Prepared By

State Pollution
Control Board, Odisha

Rapid Study on Emission Inventory and Source Apportionment for Angul & Talcher

August - 2020

Rapid Study on Emission Inventory and Source Apportionment for Angul and Talcher

STATE POLLUTION CONTROL BOARD, ODISHA
BHUBANESWAR

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State Pollution Control Board, Odisha
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August 2020

FOREWORD

ASIT TRIPATHY, IAS
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Economic activities, such as industries, transport, mining and other activities are the main cause of air pollution in urban areas. The Ministry of Environment, Forest & Climate Change, Govt. of India has identified 122 non-attainment cities on the basis of air quality. The matter of urban air pollution has also got the attention of Hon'ble National Green Tribunal and Hon'ble National Green Tribunal has directed the State Pollution Control Boards for preparation of source apportionment studies and emission inventory. The idea of having a source apportionment and emission inventory is to prepare an effective clear-air action plan.

Angul and Talcher are two of the non-attainment cities in Odisha, which are also important from economic view point. Thus, emission inventory and source apportionment is a critical step for these two cities for appropriately formulating an action plan for abatement of air pollution.

This report identifies major sources of air pollution in Angul-Talcher region and makes an assessment of their impact on air quality in Angul and Talcher. The efforts made by Dr. K Murugesan, IFS, Member Secretary, Shri Debidutta Biswal, IFS, Ex-Member Secretary and the team led by Dr. Nihar Ranjan Sahoo, Chief Env. Engineer, in preparing the report is praise-worthy. This report can be helpful to the policy makers, planner, researchers and general public at large.

Asit Tripathy, IAS

CONTENTS

LIST OF ABBREVIATION

AQ	:	Air Quality
BEL	:	Bhushan Energy Ltd.
BSL	:	Bhushan Steel Ltd.
CPA	:	Critically Polluted Area
CPCB	:	Central Pollution Control Board
CPP	:	Captive Power Plant
GLC	:	Ground Level Concentration
GMR	:	GMR Energy Ltd.
JITPL	:	Jindal India Thermal (P) Ltd.
JSPL	:	Jindal Steel and Power Ltd.
MGM	:	MGM Steel Ltd.
NAAQS	:	National Ambient Air Quality Standard
NALCO	:	National Aluminium Company
NAV	:	Nava Bharat Ventures Ltd.
NGT	:	National Green Tribunal
OB	:	Over Burden
OCP	:	Open Cast Project
PM	:	Particulate Matter
SPCB	:	State Pollution Control Board
TSTPS	:	Talcher Super Thermal Power Station
TTPS	:	Talcher Thermal Power Station

INTRODUCTION

Emission Inventory and Air Quality Modelling of Talcher-Angul Area

Talcher-Angul area, spreading over Angul and Dhenkanal district is an industrial and mining area in the State of Odisha. This area, having coal mines, thermal power stations, steel and aluminum plants and many other industries witnesses high level of air pollution, particularly with respect to PM_{10} and $PM_{2.5}$. In a recent report prepared by the Central Pollution Control Board (CPCB) Angul and Talcher have found place in the 102 non-attainment cities of the country. The CPCB report analyses the air quality for the past five years, and indicates that PM_{10} and $PM_{2.5}$ in the ambient air of Angul and Talcher remain above the National Ambient Air Quality Standard (NAAQS). Hon'ble National Green Tribunal (NGT) in its order dated the 15th November 2019, in the matter of OA No.681/2018 directed the State Pollution Control Board (SPCB) to prepare a Source Apportionment Study (SAS) within three months, taking into consideration the past air quality and other data.

Considering the urgency for an abatement plan, the SPCB prepared city-based Action Plan for abatement of air pollution, which includes Talcher and Angul. The Action Plan was prepared by the Center for Science and Environment in consultation with the F&E Department of Government of Odisha and the SPCB. The Report was reviewed by the CPCB and it observed that for further refinement of the action plan it is necessary to carry out an emission inventory and source apportionment study. Source apportionment study is a time-consuming and expensive study. Therefore, in order to meet the timeline stipulated by the Hon'ble NGT, the current study is carried out on the basis of existing data for Angul and Talcher.

To prepare an air quality management plan for Angul – Talcher, emission inventory and air quality modelling are essential. Emission inventory in Angul and Talcher is done for all the major sources of particulate matter, such as Point Sources, Area Sources and Mobile Sources. In preparing air quality management plan emission inventory data of this area is used in the air dispersion model, AERMOD view.

2. Description of Study area

Angul and Talcher are the two non-attainment cities in the district of Angul, where the air quality does not conform to NAAQS. These two cities are located at a distance of about 15 km from each other. Talcher municipality spreads over an area of 25.5 km^2 and has a population of about 40, 841 (2011 census). The population density of Talcher is 1604 per km^2. Similarly, Angul municipality spreads over an area of 22 km^2 and has a population of 44,000 (2011 Census) with a population density of 2017 per km^2.

The relative location of Talcher and Angul is shown in the Maps as **Figure 1**. The boundary depicted through the dotted line indicates the boundary of the study area.

Fig 1: Angul and Talcher study area

In between Talcher and Angul there are large industries, thermal power plants and coal mines. Besides the urban activities of both the cities, the air quality of this region is greatly influenced by these industries and mines. Therefore, for the air quality assessment, a 50 km × 50 km area is chosen so that both the municipalities Angul and Talcher are included in the study area and the

industries and mines that is expected to contribute to air pollution in this area are also included. The study area of 2500 km^2 and the relative locations of the two cities are also shown in the map at **Figure 1**.

3. Air quality in Angul-Talcher

In order to assess the air quality of this region, the State Pollution Control Board (SPCB) has established four ambient air quality monitoring stations, two each at Talcher and Angul. The sampling is usually done twice a week on a 24-hour basis. In each station, there are provisions for monitoring the gaseous pollutants, such as SO_2 and NO_x, and particulates-PM_{10} and $PM_{2.5}$.

For the purpose of this study, the monthly mean value of each parameter was determined for each station, and the average value of all the monitoring stations are reported as the air quality of the respective cities. Following this method, the air quality of Angul and Talcher was assessed with respect to SO_2, NO_x, PM_{10} and $PM_{2.5}$, over a 15-month period, starting from January 2018 till March 2019. Month-wise concentration of pollutants *vis-à-vis* the NAAQS, for both the cities, are shown through **Figure 2** to **Figure 5**.

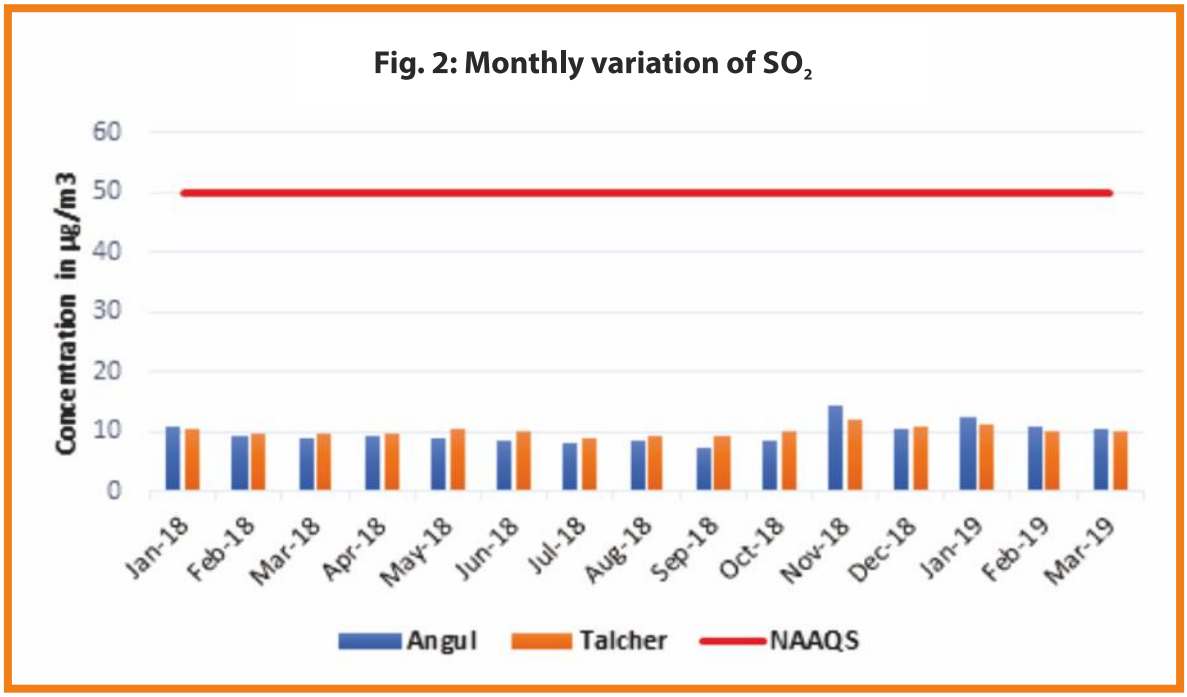


Fig. 2: Monthly variation of SO_2 in Angul and Talcher

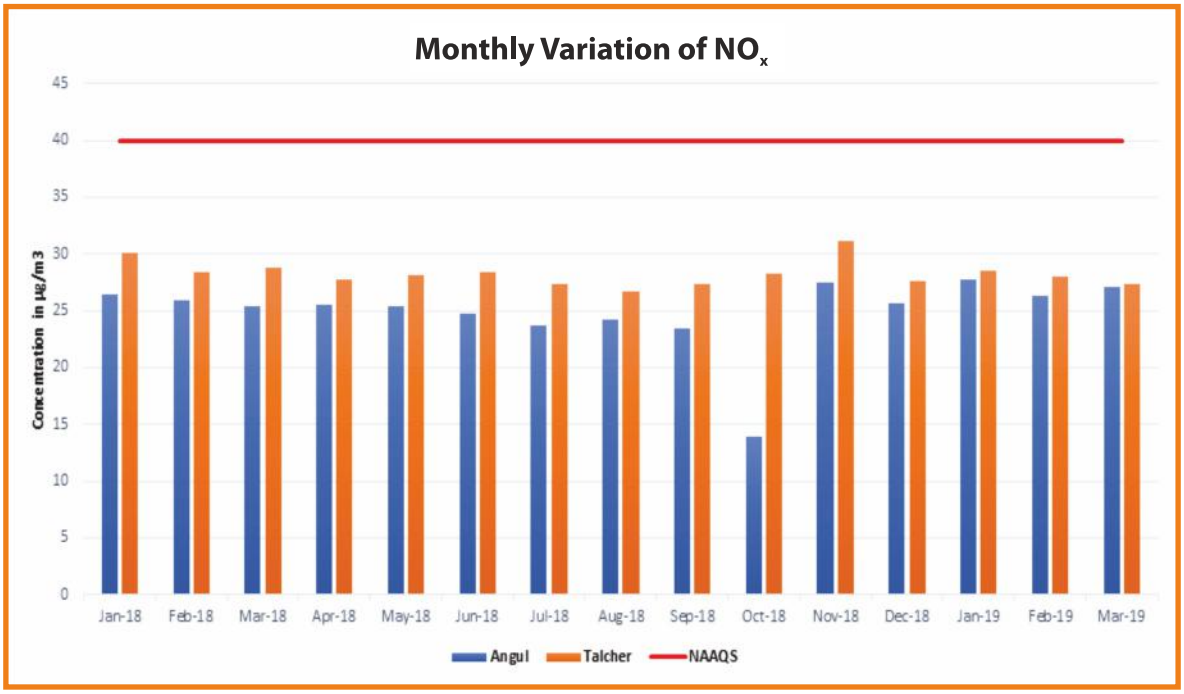


Fig. 3: Monthly variation of NO_x in Angul and Talcher

The air quality monitoring results indicate that the annual average of SO_2 concentration in 2018 in Angul and Talcher was 9.36 µg/m^3 and 9.97 µg/m^3 respectively, against the NAAQS of 50 µg/m^3. Similarly, the NO_x concentration in Angul and Talcher were observed to be 24.32 µg/m^3 and 28.34 µg/m^3 respectively, against the NAAQS of 40 µg/m^3 for NO_x.

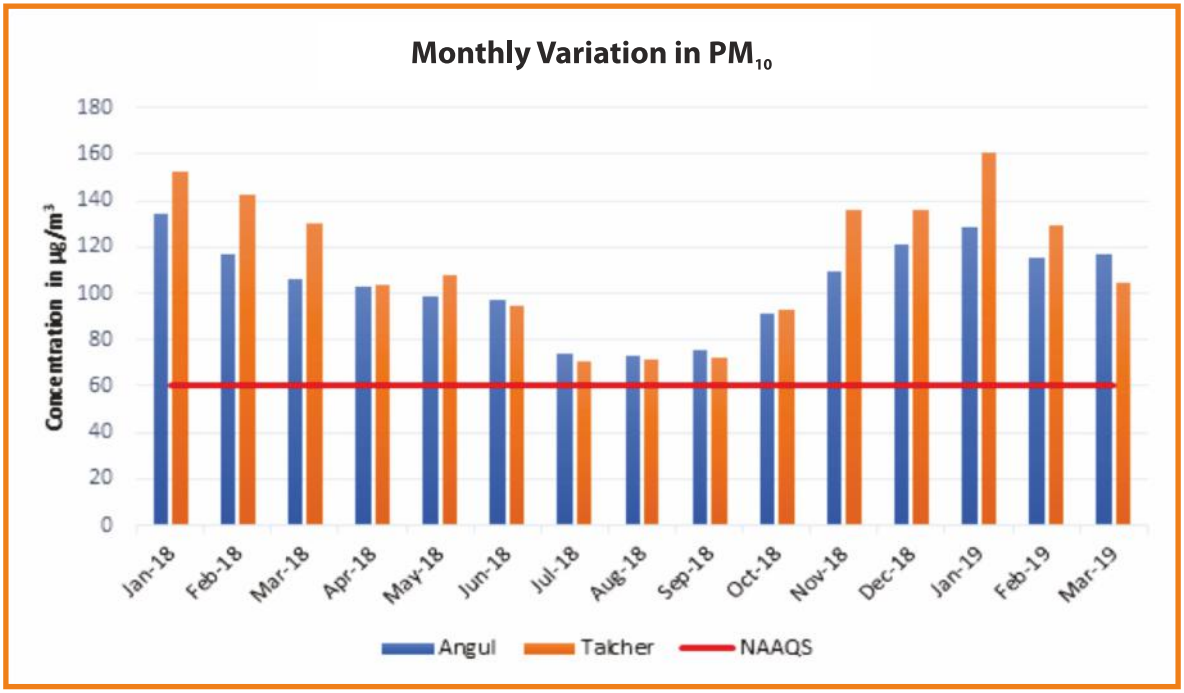


Fig. 4: Monthly variation of PM_{10} in Angul and Talcher

The results indicate that the level of SO_2, both in Angul and Talcher remain within 20% of the NAAQS. At the same time, the level of NO_x remains within 60% - 70% of the NAAQS. It is further observed that the concentration of SO_2 and NO_x in Talcher is slightly higher than that of Angul.

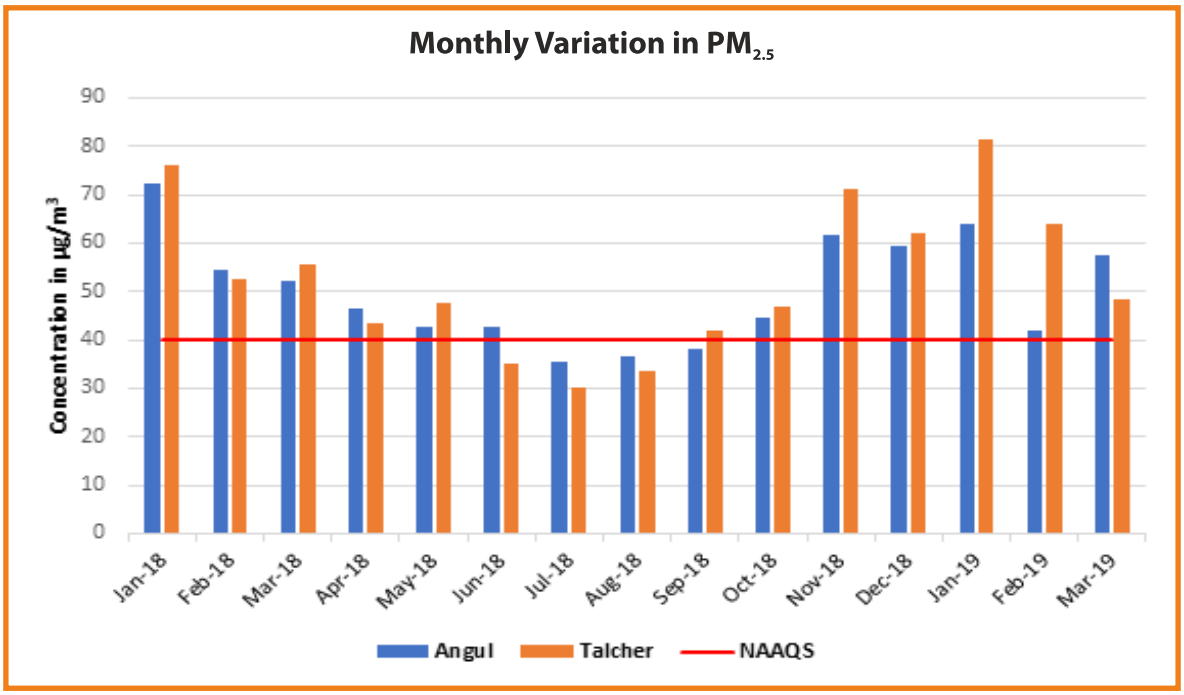


Fig. 5: Monthly variation of $PM_{2.5}$ in Angul and Talcher

Unlike gaseous pollutants, the level of PM_{10} and $PM_{2.5}$ are observed to be higher than the NAAQS. The air quality monitoring results indicate that the annual average of PM_{10} concentration in 2018 in Angul and Talcher was 100.17 µg/m^3 and 109.29 µg/m^3 respectively, against the NAAQS of 60 µg/m^3. Similarly, the $PM_{2.5}$ concentration in Angul and Talcher were observed to be 48.83 µg/m^3 and 49.63 µg/m^3 respectively, against the NAAQS of 40 µg/m^3 for $PM_{2.5}$.From the analysis of monthly concentration, it is observed that the PM_{10} remains above the Standard in all the months in a year, both in Angul and Talcher. On the other hand, $PM_{2.5}$ concentration in Angul came down below the standard during monsoon months July, August and September. Similarly, in Talcher, the $PM_{2.5}$ concentration came down below the Standard during June, July and August.

4. Study Methodology

Taking into consideration the limited sources and requirement of Hon'ble NGT's timeline of three months, the study proposes to carry out the source apportionment study by analyzing air quality dispersion model. In this limited study the predicted value of the dispersion model is compared with the observed value of monitoring carried out by the State Pollution Control Board, Odisha. The flow-diagram depicting the study methodology is presented as **Figure 6**.

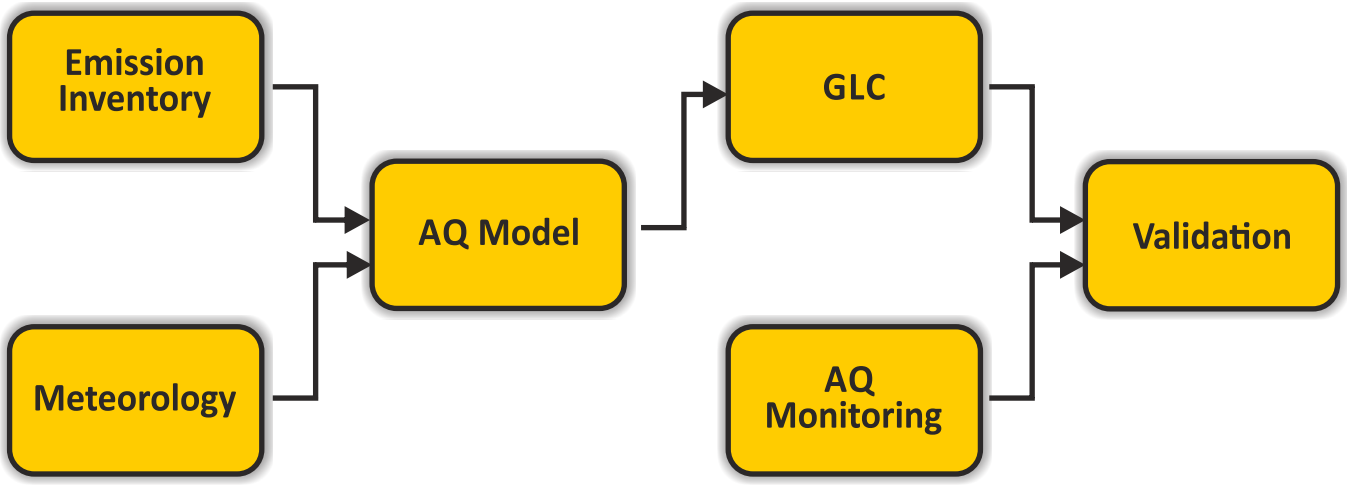


Fig. 6: Study methodology

Rigorous validation techniques which require multiple run of the model, chemical analysis of dust and chemical mass balance were not done, since the estimation is done purely on the basis of past monitoring data. A more rigorous validation is part of an elaborate source Apportionment Study being carried out by expert agencies. However, this limited study is expected to give a fair idea of contribution being made by different sources. For the present study, the sources have been broadly classified as:

i) Industries
ii) Mines
iii) Transportation

5. Emission Inventory

Emission inventories are used to help determine significant sources of air pollutants and to target regulatory actions, thus is an essential input to air dispersion and mathematical models that estimate air quality. The effect of potential regulatory actions on air quality can be predicted by applying estimated emissions reductions to emissions inventory data in air quality models. In order to prepare the emission inventory, the emission sources are divided into three categories, such as *Point Sources, Area Sources and Mobile Sources*.

The results of air quality in Angul-Talcher area show that the concentration of PM_{10} and $PM_{2.5}$ is consistently higher than the NAAQS. Therefore, in this report all the major activities that contribute to PM_{10} and $PM_{2.5}$ are listed under the following broad categories:

1. ***Emissions from stacks of industries (Point Source)***
2. ***Emissions from mining activities (Area Source)***
3. ***Emissions from traffic movement (Line Source)***

5.1 Point source

A point source is a stationary facility or process that emits a significant amount of air pollutants during manufacturing, power generation, heating, incineration, or other such industrial activities. In Angul – Talcher all the stacks were identified and were physically surveyed to determine the site coordinates, height of the emission point and the operational characteristics of the emissions such as, gas flow, outflow speed, gas temperature. In Angul – Talcher 153 stacks were identified in different manufacturing units. Since dispersion behavior of stack gas greatly depends upon the height at which the emission takes place and the mean mixing height of the study area usually remains between 100 and 200 m, the stacks were classified into three categories depending upon their height.

i. Small stacks of 100 m height or less,

ii. Medium stacks of height 100 – 200 m, and

iii. Tall stacks with height of more than 200 m.

Unit-wise number of stacks in each category are depicted in **Figure 7**.

Each stack is characterized by its emission rate in Nm^3/h (Q_i) and emission concentration in mg/Nm^3 (C_i)

From these two factors the Particulate Matter Emission Rate for each stack is calculated using the following formula.

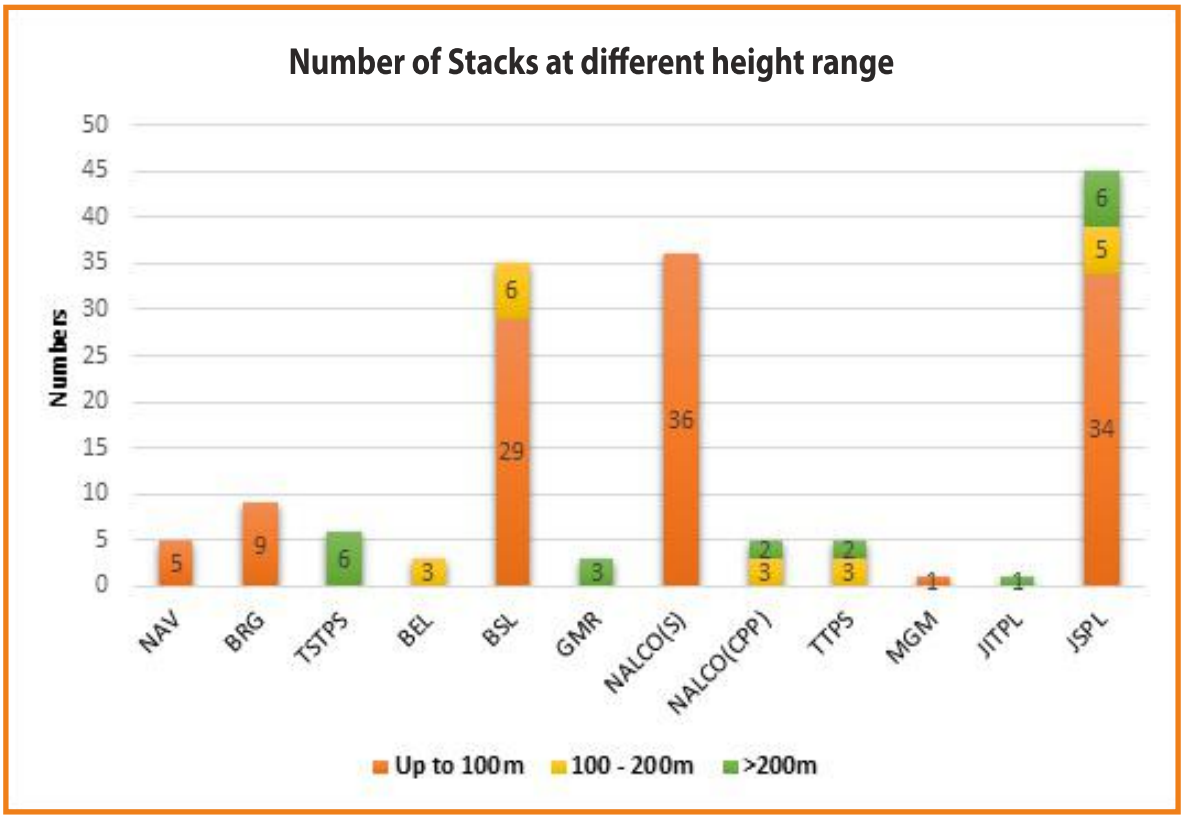


Fig. 7: Number of stacks at different height range in the study area

$$E_T^{PM10} = \sum_{i=1}^{N} \frac{Q_i \times C_i}{3.6 \times 10^6} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where

Q_i = Volumetric emission rate from stack *I (Nm³/h)*

C_i = Emission concentration from stack *I (mg/Nm³)*

N = Total number of stacks in the study area

E_T^{PM10} = Total PM_{10} emission rate from stacks in the study area *(g/s)*

Table 1: Industry-wise emission of PM_{10}.

Sl. No.	Name of Industry	PM_{10} emission from stacks (g/s)			
		Up to 100 m	100 - 200 m	>200 m	Total
1	Nav Bharat Ventures (NAV)	15.25			15.25
2	BRG Steels (P) Ltd (BRG)	13.11			13.11
3	Talcher Super Thermal Power Station (TSTPS)			333.33	333.33
4	Bhushan Energy Ltd (BEL)		51.53		51.53
5	Tata Steel BSL (BSL)	265.77	24.61		290.38
6	GMR Energy Ltd (GMR)			99.03	99.03
7	NALCO Smelter (NALCO - S)	257.62			257.62
8	NALCO CPP		163.75	30.46	194.21
9	Talcher Thermal Power Station (TTPS)	32.43	33.48		65.91
10	MGM Steel Ltd (MGM)		3.82		3.82
11	Jindal India Thermal (P) Ltd (JITPL)			30.93	30.93
12	Jindal Steel and Power Ltd (JSPL)	329.45	62.65	56.96	449.06
	Total	**913.63**	**339.84**	**550.71**	**1804.18**

The total emission rate was estimated by applying Eqation1, and the estimation was made with the following assumptions:

1. The stacks installed by the industries and power plants are generally used for emitting flue gas and the particle matters are emitted as the combustion products. Therefore, it is assumed that all the particles are of 10μ dia or less.

2. The concentration of PM_{10} in the stack gas are assumed to be approximate the standards prescribed by the SPCB.

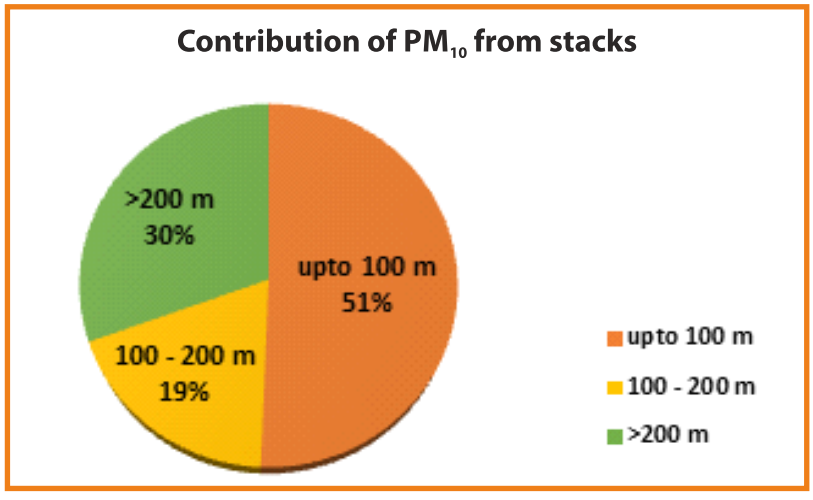


Fig. 8: Contribution of industrial emission at different heights

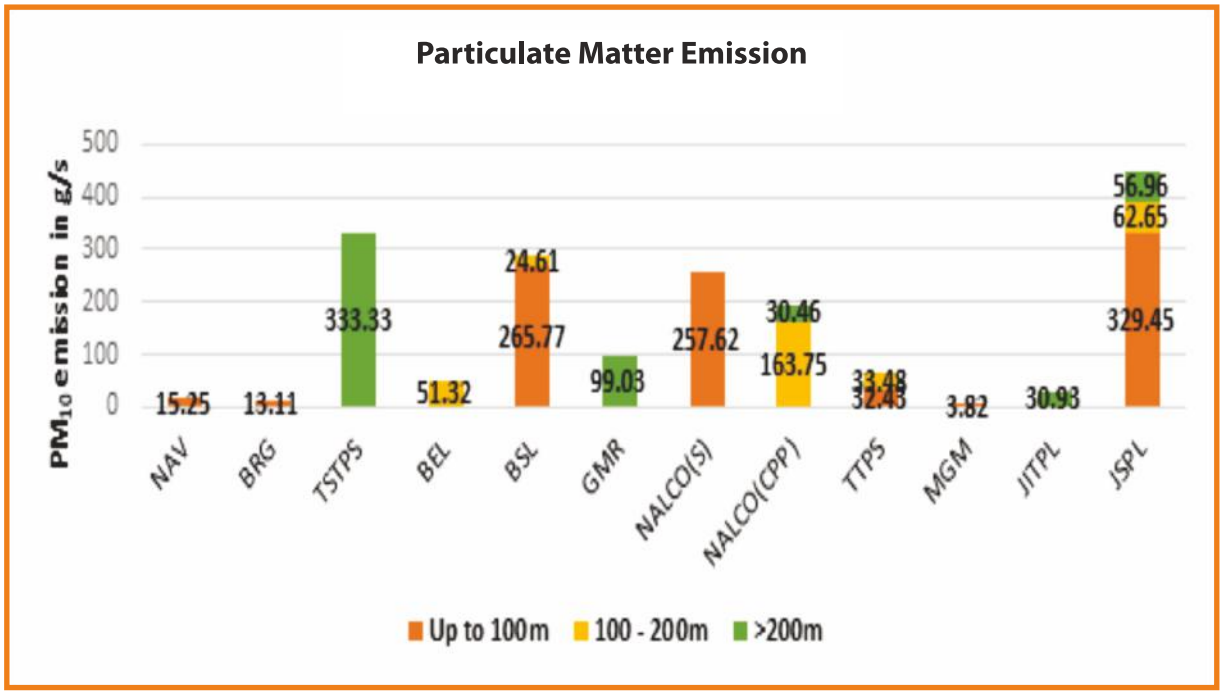


Fig. 9: Inventory of industrial emission at different heights

There are 153 number of stacks which emit PM_{10} into the atmosphere. It is estimated that 6500 kg of PM_{10} is emitted from the industrial sources per hour **(Table 1)**. Out of them 3300 kg. (51%) is emitted at a height of less than 100 m, 1220 kg. (19%) is emitted between a height of 100-200 m and 1980 kg. (30%) is emitted above a height of 200 m **(Figure 8 and 9)**.

5.2 Area Source

Area sources are small sources of air pollution which by themselves may not emit very much but, when their emissions are added together, account for a significant portion of the total emissions of air pollutants. In Angul – Talcher, seven open cast mines are operating which are the major area sources of air pollution. For estimating emission from these mines satellite images of the area were used to locate the mining area and seven patches were identified and shown in **Figure 10**.

The mines being located in close proximity, were divided on the active mining areas. Each of these areas were named as A1 to A7. The locations and areas of each patch are summarized in **Table 2**.

In coal mines all the major activities responsible for generation of PM_{10} and $PM_{2.5}$ are involved in

Over Burden (OB) removal and Coal Handling. The major activities occur in Over Burden removal are,

i. Bulldozing in OB loading area
ii. OB Loading
iii. Transportation of OB by Trucks
iv. OB Unloading
v. Bulldozing in OB unloading area

The major activities occur during coal handling are

i. Bulldozing in the coal loading area
ii. Coal Loading
iii. Transportation of Coal by Trucks
iv. Coal Unloading
v. Stocking with Bulldozer in unloading area
vi. Coal loading in train

The formulas used for particulate matter emission rate calculation under each activity in OB handling and Coal Handling are explained in **Appendix – I**. The calculated Emission Rate (g/s-m^2) for area source is presented in **Table 2** and **Figure 11**.

Table 2: Mine-wise PM_{10} emission rate estimation

Sl. No.	Area	Name of mine	Area (km^2)	Fraction of Total Area (%)	EF (g/s-m^2)	Emission in kg/s
1	A1	Hingula OCP	3.79	8.49	9.561	36.23
2	A2	Balaram OCP	5.55	12.44	13.996	77.68
3	A3	Jaganath Colliery	6.08	13.62	15.323	93.16
4	A4	Ananta OCP and Jagannath	13.51	30.27	34.071	460.30
5	A5	Ananta OCP	4.41	9.89	11.127	49.07
6	A6	Bhubaneswari OCP, Ananta OCP	2.38	5.32	5.992	14.26
7	A7	Lingaraj OCP	8.91	19.97	22.476	200.26
			44.63	**100**		**930.96**

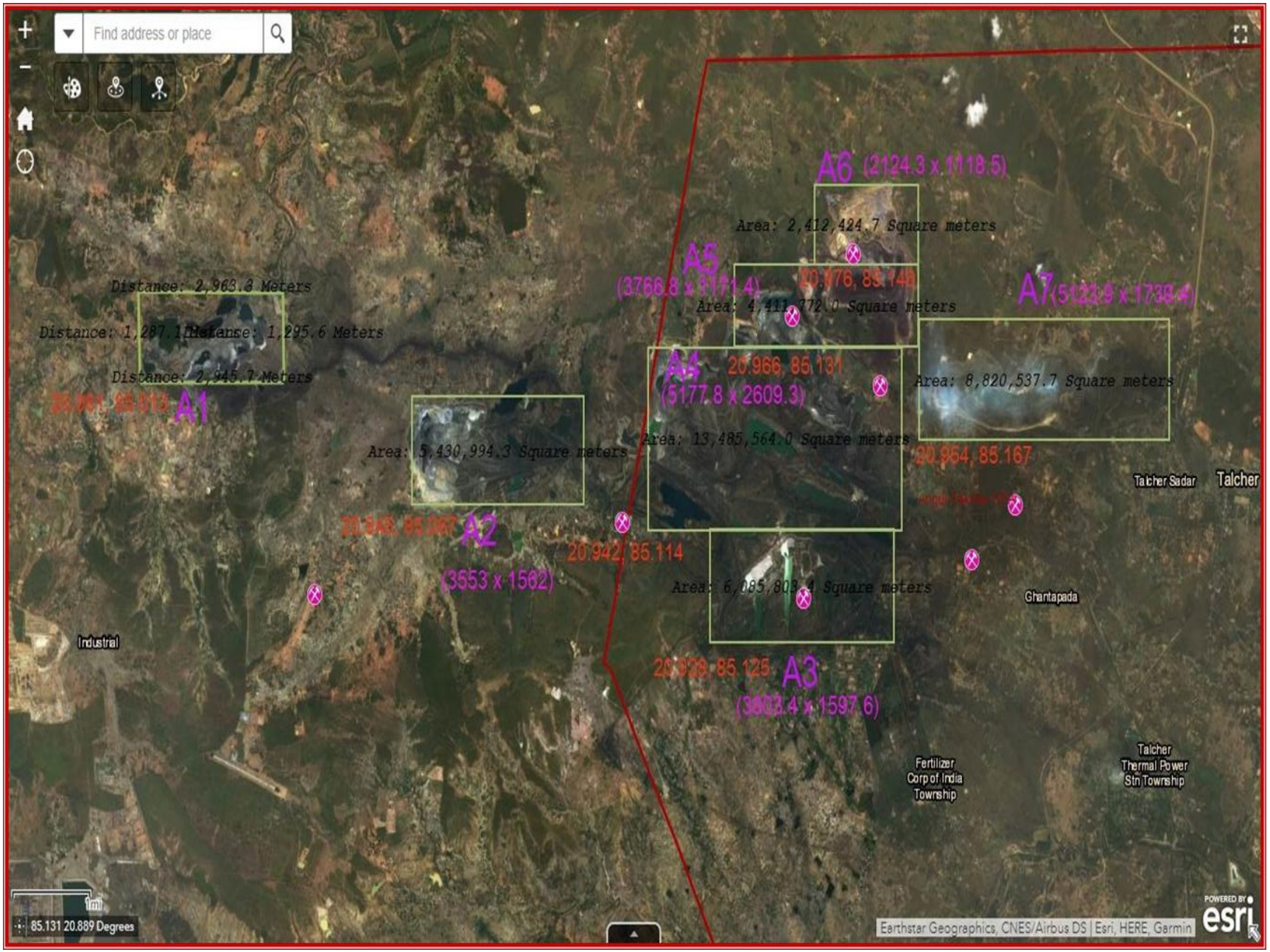


Figure – 10: Mining Area Division in Angul – Talcher CPA for Area Source Emission Inventory

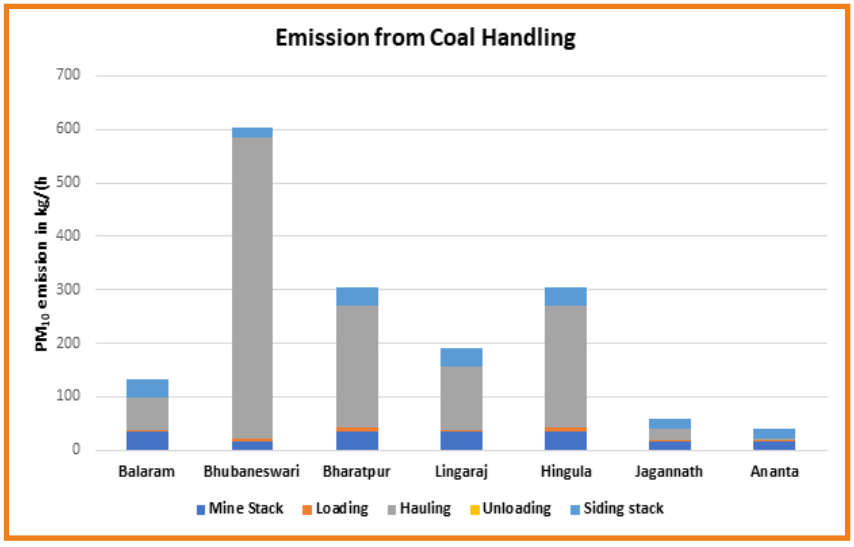


Fig. 11: Mine-wise emission from mining operation

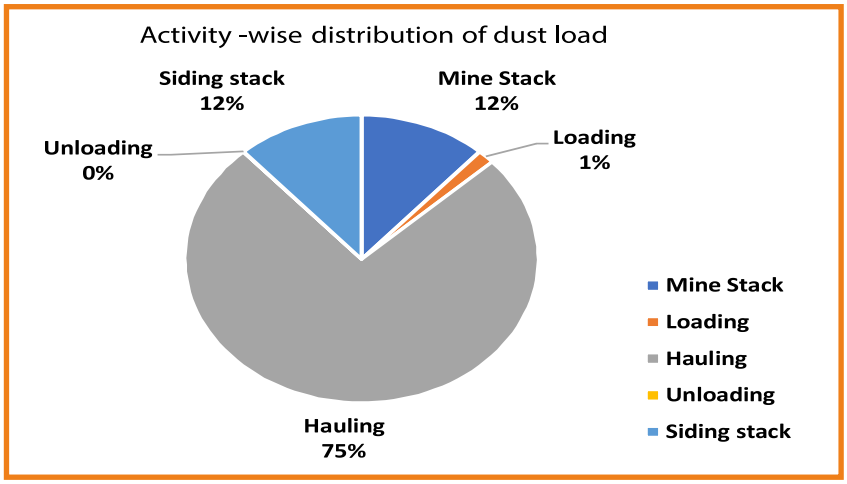


Fig. 12: Activity-wise emission of PM_{10} from mining operation

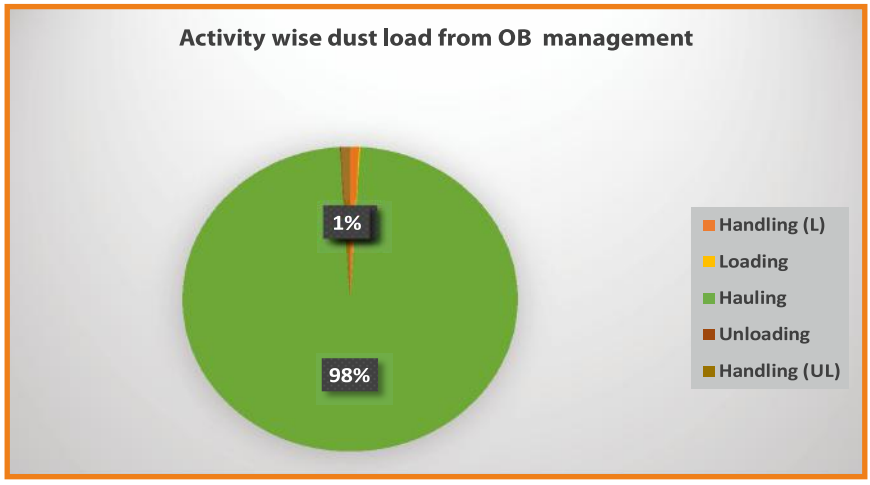


Fig. 13: Activity-wise emission from OB handling

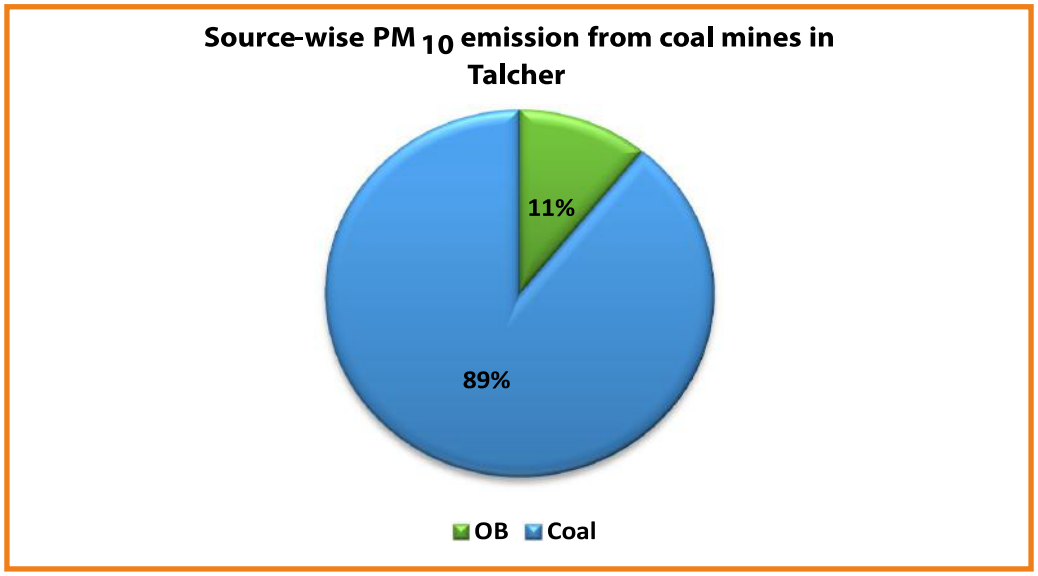


Fig. 14: Contribution of emission from mining and OB handling

5.3 Transport Emission

A study was conducted by IIT Delhi on Heat Island effect in Angul-Talcher area in the year 2018. As part of the study, a traffic volume survey was carried out on the major highways passing through the study area. The result of the survey is presented in **Table 3**. In order to estimate transport related emission, the data collected during the above study is considered.

Table 3: Details of Traffic movement in Angul – Talcher

Sl. No.	Location	Heavy Vehicle (No / Day)		Light Vehicle (No / Day)			Total (No / Day)
		Bus and Mini Bus	Long Trailers & Loaded Trucks	Cars, taxis, Trekkers, Jeeps	Auto rickshaw / Three-wheeler	Two-Wheeler, Scooter & Motorcycle	
1.	Balhar Square	1618	4332	1334	1153	2932	11369
2.	Banarpal Square	2231	5790	3036	1521	5519	18097
3.	Gudiakateni Square	2211	4402	1516	1150	2224	11503
4.	Angul–Sambalpur–Chhendipada Square	2601	4790	2093	1949	4580	15713
						Total	**56682**

For the modelling purpose, a total length of 175.40 km of the highway was taken into consideration. The width of the highway is 61 m (200ft). Transport related emission was modelled as a linear area source with an effective area of about 0.5 km^2. The emission factor for paved road was taken as per AP-42 using the following formula.

$$E = k \left(\frac{sL}{2}\right)^{0.65} \times \left(\frac{W}{3}\right)^{1.5} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where:

E = particulate emission factor (g/ sec-m^2)

k = base emission factor for particle size range of PM_{10} (4.6 g/VKT)

sL = road surface silt loading (grams per square meter)

W = vehicle weight (2 tons)

6. Air Quality Modelling and source Apportionment

6.1. Model Description

AERMOD view is a complete and powerful air dispersion modeling package that seamlessly incorporates the popular U.S. EPA models, AERMOD, ISCST3 and ISC-Prime into one interface without any modifications to the models. These models are used extensively to assess pollution concentration and deposition from a wide variety of sources. In Angul – Talcher CPA for air quality modelling, AERMOD View model is used. AERMOD is a regulatory steady-state plume modeling system with three separate components: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD Terrain Preprocessor) and AERMET (AERMOD Meteorological Preprocessor). The AERMOD model includes a wide range of options for modeling air quality impacts of pollution sources, making it a popular choice among the modeling community for a variety of applications. AERMOD contains basically the same options as the ISCST3 model.

For air quality modeling of Angul – Talcher, an area of 50km length and 50km width is selected covering all the industries and mines within the CPA. The south west corner of the area is $20^0$45' N and $84^0$55' E.

6.2 Model output and analysis of results for source apportionment

The model was run with the meteorological data of 2018 from July to December. The model estimates the concentration of PM_{10} for each grid of 1 x 1 km^2. The predicted value of the model in the grid was compared with the observed value of manual monitoring over the same period and the comparative values are presented in **Table 4**. The model outputs in terms of predicted contours of PM_{10} concentration of entire study area and the cities of Angul and Talcher are depicted in **Appendix II**, separately for each group of source-Industry, Mines and Transport.

Table 4: Comparison of predicted and observed value

Sl. No.	Station	Predicted value (PM_{10} in µgm/m^3)	Observed value (PM_{10} in µgm/m^3)
1.	Bharatpur Guest House	426.25	124.56
2.	SPCB Regional Office, Angul	102.99	98.94
3.	Nalco township, Angul	109.14	102.73
4.	TTPS Guest House, Talcher	132.98	95.4
5.	Dera Chowk, Talcher	619.66	237.34

Though it appears that more rigorous model calibration is required for model validation, the predicted value and observed values are within a range of fair degree of agreements.

The model was run by considering separate group of sources, such as industrial emission, mining emission and transport related emission for Angul and Talcher separately. In order to arrive at the contribution of each sources in both the cities the mean values of all the grids contained within the cities of Angul and Talcher was estimated for each group of sources and are presented in **Table 5**. The percentage of contribution as per the model is indicated within the parenthesis.

Table 5: Estimated value of sector-wise contribution

	Industries	Mines	Transport	Total
Angul	7.995	78.52	14.02	100.54
	(8%)	(78%)	(14%)	(100%)
Talcher	5.36	144.95	6.45	156.76
	(3.4%)	(92.5%)	(4.1%)	(100%)

The relative contribution of different sources in Angul and Talcher are shown as Figure 15.

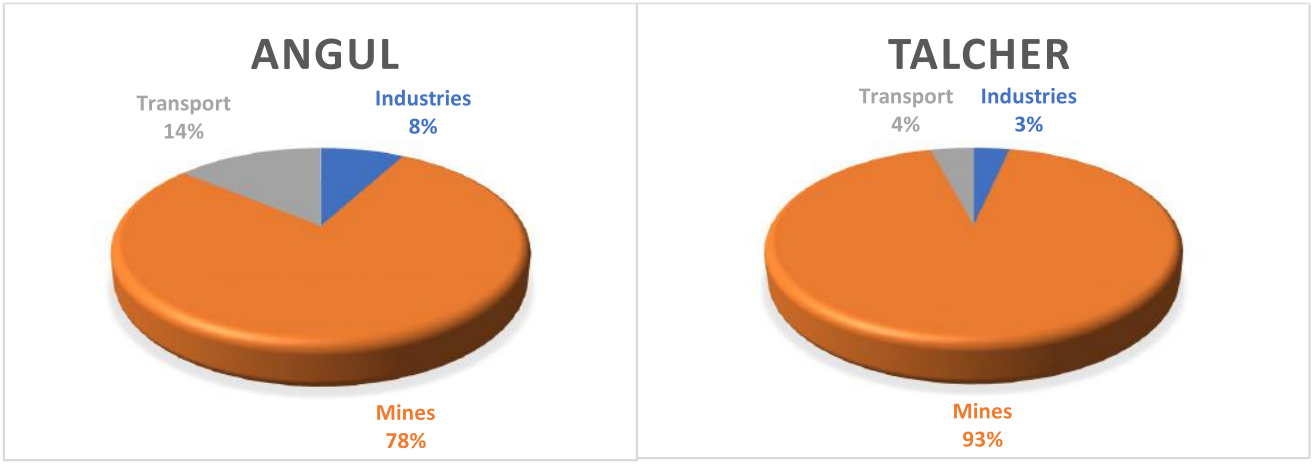


Fig. 15: Relative contribution of PM_{10} from major sources in Angul and Talcher

7. Conclusion

The study for apportionment of air pollution sources was carried out for both Angul and Talcher city, since contribution to air pollution in both the cities are common. From this rapid study the following conclusions can be drawn.

1. From the air quality monitoring conducted by the State Pollution Control Board, it is observed that the PM_{10} and $PM_{2.5}$ exceed the NAAQS level. Other gaseous pollutants level is however well below the standard. Therefore, the apportionment study was carried out for PM_{10} only.

2. The current study for apportionment of PM_{10} was carried out by using air quality dispersion model.
3. The model output and the observed value was found to be within a fair degree of agreement.
4. The study indicates that mining operation is the largest contributor to air pollution in Angul and Talcher. Its contribution in Angul is 78% and in Talcher it is 92%.
5. Transportation is the second most important contributor to air pollution in the study area. In Angul, the transport Sector contribution is about 14% and in Talcher, its contribution is only 4.1%.
6. In both the cities the contribution of industries has been observed to be the minimum.

8. Limitations of the study

Though all care has been taken to make sure that contribution of different sources of PM_{10} pollution has been taken into account, but due to paucity of time and limitation of resources, this report is constrained with certain limitation as discussed in the following section.

1. The emission inventory has been prepared on the basis of normal state of activity and generalized emission factors. The emission assessment refers to the activities of the year 2018. The present position of industrial and transport activities may be slightly different than that of the year 2018.
2. The process of inventorying the emission from industrial, mining and transport sectors are based on data available with State Pollution Control Board. Moreover, this assessment has not been subjected to rigorous quality assurance program, due to lack of adequate data. Therefore, a structured quality assurance of emission inventory may improve the reliability of the result.
3. Due to paucity of time and data insufficiency, model calibration and data validation of Air Quality Model could not be carried out. Improved data collection through field study, laboratory analysis and use of advanced chemical mass balance may substantially improve the confidence level of the study outcome.

Appendix – I

Formulas used for Particulate Matter Emission Rate Calculation for Area Source

Appendix - I

Formulas used for Particulate Matter Emission Rate Calculation for Area Source

Operation	Activity	Equation	Unit
Overburden Handling	Bulldozing in the OB loading area	$0.75(0.45)\ s^{1.5}/\ M^{1.4}$	kg PM_{10}/h
	OB Loading	$0.00056\ (U/2.2)^{1.3}\ /\ (M/2)^{1.4}$	kg PM_{10}/t
	Transportation of OB by Trucks	$0.423(s/12)^{0.9}(W/3)^{0.45}(1-\eta_s)(1-\eta_r)$	kg PM_{10}/VKT
	OB Unloading	$0.00056\ (U/2.2)^{1.3}\ /\ (M/2)^{1.4}$	kg PM_{10}//t
	Bulldozing in the OB unloading area	$0.75(0.45)\ s^{1.5}/\ M^{1.4}$	kg PM_{10}/h
Coal Handling	Bulldozing in the coal loading area	$0.75(8.44)\ s^{1.5}/\ M^{1.4}$	kg PM_{10}/ (hbulldozer)
	Coal Loading	$0.75(0.0596\ /\ M^{0.9})$	kg PM_{10}/t
	Transportation of Coal by Trucks	$0.423(s/12)^{0.9}(W/3)^{0.45}(1-\eta_s)(1-\eta_r)$	kg PM_{10}/VKT
	Coal Unloading	$0.00056\ (U/2.2)^{1.3}\ /\ (M/2)^{1.4}$	kg PM_{10}/t
	Stocking with Bulldozer in unloading area	$0.75(8.44)\ s^{1.5}/\ M^{1.4}$	kg PM_{10}/ (h bulldozer)
	Coal loading in train	$0.00056\ (U/2.2)^{1.3}\ /\ (M/2)^{1.4}$	kg PM_{10}/ t

Reference: Huertas, J.I., Camacho, D.A. & Huertas, M.E., 2012, Standardized emissions inventory methodology for open-pit mining areas, *Environmental Science Pollution Research*, vol 19, pp 2784 - 2794

List of Symbols

k: Intensity of water spray application

m: number of days in the study period

M: Moisture content of the handled material

n: Number of rainy days in the study period

p: Average day time evaporation rate

r: Average daily traffic

s: Silt content (mesh 200) of the handled material or on the surface of the road

U: Wind speed (m/s)

VKT: Vehicle Kilometer Travelled

W: Truck average weight (t)

η_s: Efficiency of emission controls for spraying water (%) : $\eta_s = 1- (0.8prt / k)$

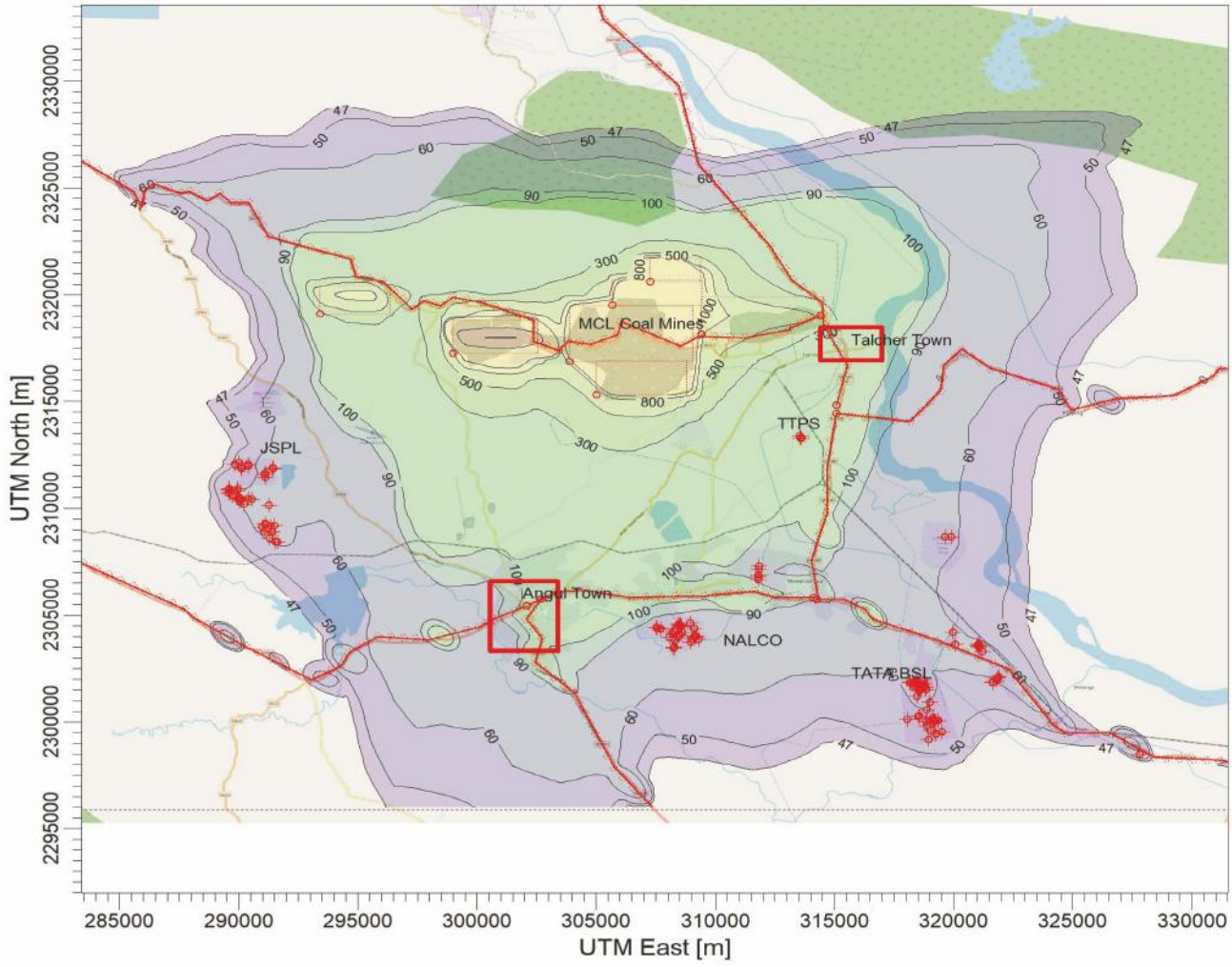
η_r: Efficiency of particulate matter emission control through natural spraying (rain) (%)
$\eta_r = 1 – ((m-n)/ m)$

Appendix – II

Model outputs in terms of predicted contours of PM_{10} concentration

PROJECT TITLE:

Rapid Source Apportionment Study for Talcher Angul
State Pollution Control Board



PLOT FILE OF PERIOD VALUES AVERAGED ACROSS 0 YEARS FOR SOURCE GROUP: ALL ug/m^3

Max: 4653 [ug/m^3] at (301500.00, 2318000.00)

47 50 60 90 100 300 500 800 1000 3000 4500 4653

COMMENTS: Contours of annual average PM10 in Angul Talcher Area - 2018 (Contribution of Industry, Mine and Transport)	SOURCES: **168**	COMPANY NAME: **State Pollution Control Board**	
	RECEPTORS: **2601**	MODELER: **Nihar R Sahoo and Subhadarshini Das**	ODISHA
	OUTPUT TYPE: **Concentration**	SCALE: 1:302,458 (0 — 10 km)	
	MAX: **4653 ug/m^3**		PROJECT NO.: **01**

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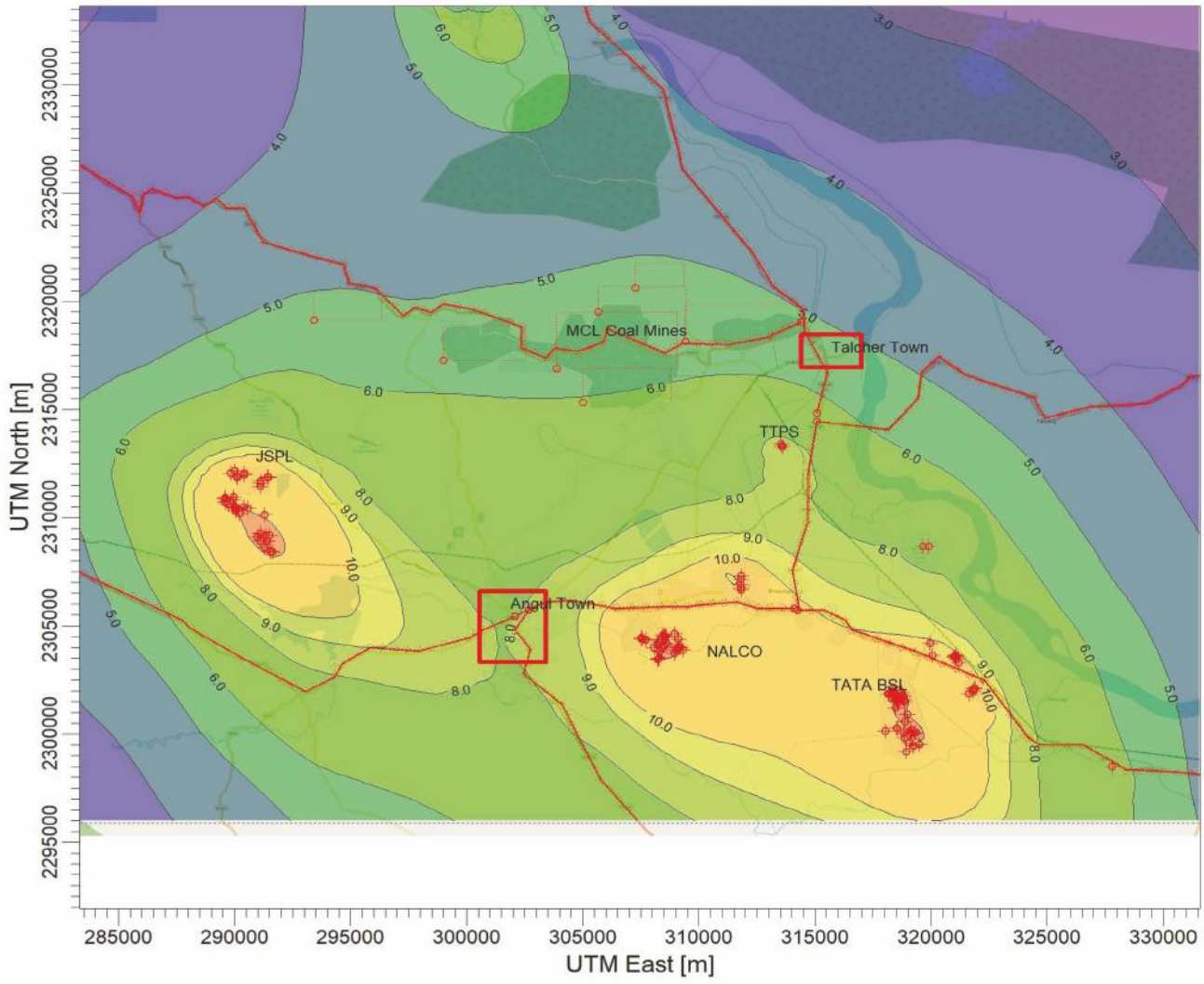
PROJECT TITLE:

Rapid Source Apportionment Study for Talcher Angul
State Pollution Control Board



PLOT FILE OF PERIOD VALUES AVERAGED ACROSS 0 YEARS FOR SOURCE GROUP: POINT ug/m^3

Max: 28.9 [ug/m^3] at (291500.00, 2309000.00)

2.0 3.0 4.0 5.0 6.0 8.0 9.0 10.0 20.0 28.9

COMMENTS: Contours of annual average PM10 in Angul Talcher Area - 2018 (Contribution of Industry only)	SOURCES: **168**	COMPANY NAME: **State Pollution Control Board**	
	RECEPTORS: **2601**	MODELER: **Nihar R Sahoo and Subhadarshini Das**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:303,450 0 10 km	
	MAX: **28.9 ug/m^3**		PROJECT NO.: **01**

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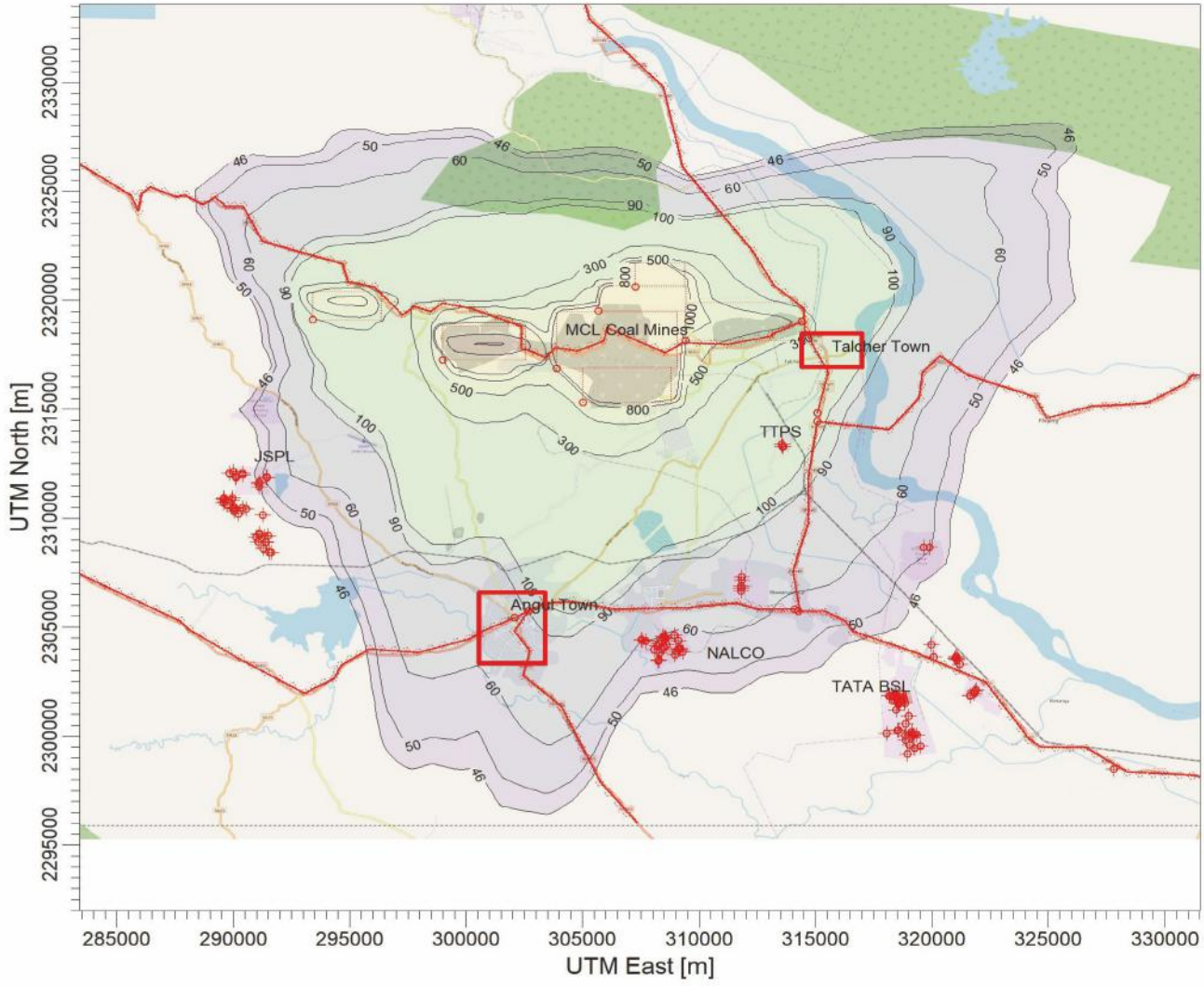
PROJECT TITLE:

Rapid Source Apportionment Study for Talcher Angul
State Pollution Control Board



PLOT FILE OF PERIOD VALUES AVERAGED ACROSS 0 YEARS FOR SOURCE GROUP: MINES ug/m^3

Max: 4640 [ug/m^3] at (301500.00, 2318000.00)

46 50 60 90 100 300 500 800 1000 3000 4500 4640

COMMENTS: Contours of annual average PM10 in Angul Talcher Area - 2018 (Contribution of Mines only)	SOURCES: **168**	COMPANY NAME: **State Pollution Control Board**	
	RECEPTORS: **2601**	MODELER: **Nihar R Sahoo and Subhadarshini Das**	ODISHA
	OUTPUT TYPE: **Concentration**	SCALE: 1:302,458 0 — 10 km	
	MAX: **4640 ug/m^3**		PROJECT NO.: **01**

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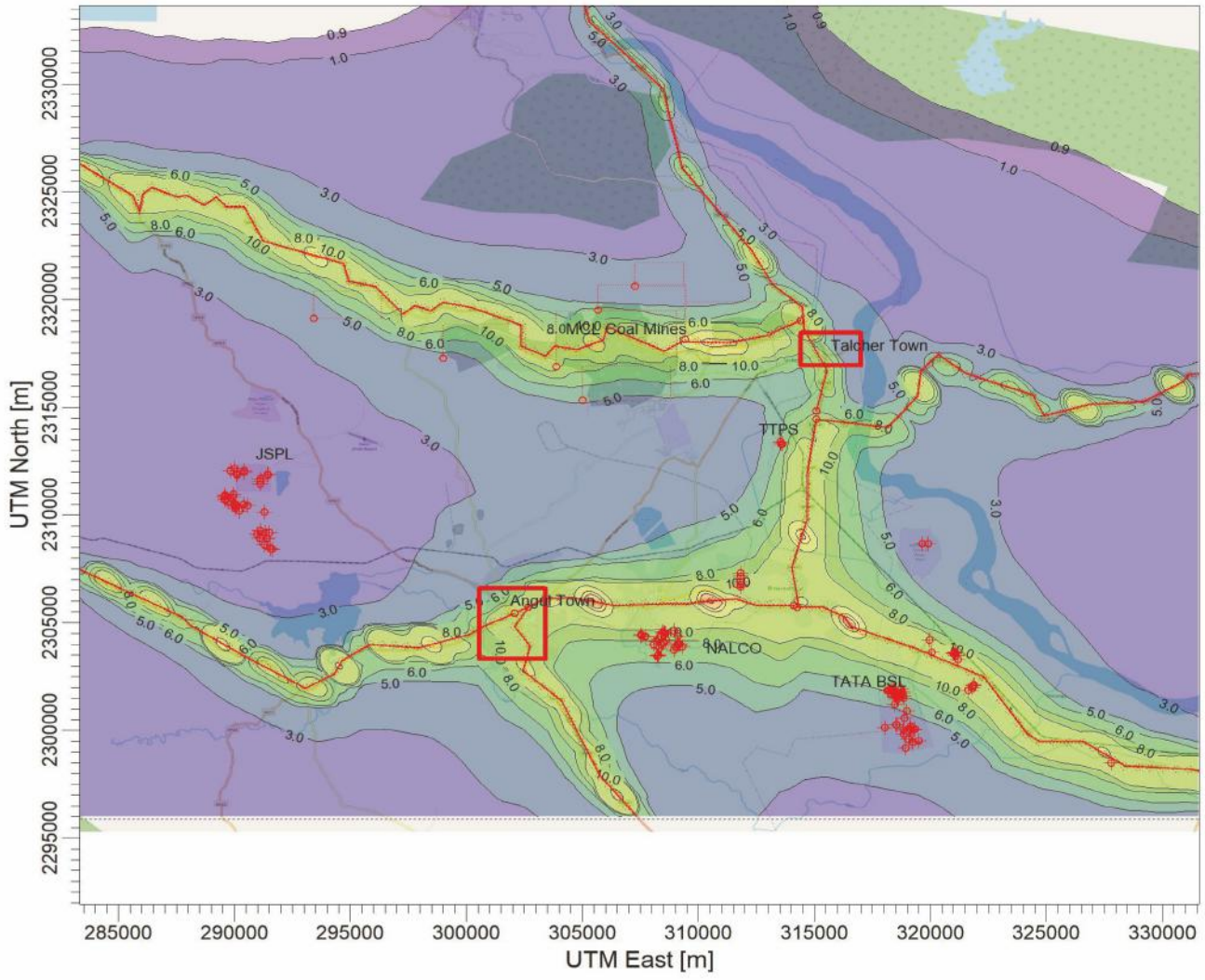
PROJECT TITLE:

Rapid Source Apportionment Study for Talcher Angul
State Pollution Control Board



PLOT FILE OF PERIOD VALUES AVERAGED ACROSS 0 YEARS FOR SOURCE GROUP: ROAD ug/m^3

Max: 87.4 [ug/m^3] at (310500.00, 2306000.00)

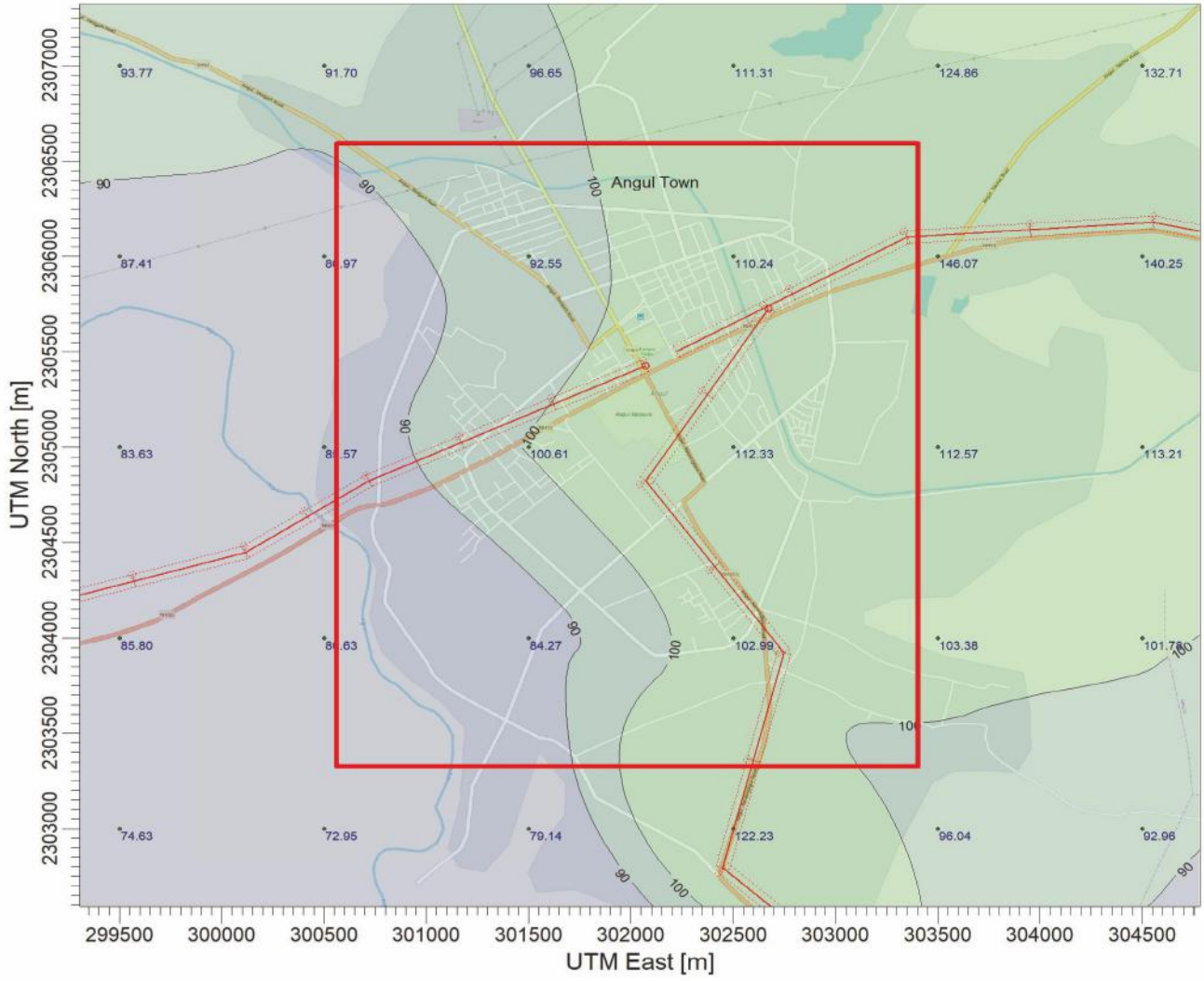
0.9 1.0 3.0 5.0 6.0 8.0 10.0 30.0 50.0 60.0 80.0 87.4

COMMENTS: Contours of annual average PM10 in Angul Talcher Area - 2018 (Contribution of Transport only)	SOURCES: **168**	COMPANY NAME: **State Pollution Control Board**	
	RECEPTORS: **2601**	MODELER: **Nihar R Sahoo and Subhadarshini Das**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:303,450 — 0 — 10 km	
	MAX: **87.4 ug/m^3**		PROJECT NO.: **01**

AERMOD View - Lakes Environmental Software F:\16_09_2019\New Project\New Project.isc

PROJECT TITLE:

Rapid Source Apportionment Study for Talcher Angul
State Pollution Control Board



PLOT FILE OF PERIOD VALUES AVERAGED ACROSS 0 YEARS FOR SOURCE GROUP: ALL ug/m^3

Max: 4653 [ug/m^3] at (301500.00, 2318000.00)

47 50 60 90 100 300 500 800 1000 3000 4500 4653

COMMENTS: Contours of annual average PM10 around Angul Town - 2018 (Contribution of Mines, Industries and Transport)	SOURCES: **168**	COMPANY NAME: **State Pollution Control Board**	
	RECEPTORS: **2601**	MODELER: **Nihar R Sahoo and Subhadarshini Das**	ODISHA
	OUTPUT TYPE: **Concentration**	SCALE: 1:34,428 (0 — 1 km)	
	MAX: **4653 ug/m^3**		PROJECT NO.: **01**

AERMOD View - Lakes Environmental Software

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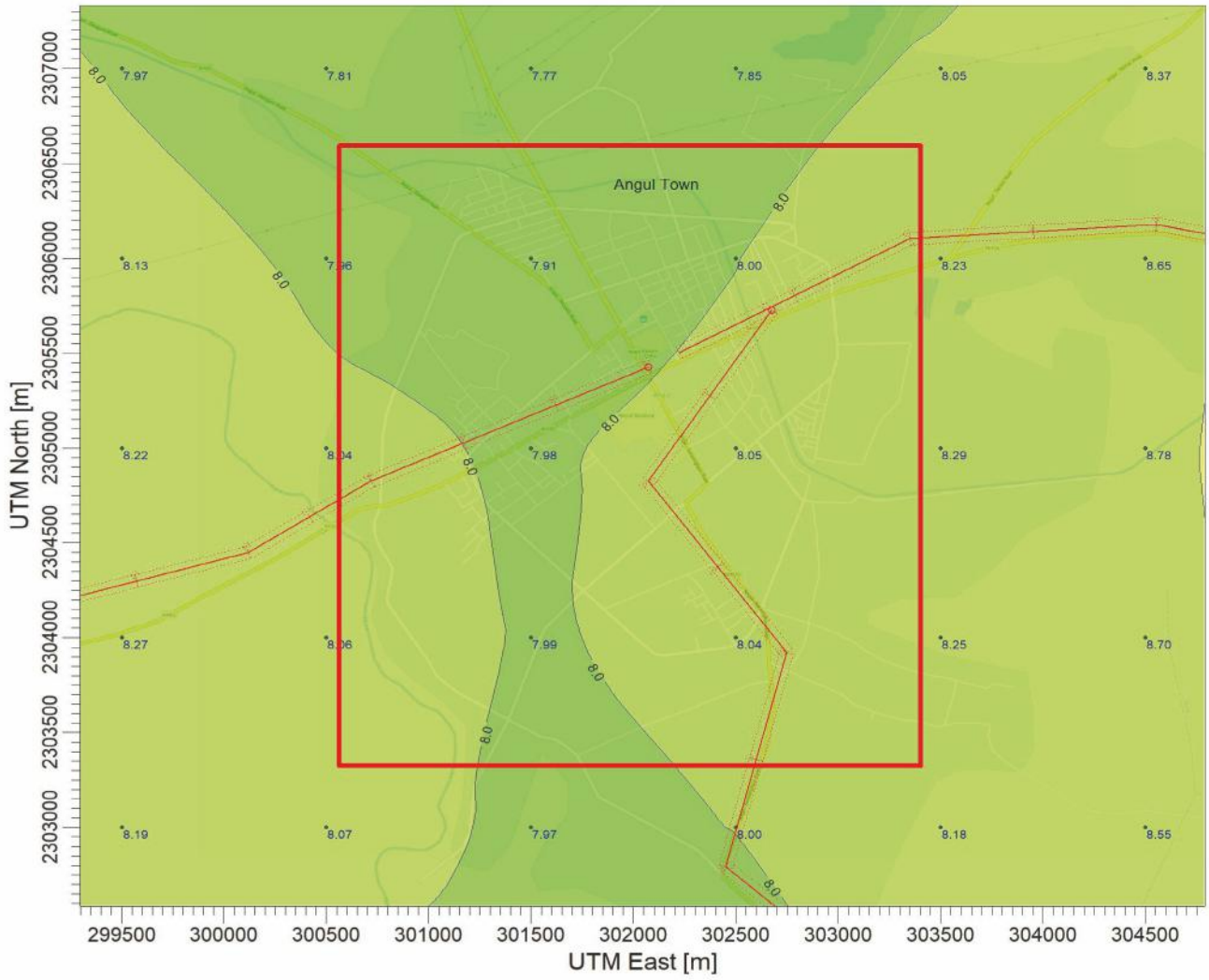
PROJECT TITLE:

Rapid Source Apportionment Study for Talcher Angul
State Pollution Control Board



PLOT FILE OF PERIOD VALUES AVERAGED ACROSS 0 YEARS FOR SOURCE GROUP: POINT ug/m^3

Max: 28.9 [ug/m^3] at (291500.00, 2309000.00)

2.0 3.0 4.0 5.0 6.0 8.0 9.0 10.0 20.0 28.9

COMMENTS: Contours of annual average PM10 around Angul Town - 2018 (Contribution of Industries only)	SOURCES: **168**	COMPANY NAME: **State Pollution Control Board**	
	RECEPTORS: **2601**	MODELER: **Nihar R Sahoo and Subhadarshini Das**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:34,540 (0 — 1 km)	
	MAX: **28.9 ug/m^3**		PROJECT NO.: **01**

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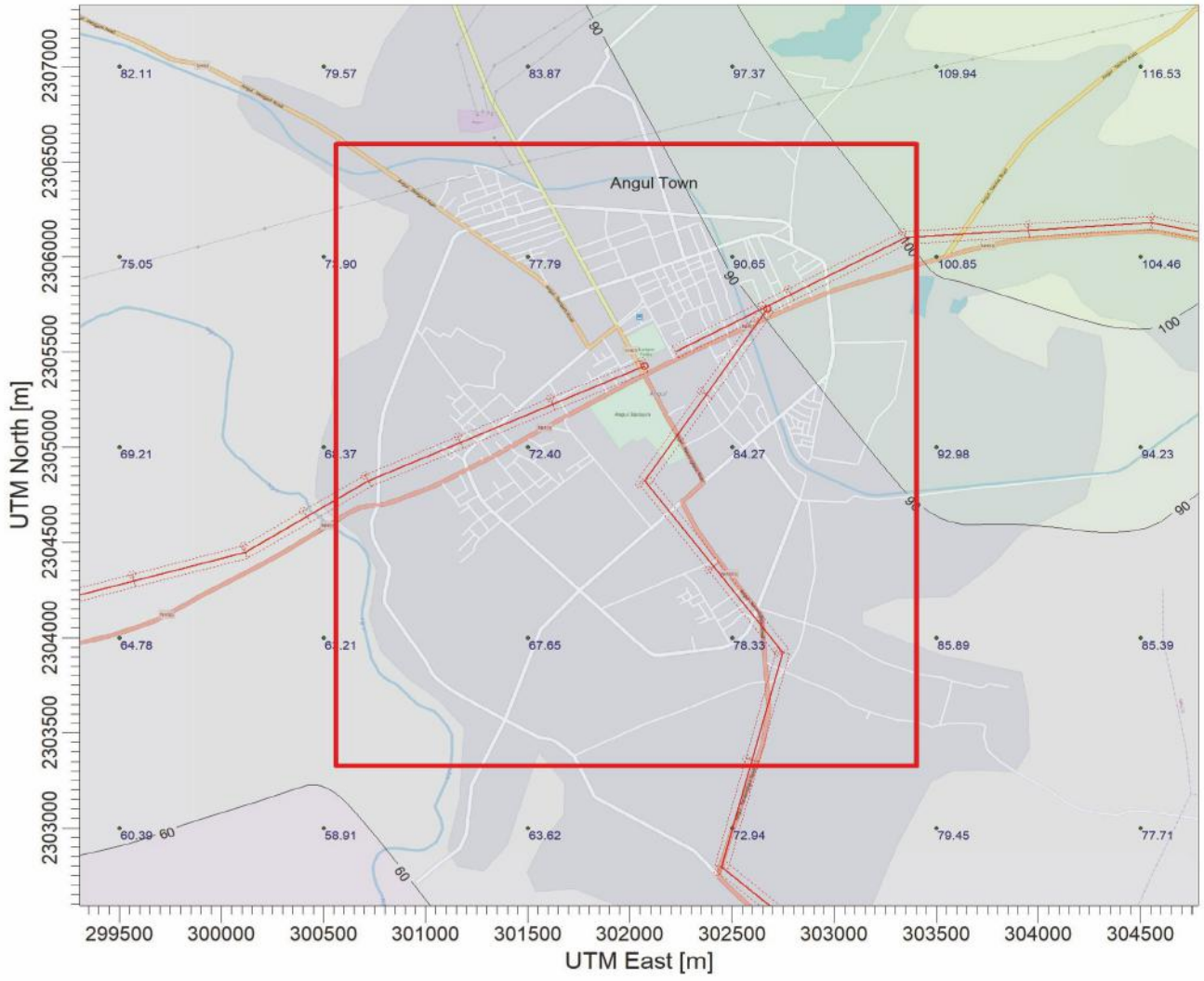
PROJECT TITLE:

Rapid Source Apportionment Study for Talcher Angul
State Pollution Control Board



PLOT FILE OF PERIOD VALUES AVERAGED ACROSS 0 YEARS FOR SOURCE GROUP: MINES ug/m^3

Max: 4640 [ug/m^3] at (301500.00, 2318000.00)

46 50 60 90 100 300 500 800 1000 3000 4500 4640

COMMENTS: Contours of annual average PM10 around Angul Town - 2018 (Contribution of Mines only)	SOURCES: **168**	COMPANY NAME: **State Pollution Control Board**	
	RECEPTORS: **2601**	MODELER: **Nihar R Sahoo and Subhadarshini Das**	ODISHA
	OUTPUT TYPE: **Concentration**	SCALE: 1:34,428 (0 — 1 km)	
	MAX: **4640 ug/m^3**		PROJECT NO.: **01**

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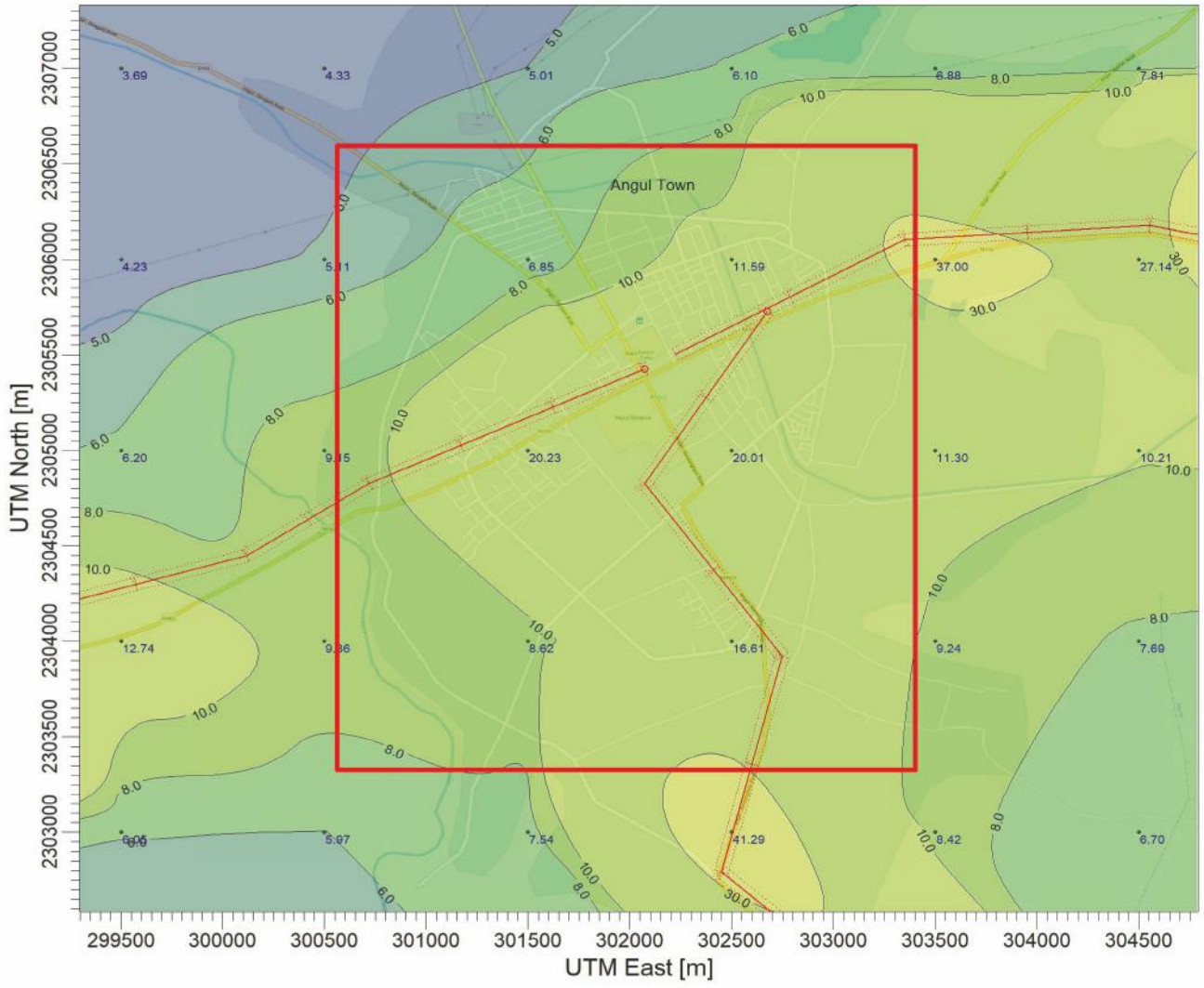
PROJECT TITLE:

Rapid Source Apportionment Study for Talcher Angul
State Pollution Control Board



PLOT FILE OF PERIOD VALUES AVERAGED ACROSS 0 YEARS FOR SOURCE GROUP: ROAD ug/m^3

Max: 87.4 [ug/m^3] at (310500.00, 2306000.00)

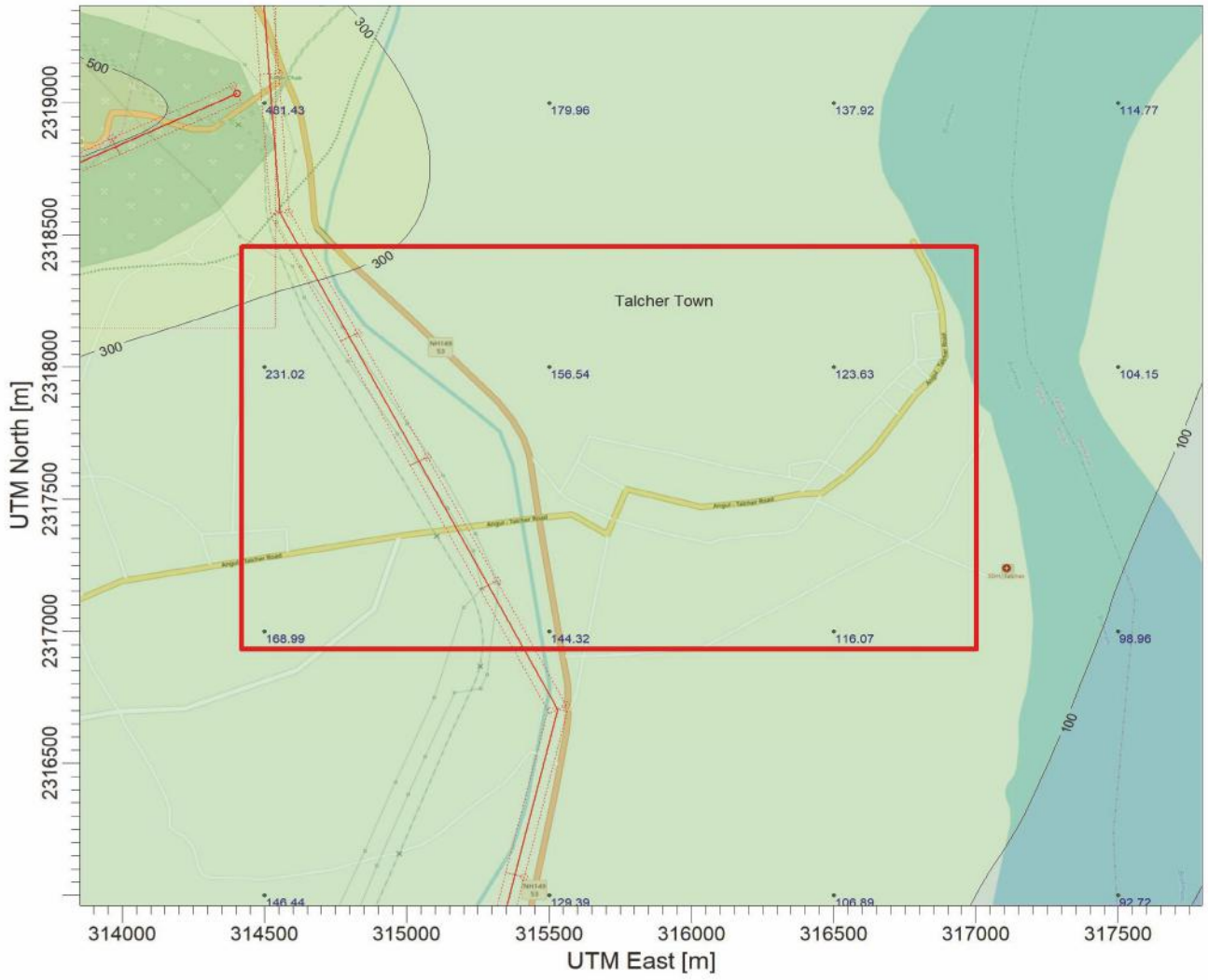
0.9 1.0 3.0 5.0 6.0 8.0 10.0 30.0 50.0 60.0 80.0 87.4

COMMENTS: Contours of annual average PM10 around Angul Town - 2018 (Contribution of Transport only)	SOURCES: **168**	COMPANY NAME: **State Pollution Control Board**	
	RECEPTORS: **2601**	MODELER: **Nihar R Sahoo and Subhadarshini Das**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:34,540 0 1 km	
	MAX: **87.4 ug/m^3**		PROJECT NO.: **01**

AERMOD View - Lakes Environmental Software F:\16_09_2019\New Project\New Project.isc

PROJECT TITLE:

Rapid Source Apportionment Study for Talcher Angul
State Pollution Control Board



PLOT FILE OF PERIOD VALUES AVERAGED ACROSS 0 YEARS FOR SOURCE GROUP: ALL ug/m^3

Max: 4653 [ug/m^3] at (301500.00, 2318000.00)

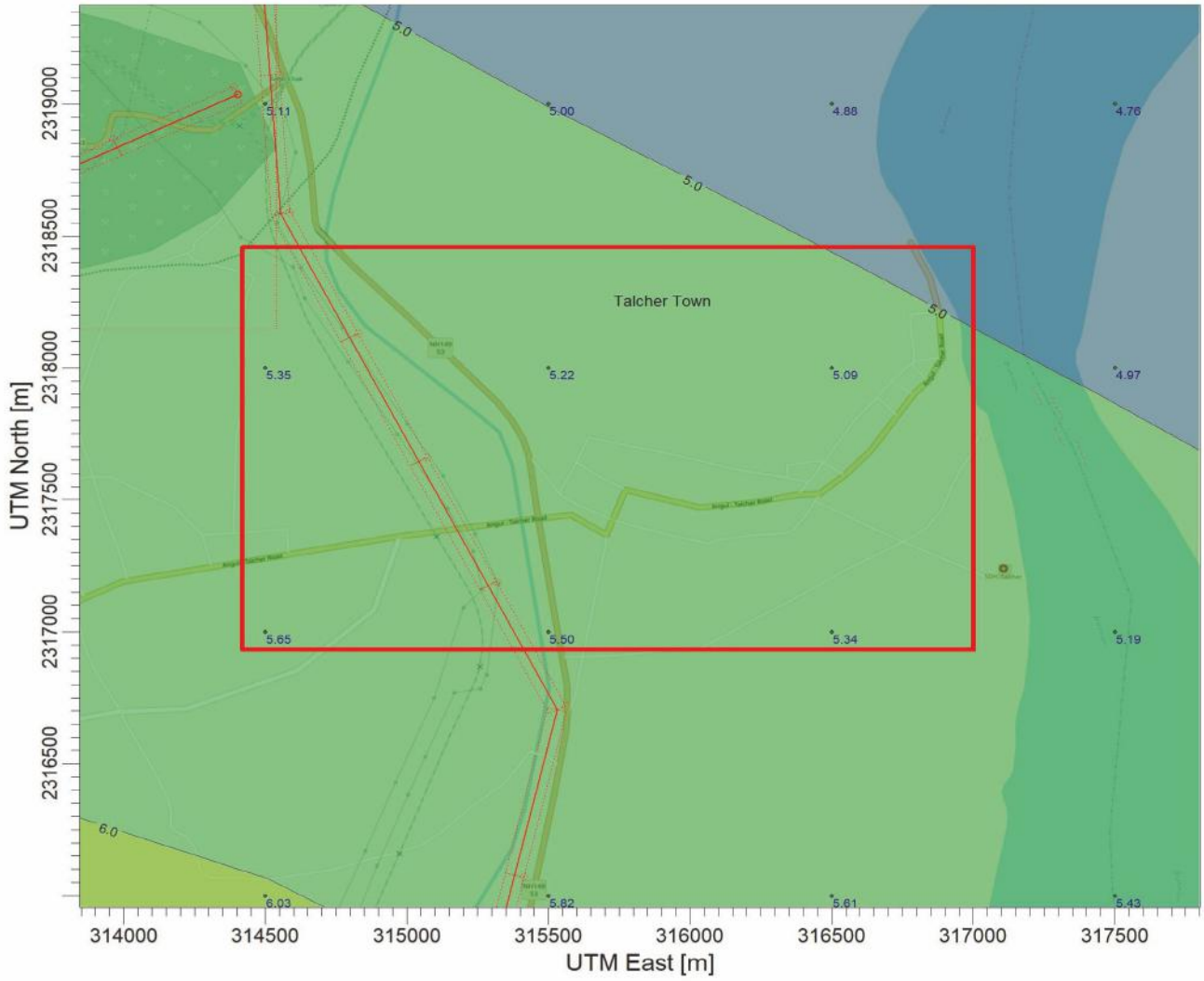
47 50 60 90 100 300 500 800 1000 3000 4500 4653

COMMENTS: Contours of anual average PM10 around Talcher Town - 2018(Contribution of Industrry, Mine and Transport)	SOURCES: **168**	COMPANY NAME: **State Pollution Control Board**	
	RECEPTORS: **2601**	MODELER: **Nihar R Sahoo and Subhadarshini Das**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:24,792 — 0 — 0.5 km	
	MAX: **4653 ug/m^3**		PROJECT NO.: **01**

AERMOD View - Lakes Environmental Software F:\16_09_2019\New Project\New Project.isc

PROJECT TITLE:

Rapid Source Apportionment Study for Talcher Angul
State Pollution Control Board



PLOT FILE OF PERIOD VALUES AVERAGED ACROSS 0 YEARS FOR SOURCE GROUP: POINT ug/m^3

Max: 28.9 [ug/m^3] at (291500.00, 2309000.00)

2.0 3.0 4.0 5.0 6.0 8.0 9.0 10.0 20.0 28.9

COMMENTS: Contours of annual average PM10 around Talcher Town - 2018 (Contribution of Industries only)	SOURCES: **168**	COMPANY NAME: **State Pollution Control Board**	
	RECEPTORS: **2601**	MODELER: **Nihar R Sahoo and Subhadarshini Das**	ODISHA
	OUTPUT TYPE: **Concentration**	SCALE: 1:24,874 (0 — 1 km)	
	MAX: **28.9 ug/m^3**		PROJECT NO.: **01**

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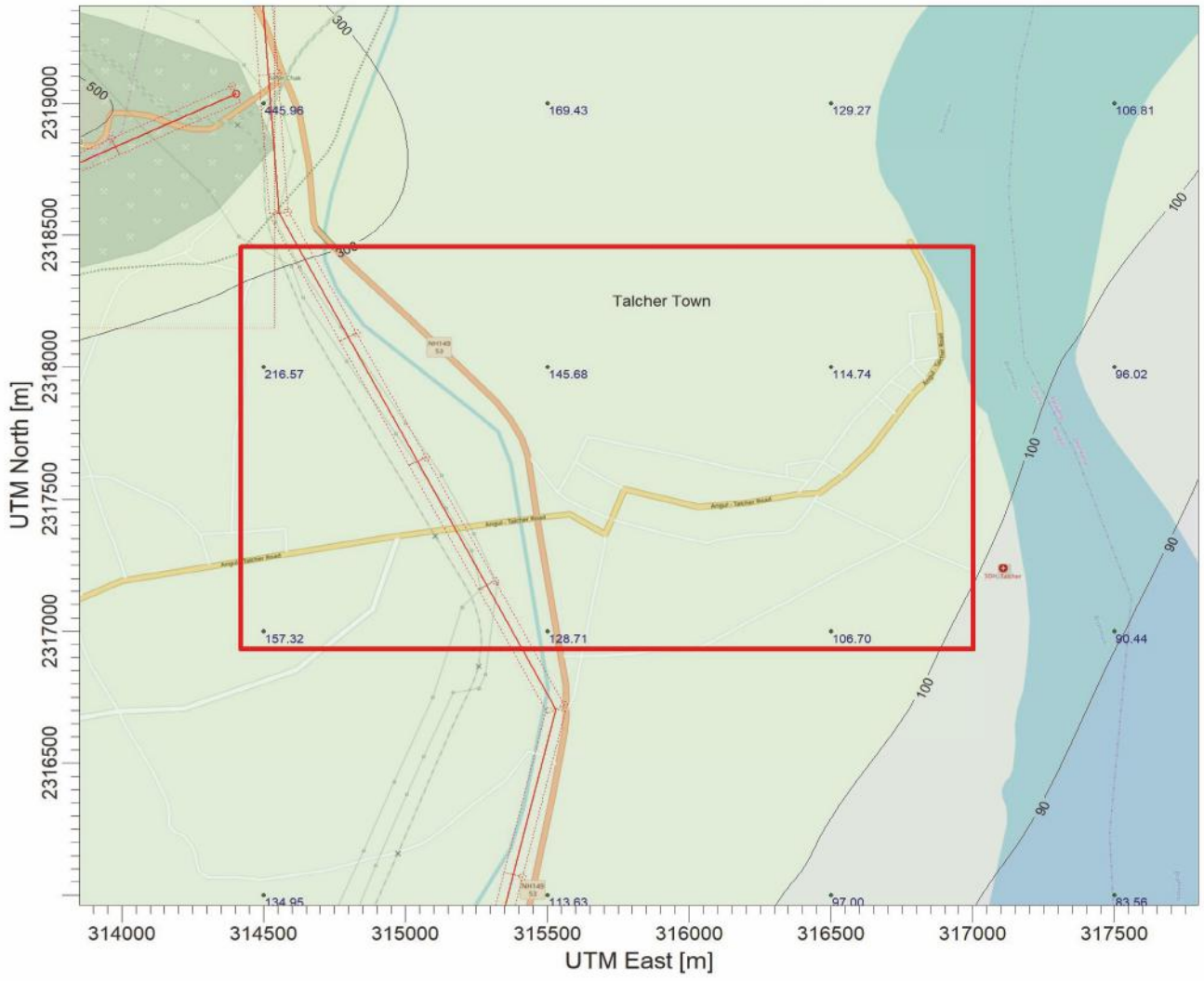
PROJECT TITLE:

Rapid Source Apportionment Study for Talcher Angul
State Pollution Control Board



PLOT FILE OF PERIOD VALUES AVERAGED ACROSS 0 YEARS FOR SOURCE GROUP: MINES ug/m^3

Max: 4640 [ug/m^3] at (301500.00, 2318000.00)

46 50 60 90 100 300 500 800 1000 3000 4500 4640

COMMENTS: Contours of annual average PM10 around Talcher Town - 2018 (Contribution of Mine only)	SOURCES: **168**	COMPANY NAME: **State Pollution Control Board**	
	RECEPTORS: **2601**	MODELER: **Nihar R Sahoo and Subhadarshini Das**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:24,792 0 0.5 km	
	MAX: **4640 ug/m^3**		PROJECT NO.: **01**

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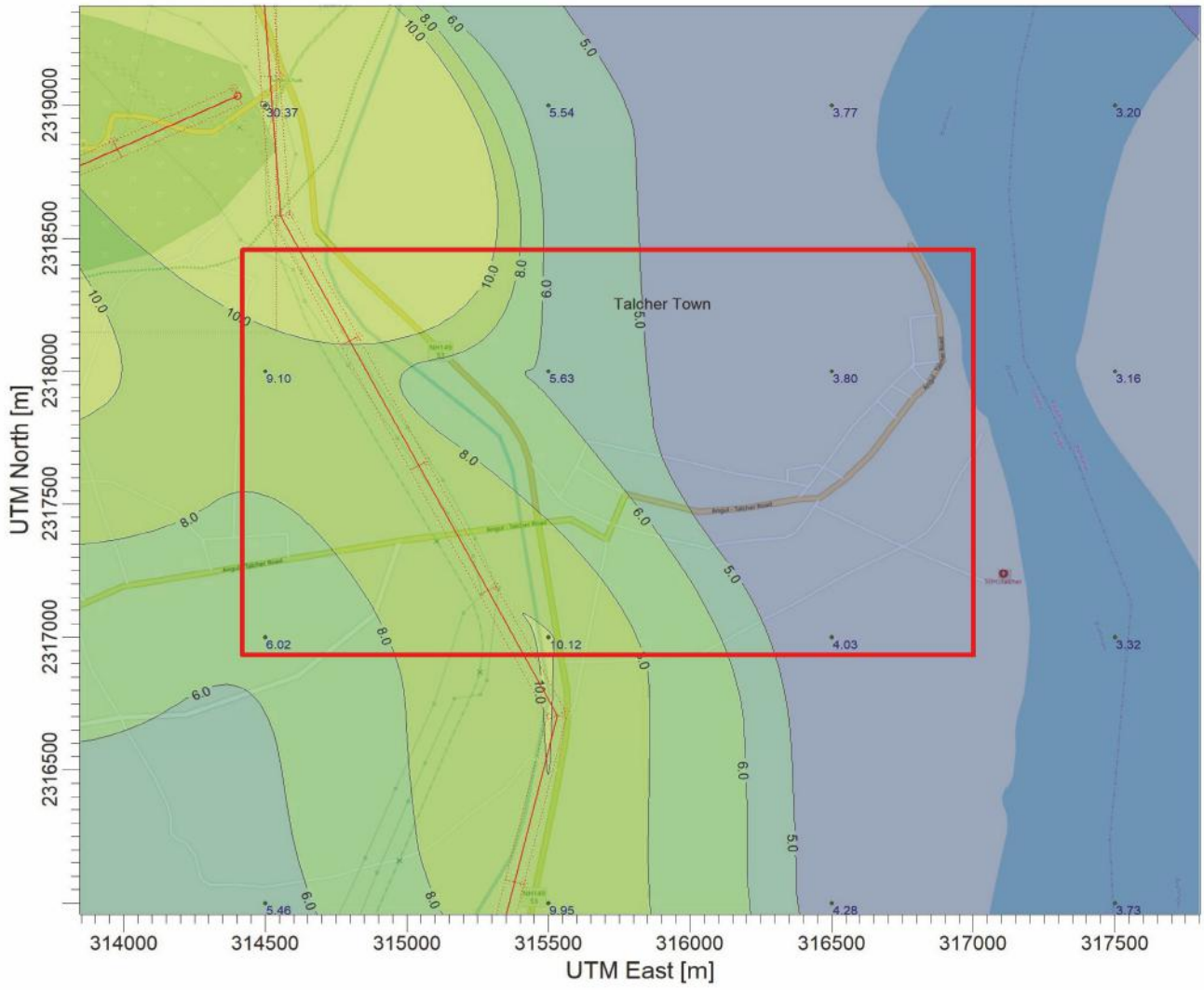
PROJECT TITLE:

Rapid Source Apportionment Study for Talcher Angul
State Pollution Control Board



PLOT FILE OF PERIOD VALUES AVERAGED ACROSS 0 YEARS FOR SOURCE GROUP: ROAD ug/m^3

Max: 87.4 [ug/m^3] at (310500.00, 2306000.00)

0.9 1.0 3.0 5.0 6.0 8.0 10.0 30.0 50.0 60.0 80.0 87.4

COMMENTS: Contours of annual average PM10 around Talcher Town - 2018 (Contribution of Transport only)	SOURCES: **168**	COMPANY NAME: **State Pollution Control Board**	
	RECEPTORS: **2601**	MODELER: **Nihar R Sahoo and Subhadarshini Das**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:24,874 0 1 km	
	MAX: **87.4 ug/m^3**		PROJECT NO.: **01**

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STATE POLLUTION CONTROL BOARD, ODISHA
PARIBESH BHAWAN, A/118, NILAKANTHA NAGAR, UNIT-VIII,
BHUBANESWAR - 751012