IJMTST is UGC Approved Journal with Journal Id: 43137

International Journal for Modern Trends in Science and Technology, 8(S04):07-11, 2022

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST08S0402
Available online at: https://www.ijmtst.com/vol8si04.html

Interpretation of Air Pollution by Air Quality Index in Mining Area-A Case Study

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To Cite this Article
Gorre Srinadh, M.Manoj, K.Trilok Reddy, Y.Vamsi and P.Swarna Mounika. Interpretation of Air Pollution by Air Quality Index in Mining Area-A Case Study. International Journal for Modern Trends in Science and Technology 2022, 8(S04), pp. 07-11. https://doi.org/10.46501/IJMTST08S0402

Article Info
Received: 26 April 2022; Accepted: 24 May 2022; Published: 30 May 2022.

ABSTRACT

The mining industry directly and indirectly supports our everyday life. Mining industry is the most vital industry to meet the people's regular needs and also for country's wealth. On the other hand, mining activities leads to various environmental pollution issues. These pollutions may include air, water, land and noise etc. The air pollutants such as particulate matter ($PM_{2.5}$ and PM_{10}) and gaseous emissions (CO_2, CO, NO_x, SO_2) are released during various mining operations. Therefore, air quality is the major concern in mining regions. Hence it is very essential to monitor these pollutants regularly. Identification of the major pollutant which is responsible for the lower air quality is also very important.Considering the above situation, the current work focuses on the monitoring of ambient air quality at granite mines using the ENVIROTECH APM equipment. The identification of the major pollutant is done by calculating the Air Quality Index from the monitoring results. quality. It is found that PM_{10} and $PM_{2.5}$ are major pollutants and it is also found that PM_{10} is major pollutant at the mine site and as the distance from mine site increases the $PM_{2.5}$ is identified as the major pollutant. It is found that the monitoring results are within the prescribed limits of CPCB. The various sources of these pollutants from the mining activities are identified and necessary preventive measures are proposed to maintain sound ambient air quality. Apart from water as dust suppressor, drills with dust extractors, dust collectors, and fog cannons are effective means to mitigate the air pollution.

KEYWORDS: Air Quality Index, major pollutant, ENVIROTECH APM, fog cannons.

1. INTRODUCTION

The mining industry directly and indirectly supports our everyday life. Most of the things we use in our daily life are made from minerals or depends on minerals for their production. In India mining is the major economic activity that contributes extremely to the country's economy. The GDP contribution of the mining industry varies from 2.2% to 2.5% only but when it comes to the total industrial sector it varies from 10% to 11% [1]. It also provides a fair amount of employment to the individuals. On the other hand, mining activities leads to various environmental pollution issues. These pollutions may include air, water, land and noise etc. the air pollutants such as particulate matter ($PM_{2.5}$ and PM_{10}) and gaseous emissions (CO_2, CO, NO_x, SO_2). These pollutants are usually released during drilling, blasting, loading, transportation, dumping and waste handling. In the cases of extraction of minerals which contain metals such as mercury, lead, silica and arsenic which are able to emission of metallic pollutants in to the ambient atmospheric air which are highly responsible for health effects. Therefore, air quality is the major concern in mining regions. Hence it is very essential to monitor these pollutants regularly and necessary control measures are vital to maintain a decent air quality.

This project is to analyse the ambient air quality by using air quality index to identify the dominant pollutants responsible for the lessen air quality in highly mining regions. Thus, to identify the sources of these major pollutants and their effects on the region's air quality and befitting precautions could be crafted.

1.1 AIR QUALITY INDEX

It is an index which is used to report air quality at a particular place, city, state or country.the air quality indices vary across countries, corresponding to their national air quality standards. The Indian ministry of environment, forest and climatic change launched National Air Quality Index (AQI) under Swachh Bharat Abhiyan in 2014 [10]. The National Air Quality Index acts as one number-one colour-one description to judge the air quality. Therefore, AQI is one such tool for effective publication of air quality information. The Air Quality Index will consider eight pollutants (PM_{10}, $PM_{2.5}$, SO_2, NO_2, O_3, CO NH_3 Pb) for which short term (up to 24hourly averaging period) National Ambient Air Quality standards are prescribed.

2. REALATED WORK

Air pollution is considered as a major concern for mining industry. The activities involved in the mining industry generate huge amount air pollutants which are responsible for lower air quality. This problem had always troubled many engineers and environmentalists.The authors studied air pollution caused by opn cast mining and its abatement measures in India [4]. Also observed the seasonal fluctuations in the emissions of pollutants. The emission rates were calculated for various mining activities by using pasquil and Gifford formula [2]. The various empirical equations were developed to calculate the emission rates of various mining activities [3].

The current project is done with the objective to represent the air quality at mining region with one number-one colour-one description. To identify the major pollutant and its sources. When the sources of the major pollutant are identified, the effective preventive measures can be adopted to control the emission of major pollutant. As a result, the impacts of the lower air quality can be reduced.

3. METHODOLOGY

To calculate the Air Quality Index the monitoring results of various pollutants are requird. For this project the required data was collected from the granite mines present in the chimakurthy region of Andhra Pradesh and air quality monitoring agency.

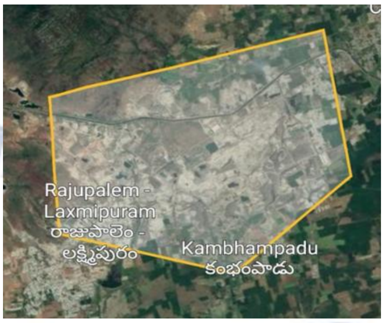

Figure 1 Location map of monitoring area

3.1 AMBIENT AIR MONITORING

In order to asses the air pollutants that are being emitted from various mining operations periodical monitoring is required. According to mining regulations the monitoring shall be carried out at least every six months. If the monitored concentrations are in excess of 50% of the maximum allowable concentrations, then monitoring should be carried out for every three months and in case of excess of 75%, the monitoring should be carried out for every three months. The monitoring should be done to know whether the emissions are in the limits prescribed by the CPCB and DGMS.

For PM_{10} sampling the ENVIROTECH APM 460DXNL respirable dust sampler isused and for $PM_{2.5}$ sampling ENVIROTECH APM 550 MFC is used. The gaseous sampling is done by using ENVIROTECH APM 411TE.

3.2 CALCULATION OF AIR QUALITY INDEX

The formulation of Air Quality Index (AQI) involves two steps:

1. Formulation of sub-indices for each pollutant.
2. Aggregation of sub-indices to get an overall Air Quality Index (AQI).

The formulation of sub-indices can be done by the formula mentioned below. Each sub-index gives a relation between pollutant concentration and health impacts.

$$I_i = [\{(I_{HI} - I_{LO})/(B_{HI} - B_{LO})\} * (C_P - B_{LO})] + I_{LO}$$

Where,

B_{HI}=breakpoint concentration greater or equal to given concentration.

B_{LO}=breakpoint concentration smaller or equal to given concentration.
I_{HI}=AQI value corresponding to B_{HI}
I_{LO}=AQI value corresponding to B_{LO}
C_P=pollutant concentration

O_3 (ppm)	PM_{10} (ug/m^3)	$PM_{2.5}$ (ug/m^3)	CO (ppm)	SO_2 (ppm)	NO_2 (ppm)	AQI Values	Level of Health Concern
0.000 – 0.059	0 – 54	0.0 – 15.4	0.0 – 4.4	0.000 – 0.034	–	0 – 50	Good
0.060 – 0.075	55 – 154	15.5 – 40.4	4.5 – 9.4	0.035 – 0.144	–	51 – 100	Moderate
0.076 – 0.095	155 – 254	40.5 – 65.4	9.5 – 12.4	0.145 – 0.224	–	101 – 150	Unhealthy for Sensitive Groups
0.096 – 0.115	255 – 354	65.5 – 150.4	12.5 – 15.4	0.225 – 0.304	–	151 – 200	Unhealthy
0.116 – 0.374	355 – 424	150.5 – 250.4	15.5 – 30.4	0.305 – 0.604	0.65 – 1.24	201 – 300	Very Unhealthy
–	425 – 504	250.5 – 350.4	30.5 – 40.4	0.605 – 0.804	1.25 – 1.64	301 – 400	Hazardous
–	505 – 604	350.5 – 500.4	40.5 – 50.4	0.805 – 1.004	1.65 – 2.04	401 – 500	Hazardous

Table 1: breakpoints for the sub-index

AGGREGATION OF SUB-INDICES

The aggregation of sub-indices is usually a summation or multiplication or simply a maximum operator. Generally, the maximum of sub-indices is considered as the overall air quality index.

$$I = \max(I_1, I_2, I_3, \ldots, I_n)$$

3.3. CASE STUDY

The data was collected from the mechanized granite mines situated in the chimakurthy of Prakasham district in Andhra Pradesh. The ambient air quality monitoring was conducted for every six months at different monitoring stations from June 2020 to December 2021. The average monitoring results are as follows.

Sl.NO	location	Date	Duration of sampling	PM_{10} (µg/m^3)	SO_2 (µg/m^3)	NO_X (µg/m^3)	$PM_{2.5}$ (µg/m^3)	CO (Mg/m^3)
1.	At mine lease area (Core zone)	20/06/2020	24 hr	63	5.4	6.0	19	BDL
2.	Near ramatirtham (buffer)	20/06/2020	24 hr	30	5.2	5.8	22	BDL
3.	Near R.L.Puram (buffer)	20/06/2020	24 hr	46	5.0	6.9	25	BDL
4.	Near kammapadu (buffer)	20/06/2020	24 hr	28	4.2	5.6	20	BDL

Table 2: Average monitoring results at mine-A

The sub indices for the average monitoring results at mine-A are calculated. The aggregation of the calculated sub indices gives the overall Air Quality Index. The calculated results are as follows

Sl.NO	location	PM_{10}	SO_2	NO_X	$PM_{2.5}$	CO	AQI	Major pollutant
1.	At mine lease area (Core zone)	63	7	8	32	0	63	PM_{10}
2.	Near ramatirtham	30	7	7	37	0	37	$PM_{2.5}$
3.	Near R.L.Puram (buffer)	46	6	9	42	0	46	PM_{10}
4.	Near kammapadu (buffer)	28	5	7	33	0	33	$PM_{2.5}$

Table 3: Calculated AQI for average monitoring results at mine-A

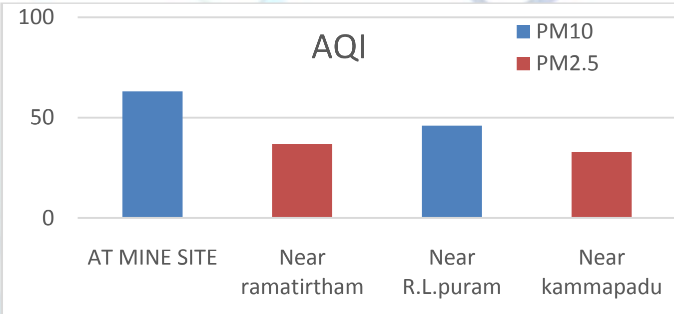

Figure 2: bar graph showing AQI for mine-A

The Air Quality Indices of the observed mines varies across the shifts. The shift wise air quality indices are as follows

Figure 3: bar graph showing shift wise AQI for mine-A

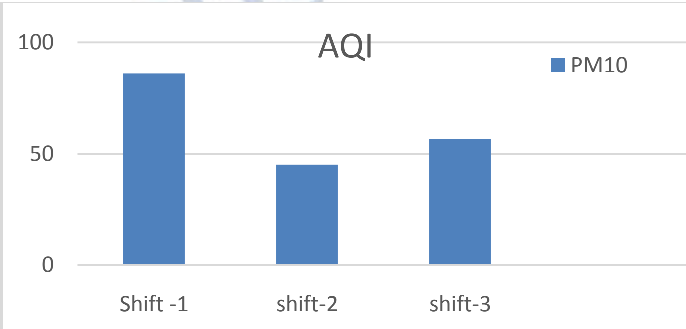

Figure 4: bar graph showing shift wise AQI for mine-B

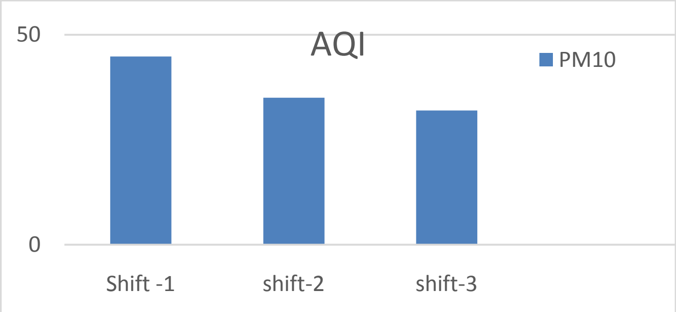

Figure 5: bar graph showing shift wise AQI for mine-C

From results obtained by calculating Air Quality Index, it is clearly observed that particulate matter is the major pollutant which is responsible for the lower ambient air quality at the mine site and also at near by buffer zones. It is clearly observed that PM_{10} is the major pollutant at the mine site and at nearby buffer zone(R.L.puram) and as the distance increases from the mine site $PM_{2.5}$ is identified as the major pollutant. From the shift wise analysis, it is noted that the air quality at shift-A is lower when compared to the remaining two shift this resembles that some of the operations are potential sources of generating particulate matter. The monitoring results of these mines are well within the prescribed limits of CPCB and NAAQs.

4. DISUSSIONS

monitoring of ambient air quality is important and equally identification of major pollutant responsible for the lower air quality. Then it is possible to identify the sources of major pollutant and so the preventive measures can be adopted. The particulate matter is generally referred as dust that is characterized by size and composition. This particulate matter generally consists of solid rock particles, inorganic and organic substances and aerosols. The particulate matter is generated during various operations in the mining industry. The particulate matter generated because of mining activities generally called as mine dusts.

The various sources of particulate matter in mines are as follows:

- Drilling operations
- Blasting operations
- Loading operations
- Haul roads
- Transporting and dumping
- Crushing plants or cutting plants
- Removal of vegetation and top soil
- The open face of overburden dumps.

4.1. PROPOSED PREVENTIVE MEASURES

As the air pollution is the concern for the mining industry necessary preventive steps are required to maintain a sound air quality. The preventive measures are must be adopted across the various operations involved in the mining industry. It is very important to maintain the ambient air quality with in CPCB guidelines. The essential precautionary steps are followed from the planning stage of the mining for effective control of air pollution.

We all know that water is the effective suppressor of the dust. Therefore, water spraying arrangement on the haul roads, loading and unloading, and at transfer points could leads to effective dust suppression. Not only at the haul roads, water sprinklers arrangement along the all transport roads can also be effective. Apart from water as dust suppressor there are some additional measures to be followed for effective dust control. Such as:

- Wet drilling and wire saw cutting method shall be adopted to control dust emissions.
- Green belt shall be developed along the boundary of the mining lease area with tall growing trees. The green belt can be very effective to control the dispersion of particulate matter.
- Roads shall be graded to mitigate the dust emission. Metal roads as haul broads can be very effective for dust control.
- Drills should be water jacketed or Drilling machines shall be equipped with dust extractors/collectors can reduce the generation of particulate matter while drilling.
- Spillage of material from the transporting material should be avoided.
- Before the blasting operation the strata can be wetted to control the generation of particulate matter.
- mobile or stationary dust collectors and dry fog system with less water consumption shall be used to control the dust from getting airborne.

5. CONCLUSION

As the mining industry is continuously evolving, it also has significant impact on the ambient air pollution. The activities involved in the mining are potential sources of releasing air pollutants. These pollutants become airborne and are responsible for major health effects to the miners as well as the residents of that region. It may lead to chronic lung diseases when people exposed to these pollutants. Therefore, it is very essential to monitor the ambient air quality. Not only monitoring identification of the major pollutant is equally important. By calculating the air quality index from the monitoring results, it is very easy to identify the major pollutant. The concept of air quality index is very easy to understand because it acts as the one number-one colour-one description to judge the air quality.

The monitoring of air quality which is done at granite mines in chimakurthy shows that the PM_{10} and $PM_{2.5}$ are identified as the major pollutants. The sources of these pollutants from the mining activities are identified. It is very important to improve ambient air quality. For these necessary precautionary steps are to be followed. Even though water is active suppressor of dust it is essential to control the generation of dust. It is proposed that drills with dust collectors are effective to control the generation of particulate matter during the drilling operations. Metal roads as haul roads also controls the generation of particulate matter. Dust collectors and fog cannons are now available to prevent the dust from getting air borne.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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