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Air Quality Monitoring in Iron Ore Mining Site

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Abstract: Iron is one of the most mined element among the metals. Most of the iron ore mines exists in dense forest zones. The activities carry to extract Iron Ore consists of blasting, excavation, loading, dumping, crushing, screening and transportation, which emits great amount of air pollutants to environment. Pollutants resulted from the anthropogenic activities effects both biotic and abiotic environment. Monitoring plays key role in understanding the extent pollutants released due to anthropogenic activities and helps to take further measures to control pollutants. Ambient air quality and fugitive emissions are measured in current work. In the part of ambient air quality monitoring studied particulate matter ($PM_{2.5}$ and PM_{10}), SO_2 and NO_x. Suspended particulate matter, reparable particulate matter and total particulate matter were measured in fugitive emissions. Sampling locations were selected as per the guidelines of CPCB, India. Sampling of SO_2 and NO_x done 8 hourly, PM2.5 and PM10 done 24 hourly. Samples were collected in Iron Ore mine, analysed in laboratory. In present study, an attempt has been made to provide a comprehensive report on air quality monitoring (Ambient air quality and fugitive emissions) in iron ore mine site.

Key words: Air quality monitoring, Iron ore mine, ambient air quality, Fugitive emissions, particulate matter.

I. INTRODUCTION

Iron is fourth most abundant material in earth crust which exists in metal form. Mostly iron ore mines found in sedimentary rocks. They formed from chemical reactions that combined iron and oxygen in both marine and fresh waters. Two most important minerals in these deposits are iron oxides: Haematite (Fe_2O_3) and Magnetite (Fe_3O4). It consists of approximately 5.6% of the earth's crust and almost the earth's entire core. Iron ore mining is major mining activity in India. India is fourth most iron producer in world placed after China, Australia and Brazil accounting around 6% of worlds total iron production.

Iron ore is part of our everyday lives and our modern world would look completely different without it. 98% of world iron ore is used to make steel, which accounts for over 90% of all metals used in the world. Steel is used in building for so many things, from cars, trains and ships through to the high rise buildings in our cities and the bridges that connect us. Steel is used to create pipes, cars, ships, engines, roofs, nails, nuts, bolts, tools, machinery, in building & construction, to make white goods, in manufacturing, food cans and much more. Iron is also plays main role plants and animals life. Animals use iron in haemoglobin molecules in blood to allow the transportation of oxygen from respiratory system to tissues throughout the body. Plants use the iron in chlorophyll, a pigment used in photosynthesis.

Iron ore mines in India mainly divided into four zones (i.e. eastern, central, southern, and western, which are zone-A, zone-B, zone-C and zone-D respectively) as per CPCB, India (COINDS, 2007-8) [1]. Present study done in central zone (zone-B) BIOM, Chhattisgarh. Which is Haematite (Fe_2O_3) based iron ore. This mines exists on hill area covered with dense forest. The hills are in the range size to a height of 1260 m above mean sea level. The hills are in the range size to a height of 1260 m above mean sea level. The area is lashed with heavy rains during monsoon season spread out during June to September and annual average rainfall is around 2500 mm. Air quality monitoring done here on basis of the guidelines given by CPCB, India (COINDS, 2007-8) [1].

Extraction of iron ore includes the activities like cleaning forest, blasting, shovelling, crushing, screening, loading and unloading, transportation etc. These activities emit the pollutants into atmosphere which arose the pollution level in the environment. Two types of mining processes are underground mining and open-pit mining (surface mining or open cast mining). Probability of air pollution is high in case of open cast mining compared to underground mining. Present study carried out in open cast iron ore mining. Main pollutants emit from iron ore mine are particulate matter (PM 2.5, PM10), NO_x, SO_2 and fugitive emissions are suspended particulate matter (SPM) and reparable particulate matter (RPM). Pollutants from mining affects both biotic and abiotic components. Basically the effect of air pollutants spreads globally. It has given global importance in management of AQM. Spreading of air pollutants are on downward direction and also wind speed plays important role in spreading of aerosols. Compared to other processing industries, mining emits less pollutants because of less combustion activity. Main sources for SO_2, NO_X, and CO are vehicular emissions, diesel machines and explosive materials. Particulate matter based on size PM2.5 sizes 2.5µm and PM10 sizes 10µm. Concentration of aerosols represented in $\mu g/m^3$. The greatest health risk is not simply with particles which are easily inhaled, but those which can become imbedded into the lung tissues. This phenomenon can result in scarring and permanent tissue damage. As a result, the EPA adopted the first PM2.5 standards in 1997[9]. Fine particulate matter is considered to be the most significant ambient air pollutant in terms of potential health impacts.

II. SAMPLING LOCATIONS AND ITS DETAILS

Meteorological factors have direct bearing on dispersion and dilution of Pollutants/ contaminants discharged into the atmosphere with consequent impact on air environment. The basic meteorological parameters which govern the transport & diffusion of the pollutants in the air are wind speed, wind direction & ambient temperature. Relative humidity, Pressure, rainfall and cloud cover are secondary meteorological parameters as these control the dispersion of the pollutants indirectly by affecting the primary parameters. The Ambient Air quality was monitored for 6 locations for significant parameters like PM_{10}, $PM_{2.5}$, SO_2, NO_x & CO in the core & buffer zones. Fugitive Dust monitoring for significant parameters such as SPM, RPM, TPM were monitored at 8 locations at the certain distance from the sources.

A. Sampling Locations Taken for Ambient Air Quality

Sampling of air quality monitoring done in both core and buffer zones for $PM_{2.5,}$ $PM_{10,}$ SO_2 and $NO_{X.}$ Air quality monitored in 6 locations given below. Samples taken at a height of 2 to 3 meters from the ground.

1) *Sampling Location-1(ASL-1):* The sampling station was located in the core zone, at a radial distance of 0.6 km in the south direction of the mine. The site is located at a height of 1108 m above MSL (Mean Sea Level). It was selected to assess present pollution level due to the crushing plant. The Combo sampler is placed in this site at about 2 m height above the ground level.
2) *Sampling Location-2(ASL-2):* The sampling station was located in the core zone, at a radial distance of 0.5 km in the NE direction of the mine. The site is located at a height of 1170 m above MSL. It was selected to assess the pollution level due to loading plant activity. The Combo sampler is placed in this site at about 2 m height above the ground level.
3) *Sampling Location-3(ASL-3):* The sampling station was located in the core zone, at a radial distance of 1.2 km in the SE direction of mine. The site is located at a height of 1200m above MSL. It was selected due to screening plant activities. Sampler placed at a height of 2m.
4) *Sampling Location-4(ASL-4):* The sampling station was located in the Buffer zone, at a radial distance of 2.5 km in the SSE direction of the mine. The site is located at a height of 550 m above MSL.
5) *Sampling Location-5(ASL-5):* The sampling station was located in the Buffer zone, at a radial distance of 2.2 km in the SE direction of the mine. The site is located at a height of 555 m above MSL.
6) *Sampling Location-6(ASL-6):* The sampling station was located in the buffer zone, at a radial distance of 4.0 km in the NE direction of the mine. The site is located at a height of 580 m above MSL.

B. Sampling Locations Taken for Fugitive Air Quality Monitoring

Fugitive dust monitoring for significant parameters such as SPM, RPM, TPM were monitored at 8 locations at the certain distance from the sources. Sampling locations and its details given below.

1) *Sampling Location-1(FSL-1):* The sampling location was located near the haul roads of mine area. This station was at a height of 1170 m above MSL. The sampling location was at a distance of 0.5 km in the NE direction of the mine. This station was located in core zone area.
2) *Sampling Location-2(FSL-2):* This sampling station was located at a distance of 2.5 km in south west direction from the mine area. A fugitive dust sampler was placed at 2 m above ground level to assess the particulate levels due to the drilling and allied activities.
3) *Sampling Location-3(FSL-3):* This sampling station was located near the excavation area of mine. A fugitive dust sampler was placed at 2 m above ground level to assess the particulate levels due to the excavating of material and allied activities.
4) *Sampling Location-4(FSL-4):* This location was nearby crushing plant which is in south west direction from the mine office. A fugitive dust sampler was placed at 2 m above ground level to assess the particulate levels due to the crushing activities and vehicular movements.
5) *Sampling Location-5(FSL-5):* This sampling station was located at a distance of 10 km from the mine office in east direction. A fugitive dust sampler was placed at 2 m above ground level to assess the particulate levels due to screening plant activities and vehicular movements.

6) *Sampling Location-6(FSL-6):* This sampling station was located at a distance of 20 km from the mine office in east direction. A fugitive dust sampler 02 was placed at 2 m above ground level to assess the particulate levels due to fine ore stock pile and loading of ore in trucks.
7) *Sampling Location-7(FSL-7):* This sampling station was located at a distance of 18 km from the mine office in east direction. This station was located near to loading plant in core zone area. A fugitive dust sampler was placed at 2 m above ground level to assess the particulate levels due to loading and unloading of materials from the wagon.
8) *Sampling Location-8(FSL-8):* This sampling station was located at a distance of 20 km from the mine office in east direction. This station was in core zone area. A fugitive dust sampler was placed at 1.5 m above ground level to assess the particulate levels due to loading plant activities and vehicular movements.

III. METHODOLOGY

A. *Ambient Air Quality*

6 ambient air quality monitoring stations were identified and installed during the study period. Instruments were installed between 2 to 3 m height to avoid obstructions. Particulate matter (PM_{10} and $PM_{2.5}$), Sulphur dioxides(SO_2) and Nitrogen oxides(NO_x) were monitored by using calibrated Combo Dust sampler.

1) *Particulates:* Combo dust sampler was used for PM_{10} and $PM_{2.5}$ monitoring apart from gaseous pollutants. It separates the coarser particles from the air stream before filtering it on the 0.3 μ pore size filter allowing the measurement of both the parameters. Based on the volume, time period and difference in gravitational weights the concentrations of PM_{10} and $PM_{2.5}$ are calculated using the following formulae.

$$\mathbf{PM_{10}\ (\mu g/m^3) = \frac{(F_2 - F_1)}{V_a} \times 10^6}$$

Where,

F_1= Initial weight of Watman glass fiber Filter Paper, gm
F_2 = Final weight of Watman glass fiber Filter Paper, gm
Va = Volume of Air Sampled, m^3

$$\mathbf{PM_{2.5}\ (\mu g/m^3) = \frac{(F_2 - F_1)}{V_a} \times 10^6}$$

Where,

F_1= Initial weight of PTFE Filter Paper, gm

F_2 = Final weight of PTFE Filter Paper, gm

Va = Volume of Air Sampled, m^3

2) *Sulphur Dioxide:* For measurement of Sulphur dioxide (SO_2), Improved West and Geake method is adopted. The pollutant will be trapped in absorbent Potassium- tetra- chloromercurate and forms a non-volatile dichloro-sulphito-mercurate complex. The absorbent was brought to the laboratory to determine the absorbance value with the help of calibrated Spectrophotometer at a wavelength of 560 nm. Concentration of SO_2 measured using graph.
3) *Nitrogen Oxides:* For measurement of nitrogen oxides, Jacob and Hochheiser Modified Method is adopted. Nitrogen oxides are collected by bubbling air through a sodium hydroxide-sodium arsentite solution to form a stable solution of sodium nitrite. The absorbent was brought to the laboratory to determine the absorbance value with the help of calibrated Spectrophotometer at a wavelength of 540 nm. The absorbance value of the sample along with the standards are represented on graph and from the known concentrations of standards, the unknown concentration of NO_x in the absorbent is determined from graph.

B. *Fugitive Dust Emission*

A Fugitive Dust Sampler was installed at a height of 1-2 meters above ground which was free from obstructions. SPM samples were collected in dust collection cone; RPM samples were collected on the filter paper. The total suspended particulate matter (TSPM) collected is measured gravimetrically by combining the weight of particulate matter collected in cyclone cup and on filter paper and is calculated per cubic meter of air.

Based on the volume, time period and difference in gravitational weights the concentrations of TSPM are calculated using the following formulae.

$$\text{TSPM } (\mu g/m^3) = \frac{[(W_1 - W_2) + (CW_1 - CW_2)]}{V_a} \times 10^6$$

Where,

W_1 = Final weight of filter paper, g

W_2 = Initial weight of filter paper, g

CW_1 = Final weight of dust cone, g

CW_2 = Initial weight of dust cone, g

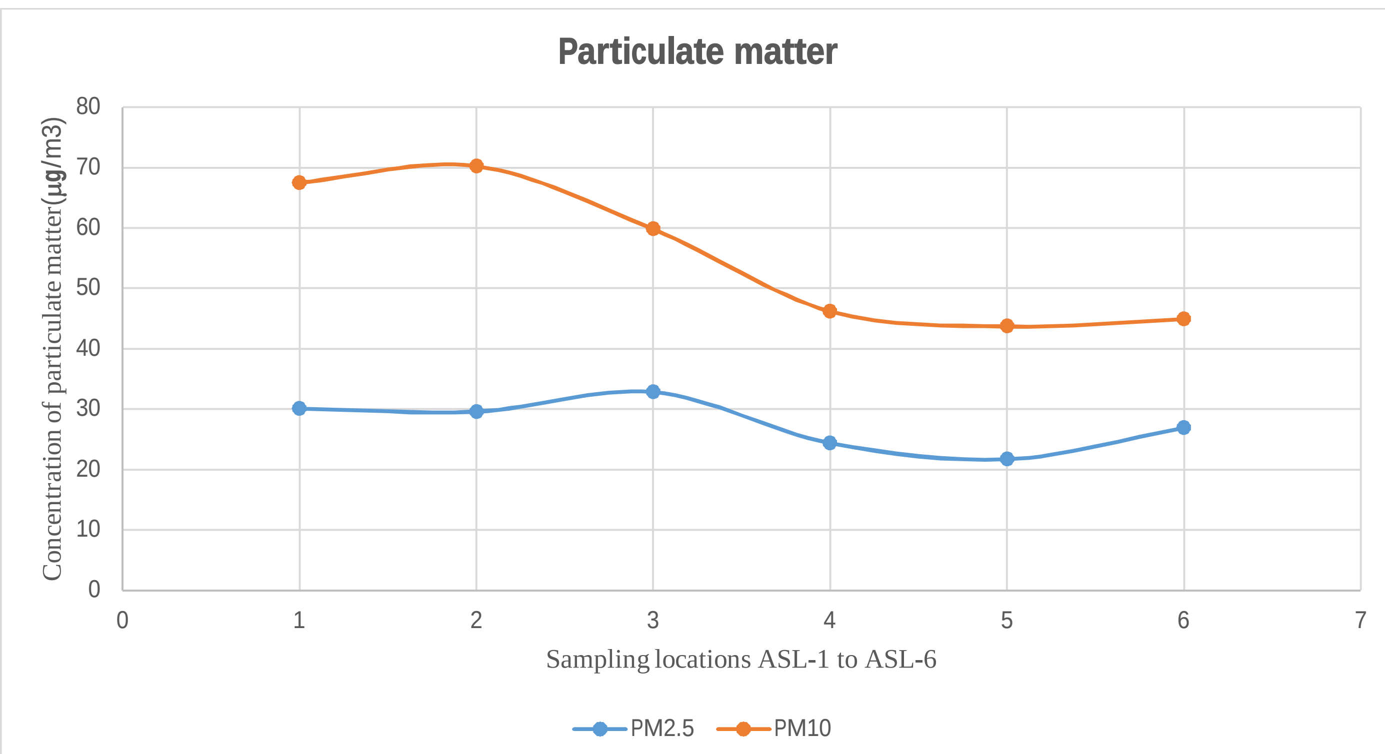
Va = Volume of Air Sampled, m^3

IV. RESULTS

Results obtained from laboratory have represented as graphs below

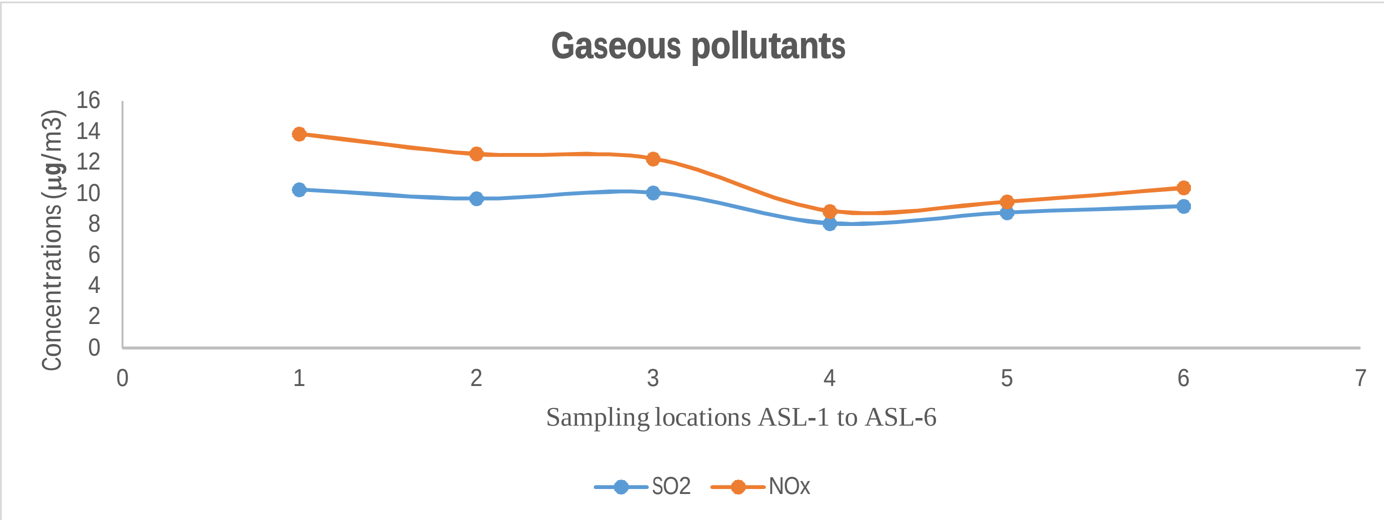
A. Ambient Air Quality

Particulate matter (PM2.5 and PM10)



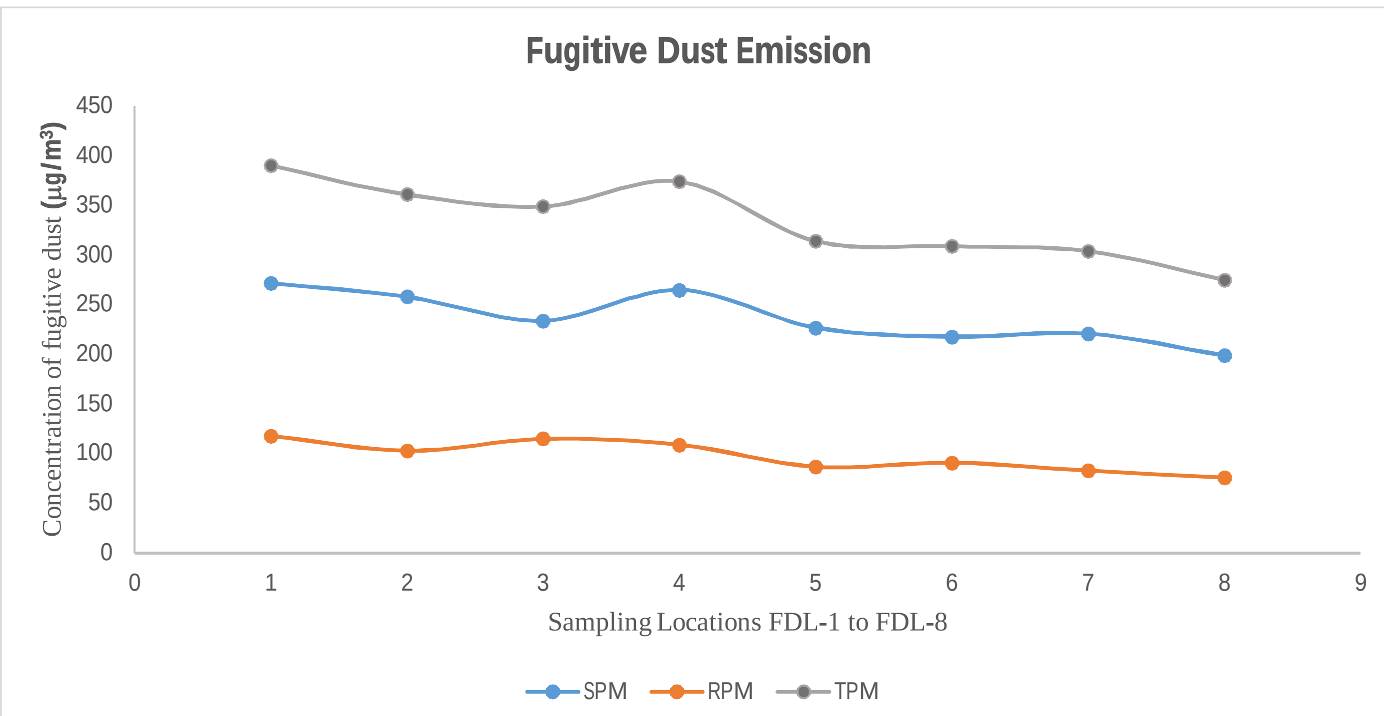
Graph-1: Particulate matter in Ambient Air quality zone.

Gaseous pollutants SO_2 and NO_X



Graph-2: Gaseous pollutants (SO_2 and NOx) in Ambient Air Quality zone

B. Fugitive Dust Emission



Graph-3: Fugitive Dust Emissions

V. CONCLUSION

As the mining is carried out by opencast method, the chief anticipated pollutant is particulate matter. Mining, excavation activities, transportation and other mining allied activities are contributing to the dust emissions. Gaseous emissions are anticipated due to blasting operations and machinery used while drilling and transportation of ore. Ambient Air Quality is monitored at 6 locations ASL-1 to ASL-6 for PM_{10}, $PM_{2.5}$, SO_2 and NO_2. In which ASL-1, ASL-2 and ASL-3 represents core zone sampling locations and ASL-4, ASL-5 and ASL-6 represents Buffer zone sampling locations. Concentrations of particulate matter lies well below CPCB the limits 100, 60 for PM10 and PM2.5 respectively. Hence, it is concluded from the air quality data that air quality in mine is well within the permissible limit as specified for industrial area by National Ambient Air Quality Standards (NAAQS) [1].

Fugitive dust emissions were monitored at 8 locations for TPM, SPM and RPM. Based on the activities in the mining, Particulate pollution is the critical pollutant. So, more emphasis was given to understand the distribution of particulates within and outside of the mine. It is observed that the pollutants are well below CPCB limits.

To reduce these particulate levels, water sprinkling is done at mine haul roads, around the crushers and dumpers at regular basis. The area is surrounded by forest and existing natural green cover. Apart from this the proponents are developing green belt at strategic locations to act as sink of dust and gaseous pollutants.

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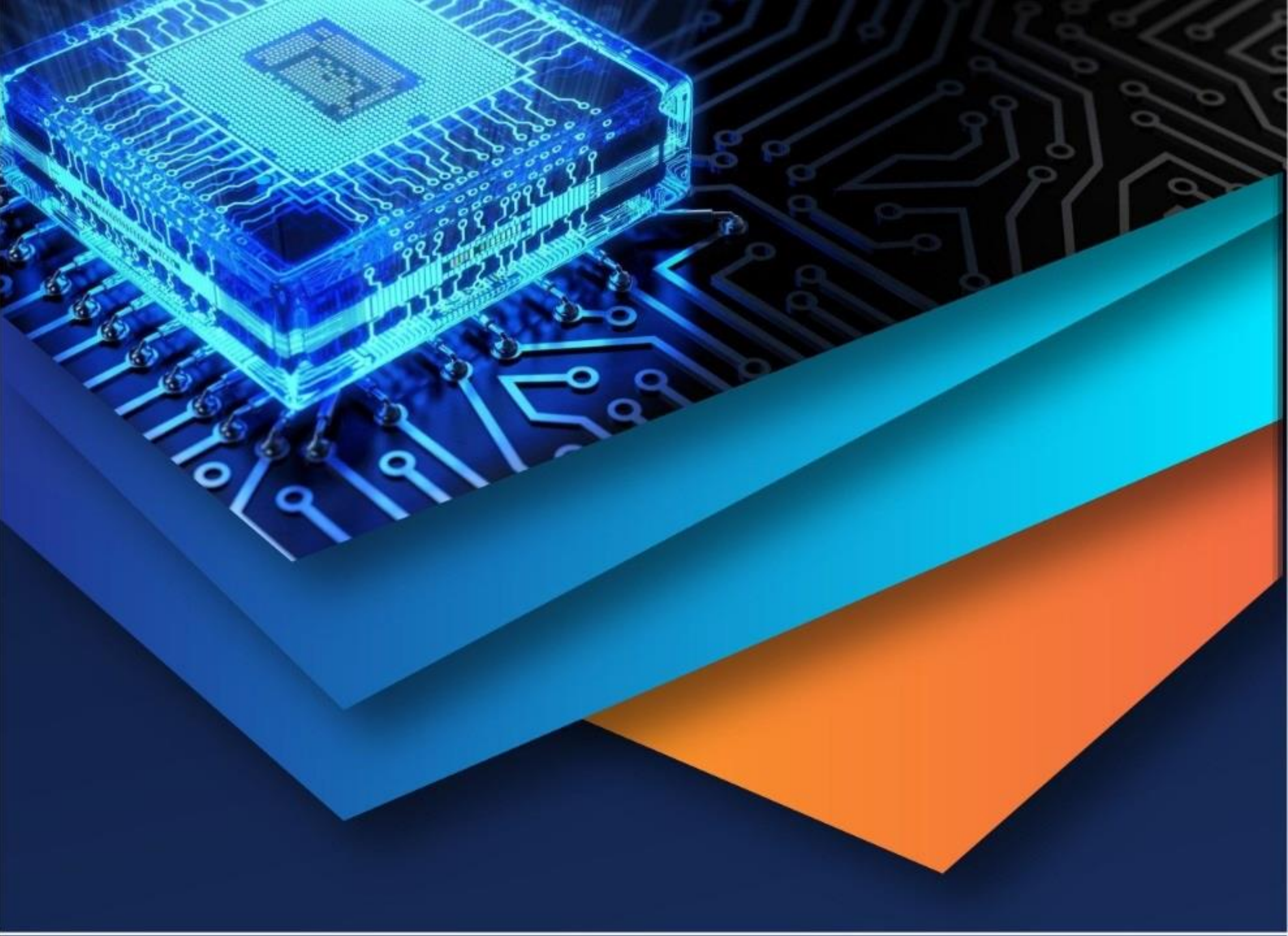

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