER PLANTS ARE BOTH DISCHARGING EFFLUENTS DIRECTLY INTO LOCAL STREAMS AND RIVERS INCLUDING THE KOLAR AND KANHAN RIVERS, AND THIS INCLUDES FLY ASH MIXED EFFLUENTS. LEAKAGES, DIRECT DISCHARGES AND LEACHING OF WATER FROM ASH PONDS IS FURTHER CONTAMINATING WATER BODIES, INCLUDING GROUNDWATER

The 2400 MW Koradi and 1340 MW Khaparkheda thermal power plants, both just outside Nagpur city, in Maharashtra have been important for the Maharashtra State Power Generation Company (MAHAGENCO) in meeting its goal of providing adequate power to the state. Yet, they have failed to meet their own goal of improving quality of life for the people who live and work in the power plants' vicinity. The two power plants along with the related infrastructure including two ash ponds of the Koradi TPS and one ash pond of Khaparkheda TPS have a long history of causing rampant pollution in the area.
This pollution has been extensively documented by media, by civil society groups, by official agencies and by the local communities, since at least a decade. This includes reports of discharges of untreated water directly into nallas, high levels of noise, high levels of sulphur dioxide and particulate matter emissions, fly ash discharges into local rivers and streams, fly ash being blown in the wind causing intense dust pollution, fly ash depositing on crops, horticulture and vegetable, severally impacting the yields and in turn livelihoods of farmers and fly ash settling on water bodies and water sources. Impacts have also been recorded in the Nagpur city. The severe health impacts of this pollution like wide-spread respiratory ailments, asthma, etc., have also been recorded.

Yet, no meaningful action has been taken by the authorities. On the contrary, the MoEF&CC has given ToRs for the further expansion of Koradi TPS with two 660 MW units, which will lead to even more pollution.

Given this, Centre for Sustainable Development, Nagpur, Manthan Adhyayan

Kendra, Pune, and Asar Social Impact Advisors Pvt. Ltd. came together to carry out a comprehensive assessment with the involvement of the local communities and suggest ways in which the issues could be addressed.

This study had three components. One was a detailed questionnaire-based survey of the villages in the surrounding areas. Second was the collection and testing of water samples from surface and ground water locations in the area, as well as fly ash samples, to be carried out in three seasons of winter, summer and monsoon. Third part was the direct observations by the study team.

Water samples were collected from 25 locations including surface and ground water and treatment facilities. Fly ash samples were collected from 5 locations including ash ponds of the two power plants and a couple of households. Detailed village level surveys were done for 21 villages, as well with similar number of individual households and farmers. Information through discussions was also collected from Nagpur city wards that are located towards the power plants.

Our assessment shows that the entire study area around the Koradi and Khaparkheda thermal power plants is facing rampant and unchecked pollution, affecting air, surface and ground water and soil.

Airborne fly ash is leading to extensive air pollution. This airborne fly ash is also depositing over a large area on houses, open spaces, water bodies and agricultural fields. This is fly ash that is being blown from dry parts of ash ponds, as well other sources like fugitive emissions from inside the plant, and from the stacks of the power plants.

Almost every water sample, in every season including monsoon, failed to pass the standards set for drinking water by the Bureau of Indian Standards, the IS 10500: 2012 (acceptable limits) and other relevant standards, with the sole exceptions of samples from Water ATM output

Koradi and Khaparkheda thermal power plants are both discharging effluents directly into local streams and rivers including the Kolar and Kanhan rivers, and this includes fly ash mixed effluents. Leakages, direct discharges and leaching of water from ash ponds is further contaminating water bodies, including ground water.

Almost every water sample, in every season including monsoon, failed to pass the standards set for drinking water by the Bureau of Indian Standards, the IS 10500: 2012 (acceptable limits) and other relevant standards, with the sole exceptions of samples from Water ATM output. Surface as well as groundwater sources are found affected by high levels of turbidity, hardness, alkalinity and total dissolved solids (TDS) which exceed the limits. More worrying is the presence in high concentrations of elements like antimony, aluminium, arsenic, boron, fluoride, iron, manganese, magnesium, mercury, molybdenum, lithium lead and selenium.

Fly ash from the two power plants itself contains many of these pollutants including arsenic, cadmium, chromium,

We found several water samples with toxic elements like mercury, arsenic, lithium, aluminium etc., exceeding the safe limits by 10–15 times. Mercury is among the most toxic substances known to mankind. Arsenic is associated with cancers of liver and bladder

lead, manganese, mercury, selenium, cobalt, copper, nickel, zinc, fluoride as well as oil and grease. These can directly enter the lungs as fly ash dust is inhaled, as well as leach into water when fly ash mixes with water.

These are elements that can have very serious impacts on human health as well as the health of cattle and on the ecology.

These contaminated ground and surface waters are being used by local communities extensively, for all purposes include drinking (with and without treatment), other domestic use, bathing, washing clothes, fishing, irrigation and water for cattle. This has serious implications for their health and well-being.

We found several water samples with toxic elements like mercury, arsenic, lithium, aluminium etc. exceeding the safe limits by 10-15 times. Mercury is among the most toxic substance known to mankind. Arsenic is associated with cancers of liver and bladder. The questionnaire-based survey also revealed many serious impacts of fly ash. Out of 21 villages surveyed, 18 villages are being affected due to fly ash depositing in various parts of the village. This includes water bodies, houses, agricultural fields, open spaces and vehicles.

Almost all the farmers in the survey responded that fly ash was depositing on their lands and crops, impacting the growth of their crops, reducing crop yields, impacting cattle and affecting milk production.

Many of the surveyed villages reported health issues like difficulty in breathing, respiratory diseases like bronchitis and asthma, cough and cold, throat infection, irritation in the eyes and eye infections, skin problems, skeletal problems, etc. Skeletal problems were also reported in cattle. All of these ailments can be linked to the contaminants that our study identified.

We also found that several areas on the outskirts of Nagpur city were being affected by the deposition of fly ash. In spite of such clear evidence of pollution from the power plants, the concerned agencies, including the MPCB and the MoEFCC have totally failed in their responsibility to control and address the issue. This is a gross dereliction of duty by the thermal power plants as well as the regulatory agencies. Moreover, they have shown complete indifference to local people who have been repeatedly raising the issue and petitioning the authorities. Most local people including elected representatives like the sarpanchs told us that their letters went unanswered and they were not even given appointments to meet.

Based on our assessment, we recommend that:

1. *MAHAGENCO take immediate steps to stop all pollution, especially the discharge of fly ash in local water bodies, and the dispersal of dry fly ash as dust and particles, in a time bound manner.*

2. *MPCB and MoEF&CC must immediately put in place a mechanism to monitor this plan and must take strict and quick action, including suspending the work of the power plant in case pollution persists.*

3. *A committee of key representatives/ sarpanchs of the villages in the vicinity, along with representatives of civil society groups and independent experts should be set up which will monitor the progress from the local people's point of view.*

4. *MAHAGENCO should also ensure clean-up of places already polluted.*

5. *Both Koradi and Khaparkheda TPS should ensure strict implementation of all legally binding pollution control laws, including 100% utilisation of fly ash.*

6. *Until the issue of pollution is fully addressed and clean air, water and soil/land is ensured, there should be no further addition to the pollution load and installation of new units at Koradi and the new ash pond at Nandgaon should be put on hold.*

Several areas on the outskirts of Nagpur city were being affected by the deposition of fly ash

Introduction and background

THIS REPORT IS ABOUT TWO POWER PLANTS, KORADI AND KHAPARKHEDA OWNED AND OPERATED BY MAHAGENCO, AND HOW THE QUALITY OF LIFE OF THE PEOPLE THERE HAS BEEN BADLY AFFECTED DUE TO POLLUTION FROM THESE POWER PLANTS AND THEIR RELATED INFRASTRUCTURE

The website of the Maharashtra State Power Generation Company, or MAHAGENCO as it is called (MAHAGENCO, 2021a), proclaims its vision as "Generating adequate power for Maharashtra on a sustainable basis at competitive rates in a socially responsible manner". While it has certainly achieved the first part of this vision, the second part, which claims to do this in a socially responsible manner is questionable. This is particularly true about one of the five missions under this vision which mandates MAHAGENCO to "Strive to improve the quality of life for the people who live and work in our operational territory and power plants' vicinity."

This report is about one such region in the vicinity of two power plants owned and operated by MAHAGENCO, and how the quality of life of the people there has been badly affected due pollution from these power plants and their related infrastructure.

KHAPARKHEDA AND KORADI TPS AND RELATED INFRASTRUCTURE

Koradi and Khaparkheda thermal power plants are the two power plants in question, close to each other and just outside Nagpur city, in Nagpur district of Maharashtra.

The 1340 MW (Mega Watt) Khaparkheda Thermal Power Station (KhTPS) has four units of 210 MW each, and one unit of 500 MW (MAHAGENCO, 2021B). The first unit was commissioned in 1989, and the latest of 500 MW was commissioned in 2011 (CEA, 2020A).

The 2400 MW Koradi Thermal Power Station (KTPS) has two units of 210 MW and three units of 660 MW commissioned in 1982/83 and 2015/16 respectively. These are the Units 6 and 7, and Units 8, 9, 10 respectively (CEA, 2020A). Five older units, namely the Units 1 to 5 of KTPS have been retired in 2016/17 (Lok Sabha, 2021)[1]. MAHAGENCO has now proposed to expand the capacity of Koradi TPS by adding two more units of 660 MW. On 26 June 2020, the Ministry of Environment, Forests and Climate Change (MoEF&CC) gave the Terms of Reference (ToRs) for this expansion, thus taking an important step in the process of installing this capacity (MoEF&CC, 2020).

The ash ponds of these two power plants are also located in the vicinity. Khaparkheda TPS's ash pond, also called Waregaon Ash Pond is spread over 282.5 hectare (EAC, 2019b, p. 48) and lies 500 metres to the South of Waregaon village with Kanhan River flowing 419 metres away on the East. This ash pond has been constructed by acquiring land from Khairi village according to the sarpanch of Khairi. This pond is unlined. A new ash pond with an area of 258 ha is under construction at Nandgaon since the existing one is almost full. Nandgoan is across both Kanhan and Pench rivers from the Khaparkheda power plant, around 10 kms North-East of the plant as the crow flies. A field visit by a team from the authors and publishers of this report, Centre For Sustainable Development (CFSD), in the last week of September 2021 showed that the construction of the ash pond is almost complete. And though the lining has not been done and pitching remains to be carried out on almost half of the total bund, plans were on to make it operational from 1st October 2021. This was as informed to the team by the sarpanch of Nandgaon and Bakhari, as they have received notices from Khaparkheda TPP.

Koradi TPS has two ash ponds. The old ash pond is located on land that was acquired from the residents of Koradi village, and is of about 150 ha (EAC, 2019b, p. 48). According to the sarpanch of New Khasala village, this old Koradi ash pond, which is also unlined, is being emptied again to be reutilised for ash dumping. As per a MAHAGENCO report dated 20 November 2019 presenting compliance of recommendations of a MoEF&CC's Expert Appraisal Committee (EAC) Sub-Committee field visit, the old Koradi ash bund is about 70–75% empty, for which also HDPE (High Density Polyethylene) lining is proposed. The said work was scheduled to be completed in March 2021 (MAHAGENCO, 2019, p. 4). However, the field visit by CFSD team on 28–29 September 2021 revealed that the pond was unlined and there was no activity happening in terms of lining it. In fact, the ash pond was covered in thick vegetation. There were some trucks removing ash from the ash pond.

Koradi TPS's New ash pond, the Khasala Ash Pond is about 250 ha in size (EAC, 2019B, p. 48), and is at a distance of 5.98 kilometres west from Waregaon. The new ash pond has been constructed on the lands acquired from the Khasala village which was displaced and renamed as New Khasala. The construction of the new ash pond started in 1984 according to New Khasala sarpanch. The Khasala Ash Pond is also unlined. Table 1 below gives the details of the installed capacity at the KhTPS and KTPS.

TABLE 1: DETAILS OF EXISTING UNITS AT KORADI AND KHAPARKHEDA TPPs

PLANT	CAPACITY (MW)	YEAR OF COMMISSION (CEA, 2020A)
KHAPERKHEDA		
UNIT I	210	1989
UNIT II	210	1990
UNIT III	210	2000
UNIT IV	210	2001
UNIT V	500	2011
TOTAL	1340 MW	
KORADI		
UNIT VI	210	1982
UNIT VII	210	1983
UNIT VIII	660	2015
UNIT IX	660	2016
UNIT X	660	2016
TOTAL	2400 MW	

COAL MINES IN THE AREA

There are also several coal mines in the same area, namely Silewara Underground (UG) mine, Singhori Open Cast (OC), Bhanegaon OC, Gondegaon and Ghat Rohana OC, Inder OC and Kamptee OC. (CMPDI, 2020, p. 26 & 27) Together, these mines have a production capacity of about 9 million tonnes per annum (MTPA)[2].

MANGANESE MINES IN THE AREA

There are also two MOIL (Manganese Ore India Limited) mines at Gumgaon, very close to the banks of Kanhan River, with a production capacity of 0.2 MTPA (MOIL Limited, 2019). These mines are about 18.5 Km upstream (coordinate distance) from Khaparkheda TPS[3].

OTHER INDUSTRIES IN THE AREA

The Uppalwadi industrial area is located near New Khasala village, and has industries manufacturing medicines, insecticides, pesticides, fertilisers, cement, lime, paint, plastic as well as iron and steel and textile/garments units. There are also a number of brick manufacturing units in the area, producing both, red bricks as well as fly ash bricks.

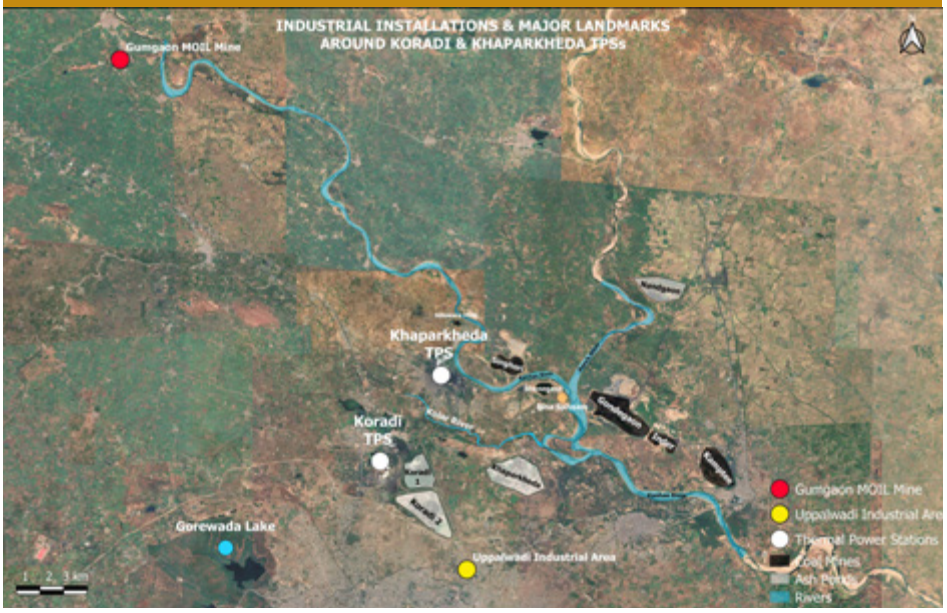
RIVERS AND STREAMS

Several important rivers and streams run through the area where these power plants, ash ponds and related facilities are located. These include the Kanhan River and its tributaries Kolar River and Yerkheda Nala. These rivers are an important source of water supply to many villages and towns in the area including to Nagpur city and Kamptee Cantonment.

Apart from these rivers and streams, groundwater from dug wells and borewells are also an important source of water for the local communities. The map at Figure 1 gives shows the locations of some of these important features.

Originally our study to understand the pollution impacts of the two power plants and related infrastructure had aimed to cover this entire area. However, due to limitations imposed by the Covid-19 situation, we were forced to restrict the scope of our study mainly to the area on the right bank of the Kanhan River including the river itself. This is explained in detail in a later section. We hope to cover the other areas extending to the left bank of the river, the coal mines etc., at a later stage.

FIGURE 1: MAP SHOWING KORADI AND KHAPARKHEDA THERMAL POWER PLANTS AND OTHER IMPORTANT FEATURES IN THE AREA



The Kanhan River and its tributaries Kolar River and Yerkheda Nala—important sources of water to many villages and towns—run through the area where these power plants, ash ponds and related facilities are located

Brief history of pollution from koradi & khaparkheda TPS

THESE HAVE A LONG HISTORY OF CAUSING POLLUTION IN THE AREA. THIS POLLUTION HAS BEEN MONITORED AND DOCUMENTED BY THE MEDIA, BY CIVIL SOCIETY GROUPS, BY OFFICIAL AGENCIES AND BY THE LOCAL COMMUNITIES, WHO HAVE ALSO BEEN RAISING THIS ISSUE FROM TIME TO TIME

The Koradi and Khaparkheda power plants have a long history of causing pollution in the area. This pollution has been monitored and documented by media, by civil society groups, by official agencies and by the local communities, who have also been raising this issue from time to time.

Yet, the authorities, starting from the Government, the pollution control board and the power plants themselves have done little to address the issue. Due to this, pollution of air, soil and water in the area persists, leading to serious impacts on the ecology of the area, and the health of local communities, cattle and other flora, fauna.

MEDIA REPORTS

PREVALENCE OF POLLUTION FOR OVER A DECADE

The seriousness of pollution as an issue and its repercussions has been flagged by media reports for at least over a decade now.

A Times of India (TOI) article dated 24th July 2010 reports that ... "three companies, Maharashtra State Power Generation Company Limited Koradi, Maharashtra State Power General Company Limited, Khaparkheda, and Messers Murli Power Industries Limited, Wadoda, Kamptee, were discharging untreated water into nullahs, which later gets mixed with Kanhan River" (Times News Network, 2010).

On 4th May 2011, the Economic Times reported (PTI, 2011) that "The auditor (CAG) also found that the thermal power plants at Khaperkheda, Paras, Bhusawal and Parli had high noise levels, particularly during night hours." This highlighted the issue of noise pollution is yet to get the attention it needs.

AIR POLLUTION

Air pollution from the power plants has also been a major issue in the area and has been regularly highlighted by media over the years.

A Times of India news report dated 22nd April, 2017 states that "The sulphur dioxide (SO_2) levels of the three new units at the Koradi Thermal Power Station (KTPS) recorded at the stack (chimney) are over five times the permissible limit set by the Ministry of Environment, Forests and Climate Change (MoEFCC)" (Behl, 2017a). Another Times of India news report dated 12th January 2018 mentions that "The board had also directed KTPS to augment the efficiency

of electrostatic precipitator (ESP), a device which controls industrial particulate emissions. According to the board, the emission of particulate matter from unit 7 was found to be 244 milligrams per cubic meter (mg/Nm3) against the permissible limit of 100 mg/NM3" (Times News Network, 2018).

The pollution evidently persisted, as is clear from this report from the Times of India dated 27th June 2019, which said that "Taking serious note of high pollution levels from KTPS, the Union environment ministry has refused to initiate the process for granting environmental clearance to the proposed two new units of the plant. As per ministry's report, the sulphur dioxide emissions from the plant are 7–14 times more than the permissible standards" (Roy & Behl, 2019).

WATER POLLUTION

Water pollution has also been a serious and ongoing concern. Times of India News reported on 27th April 2017 that, "If crop damage and air pollution was not enough, KTPS is also polluting drinking water in many villages. MAHAGENCO releases water through a canal near our village. Sometimes oil flows with water and pollutes our groundwater. When we complain, the officials just take perfunctory steps to solve the problem," says Maharoti Bhange from Ghogli" (Behl, 2017b).

A HuffPost India News report dated 10th September 2019 states that "On the morning of 10 July 2019, residents of Varegaon village in Maharashtra's Nagpur district awoke to a breach in Khaparkheda Thermal Power Plant's ash pond...the breach dumped millions of litres of coal ash into the Kolar River, according to reports in local papers" (Raheja, 2019).

Another Times of India News report dated 7th August 2020 noted that, "Once again fly ash from Khaparkheda Thermal Power Station leaked into Kanhan River and forced Nagpur Municipal Corporation (NMC) to stop Pumping for 2 hours" (Roy, 2020). The same report also documents how such fly ash discharges into Kanhan had polluted the city water supply and/or forced NMC to stop pumping supply to the Nagpur city in 2018, in December 2012 and January 2013.

IMPACT ON AGRICULTURE

The pollution, particularly from fly ash has also badly affected agriculture, and media has reported extensively on this.

A Times of India reported on dated 29th December 2012 about the issue. It said: "Shailendrakumar Bhoyar, sarpanch of Lonkhairi village, which was one of the worst affected (from fly ash), told TOI, "Crops in 150 acre near the village was damaged badly"" (Roy, 2012).

Another Times of India news report dated 27th April 2017 quoted a resident of Suradevi village to establish the gravity of the situation. ""We are virtually forced to breathe, eat and drink fly ash. The vegetables that are growing in the fields are covered with it. If we keep papads to dry or a bucket of water outside they get coated with a layer of ash" Says Rekha Kautare, of Suradevi" (Behl, 2017b).

This news report also had this to say: "Since last year, we have stopped growing them (Leafy Vegetables) because the quality and quantity was not good.

Many times, our crops wilt due to high deposition of fly ash. If our yield in normal conditions should have been 75%, now it is only 30–35%," says Ramesh Kawde, a farmer of the same village" (Behl, 2017b).

"Even a village like Bailwada, which is some 10 km away from the plant, suffers from KTPS pollution. "Our crop yield has reduced by 20% due to fly ash. Asthma is a common problem. Every morning, we find our utensils, vehicles, in fact everything, covered with a thick layer of dry ash," says resident Rishi Dakhore" (Behl, 2017b).

HEALTH IMPACTS

Times of India news report on 27th April 2017 speaks about health impacts of the pollution. It says: "Dr. Gyaneshwar Dhanole, a medical practitioner in Mahadula, another village close to KTPS, concurs with the villagers. "Respiratory ailments are common in the area. Those who fall prey to them are unable to recuperate completely. While in other places kids get viral fever mostly when season changes. However, here they suffer from it all the year round," he says" (Behl, 2017b).

IMPACT ON NAGPUR CITY OUTSKIRTS

Times of India reported on 29th December 2012 that "The fly ash is wreaking havoc in suburbs of Nagpur too. Mamta Nandi, a resident of Godhni, told TOI, "My plants have stopped flowering and are wilting. Piped water supply is not available in the area and we solely depend on wells. But this water is gradually becoming unfit for drinking. Many people have developed chronic respiratory problems"" (Roy, 2012).

Another Times of India report dated 27th April 2017 mentions that the "Nagpur city is also feeling the effects pollution." When activist Ankita Shah recently shared TOI's story about KTPS pollution on the social media, Nagpurians complained that the pollution has reached city's northern areas. "A friend complains that he has his office at Nelson Square, and if windows are left open for half-an-hour, he gets asthma attack," commented Deepanshu Khirwadkar. Madhurita Dhar, a resident of Mankapur, says, "Residents living on higher floors are constantly exposed to dry ash. If we don't do dusting every day, a thick layer gets deposited on everything"" (Behl, 2017).

CIVIL SOCIETY AND NGO MONITORING

Manthan Adhyayan Kendra (Manthan), one of the publishers of this report, has been tracking the pollution in the region for the last 5–6 years. In a field visit in March 2016, a team member of Manthan had made the following observation (Sandbhor, 2016):

"Downstream of the Khaperkheda thermal power station the drain which carries effluents—clearly untreated—from the plant enters directly into river Kanhan. The effluents are turbid and black in colour with load of suspended solids in it. There is layer of black oil on the effluents. As this effluent stream meets the river, it turns the flowing river water into turbid and black in colour. The suspended solids in effluents which are mainly fly ash and coal particles settle..."

A subcommittee of the MoEF&CC's Expert Appraisal Committee (EAC) in August 2019 found that the effluent generated from the washing of ESP having mixed with fly ash is directly discharged into nearby drains

Significantly, Manthan's observations remained largely the same on two field visits—one before this in November 2014 (Sandbhor, 2016) and one after that in May 2019 (See Figure 2).

Some of the serious problems documented by the Manthan team in its field visit of the area on 28th May 2019 include:

- Ash effluent discharge directly from Khaparkheda Thermal Power Plant was mixing into Kanhan River.
- Ash effluent was getting discharged from Waregaon ash bund (KTPS's ash pond) into a local Nala that finally meets Kanhan River.
- Fugitive emission from Waregaon fly ash pond is creating menace for the people of one Waregaon village which lies 500 metres from the ash pond.
- According to the local people, fly ash from the Khaparkheda (Waregaon) Ash Pond is affecting people's health, agriculture and water.

FIGURE 2: ASH LADEN WATER IN NALA FLOWING OUT OF KHAPARKHEDA TPS BOUNDARY, AND FLY ASH DEPOSITED AT BOTTOM OF NALA. OBSERVED DURING FIELD VISIT BY MANTHAN, MAY 2019 | PHOTO: SEHR RAHEJA/MANTHAN ADHYAYAN KENDRA

REPORTS OF OFFICIAL AGENCIES

From time to time, official agencies have validated such findings by documenting the serious pollution impacts from these power plants.

For example, the Consent Appraisal Committee (CAC)[4] of Maharashtra Pollution Control Board (MPCB) in its 14th meeting held on 2nd February 2016 decided that the bank guarantee of Khaparkheda TPS (expansion) and Khaparkheda (Units I to IV) should be forfeited (MPCB, 2016). This decision was taken due to non-compliance by the thermal power station to the consent conditions. The committee also noted that the Joint Visit Sampling (JVS) analysis reports of air and water are exceeding the limits. Unfortunately, the CAC still went ahead and renewed the consent permission for the power plant, after a forfeiture of a mere Rs. 42.5 lakhs

of bank guarantee. This is a paltry amount for such a large power plant and expectedly, did not result in any meaningful check on the pollution. A random inspection visit carried out by the Regional Office (Nagpur) of the MoEF&CC in January 2019 noted gross violations of the environmental clearance conditions at Khaparkheda TPS including unsatisfactory fugitive emissions, SPM (suspended particulate matter) levels of Unit 1 and 2 (220 mg/Nm3) exceeding the limits, groundwater monitoring near ash pond not being done and plantation for greenbelt not satisfactory (MoEF&CC, 2019, p. 2).

Similar issues have also been found at the Koradi plant. A visit to the Koradi and Khaparkheda plants, ash ponds and the surrounding areas by a subcommittee of the MoEF&CC's Expert Appraisal Committee (EAC) in August 2019 found that (EAC, 2019B, p. 50):

"The Effluent Treatment Plant is not functional. The effluents... are pumped to ash slurry making without treating the effluent. Further, the effluent generated from the washing of ESP having mixed with fly ash is not sent to settling pond, instead it is directly discharged into nearby drains. There are leakages observed at the ash slurry mixing unit and some portion is going into the drain to discharge outside the premises. Further, Ash water recycling unit of Koradi ash pond is not functional during the visit. The overflow water is going to adjacent drain."

The same report also noted many other problems including that "emissions from the fluegas of Koradi Power Plant and Khaperkheda Power Plants are exceeding the standards".

FIGURE 3: PHOTOGRAPH FROM THE VISIT REPORT OF THE EAC SUB-COMMITTEE OF MOEF&CC OF POLLUTION FROM THE KORADI TPS WITH THEIR ORIGINAL CAPTIONS

DISCHARGE OF EFFLUENT IN OPEN DRAIN

LEAKAGE FROM ASH SLURRY MIXING UNIT

Given these serious problems, it is not surprising that the local people have been complaining for years about the air, water and land/soil pollution from these two power plants, besides severe health impacts on both humans and cattle. Media records of the same have been mentioned above, and instances of citizen/community protest against addition of new units and/or demanding the closure of existing polluting units can be found from as early as a decade ago (Pallavi & Chakravartty, 2011). In the subsequent sections of this report, we will present findings from our community surveys that describe in detail how local people have been raising the issue for several years.

It is now clear from all this information that the Koradi and Khaparkheda power plants have been causing serious pollution which impacts the health and livelihoods in the area for at least a decade. Unfortunately, pollution continues to be a major issue and this is one of the most important reasons for taking up this study, as we elaborate next.

objectives, structure and approach of the study

THE OBJECTIVE IS TO MEET AN URGENT NEED FOR A COMPREHENSIVE DOCUMENTATION AND ASSESSMENT OF THE ISSUE, WITH THE HELP AND INVOLVEMENT OF THE LOCAL COMMUNITIES TO SUGGEST WAYS TO ADDRESS THE ISSUE

The issue of pollution caused by two power plants has assumed serious proportions, and yet no meaningful action has been taken by the authorities. On the contrary, the MoEF&CC by giving ToRs for the further expansion of Koradi TPS by installing two new units of 660 MW each, has taken the next step towards creating more pollution in the area (MoEF&CC, 2020).

In this context, there is an urgent need for a comprehensive documentation and assessment of the issue, with the help and involvement of the local communities. The assessment would also suggest ways to address the issue. With this objective, Centre for Sustainable Development, Nagpur, Manthan Adhyayan Kendra, Pune, and Asar Social Impact Advisors Pvt. Ltd. came together to carry out such an assessment in the form of this study. The following approach was formulated for the study.

STUDY OBJECTIVES AND STRUCTURE

The objectives of the study were

1. To prepare a comprehensive assessment of the pollution of air, water, soil in the area
2. To prepare an assessment of the impact of this pollution on the health of human beings, cattle, other flora and fauna
3. To carry out these assessments with the involvement of local communities and ensure that their experiences are recorded as a part of the assessment
4. Prepare recommendations for various actors and agents towards finding a solution
5. Share the assessment, analysis and recommendations with local communities in a manner that they are able to more actively and effectively take up the issue with various authorities

It was planned to include the following components in the study.

1. Study of air, water and soil pollution in the area using primary and secondary sources
2. Collection and testing of samples to assess presence of contaminants in air, water and soil
3. Detailed questionnaire-based survey of villages in the affected

area to understand status of pollution, impacts on health, cattle, livelihoods. Surveys to include: *a) Village profile, b) Household profiles (villager profiles) in each of the villages, and c) Farmer profiles*

4. Study of likely health impacts of pollution including a detailed health survey

5. Observations by the study team in the area

It was proposed to carry out the study with respect to the pollution due to the power plants (including their ash ponds) and the coal mines in the area.

METHODOLOGY

IDENTIFICATION OF SAMPLING AND SURVEY LOCATIONS

Team members of Manthan have been making regular field visits to the area since 2014. During these visits, several locations that were particularly polluted were identified. Several other locations from where pollutants were being discharged from the thermal power plants, ash ponds and mines were also identified during these visits. Media reports on the pollution for over a decade have also highlighted certain areas as being severely impacted. Further, several official reports have documented pollution from these facilities. Based on all these, areas around the facilities likely to be affected by pollution were identified on a preliminary basis.

Several reconnaissance visits were made to the area by CFSD team and Manthan to assess the likely areas impacted and also to meet with the local communities and their representatives. Apart from

finalising the areas to be studied in detail, this exercise was also meant to get the local people involved in the study.

WATER SAMPLE COLLECTION AND TESTING

Based on this exercise, 25 locations were identified for collecting water samples to test for contamination. These locations included spots on rivers and streams, as well as some spots in select villages.

The criteria for selection of specific water sampling locations included

1. Locations where at some point of time effluent discharge into water bodies had been observed, recorded or documented, or places where such discharge is suspected

2. Locations that are important from a supply or usage perspective—places from where water is being lifted for water supply to various villages or towns/Nagpur city, or sources from where local people are using water for various uses

3. Control locations

4. Water treatment plants (WTP) in several villages. Where a WTP was selected, sampling included samples from the outlet/output of the WTPs; and samples from the water inlet point of the WTPs or from the locations where raw water for the WTPs is picked up, which could be ground water or water lifted from some river or stream

5. Water ATMs[5] in several villages. Where a water ATM was selected, sampling included samples from the outlet of the water ATMs; samples from the source of water for the water ATM (input to the ATM), which in all the cases are ground water sources; and samples of the waste water discharge of the water ATMs.

It was decided to carry out the sample collection and testing during the three seasons—winter, summer and monsoon, as the seasons can influence the intensity of the pollution and its impacts. In case

of WTP, in any given season water was collected from outlet or inlet end. Similarly for Water ATMs, in any given season, water was collected from only one part i.e., outlet, inlet or waste water.

FLY ASH SAMPLE COLLECTION AND TESTING

Apart from water samples, it was also decided to collect samples of fly ash from five locations, in three seasons. Four of these locations consisted of one spot each in the fly ash ponds of Khaparkheda and Koradi power plants (location 1 and 2), and two households in Chankapur village (locations 3 and 4). Chankapur is very close to the Khaparkheda TPS. The fifth location was the Electro Static Precipitator (ESP) of the Khaparkheda thermal power plant from where the fly ash sample was collected directly[6]. The reason for restricting the fly ash sample collection to the households in Chankapur was that our preliminary field visit and survey had revealed that this was one of the places where fly ash deposition into the homes was quite high and also that we could have access here despite the Covid-19 situation. Analysis/ testing of fly ash that we had planned require a certain minimum quantity of ash and at this location we were able to collect the required quantity.

The water as well as fly ash samples collected were to be analysed by a competent laboratory accredited by ISO 9001:2015 (ISO, 2015) and recognised by Bureau of Indian Standards. The fly ash samples were to be tested for 14 metals, Polychlorinated Biphenyls (PCBs) and total petroleum hydrocarbons in terms of oil and grease. Water samples were to be tested for eight basic parameters including pH, TDS, turbidity, total hardness, alkalinity, chlorides, sulphates and nitrates, and 30 metals. Biological testing of water samples was not planned.

QUESTIONNAIRE-BASED VILLAGE, HOUSEHOLD- AND FARMER- SURVEYS

A detailed questionnaire-based survey was prepared to get the picture of pollution and its impacts directly from the local communities and as experienced and perceived by them. Apart from these details, the survey was also intended to collect information on the attempts by local people to raise the issue and seek redressal from the authorities and the responses they had received.

The survey was to have three parts—village profiles surveys based on discussions with several people and groups in the village from which would capture the information about the overall situation in the village, household profiles (villager profile) surveys of between 5–20 households in each village, which would capture experiences and perceptions of individual households, and farmer profiles based on survey of 5–10 farmers in each village to capture the impacts of pollution on agriculture faced by individual farmers.

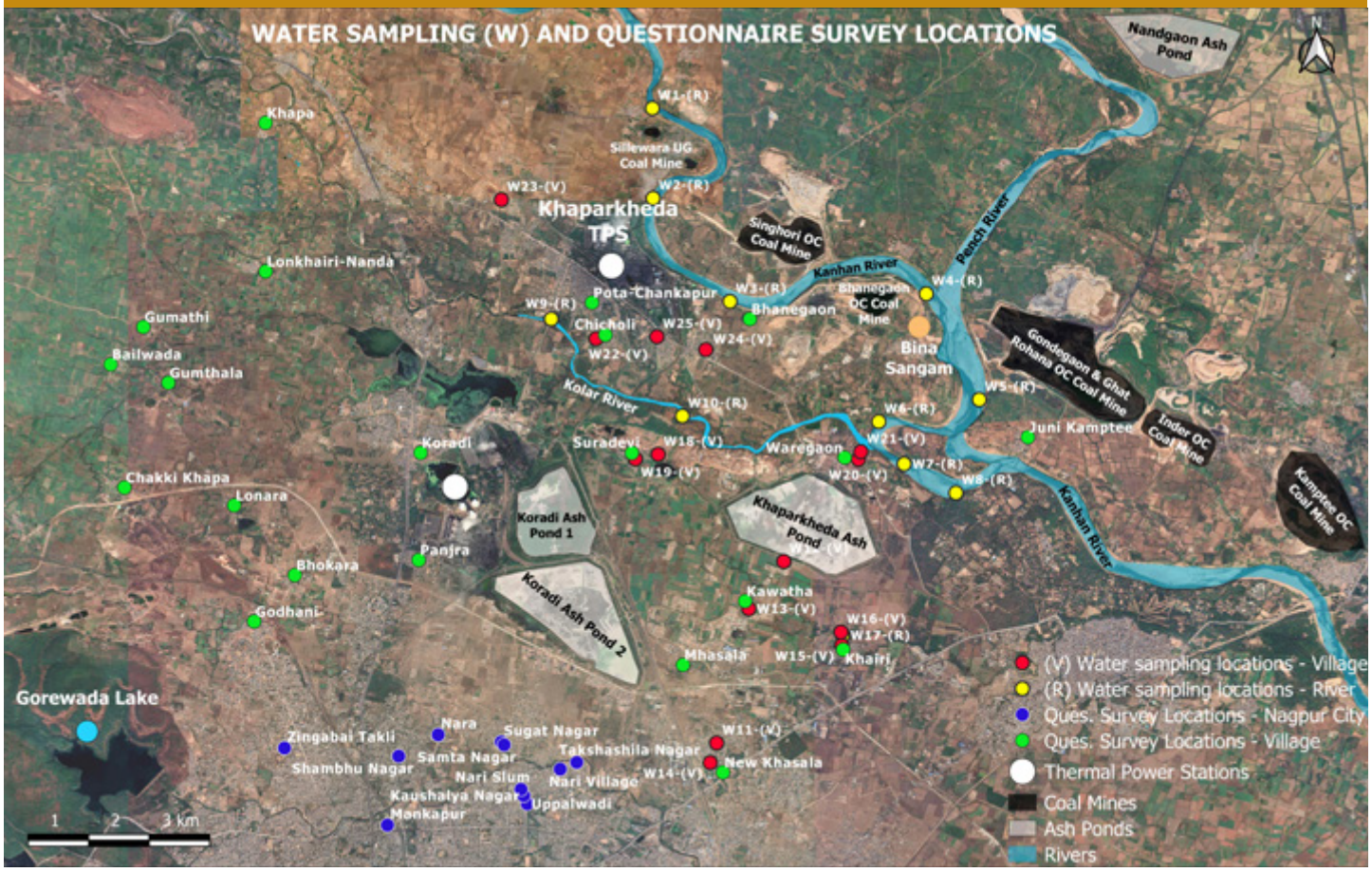
The villages for the survey were selected based on the preliminary reconnaissance and studies as elaborated earlier. It may be mentioned that water sampling was also planned in some of the village surveyed with questionnaires.

QUESTIONNAIRE-BASED SURVEYS IN OUTSKIRTS OF NAGPUR

We had heard from various people that areas on the outskirts of Nagpur city situated towards the two power plants were also facing problems from fly ash dust depositing in their homes and open spaces. So the questionnaire-based surveys were planned in four localities in the city outskirts.

Map at Figure 4 shows the water sample collection locations as well as the villages and Nagpur wards where questionnaire-based surveys were carried out.

FIGURE 4: MAP SHOWING WATER SAMPLE COLLECTION LOCATIONS AS WELL AS THE VILLAGES AND NAGPUR WARDS WHERE QUESTIONNAIRE BASED SURVEYS WERE CARRIED OUT.



EXECUTION OF THE STUDY, CHANGES DUE COVID-19 DISRUPTIONS

The work on carrying out the study was started in January 2021. Unfortunately, Covid-19, especially the severity of second wave majorly disrupted our plans. There were several restrictions including on access to villages, to local communities, any kind of door to door surveys since we followed all Covid-19 Guidelines and Covid-appropriate behaviour. Consequently and also looking at the resource availability, the study was restructured in parts.

Given the new circumstances, it was decided that in the first phase, we will look only at the thermal power plants and ash ponds. The impacts of coal mines will be taken up in the next phase. Similarly, since some of the air pollution related aspects were relatively better documented, we decided to focus on the water pollution. The scope of the detailed questionnaire-based surveys

was also narrowed down to focussing on village profiles. Instead of surveying several households and several farmers in each village, the villager profiles and farmer profiles were done only as indicative surveys with just one household and farmer from each village. This was because access to villages was restricted and also given the Covid-related situation, it would not be prudent to visit and meet with so many households. Lastly, the health impact survey was limited to responses and perceptions of the local community, since we decided to avoid bringing in health and medical workers for health surveys and check-ups. We hope to undertake these components in the next phase of the study.

In spite of these restrictions, the study we have been able to carry out is sound methodologically, and gives a robust picture on the prevalence of pollution due to the thermal power plants and its impacts on the local communities.

The three rounds of water and ash sample collection were carried out on 25th and 26th February 2021 (1st season), 31st May and 1st June 2021 (2nd season), and 26th and 27th July 2021 (3rd season), corresponding to the three seasons of winter, summer and monsoon respectively.

While we had identified 25 locations for water sample collection, the actual samplings were done at 23 locations in the 1st season (winter), 25 locations in the 2nd (summer) and 20 locations in the 3rd. (monsoon). In season 1, we had problems of access at 2 locations due to non-availability of the local contact. In the 3rd season we were not able to take water samples from 5 locations. Three of these were river locations, where access became a problem due monsoon. At one village location, water samples could not be collected due to non-functioning of the motor-pump of the borewell.

Out of the 25 locations, 11 were river locations, with samples being taken directly from rivers or streams, and 14 locations were villages with samples being collected from borewells, dug wells, Water Treatment Plants (WTP) and water ATMs.

As far as possible, samples in each round were collected from the same locations (though in monsoon, it was not possible to reach the exact locations in some cases). Water ATMs were an exception, with samples being taken from outlet, wastewater discharge and inlet respectively, for the three rounds. For WTPs at Kawatha and Chankapur WTP output water was taken as sample in the 1st (winter) and 2nd (summer) season, while in the 3rd season (monsoon), input/raw water was taken as water sample for analysis.

Fly ash samples from households were collected only during two seasons (winter and summer). In the 1st season (winter) fly ash sample was collected from two households and in the 2nd season (summer), the sample could be collected from only one household due to covid related health issues.

The village profiles were collected for 21 villages, but the household or villager profiles were restricted to an indicative one household per village (total 23 responses) and one farmer per village (20 responses).

In the wards on outskirts of Nagpur city, Covid restrictions meant that we were not able to carry out full-fledged

FIGURE 5: WATER SAMPLE BEING COLLECTED FOR TESTING FROM THE STREAM NEAR KHAIRI VILLAGE. YEAR 2021. PHOTO: CFSD TEAM

surveys and had to limit to collecting the information through detailed discussion with some of the local people including the local corporators.

key findings: massive pollution, serious impacts

THE ENTIRE STUDY AREA AROUND THE KORADI AND KHAPARKHEDA THERMAL POWER PLANTS IS FACING RAMPANT AND UNCHECKED POLLUTION, AFFECTING AIR, SURFACE AND GROUNDWATER, AND SOIL. IT IS A MATTER OF GREAT CONCERN THAT THESE CONTAMINATED GROUND AND SURFACE WATERS ARE BEING USED BY LOCAL COMMUNITIES EXTENSIVELY, FOR ALL PURPOSES INCLUDE DRINKING (WITH AND WITHOUT TREATMENT)

Our assessment shows that the entire study area around the Koradi and Khaparkheda thermal power plants is facing rampant and unchecked pollution, affecting air, surface and ground water, and soil.

Airborne fly ash is leading to extensive air pollution. This airborne fly ash deposits over a large area on houses, open spaces, water bodies and agricultural fields. The fly ash is being blown from dry parts of ash ponds, as well other sources like fugitive emissions from inside the plant, and from the stacks of the power plants.

Koradi and Khaparkheda Thermal Power Plants both discharge effluents directly into local streams and rivers including the Kolar and Kanhan rivers, and this includes fly ash mixed effluents. Leakages, direct discharges and leaching of water from ash ponds is further contaminating water bodies, including ground water.

Surface as well as groundwater sources are affected by high levels of turbidity, hardness, alkalinity and total dissolved solids (TDS) which exceed the limits given in Indian standards for drinking water, the IS 10500: 2012 (acceptable limits)[7] (Bureau of Indian Standards, 2012). More worrying is the presence of elements like aluminium, arsenic, boron, fluoride, iron, manganese, magnesium, mercury, molybdenum, lead and selenium, which is found at levels exceeding the IS 10500: 2012 drinking water standards. These are elements that can have very serious impacts on human

health as well as the health of cattle and on the ecology.

Further, several other elements that can have serious health impacts have been found in surface or groundwater for which there are no limits mentioned in the IS 10500: 2012 drinking water standards, but whose concentrations exceed limits specified by other regulatory agencies like the Environment Protection Agency of the United States of America (US–EPA). These elements include lithium (USGS, 2021) and antimony (U.S.–EPA, 2018, p. 16).

It is a matter of great concern that these contaminated ground and surface waters are being used by local communities extensively, for all purposes include drinking (with and without treatment)[8], other domestic use, bathing, washing clothes, fishing, irrigation and water for cattle. This has serious implications for their health and well-being.

We refer to some of the specific health impacts of these metals in the discussion that follows. Annexure A provides a more detailed compilation of various metals and contaminants and their potential impact on human, animal and ecological health.

We also want to emphasise that while we have highlighted and discussed here only those metals whose concentrations exceeded the standards as mentioned above, there were many locations where these metals (and others) were found present in the water samples but in quantities below the limits placed by the standards. However it would be wrong to therefore treat this as of no consequence. Metals found below the limits also can lead to serious health impacts due to their persistence in water and the property of bio-accumulation and bio-magnification. As the report "*Status of Trace & Toxic Metals in Indian Rivers*" by the Central Water Commission (CWC) (CWC, 2019, p. 29) notes:

"Owing to their chemical characteristics, metals remain in the environment, in many cases only changing from one chemical state to another one and eventually accumulating in the food chain...Because of their high water solubility, heavy metals can be easily absorbed by living organisms and, due to their mobility in natural water ecosystems and their toxicity to living forms, have been ranked as major inorganic contaminants in surface and ground waters. Even if they may be present in dilute, almost undetectable quantities, their recalcitrance to degradation and consequent persistence in water bodies imply that, through natural processes such as bio-magnification, their concentration may become elevated to such an extent that they begin exhibiting toxic effects."

DETAILED FINDINGS

WATER POLLUTION OVERVIEW

As mentioned earlier, we carried out three rounds of testing of water samples, corresponding to three seasons, from 25 locations, with 11 samples from rivers or streams, and 14 samples from village locations including borewells, dug wells, Water Treatment Plants (WTP) and water ATMs. Table 2 gives the details and Figure 6 gives the map showing these locations. Samples were tested for basic parameters like pH, TDS, alkalinity, etc., and for the presence of a set of heavy metals and other pollutants which are normally found in waste water discharges from coal fired power plants. Samples were not tested for biological parameters.

TABLE 2: SEASON-WISE DETAILS OF LOCATIONS OF WATER SAMPLES COLLECTED

NUMBER OF LOCATIONS FROM WHERE WATER SAMPLES COLLECTED	
RIVER LOCATIONS	
WINTER SEASON	11
SUMMER SEASON	11
MONSOON SEASON	8
VILLAGE LOCATIONS	
WINTER SEASON	12
SUMMER SEASON	14
MONSOON SEASON	12
TOTAL SAMPLES	
WINTER SEASON	**23**
SUMMER SEASON	**25**
MONSOON SEASON	**20**

FIGURE 6: MAP SHOWING WATER SAMPLING LOCATIONS | R REFERS TO RIVER LOCATIONS, V REFERS TO VILLAGE LOCATIONS.

The findings are shocking.

Almost every water sample, in every season including monsoon, failed to pass the standards set for drinking water by the Bureau of Indian Standards, namely the IS the IS 10500: 2012 (acceptable limits). The only samples to pass the test were the samples collected from the output side of the Water ATMs—which is not surprising as Water ATMs are basically RO plants filtering out most of the dissolved constituents. This also has some health implications, which we will discuss later.

In all three seasons, most of the samples showed high[9] turbidity, hardness, alkalinity and total dissolved solids (TDS), exceeding the standards. Because of this, we will not repeat the mention of these parameters in the detailed discussion of river and ground water pollution given below. Many locations also showed serious contamination due to metals, which is the main focus of discussion in the next section.

RIVER POLLUTION

Samples collected from the Kanhan river show that the entire stretch of the river from just upstream of the Khaparkheda TPS to downstream of the Khaparkheda ash pond is highly polluted. Looking at the results of the three sampling rounds, Kanhan River shows high concentrations of aluminium, magnesium, manganese, mercury, iron, molybdenum, lithium and fluoride. Similarly, the samples tested from Kolar River showed high

concentrations of Aluminium, Magnesium and Mercury. Another stream that flows past Khairi village was also found to be highly polluted with many of these pollutants.

While not all locations show presence of all the elements, it should be noted that a river is a continuum and pollutants seen at one place are likely to be found downstream too. The pollution at these locations is of great concern as water from these locations is being used in-situ for a range of uses and is also drawn and lifted for use at other places. Table 3 below gives results of testing of samples listing contaminants that are exceeding the standards for all locations, seasons-wise, as also how the water from the sampling locations is being used.

Aluminium contamination can lead to fluid imbalance in fish, and exposure in high concentrations is associated with Alzheimer's disease in human beings. 10 location samples in the second season and 11 in the third season showed high level of aluminium. What is shocking is that in the third season, several locations showed aluminium concentrations at 100 times higher than the limits set by the standards (for e.g., W1, W2, W4). These are the locations where water is being used for domestic use, drinking, bathing, and fishing and by cattle.

Exposure to high concentrations of ***manganese*** can impact the nervous systems (U.S.–EPA, 2013a, pp. 3–4). While two locations showed high levels of manganese in the second round[10], 7 locations showed high concentrations of Manganese in third round. In several locations, levels exceeded standards by 5–6 times (W1, W2, W4, W5, W7).

According to the Central Pollution Control Board (CPCB) (CPCB, 2009, p. 8 & 37), "***Mercury*** is the most toxic substance known to mankind" and "Mercury … may be fatal if inhaled and harmful if absorbed through the skin. It may cause harmful effects on the nervous system, digestive and respiratory systems and kidneys." Four locations in season three, and one each in earlier two seasons showed mercury exceeding limits.

At Location W4 on Kanhan river, between Bhanegaon mine and the Pench-Kanhan Confluence, where water is used mainly for bathing, mercury exceeded the standard by three times.

Iron was found exceeding the standards at one location in first season. Human exposure to high concentrations of iron can cause metabolic changes and damage to the pancreas, liver, spleen, and heart (U.S.–EPA, 2013A, pp. 3–4). The stream that flows near Khairi village was also found as being heavily polluted. This stream is polluted with high concentrations of arsenic, mercury, molybdenum, selenium, boron, fluoride, lithium, aluminium and magnesium. Water from this stream is utilised for various purposes including drinking water for cattle, cattle washing/bathing, fishing, bathing usage for human beings, irrigation etc. (see Figure 7).

Surface as well as groundwater sources are affected by high levels of turbidity, hardness, alkalinity and total dissolved solids… More worrying is the presence of elements like aluminium, arsenic, boron, fluoride, iron, manganese, magnesium, mercury, molybdenum, lead and selenium

FIGURE 7: STREAM NEAR KHAIRI VILLAGE SHOWING CATTLE BATHING IN THE WATER. THE WATER FROM HERE IS USED FOR MANY DIFFERENT PURPOSES. OUR SAMPLING SHOWED WATER HERE TO BE HIGHLY POLLUTED. SAMPLING IN PROGRESS CAN ALSO BE SEEN. YEAR 2021. PHOTO: ASHISH SINHA/MANTHAN ADHYAYAN KENDRA

According to the World Health Organisation (WHO)(WHO, n.d.), "Ingestion of excess ***fluoride***, most commonly in drinking water, can cause fluorosis which affects the teeth and bones. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems."

It is important to note that among the impacts as described by the people of Khairi village was high prevalence of bone related illnesses in humans and cattle. They mentioned that in humans, weakening of bones were seen, and bones were breaking easily if anyone had a fall. Similar prevalence of skeletal problems, knots all over the body and bent legs were seen in cattle. Such skeletal illness is associated with fluoride pollution, identified as exceeding the limit by two times in the stream near Khairi (Location W17) in season two (Fluoride was found in high concentrations even in groundwater in Khairi as we will describe in the groundwater section).

Arsenic is associated with an increased risk of cancer of liver and bladder in human beings and has numerous impacts on fish (U.S.–EPA, 2013a, pp. 3–4).

Note that this region is not prone to arsenic problem, as per the Ministry of Water Resources, Government of India publication, "Arsenic Hot Spot in Ground Water in India" (Ministry of Jal Shakti, n.d.).

Arsenic was found at concentrations three times the limit at the Khairi stream (W17) in season one and season two.

In the case of ***selenium***, the US-EPA report on *Environmental Assessment for the Proposed Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category* states that "short-term exposure to selenium at levels above the Maximum concentration limit (50 µg/L) can cause hair and fingernail changes, damage to the peripheral nervous system, and fatigue and irritability. Long-term exposure can damage the kidney, liver, and nervous and circulatory systems" (U.S.–EPA, 2013a, pp. 3–4).

Selenium in high concentrations was found in the Khairi stream in season one and season three.

In case of ***Lithium***, Indian Standards do not put any limits. So, we used the standards from the US-EPA, which also are not binding, but in the nature of health advisory. We used the U.S. Geological Survey guidance (USGS, 2021) that gives "a non-regulatory Health-Based Screening Level (HBSL) for drinking water of 10 micrograms per litre (µg/L) or parts per billion to provide context for evaluating lithium concentrations in groundwater."

According to the US Geological Survey, "Pharmaceutical use of lithium at all therapeutic dosages can cause adverse health effects—primarily impaired thyroid and kidney function" (USGS, 2021). The handbook on the *Toxicology of Metals* states that "there is no evidence that environmental Li may cause adverse effects on the general population" but with an important rider that this is the case "With the exception perhaps of areas with very high levels of Li in drinking water" (Nordberg, Fowler, & Nordberg, 2015, p. 969).

Lithium limits were found to have been exceeded at six locations in season one, six locations in season 2 and eight locations in season three with one location (W17) exceeding the limits 14 times, 16 times and 14 times in the first, second and third season respectively, and another location (W5) by nine times in season one.

Molybdenum was found to exceed the limits at two locations in season one, two locations in season two and one location in season three.

Molybdenum is an important micro-nutrient for human beings, but exposure to excessive levels has adverse health impacts, with the possibility of respiratory and renal health impacts for humans. The toxicity of molybdenum has been well established in cows and sheep (ATSDR, 2020, p. 1 & 2).

These are some of the main pollutants found in high concentrations in the rivers and streams in the area, as revealed by our sampling and testing. It is not surprising that direct discharge of ash laden water from Koradi or Khaparkheda plants/ash ponds has been observed and documented in all three water bodies—Kolar river, Kanhan river and the Khairi stream mentioned above. In fact, so serious is the fly ash discharge in the Khairi stream that it was given the name "Fly ash nala".

Many of the pollutant elements described above are the very elements that are found in fly ash and in the discharges from thermal power plants, as we will present in detail in subsequent sections.

The deployment of Water ATMs in many villages is a clear admission that the water is contaminated and unfit to drink

GROUND WATER POLLUTION

Many of the samples collected in the villages were from ground water. Ground water in these villages is either being used directly, or after being treated in a WTP, or after treatment in a Water ATM (for drinking use).

Ground water in the area was found to have high concentrations of various metals like aluminium, arsenic, calcium, copper, fluoride, lead, magnesium, manganese, mercury, molybdenum, lithium and selenium. The impacts of these metals have been described in the river pollution section so here we don't repeat them, but elaborate on the pollutants found in groundwater.

Location W14 is a borewell in the Mhasala village. Water from here is used for drinking and domestic use. While tests in season one showed high levels of magnesium, we found high concentrations of molybdenum, fluoride, magnesium and copper in season two and of mercury, aluminium and magnesium in season three. Lithium was found in high levels in all three seasons. Mercury here exceeded standards by 5 times in the third round.

Location W16 is a dug well which is next to the Khairi "fly ash nala" and water from this dug well is used for domestic as well as agricultural use. The water sample from this well showed high levels of magnesium and lithium in season one, high levels of arsenic, lead, manganese, mercury, selenium, lithium and magnesium in season two, and high levels of manganese, selenium, lithium, calcium and magnesium in season three. What is shocking is that mercury levels here exceeded standards by 51 (fifty one) times, arsenic exceeded the limits by 13 times and selenium levels exceeded the standards by 10 times in season two. Arsenic, mercury and selenium are among the metals with very serious health impacts.

Mercury was also found exceeding standards at Location W13 in season three, which is the borewell that serves as water source for the Water ATM in Kawatha.

Lithium was also found in high concentrations at many groundwater sites, three locations in season one and two, and seven locations in season three.

As several of these villages are close to the ash ponds (e.g., Kawatha, Mhasala —Location W13, W14) it is likely that the groundwater is being contaminated by fly ash leaching into groundwater. Ash ponds of both the power plants are unlined.

WTPS AND WATER ATMS

In several villages water is being pumped from some river and being treated in a WTP before being supplied to the village. E.g., Pota–Chankapur (W23), Kawatha (W12) etc. At these places we tested both, output water as well as input (raw) water, albeit, in different seasons.

We found that in several places, pollutants persisted in the water in spite of the treatment. For instance, at Kawatha, the treated water being supplied from the WTP contained high levels of aluminium, lithium and magnesium. Similarly, at Location W18, we found that the water at the sump house in the temple premises of Suradevi had high levels of aluminium and magnesium in season two and three. The sump house is where water pumped from Kanhan river is stored after filtration then supplied to the village.

The Water ATM is an interesting phenomenon. The deployment of Water ATMs in many villages is a clear admission that the water is contaminated and unfit to drink. They appear to be projected as a solution to the polluted water sources. It is also true, as our tests showed, that the ATM water output were the only samples to meet the drinking water standards. However, this can provide a false sense of security, because the polluted water would (and is) continue to be used for other uses, and sometimes even for drinking water purposes. We were informed in some places that people from poorer backgrounds did not take water from the ATMs due to the cost issue, and were using other (polluted) sources even for drinking water.

Also, while the villages do not have to bear the cost of installation of the ATMs, the maintenance is the responsibility of the gram panchayat. Given the resource constraints of most panchayats, in several cases they are not able to maintain Water ATMs, which then become dysfunctional, often for long durations. The people are then forced to rely on the local water resources, which are often highly contaminated. So, the provision of ATM cannot be seen as an option to address the problem of polluted water sources.

Secondly, in doing a very efficient job at stripping away elements from the polluted water, the water ATMs may actually also be undermining people's health. It takes away elements like Magnesium which in some quantity are found to be important. For example, a paper in the International Journal of Preventive Medicine (Sengupta, 2013) notes that:

"...drinking-water may be a source of calcium and magnesium in the diet and could be important for those who are marginal for calcium and magnesium intake. Where drinking-water supplies are supplemented with or replaced by dematerialized water that requires conditioning, consideration should be given to adding calcium and magnesium salts..."

Our tests show that many water ATMs strip away Magnesium from water to below detectable limits.

Lastly, what is probably a very serious issue is that while the output water from the water ATMs (tested in season one) passed the Indian Standards for all parameters, we found that all the five water ATMs had significant presence of Mercury in the output water. Even though the concentrations of this Mercury were within the acceptable limits (they were around 50% of the acceptable concentrations laid down by the standards), this is still worrisome as Mercury can bio accumulate, and we would like to reiterate what the CWC report quoted earlier says (CWC, 2019, p. 29):

"Even if they [metals] may be present in dilute, almost undetectable quantities, their recalcitrance to degradation and consequent persistence in water bodies imply that, through natural processes such as bio-magnification, their concentration may become elevated to such an extent that they begin exhibiting toxic effects."

4 villages reported health problems due to contamination of water... 9 out 21 villages reported health problems which they attributed to air pollution due to fly ash

TABLE 3: SEASON WISE, LOCATIONS WISE RESULTS OF WATER SAMPLE TESTING SHOWING CONTAMINANTS EXCEEDING STANDARDS AND USAGE OF WATER AT ALL LOCATIONS

SL. NO.	LOCATION AND DESCRIPTION OF SAMPLE COLLECTION POINT	LOCATION NO.	USAGES	METALS WITH CONCENTRATIONS EXCEEDING STANDARDS SEASON 1	METALS WITH CONCENTRATIONS EXCEEDING STANDARDS SEASON 2	METALS WITH CONCENTRATIONS EXCEEDING STANDARDS SEASON 3
1	Upstream of Pota. Control Point, on Kanhan River (Right Bank)	W1	Washing Clothes, Domestic Use, Fishing	Magnesium	Manganese, Aluminium, Magnesium	Manganese, Aluminium
2	Between Silewada town & Khaparkheda TPS, on Kanhan River (Right Bank)	W2	Drinking, Domestic, Agriculture, Fishing, Swimming / Bathing	Magnesium	Aluminium, Magnesium	Manganese, Aluminium
3	After Khaparkheda TPS Discharge Point into River Kanhan (Right Bank), on Kanhan River	W3	Unspecified	Magnesium	Aluminium, Magnesium	No sample taken
4	Between Bhanegaon Mine and Pench -Kanhan confluence, on Kanhan River (Right Bank)	W4	Swimming	Magnesium	Aluminium, Magnesium	Manganese, Mercury, Aluminium
5	After Gondegaon Mine, Upstream of OCW Intake Point, on Kanhan River (Left Bank)	W5	Domestic, Agriculture, Cattle Drinking, Washing Clothes	Iron, Molybdenum, Fluoride, Lithium, Magnesium	Aluminium, Magnesium	Manganese, Aluminium
6	Upstream of Kolar-Kanhan Confluence, Opposite Water Intake Point of Kawatha WTP, on Kanhan River (Right Bank),	W6	Washing Clothes, Agriculture, Fishing	Magnesium	Aluminium, Magnesium	No sample taken
7	Downstream of Kolar-Kanhan Confluence, on Kanhan River (Left Bank)	W7	Clothes Washing, Agriculture, Fishing	Magnesium, Lithium	Magnesium	Manganese, Aluminium
8	Before Kamptee Cantonment Water Lifting Point, on Kanhan River (Left Bank)	W8	Agriculture	Magnesium	Magnesium, Lithium	No sample taken
9	Upstream of Khaparkheda Village, Control Point, on Kolar River (Right Bank)	W9	Washing Clothes	Magnesium	Aluminium, Magnesium	Aluminium, Magnesium
10	At Suradevi Village, 250 Meters Downstream from the Ash Discharge Point from Khaparkheda TPS—Kolar River (Right Bank)	W10	Unspecified	Magnesium	Magnesium	Mercury, Aluminium
11	New Khasala Village Water ATM | 1st Season: Water ATM Output Water, 2nd season: Wastewater, 3rd Season: Water ATM's Water Source	W 11		None	Not Applicable	Magnesium, Antimony, Lithium
12	Kawatha Village MJP WTP for Drinking Water | 1st & 2nd Season: Output Water, 3rd Season: Input water (comes from Kanhan River, Near Waregaon)	W12	Drinking & Domestic	Aluminium	Magnesium, Lithium	Manganese, Aluminium

13	Kawatha Village Water ATM | 1st Season: Water ATM Output Water, 2nd Season: Wastewater, 3rd Season: Water ATM's Water Source	W 13		None	Not Applicable	Mercury, Calcium, Magnesium, Lithium
14	Mhasala Toli Village, Borewell for Drinking & Domestic Water	W 14	Drinking & Domestic	Magnesium, Lithium	Molybdenum, Fluoride, Magnesium, Copper, Lithium	Mercury, Aluminium, Magnesium, Lithium
15	Khairi Village Water ATM | 1st Season: Water ATM Output Water, 2nd Season: Wastewater, 3rd Season: Water ATM's Water Source	W 15		None	Not Applicable	Calcium, Magnesium, Antimony, Lithium
16	Khairi Village, Dug well for Domestic Water Usage, 15 m Beside the Fly Ash Stream from Koradi Ash Pond (Left Bank)	W 16	Domestic, Agriculture	Magnesium, Lithium	Arsenic, Lead, Manganese, Mercury, Selenium, Magnesium, Lithium	Manganese, Selenium, Calcium, Magnesium, Lithium
17	Fly Ash Stream, Near Khairi Village	W 17	Cattle Drinking, Fishing, Agriculture, Bathing	Arsenic, Mercury, Molybdenum, Selenium, Lithium, Magnesium	Arsenic, Boron, Molybdenum, Aluminium, Fluoride, Lithium, Magnesium	Boron, Molybdenum, Selenium, Aluminium, Lithium, Magnesium
18	Treated Surface Water (pumped from Kolar River) and stored in Suradevi Village Sump House in Temple Premises	W 18	Domestic	Magnesium	Magnesium, Aluminium	Magnesium, Aluminium
19	Suradevi Water ATM | 1st Season: Water ATM Output Water, 2nd Season: Wastewater, 3rd Season: Water ATM's Water Source	W 19		None	Not Applicable	Calcium, Lithium
20	Waregaon Water ATM | 1st Season: Water ATM Output Water, 2nd Season: Wastewater, 3rd Season: Water ATM's Water Source	W 20		None	Not Applicable	No sample taken
21	Waregaon Village, Tap Water in Primary School, Water Coming from Dugwell in a nearby Field	W 21	Drinking (those who can't afford ATM water) & Domestic	Magnesium, Lithium	Magnesium, Lithium	Magnesium, Calcium, Lithium
22	Chicholi Village, Tap Water Coming from Dug well	W 22	Drinking & Domestic	Magnesium	Magnesium	Magnesium, Calcium
23	Pota-Chankapur Village MJP WTP | 1st & 2nd Season: Output Water, and 3rd Season: Input Water (Comes from Kanhan River at Rohana)	W 23	Drinking & Domestic	Aluminium, Magnesium	Aluminium, Magnesium	Aluminium
24	Bhanegaon Dug well 1 (In School)	W 24	Drinking & Domestic	No sample taken	Magnesium	No sample taken
25	Bhanegaon II Dug well 2	W 25	Drinking & Domestic	No sample taken	Magnesium	Magnesium

Many farmers reported their health or the health of the workers working on their farms was being impacted by fly ash. They faced problems like respiratory issues, throat infection, eye irritation and skin problems

AIR BORNE FLY ASH POLLUTION

Airborne fly ash, mainly dry ash that is being blown from ash ponds and also other sources like stack emissions and fugitive emissions from the plants is a huge menace in the entire area. Our team encountered this problem first-hand several times during our visits. At times, driving became difficult due to fly ash being blown in the air. The sarpanch of Khairi village told us that in summer (when the problem is very bad), the whole village is covered in fly ash. The sarpanch of New Khasala village told us that all the stream and wells have water contaminated with fly ash.

The impacts of airborne fly ash were chiefly assessed through a questionnaire-based survey carried out in 21 villages (see Figure 8 for the map showing locations of these villages).

FIGURE 8: MAP SHOWING LOCATIONS AND NAMES OF VILLAGES SURVEYED

This questionnaire-based survey showed that out of these 21 villages, 18 villages were affected due to fly ash depositing in various parts. This includes water bodies, houses, agricultural fields, open spaces and vehicles (see Figure 10).

14 villages—67% of the total—reported fly ash depositing on and contaminating water resources like wells (9 villages) and water tanks (7 villages)(see Figure 9, for example). At the same time, 14 villages reported that their agricultural lands were also impacted by fly ash. Some villages have no agricultural lands left and some have seen significant reduction in agricultural land due to acquisition by industry, including the power plants, or because of leasing to brick kilns, etc. We discovered this in several villages like Bhanegaon, Chicholi, New Khasala, Chankapur (Pota-Chankapur), and Waregaon during our preliminary visits and during the survey. Fly ash pollution has also led to a change in the land use pattern among the villagers. For example, in Kawatha village, farmers have abandoned farming activities due to fly ash pollution and leased their land to brick manufacturing units.

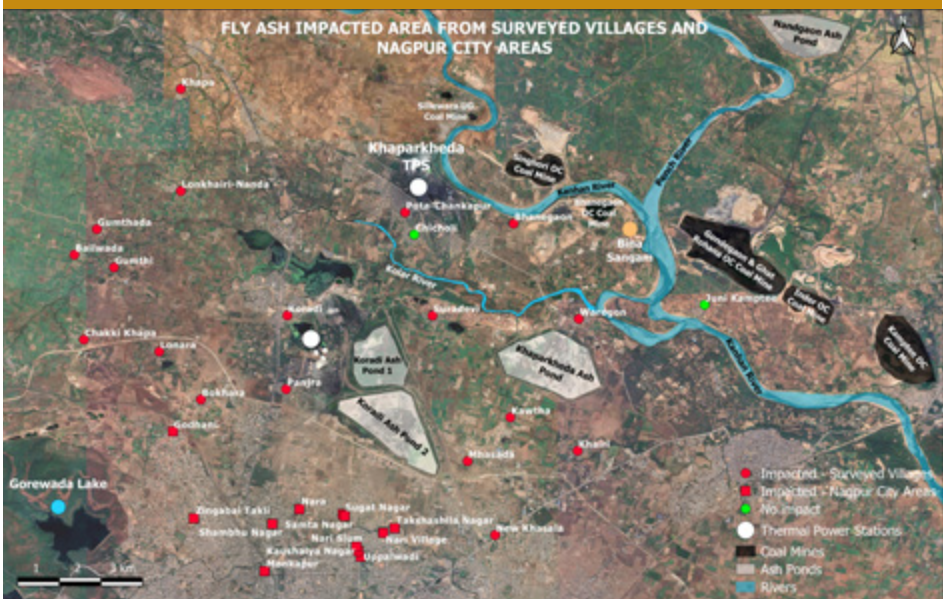
FIGURE 9: FLY ASH DEPOSITION ON WATER STORED IN A DRUM IN A HOUSE, IN VILLAGE WAREGOAN. YEAR 2021 | PHOTO: ATIM NEWARE, FOR CFSD

The fly ash menace has had serious impacts on the health of human beings as well as cattle.

A total of four villages reported health problems due to contamination of water, either due to fly ash settling in water or due to other forms of contamination. At the same time, 9 out 21 villages reported health problems which they attributed to air pollution due to fly ash. These problems included difficulty in breathing (9 villages), respiratory diseases like bronchitis and asthma (5 villages), frequent cough and cold, throat infection (4 villages) and irritation in the eyes and eye infections (7 villages).

Apart from these villages in the vicinity of the power plants, we also found that several areas on the outskirts of Nagpur city were also affected by fly ash deposits. Though we were not able to carry out detailed surveys there, our discussions revealed that the areas affected include Nari slum, Uppalwadi, Nara, Bhante Anand Kaushalya Nagar, Mankapur and Pagal Khana Square, Sugat Nagar, Samta Nagar, Takshshila Nagar, Zingabai Takali, Godhni and Shambhu Nagar. (See map at Figure 10)

FIGURE 10: MAP SHOWING AREAS IMPACTED BY FLY ASH FROM AMONG THE SURVEYED VILLAGES AND NAGPUR CITY AREAS



A questionnaire-based survey was also carried out among individual farmers in these villages to get an assessment of the impact of pollution on agriculture. The survey couldn't be done with multiple respondents in each village due to the covid situation. The survey covered 20 farmers from 19 villages. The discussions suggest that response of these farmers can be considered as indicative for their neighbouring farmers also.

Almost all the farmers in the survey responded that fly ash was depositing on their lands and crops, with 16 out of 20 reporting that their complete holdings (sizes ranging from 1.5 ha to 24 acres) were impacted, and 3 reporting that their holding were partially impacted (See Figure 11 and 12, for example). Ironically, the one person who said that fly ash was not being deposited in his field however said that it was being impacted by dust from the nearby mine, and water used for irrigation was being affected by the mine discharge.

FIGURE 11: FLY ASH DEPOSITION ON COTTON CROP OF A LOCAL FARMER. YEAR 2021 | PHOTO: ATIM NEWARE, FOR CFSD

FIGURE 12: A FARMER IN HIS FIELD IN VILLAGE NEW KHASALA WHERE FLY ASH HAS BEEN DEPOSITED EXTENSIVELY. YEAR 2021 | PHOTO: ATIM NEWARE, FOR CFSD

Almost all the farmers in the survey responded that fly ash was depositing on their lands and crops

From these surveyed farmers, 17 also reported that the fly ash was impacting the growth of their crops, 8 of them reported fall in yields and 8 reported that the fertility of their soil was being adversely impacted. Two farmers said that though ash was being deposited on their farms, they did not notice any adverse impacts on the crops.

Equally serious was the fact that many farmers reported their health or the health of the workers working on their farms was being impacted by this fly ash. They faced problems like respiratory issues (5), throat infection (5), eye irritation (5) and skin problems (1).

Ten farmers reported that the milk production from their cattle had reduced, while eight reported that the health of their livestock was being adversely affected.

health impacts of the pollution

As has been clarified earlier, the health survey planned with the help of professional health and medical workers could not be done due to the Covid-19 situation. But the questionnaire surveys and other discussions with local communities revealed wide-spread and serious health impacts on human beings and cattle due to water and air pollution. Some instances have been mentioned above.

People are more easily able to relate health impacts of air pollution to the airborne fly ash as the relation is often directly perceived. It is more difficult to relate health impacts to water pollution. That is why the questionnaire survey has 9 out of 21 villages reporting health problems that they attributed to air pollution due to fly ash, including difficulty in breathing, respiratory problems, irritation in eyes, etc. On the other hand, four villages reported health problems due to contamination of water.

Some villages reported health problems during discussions, but did not relate it to the water pollution. For example, in New Khasala village our team was informed that many of the residents have ailments related to heart, liver, and kidney. Asthma is the most common issue faced by the people here. Another problem reported by residents here was the mal-development of teeth—the teeth were not growing fully and remaining restricted in size.

It may be noted that the groundwater was found to have high levels of magnesium, lithium and antimony, and the sarpanch has reported that fly ash is contaminating almost every water source in the village.

We have already mentioned the skeletal and bone weakening problems suffered by people in Khairi village. Since they were not aware of the contaminants in their water source, they are not able to see a possible link to the high fluoride levels in the water. The residents of Bhanegaon village are also reporting health issues like pneumonia and bone related llness among the cattle. Similarly, people from Kawatha and Waregaon complained of series of problems in cattle like pneumonia, bones problem, weakening of bones, knots on skin, and bent legs.

ON THE BASIS OF THE INPUTS SHARED BY THE LOCAL PEOPLE, IT IS CERTAIN THAT THE SPREAD AND PREVALENCE OF HEALTH IMPACTS RELATED TO THE POLLUTION IS LIKELY TO BE MUCH HIGHER THAN WHAT IS SEEN ON THE FACE OF IT

FIGURE 13: FARMER FROM VILLAGE NEW KHASALA SHOWING SKIN AILMENT. YEAR 2021 | PHOTO: ATIM NEWARE, FOR CFSD

Experiences from other parts of India will be important to help us assess the health impact issue here.

For example, studies (Narayan , 2017) (Rinchin, Chatterjee, Ganguli, & Jana, 2017) done by a team of medical and environmental professionals who have worked in partnership with People First Collective, India and Adivasi Dalit Mazdoor Sangathan in Raigarh district of Chhatisgarh used a *"house-to-house survey documenting self-reported health complaints... follow up medical examinations undertaken by a team of qualified and experienced medical doctors... (and) sampling of air, water, soil, fly ash and sediment pollutants"* (Rinchin, Chatterjee, Ganguli, & Jana, 2017, p. vi) to understand the pollution and its health impacts in this region caused by coal mines, washery and power plants. This study examined self-reported complaints like *"hair loss—and brittle hair—musculoskeletal joint pain, body ache and backache, dry, itchy and/or discoloured skin and cracked sole and dry cough"* and found that *"exposure to dangerous levels of toxic substances including heavy metals found in air, water, soil and sediment samples are likely to be connected to poor human health experienced by residents..."* (Rinchin, Chatterjee, Ganguli, & Jana, 2017, p. viii).

Similarly, a general warning by the Physicians for Social Responsibility (the US Affiliate of the International Physicians for the Prevention of Nuclear War, which was the recipient of the 1985 Nobel Peace Prize) states (Physicians for Social Responsibility, n.d.):

"...coal ash typically contains heavy metals including arsenic, lead, mercury, cadmium, chromium and selenium, as well as aluminium, antimony, barium, beryllium, boron, chlorine, cobalt, manganese, molybdenum, nickel, thallium, vanadium, and zinc. If eaten, drunk or inhaled, these toxicants can cause cancer and nervous system impacts such as cognitive deficits, developmental delays and behavioural problems. They can also cause heart damage, lung disease, respiratory distress, kidney disease, reproductive problems, gastrointestinal illness, birth defects, and impaired bone growth in children."

Given these experiences in India and other parts of the world, and looking at the extent of pollution, the large number of contaminants detected, and on the basis of the inputs shared by the local people, we feel certain that the spread and prevalence of health impacts related to the pollution is likely to be much higher than what is seen on the face of it.

thermal power plants responsible for pollution

THE FLY ASH FROM THE TWO POWER PLANTS ALSO CONTAINS MANY HEAVY METALS. THUS, WHILE AIRBORNE FLY ASH IS A POLLUTANT AS A "PARTICULATE MATTER" IT IS ALSO A POLLUTANT OF CONCERN DUE TO THE PRESENCE OF HEAVY METALS. THESE HEAVY METALS CAN CAUSE SERIOUS PROBLEMS FOR HUMAN HEALTH

There is little doubt that this pollution is mainly and overwhelmingly due to the two thermal power plants and their ash ponds. The pollutants we have documented—air borne fly ash as well as pollutants in water are typical of pollution likely from thermal power plants.

The Technical EIA Guidance Manual for Thermal Power Plants (IL&FS Ecosmart Ltd., 2010, pp. 3-22) published by the Ministry of Environment and Forests states that:

"The constituents of wastewater [from thermal power plants] are wide and include: Temperature, pH, TOC, Colour, TDS, BOD, COD, N (total), Mineral oils, Free chlorine, NH3, Fish, toxicity, Sb, PAH Metals (Co, Mn, Tl, V, Sn, Cd, Cr, Ni, Cu, Hg, Pb, Zn, etc.) CN, S, SO3, SO4, EOX, Phenol, PCDD/PCDF, P (total) TSS, Cl-, FAs, BTEX etc...Because of their physical, chemical and biological characteristics, release of such compounds may have a high impact on the aquatic environment. These substances can impart significant toxicity to the receiving water. For instance, water from slag flush and ash transport has an alkaline character due to the composition of the ash..."

Interestingly, a large number of water samples we tested were high in alkalinity.

The US EPA notes, in its *"Technical Development Document for the Proposed Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category"* that (U.S.–EPA, 2013b, pp. 6–12):

"fly ash transport water contains significant concentration of metals, including arsenic, calcium, and titanium. Some metals are primarily present in the dissolved phase, such as boron, molybdenum, and selenium..."

A table along with this lists many other elements that are likely to be present in the fly ash water.

The elements we have found to be present in high concentrations in our testing are all listed in these key technical documents as likely pollutants from thermal power plants.

The elements we have found to be present in high concentrations in our testing are all listed in these key technical documents as likely pollutants from thermal power plants

As mentioned earlier we had first-hand experience of seeing fly ash being blown in large dust clouds, have had many similar reports from local people and have recorded the airborne fly ash depositing widely on houses, lands, crops, etc. (see Figure 14 for example). Similarly, we personally observed at least 5 places where effluent discharges, including fly ash, from either the Koradi or Khaparkheda power plant or their ash ponds were being released directly into a river or stream, and at least one place where it was reported to us and we found fly ash on the riverbed (See Figure 15, and 16 for example). This has resulted in the waters being highly contaminated from fly ash and other pollutants discharged by the power plants. We have been able to cover only parts of the area but it is very likely that there are other such discharges. We also recorded discharges directly into the Kanhan river from mines at two places.

FIGURE 14: DRIED SECTION OF KHAPARKHEDA ASH POND AND ASH BEING BLOWN BY THE WIND. YEAR 2019 | PHOTO: SEHR RAHEJA/MANTHAN ADHYAYAN KENDRA

FIGURE 15: PHOTO SHOWING FLY ASH LADEN WATER BEING DISCHARGED INTO A CHANNEL FROM THE KHAPARKHEDA ASH POND. THIS CHANNEL IS UNLINED AND WATER WILL SEEP INTO GROUND WATER FROM THIS CHANNEL AND ALSO POSSIBLY CONTAMINATE OTHER SURFACE WATER BODIES | PHOTO: SHRIPAD DHARMADHIKARY/MANTHAN ADHYAYAN KENDRA | YEAR 2021

More importantly, the fly ash from the two power plants also contains many heavy metals. Thus, while airborne fly ash is a pollutant as a "particulate matter" it is also a pollutant of concern due to the presence of heavy metals. These heavy metals can cause serious problems for human health, when the particles are inhaled, as well as due to the metals leaching out from the ash into surface and ground water where ash comes in contact with water.

The US-EPA in its report *Human and Ecological Risk Assessment of Coal Combustion Residuals* (CCRs, which is mainly fly ash) (U.S–EPA, 2014, pp. ES-3 and 2–3, 2–4) notes some important pathways of how these "pollutants of concern" in combustion residues (fly ash) can impact human and ecological receptors, and identifies *"potential risks to human and ecological receptors resulting from the releases of particulate matter and the chemical constituents contained therein through wind and run-off. Under an uncontrolled management scenario, risks to human receptors resulted from the inhalation of windblown particulates in ambient air..."* and *"Chemical constituents can be released from surface impoundments [fly ash ponds] through the leaching of soluble constituents into the water that comes in contact with the CCRs and percolation of the resulting leachate into the subsurface soil and ground water. Constituents can then be transported underground through the ground water (GW) to downgradient drinking water (DW) wells (GW_DW pathway), where residents may be exposed through ingestion of contaminated drinking water, as well as dermal contact with and inhalation of constituents through bathing and showering in that water. Contaminated ground water may also discharge to surface water (SW)... The CCR solids, along with any constituents contained within them, may also be released aboveground from operating impoundments through particulate matter disturbed by wind or runoff..."*

FIGURE 16 : FLY ASH LADEN WATER BEING DISCHARGED FROM WAREGAON ASH DAM INTO LOCAL WATER BODY | YEAR 2021 | PHOTO: ATIM NEWARE, FOR CFSD

All these pathways are clearly seen in the case of the Koradi and Khaparkheda power plants and their ash ponds.

As a part of our assessment, we carried out sampling and testing of fly ash collected from five locations—the ash pond of Koradi TPS, ash pond of Khaparkheda TPS, ash from the ESP of Khaparkheda TPS, and ash that was being deposited on two houses in Chankapur. These samples show the presence of many metals like arsenic, cadmium, chromium, lead, manganese, mercury, selenium, cobalt, copper, nickel, zinc, fluoride as well as oil and grease.

Several of these metals are present in quite high quantities in the fly ash as compared to other places.

For example, *The Technical EIA Guidance Manual for Thermal Power Plants* by MoEF states that (IL&FS Ecosmart Ltd., 2010, p. 160 (pdf)):

"Upon combustion, coal flyash tends to have a higher concentration of mercury, and estimates indicate that Indian coal ash has an average mercury concentration of 0.53 mg/kg, based on measurements from a few selected power plants."

Compared to this, fly ash tested by us had mercury content ranging from a minimum of 0.53 mg/kg to a maximum of 1.72 mg/kg.

In another instance, we compared the concentrations of select toxic metals found in fly ash from Koradi/Khaparkheda TPSs with concentrations in the fly ash of SembCorp Gayatri Power Ltd., Nellore of 2018 which we had obtained under RTI for some other analysis[11]. Comparisons were also made with results of fly ash testing carried out by Community Environmental Monitoring and Dalit Adivasi Mazdoor Sangathan power plants in Tamnar Block, Raigarh district of Chhatisgarh (Narayan, 2017, p. 15) in 2017. The comparison is given below in Table 4. The SembCorp fly ash test analysis has been submitted by the power plant.

TABLE 4: COMPARISON OF CONCENTRATIONS OF SELECT TOXIC METALS IN FLY ASH FROM VARIOUS THERMAL POWER PLANTS

	UNITS	SEMBCORP GAYATRI TPS	TAMNAR, RAIGARGH DIST SAMPLES		KORADI/KHAPARKHEDA TPS TESTING RESULTS	
			SAMPLE 1: REGAON	SAMPLE 2: KOSAMPALI	MINIMUM	MAXIMUM
ARSENIC	PPM (MG/KG)	<0.5	20.56	BDL	3.18	9.44
MERCURY	PPM (MG/KG)	<0.5			0.53	1.72
CHROMIUM	PPM (MG/KG)	<0.5	172	186.9	0.47	120.34
LEAD	PPM (MG/KG)	<0.5	54.6	90.84	4.52	56.00

It is thus evident that the fly ash of the Koradi-Khaparkheda plants has high concentrations of heavy metals. The levels of heavy metals found in the fly ash indicate a serious health risk for those exposed to the fly ash through the airborne route, by inhalation and ingestion of the airborne particles or by drinking the water in which these particles have settled on. The metal constituents of the fly ash are also partly responsible for the pollutants found in the water testing results.

Effluent from thermal power plants include many other components apart from fly ash and fly ash water—for example, cooling tower blow down, metal cleaning wastewater, floor and yard drains and sumps and so on. Contaminants from these components can also lead to pollution apart from constituents of fly ash. Of course, none of this is supposed to be discharged into the water bodies, but it is happening extensively in the area as per our assessment.

One important point to be noted about the sources of pollution is that our tests show many locations where manganese is found in high concentrations. One possible source could be the manganese mine located close to Kanhan River upstream of the Khaparkheda TPS.

However, given the high concentrations of manganese found in the fly ash samples, and in some samples from locations far away from the Kanhan river that also tested high for manganese, it is clear that fly ash is also an important reason for the high manganese levels at many places.

Looking at the high levels of heavy metals in fly ash in the Koradi and Khaparkheda power plants, and the consequent serious pollution issue, we would like to reiterate a recommendation made by *The Technical EIA Guidance Manual for Thermal Power Plants* (IL&FS Ecosmart Ltd., 2010, pp. 3-26), which has evidently not been followed. We urge that it be implemented immediately. The recommendation is:

"Fly ash generated is typically not classified as a hazardous waste due to its inert nature. However, it may be enriched with metals being constituents of concern ... as a result ash residues and the dust removed from exhaust gases may contain significant levels of heavy metals and some organic compounds... Therefore, where ash residues are expected to have potentially significant levels of heavy metals or other potentially hazardous materials, they are required to be tested at the start of plant operations to verify their classification as hazardous or non-hazardous according to National Hazardous Waste rules."

failure of monitoring & regulatory agencies

THE MAJOR AND DIRECT RESPONSIBILITY OF THIS POLLUTION LIES WITH THE TWO POWER PLANTS AND THEIR OWNER/OPERATOR MAHAGENCO, THE PERSISTENCE OF THIS POLLUTION ALSO SHOWS A COMPLETE FAILURE OF THE MONITORING AND REGULATORY AGENCIES, INCLUDING THE STATE AND CENTRAL POLLUTION CONTROL BOARDS, THE MINISTRY OF ENVIRONMENT, FORESTS AND CLIMATE CHANGE, THE STATE GOVERNMENT, THE DISTRICT AUTHORITIES AND OTHERS

The two thermal power plants have been operational since early 1980s. Their functioning has been marred by a long history of rampant pollution in the region, be it air, water or land pollution. This has been documented earlier in this report.

Throughout the years, the status of pollution in the area has not changed, and as our report has documented, remains extremely serious.

While the major and direct responsibility of this pollution lies with the two power plants and their owner/operator MAHAGENCO, the persistence of this pollution also shows a complete failure of the monitoring and regulatory agencies, including the State and Central Pollution Control Boards, the Ministry of Environment, Forests and Climate Change, the state government, the district authorities and others.

These agencies have failed to take proper cognisance of the serious pollution and violations of environmental norms by the power plants, and even when cognisance is taken, have failed to enforce any meaningful action, often turning a blind eye to these violations. By their acts of commission and omissions, these agencies are equally responsible for the situation.

What is most worrying is the complete indifference that the agencies have shown to local people and their petitions.

A cursory look at just some of the instances of (in)action by the agencies highlight this apathy.

KHAPARKHEDA TPS OPERATING WITHOUT CONSENT UNDER WATER & AIR ACT

We have already noted earlier in this report that the Consent Appraisal Committee (CAC) of MPCB in its 14th meeting held on 2nd February 2016 (MPCB, 2016) had found non-compliance of consent conditions by the Khaparkheda thermal power station and also noted that a Joint Visit Sampling (JVS) analysis report showed pollutants in air and water are exceeding the limits. In spite of that, the CAC still went ahead and renewed the Consent permission for the power plant, after a forfeiture of a mere Rs. 42.5 lakhs of bank guarantee. This is a paltry amount for such a large power plant and as can be expected, did not result in any meaningful check on the pollution.

This entire approach of the plant and MPCB authorities, particularly their behaviour towards the elected representatives is completely against the basic democratic norms of transparency and participation

The fact that this paltry fine did not deter the Khaparkheda TPS is clear from the fact that though the Consent has been renewed only till 31.08.2016, the plant still kept on operating for at least two and half years without the legally binding Consent under Air and Water Act, as was noted during an inspection by the Regional Office of the MoEF&CC on 30 January 2019 (MoEF&CC, 2019, p. 7).

How did the MPCB and MoEF&CC allow the plant to keep working without a Consent letter? This is clearly a signal to the plant that no action would be taken even if it continued to pollute and grossly violate laws and binding conditions.

VIOLATION OF EC CONDITION TO INSTALL FGD AT KORADI

Similar is the case of how the Koradi TPS has been able to evade the installation of a Flue Gas Desulphurisation (FGD) unit for last 10 years or so. The MoEF&CC had granted clearance on 4 January 2010 to the 3x660 MW (Units 8,9,10) expansion of Koradi TPS and had put a condition to install FGD for one unit. This condition was based on the recommendation of the EAC to first install FGD for one unit and then for the other two if necessary, after monitoring the SO2 levels (EAC, 2019a, p. 6).

MAHAGENCO, instead of attempting to fulfil this condition, came back to the EAC on 2012 asking for waiver of this condition. EAC in its meeting of August 2012 noted categorically that *"the justification provided by the project proponent is only valid from its commercial interest and does not hold merit when it comes to public health interest"* and refused to allow waiver as "the decision to stipulate FGD for initially one unit was taken consciously keeping Nagpur air quality in mind." Again, MAHAGENCO came back to EAC in 2016 and EAC rejected it in its meeting of 27 July 2016. By then, the units had already been commissioned. Finally, the EAC in its meeting of 28 December 2016 agreed to give more time (EAC, 2019A, p. 6). Even today, the FGD has not been installed at Koradi TPS (CEA, 2021). This is in spite of several reports of MoEF&CC as well as the Consent Committee of the MPCB themselves observing the high air pollution levels around the Koradi and Khaparkheda plants (MoEF&CC, 2019, p. 7) (EAC, 2019b, p. 52) (MPCB, 2016).

Instead of taking action on this, the MoEF&CC has issued ToRs to Koradi taking further the process of installing new units and expanding the plant capacity.

VIOLATION OF FLY ASH UTILISATION REQUIREMENTS

The Fly Ash Notification 1999 along with its modification legally mandates that all the power plants must achieve 100% utilisation of ash by the end of the fourth year after commissioning. This means that both Koradi and Khaparkheda need to fully utilise the fly ash they produce. Yet, both the plants are grossly violating this norm since years. In 2019–20, Koradi TPS utilised only 42% of the ash generated, and Khaparkheda TPS utilised only 56%[12] (CEA, 2020b, p. 39). In spite of this, none of the agencies including MoEF&CC or MPCB have taken any action. If this law was diligently followed, it would significantly limit the fly ash pollution from the two plants. Of course, the MPCB and MoEF&CC may have their explanations on not taking action, but these are excuses at best. Ultimately, results matter and it is the duty of these agencies to ensure that pollution does not take place. Under the circumstances, there is no greater evidence of the failure and abdication of this duty by these agencies than the very fact that pollution is persisting and at serious levels, affecting the health of the people.

INDIFFERENCE TO LOCAL PEOPLE

During our pre and post survey field visits, meetings and discussions with the sarpanchs, we were told that several requests and complaints, both oral and in writing, had been made by the sarpanchs of several villages to the MAHAGENCO authorities about taking measures to reduce the pollution caused due to the operations of the two thermal power stations. But the repeated requests were of no avail.

For example, the sarpanch of Khairi village told us that he has written 6 letters to the MAHAGENCO authorities about water, air and land pollution caused due to the fly ash discharge from the Khasala ash bund and fugitive emissions from Khaparkheda ash bund. But there has not even been a response from the MAHAGENCO/MPCB, let alone any action.

In Suradevi village, the upa-sarpanch informed us that several requests had been made to the Khaparkheda plant authorities to stop the discharge of fly ash effluent and sewage effluent from the thermal power station and the plant's colony into the Kolar River as the village picks up water from this river to be used for domestic purposes. But there was no response from the plant authorities. Pollutant discharge has not stopped either (see Figure 17).

The sarpanch of Mhasala village told us that there were many issues to be discussed and resolved with the power plant authorities, including pollution. But the officers concerned were not giving them an appointment to meet. Since March 2020, the Covid-19 situation is also being used as an excuse for the denial of appointments.

One of the most important issues raised by several sarpanchs in the area was the lack of transparency by the power plants. In several villages, MAHAGENCO has installed devices to monitor air quality. The installation and collecting the readings of the devices has been handed over to some private agency. The agencies send their own persons to operate them and check the readings every week or two, but the data and readings are not being shared with the local people. This

FIGURE 17: KOLAR RIVER AT SURADEVI VILLAGE. ASH FROM THE KHAPARKHEDA TPS DEPOSITED ON THE RIVER BED CAN BE SEEN IN THE PICTURE ON THE RIVER BANK. YEAR 2021 | PHOTO: ASHISH SINHA/ MANTHAN ADHYAYAN KENDRA

despite some sarpanchs specifically asking for the data. We personally observed these devices at the gram panchayat buildings of villages Kawatha, Mhasala and Khairi, and at New Khalasa it was kept locked. Moreover, we were informed that there are devices for continuous monitoring of emissions in the power plant, but the readings were not made available to the local people. This entire approach of the plant and MPCB authorities, particularly their behaviour towards the elected representatives is completely against the basic democratic norms of transparency and participation. It also betrays their audacity that comes from the belief that they cannot be held accountable. This has to be fundamentally changed for the problem of pollution to be effectively addressed.

conclusions & recommendations

MAHAGENCO MUST TAKE IMMEDIATE STEPS TO STOP ALL POLLUTION, ESPECIALLY THE DISCHARGE OF FLY ASH IN LOCAL WATER BODIES....MPCB AND MOEF&CC MUST IMMEDIATELY PUT IN PLACE A MECHANISM TO MONITOR THIS

CONCLUSIONS

The findings from our assessment are very stark. The Koradi and Khaparkheda power plants and their associated infrastructure are causing massive pollution in the area. This pollution has been going on for more than a decade, and had been documented by media reports, Non Governmental Organisations (NGOs), and even official agencies. Local people have been raising the issue for years, with no avail.

Little action has been taken, and whatever has been taken was ineffective in controlling the pollution.

Our assessment report brings a fresh, systematic documentation of the pollution, including water pollution based on testing of water sample, as well as extensive surveys. It establishes beyond doubt the seriousness of the pollution and documents the impact of the pollution on the health of people, on their livelihoods and on cattle and the ecology.

It also clearly establishes the fact this pollution is entirely preventable if the laws and regulations were duly followed. Thus, the persistence of pollution highlights the complete failure of MAHAGENCO as well as the monitoring and regulatory agencies in controlling the pollution, and their indifference to the local communities. Their functioning is clearly non-transparent and undemocratic.

It highlights how local people have tried to repeatedly raise the issue but their efforts have been stonewalled.

Based on our assessment, we would like to suggest a series of recommendations to address the issues.

RECOMMENDATIONS

#01

MAHAGENCO must take immediate steps to stop all pollution, especially the discharge of fly ash in local water bodies, and the dispersal of dry fly ash as dust and particles. A timeline must be prepared for this, and should include measures that can be taken right away (like stopping fly ash discharges into local streams) and those that may take some time (for example, those which may involve installation of some equipment). These measures should be undertaken on an emergency basis, and bureaucratic procedures should not be allowed to delay these. We suggest that all the measures should be fully implemented in four months, with the most urgent measures in two months.

#02

MPCB and MoEF&CC must immediately put in place a mechanism to monitor this plan and timeline and ensure that MAHAGENCO implements the measures to bring pollution under control as per this plan. They should not hesitate to take strict and quick action, including suspending the operation of the power plant in case pollution persists. However, it should be ensured that in case of such suspension of plant operation, the livelihoods of all the employees, including permanent, temporary, contract and daily wage employees must be protected.

#03

MAHAGENCO must make the set of measures and the timeline public. MPCB and MoEF&CC should also make public their steps to ensure regulation and implementation of the plan.

#04

A committee of key representatives/ sarpanchs of the villages in the vicinity, along with representatives of civil society groups and independent experts should be set up to monitor the progress from the local people's point of view. This committee would give suggestions to MAHAGENCO, would carry out public inspections/fact findings of key pollution hot spots, keep tabs on pollution in the villages etc. This committee would play a key role in monitoring the implementation of the plan described in Point 1 above. This committee should be constituted as a formal, legally recognised committee and should have a decisive role in making suggestions and in monitoring the implementation of the plan.

#05

A formal structure of regular interaction between this committee, MAHAGENCO and MPCB should be established. This should ensure regular, in depth and meaningful liaison between the three.

#06

The expenses for this committee, including support for their travel in the area to monitor pollution hot spots should be met by MAHAGENCO. However, MAHAGENCO should not directly pay for these expenses as this could lead to conflict of interest. A mechanism by which MAHAGENCO pays these funds to some independent authority—(DM, ZP etc.) and which in turn pays the committee can be set up.

#07

The money which MAHAGENCO spends on this committee, as well as any other measures to control, mitigate and compensate for pollution should not be treated as CSR expense. MAHAGENCO is supposed to control the pollution through its regular spending and control of pollution is a part of the cost of generating power. Hence, it should be accounted for in MAHAGENCO's regular expenses.

#08

Measures like provision of water ATM etc., are important in the immediate run to address the pollution problem and provide clean water, but these are neither feasible nor appropriate as solutions in the long run. They don't provide clean water for all needs including for cattle, and have their own issues as already pointed out in the report. Hence, water ATMs and WTPs should not be seen as an excuse or justification to play down the seriousness of the water pollution and should not be used as an excuse to allow continuation of water pollution. Ensuring that all water from all sources becomes and remains unpolluted should be the main objective.

#09

Apart from ensuring that pollution is stopped immediately, MAHAGENCO should also ensure clean-up of places already polluted. A comprehensive plan for this must be worked out by MAHAGENCO with the involvement of local communities, NGOs and independent experts. The clean-up process must also include compensation for and mitigation and a melioration of damage already caused to the environment and the health of human beings and cattle.

#10

Both, the immediate control and stoppage of pollution, as well as the clean-up are legally binding responsibilities of MAHAGENCO, and the MPCB and MoEFCC should ensure that they are recognised and implemented as such.

#11

MAHAGENCO must ensure that all the units of Koradi and Khaparkheda TPS follow the legally binding requirements of pollutions control, including the 2015 norms for SO2, PM, NOx and Mercury emissions, water consumption limits. It should also ensure the installation of necessary equipment like FGD, ESP etc. without any delay.

#12

In particular, both Koradi and Khaparkheda TPS should ensure strict implementation of the legally binding 100% utilisation of fly ash as this is one of the most important causes of pollution in the area.

#13

As our analysis of fly ash from both Koradi and Khaparkheda show high concentrations of toxic metals, a comprehensive examination to assess whether the ash needs to be classified as hazardous waste, as suggested by MoEF's *Technical EIA Guidance Manual for Thermal Power Plants*, should be carried out.

#14

Until the issue of pollution is fully addressed and clean air, water and soil/land is ensured, there should be no further addition to the pollution load. This means that the process of installation of new units at Koradi should be put on hold and the new ash pond at Nandgaon should not start operation.

#15

With 100% utilisation of ash at Khaparkheda, the Nandgoan ash pond may not be needed. Achieving this should be a priority objective. In any case, issues of Nandgaon ash pond not undertaking basic environmental precautions like HDPE lining and pitching should be immediately addressed.

#16

One of the most important things which is basic or fundamental to addressing the pollution issues is to build trust between MAHAGENCO/MPCB/MoEFCC and the communities,and to have good communication between them. Towards this, addressing all the grievances and not just those related to pollution, is necessary. In fact, pollution related issues needs to be addressed in the larger context of addressing all the issues of the community. Among those issues which people mentioned to us during our discussion as priority issues are creating job opportunities, skill based training for particularly for women since they have lost their fields and livelihood opportunity, payment of proper tax to local Panchayati Raj bodies, issues of pending rehabilitation, use of CSR funds to benefit the villages, etc. Therefore, we recommend that—even though not directly a part of the pollution issue—MAHAGENCO and other agencies should meaningfully engage with the communities to address the other issues too.

annexure A: compilation of potential impacts of exposure to metals on human & animal health

The information in this compilation is drawn mainly from the Toxicological Profiles published by the Agency for Toxic Substances and Disease Registry (ATSDR) of the U.S. Department of Health and Human Services, a federal public health agency of the USA.

As the ATSDR website explains, "Toxicological Profiles (Tox Profiles) are a unique compilation of toxicological information on a given hazardous substance. Each peer-reviewed Tox Profile reflects a comprehensive and extensive evaluation, summary, and interpretation of available toxicological and epidemiological information on a substance." (ATSDR, n.d.)

Some of the information in this compilation is also taken from other sources as cited.

#1

ALUMINIUM

HUMANS

"Human exposure to high concentrations has been linked to Alzheimer's Disease." (U.S.–EPA, 2013A, pp. 3-4) "Brain and bone disease caused by high levels of aluminum in the body have been seen in children with kidney disease. Bone disease has also been seen in children taking some medicines containing aluminum." (ATSDR, 2008, p. 6)

"Most aluminum in food, water, and medicines leaves your body quickly in the feces. Much of the small amount of aluminum that does enter the bloodstream will quickly leave your body in the urine." (ATSDR, 2008, p. 4)

ANIMALS

"Aluminum contamination can lead to the inability of fish to maintain the balance of their fluids and is associated with damage to amphibian eggs and larvae, mostly in areas under acid stress." (U.S. - EPA, 2013a, pp. 3-4)

#2

ANTIMONY

HUMANS

"Adverse health effects have also been observed in humans and animals following inhalation, oral, or dermal exposure to antimony and antimony compounds." (ATSDR, 2019, p. 2)

"Myocardial effects and EKG alterations are a suspected health effect for humans. Gastrointestinal effects are a presumed health effect for humans. Developmental effects are a suspected health effect for humans. Alterations in blood glucose levels are a suspected health effect for humans." (ATSDR, 2019, p. 2)

ANIMALS

"Other health effects that have been observed in animals orally exposed to higher doses of antimony include hepatocellular vacuolization (NTP 1992), hematological alterations including decreases in red blood cell counts (Poon et al. 1998) and hemoglobin levels (Sunagawa 1981), and histological alterations in the thyroid (Poon et al. 1998)." (ATSDR, 2019, p. 2)

#3

ARSENIC

HUMANS

Arsenic "is associated with an increased risk of cancer in humans in the liver and bladder." (U.S.–EPA, 2013A, pp. 3–4) "Swallowing arsenic has also been reported to increase the risk of cancer in the liver, bladder, and lungs. The Department of Health and Human Services (DHHS) has determined that inorganic arsenic is known to be a human carcinogen (a chemical that causes cancer)." (U.S.–EPA, 2013A, pp. 3–4)

ANIMALS

"Arsenic contamination causes poisoning of the liver, developmental abnormalities, behavioral impairments, metabolic failure, reduced growth, and appetite loss in fish". (U.S.–EPA, 2013A, pp. 3–4)

#4

BORON

HUMANS

"Exposure to large amounts of boron (about 30 g of boric acid) over short periods of time can affect the stomach, intestines, liver, kidney, and brain and can eventually lead to death." (ATSDR, 2010, p. 5)

"Epidemiology studies of intermediate—to chronic—duration exposures (involving repeated occupational exposure to dusts of borates or repeated exposure to boron in drinking water) have not clearly identified a toxic effect in humans, but have found no associations between boron exposure and impaired pulmonary function or impaired fertility". (ATSDR, 2010, p. 105)

ANIMALS

"Oral exposure animal studies have clearly identified the reproductive system and developing fetus as the most sensitive targets of boron toxicity." (ATSDR, 2010, p. 11)

"Low birth weights, birth defects, and developmental delays have occurred in newborn animals whose mothers were orally exposed to high doses of boron (as boric acid)." (ATSDR, 2010, p. 5)

"Studies of dogs, rats, and mice indicate that the male reproductive organs, especially the testes, are affected if large amounts of boron are ingested for short or long periods of time." (ATSDR, 2010, p. 5)

#5

CADMIUM

HUMANS

"Human exposure to high concentrations can lead to kidney, liver, and lung failure." (U.S.–EPA, 2013A, pp. 3–4)

"Eating food or drinking water with very high cadmium levels severely irritates the stomach, leading to vomiting and diarrhea, and sometimes death. Eating lower levels of cadmium over a long period of time can lead to a build-up of cadmium in the kidneys. If the build-up of cadmium is high enough, it will damage the kidneys. Exposure to lower levels of cadmium for a long time can also cause bones to become fragile and break easily" (ATSDR, 2012C, p. 5)

"The U.S. Department of Health and Human Services (DHHS) has determined that cadmium and cadmium compounds are known human carcinogens." (ATSDR, 2012C, p. 5)

ANIMALS

"Cadmium contamination can lead to developmental impairments in wildlife and skeletal malformations in fish." (U.S.–EPA, 2013A, pp. 3–4)

#6

CHROMIUM

HUMANS

"Human exposure to high concentrations can cause gastro-intestinal bleeding and lung problems." (U.S.–EPA, 2013A, pp. 3–4) "The International Agency for Research on Cancer (IARC) has determined that chromium(VI) compounds are carcinogenic to humans. In workers, inhalation of chromium(VI) has been shown to cause lung cancer. Mixed results have been found in studies of populations living in areas with high levels of chromium(VI) in the drinking water." (ATSDR, 2012D, p. 4)

ANIMALS

"In laboratory animals, chromium(VI) compounds have been shown to cause tumors to the stomach, intestinal tract, and lung". (ATSDR, 2012d, p. 4) "Sperm damage and damage to the male reproductive system have also been seen in laboratory animals exposed to chromium(VI)." (ATSDR, 2012d, p. 4)

"Chromium(III) compounds are much less toxic and do not appear to cause these problems." (ATSDR, 2012d, p. 4) "Chromium is not known to bioaccumulate in fish; however, high concentrations of chromium can lead to gill damage, reduced growth, and altered metabolism in fish." (U.S. - EPA, 2013a, pp. 3-4)

#7

COPPER

HUMANS

"Ingesting high levels of copper can cause nausea, vomiting, and diarrhea. Very high doses of copper can cause damage to your liver and kidneys, and can even cause death." (ATSDR, 2004A) "If you drink water that contains higher than normal levels of copper, you may experience nausea, vomiting, stomach cramps, or diarrhea. We do not know if copper can cause cancer in humans." (ATSDR, 2004B, p. 7)

ANIMALS

"Copper contamination can lead to reproductive failure, gill damage, and reduced sense of smell in fish." (U.S.–EPA, 2013A, pp. 3–4)

#8

FLUORIDE

HUMANS

"Skeletal fluorosis can be caused by eating, drinking, or breathing very large amounts of fluorides. This disease only occurs after long-term exposures and can cause denser bones, joint pain, and a limited range of joint movement. In the most severe cases, the spine is completely rigid." (ATSDR, 2003b, p. 7)

"Drinking or eating excessive fluoride during the time teeth are being formed can cause visible changes in teeth. The condition is called dental fluorosis. The changes increase in severity with increasing levels of fluoride." (ATSDR, 2003b, p. 9)

"Fluoride can cross the placenta from the mother's blood to the developing fetus. Only a very small portion of fluoride ingested by women is transferred to a child through breast milk. Several human studies found an increase in birth defects or lower IQ scores in children living in areas with very high levels of fluoride in the drinking water." (ATSDR, 2003B, p. 10)

"Studies involving exposure to higher doses of fluoride have consistently found significant increases in the risk of nonvertebral fractures, particularly hip fractures. A study involving lifetime exposure to 4.3–8 ppm fluoride in drinking water found an elevated risk of hip fractures among elderly men and women; this elevated risk of hip fracture was also observed in a community with very low fluoride (0.25–0.34 ppm) in the water." (ATSDR, 2003B, p. 20)

#9

IRON

HUMANS

"Human exposure to high concentrations can cause metabolic changes and damage to the pancreas, liver, spleen, and heart." (U.S.–EPA, 2013A, pp. 3–4)

ANIMALS

"Iron contamination can lead to growth reduction, greater susceptibility to injury and disease, and decreased egg hatchability in fish." (U.S.–EPA, 2013A, pp. 3–4)

#10

LEAD

HUMANS

"Human exposure to high concentrations in drinking water can cause serious damage to the brain, kidneys, nervous system, and red blood cells." (U.S.–EPA, 2013a, pp. 3–4) "PbB levels associated with adverse effects vary by endpoint. Adverse effects occur at PbB <5 µg/dL and for the most studied endpoints (neurological, renal, cardiovascular, hematological, immunological, reproductive, and developmental), effects occur at the lowest PbBs studied (≤5 µg/dL). CDC (2018b) states that "no safe blood lead level in children has been identified."" (ATSDR, 2020A p. 3)

"Neurological effects of Pb [Lead] are of greatest concern because effects are observed in infants and children and may result in life-long decrements in neurological function. Infants are born with a Pb burden derived from maternal transfer in utero and subsequently can continue to absorb maternal Pb from ingestion of breast milk." (ATSDR, 2020A, p. 4)

"Gastrointestinal absorption of ingested Pb is higher in children compared to adults" (ATSDR, 2020a, p. 4)

ANIMALS

"Lead contamination can result in delayed embryonic development, suppressed reproduction, and inhibited growth in fish." (U.S.–EPA, 2013A, pp. 3-4)

#11

LITHIUM

HUMANS

"Pharmaceutical use of lithium at all therapeutic dosages can cause adverse health effects—primarily impaired thyroid and kidney function." (USGS, 2021) The Handbook on the Toxicology of Metals states that "there is no evidence that environmental Li may cause adverse effects on the general population" but with an important rider that this is the case "With the exception perhaps of areas with very high levels of Li in drinking water" (Nordberg, Fowler, & Nordberg, 2015, p. 969)

#12

MANGANESE

HUMANS

"The most common impacts due to human exposure to high concentrations involve the nervous system." (U.S.–EPA, 2013A, pp. 3–4) "The most common health problems in workers exposed to high levels of manganese involve the nervous system. These health effects include behavioral changes and other nervous system effects, which include movements that may become slow and clumsy. This combination of symptoms when sufficiently severe is referred to as "manganism." Other less severe nervous system effects such as slowed hand movements have been observed in some workers exposed to lower concentrations in the work place." (ATSDR, 2012E, p. 5)

"Studies in children have suggested that extremely high levels of manganese exposure may produce undesirable effects on braindevelopment, including changes in behavior and decreases in the ability to learn and remember. In some cases, these same manganese exposure levels have been suspected of causing severe symptoms of manganism disease (including difficulty with speech and walking)." (ATSDR, 2012e, p. 6)

ANIMALS

"Manganese primarily accumulates in organisms lower in the food chain such as phytoplankton, algae, mollusks, and some fish." (U.S. - EPA, 2013a, pp. 3-4)

#13

MERCURY

HUMANS

"The pollutant can convert into methylmercury, increasing the potential for bioaccumulation." (U.S. - EPA, 2013a, pp. 3-4)

"Human exposure at levels above the Maximum Concentration limit (2 µg/L) for relatively short periods can result in kidney and brain damage. Fetuses, infants, and children are particularly susceptible to impaired neurological development from methylmercury exposure." (U.S. - EPA, 2013a, pp. 3-4)

"The nervous system is very sensitive to mercury. In poisoning incidents that occurred in other countries, some people who ate fish contaminated with large amounts of methylmercury or seed grains treated with methylmercury or other organic mercury compounds developed permanent damage to the brain has also been shown to occur from exposure to sufficiently high levels of metallic mercury." (ATSDR, 1999, p. 12) "Breathing in or swallowing large amounts of methylmercury also results in some of the mercury moving into the brain and affecting the nervous system." (ATSDR, 1999, p. 13)

"The kidneys are also sensitive to the effects of mercury, because mercury accumulates in the kidneys and causes higher exposures to these tissues, and thus more damage. All forms of mercury can cause kidney damage if large enough amounts enter the body." (ATSDR, 1999, p. 13)

"In addition to effects on the kidneys, inorganic mercury can damage the stomach and intestines, producing symptoms of nausea, diarrhea, or severe ulcers if swallowed in large amounts. Effects on the heart have also been observed in children after they accidentally swallowed mercuric chloride. Symptoms included rapid heart rate and increased blood pressure." (ATSDR, 1999, p. 14)

"Children who had been exposed to excessive amounts of mercurous chloride tablets for worms or mercurous chloride-containing powders for teething discomfort had increased heart rates and elevated blood pressure. Abnormal heart rhythms were also seen in children who had eaten grains contaminated with very high levels of methylmercury." (ATSDR, 1999, p. 16)

"Methylmercury eaten or swallowed by a pregnant woman or metallic mercury that enters her body from breathing contaminated air can also pass into the developing child. Inorganic mercury and methylmercury can also pass from a mother's body into breast milk and into a nursing infant." (ATSDR, 1999, p. 16)

Continued overleaf

#13

MERCURY

ANIMALS

"Studies using animals indicate that long-term oral exposure to inorganic mercury salts causes kidney damage, effects on blood pressure and heart rate, and effects on the stomach." (ATSDR, 1999, p. 14)

"Animals exposed orally to long-term, high levels of methylmercury or phenylmercury in laboratory studies experienced damage to the kidneys, stomach, and large intestine; changes in blood pressure and heart rate; adverse effects on the developing fetus, sperm, and male reproductive organs; and increases in the number of spontaneous abortions and stillbirths. Adverse effects on the nervous system of animals occur at lower doses than do harmful effects to most other systems of the body. ... evidence suggests that the effects worsen with age, even after the exposure stops." (ATSDR, 1999, p. 15)

"Methylmercury contamination can lead to reduced growth and reproductive success in fish and invertebrates." (U.S. - EPA, 2013a, pp. 3-4)

#14

MOLYBDENUM

HUMANS

"Biologically, molybdenum plays an important role as a micronutrient in plants and animals, including humans." (ATSDR, 2020b, p. 1) "Molybdenum is an essential nutrient...Exposure to excess levels has been associated with adverse health outcomes. The most sensitive effects appear to be respiratory effects following inhalation exposure to molybdenum trioxide, and decreases in body weight, kidney damage, decreases in sperm count, and anemia following oral exposure..."

"A systematic review of the available human and laboratory animal health effects database resulted in the following hazard identification conclusions:

- Respiratory effects are a presumed health effect for humans for molybdenum oxides.
- Renal effects are a presumed health effect for humans.
- The data were inadequate to conclude whether hepatic, uric acid level, reproductive, or developmental effects will occur in humans" (ATSDR, 2020B, p. 2)

ANIMALS

"The oral toxicity of molybdenum has been well-established in ruminants, particularly cows and sheep." (ATSDR, 2020b, p. 8) "The observed effects can include decreases in weight gain, alterations in hair/wool texture and pigmentation, delayed puberty, and reduced conception rates." (ATSDR, 2020b, p. 8) "A large number of animal studies reported alterations in body weight following acute—or intermediate duration oral exposure to molybdenum." (ATSDR, 2020b, p. 34)

#15

NICKEL

HUMANS

"Human exposure to high concentrations can cause gastrointestinal and kidney damage." (U.S. - EPA, 2013a, pp. 3-4)

"Workers who drank water containing high amounts of nickel had stomach ache and suffered adverse effects to their blood and kidneys." (ATSDR, 2005a, p. 2)

"The U.S. Department of Health and Human Services (DHHS) has determined that nickel metal may reasonably be anticipated to be a carcinogen and nickel compounds are known human carcinogen." (ATSDR, 2005b, p. 7)

"Nickel can be transferred from the mother to an infant in breast milk and can cross the placenta." (ATSDR, 2005a, p. 2)

ANIMALS

"Eating or drinking levels of nickel much greater than the levels normally found in food and water have been reported to produce lung disease in dogs and rats and to affect the stomach, blood, liver, kidneys, and immune system in rats and mice, as well as their reproduction and development." (ATSDR, 2005, p. 2)

"Animal studies have found increases in newborn deaths and decreased newborn weight after ingesting very high amounts of nickel." (ATSDR, 2005, p. 2)

"At low concentrations, nickel can inhibit the growth of microorganisms and algae. Nickel toxicity in fish and aquatic invertebrates varies among species, and can damage the lungs, immune system, liver, and kidneys." (U.S. - EPA, 2013a, pp. 3-4)

#16

SELENIUM

HUMANS

"In humans, short-term exposure at levels above the Maximum concentration limit (50 µg/L) can cause hair and fingernail changes, damage to the peripheral nervous system, and fatigue and irritability. Long-term exposure can damage the kidney, liver, and nervous and circulatory systems." (U.S. - EPA, 2013a, pp. 3-4)

"Selenium has both beneficial and harmful effects. Low doses of selenium are needed to maintain good health. However, exposure to high levels can cause adverse health effects. Short-term oral exposure to high concentrations of selenium may cause nausea, vomiting, and diarrhea. Chronic oral exposure to high concentrations of selenium compounds can produce a disease called selenosis. *Continued overleaf.*

#16

SELENIUM

The major signs of selenosis are hair loss, nail brittleness, and neurological abnormalities (such as numbness and other odd sensations in the extremities)." (ATSDR, 2003a, p. 2)

"It is likely that the health effects seen in children exposed to selenium will be similar to the effects seen in adults." (ATSDR, 2003a, p. 2)

ANIMALS

"Animal studies have shown that very high amounts of selenium can affect sperm production and the female reproductive cycle." (ATSDR, 2003a, p. 2)

"Selenium readily bioaccumulates. Elevated concentrations have caused fish kills and numerous sublethal effects (e.g., organ damage, decreased growth rates, reproductive failure) to aquatic and terrestrial organisms." (U.S.–EPA, 2013a, pp. 3–4)

#17

VANADIUM

HUMANS

"There are very few reported cases of oral exposure to vanadium in humans; however, a few reported incidences documented diarrhea and stomach cramps. It also has been linked to the development of some neurological disorders and cardiovascular diseases." (U.S. - EPA, 2013a, pp. 3-5)

"Nausea, mild diarrhea, and stomach cramps have been reported in people some vanadium compounds." (ATSDR, 2012a, p. 1)

"The International Agency for Research on Cancer (IARC) has classified vanadium pentoxide as possibly carcinogenic to humans based on evidence of lung cancer in exposed mice." (ATSDR, 2012a, p. 2)

ANIMALS

"A number of effects have been found in rats and mice ingesting several vanadium compounds. The effects include: Decreases in number of red blood cell, Increased blood pressure, Mild neurological effects, Developmental effects in animals." (ATSDR, 2012b, p. 6)

CITATIONS

citations & endnotes

- ATSDR. (1999, March). Toxicological Profile for Mercury. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxprofiles/tp46.pdf
- ATSDR. (2003a, September). ToxFAQs : Selenium. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxfaqs/tfacts92.pdf
- ATSDR. (2003b, September). Toxicological Profile for Fluorides, Hydrogen Fluoride, and Fluorine. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/ToxProfiles/tp11.pdf
- ATSDR. (2004a, September). ToxFAQs : Copper. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxfaqs/tfacts132.pdf
- ATSDR. (2004b, September). Toxicological Profile for Copper. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxprofiles/tp132.pdf
- ATSDR. (2005a, August). ToxFAQs : Nickel. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxfaqs/tfacts15.pdf
- ATSDR. (2005b, August). Toxicological Profile for Nickel. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxprofiles/tp15.pdf
- ATSDR. (2008, September). Toxicological Profile for Aluminum. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxprofiles/tp22.pdf
- ATSDR. (2010, November). Toxicological Profile for Boron. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxprofiles/tp26.pdf
- ATSDR. (2012a, October). ToxFAQs : Vanadium. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxfaqs/tfacts58.pdf
- ATSDR. (2012b, September). Toxicological Profile for Vanadium. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxprofiles/tp58.pdf
- ATSDR. (2012c). Toxicological Profile for Cadmium. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxprofiles/tp5.pdf
- ATSDR. (2012d). Toxicological Profile for Chromium. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxprofiles/tp7.pdf
- ATSDR. (2012e, September). Toxicological Profile for Manganese. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxprofiles/tp151.pdf
- ATSDR. (2019, October). Toxicological Profile for Antimony and Compounds. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxprofiles/tp23.pdf
- ATSDR. (2020a, August). Toxicological Profile for Lead. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved from https://www.atsdr.cdc.gov/toxprofiles/tp13.pdf
- ATSDR. (2020b, May). Toxicological Profile for Molybdenum. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Retrieved September 1, 2021, from ATSDR website: https://www.atsdr.cdc.gov/toxprofiles/tp212.pdf

- ATSDR. (n.d.). Toxicological Profiles. Retrieved from Agency for Toxic Substances and Disease Registry: https://www.atsdr.cdc.gov/toxprofiledocs/index.html

- Behl, M. (2017a, April 22). Koradi Power Plant Clarification Reveals SO2 Levels. Nagpur, Maharashtra, India: Times of India. Retrieved September 25, 2021, from https://timesofindia.indiatimes.com/city/nagpur/koradi-power-plant-clarification-reveals-so2-levels-5-times-higher-than-permitted/articleshow/58301936.cms

- Behl, M. (2017b, April 27). Villagers Around Koradi Eat and Breathe Fly Ash. Nagpur, Maharashtra, India: Times of India. Retrieved September 25, 2021, from https://timesofindia.indiatimes.com/city/nagpur/villagers-around-koradi-eat-and-breathe-fly-ash/articleshow/58387105.cms

- Bureau of Indian Standards. (2012, May). Indian Standards Drinking Water - Specification. New Delhi, India. Retrieved August 10, 2021, from http://cgwb.gov.in/Documents/WQ-standards.pdf

- CEA. (2020a, April 1). List of Thermal Power Stations As On 31.03.2020. New Delhi, India: Central Electricity Authority, Ministry of Power, Government of India. Retrieved August 10, 2021, from Central Electricity Authority Website: https://cea.nic.in/old/reports/others/planning/pdm/list_power_stations_2020.pdf

- CEA. (2020b, November). Report on Fly Ash Generation at Coal / Lignite Based Thermal Power Stations and Its Utilization in The Country for the Year 2019 - 20. New Delhi, New Delhi, India: Central Electricity Authority. Retrieved September 1, 2021, from https://cea.nic.in/wp-content/uploads/tcd/2021/01/flyash_2019-20.pdf

- CEA. (2021, September 19). Unit wise FGD Implementation Status and Summary Sheet for September 2021. New Delhi, India: Central Electricity Authority. Retrieved Septmber 25, 2021, from CEA website: https://cea.nic.in/wp-content/uploads/tprm/2021/09/Unit_wise_FGD_implementation_status_and_summary_sheet_for_September_2021.pdf

- CMPDI. (2020, February). Report on Land Use/Vegetation Cover Mapping of Kamptee Coalfield Based on Satellite Data for the Year 2019. Ranchi: Central Mine Planning & Design Institute Limited. Retrieved August 10, 2021, from Western Coal Fields Website: http://www.westerncoal.in/sites/default/files/userfiles/Kamptee_coalfield_CF_2019.pdf

- CPCB. (2009, November 17). Mercury : Environmental Implications & Toxicity. New Delhi, India: Central Pollution Control Board. Retrieved August 31, 2021, from CPCB website: https://cpcb.nic.in/uploads/News_Letter_Mercury_2017.pdf

- CWC. (2019, August). Status of Trace & Toxic Metals in Indian Rivers. New Delhi: Central Water Commission, Ministry of Jal Shakti , Government of India. Retrieved September 10, 2021, from Central water commission website: http://cwc.gov.in/sites/default/files/status-trace-toxic-metals-indian-rivers-2019-2.pdf

- Dharmadhikary, S., & Asher, M. (2016). Environmental Violations in and around Coalmines, Washeries and Thermal Power Plants of Tamnar & Gharghoda Blocks, Dist. Raigarh, Chhattisgarh.

- EAC. (2019a, May 28). Minutes of the 28th Meeting of the Expert Appraisal Committee on EIA of Thermal Power Projects. New Delhi, India: Ministry of Environment, Forests and Climate Change. Retrieved January 12, 2020, from PARIVESH Website Ministry of Environment, Forest and Climate Change, Government of India: http://environmentclearance.nic.in/writereaddata/Form-1A/Minutes/17062019UI2ARQ7328thMoMThermal28thMay2019final.pdf

- EAC. (2019b, August 23). Minutes ofthe 32nd Meeting of the Expert Appraisal Committee On Environmental Impact Assessment of Thermal Power Projects. New Delhi: Ministry of Environment, Forests and Climate Change, Government of India. Retrieved September 20, 2019, from PARIVESH Website Ministry of Environment, Forest and Climate Change , Government of India: http://environmentclearance.nic.in/writereaddata/Form-1A/Minutes/160920198ZXC8ZD332ndMoMFinal.pdf

- IL&FS Ecosmart Ltd. (2010, August). Technical EIA Guidance Manual for Thermal Power Plants, Prepared for the Ministry of Environment and Forests, Government of India. New Delhi: MoEF&CC. Retrieved August 10, 2015, from PARIVESH: http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_Thermal%20Power%20Plants_010910_NK.pdf

- ISO. (2015, September). ISO 9001:2015 Quality Management Systems — Requirements. Geneva: International Organization for Standardization. Retrieved September 25, 2021, from https://www.iso.org/standard/62085.html

- Lok Sabha. (2021, July 30). Lok Sabha Unstarred Question No. 2059 : Pollution from Coal-based Power Plants. Lok Sabha, Parliament of India. Retrieved September 10, 2021, from PARLIAMENT OF INDIA : LOK SABHA Website: http://164.100.24.220/loksabhaquestions/annex/176/AU2059.pdf

- MAHAGENCO. (2019, November 20th). Compliance Report 20 Nov 2019. Ministry of Environment, Forests

and Climate Change, Government of India. Retrieved August 10, 2021, from PARIVESH Website, Ministry of Environment, Forest and Climate Change , Government of India: http://environmentclearance.nic.in/writereaddata/Online/EDS/0_0_21_Nov_2019_1223406531ComplianceofADS.pdf

- MAHAGENCO. (2021a, September 10). Home Page. Retrieved from Maharashtra State Power Generation Company: https://www.mahagenco.in/

- MAHAGENCO. (2021b, September 24). Installed Capacity. Retrieved from MAHAGENCO Website: https://mahagenco.in/index.php/generation

- Ministry of Jal Shakti. (n.d.). Arsenic Hot Spot in Ground Water in India. New Delhi: Ministry of Jal Shakti, Government of India. Retrieved August 27, 2021, from Ministry of Jal Shakti website: https://jalshakti-dowr.gov.in/sites/default/files/ARSENIC.pdf

- MoEF&CC. (2019, April 15). Inspection Report of Random Site Visit of Khaparkheda TPS by Regional Office, MoEFCC. Regional Office Nagpur, MoEFCC, Government of India. Retrieved from PARIVESH: http://environmentclearance.nic.in/writereaddata/Monitoring/S1B1WBCP_EC-274-RON-2017-NGP.pdf

- MoEF&CC. (2020, June 26). TOR for Proposed 2X660 MW Super Critical Thermal Power Project Within the Premises of 2400 MW Koradi Power Plant at Village Koradi, Tehsil - Kamptee, District - Nagpur, Maharashtra by M/S Maharashtra State Power Generation Company Limited (MAHAGENCO). New Delhi, India: Ministry of Environment, Forests and Climate Change, Government of India. Retrieved September 25, 2021, from http://environmentclearance.nic.in/DownloadPfdFile.aspx?FileName=YCmpmoBmSAtuwpAcPaXlcfFXGATBWYmaC5SXG6HOiNERI6h8zq1+R6nW/82iCaK7Tr9CapO3/gljwKgaDYm8U/isDUgQ2KAeYv6V/UiYvDo=&FilePath=93ZZBm8LWEXfg+HAlQix2fE2t8z/pgnoBhDlYdZCxzUI4DoyoDyH4SbeEYqwvEmbw63j4fms

- MOIL Limited. (2019, June 19). Mines Location. Retrieved September 25, 2021, from MOIL Limited: https://www.moil.nic.in/content/58/Mines%20Location

- MPCB. (2016, February). Minutes of the 14th Meeting of the Consent Appraisal Committee (CAC) of Maharashtra Pollution Control Board. Mumbai, Maharashtra, India: Maharashtra Pollution Control Board. Retrieved April 2, 2016, from http://mpcb.gov.in/consentappraisal/pdf/minCACBook_32_part_1_2.pdf

- Narayan , S. (2017). POISONED: Report on the Environmental Sampling around the Coal Mines, Thermal Power Plants and Ash Ponds in Tamnar Block of Raigarh, Chhatisgarh. Community Environmental Monitoring & Dalit Adivasi Mazdoor Sangathan.

- Nordberg, G. F., Fowler, B. A., & Nordberg, M. (Eds.). (2015). Handbook on the Toxicology of Metals: Volume I: General Considerations. Elsevier.

- Pallavi, A., & Chakravartty, A. (2011, September 27). Green Tribunal Seeks Details on Radiation from Thermal Power Plants. New Delhi, New Delhi, India: Down to Earth. Retrieved September 25, 2021, from https://www.downtoearth.org.in/news/green-tribunal-seeks-details-on-radiation-from-thermal-power-plants--34096

- Physicians for Social Responsibility. (n.d.). Coal Ash: Hazardous to Human Health. Retrieved September 10, 2021, from Physicians for Social Responsibility: https://www.psr.org/wp-content/uploads/2018/05/coal-ash-hazardous-to-human-health.pdf

- PTI. (2011, May 4). Maharashtra Power Plants Slip on Green Parameters: CAG. New Delhi, India: Economic Times. Retrieved September 1, 2021, from https://economictimes.indiatimes.com/industry/energy/power/maharashtra-power-plants-slip-on-green-parameters-cag/articleshow/8159035.cms?from=mdr

- Raheja, S. (2019, September 10). Life in Grey-Scale: What Life is Like When You're Sandwiched Between Two Coal Plants. Nagpur, Maharashtra, India: HuffPost India. Retrieved September 25, 2021, from https://www.huffpost.com/archive/in/entry/maharashtra-village-shows-impact-of-coal-plants-fly-ash_in_5d5d406de4b09e2b9fe4b81f

- Rinchin, Chatterjee, P., Ganguli, M., & Jana, S. (2017, November). The Health and Environmental Impact of Coal Mining in Chhattisgarh. Raigarh, Chhattisgarh, India.

- Roy, A. (2012, December 29). Increased Pollution by Power Plants Puts Villagers at Risk. Nagpur, Maharashtra, India: Times of India. Retrieved September 25, 2021, from https://timesofindia.indiatimes.com/city/nagpur/increased-pollution-by-power-plants-puts-villagers-at-risk/articleshow/17800873.cms

- Roy, A. (2020, August 7). Fly-Ash Leaks into Kanhan River, Hits Pumping. Nagpur, Maharashtra, India: Times of India. Retrieved September 25, 2021, from https://timesofindia.indiatimes.com/city/nagpur/khaparkheda-fly-ash-leaks-into-kanhan-river-hits-pumping/articleshow/77401705.cms

- Roy, A., & Behl, M. (2019, June 27). High-SO2-Emissions-Create-Hurdles-for-Koradi-Power-Units. Nagpur, Maharashtra, India: Times of India. Retrieved September 25, 2021, from https://timesofindia.indiatimes.com/city/nagpur/high-so2-emissions-create-hurdles-for-koradi-power-units/articleshow/69964831.cms

- Sandbhor, J. (2016, June 4). Dear Nagpur, This is What You Drink! Pune, Maharashtra, India: Manthan Adhyayan Kendra. Retrieved September 25, 2021, from http://jinda.manthan-india.org/

- Sengupta, P. (2013, August). Potential Health Impacts of Hard Water. International Journal of Preventive Medicine, 4(8), 866-875. Retrieved September 1, 2021, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3775162/

- Times News Network. (2010, July 24). Paoni Residents Protest Pollution in Wainganga river. Nagpur, Maharashtra, India: Times of India. Retrieved September 1, 2021, from https://timesofindia.indiatimes.com/city/nagpur/paoni-residents-protest-pollution-in-wainganga-river/articleshow/6208618.cms

- Times News Network. (2018, January 12). Koradi Plant was Asked to Shut Down 3 Units. Nagpur, Maharashtra, India: Times of India. Retrieved September 25, 2021, from https://timesofindia.indiatimes.com/city/nagpur/koradi-plant-was-asked-to-shut-down-3-units/articleshow/62462212.cms

- U.S. - EPA. (2013a). Environmental Assessment for the Proposed Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category. Washington D.C.: United States Environment Protection Agency.

- U.S. - EPA. (2013b). Technical Development Document for the Proposed Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category. Washington D.C.: United States Environmental Protection Agency. Retrieved September 30, 2021, from https://www.epa.gov/sites/default/files/2015-10/documents/steam-electric-tdd_10-21-15.pdf

- U.S. - EPA. (2014). Human and Ecological Risk Assessment of Coal Combustion Residuals - Final. United States Environmental Protection Agency. Retrieved July 21, 2021, from https://downloads.regulations.gov/EPA-HQ-OLEM-2019-0173-0008/content.pdf

- U.S. - EPA. (2018, March). 2018 Edition of Drinking Water Standards and Health Advisories Tables. Washington D.C., District of Columbia, United States of America: Office of Water, U.S. Environmental Protection Agency. Retrieved September 10, 2021, from https://www.epa.gov/sites/default/files/2018-03/documents/dwtable2018

- USGS. (2021, February 11). Lithium in U.S. Groundwater. Retrieved September 20, 2021, from United States Geological Survey: https://www.usgs.gov/center-news/lithium-us-groundwater

- WHO. (n.d.). Water Sanitation and Health. Retrieved September 10, 2021, from World Health Organisation: https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/burden-of-disease/other-diseases-and-risks/fluorosis

ENDNOTES

1. One more unit, the 210 MW Unit 7 was also retired by Mahagenco in September 2021, just as this report was going to press. The effective capacity of Koradi TPS is now 2190 MW. See https://cea.nic.in/wp-content/uploads/installed/2021/09/installed_capacity.pdf

2. Compiled by authors from various environment clearance and related documents.

3. Distance given is of Gumgoan mine. We could not locate on google maps the Ramdongari mine shown on MOIL map as being close to Kanhan river to be able to measure its distance.

4. The CAC is the Committee that recommends the approval of Consent to Establish and Consent to Operate under the Water (Prevention and Control of Pollution) Act 1974 and Air (Prevention and Control of Pollution) 1981 Act to large projects.

5. Water ATMs are installations that filter and purify water using a reverse osmosis process. They dispense the purified water on payment of money, made in cash or using a pre-paid card. Some people expand the acronym ATM used here to mean "Any Time water Machine, but its most likely that the acronym is used as a word in itself, borrowed from the Automated Teller Machines that dispense money, indicating a 24 x 7 availability.

6. Sample from ESP was made available by a well-wisher who wishes to remain anonymous.

7. The Standard states, in its Foreword, that "This Standard specifies the *acceptable limits* and the *permissible limits* in the absence of alternate source. *It is recommended that the acceptable limit is to be implemented* as values in excess of those mentioned under 'Acceptable' render the water not suitable. Such a value may, however, be tolerated in the absence of an alternative source." (Emphasis added) In our study, we have used the "Acceptable" limits to assess quality of the water samples tested.

8. For example, in Villages Waregaon, Chicholi, Bhanegaon and Mhasala Toli, borewell water is used without treatment for drinking. Similarly, water from the Kanhan river at LocationW2 is being used for drinking without treatment.

9. In this report, where we refer to "high levels" of contaminants, it will mean exceeding the Indian standards (acceptable limits), unless otherwise clarified.

10. We use the terms first/second/ third season or first / second/third round interchangeably to refer to the sampling done in three seasons.

11. Quantitative information about constituents of fly ash from various TPPs is very limited in public domain, so we have carried out comparisons with whatever information is available to us.

12. Also, see CEA reports on fly ash utilisation of previous years for record of non-utilisation in earlier years.

POLLUTED POWER

How Koradi & Khaperkheda Thermal Power Stations are Impacting the Environment

NOVEMBER 2021

CFISD
CENTRE FOR SUSTAINABLE DEVELOPMENT

manthan
मंथन अध्ययन केंद्र

asar