BRIEFING: Health Impacts Assessment of Integrated Steel Plant, JSW Utkal Steel Limited, Odisha, India

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Introduction

JSW Utkal Steel Limited, an Indian steel company, has proposed an integrated steel plant for the production of 13.2 MTPA crude steel near the Paradip port in Jagatsinghpur district, Odisha, India. The steel plant is proposed to have a 900 MW captive power plant, a 10 MTPA cement plant and captive jetties with a capacity of 52 MTPA handling capacity. The recent conflict with the local community put the company on national news.

As part of requirements, as detailed in the Terms of Reference (TOR), the project proponent was mandated to conduct an Environmental Impact Assessment, including recording ambient air quality. The TOR mandates recording PM_{10}, $PM_{2.5}$, SO_2, NO_x, CO, NH_3 and O_3 levels within the study area twice a week on a 24 hrs basis for a total duration of 12 weeks.

Section 3.4.7 'Ambient Air Quality Recorded' of the EIA report mentions: "The annual P98 values of PM_{10} and $PM_{2.5}$ are in the range of 78.0–90.0 µg/m^3 and 49.1–52.0 µg/m^3 respectively". The annual average (average of readings in three seasons) concentration of PM_{10} and $PM_{2.5}$ around the proposed project location were found to be 75–84 µg/m^3 and 41–44 µg/$m^{3,}$ respectively **(Appendix-I)**. Therefore, the recorded data suggests that the ambient air pollutant concentrations are above the National Ambient Air Quality Standards (NAAQS) for PM_{10} and $PM_{2.5,}$ which are prescribed to be 60 µg/m^3 for PM_{10} and 40 µg/m^3 for $PM_{2.5}$ on an annual level.

The dispersion modelling results from the EIA report also shows that the project will be adding a significant pollution load to the already existing AAQ levels, making it even more hazardous.

The average PM_{10} concentrations post-project are estimated to be around ~92 µg/m^3 at eight monitoring locations, reaching as high as 96 µg/m^3 at one of these locations (Dhenkia). Compared to the annual standards for national and international agencies, these readings are 54% higher than the NAAQS and 515% higher than the WHO guidelines.

The EIA report claims that the PM_{10} levels in the ambient air during the operation of the proposed plant would remain within the National Ambient Air Quality Standards (NAAQS) as prescribed by MoEFCC. The statement by the EIA consultant is misleading as the prevailing PM_{10} levels (average of three seasons/annual) at the monitored locations are already higher than the prescribed standards. Additional emissions from the proposed plant will deteriorate air quality further, as depicted in the following table.

Table 1: Predicted Post Project Pollutant Concentration In The Air (Three Seasons)

AAQ Station Code	AAQ Station Name	Parameter	Baseline Annual (Three seasons) Average µg/m3 (A)	Contribution from vehicular movement & point source emission, µg/m3 (B)	Post project Ambient Air Quality, µg/m3 (A + B)
A1	Iribina	PM_{10}	82.2	7.7	89.9
		SO_2	7.3	2.7	10.0
		NO_x	15.9	14.9	30.8
A2	Khu- runtha	PM_{10}	83.6	3.7	87.3
		SO_2	6.0	0.8	6.8
		NO_x	21.4	20.9	42.3

A3	Ucha Naugan	PM_{10}	82.3	11.7	94.0
		SO_2	6.3	2.7	9.0
		NO_x	20.0	14.9	34.9
A4	Rangia-garh	PM_{10}	83.4	7.7	91.1
		SO_2	11.8	6.6	18.4
		NO_x	27.3	8.9	36.2
A5	Chatua	PM_{10}	78.0	15.7	93.7
		SO_2	6.9	6.6	13.5
		NO_x	19.7	8.9	28.6
A6	Badaga-pur	PM_{10}	78.3	15.7	94.0
		SO_2	<4.0	8.6	8.6
		NO_x	19.5	14.9	34.4
A7	Kujang	PM_{10}	83.9	7.7	91.6
		SO_2	6.3	4.7	11.0
		NO_x	22.1	8.9	31.0
A8	Dhenkia	PM_{10}	74.8	21.5	96.3

		SO_2	7.4	16.4	23.8
		NO_x	25.4	32.8	58.2

Other shortcomings of the Environment Impact Assessment report are listed as below:

- The EIA compares the three-season average to daily PM_{10} levels. This comparison is skewed as there is a significant difference between the aforementioned data points. While the daily PM_{10} standard is 100 µg/m^3, the annual standard is 60 µg/m^3. Therefore, seasonal and cross-seasonal averages should always be compared to annual rather than daily standards.

  As part of the EIA report, 50 readings per station were collected across seasons to assess ambient air quality. According to the CPCB protocol, 50 or more days of monitoring in a year should be compared to the average annual concentration (CPCB, 2020).

- The EIA report misses out on accounting for incremental $PM_{2.5}$ from the plant operation. The PM2.5 particles are the most harmful part of particulate pollution and should be integral to Environment and Health Impact Assessments.

- The EIA report also misses out on accounting for Mercury (Hg) or any other heavy metal from the plant operation, which should have been reported in the Environment and Health Impact Assessments.

- The EIA report uses an air pollution dispersion model which doesn't account for secondary particulate formation, $PM_{2.5}$ formed from SO_2 and NO_x emissions. These formed secondary $PM_{2.5}$ make up a more significant component of the total $PM_{2.5}$ emission load from any fossil fuel combustion facility (Dahiya & Myllyvirta, 2021). Accounting for secondary particulates make the predicted PM levels from the plant multiple times higher (CREA, 2021). Therefore, the ignorance of secondary particulate formation leads to a significant underestimating of the total pollutant concentrations

- Lime Kiln, Cement Plant, and a few other combustion sources have entirely omitted data on NO_x emissions without any explanation. Combustion of any fuel produces NO_x emissions, which should be accounted for to ensure environmental impact assessments are comprehensive and nuanced.

As, PM_{10}, $PM_{2.5}$, SO_2, NO_x, Hg and other pollutants lead to significant health impacts both in terms of mortality and morbidity, it would be valuable to see how the incremental pollution from the project will impact human health. For that reason, the current assessment builds on the findings from the EIA report. The assessment also included projections of the health impacts of the integrated project. This study shows the human health impact of the project using cropper et., al 2012, methodology.

Materials and Methods

Emissions

The emission inventory was built from the stack parameter data available in the EIA report by the project proponent. The stack parameter and emission data was used to estimate the annual cumulative emissions from all stacks for the Integrated Steel Plant. The annual operation days were taken to be 330 (90.4%) as provided in the EIA report with 24-hour operation for each day.

Population exposure

To project the population exposure to $PM_{2.5}$ resulting from the air pollutant emissions, we applied a regression model developed by Zhou et al. (2006), based on dispersion modelling results for 29 plant sites in China, and earlier applied for India by Cropper et al. (2012). The model predicts population exposure based on the total amount of population within different distances of the power plant, taking into account the contribution of SO_2 and NO_x emissions to the formation of secondary $PM_{2.5}$. However, the health impacts of direct exposure to SO_2 and NO_2 are not taken into account, owing to the limitations of the methodology, which makes the results conservative.

The spatial distribution of the population was based on Gridded Population of the World v4 (CIESIN 2018). Precipitation data required by the model was taken from WorldClim 2.1 (Fick & Hijmans 2017).

The Zhou et al. (2006) model used the entire mainland China as the domain for which population exposure was assessed. To make the model globally applicable, we limited the domain to a distance of 2000km from the project.

Health impacts

The health impact assessment methodology is adapted from CREA's "Quantifying the Economic Costs of Air Pollution from Fossil Fuels" (Myllyvirta 2020e).

The calculation of health impacts follows a standard epidemiological calculation:

$$\Delta cases = POP \times \sum_{age}\left[Frac_{age} \times Incidence_{age} \times \left(1 - \frac{RR(c_{base} + \Delta c_{coal}, age)}{RR(c_{base}, age)}\right)\right],$$

where *POP* is the total population in the grid location, *age* is the analysed age group (in the case of age-dependent concentration-response functions, a 5-year age segment; in other cases, the total age range to which the function is applicable), $Frac_{age}$ is the fraction of the population belonging to the analysed age group, *Incidence* is the baseline incidence of the analysed health condition, *c* is pollutant concentration, with c_{base} referring to the baseline concentration and Δc_{coal} is the concentration attributed to coal-fired power plants, with the contribution from existing plants having a negative sign (subtracted from the baseline concentration) and projected future incremental concentration from new plants a positive sign (added on top of the baseline concentration). *RR(c, age)* is the function giving the risk ratio of the analysed health outcome at the given concentration, for the given age group, compared with clean air.

In the case of a log-linear, non-age specific concentration-response function, the RR function becomes:

$$RR(c) = RR_0^{\frac{c - c_0}{\Delta c_0}} \; when\; c > c_0,\; 1\; otherwise,$$

where RR_0 is the risk ratio found in epidemiological research, Δc_0 is the concentration change that RR_0 refers to, and c_0 is the assumed no-harm concentration (generally, the lowest concentration found in the study data).

Data on total population and population age structure in each country was taken from Global Burden of Disease (GBD) results for 2019 (IHME 2020), which collects and aggregates data from health departments of national governments.

Adult deaths and years of life lost from $PM_{2.5}$ exposure were estimated using the risk functions developed by Burnett et al. (2018), as applied by Lelieveld et al. (2019). Deaths of small children from lower respiratory infections linked to $PM_{2.5}$ pollution were assessed using the GBD risk function for lower respiratory diseases (IHME 2020).

For all mortality results, the baseline death rates and years of life lost were taken from the GBD project 2019 (IHME 2020); sources of incidence data for other health outcomes are given in the table below. As the non-linear concentration-response functions require information on baseline concentrations of $PM_{2.5}$, these were taken from van Donkelaar et al. (2016).

Table 2. Input parameters and data used in estimating physical health impacts

Age group	Effect	Pollutant	Concentration response function*	Concentration change	No-risk threshold	Reference	Incidence data
0-17	Asthma emergency room visits	$PM_{2.5}$	1.03 (1.01–1.04)	10 ug/m3	6 ug/m^3	Zheng et al. 2015	Anenberg et al. 2018
18-99	Asthma emergency room visits	$PM_{2.5}$	1.02 (1.02–1.03)	10 ug/m3	6 ug/m^3	Zheng et al. 2015	Anenberg et al. 2018
Newborn	Preterm birth	$PM_{2.5}$	1.15 (1.07, 1.16)	10 ug/m3	8.8 ug/m^3	Trasande et al. 2016	Chawanpaiboon et al. 2019
0-4	Deaths from	$PM_{2.5}$	GBD 2019		5.8	GBD 2019	GBD 2019

	lower respiratory infections				ug/m^3		
25-99	Premature deaths from non-communicable diseases	$PM_{2.5}$	Burnett et al. 2018		2.4 ug/m^3	Burnett et al. 2018	GBD 2019
25-99	Disability caused by diabetes, stroke and chronic respiratory disease	$PM_{2.5}$	GBD 2019		2.4 ug/m^3	Burnett et al. 2018	GBD 2019

**Numeric values in the "Concentration-response function" refer to relative risk corresponding to the increase in concentrations given in the "concentration change" column. Literature references indicate the use of a non-linear concentration-response function. No-harm threshold refers to a concentration below which health impact is not quantified, generally due to lack of evidence in the studies on which the function is based.*

Results

Emissions

The central input to the health impact assessment of such projects is the annual emissions volumes. The emission inventory was built from the stack parameter data available in the EIA report by the project proponent. The stack parameter and emission data were used to estimate the annual cumulative emissions from the Integrated Steel Plant stacks. The annual operation days were taken to be 330 (90.4% utilization) as provided in the EIA report with a 24-hour operation for each day. More detailed information on the sources of emissions data is given in the table below.

Table 3: Estimates Project Pollutant Emission Load The Air

Pollutant	Emissions	Unit

SO_2	1470	kg/hour
NO_x	1658	kg/hour
PM	1191	kg/hour
SO_2	11642	t/a[1]
NO_x	13131	t/a
PM	9433	t/a

Paradeep, Jagatsinghpur (~5- 10 km aerial distance from the proposed ISP site) is known as one of the most polluted geographies in India and has been classified as a severely polluted area under the Comprehensive Environmental Pollution Index (CEPI)(OSPCB, 2020). The average PM_{10} and $PM_{2.5}$ levels in 2018 for Paradeep area were respectively reported at 119 (36-317) ug/m^3 and 48 (16-161) ug/m^3 as monitored by the Odisha State Pollution Control Board, which are higher than the prescribed annual permissible limits of 60 ug/m^3 and 40 ug/m^3 for the pollutants.

The total emission load was at 12,700 kg/day for PM; and 43,600 kg/day for SO_2 for the entire industrial cluster of 15 Red category industries in the area at Paradeep. On the other hand, the emission load from the proposed ISP is estimated at ~25,800 for PM and ~31,900 kg/Day for SO_2, respectively, Making the project a highly polluting source within the same district.

The above-presented data highlights that:

- The proposed project site is just 5-10 km away from the already severely polluted area of Paradeep and receives pollution from the region resulting in already high air pollution levels at the proposed project site as reported in the EIA report and mentioned in the earlier section.

[1] ton/annum

- The emission load of the proposed plant will be ~2 times the emissions for the entire cluster at Paradeep for PM and 2/3rd for SO_2, which means that the air quality will deteriorate further, resulting in severe health impacts and extension of the intensity and geographical reach of already existing CEPI area in the Jagatsinghpur district.

Health impacts

The air pollutant emissions would be responsible for an estimated 94 deaths per year (95% confidence interval: 65 - 129). Air pollution would also lead to a projected 180 emergency room visits due to asthma, 160 preterm births and 75,000 days of work absence per year.

Table 4: ***Projected health impacts from pollution from the studied Integrated Steel Plant, per year***

Outcome	Cause	Pollutant	JSW_central	JSW_CI
deaths	total	Total	94	(65 - 129)
deaths	all	$PM_{2.5}$	92	(64 - 126)
deaths	chronic obstructive pulmonary disease	$PM_{2.5}$	17	(6 - 32)
deaths	diabetes	$PM_{2.5}$	1	(0 - 2)
deaths	ischaemic heart disease	$PM_{2.5}$	38	(28 - 49)
deaths	lower respiratory infections	$PM_{2.5}$	10	(4 - 18)
deaths	lower respiratory infections in children	$PM_{2.5}$	2	(1 - 3)
deaths	lung cancer	$PM_{2.5}$	3	(1 - 6)

deaths	stroke	$PM_{2.5}$	18	(7 - 32)
asthma emergency room visits, adults	asthma emergency room visits, adults	$PM_{2.5}$	99	(65 - 133)
asthma emergency room visits, children	asthma emergency room visits, children	$PM_{2.5}$	80	(42 - 118)
preterm births	preterm births	$PM_{2.5}$	163	(79 - 173)
work absence (sick leave days)	work absence (sick leave days)	$PM_{2.5}$	74,547	(63,417 - 85,602)
years lived with disability	chronic obstructive pulmonary disease	$PM_{2.5}$	88	(33 - 158)
years lived with disability	diabetes	$PM_{2.5}$	28	(4 - 54)
years lived with disability	stroke	$PM_{2.5}$	38	(12 - 76)

CREA

References

Anenberg, S.C., Henze, D.K., Tinney, V., Kinney, P.L., Raich, W., Fann, N., Malley, C.S., Roman, H., Lamsal, L., Duncan, B., Martin, R.V., Donkelaar, van A., Brauer, M., Doherty, R., Jonson, J.E., Davila, Y., Sudo, K. & Kuylenstierna, J.C.I. 2018. Estimates of the Global Burden of Ambient PM2.5, Ozone, and NO2 on Asthma Incidence and Emergency Room Visits. Environmental Health Perspectives 126:10. https://doi.org/10.1289/EHP3766

Burnett, R. et al. 2018. Global estimates of mortality associated with long-term exposure to outdoor fine particulate matter. Proceedings of the National Academy of Sciences 115(38):9592-9597. https://doi.org/10.1073/pnas.1803222115

Center for International Earth Science Information Network (CIESIN) - Columbia University 2018. Gridded Population of the World, Version 4 (GPWv4): Population Density Adjusted to Match 2015 Revision UN WPP Country Totals, Revision 11. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/10.7927/H4F47M65

Dahiya, S., & Myllyvirta, L. 2021. Health and Economic Impacts of Unabated Coal Power Generation in Delhi-NCR. https://energyandcleanair.org/wp/wp-content/uploads/2021/03/Health-and-economic-impacts-of-unabated-coal-power-generation-in-Delhi-NCR_Report-22nd-March-2021_Final-Report.pdf

Chawanpaiboon, S., Vogel, J.P., Moller, A.B., Lumbiganon, P., Petzold, M., Hogan, D., Landoulsi, S., Jampathong, N., Kongwattanakul, K., Laopaiboon, M., Lewis, C., Rattanakanokchai, S., Teng, D.N., Thinkhamrop, J., Watananirun, K., Zhang, J., Zhou, W. & Gülmezoglu, A.M. 2019. Global, regional, and national estimates of levels of preterm birth in 2014: a systematic review and modelling analysis. Lancet Glob Health 7(1):e37-e46. https://doi.org/10.1016/S2214-109X(18)30451-0

Central Pollution Control Board (CPCB). 2020.National Ambient Air Quality Status and Trends. https://cpcb.nic.in/upload/NAAQS_2019.pdf

Centre for Research on Energy and Clean Air (CREA). 2021. Assessment of the Banskhali S. Alam coal power (SS Power I) project EIA. https://energyandcleanair.org/wp/wp-content/uploads/2021/06/Assessment-of-the-Banskhali-SS-Power-I-coal-power-project-EIA.pdf

Cropper, M., Gamkhar, S., Malik, K., Limonov, A., & Partridge, I. 2012. The Health Effects of Coal Electricity Generation in India (SSRN Scholarly Paper ID 2093610). Social Science Research Network. https://doi.org/10.2139/ssrn.2093610

Donkelaar, van A., Martin, R.V., Brauer, M., Hsu, N. C., Kahn, R. A., Levy, R. C., Lyapustin, A., Sayer, A. M. & Winker, D. M. 2016. Global Estimates of Fine Particulate Matter using a Combined Geophysical-Statistical Method with Information from Satellites, Models, and Monitors, Environ. Sci. Technol. 50(7):3762-3772,https://doi.org/10.1021/acs.est.5b05833

Europe Beyond Coal (EBC) 2021. Coal Exit Tracker. https://beyond-coal.eu/coal-exit-tracker/

Fick, S. E., & Hijmans, R. J. 2017. WorldClim 2: New 1-km spatial resolution climate surfaces for global land areas. International Journal of Climatology, 37(12), 4302–4315. https://doi.org/10.1002/joc.5086

Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2019 (IHME) 2020. Results. Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2020. http://ghdx.healthdata.org/gbd-results-tool

International Finance Corporation (IFC) 2017. Environmental, Health, and Safety Guidelines for Thermal Power Plants. https://www.ifc.org/wps/wcm/connect/9ec08f40-9bc9-4c6b-9445-b3aed5c9afad/Thermal+Power+Guideline+2017+clean.pdf?MOD=AJPERES&CVID=lNwcJZX

Kiko Network 2020. https://sekitan.jp/plant-map/en/v2/table_en

Lelieveld, J., Klingmüller, K., Pozzer, A., Burnett, R.T., Haines, A. & Ramanathan V. 2019. Effects of fossil fuel and total anthropogenic emission removal on public health and climate. PNAS 116(15):7192-7197. https://doi.org/10.1073/pnas.1819989116

M.N. Dastur & Company (P) Ltd. 2021. Common Environmental Impact Assessment Report on setting up of integrated steel plant for production of 13.2 MTPA crude steel, 900 MW captive power, 10 MTPA cement plant and captive jetty(ies) of 52 MTPA handling capacity near Paradeep for JSW Utkal Steel Limited. http://environmentclearance.nic.in/writereaddata/EIA/02092021puyqhkvug3y52987089JSWEIAText.pdf

Myllyvirta, L. 2020e. Quantifying the Economic Costs of Air Pollution from Fossil Fuels. Centre for Research on Energy and Clean Air. https://energyandcleanair.org/publications/costs-of-air-pollution-from-fossil-fuels/

Odisha State Pollution Control Board (OSPCB). 2020. Action plan for Abatement of Pollution in Industrial Areas of Paradeep. https://cpcb.nic.in/industrial_pollution/New_Action_Plans/CEPI_Odisha%20AP_Paradeep.pdf

Zheng, X., Ding, H., Jiang, L., Chen, S., Zheng, J., Qiu, M. et al. 2015. Association between air pollutants and asthma emergency room visits and hospital admissions in time series studies: a systematic review and meta-analysis. PloSOne 10(9):e0138146, PMID:26382947, https://doi.org/10.1371/journal.pone.0138146

Zhou, Y., Levy, J. I., Evans, J. S., & Hammitt, J. K. 2006. The influence of geographic location on population exposure to emissions from power plants throughout China. Environment International, 32(3), 365–373. https://doi.org/10.1016/j.envint.2005.08.028

Appendix-I

TABLE 3-6 - AMBIENT AIR QUALITY IN THE STUDY AREA

Monitoring Location Map : 11466-97A-000-ENV-0006
Frequency of Monitoring : Twice a week
Monitoring Period : Jan'18 - April'18; Nov'18 - Feb'19; Apr'19 - Jun'19
Standard : NAAQS 2009 (Refer Appendix 3-1)

[Pollutants in μg/m³ (24 hrs), BaP, As & Ni in ng/ m³, CO in mg/m³]

Stn. Code	Location	Monitored Parameter	Winter			Summer			Post Monsoon			Annual			
			Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.	P_{98}
A_1	Iribina	PM_{10}	86.8	76.5	83.8	86.7	67.2	80.6	84.8	81.2	83.0	86.8	67.2	82.2	86.6
		$PM_{2.5}$	51.1	41.3	48.0	50.1	34.3	38.8	49.9	47.8	48.8	51.1	32.5	43.0	50.9
		SO_2	<4.0	-	-	8.3	4.0	-	<4.0	-	-	8.3	4.0	7.3	8.3
		NO_X	25.0	12.5	18.1	23.5	7.8	18.6	23.5	16.5	20.6	25.0	7.8	15.9	24.3
		O_3 (8 hrs)	<10.0	-	-	<10.0	-	-	<10.0	-	-	<10.0	-	-	-
		CO (8 hrs)	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	-
		NH_3	<4.18	-	-	<4.18	-	-	<4.18	-	-	<4.18	-	-	-
		Pb	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		C_6H_6	<0.74	-	-	<0.74	-	-	<0.74	-	-	<0.74	-	-	-
		As	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		Ni	<0.02	-	-	<0.02	-	-	<0.02	-	-	<0.02	-	-	-
		BaP	<0.36	-	-	<0.36	-	-	<0.36	-	-	<0.36	-	-	-
A_2	Khu-runtha	PM_{10}	89.5	77.4	84.7	89.5	75.1	83.1	86.5	80.5	82.9	89.5	75.1	83.6	89.4
		$PM_{2.5}$	51.8	42.3	48.5	52.2	33.8	40.5	50.9	47.4	48.8	52.2	32.5	43.9	51.8
		SO_2	8.5	4.5	6.0	8.3	4.8	6.0	<4.0	-	-	8.5	4.0	6.0	8.4
		NO_X	26.8	16.5	21.6	25.0	16.2	21.1	25.0	16.5	20.5	26.8	16.2	21.4	25.0
		O_3 (8 hrs)	<10.0	-	-	<10.0	-	-	<10.0	-	-	<10.0	-	-	-
		CO (8 hrs)	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	-
		NH_3	<4.18	-	-	<4.18	-	-	<4.18	-	-	<4.18	-	-	-
		Pb	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		C_6H_6	<0.74	-	-	<0.74	-	-	<0.74	-	-	<0.74	-	-	-
		As	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		Ni	<0.02	-	-	<0.02	-	-	<0.02	-	-	<0.02	-	-	-
		BaP	<0.36	-	-	<0.36	-	-	<0.36	-	-	<0.36	-	-	-
A_3	Ucha naugan	PM_{10}	87.6	77.4	82.7	88.5	74.2	82.7	87.5	80.5	83.7	88.5	73.4	82.3	87.8
		$PM_{2.5}$	51.1	45.5	48.5	50.7	18.5	37.4	49.7	43.5	47.3	51.5	32.6	43.6	51.0
		SO_2	7.2	4.0	6.0	11.2	5.0	6.6	<4.0	-	-	11.2	4.0	6.3	10.0
		NO_X	28.5	12.5	19.9	26.5	12.5	19.2	25.0	16.5	20.7	28.5	12.5	20.0	26.5
		O_3 (8 hrs)	<10.0	-	-	<10.0	-	-	<10.0	-	-	<10.0	-	-	-
		CO (8 hrs)	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	-
		NH_3	<4.18	-	-	<4.18	-	-	<4.18	-	-	<4.18	-	-	-
		Pb	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		C_6H_6	<0.74	-	-	<0.74	-	-	<0.74	-	-	<0.74	-	-	-
		As	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		Ni	<0.02	-	-	<0.02	-	-	<0.02	-	-	<0.02	-	-	-
		BaP	<0.36	-	-	<0.36	-	-	<0.36	-	-	<0.36	-	-	-
A_4	Rangia-garh	PM_{10}	89.8	78.2	85.3	92.5	68.5	83.9	89.6	83.8	87.1	92.5	88.5	83.4	90.0
		$PM_{2.5}$	52.8	44.5	49.5	48.3	34.1	40.6	52.7	49.3	51.2	52.4	32.5	44.3	52.0
		SO_2	23.5	4.8	11.1	23.8	4.8	15.0	20.0	7.5	15.0	23.8	4.0	11.8	21.5
		NO_X	52.8	20.0	31.2	45.0	15.0	32.5	42.5	30.0	34.8	45.0	15.0	27.3	44.3
		O_3 (8 hrs)	<10.0	-	-	28.8	10.0	21.1	<10.0	-	-	28.5	10.0	19.9	24.2
		CO (8 hrs)	<0.1	-	-	0.68	0.10	0.49	<0.1	-	-	0.68	0.10	0.44	0.63
		NH_3	<4.18	-	-	<4.18	-	-	<4.18	-	-	<4.18	-	-	-
		Pb	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		C_6H_6	<0.74	-	-	1.2	0.74	0.9	<0.74	-	-	1.2	0.74	0.9	1.2
		As	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		Ni	<0.02	-	-	<0.02	-	-	<0.02	-	-	<0.02	-	-	-
		BaP	0.58	-	-	0.62	0.36	0.48	<0.36	-	-	0.62	0.36	0.48	0.58

TABLE 3-6 (cont'd)

Stn. Code	Location	Monitored Parameter	Winter			Summer			Post Monsoon			Annual			
			Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.	P_{98}
A_5	Chatua	PM_{10}	83.4	73.5	77.8	83.8	51.2	77.2	83.5	82.5	83.0	83.8	51.2	78.0	83.5
		$PM_{2.5}$	49.3	43.2	46.0	48.8	28.5	39.3	49.1	48.4	49.0	49.3	28.5	42.5	49.1
		SO_2	<4.0	-	-	8.8	6.9	7.7	<4.0	-	-	8.8	4.0	6.9	8.1
		NO_X	25.0	16.5	20.4	23.5	15.0	19.8	21.8	15.0	19.0	25.0	15.0	19.7	24.4
		O_3 (8 hrs)	<10.0	-	-	<10.0	-	-	<10.0	-	-	<10.0	-	-	-
		CO (8 hrs)	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	-
		NH_3	<4.18	-	-	<4.18	-	-	<4.18	-	-	<4.18	-	-	-
		Pb	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		C_6H_6	<0.74	-	-	<0.74	-	-	<0.74	-	-	<0.74	-	-	-
		As	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		Ni	<0.02	-	-	<0.02	-	-	<0.02	-	-	<0.02	-	-	-
		BaP	<0.36	-	-	<0.36	-	-	<0.36	-	-	<0.36	-	-	-
A_6	Badaga-pur	PM_{10}	83.8	74.6	79.1	84.5	51.2	78.0	84.1	82.5	82.9	84.5	51.2	78.3	84.2
		$PM_{2.5}$	52.8	41.2	47.2	51.1	28.5	39.8	48.9	43.2	47.4	52.8	28.5	42.7	52.0
		SO_2	<4.0	-	-	<4.0	-	-	<4.0	-	-	<4.0	-	-	-
		NO_X	26.8	16.5	21.5	23.5	12.5	18.3	23.5	15.0	18.9	26.8	12.5	19.5	26.5
		O_3 (8 hrs)	<10.0	-	-	<10.0	-	-	<10.0	-	-	<10.0	-	-	-
		CO (8 hrs)	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	-
		NH_3	<4.18	-	-	<4.18	-	-	<4.18	-	-	<4.18	-	-	-
		Pb	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		C_6H_6	<0.74	-	-	<0.74	-	-	<0.74	-	-	<0.74	-	-	-
		As	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		Ni	<0.02	-	-	<0.02	-	-	<0.02	-	-	<0.02	-	-	-
		BaP	<0.36	-	-	<0.36	-	-	<0.36	-	-	<0.36	-	-	-
A_7	Kujang	PM_{10}	90.2	78.4	85.3	90.1	46.2	83.6	88.5	80.5	83.7	90.2	46.2	83.9	89.9
		$PM_{2.5}$	52.6	46.1	49.1	51.6	23.5	41.3	52.1	47.4	49.2	52.6	23.5	44.2	52.1
		SO_2	8.2	4.8	6.2	7.5	4.8	6.3	6.8	5.2	5.9	8.2	4.8	6.3	7.8
		NO_X	30.0	12.5	22.4	26.8	12.5	21.8	25.0	20.0	22.6	30.0	12.5	22.1	29.3
		O_3 (8 hrs)	<10.0	-	-	<10.0	-	-	<10.0	-	-	<10.0	-	-	-
		CO (8 hrs)	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	-
		NH_3	<4.18	-	-	<4.18	-	-	<4.18	-	-	<4.18	-	-	-
		Pb	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		C_6H_6	<0.74	-	-	<0.74	-	-	<0.74	-	-	<0.74	-	-	-
		As	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		Ni	<0.02	-	-	<0.02	-	-	<0.02	-	-	<0.02	-	-	-
		BaP	<0.36	-	-	<0.36	-	-	<0.36	-	-	<0.36	-	-	-
A_8	Dhenkia	PM_{10}	78.5	70.1	74.9	78.1	58.2	74.6	77.9	71.5	75.4	78.5	58.2	74.8	78.0
		$PM_{2.5}$	50.9	37.5	44.6	45.6	31.5	38.9	45.8	42.1	44.4	50.9	23.8	41.1	50.7
		SO_2	9.5	5.8	7.4	9.2	5.6	7.4	6.8	5.8	6.4	9.5	5.6	7.4	9.2
		NO_X	32.5	15.0	23.0	36.5	15.0	28.0	30.0	23.5	26.4	36.5	15.0	25.4	36.5
		O_3 (8 hrs)	<10.0	-	-	<10.0	-	-	<10.0	-	-	<10.0	-	-	-
		CO (8 hrs)	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	-
		NH_3	<4.18	-	-	<4.18	-	-	<4.18	-	-	<4.18	-	-	-
		Pb	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		C_6H_6	<0.74	-	-	<0.74	-	-	<0.74	-	-	<0.74	-	-	-
		As	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	-
		Ni	<0.02	-	-	<0.02	-	-	<0.02	-	-	<0.02	-	-	-
		BaP	<0.36	-	-	<0.36	-	-	<0.36	-	-	<0.36	-	-	-

Notes:
1. Method of measurement - as per schedule VII of National Ambient Air Quality Standard (NAAQS of CPCB)
2. For more details, refer Section-II of Appendix-Field Reports