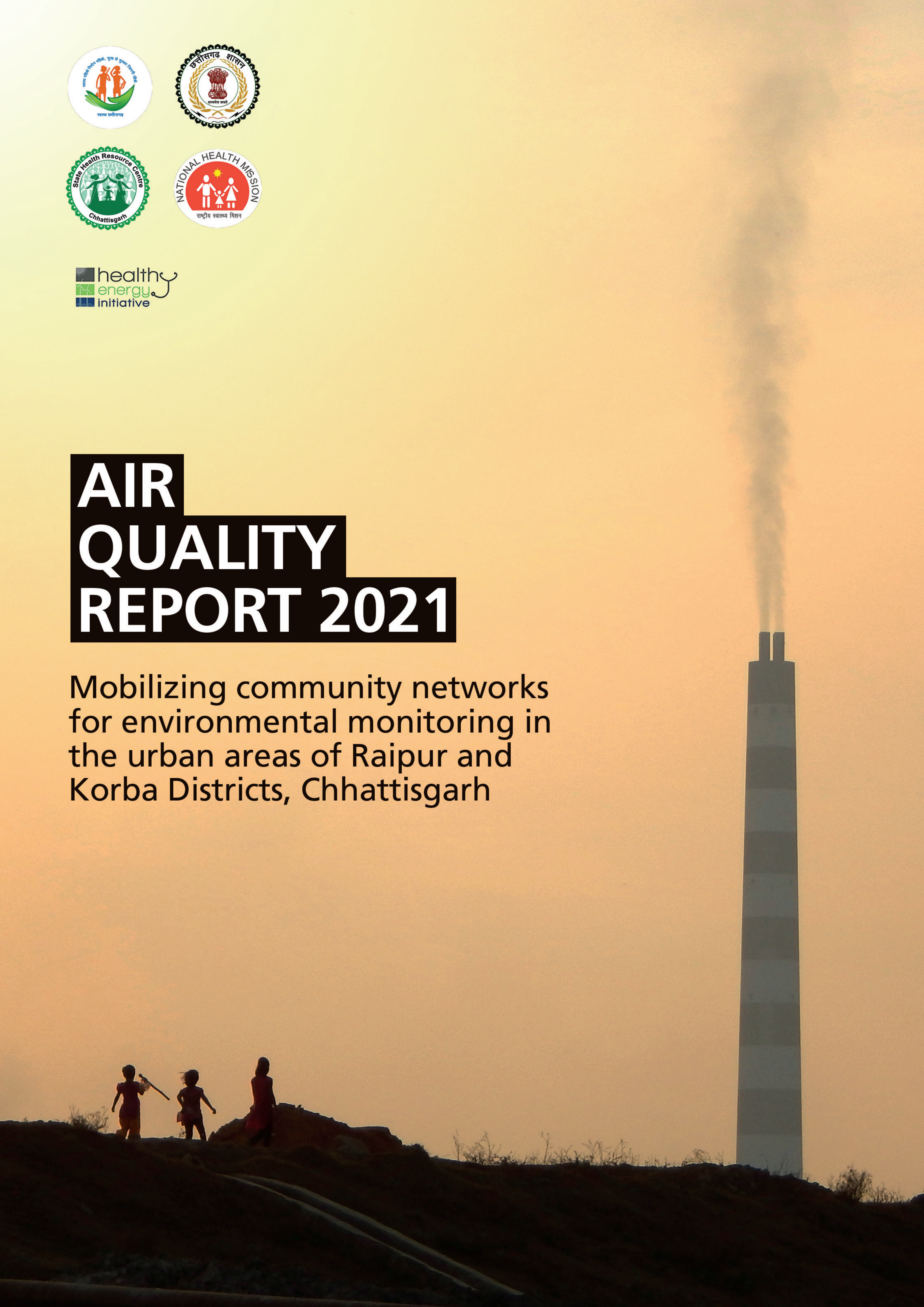

AIR QUALITY REPORT 2021

Mobilizing community networks for environmental monitoring in the urban areas of Raipur and Korba Districts, Chhattisgarh

Acknowledgement

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Heather Bedi Plumridge

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Contents

Executive Summary

The air sampling report is a featured activity under the National Program Of Climate Change and Human Health (CG-SNPCCHH) headed by Prof & Dr. Kamlesh Jain as it State Nodal Officer, in coordination with Healthy Energy Initiative (HEI) and the of State Health Resource Center (SHRC), Chhattisgarh.

On following regular and frequent complaints by residents on air pollution and the reports of deteriorating air quality in general, this is also being needed for sentinel surveillance in two of the most venerable districts of Chhattisgarh to identify the association of Acute Respiratory Infections (ARI) and air quality.

Twelve air samples from Raipur were collected from November 2020 to May 2021. These were from: Changorabhata, Tikrapara, Mandir Hasaud, Sitlapara Bhatagaon, Acholi Urla, Utkal Nagar, Sendhwapara.

Fourteen air samples were collected from Korba between March 2021 to June 2021. These were from: Rani Danraj Kuwar PHC, District Hospital, Ghandhi Nagar Sirki, Khurda, Sirki- Khurda, Chainpur, Beltekri , Beltekri 2, Hardi Bazar, Dharampur Gerva, Emli Chhapar, Pankhadafai, Kanshinagar – Niharika, Checkpost- Balco, Manikpur.

The results of the ambient air samples from Raipur and Korba show that the air quality in the region has worsened and has drastically increased over a period of two years. The air quality in Raipur and Korba has reached a very dangerous level. Some of the key findings are as follows:

1. PM2.5 levels in all samples from Raipur ranged from 131.4 to 653.8µg/m^3 and were between 2.18 and 10.88 times higher than standards prescribed by the Ministry of Environment, Forests and Climate Change (MoEFCC) of (60µg/m^3). In Korba, the levels of PM2.5 in all the samples were 2.5 to 28.3 times above the prescribed limits of MoEFCC. The levels of PM2.5 in all the air samples pose a significant risk to the human health of residents.
2. Levels of crystalline silica were seen elevated in all the samples of Raipur and Korba. Both coal ash and construction sand have high levels of crystalline silica and could be prominent contributors. Acute exposure to silica causes a fatal lung disease called Silicosis. Silica also irritates the respiratory system and causes lung disorders.
3. In Raipur as well as in Korba, nickel levels in all samples exceed the WHO annual health-based guidelines value of 0.0025µg/m^3, which is based on the risk of cancer associated with long-term exposure to nickel. Exposure to nickel in ambient air also affects the respiratory and immune systems in the body.
4. From Raipur out of 12 samples, six samples shows higher levels of lead (Pb) when compared with the US EPA standard of 0.15µg/m^3, averaged for three month. Lead is a known neurotoxin. Children are particularly vulnerable to the effects of this heavy metal. Exposures to even low levels of lead early in life have been linked to effects on IQ, learning, memory and behavior.

5. In Raipur levels of manganese in all the twelve samples exceed the U.S. EPA Reference Concentration for exposure to manganese (0.05µg/m^3). In Korba, samples from 11 locations out of 14 had manganese exceeding the WHO annual health-based guidelines value of 0.15µg/m^3. Manganese is commonly used as a melting agent in ferrous foundries. Owing to the small particle size, manganese tends to remain suspended in the air for long periods of time. Manganese level is highest in one area which is nearly 4 Km away from power plant. There are no standards in India for manganese in ambient air. Manganese is a known neurotoxin and affects the neurobehavioral functions. According to the US EPA, chronic (long-term) exposure to high levels of manganese by inhalation in humans may result in central nervous system (CNS) effects. Visual reaction time, hand steadiness, and eye-hand coordination were affected in chronically exposed worker.

The pollution situation in Raipur and Korba has reached a very dangerous level and has worsened over a period of two years. High levels of PM 2.5 value are shown by all twenty six (26) samples taken from Raipur and Korba. All the samples have also shown higher levels of heavy metals such as Lead, manganese, nickel, and silica. Heavy metal toxicity can have several health effects in the body. Heavy metals can damage and alter the functioning of organs such as the brain, kidney, lungs, liver, and blood. There is no doubt that the districts and neighboring districts of Raipur and Korba may have health disasters. Existing environmental health impacts of Climate Change and air pollution is life threatening combination for the short- & long-term disasters in Raipur and Korba. Therefore, it is essential to strengthen health system with mitigation strategies to address the health burden in association with air pollution and take necessary preventive measures to control the pollution levels in ambient air across Raipur and Korba.

Recommendations:

Health:

1. Specialized health care infrastructure operated by the State health departments at polluters' cost, under the "polluter pays" principle, to cater to health issues of residents in the region of Korba, and Raipur.
2. Facilities like spirometer at the district hospitals with provision of technical expertise, adequate provision for respiratory illnesses and other medicines, and consumables, trained staff and infrastructure should be made accessible at the public health facilities.
3. Concept of "Disaster Epidemiology" should also be included in the state epidemiology cell provide timely and accurate health information for decision-makers; improve prevention and mitigation strategies for future disasters by collecting information for future response preparation.
4. State agencies provide for long-term health monitoring by initiating air quality and its health impact associated and correlated health studies among the residents of Korba and Raipur.
5. Committee for air quality testing should be established with multi stake holders like Health Department, Pollution Control Board, Academic and Research Institutes and Municipality.

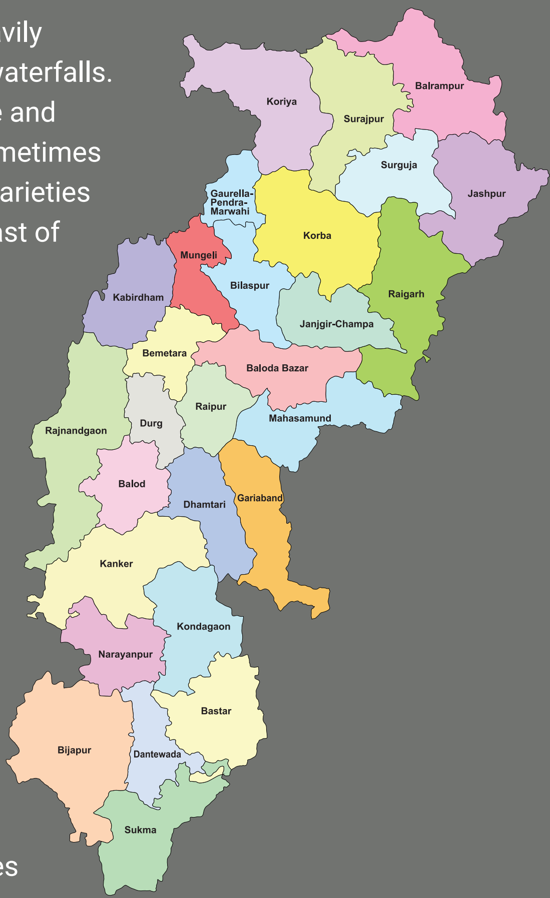
Environment:

1. State and Central Pollution Control Board should initiate continuous monitoring of heavy metals in dust and publish results periodically. Health advisories by consulting reputed health agencies should also be issued regularly.
2. A pollution cess to be levied on units and activities not confirming with National Ambient Air Quality Standards (NAAQS).
3. State agencies should use the pollution data to apprehend polluters and take corrective action to bring levels of dust and heavy metals in dust to below detection limits in residential areas.
4. Strict monitoring of emissions from coal fired power plants, coal mines, and coal transport to be undertaken in Raipur and Korba.
5. Urgent plan is to be formulated to shift out the iron and steel manufacturing units from the residential zones of Raipur city. if this is not possible, strict measures to be taken enforce the pollution control norms by these units.
6. The decision on the legitimate expansion of the industrial areas should be immediately reviewed and should be reconsidered in the existing COVID 19 situation.

(https://cpcb.nic.in/industrial_pollution/New_Action_Plans/CEPI_Action%20Plan_Raipur.pdf)

Air Quality Report 2021

Chhattisgarh is a progressive mineral rich state. It is a heavily forested state in central India known for its temples and waterfalls. Urban development is rapidly occurring with infrastructure and industries. It is located near the center of a large plain, sometimes referred to as the “rice bowl of India”, where hundreds of varieties of rice are grown. There is a large river that flows to the east of Raipur and the southern area is covered by dense forests.



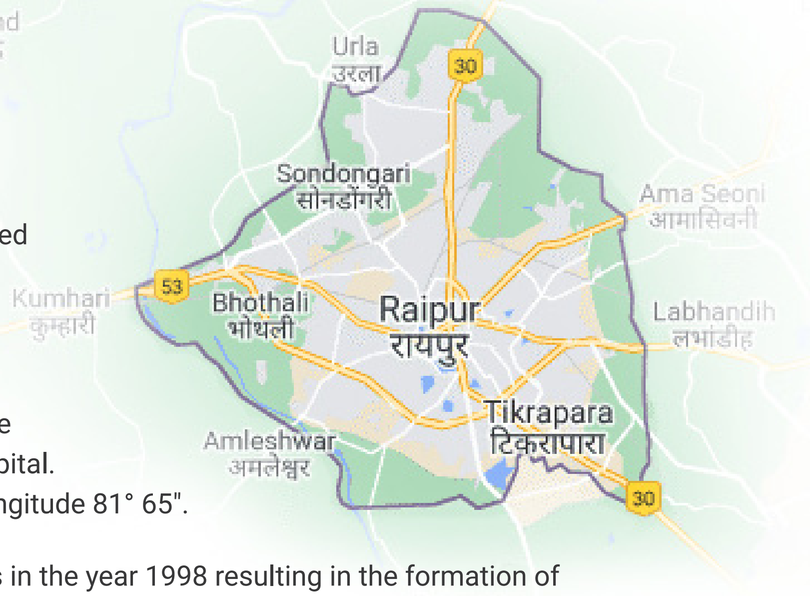
The air quality report is from two districts of Chhattisgarh namely, Raipur and Korba. Raipur is the one of the youngest capital city of the India. It is the state capital of Chhattisgarh. In 2011 the population was estimated at over 1 million people in the metropolitan area. The figure is probably higher now as 10 years have passed. At the same time Korba is Home to more than 10 thermal power plants with 6,000 megawatts capacity, Korba is known as power capital or power hub of Chhattisgarh. It is situated about 200 KM from the capital city Raipur. The rivers Hasdeo and Ahiran flow through Korba. It is also a hub of coal mines.
According to data, the people of Raipur could live 4.9 years longer if the World Health Organization guidelines were achieved. Meeting the same air quality standard in 1998 would have increased life expectancy by 2.2 years.

https://www.euro.who.int/__data/assets/pdf_file/0019/331660/Evolution-air-quality.pdf

Raipur

Raipur is the capital city of the Indian state of Chhattisgarh. In 2011 the population was estimated at over 1 million people in the metropolitan area. The figure is probably higher now as 10 years have passed.

Raipur being Geographically Located almost at the centre of the Chhattisgarh state, was made its capital. District Raipur Extends from latitude 21° 23" to longitude 81° 65".



Area – District Raipur was divided into three parts in the year 1998 resulting in the formation of Mahasamund and Dhamtari districts. Similarly, in the year 2011, Raipur was again divided forming two new districts namely Gariaband and Balodabazar-Bhatapara. Raipur district includes Dharsiwa, Arang, Abhanpur and Tilda plains.Raipur district is situated at 244 to 409 meters above sea level.

Neighbouring Districts – Durg, Bemetara, Balodabazar-Bhatapara, Mahasamund,and Dhamtari.

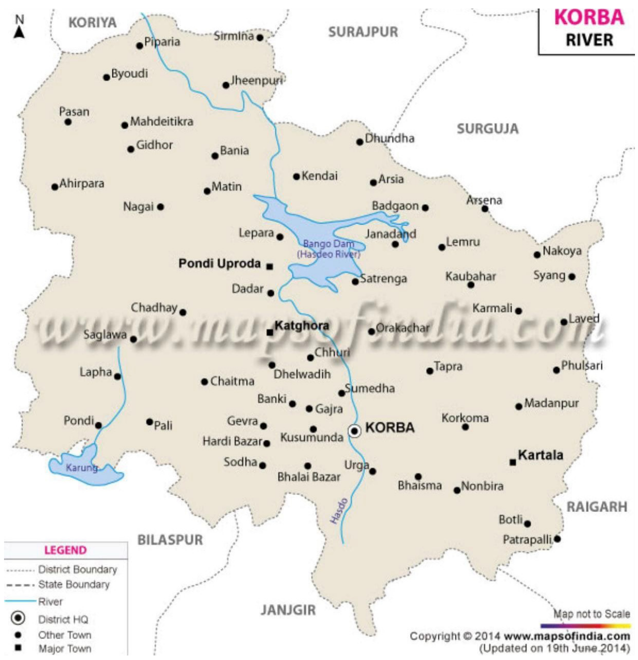
Rivers – Mahanadi and Kharun are the major rivers of Raipur district. Mahanadi is the most important river of Chhattisgarh, originating from Shrungi Mountains in Sihawa Tehsil of Dhamtari district. Kharun is another important river flowing in Raipur and Durg districts which originates in the hills of Petchuva in Durg district.

Climate and Rainfall – Raipur district has the maximum temperature of 44.3° C and minimum of 12.5° C The total average rainfall in the district is 1370 mm.

Soil – The area includes Kanhar, Dorsa, Matasi, Kachar and Bhatha lands with a PH average of 6.5 to 7.5 which is considered very useful for agriculture. *https://raipur.gov.in/about-district*

Korba

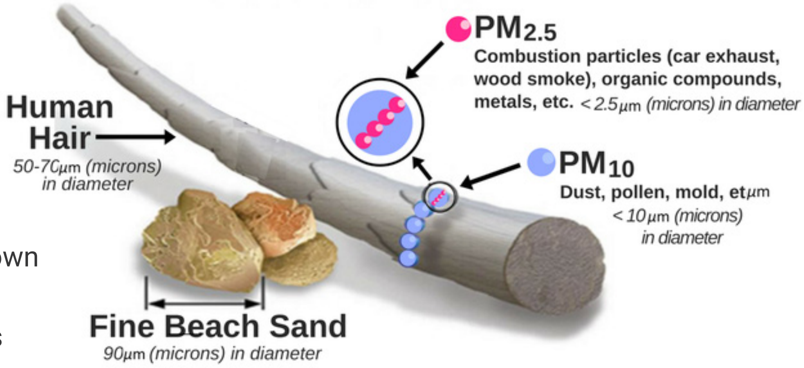
Korba district is situated in the northern half of the Chhattisgarh state and surrounded by the districts Korea, Surguja, Bilaspur, Janjgir-Champa etc. The headquarter of Korba districts situated about 200 KM. from the capital city Raipur. The District's total area is 7, 14,544 hectare out of which 2,83,497 hectares is forest land. Chhattisgarh is home to many coal-based thermal power plants, including National Thermal Power Corporation and Chhattisgarh State Electricity Board. It is the Power Hub and Power capital of Chhattisgarh and was accorded the full-fledged revenue district on 25th May 1998.



About Air Quality

Particulate Matter

Relative Size of Particular Matter



Particles that are smaller than 2.5 micrometers in diameter (more than 100 times thinner than a human hair) are called PM2.5, or fine particles. PM2.5 is known to carry toxic chemicals and heavy metals. The key documented sources of PM2.5 pollution are automobile exhaust, burning of coal, burning garbage and landfill, smelting and processing of metals. They remain suspended in the ambient air for longer durations in comparison to other pollutants and travel great distances. PM2.5 particles are lighter and go deeper into the lungs and cause greater damage in the long term.

The prescribed standard for the annual average of PM2.5 is 60µg/m³ in India, while WHO recommends a global standard of 10µg/m³. Research shows that every 10µg/m³ increase in PM2.5, increases all-cause mortality between 3-26%, chances of childhood asthma by 16%, chances of lung cancer by 36% and heart attacks by 44%. Air pollution is a leading cause of death in India with about 1.1 million premature deaths occurring from PM2.5 pollution- related diseases in 2015. It said the long-term exposure to PM2.5 contributed to 4.2 million premature deaths and to a loss of 103 million healthy years of life in 2015, making air pollution the 5th highest cause of death among all health risks, including smoking, diet, and high blood pressure.

Table 1: Air Quality Index for PM10 (µg/m³)

PM10 (µg/m³) for 24hr	AQI Category (Range)	Associated Health Impacts
0–50	Good	Minimal impact
51–100	Satisfactory	May cause minor breathing discomfort to sensitive people.
101–250	Moderately polluted	May cause breathing discomfort to people with lung disease such as asthma, and discomfort to people with heart disease, children and older adults.
251–350	Poor	May cause breathing discomfort to people on prolonged exposure, and discomfort to people with heart disease.
351–430	Very poor	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases.
430+	Severe	May cause respiratory impact even on healthy people, and serious health impacts on people with lung/heart disease. The health impacts may be experienced even during light physical activity.

Table 2: Air Quality Index for PM2.5 (µg/m³)

PM2.5 Range	Air Quality	Health Implications		
		Healthy Person	Elderly; Pregnant Women; Children	Persons with Chronic Lung Disease, Heart Disease
0–30	Good	Normal activities	Normal activities	Minimal impact
31–60	Satisfactory	Normal activities	Normal activities; however, there may be a moderate health concern for a very small number of people who are unsually sensitive to air pollution	Normal activities; however, there may be a moderate health concern for a very small number of people who are unsually sensitive to air pollution
61–90	Moderately polluted/ Unhealthy	**Reduce** prolonged or strenuous outdoor physical exertion	**Minimise** prolonged or strenuous outdoor physical exertion	**Avoid** prolonged or strenuous outdoor physical exertion
91–120	Poor/ Unhealthy	**Avoid** prolonged or strenuous outdoor physical exertion	**Minimise** outdoor activity	**Avoid** outdoor activity
121–250	Very poor/ Hazardour	**Minimise** outdoor activity	**Avoid** outdoor activity	**Avoid** outdoor activity
> 250	Severe/ Hazardour	**Minimise** outdoor activity	**Avoid** outdoor activity	**Avoid** outdoor activity

Statutory Guidelines:

- Indian Government: 60µg/m³ (24 hours mean); 40µg/m³ (annual mean)
- World Health Organization (LATEST AQG of 2021): 15µg/m³ (24 hours mean); 5µg/m³ (annual mean)

Main Sources of Air Pollution in Raipur and Korba

The major sources of ambient particulate matter pollution are the industrial emissions, Fly ash, burning of domestic and commercial biomass, wind-blown mineral dust, the burning of coal for energy production, and fly ash. There are construction works, brick furnaces, emissions produced by traffic vehicles and diesel generators. Domestic pollution comes from solid fuels used for cooking and heating include dried animal dung (*Kande*), *chena* (prepared by coal dust and wooden residue sometimes cow dung), coal stoves or *sigdi*, burning of tyres and tubes to ignite fires as kerosene oil was stooped in the PDS system, stone crushing and charcoal preparation.

These pollutants often react with hydrocarbons emitted from various sources due to strong sunlight. The resultant product is very dangerous ground-level ozone (O_3).

The capital of Chhattisgarh (Raipur) has become one of the major polluted cities in the world. Since the formation of the state in 2000, tremendous industrial development has been taking place in the last 20 years. It is one of the few states in the country where electricity is in excess. To generate electricity, the state burns millions of tons of coal every day, due to which carbon and ash generated are polluting the industrial areas on a large scale. The Abo-Hawa of the capital Raipur is badly polluted due to the Urala Silatra industrial areas adjoining it. For eight months of the year, the entire city is contaminated by ash. The same situation is found in the cities of Bilaspur, Korba and Raigarh. *https://www.iqair.com/india/chhattisgarh/raipur*

There are presently 06 coal based power plants with total generation 4700 MW and a aluminum smelter unit situated in the critically problem zone at Korba. The main source of water pollution is the overflow of ash pond in all the power plants.

The main sources of industrial air pollution are Coal Based Power Plants and Smelter Plant.

- This area also comprises of large open cast mines of SECL, i.e., Dipka, Gevra and Kusmunda. The main source of problem of fugitive emission in Korba is as below:
  - Large scale transportation of coal
  - Blowing of fly ash from ash pond especially during summer season
  - Un-organized burning of coal in the areas Le. Sitamani, Parsabhata and nearby areas by the dwellers
  - Heavy vehicular traffic

https://cpcb.nic.in/displaypdf.php?id=S29yYmEucGRm

Why the Air Sampling Report?

The air sampling report is a featured activity under the National Program Of Climate Change and Human Health (CG-SNPCCHH) headed by Prof & Dr. Kamlesh Jain as its State Nodal Officer, the State Health Resource Center (SHRC), Chhattisgarh and Healthy Energy Initiative (HEI), India.

On following regular and frequent complaints by residents on air pollution and the reports of deteriorating air quality in general, this is also being needed for sentinel surveillance in two of the most venerable districts of Chhattisgarh to identify the association of Acute Respiratory Infections (ARI) and air quality.

For a healthy as well as socially protected society and environment in the future we not only need to work for it today but also need to create a vigilant, mobilized and responsible society with community leaders leading with scientific evidence to contribute for a healthy and safe environment. It is very much needed that the communities are scientifically made aware of the consequences that they themselves take the initiative to collect scientific evidence and do environmental monitoring to provide evidence based feedback to the government for considering climate change in the plans and policies. The study would seek to not only create evidences but bring transformation by promoting ownership, accountability and communities emerging as the researchers and presenting the finding to the respective authorities for planning and policies.

Aim

Mobilizing community networks for environmental monitoring in the urban areas of Raipur and Korba Districts, Chhattisgarh.

Objective

1. To initiate environmental monitoring by communities for air pollution.
2. To build capacities of community health workers/volunteers for environmental monitoring for air pollution.

Methodology

Samples of dust in ambient air were taken from various places including residential houses and on top of public health centers by the community health workers/volunteers and a Civil Society Organization volunteers after the desk and on field training on air sample collection. Prior to taking samples, comprehensive orientation workshops were organized to train the health workers in the science of air sampling and the Quality Assurance and Quality Control (QA QC) processes. These samples were taken from around the Raipur and Korba city from public and private places outside the premises of industries and coal mines in the region.

1. From Raipur twelve (12) air samples were collected and from Korba fourteen (14) air samples.
2. Raipur Samples were collected between November 2020 to February 2021 and for Korba between March 2021 to May 2021.
3. All samples were taken continuously over a period of 24-hour.
4. The weather of the sample collection days was clear. The details of the locations and weather conditions of Raipur and Korba with are in the Annexure 1.
5. The equipment used is a low volume air-sampling device called the MiniVol[1].

1 http://www.airmetrics.com/index.html

6. The samples were sent for analysis to the Chester LabNet[2]. The laboratory tested the samplers for Particulate Matter (PM2.5) using the Gravimetry technique[3] and used the X-ray Fluorsescence (XRF) technique to detect the presence of heavy metals. XRF is a US EPA approved technique.

The air samples from Raipur were collected from November 2020 to May 2021. Twelve (12) Samples were collected from Raipur. The location and areas covered are namely: Changorabhata, Tikrapara, Mandir Hasaud, Sitlapara Bhatagaon, Acholi Urla, Utkal Nagar, Sendhwapara.

The air samples from Korba Fourteen (14) samples were collected between March 2021 to June 2021. The locations and areas are: Rani Danraj Kuwar PHC, District Hospital, Ghandhi Nagar Sirki, Khurda, Sirki- Khurda, Chainpur, Beltekri , Beltekri 2, Hardi Bazar, Dharampur Gerva, Emli Chhapar, Pankhadafai, Kanshinagar – Niharika, Checkpost- Balco, Manikpur.

The equipment used is MiniVol[1] low volume air-sampling 2 device. All samples were taken continuously over a period of 24-hour. The samples were tested through the support of Healthy Energy Initiative (HEI), India. The samples were sent for analysis to the Chester LabNet[2], a laboratory based in 3 Oregon, USA. The laboratory tested the samplers for Particulate Matter (PM2.5) using the Gravimetry technique[3] and used the X-ray Fluorsescence (XRF) 4 technique to detect the presence of heavy metals. XRF is a US EPA approved technique. Complete QA-QC was maintained while collecting and shipping the samples.

2 https://chesterlab.net/
3 http://chesterlab.net/analytical-capabilities/#gra

Results: Raipur

Table 3: Raipur – Location and Air Sample Analysis

Location Name	PM2.5	Fe	Mn	Zn	Cu	Ni	Pb	Si	Ca	S	Al	Na	Cl	Comments re PM2.5 level
Changorabhata	131.4	5.1	0.321	0.40	0.0110	0.0100	0.0800	8.1	6.0	3.8	3.6	0.71	0.4	Unhealthy
Tikrapara	203.2	4.6	0.245	0.42	0.1569	0.0055	1.6670	6.8	5.3	11.5	13.7	1.40	1.7	Very Unhealthy
Mandir Hasaud	146.5	7.8	0.230	0.10	0.0093	0.0097	0.0322	9.3	7.7	3.8	4.1	0.56	0.4	Very Unhealthy
Sitlapara Bhatagaon	197.8	12.4	0.755	1.24	0.0115	0.0130	0.2175	11.9	12.2	6.7	5.3	1.01	0.8	Very Unhealthy
Acholi Urla	653.8	39.4	24.190	7.02	0.0534	0.0474	1.4610	32.3	21.3	12.8	14.6	3.72	6.3	Hazardous
Utkal Nagar	382.8	16.8	1.276	3.15	0.0389	0.0243	0.3527	18.4	16.4	9.4	8.6	1.93	4.1	Hazardous
Sendhwapara	355.3	26.5	1.101	3.34	0.0526	0.0494	4.2030	18.1	15.6	5.0	8.3	1.64	6.3	Hazardous
Birgaon Saheed Nagar1	410.8	27.3	4.810	2.83	0.1144	0.0348	0.9392	20.6	12.1	15.1	9.5	2.39	7.0	Hazardous
Birgaon Saheed Nagar2	290.7	28.4	1.835	5.33	0.0217	0.0370	0.3561	15.6	9.4	8.0	7.9	2.54	4.8	Hazardous
Urla Raipur	563.5	55.5	2.580	5.29	0.0413	0.0634	2.7560	33.8	29.3	5.8	15.9	1.62	8.0	Hazardous
Mazdoor Nagar Raipur	569.9	48.4	2.579	10.05	0.1941	0.0524	5.3990	32.3	22.1	6.7	15.1	3.40	11.8	Hazardous
Amlidih Mahaveer Nagar	283.5	16.5	0.813	1.69	0.024	0.011	0.229	19.0	13.8	3.75	8.3	1.38	2.79	**Hazardous**
Health-based standards														
EPA Air Quality Index, 24-hour	**>250.5**	**Hazardous - This would trigger a health warnings of emergency conditions. The entire population is more likely to be affected.**												
EPA Air Quality Index, 24-hour	**150.5–250.4**	**Very Unhealthy - People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.**												
EPA Air Quality Index, 24-hour	**55.5-150.4**	**Unhealthy - People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion**												
EPA Air Quality Index, 24-hour	**35-5-55.4**	**Unhealthy for Sensitive Groups - People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.**												
WHO 24-hour	25	None	None	None	None	None	None	None						
WHO annual	10	None	0.15	None	None	0.0025	0.50	None						
EPA 24-hour	35	None	None	None	None	None	None	None						
EPA 3-month	None	None	None	None	None	None	0.15	None						
EPA annual	12	None	None	None	None	None	None	None						
India NAAQS 24-hour	60	None	None	None	None	None	1.00	None						
India NAAQS Annual	40	None	None	None	None	0.02	0.50	None						
California OEHHA 24-hour	None	None	None	None	None	0.2	None	None						
California OEHHA annual*	None	None	0.09	None	None	0.014	None	3						
EPA RfC	None	None	0.05	None	None	None	None	None						
Comparative Background Urban Levels (Wilmington, USA)	18.5	0.11	0.004	0.013	0.013	0.004	0.006	0.08	0.035	1.82	0.0228	0.23	0.035	
* Standard for crystalline silica														
http://oehha.ca.gov/air/allrels.html														
(red)	Sample level exceeds 24-hour standard (directly comparable)													
(yellow)	Sample level exceeds annual standard (of significance if reflects generally prevailing air quality)													

Table 4: Raipur – Location and PM2.5 in the Air

Location Name	PM2.5 (µg/m³)	India NAAQS (60µg/m³)	Health Implications (As per US EPA Categorisation)
Changorabhata	131.4	60.0	Unhealthy
Mandir Hasaud	146.5	60.0	Very Unhealthy
Sitlapara Bhatagaon	197.8	60.0	Very Unhealthy
Tikrapara	203.2	60.0	Very Unhealthy
Amlidih Mahaveer Nagar	283.5	60.0	Hazardous
Birgaon Saheed Nagar2	290.7	60.0	Hazardous
Sendhwapara	355.3	60.0	Hazardous
Utkal Nagar	382.8	60.0	Hazardous
Birgaon Saheed Nagar1	410.8	60.0	Hazardous
Urla Raipur	563.5	60.0	Hazardous
Mazdoor Nagar Raipur	569.9	60.0	Hazardous
Acholi Urla	653.8	60.0	Hazardous

Graph 1: Raipur – Location and PM2.5 in the Air

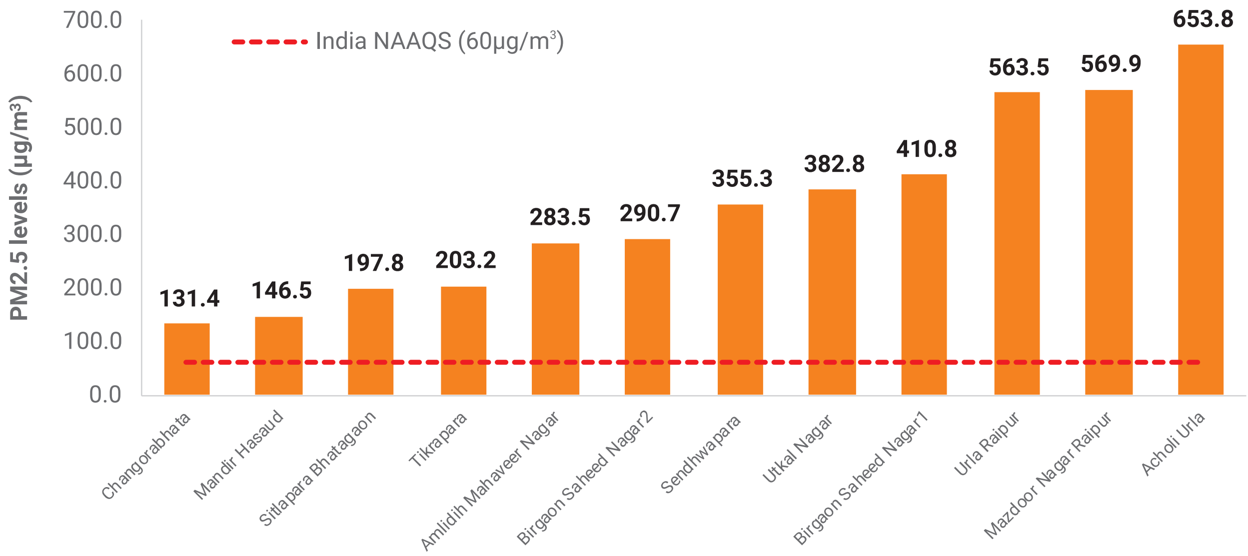


Table 5: Raipur – Location and Silica (Si) in the Air

Location Name	Si	California OEHHA Annual (3µg/m³)
Tikrapara	6.8	3
Changorabhata	8.1	3
Mandir Hasaud	9.3	3
Sitlapara Bhatagaon	11.9	3
Birgaon Saheed Nagar2	15.6	3
Sendhwapara	18.1	3
Utkal Nagar	18.4	3
Amlidih Mahaveer Nagar	19.0	3
Birgaon Saheed Nagar1	20.6	3
Mazdoor Nagar Raipur	32.3	3
Acholi Urla	32.3	3
Urla Raipur	33.8	3

Graph 2: Raipur – Location and Silica (Si) in the Air

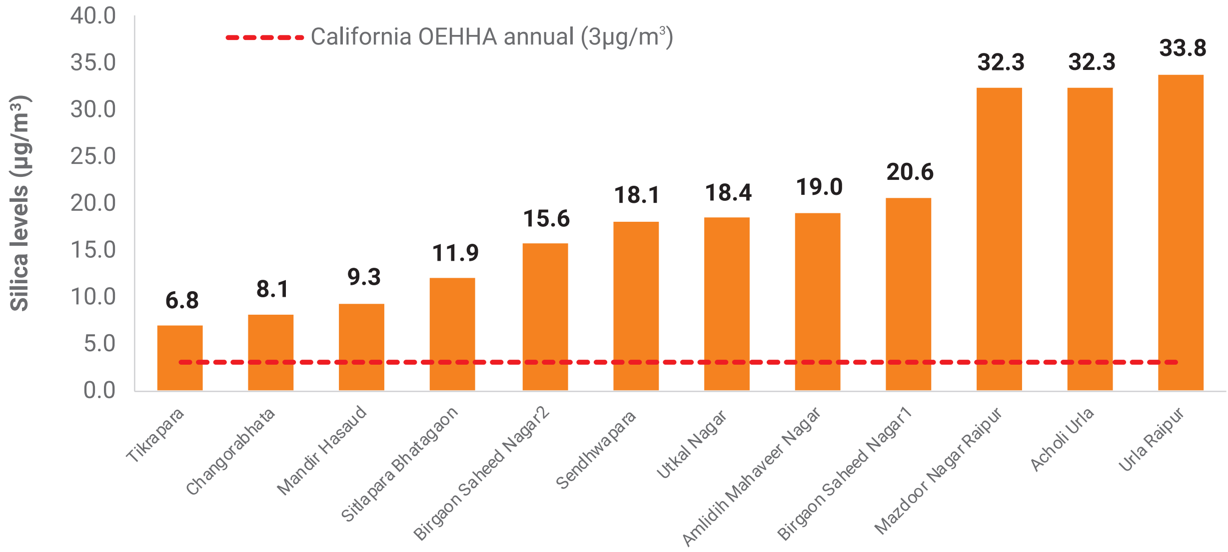


Table 6: Raipur – Location and Nickel (Ni) in the Air

Location Name	Ni	WHO Annual Average (0.0025µg/m³)
Tikrapara	0.0055	0.0025
Mandir Hasaud	0.0097	0.0025
Changorabhata	0.0100	0.0025
Amlidih Mahaveer Nagar	0.011	0.0025
Sitlapara Bhatagaon	0.0130	0.0025
Utkal Nagar Civil Lines	0.0243	0.0025
Birgaon Saheed Nagar1	0.0348	0.0025
Birgaon Saheed Nagar2	0.0370	0.0025
Acholi Urla	0.0474	0.0025
Sendhwapara	0.0494	0.0025
Mazdoor Nagar Raipur	0.0524	0.0025
Urla Raipur	0.0634	0.0025

Graph 3: Raipur – Location and Nickel (Ni) in the Air

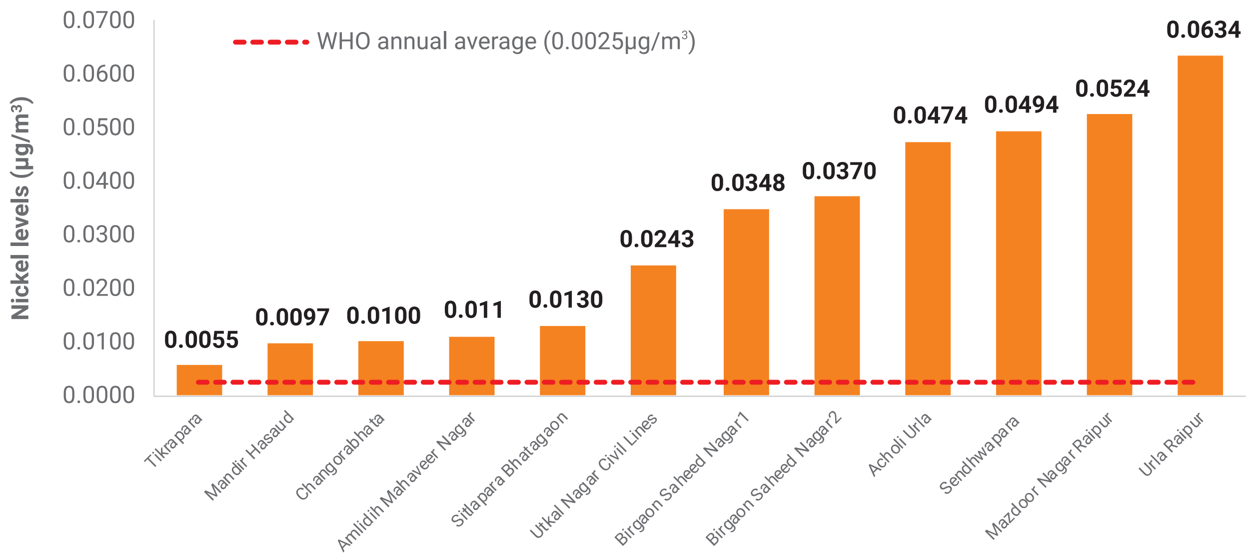


Table 7: Raipur – Location and Lead (Pb) in the Air

Location Name	Lead (Pb)	India NAAQS 24-hour
Mandir Hasaud	0.0322	1
Changorabhata	0.0800	1
Bhatagaon	0.2175	1
Amlidih Mahaveer Nagar	0.229	1
Civil Lines	0.3527	1
Birgaon Saheed Nagar2	0.3561	1
Birgaon Saheed Nagar1	0.9392	1
Acholi Urla	1.4610	1
Tikrapara	1.6670	1
Urla Raipur	2.7560	1
Nagar Sendhwapara	4.2030	1
Mazdoor Nagar Raipur	5.3990	1

Graph 4: Raipur – Location and Lead (Pb) in the Air

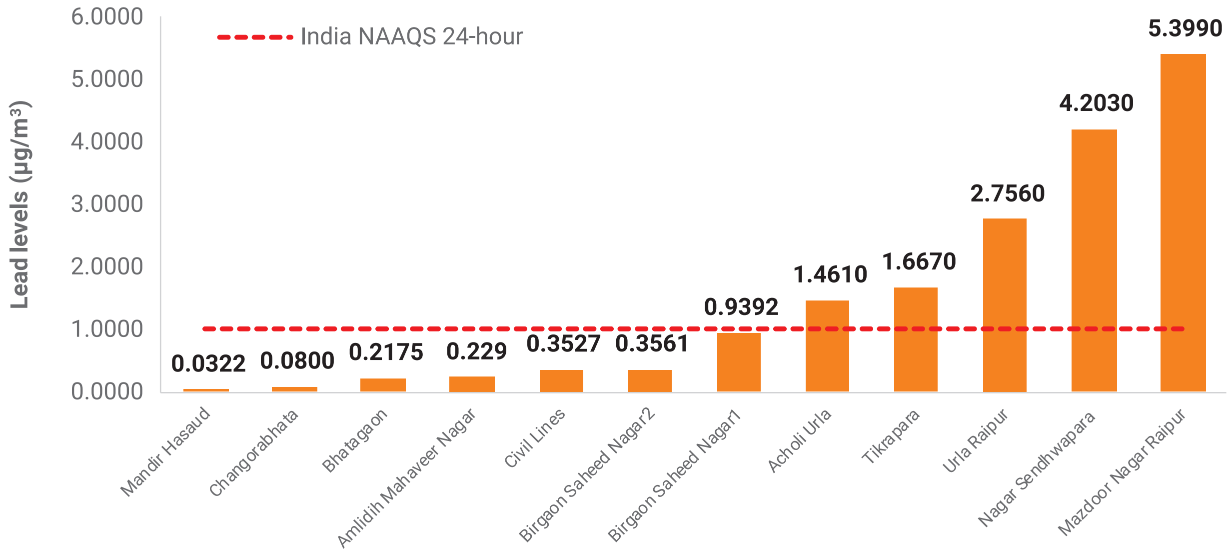
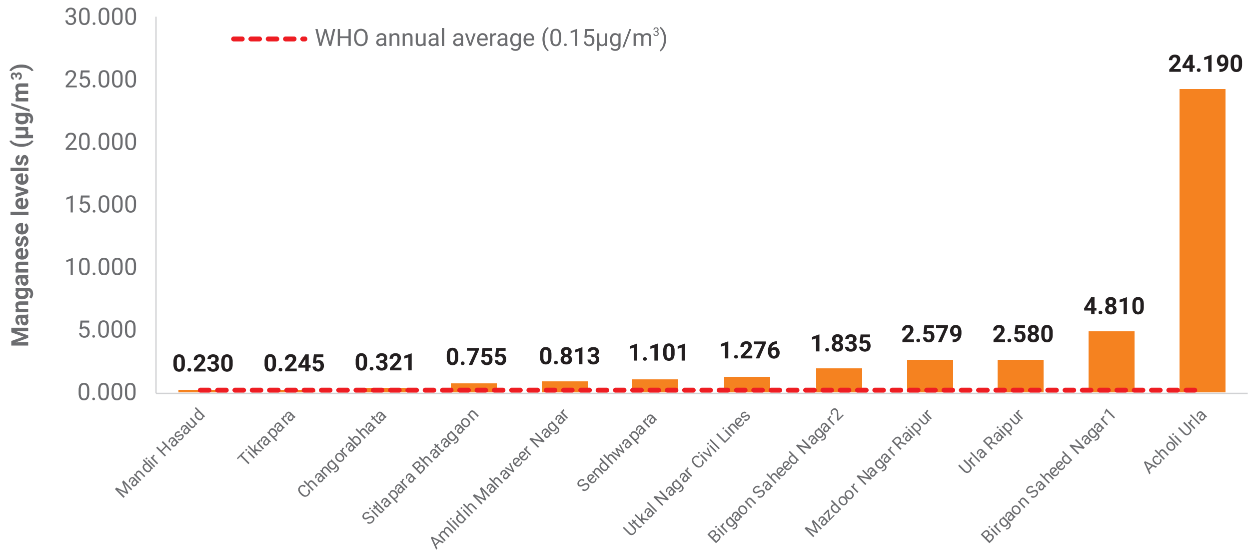


Table 8t: Raipur – Location and Manganese (Mn) in the Air

Location Name	Manganese (Mn)	WHO Annual Average (0.15µg/m³)
Mandir Hasaud	0.230	0.15
Tikrapara	0.245	0.15
Changorabhata	0.321	0.15
Sitlapara Bhatagaon	0.755	0.15
Amlidih Mahaveer Nagar	0.813	0.15
Sendhwapara	1.101	0.15
Utkal Nagar Civil Lines	1.276	0.15
Birgaon Saheed Nagar2	1.835	0.15
Mazdoor Nagar	2.579	0.15
Urla Raipur	2.580	0.15
Birgaon Saheed Nagar1	4.810	0.15
Acholi Urla	24.190	0.15

Graph 5: Raipur – Location and Manganese (Mn) in the Air



Results: Korba

Table 9: Korba – Location and Air Sample Analysis

Location Name	PM2.5	Fe	Mn	Zn	Cu	Ni	Pb	Si	Ca	S	Al	Na	Cl	Comments re PM2.5 level
Rani Danraj Kuwar PHC	265.0	6.9	0.129	0.19	0.025	0.013	0.057	23.2	10.5	2.91	11.7	0.86	0.69	**Hazardous**
District Hospital	186.5	4.2	0.070	0.15	0.012	0.042	0.030	14.1	4.5	2.48	9.1	1.22	0.82	**Very Unhealthy**
Ghandhi Nagar Sirki,	1,699.2	32.0	0.557	0.35	0.067	0.048	0.060	82.1	29.7	5.76	45.5	1.46	1.39	**Hazardous**
Sirki, Khurda	888.1	15.4	0.249	0.19	0.033	0.025	0.060	58.3	13.6	5.29	34.5	1.30	0.93	**Hazardous**
Chainpur	459.2	12.9	0.326	0.24	0.020	0.019	0.046	38.7	8.3	5.18	22.5	0.59	0.80	**Hazardous**
Beltekri 1	427.8	8.2	0.398	0.16	0.018	0.012	0.036	31.9	6.0	4.95	18.3	0.39	0.65	**Hazardous**
Beltekri 2	762.8	12.7	0.994	0.30	0.030	0.023	0.063	53.1	7.9	7.12	32.4	0.54	0.77	**Hazardous**
Hardi Bazar	562.1	11.1	0.290	0.19	0.025	0.021	0.086	44.6	8.7	4.80	25.9	0.80	0.83	**Hazardous**
Dharampur Gerva	482.1	18.4	0.242	0.16	0.022	0.019	0.051	39.6	17.5	2.79	20.9	0.58	0.90	**Hazardous**
Emli Chhapar	1,613.3	48.7	0.718	0.36	0.084	0.050	0.117	89.9	52.2	4.47	47.3	1.53	1.57	**Hazardous**
Pankhadafai	491.5	14.3	0.309	0.23	0.024	0.021	0.057	39.1	12.8	4.27	20.6	0.88	1.09	**Hazardous**
Kanshinagar, Niharika	278.1	6.9	0.162	0.13	0.043	0.011	0.044	25.8	5.7	5.64	14.6	0.85	0.45	**Hazardous**
Checkpost, Balco	150.3	3.6	0.092	0.10	0.033	0.014	0.025	12.3	2.7	4.49	7.6	0.78	0.15	**Very Unhealthy**
Manikpur	309.2	5.3	0.109	0.10	0.010	0.011	0.025	29.4	2.3	4.44	17.7	0.6078	0.29	**Hazardous**
Health-based standards														
EPA Air Quality Index, 24-hour	**>250.5**	**Hazardous - This would trigger a health warnings of emergency conditions. The entire population is more likely to be affected.**												
EPA Air Quality Index, 24-hour	**150.5–250.4**	**Very Unhealthy - People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.**												
A Air Quality Index, 24-h	**55.5-150.4**	**Unhealthy - People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion**												
A Air Quality Index, 24-h	**35-5-55.4**	**Unhealthy for Sensitive Groups - People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.**												
WHO 24-hour	25	None	None	None	None	None	None	None						
WHO annual	10	None	0.15	None	None	0.0025	0.50	None						
EPA 24-hour	35	None	None	None	None	None	None	None						
EPA 3-month	None	None	None	None	None	None	0.15	None						
EPA annual	12	None	None	None	None	None	None	None						
India NAAQS 24-hour	60	None	None	None	None	None	1.00	None						
India NAAQS Annual	40	None	None	None	None	0.02	0.50	None						
California OEHHA 24-ho	None	None	None	None	None	0.2	None	None						
California OEHHA annua	None	None	0.09	None	None	0.014	None	3						
EPA RfC	None	None	0.05	None	None	None	None	None						
Comparative Backgroun	18.5	0.11	0.004	0.013	0.013	0.004	0.006	0.08	0.035	1.82	0.0228	0.23	0.035	
Levels (Wilmington, USA)														
* Standard for crystalline silica														
http://oehha.ca.gov/air/allrels.html														
(red)	Sample level exceeds 24-hour standard (directly comparable)													
(yellow)	Sample level exceeds annual standard (of significance if reflects generally prevailing air quality)													

Table 10: Korba – Location and PM2.5 in the Air

Location Name	PM2.5 (µg/m³)	India NAAQS (60µg/m³)
Checkpost, Balco	150.3	60
District Hospital	186.5	60
Rani Danraj Kuwar PHC	265.0	60
Kanshinagar, Niharika	278.1	60
Manikpur	309.2	60
Beltekri 1	427.8	60
Chainpur	459.2	60
Dharampur Gerva	482.1	60
Pankhadafai	491.5	60
Hardi Bazar	562.1	60
Beltekri 2	762.8	60
Sirki, Khurda	888.1	60
Emli Chhapar	1,613.3	60
Ghandhi Nagar Sirki, Khurda	1,699.2	60

Graph 6: Korba – Location and PM2.5 in the Air

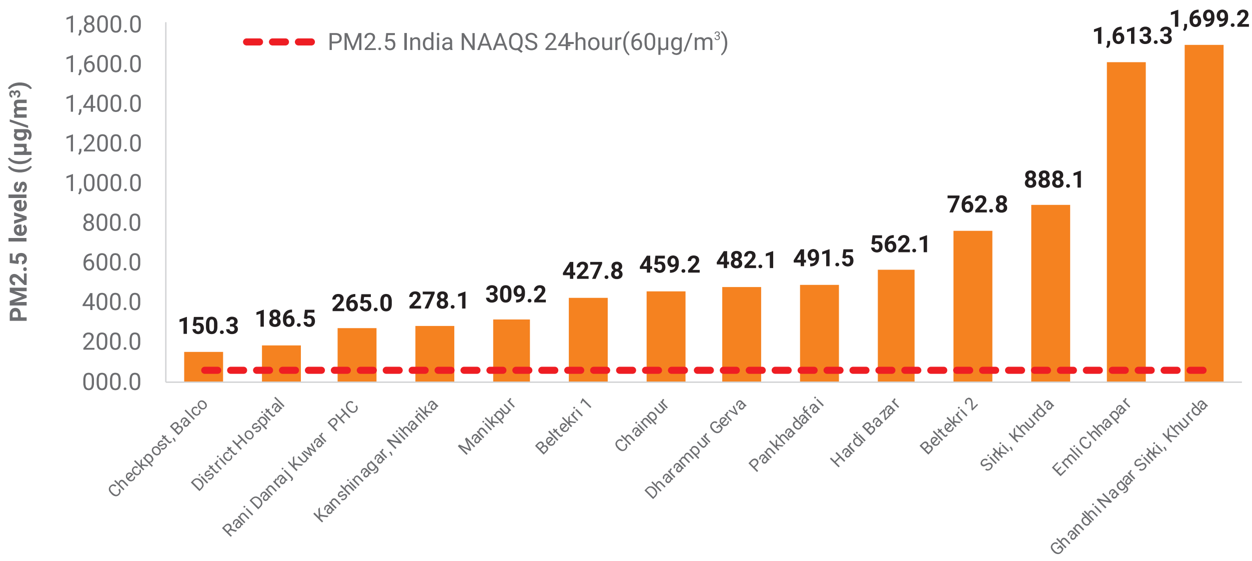


Table 11: **Korba** – Location and Silica (Si) in the Air

Location Name	Silica Levels (µg/m³)	California OEHHA Annual (3µg/m³)
Checkpost, Balco	12.3	3
District Hospital	14.1	3
Rani Danraj Kuwar PHC	23.2	3
Kanshinagar, Niharika	25.8	3
Manikpur	29.4	3
Beltekri 1	31.9	3
Chainpur	38.7	3
Pankhadafai	39.1	3
Dharampur Gerva	39.6	3
Hardi Bazar	44.6	3
Beltekri 2	53.1	3
Sirki, Khurda	58.3	3
Ghandhi Nagar Sirki, Khurda	82.1	3
Emli Chhapar	89.9	3

Graph 7: **Korba** – Location and Silica (Si) in the Air

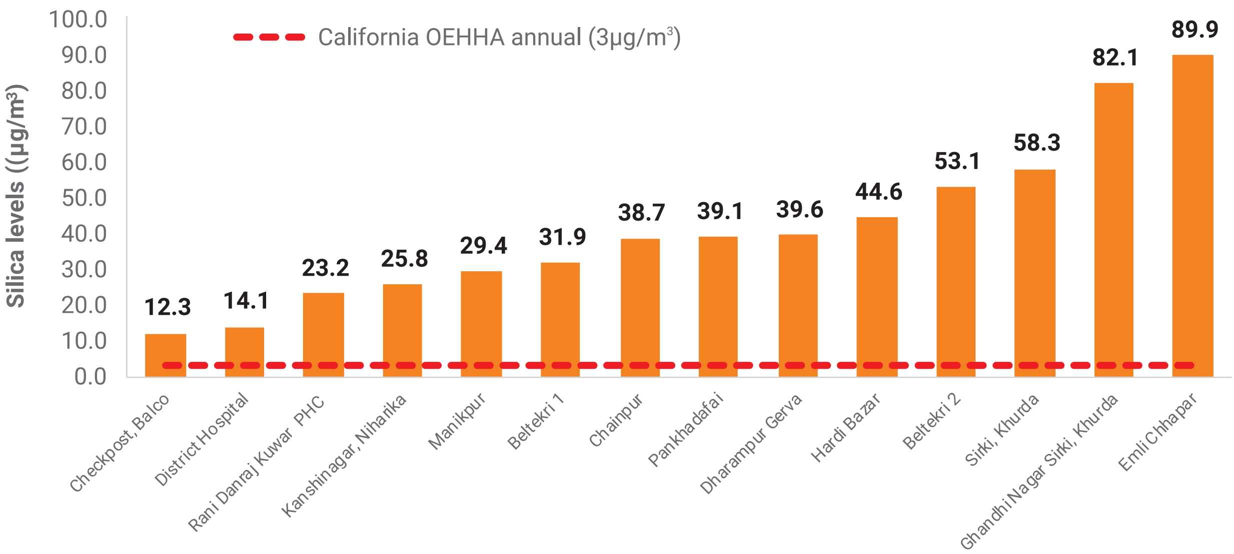


Table 12: Korba – Location and Nickel (Ni) in the Air

Location Name	Nickel Levels (µg/m³)	WHO Annual Average (0.0025µg/m³)
Kanshinagar, Niharika	0.011	0.0025
Manikpur	0.011	0.0025
Beltekri 1	0.012	0.0025
rani Danraj Kuwar PHC	0.013	0.0025
Checkpost, Balco	0.014	0.0025
Dharampur Gerva	0.019	0.0025
Chainpur	0.019	0.0025
Pankhadafai	0.021	0.0025
Hardi Bazar	0.021	0.0025
Beltekri 2	0.023	0.0025
Sirki, Khurda	0.025	0.0025
District Hospital	0.042	0.0025
Ghandhi Nagar Sirki, Khurda	0.048	0.0025
Emli Chhapar	0.050	0.0025

Graph 8: Korba – Location and Nickel (Ni) in the Air

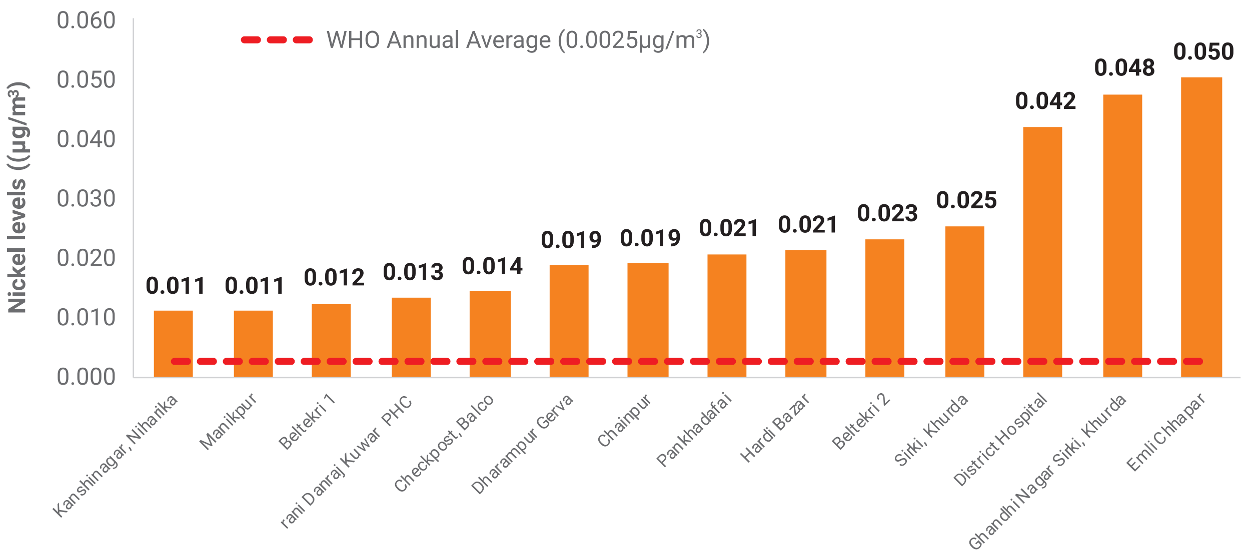


Table 13: **Korba** – Location and Lead (Pb) in the Air

Location Name	Lead Levels (µg/m³)	US EPA 3-month Average (0.15µg/m³)
Manikpur	0.025	0.15
Checkpost, Balco	0.025	0.15
District Hospital	0.030	0.15
Beltekri 1	0.036	0.15
Kanshinagar, Niharika	0.044	0.15
Chainpur	0.046	0.15
Dharampur Gerva	0.051	0.15
Pankhadafai	0.057	0.15
rani Danraj Kuwar PHC	0.057	0.15
Ghandhi Nagar Sirki, Khurda	0.060	0.15
Sirki, Khurda	0.060	0.15
Beltekri 2	0.063	0.15
Hardi Bazar	0.086	0.15
Emli Chhapar	0.117	0.15

Graph 9: **Korba** – Location and Lead (Pb) in the Air

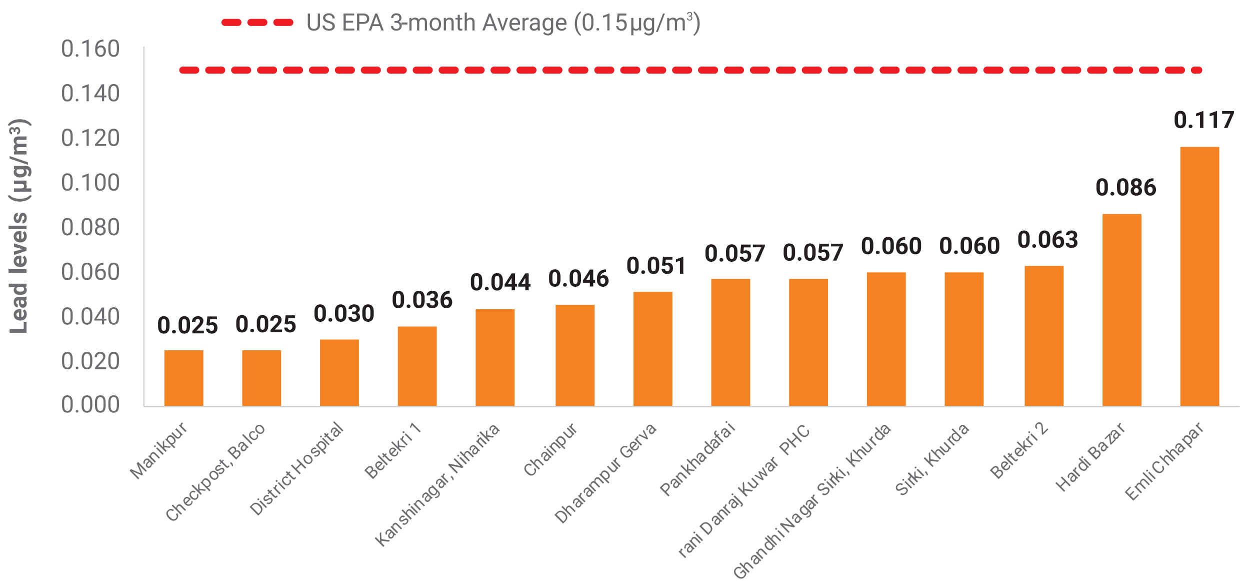
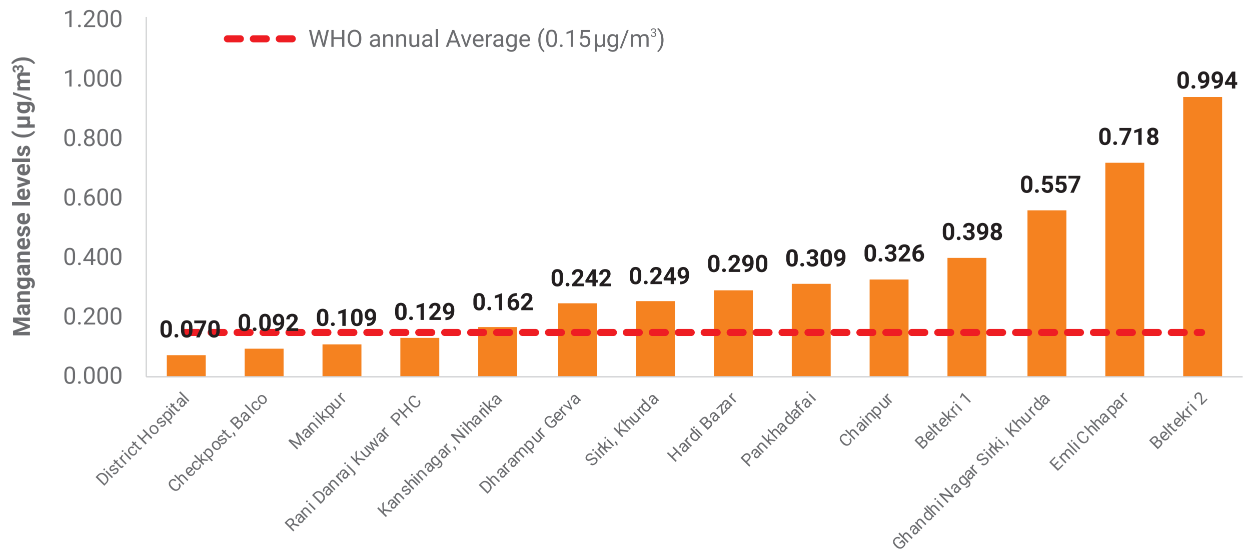


Table 14: **Korba** – Location and Manganese (Mn) in the Air

Location Name	Manganese Levels (µg/m³)	WHO Annual Average (0.15µg/m³)
District Hospital	0.070	0.15
Checkpost, Balco	0.092	0.15
Manikpur	0.109	0.15
Rani Danraj Kuwar PHC	0.129	0.15
Kanshinagar, Niharika	0.162	0.15
Dharampur Gerva	0.242	0.15
Sirki, Khurda	0.249	0.15
Hardi Bazar	0.290	0.15
Pankhadafai	0.309	0.15
Chainpur	0.326	0.15
Beltekri 1	0.398	0.15
Ghandhi Nagar Sirki, Khurda	0.557	0.15
Emli Chhapar	0.718	0.15
Beltekri 2	0.994	0.15

Graph 10: **Korba** – Location and Manganese (Mn) in the Air



Overall Findings

1. PM2.5 levels in all samples in Raipur ranged from 131.4 to 653.8µg/m^3 and were between 2.18 and 10.88 times higher than standards prescribed by the Ministry of Environment, Forests and Climate Change (MoEFCC) of 60µg/m^3. In Korba the levels of PM2.5 in all samples were at least 2.5 to 28.3 times above the prescribed limits of the MoEFCC limits. The levels of very fine particulates in all the air samples pose a significant risk to the human health of residents.
2. Levels of crystalline silica were seen elevated in all the samples of Raipur and Korba. Both coal ash and construction sand have high levels of crystalline silica and could be prominent contributors. Acute exposure to silica causes a fatal lung disease called Silicosis. Silica also irritates the respiratory system and causes lung disorders.
3. In Raipur as well as in Korba nickel levels in all samples exceed the WHO annual health-based guidelines value of 0.0025µg/m^3, which is based on the risk of cancer associated with long-term exposure to nickel. Exposure to nickel in ambient air also affects the respiratory and immune systems in the body.
4. From Raipur out of 12 samples, six samples, shows higher levels of lead (Pb) when compared with the US EPA standard of 0.15µg/m^3, averaged for three month. Lead is a known neurotoxin. Children are particularly vulnerable to the effects of this heavy metal. Exposures to even low levels of lead early in life have been linked to effects on IQ, learning, memory and behavior.
5. In Raipur levels of manganese in all the twelve samples exceed the U.S. EPA Reference Concentration for exposure to manganese (0.05µg/m^3). In Korba, samples from 11 locations out of 14 had manganese exceeding the WHO annual health-based guidelines value of 0.15µg/m^3. Manganese is commonly used as a melting agent in ferrous foundries. Owing to the small particle size, manganese tends to remain suspended in the air for long periods of time. Manganese level is highest in one area which is nearly 4 Km away from power plant. There are no standards in India for Manganese in ambient air. Manganese is a known neurotoxin and affects the neurobehavioral functions. According to the US EPA, chronic (long-term) exposure to high levels of manganese by inhalation in humans may result in central nervous system (CNS) effects. Visual reaction time, hand steadiness, and eye-hand coordination were affected in chronically exposed worker.

PM2.5

The pollutants present in the air are a mixture of particulate matter and gaseous particles. The Particulate Matter (PM) mainly comprises of dust, pollen, ash, soot, heavy metals and carbon. The particulate matter are generally classified as coarse particles (particles size that is 10 microns and below) and fine particles (particles size less than 2.5 micrometer).

Because of the fine nature of the particles, PM2.5 are easily inhalable; penetrate deep into the alveoli of the lungs; enter the circulatory systems and pose a wide range of health impacts in human beings. Previous studies have proven that PM2.5 causes respiratory illness, cardiovascular diseases, stroke and psychological impacts among the individuals who are exposed. Research has also proven that PM2.5 crosses the placental barriers and results in birth defects among newborn babies. It has been demonstrated that long-term exposure to air pollution is associated with an increased prevalence of respiratory diseases and deaths. Fine particulate matter with size <2.5µm, PM2.5 is considered is one of the major health risk factors in the environment, causing millions of deaths annually around the world. The presence of PM2.5 and another one also PM10 are specifically associated with an increased rate of respiratory diseases, and of hospitalization for chronic lung disease and pneumonia. *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7725793/*

Silica

The naturally occurring element Silicon when combined with oxygen gives rise to Silicon dioxide widely known as Silica. The crystalline Silica compound is fine in nature and enters the human body through inhalation. Construction and demolition sites, rock crushing units, mining and excavation sites, coal ash, etc., contribute to silica dust. Permissible Exposure Limits (PEL) for silica for the general public is not provided by US EPA, WHO AQ standards or India NAAQS. US EPA has provided an 8-hour average of PEL for Silica as 50μg/m^3 for the individuals who are working in industries related to Silica (eg: Construction workers)[4]. Generally, workers and local populations who are chronically exposed to Silica develop silica related respiratory illnesses. The fine silica particle can easily enter the lungs and causes incurable scarring of lung tissues known as silicosis which is fatal. Exposure to Silica is also associated with lung cancer, kidney diseases and musculoskeletal problems

Nickle

Nickel levels in all samples exceed the WHO annual health-based guidelines value of 0.0025μg/m^3, which is based on the risk of cancer associated with long-term exposure to nickel. The WHO air quality guidelines state the following: "Nickel compounds are human carcinogens by inhalation exposure. The present data are derived from studies in occupationally exposed human populations. Assuming a linear dose-response, no safe level for nickel compounds can be recommended. On the basis of the most recent information of exposure and risk estimated in industrial populations, an incremental risk of 3.8×10^{-4} can be given for a concentration of nickel in the air of 1μg/m^3. The concentrations corresponding to an excess lifetime risk of 1:10 000, 1:100 000 and 1: 1 000 000 are about 250, 25 and 2.5μg/m^3, respectively."

Lead

Lead can enter the human body through inhalation, swallowing or absorption. The health effects are almost the same for all the routes of entry. When an individual gets exposed to very high levels of lead over a short period of time, it results in Lead poisoning which is characterized by abdominal pain, constipation, fatigue, headache, irritability, loss of appetite, memory loss, pain or tingling in the hands and/or feet and generalized weakness. As these symptoms are relatively common and may occur due to other conditions, lead poisoning can be easily overlooked. Exposure to very high levels of Lead causes anemia, kidney and brain damages and can even result in death. Lead can also cross the placental barrier, impact fetal brain development and can cause miscarriage, stillbirths, and infertility.

Manganese

Long term, as well as acute high-level exposure to Manganese, is proven to cause neurological damages and resulting in a condition known as manganism (Manganism is a distinct medical condition from Parkinson's disease), in the advanced stage it is characterized by a mask-like face, altered gait, fine tremors and other psychological disturbances. As the particle size of Manganese is less than 6μm, it is easily inhalable and results in the inflammatory response in the lungs. Though there is conclusive evidence on Manganese and its impact on human health, there are no standards recommended for Manganese in ambient air by India NAAQS.

4 https://www.osha.gov/silica/factsheets/OSHA_FS-3683_Silica_Overview.html

Discussion

PM2.5

The levels of PM2.5 in all the samples were above the prescribed limits of Government of India (60µg/m^3). Samples taken from seven areas in Raipur (Acholi Urla, Mazdoor Nagar Raipur, Urla Raipur, Birgaon Saheed Nagar1, Utkal Nagar, Sendhwapara, Birgaon Saheed Nagar2) were found to be more than 250µg/m^3". Six out of seven sites are located around the sponge, iron, timber industries and Bajrang power plant.

Samples taken from thirteen areas in Korba (Ghandhi Nagar Sirki, Khurda, Emli Chhapar, Sirki, Khurda, Beltekri 2, Hardi Bazar, Pankhadafai, Dharampur Gerva, Chainpur, Beltekri 1, Manikpur, Kanshinagar, Niharika, Rani Dhanraj Kunwar PHC Korba) were found to be in category of "Hazardous". Most of them are located near to thermal power plants which includes Chhattisgarh State Electricity Board power stations. Manikpur is located 1 Km away from a garbage dump yard.

Samples taken from two areas in Korba around the power plants (District Hospital Korba, Checkpost, Balco) have "Very Unhealthy" levels of PM2.5. Because of the fine nature of the particles, PM2.5 are easily inhalable; penetrate deep into the alveoli of the lungs; enter the circulatory systems and pose a wide range of health impacts in human beings. Previous studies have proven that PM2.5 causes respiratory illness, cardiovascular diseases, stroke and psychological impacts among the individuals who are exposed[5]. Researches have also proven that PM2.5 crosses the placental barriers and results in birth defects among newborn babies[6]. PM induces inflammation in lung cells and exposure to PM could increase the susceptibility and severity of the COVID-19 patient symptoms[7].

Silica

All the 12 samples in Raipur had silica levels higher than that of California OEHHA annual average for exposure of 3µg/m^3. Sample location at Urla Raipur (S18) showed the highest level of Silica at 33.8µg/m^3.

All the 14 samples in Korba had silica levels higher than that of California OEHHA annual average for exposure of 3µg/m^3. Emli Chhapar showed highest value of 89.9µg/m^3.

US Environmental Protection Agency (EPA) has provided 8-hour average for Silica as 50µg/m^3 for the individuals who are working in industries related to Silica (eg: Construction workers). Generally, workers and local populations who are chronically exposed to Silica develop silica-related respiratory illnesses. The fine silica particle can easily enter into the lungs and causes incurable scarring of lung tissues known as silicosis which is fatal. Exposure to Silica is also associated with lung cancer, kidney diseases and musculo-skeletal problems.

Nickle

Nickle levels in the filtered air samples from Raipur in November 2020 to February 2021, and all the filtered samples from Korba between February 2021 to June 2021 reflect conditions that generally prevail over the long-term, then persons in these areas would suffer an excess lifetime risk of cancer of 4 per 1 million (compared to 1.6 per 1 million for typical levels of nickel in urban air).

5 http://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf
6 http://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf
7 Comunian, 2020, Air Pollution and COVID-19: The Role of Particulate Matter in the Spread and Increase of COVID-19's Morbidity and Mortality, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7345938/

Lead

Out of 12 samples in Raipur, six samples from Mazdoor Nagar, Tikrapara, Acholi Urla, Sendhwapara), Urla Raipur, Amlidih (Galaxy Residency) shows higher levels of lead when compared with the US EPA standard of 0.15µg/m^3, averaged for three months. Lead can enter into the human body through inhalation, swallowing or absorption.

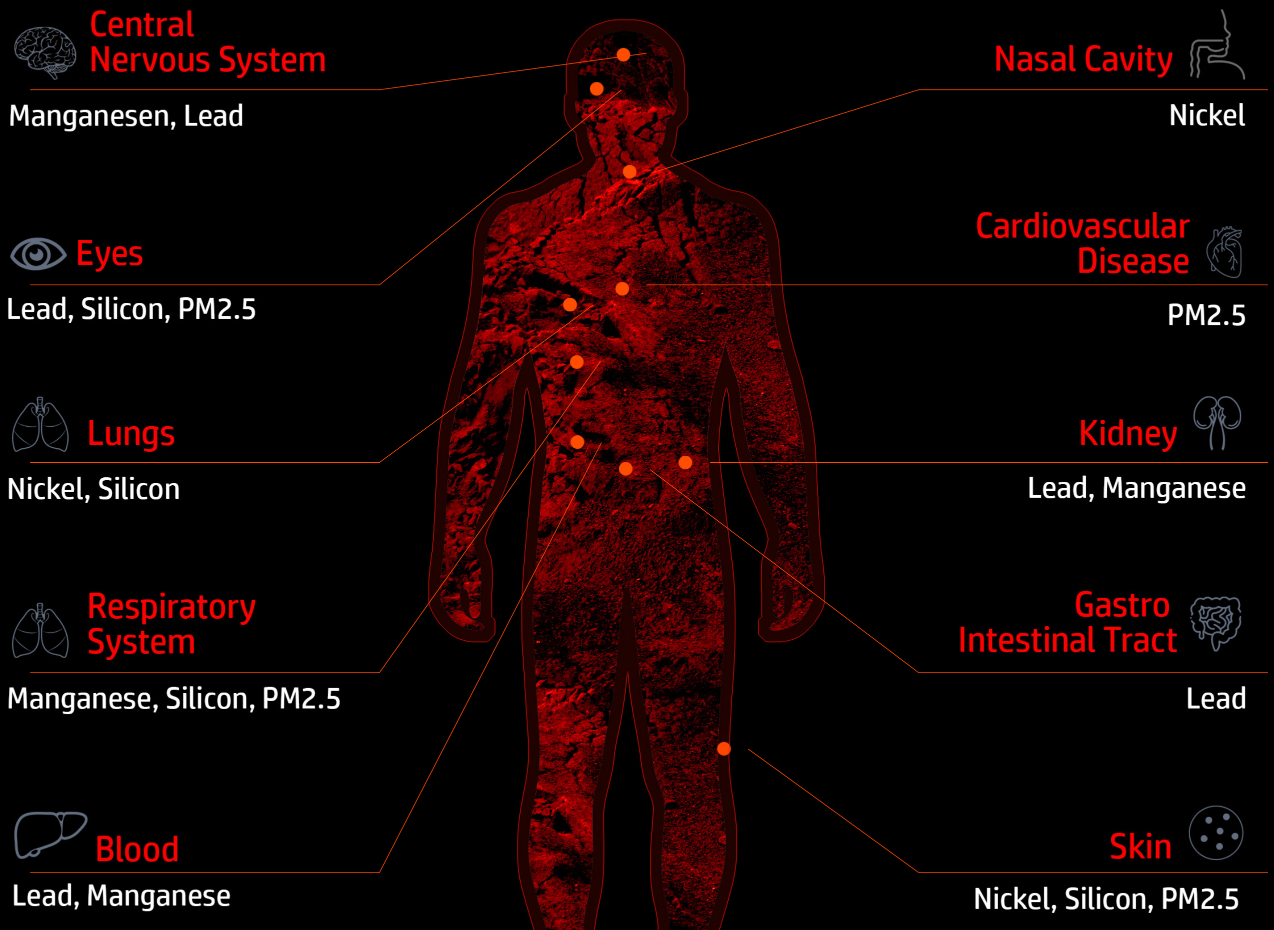
Raipur samples indicate high level of presence of lead (Pb) compared to Korba.

Manganese

Raipur samples from all 12 locations had manganese exceeding the US Environmental Protection Agency (EPA) reference concentration (0.05µg/m^3). Out of these 12 samples, all the samples showed manganese level above the WHO annual health-based guidelines value of 0.15µg/m^3. Sample from Acholi Urla (S5) shown highest value of 24.190µg/m^3. Manganese is commonly used as a melting agent in ferrous foundries. Owing to the small particle size, manganese tends to remain suspended in air for long periods of time[8]. From Korba samples from 11 locations out of 14 indicated manganese exceeding the WHO annual health-based guidelines value of 0.15µg/m^3. As the particle size of manganese is less than 6 µm, it is easily inhalable and results in the inflammatory response in the lungs. Though there is conclusive evidence on manganese and its impact on human health, there are no standards recommended for manganese in ambient air by India, National Ambient Air Quality Standards (NAAQS)

8 Mirmohammadi S (2014) Manganese Exposure and Toxicity. J Pollut Eff Cont 2: 116 doi: 810.4172/2375-4397.1000116

Health Implications of the Results



The result of the ambient air quality analysis of Raipur and Korba shows that the air quality in the region has worsened in the last few years. When compared with the previous SHRC reports on ambient air quality from the region in 2019 and 2020 *https://shsrc.org/wp-content/uploads/2020/05/Korba-AQ-report-2020.pdf* it seems like that the level of pollutants in the air has drastically increased in 2021. It would thus not be wrong to allude that the pollution situation in Raipur and Korba has reached a very dangerous level and has worsened over a period of two years. High levels of PM2.5 value is shown by all twenty six (26) samples taken from Raipur and Korba .All the samples have also shown higher levels of heavy metals such as lead, manganese, nickel, and silica.

It has also been observed in the field visits over a period of two years that the disposal of in open areas, near agricultural field, entering the premises of the residential areas has been increased, which has worsen the air quality of the district. The Manikpur mine which has been commercially consumed leaving behind the huge crater. The huge crater has been filled and covered by fly ash thus making the ground water of Korba more vulnerable for poisoning. The land around the mine also becomes vulnerable to sink with a slight tremor of earthquake. Though Chhattisgarh region is less prone to earthquake yet the possibility cannot be completely ruled out keeping in view the changing trends of climatic and geological conditions due to Climate Change.

Conclusion

Heavy metal toxicity can have several health effects in the body. Heavy metals can damage and alter the functioning of organs such as the brain, kidney, lungs, liver, and blood. There is no doubt that the districts and neighboring districts of Raipur and Korba may face and have health disasters in the future. Existing environmental health impacts of climate change and air pollution is life threatening combination for the short- & long-term disasters in Raipur and Korba. Children and asthmatics of any age, those with allergies and the elderly who have reduced lung capacity can be affected in less time. It is thus essential to strengthen health system with mitigation strategies in order to address the health burden in association with air pollution and take necessary preventive measures to control the pollution levels in ambient air across Raipur and Korba.

Raipur is also one the non-attainment cities accruing to National Clean Air Program (NCAP) *https://pib.gov.in/PressReleasePage.aspx?PRID=1655203* and despite the recommendations made in the previous reports and considering the ongoing situation of the pandemic Covid-19, it seems like no initiative or action has been taken in order to check the poor air quality.

Studies have shown that air pollution increases vulnerability to COVID-19 and exacerbates it symptoms. Emerging research is indicating that people affected by air pollution are more vulnerable to risks and complexities of COVID-19. A study from Harvard University's T.H. Chan School of Public Health has found correlation between air pollution and COVID-19 deaths in the US. "The results of this paper suggest that long-term exposure to air pollution increases vulnerability to experiencing the most severe Covid-19 outcomes." *https://www.nytimes.com/2020/04/07/climate/air-pollution-coronavirus-covid.html* by Earlier, a Paper Published the Italian Society of Environmental Medicine suggests that "the rapid increase of contagion rates that has affected some areas of Northern Italy could be tied to atmospheric particulate pollution acting as a carrier and booster there". Air pollution is exacerbating the COVID-19 pandemic. Globally, approximately 15% of deaths from COVID-19 are linked to PM 2.5 Air Pollution. *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7345938/* The authors estimate that average PM2.5 concentrations above 3.6µg/m^3 (range: 0.0–6.7) increase the risk of death for COVID-19 patients, also underscoring the need to devise stringent health-based air quality standards.

The Chhattisgarh studies have also shown that air pollution increases vulnerability to COVID-19 and exacerbates its symptoms. The pattern in Chhattisgarh has confirmed this view. *Journal Chikitsak Vol:6 Issue: 1, January 2021 Kamlesh Jain, Punita Kumar, Shweta Narayan, Vishvaja Sambath, State Nodal Officer, National Program for Climate Change and Human Health, Chhattisgarh Unit & Professor, Department of Community Medicine, Pt JNM medical college Raipur, 2- Climate Change & Human Health Cell, State Health Resource Centre, Chhattisgarh, 3- Advisor, Healthy Energy Initiative India, 4- Senior Researcher, Healthy Energy Initiative India.*

Disposal of fly ash, especially in Korba District has also contributed to the dangerous levels of pollutants. To overcome pollution in Raipur and Korba and other vulnerable districts in with respect to air pollution, serious efforts should be made by the government to control pollution caused by industries, mining, vehicles, construction works and coal transport etc. Local governments should leverage air quality information and emissions data to guide their city planning decisions in ways that protect residents from exposure to air pollution. Urgent measures need to be taken to mitigate the health ill effects of air pollution and upgrade the capacity of the existing health infrastructure to ensure that immediate care and relief is provided to the populations affected by air pollution. It is also concluded that geological conditions need to be considered keeping Climate Change in the view. Climate change is an acknowledged phenomenon and Korba and other nearby district indicates the vulnerability to climate change.

Further, the health system needs to take note of the presence of these levels of heavy metals and commission a health survey to put in place measures for follow up of the population indicating long term exposure.

Recommendations

Health

1. Specialized health care infrastructure operated by the State health departments at polluters' cost, under the "polluter pays" principle, to cater to health issues of residents in the region of Korba, and Raipur.
2. Facilities like spirometer at the district hospitals with provision of technical expertise, adequate provision for respiratory illnesses and other medicines, and consumables, trained staff and infrastructure should be made accessible at the public health facilities.
3. Concept of "Disaster Epidemiology" should also be included in the state epidemiology cell provide timely and accurate health information for decision-makers; improve prevention and mitigation strategies for future disasters by collecting information for future response preparation.
4. State agencies provide for long-term health monitoring by initiating air quality and its health impact associated and correlated health studies among the residents of Korba and Raipur.
5. Committee for air quality testing should be established with multi stake holders like Health Department, Pollution Control Board, Academic and Research Institutes and Municipality.

Environment

1. State and Central Pollution Control Board should initiate continuous monitoring of heavy metals in dust and publish results periodically. Health advisories by consulting reputed health agencies should also be issued regularly.
2. A pollution cess to be levied on units and activities not confirming with National Ambient Air Quality Standards (NAAQS).
3. State agencies should use the pollution data to apprehend polluters and take corrective action to bring levels of dust and heavy metals in dust to below detection limits in residential areas.
4. Strict monitoring of emissions from coal fired power plants, coal mines, and coal transport to be undertaken in Raipur and Korba.
5. Urgent plan is to be formulated to shift out the iron and steel manufacturing units from the residential zones of Raipur city. If this is not possible, strict measures to be taken enforce the pollution control norms by these units.
6. The decision on the legitimate expansion of the industrial areas should be immediately reviewed and should be reconsidered in the existing COVID 19 situation. *(https://cpcb.nic.in/industrial_pollution/New_Action_Plans/CEPI_Action%20Plan_Raipur.pdf)*

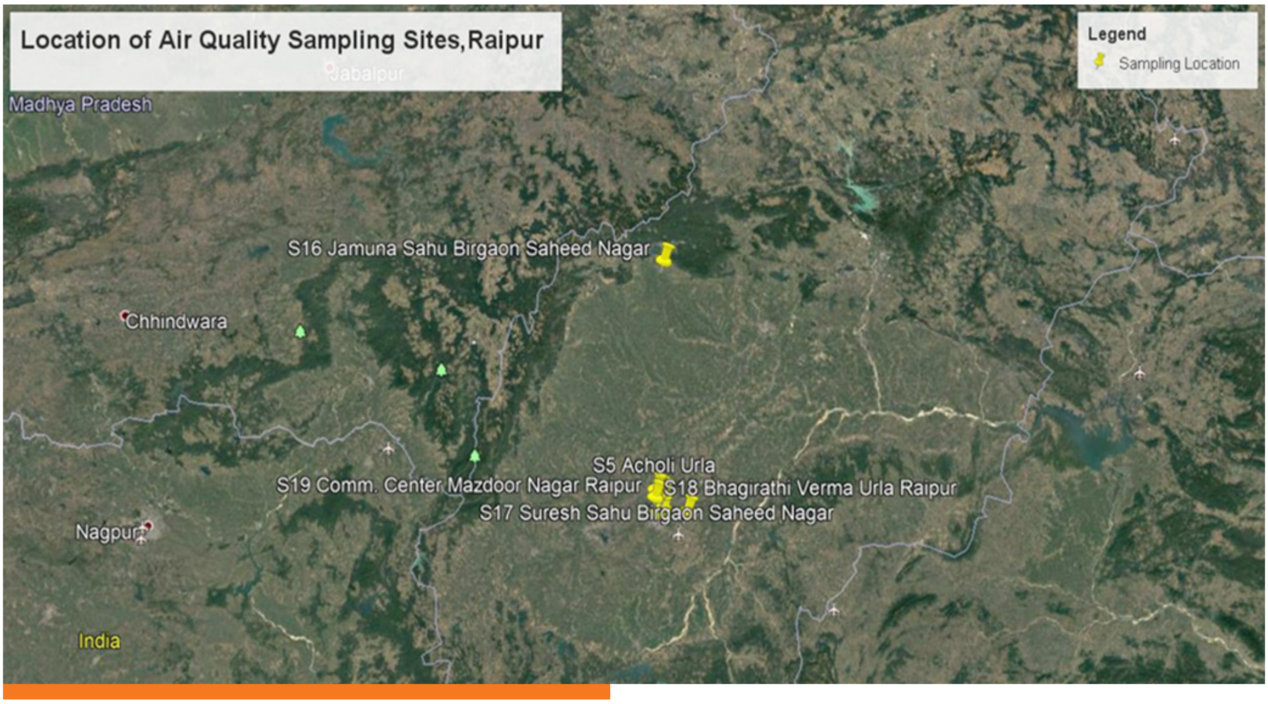
Annexure

Details of Air Sample - Raipur

Table 1: Location, Weather Details and Description of Potential Sources of Pollution

Location Name	Weather details	Description
Changorabhata	Sunny and windy day	Vehicular Emissions, Road Dust
Tikrapara	Sunny Weather Details and bright day	Vehicular Emissions, Road Dust, Industrial Emissions from Sponge Iron Factory
Mandir Hasaud	Sunny and bright day	Coal trains, vehicular traffic, road dust
Sitlapara Bhatagaon	Sunny Day	Vehicular Emissions, Road Dust
Acholi Urla	Cool and Breezy	Vehicular Emissions, Road Dust, Industrial Emissions from Sponge and Timber Factory
Utkal Nagar	Sunny and cool day	Vehicular Emissions, Road Dust
Sendhwapara	Sunny Day	Vehicular Emissions, Road Dust, Industrial Emissions from jute mill
Birgaon Saheed Nagar 1	Clear and sunny day over all with intermittent rains for about an hour	Vehicular Emissions, Road Dust, Industrial Emissions from Sponge Factory
Birgaon Saheed Nagar 2	Cloudy day	Vehicular Emissions, Road Dust, Industrial Emissions from Sponge and iron Factory
Urla Raipur	Clear and sunny	Vehicular Emissions, Road Dust, Industrial Emissions from Bajrang power plant
Mazdoor Nagar Raipur	Clear and sunny	Vehicular Emissions, Road Dust, Industrial Emissions from Sponge and Iron factories
Amlidih Mahaveer Nagar	Breeze and Sunny	Residencial Area/4 Kms from Highway/ Construction work in progress

Figure 1: Location of 24-hour air quality sampling sites



Details of Air Sample - Korba

Table 2: Location, Weather Details and Description of Potential Sources of Pollution

Location Name	Weather details	Description
Rani Danraj Kuwar PHC	Clear	Korba main road/7km power plant CSEB
District Hospital	Clear	Main road /3km power plant CSEB
Ghandhi Nagar Sirki, Khurda	Clear	4km from Dipka main road/4km from ACB power plant
Sirki, Khurda	Bad weather	4km from Dipka main/4km from ACB power plant
Chainpur	Clear	1km from ACB power plant/1km from Dipka main road
Beltekri 1	Bad weather	5km from ACB power plant/2km from Deepka main road
Beltekri 2	Clear	4km from ACB power plant/3km from Dipka main road
Hardi Bazar	Clear	4km from ACB power plant/2km from Deepka main road
Dharampur Gerva	Clear	2km from Gerva main
Emli Chhapar	Clear	3km Kusmunda main road-NTPC Korba super thermal power station
Pankhadafai	Clear	2km from surakachhar main
Kanshinagar, Niharika	Clear	3km from CSEB power plant
Checkpost, Balco	Bad weather	3km from Balco power plant
Manikpur	Clear	2km from Manikpur main road/1km from Manikpur dumping yard

Figure 2: Location of 24-hour air quality sampling sites