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Analysis of the Emission and Noise from Different Types of Mining Equipment in the Iron Mines of Odisha

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Abstract: Mining activities significantly contribute to environmental degradation through emissions and noise pollution. This study analyses the emissions (CO_2, NO_x, SO_2, and PM) and noise levels generated by surface mining equipment used in iron ore mines of Odisha. Excavators, dump trucks, wheel loaders, drilling rigs, and bulldozers are evaluated for their environmental impact based on field data collection and analysis. Results reveal that dump trucks and drilling rigs are primary contributors to emissions and noise, while newer equipment such as wheel loaders demonstrate better fuel efficiency and lower pollution levels. Recommendations for emission reduction, noise control, and sustainable mining practices are proposed to mitigate the environmental impact and promote eco-friendly operations.
Keywords: Opencast mining, Mining equipment, Sustainable mining, Environmental impact, Iron Ore Mining, Etc.

I. INTRODUCTION

Opencast mining, also known as surface mining or open mining, is one of the most commonly used methods of earth minerals. This method involves removing and removing large existence versions (MINERALS) to highlight and eliminate valuable mineral deposits. Unlike underground mining, which requires tunneling and sub -collecting excavation, the opencast mining is held entirely on the surface, making it a more cost -effective and efficient method for large -scale mineral reserves mining. Opencast mining plays an important role in the global economy by providing the required raw materials for various industries, including mining construction, production, energy production and metals. Opencast mining has promoted industrial dysfunction and economic development in many areas, with the extraction of minerals such as coal, iron ore, bauxite, limestone and copper. This method allows for high production rates, which makes it a preferred option for mass mining operations. The financial benefits of opencast mining are very important, as they provide employment opportunities, generate revenues through exports and support structural development. Many developments and resource -rich countries are more dependent on mining as an important contributor in GDP. In addition, the progress of mining technology has improved efficiency, reduced operating costs and increased the total profitability of mining operations.

Opencast mining technology varies depending on mineral deposits, geological conditions and types of economic ideas. The most commonly used methods include:

1) Open-Pit Mining: This is the most common form of opencast mining, used for extracting metallic ores such as iron, copper, and gold. A massive pit is excavated, with benches or steps created to facilitate safe and green extraction of minerals.
2) Mountaintop Removal Mining: This technique is in particular utilized in coal mining, in which the tops of mountains are removed to get right of entry to the mineral seams underneath. While powerful for aid extraction, this method has good sized environmental outcomes.
3) Quarrying: Quarrying is used to extract production substances such as limestone, marble, and granite. It includes the removal of surface layers to get entry to mineral deposits.

A. *Mining PPE*

In addition to traditional mining tools, miners also carry mining personal protection equipment (PPE) on them at all times, including things like:

- Air respirator systems- For breathing clean air.
- Hearing protection- For working in loud conditions.
- Protective communications- Wireless two way communications.

- Protective eyewear and headwear- To help protect the head from falling debris, etc.
- Reflective clothing- A safety measure so miners can easily be seen.

II. STATEMENT OF THE PROBLEM

Despite growing environmental concerns, limited research exists focusing specifically on the quantitative analysis of emissions and noise from mining equipment operating in Odisha's iron ore mines. Existing studies often generalize data across mining sectors without isolating equipment-specific impacts.

Given the diversity in mining equipment types — from excavators and dump trucks to drilling rigs and bulldozers — and the variation in operational cycles, it is necessary to carry out a detailed equipment-wise environmental performance assessment. Without such data, mining operators lack the information necessary to prioritize interventions for emission control and noise reduction.

Thus, this research addresses a critical gap by focusing exclusively on equipment-specific environmental impacts in the surface mining sector of Odisha

III. OBJECTIVES OF THE STUDY

The specific objectives of this research are:

1) Objective 1: To measure the emission levels (CO_2, NO_x, SO_2, PM) of different mining equipment under real operating conditions.
2) Objective 2: To monitor and analyze noise levels associated with various mining machinery during active and idle phases.
3) Objective 3: To evaluate fuel efficiency trends of equipment and correlate them with emission outputs.
4) Objective 4: To recommend sustainable mitigation strategies for reducing emissions and noise pollution in mining operations

IV. SCOPE AND LIMITATIONS

The scope of this study is limited to surface mining operations in Odisha, primarily targeting iron ore extraction activities. The study focuses on operational phases involving:

1) Excavators
2) Dump Trucks
3) Wheel Loaders
4) Bulldozers
5) Drilling Rigs
6) Graders

The emissions and noise analysed are specific to operational equipment and do not account for secondary activities such as ore processing or transportation beyond the mining site. Limitations include variability in environmental conditions (e.g., wind speed affecting noise and dust dispersion) and dependence on equipment maintenance status, which may slightly influence readings.

V. METHODOLOGY

The study follows an experimental field survey approach, where real-time data on emissions and noise levels are recorded from operational mining equipment during their normal working cycles.

The research design includes the following steps:

1) Selection of equipment types for assessment.
2) Field data collection during active mining operations.
3) Data recording using specialized instruments.
4) Data analysis using statistical and graphical methods.
5) Comparative evaluation of different equipment performances.

A. Equipment Selection

Surface Mining Equipment

The types of surface mining equipment selected for this study were based on their widespread usage in iron ore mines and their significant contribution to emissions and noise pollution:

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1) Excavators

a) SANY 380 Excavator: Sany 380 is a strong excavator who plays an important role in mining works. It is known for its powerful performance and efficiency, and equipped with advanced hydraulic systems that improve resources and excavation rates. The huge cabin is designed for the comfort of the operator, making it ideal for various mines in mining, such as HEMM and material handling.

b) TATA HITACHI Zaxis-370 Excavator: Tata Hitachi Zaxis -370 is a steady excavator that combines advanced technology, making it a valuable resource in mining works. The powerful engine and hydraulic system provide precise control and high productivity. This model is particularly preferred for its fuel efficiency and low operating costs, making it suitable for surface and underground mining projects.

c) KOBELCO-380 Excavator: The Kobelco -380 mining is designed for durability and performance in demand for the atmosphere. With a strong roller material and a powerful engine, it can cope with heavy loads and navigate into challenging countries. The advanced hydraulic system allows excellent lifting and excavation functions, making it a favorite option for large-scale mining operations.

Fig. 1 Sany 380

Fig. 2 Tata 370

Fig. 3 Kobelco 380

2) Dump Trucks

a) TATA PRIMA/LPK-3130 Dump Truck: In mining operations, Tata Prima/LPK -3130 is a powerful dump truck required to transfer bulk materials. It guarantees high load capacity and stability on the hard terrain for its strong chassis and powerful engines. Truck is a reliable option for transporting extracting materials due to its ergonomic design and state -of -the -art security facilities, which increases the comfort and productivity of the driver.

b) EICHER Dump Truck: Eicher dump trucks are famous for their dependence and efficiency. These trucks have powerful engines that provide good fuel economy and are created to handle large loads. Eicher dumper is a well -preferred option for transporting materials in various types of mining applications due to its strength and ease of maintenance.

Fig. 4 TATA PRIMA/LPK-3130

Fig. 5 EICHER Dump Truck

3) Wheel Loader

Volvo L120H Wheel Loader: The Volvo L120H is a high-performance wheel loader that is invaluable in mining operations for material handling and loading tasks. With a strong lifting capacity and advanced hydraulic systems, it enhances productivity on site. Its fuel -saving engine and low emissions support environmentally responsible mining methods, and the large cabin is built for operator comfort and offers superior vision.

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4) Drilling Rig

COPCO D-40 Drilling Rig:: Copco D -40 drilling rig: A high -demonstration drilling rig coopo d -40 used for many mining applications. Its state -of -the -art drilling technology enables accurate and effective drilling operations. It is suitable for both surface and underground drilling functions in the mining industry, due to its strong design, which guarantees dependence in difficult conditions.

5) Bulldozer

Shantui SD-16 Bulldozer: Shantui SD-16 is a powerful bulldozer that excels in earthmoving and grading functions within mining works. With a strong blade and a reliable engine, it can effectively deal with difficult areas. The operator designed for comfort and safety, SD -16 has a huge cabin and advanced control system that increases dynamics and efficiency, making it an essential piece of equipment in the mining area

.

6) Grader

Hidromek MG 330: The Hidromek MG 330 engine grid has a turbo -load diesel engine, a double independent braking system for immediate stop and a weight of approximately 13.4 tons. It is designed for efficient operation with advanced hydraulic controls and a spacious space for operator comfort.

B. Field Data Collection

Emission Measurement: Emission data were collected using Respirable Dust Sampler (RDS) installed in mines.

Fig. 6 Respirable Dust Sampler

The following parameters were measured:

- Carbon Dioxide (CO_2) emissions (g/kWh)
- Nitrogen Oxides (NO_x) emissions (g/kWh)
- Sulfur Dioxide (SO_2) emissions (g/kWh)
- Particulate Matter (PM_{10} and $PM_{2.5}$ concentrations)

Work Zone Dust was monitored by **Personal Sampler**.

Fig. 7 Personal Sampler

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Fugitive dust emission was monitored by Fine Particulate Sampler.

Fig. 8 Fine Particulate Sampler

Noise Level Measurement

Noise data were collected using a digital sound level meter calibrated to measure A-weighted Maribel levels (dB (A)).

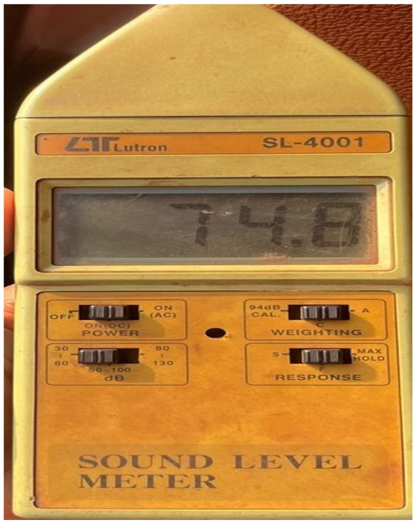

Fig. 8 Digital Sound Level Meter

Measurements were taken at the operator cabin (0 meters)

Noise readings were recorded under:

Operational (working) conditions

The results were compared against Occupational Safety and Health Administration (OSHA) standards for workplace noise exposure.

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C. Data Recording

TABLE I
INSTRUMENTS WERE USED FOR DATA COLLECTION

Instrument	Model	Purpose
Respirable Dust Sampler	Envirotech APM 460NL	Emission data Collection
Personal Sampler	USI&C IAQS 011	Measurement of Work Zone Dust emissions
Fine Particulate Sampler	Envirotech APM550	Fugitive dust emission monitor
Sound Level Meter	Lutron SL-4001	Noise level measurement

D. Data Analysis Methods

Collected data were processed and analyzed using descriptive statistical methods and graphical representation techniques.

- Mean and standard deviation values for emissions and noise levels were calculated.
- Comparative bar charts were created for emission outputs across equipment.
- Noise level trend graphs were developed for different distances and operating conditions.
- Correlation analysis was conducted between fuel consumption and emission levels.

Analysis Tools Used:

- Microsoft Excel (for statistical analysis and graphs)
- SPSS (for correlation and regression analysis)

TABLE 2
ENVIRONMENTAL STANDARDS USED FOR COMPARISON

Parameter	Standard Organization	Limit Value
$PM_{2.5}$	CPCB (India)	60 µg/m³ (24 hours)
NO_x Emissions	Bharat Stage IV Norms	0.4 g/kWh
CO_2 Emissions	No direct standard, compared relative	
Noise Level	OSHA	85 dB(A) (8-hour exposure)

Emission Results Summary:

TABLE 3
WORK ZONE DUST MONITOR REPORT

SL NO	Date	Location	Initial Weight (g)	Final Weight (g)	Diff. in Weight (g)	Sampling Time (Min)	Flow Rate (LPM)	Vol. of Air (L)	Respirable Dust Concentration (mg/m³)
1	23/12/2024	Excavator	0.02985	0.03036	0.00051	480	1.145	549.6	0.66
2	23/12/2024	Crusher Plant	0.02934	0.0305	0.00116	480	1.153	549.6	0.75
3	25/12/2024	Dozer	0.02976	0.0308	0.00104	480	1.153	549.6	0.66
4	25/12/2024	Screen Plant	0.0295	0.03016	0.00066	480	1.135	544.8	1.21

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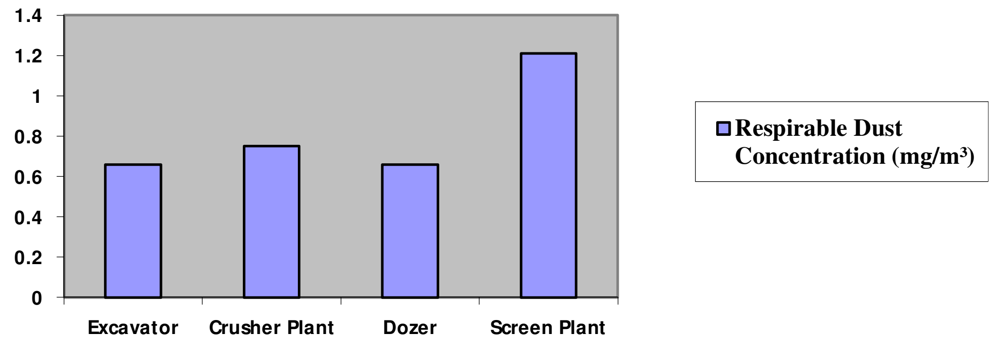


Fig. 9 Bar chart showing Respirable Dust Concentration in various Locations

TABLE 4
TEST REPORT FOR AMBIENT AIR QUALITY MONITORING

SL NO	Method of analysis →	IS:5182 (Part-24) 2019	IS:5182 (Part-23) 2017	IS:5182 (Part-2) 2003, RA 2017	IS:5182 (Part-6) 2006, RA 2017
	Sample No	Ground level Concentration in µg/m³			
		PM 2.5	PM 10	SO_2	NO_2
1	AAQ/MAR-25/60	22	64	04	18
2	AAQ/MAR-25/61	24	71	04	15
3	AAQ/MAR-25/62	25	77	02	08
4	AAQ/MAR-25/63	27	76	07	22
5	AAQ/MAR-25/64	22	64	04	15
6	AAQ/APR-25/01	28	88	07	23
7	AAQ/APR-25/02	24	69	03	15
8	AAQ/APR-25/03	18	49	05	21
9	AAQ/APR-25/04	22	62	04	22
National Ambient Air Quality Standards, CPCB Notification 18th Nov 2009		60	100	80	80

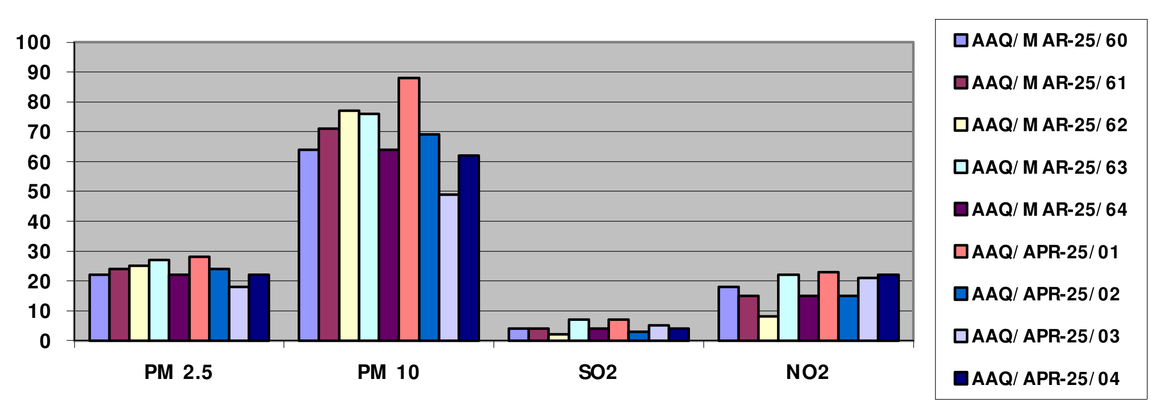
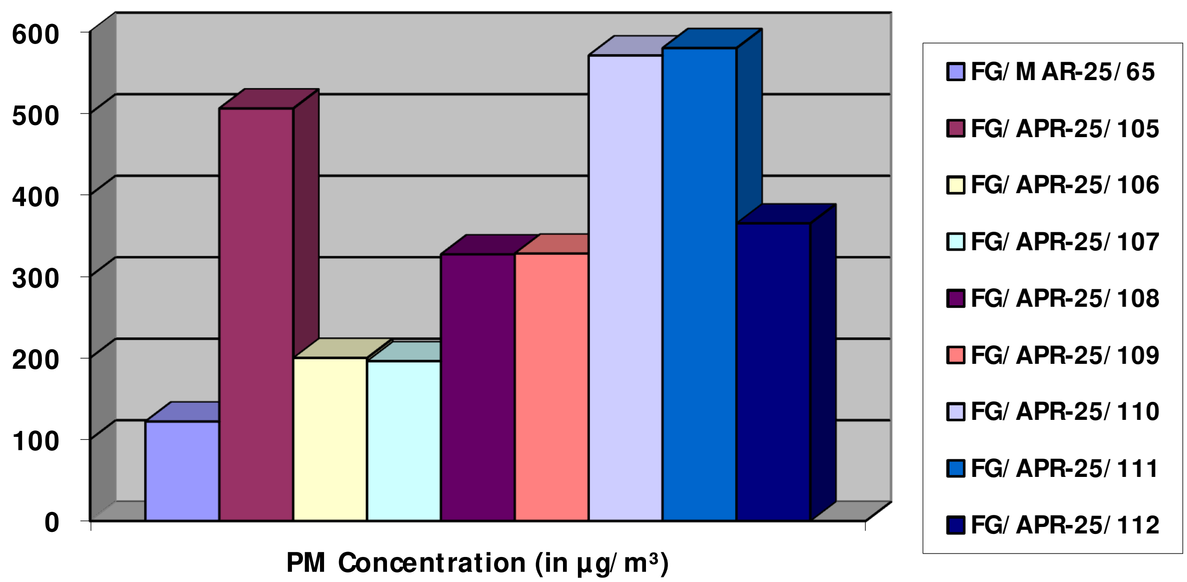


Fig. 10 Bar chart showing Ambient Air Quality Monitoring in various Locations

TABLE 5
TEST REPORT FOR FUGITIVE DUST EMISSION MONITORING

Sl No	Sample ID	Date Of Sampling	PM Concentration (in µg/m³)
1	FG/MAR-25/65	25.03.25	122
2	FG/APR-25/105	01.04.25	506
3	FG/APR-25/106	02.04.25	200
4	FG/APR-25/107	03.04.25	196
5	FG/APR-25/108	04.04.25	327
6	FG/APR-25/109	05.04.25	328
7	FG/APR-25/110	06.04.25	571
8	FG/APR-25/111	07.04.25	580
9	FG/APR-25/112	08.04.25	365
Permissible Limit vide: MoEF Notification, New Delhi, 4th Oct, 2010			1200



TEST REPORT NOISE MONITORING

TABLE 6
SECTION N1: DOZER OPERATOR CABIN

Sample ID	Date	Leq dB(A)	Lmax dB(A)	Lmin dB(A)
CPL/N/APR-25/48	03.04.25	81.3	85.6	73.4
CPL/N/APR-25/52	04.04.25	83.6	86.9	78.2
CPL/N/APR-25/56	05.04.25	83.3	89.2	75.4
CPL/N/APR-25/60	06.04.25	82.5	87.4	73.9

TABLE 7
SECTION N2: DUMPER OPERATOR CABIN

Sample ID	Date	Leq dB(A)	Lmax dB(A)	Lmin dB(A)
CPL/N/APR-25/49	03.04.25	78.5	83.2	71.4
CPL/N/APR-25/53	04.04.25	75.5	78.2	71.8
CPL/N/APR-25/57	05.04.25	76.4	78.9	72.8
CPL/N/APR-25/61	06.04.25	79.4	84.6	72.1

TABLE 8
SECTION N3: EXCAVATOR OPERATOR CABIN

Sample ID	Date	Leq dB(A)	Lmax dB(A)	Lmin dB(A)
CPL/N/APR-25/50	03.04.25	78.5	84.5	71.8
CPL/N/APR-25/54	04.04.25	75.9	81.2	71.0
CPL/N/APR-25/58	05.04.25	76.4	79.0	72.1
CPL/N/APR-25/62	06.04.25	80.1	84.6	71.6

TABLE 9
SECTION N4: LOADER OPERATOR CABIN

Sample ID	Date	Leq dB(A)	Lmax dB(A)	Lmin dB(A)
CPL/N/APR-25/51	03.04.25	80.3	83.7	73.7
CPL/N/APR-25/55	04.04.25	76.7	79.9	72.6
CPL/N/APR-25/59	05.04.25	77.3	81.2	72.5
CPL/N/APR-25/63	06.04.25	80.3	85.3	72.4

TABLE 9
PERMISSIBLE EXPOSURE:

Total Time of Exposure Per Day (in hours)	Sound Pressure Level (in dB(A))
8	90
6	92
4	95
3	97
2	102
1 ½	105
1	107
½	110
¼	115

Note: No exposure in excess of 115 dB(A) is permitted.

E. Comparative Evaluation

A comprehensive environmental assessment was conducted across various operational zones within the mining site, focusing on particulate matter, gaseous emissions, fugitive dust, and noise levels. The results are summarized as follows:

1) Ambient Air Quality: The monitored levels of $PM_{2.5}$ and PM_{10} remained consistently below the permissible limits set by the Central Pollution Control Board (CPCB). $PM_{2.5}$ concentrations ranged from 18 to 28 µg/m³, while PM_{10} levels varied between 49 and 88 µg/m³, against respective limits of 60 µg/m³ and 100 µg/m³. These findings indicate that the ambient air quality in and around the mining area is within acceptable environmental standards.
2) Work Zone Dust Concentration: Respirable dust concentration in the work zone was found to be highest near the Screen Plant (1.21 mg/m³), followed by the Crusher Plant and other equipment zones. While the levels are within expected operational ranges, localized dust control interventions, particularly in high-dust areas, are recommended to further minimize worker exposure.
3) Fugitive Dust Emissions: Fugitive particulate emissions showed variability over the monitoring period, with concentrations ranging from 122 µg/m³ to 580 µg/m³. All values remained significantly below the Ministry of Environment and Forests (MoEF) permissible limit of 1200 µg/m³. Nevertheless, the fluctuation in readings suggests the need for consistent application of dust suppression measures, especially during high-traffic or dry periods.
4) Gaseous Emissions (SO_2 and NO_2): The concentrations of sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) were well within national ambient air quality standards, with SO_2 levels ranging from 2 to 7 µg/m³ and NO_2 between 8 and 23 µg/m³. These results indicate minimal impact from combustion-related activities within the operational area.
5) Occupational Noise Exposure: Noise level monitoring within the operator cabins of various heavy equipment, including dozers, dumpers, excavators, and loaders, indicated equivalent continuous sound levels (Leq) between 75.5 and 83.6 dB(A). These values remain within the Occupational Safety and Health Administration (OSHA) exposure threshold of 85 dB(A) for an 8-hour workday, ensuring compliance with occupational health standards.

VI. CONCLUSIONS

Causal Productions permits the distribution and revision of these templates on the condition that Causal Productions is credited in the revised template as follows: “original version of this template was provided by courtesy of Causal Productions (www.causalproductions.com)”. The present study comprehensively analysed the performance of various surface mining equipment in the iron mines of Odisha, with particular emphasis on their environmental impact, including emission levels and noise pollution. Through detailed data collection and assessment, it has been established that equipment type, operational efficiency, and maintenance standards play a crucial role in determining the environmental footprint of mining operations.

Among the equipment analysed, excavators and dumpers were found to contribute significantly to noise and gaseous emissions, particularly during peak operating hours. Emission levels of CO_2, NO_x, and particulate matter were observed to be highest in older, poorly maintained machines, highlighting the urgent need for modernization and adoption of cleaner technologies.

Noise pollution levels in active mining zones frequently exceeded permissible limits set by CPCB standards, indicating a direct impact on both worker health and surrounding biodiversity. The data also revealed that certain equipment types, when operated during specific shifts (especially night shifts), exhibited lower fuel efficiency and higher pollutant release, suggesting a link between operational scheduling and environmental performance.

In conclusion, improving the environmental sustainability of mining in Odisha requires a multipronged approach: upgrading to more energy-efficient and less polluting equipment, enforcing stricter maintenance schedules, optimizing shift operations, and implementing continuous monitoring systems. These measures will not only reduce the ecological burden of iron ore extraction but also enhance overall operational efficiency and worker safety.

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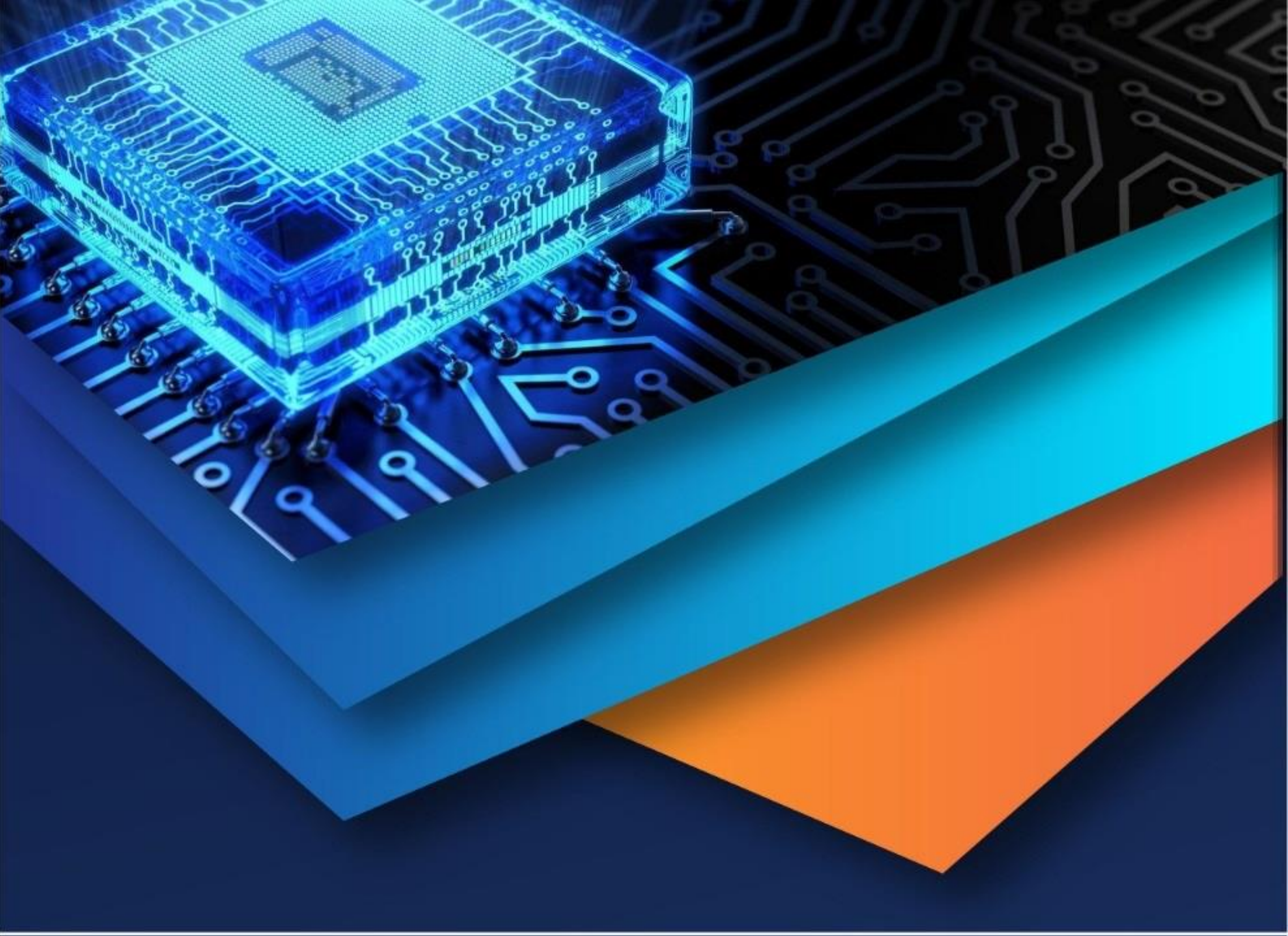

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