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Assessment of the air quality in and around Joda Iron ore mining, Keonjhar District, Odisha

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ABSTRACT

Opencast mining creates serious air pollution in the mining area which affects the environment and creates health issues. The objective of this paper is to assess the air quality status in the mining area, industrial area and rural residential area of Joda, Keonjhar, Odisha. Different sites have been selected to measure the standard of air quality of this region. The air quality was assessed by measuring Suspended Particulate Matter (SPM), PM_{10} (Respirable Suspended Particulate matter), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2). It is found that the average AQI Value is more in mining area than the industrial and residential area.

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1. INTRODUCTION

Air quality is a measure of the suitability of air for breathing by people, plants and animals. On average, a person inhales about 14,000 liters of air every day. Therefore, poor air quality may affect the quality of life of present and future generations by affecting the health and environment (Singh and Perwez, 2018; Freitas et al., 2022). Mineral resources of Odisha form a very significant constituent of India's mineral wealth. The main resources are chromite, bauxite, coal, iron ore and manganese ore. About 1200 sq Km of the state is under mining leases, which accounts more than 0.7% of the total geographical area of the state. Bonai – Keonjhar belt of Odisha is concentrated with manganese deposits. This belt is associated with Banded Iron Formation (BIF) of North Odisha. The major litho units of the area include BIF, Banded shales and mixed facies formation of the Iron Ore Group (Goswami et al., 2008). Mining and related activities contribute to significant growth in infrastructure and raising the living standards of the people. However, they also bring the degeneration and degradation of the environment, create health problem, pollution and socio-economic instability (Gowda, 2016; Panda et al., 2013; Dash and Dash, 2015; Sahoo and Behera, 2013). There are definite rules related to the mining sector, big or small, operating or new has to obtain environmental clearance from the Govt. of India (Ghose, 1991). In India, the national ambient air quality standard (NAAQS) was formulated in 1994 to assess and compare the air pollution level for different areas (CPCB, 1994).

2. STUDY AREA

Iron ore mining in Joda is highly mechanized open cast mining. Major sources of atmospheric emissions from open cast mining activity include land clearing, removal of overburden, vehicular movement, excavation, loading and unloading of ore materials. Dust emanating from the vehicular activity is noticed to be the most contributing factor to the particulate matter content in the atmosphere. The study area (Fig. 1) is located between latitude 21° 59′ N to 22° 03′ and longitude 85° 25′ E to 85° 27′. It lies at an average elevation of 477 m above the mean sea level. Forty-nine (49) mines are operative within the study area, which directly and indirectly impact the inhabitants and environment.

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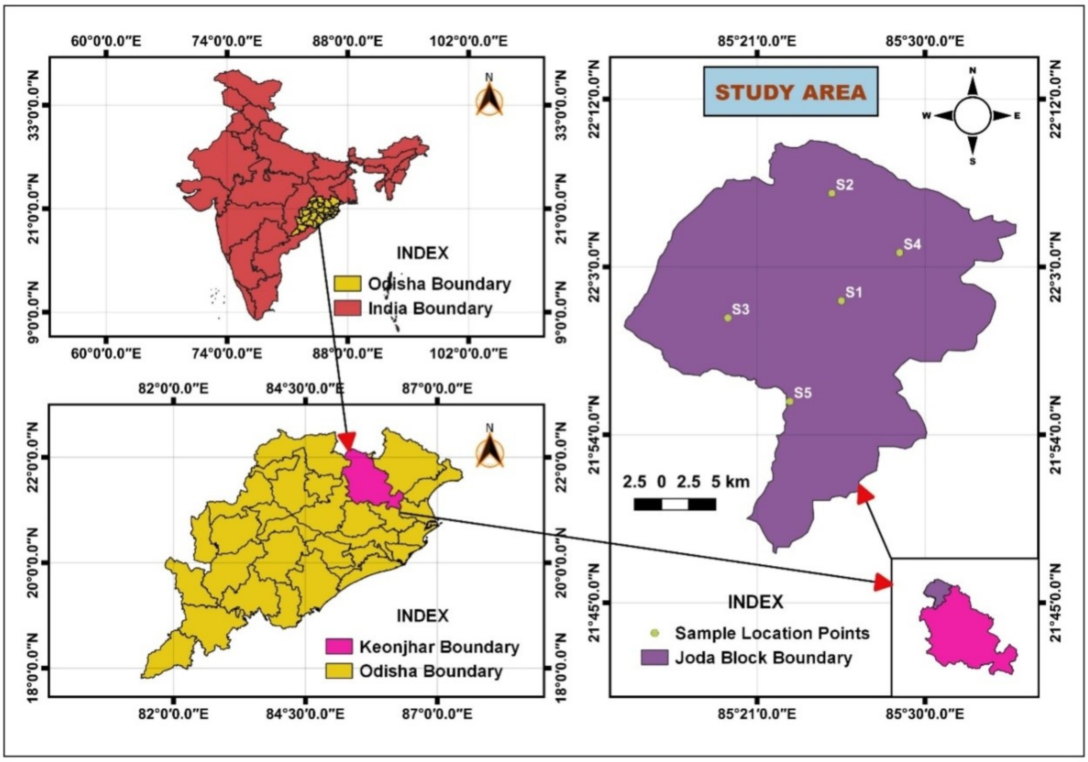

Fig. 1. Location of the study area.

Table 1. Locations of the sample collection sites.

Name of the location	Index	Latitude & Longitude	Source of pollution
Joda	S1	22 1′ 11″ N & 85 25′ 31″ E	Industry, mining and Transportation
Khandhabanda	S2	22 04′ 44″ N & 85 44′ 28″ E	Mining and transportation
Thakurani	S3	22 6′ 57″ N & 85 25′ 00″ E	Mining and transportation
Bamebari	S4	22 04′ 44″ N & 85 44′ 28″ E	Mining and transportation
Rugudi	S5	22 0′ 16″ N & 85 19′ 26″ E	Transportation
Bileipada	S6	22 3′ 46″ N & 85 28′ 38″ E	Industry and Transportation

3. MATERIALS AND METHODS

The methods for sampling particulate pollutants are based on their sizes. The selected sampling sites are industrial, residential, mining-cum-residential and urban-cum-vehicular areas. Continuous monitoring of SPM, PM_{10}, SO_2, and NO_X was done every month during 2017-19. Ambient air quality was monitored using APM-460 DXNL Respirable dust sampler (RDS) and fine particulate sampler APM-550 followed by cyclonic and impactor based technique for measurement of PM_{10} and $PM_{2.5}$ respectively. The sampling inlet was placed 3-10 meters above the ground level for monitoring of the air samples basing upon the site availability. To study PM_{10} the atmosphere air was drawn for 24 hours by using glass fiber filler (GFF) paper at a flow rate of 1.1 m^3/min, whereas for $PM_{2.5}$ the air was drawn through polytetrafluoroethylene (PTFE) filter paper at a flow rate of 16.6 L/min. The mass concentrations of particulates pollutant were estimated by taking the difference of the final and initial weight of the filter paper used for air sampling. The results are finally expressed as weight of particulates collected per cubic meter of air sampled (µg/m^3). The weather conditions were suitable during sampling at most of the sites of the present investigation.

3.1. Sulphur Dioxide

Ambient air samples were continuously drawn in the solution of potassium tetracholomercurate. A dicholrosulphitomercurate complex was formed. After collecting the gas in the absorbent, sulphamic acid, formaldehyde and pararosaniline reagents were added which forms the intensively colored pararosanilinemethy lsuphonic acid. The absorbance of the colour was measured after half an hour by taking optical density at a wavelength of 560 nm.

Table 2. Rating scale of AQI (Index values of air quality index calculation).

AQI value	Remarks	Health concern
00-25	Clean Air (CA)	Minimal/none health effect
26-50	Light Air Pollution(LAP)	Possible respiratory or cardiac effect for most sensitive group
51-75	Moderate Air Pollution(MAP)	Increasing symptoms of respiratory and cardiovascular diseases
76-100	Heavy Air Pollution (HAP)	Aggravation of heart and lungs diseases
>100	Severe Air Pollution (SAP)	Serious aggravation of heart and lung diseases. Risk of death in children

Table 3. The National ambient Air Quality Standards (NAAQS), 2009 (Figures are in microgram per cubic meter).

Pollutant	Time weighted average	Industrial area	Residential Area	Ecologically sensitive Area (Notified by central Goverment)
SPM	Annual	360	140	70
	24 hours	500	200	100
RPM	Annual	120	60	50
	24 hours	150	100	75
SO2	Annual	50	50	20
	24 hours	80	80	80
NO2	Annual	40	40	30
	24 hours	80	80	80

3.2. Nitrogen Dioxide

The ambient air samples were continuously drawn by bubbling air through a solution of sodium hydroxide and sodium arsenate which forms a stable solution of sodium nitrate ion. Its concentration was determined calorimetrically by reacting the exposed absorbing reagent with phosphoric acid, sulphanilamide and NEDA (1-napthyl ethylene diaminedihydrochloride). The absorbance fixed for this is 540 nm. It is to be noted that the weather conditions were suitable during sampling at most of the sites of the present investigation.

3.3. Air Quality Index

It is an environmental index which describes the overall ambient air status and trend of a particular place based on specific standards. It is a tool that transforms the calculated values of individual air pollutants into a single number. There are several methods to calculate the air quality index. The AQI method developed by Ziauddin and Siddique (2006) was adopted to measure the concentration of pollutant in the present study.

$$AQI = 1/4 \times (I_{SPM}/S_{SPM} + I_{RSPM}/S_{RSPM} + I_{SO2}/S_{SO2} + I_{NOX}/S_{NOX}) \times 100$$

I_{SPM}, I_{RSPM}, I_{SO2} and I_{NOX} are individual values of suspended particulate matter, respirable particulate matter, sulphur dioxide and oxides of nitrogen respectively.

S_{SPM}, S_{RSPM}, S_{SO2}, and S_{NOX} are standards of ambient air quality as prescribed by the central pollution control board of India.

The higher the AQI value, greater is the level of air pollution and greater is the health risk (Panda and Panda, 2012). The AQI scale is divided into five categories as depicted in Table 2. It describes the range of air quality and its associated potential health effect. The National ambient Air Quality Standards are given in Table 3.

4. DISCUSSION

The concentration of ground level pollutants at various locations in and around the iron ore mine sites of Joda mining area was estimated and its prediction was also put forth. Based on the air quality modeling, it was predicted that dust concentrations, which was the prime pollution impacting the surrounding local dwellers, could be reduced.

4.1. SPM concentration level in ambient air

The data seen in Table 4 that during 2017 the SPM level ranged from 470.00 µg/m^3 (S5-Rugudi) to 770.1 µg/m^3 (S3-Thakurani).The 24 hours average SPM value in all the monitoring areas also exceeds the permissible limit. In the year 2018 the SPM level recorded from 510 µg/m^3 (S5) to 820 µg/m^3(S3) mentioned in Table 5 and in 2019 it is 552 µg/m^3 (S6) to 845 µg/m^3 (S3) in Table 6. During 2017, 2018 and 2019, the annual SPM contamination levels in all the study areas were exceeding the National Ambient Air Quality standard mentioned in Table 3. It is also noticeable that the SPM concentration level has been gradually increased.

Table 4. Ambient air quality data (in µg/m^3), 2017.

Pollutants	Locations					
	S1	S2	S3	S4	S5	S6
SPM	620	630	770	765	631	470
RPM	290	298	315.3	312	306	260
SO_2	32.4	33.5	34.2	33.6	32.6	33.0
NO_2	34	38.0	32.6	32.0	31.4	34.9

Table 5. Ambient air quality data (in µg/m^3), 2018.

Pollutants	Locations					
	S1	S2	S3	S4	S5	S6
SPM	644.9	650	820	489	790	510
RPM	320.1	305	398.3	298	340	300
SO_2	33.0	37.2	37.9	34.2	37.2	37.2
NO_2	34.0	37.6	38.2	33.6	38.6	36.5

Table 6. Ambient air quality data (in µg/m^3), 2019.

Pollutants	Locations					
	S1	S2	S3	S4	S5	S6
SPM	688	670	845	810	660	552
RPM	345	329	308	340	314	305
SO_2	33.9	38	39.2	38	33	40
NO_2	35.2	38	41.2	40	38	39.5

The Air Quality Index of these areas was beyond the permissible limit of yearly average in all the monitoring stations located in the residential area as well as around the iron ore mining in and around Joda block.

4.2. RPM concentration level in ambient air

From the Table 4 it is observed that the RPM concentration ranges from 260 µg/m^3 (S6) to concentrations 315.3 µg/m^3 (S3) in 2017. From Table 5 it was 300 µg/m^3 (S6) to 398.3 µg/m^3 (S3) in 2018 and in the 2019 it was ranged from 305 µg/m^3 (S6) to 345 µg/m^3 (S1) according to Table 6. It has been analyzed that the RPM concentration in all the stations during the year 2017, 2018 and 2019 were much higher than the NAAQ value as in Table 3. In all the study mining areas' concentration level is higher in winter and low level in the rainy season. Both SPM and RPM are found to have a maximum rise during winter season and the minimum in the rainy season. Humidity is also a also a factor to impact particulate matter (SPM and RSPM). Increase of humidity decreases the concentrations of SPM and RPM.

5. CONCLUSION

The assessment of air quality in and around the Joda Iron ore mining region of Keonjhar District, Odisha, has revealed significant insights into the levels of various air pollutants over the period of 2017-2019. The primary pollutants identified across six monitoring sections include Suspended Particulate Matter (SPM), Respirable Particulate Matter (RPM), Sulfur Dioxide (SO), and Nitrogen Dioxide (NO_2). Among these, SO is notably a major contributor to air pollution primarily due to mining activities and transportation associated with the industry. SO exposure can cause mucosal irritation in the upper respiratory tract, leading to symptoms such as watery nasal discharge, sneezing, dysphonia, and productive cough. However, the study indicates that the SO concentration levels in the area remain within the National Ambient Air Quality (NAAQ) standards, thereby reducing the risk of these health issues.

NO_2 exposure is another concern, as it can impair gas exchange in the blood and cause irritation of mucous membranes. NO_2 interacts with hemoglobin, reducing the oxygen-carrying capacity of blood, which can have serious health implications. Dust pollution from opencast mining operations is a predominant issue, contributing to higher average Air Quality Index (AQI) values in mining areas compared to industrial and residential zones.

The findings underscore the necessity for rigorous monitoring throughout all phases of mining, from exploration to consumption. The ambient air quality and work zone measurements highlight the high pollution potential in the study area and its surroundings. Effective air pollution control necessitates the implementation of a series of preventive and suppression measures, including dust extraction systems. With appropriate abatement strategies, air pollution in opencast mining can be effectively managed.

Recommendations for Air Pollution Abatement in and around Joda area

1. **Implementation of Dust Control Systems:**
   - Deploy advanced dust suppression systems such as water sprays, fog cannons, and dust collection systems at critical points in the mining process.
   - Use windbreaks and vegetative barriers to reduce the spread of dust.
2. **Regular Monitoring and Maintenance:**
   - Establish a comprehensive air quality monitoring network to continuously track pollutant levels.

- Regularly maintain and calibrate monitoring equipment to ensure accurate readings.

3. **Green Belt Development:**
   - Develop and maintain green belts around mining and industrial areas to act as natural air filters.
   - Select plant species that are known for their dust and pollutant absorption capabilities.
4. **Transportation Management:**
   - Optimize transportation routes to minimize dust generation and pollutant emissions.
   - Enforce strict regulations on vehicle emissions and encourage the use of cleaner fuels and technologies.
5. **Occupational Health and Safety Measures:**
   - Provide protective gear and regular health check-ups for workers to mitigate health risks associated with air pollution.
   - Implement stringent workplace safety protocols to minimize exposure to harmful pollutants.
6. **Public Awareness and Community Engagement:**
   - Conduct awareness programs for local communities on the health impacts of air pollution and preventive measures.
   - Engage local communities in the development and implementation of pollution control strategies.
7. **Use of Cleaner Technologies:**
   - Invest in cleaner and more efficient mining technologies to reduce pollutant emissions.
   - Promote the use of renewable energy sources within the mining operations.
8. **Regulatory Compliance and Enforcement:**
   - Ensure strict compliance with environmental regulations and standards.
   - Impose penalties for non-compliance and incentivize best practices in air pollution control.

By adopting these recommendations, it is possible to significantly reduce air pollution levels in the Joda Iron ore mining region, thereby protecting public health and the environment.

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