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Assessment of Ambient Air Quality Index of Coal City Dhanbad for Public Health Information

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Abstract—"*Air pollution and population health" is one of the most important environmental and public health issues. Economic development, urbanization, energy consumption and transportation are major driving forces of air pollution in large cities, especially in urban cities. The Air Quality Index (AQI) is a scale designed to help one understand what the air quality around one means to one's health. It is a health protection alarming tool that is designed to help in making one to take decision to protect one's health by limiting short-term exposure to air pollution and adjusting one's activity levels during increased levels of air pollution.*

1. INTRODUCTION

Over the past few decades, Air borne diseases have increased their number in the living environment. Increasing concentration of different pollutants in ambient air is degrading the quality of the surrounding air [9]. Vehicular emissions are considered as a primary reason in the degradation of ambient air quality. Industries are also, in recent, creating a havoc to the environment and doing same with air quality [10]. Air Quality, in general, is defined via air surrounding the unconfined part of the atmosphere, in which human and other organisms live and breathe. The content and quality of the air is directly and foremost affected by the day to day activities of humans. Our everyday choices, such as driving cars and burning wood, can have a significant impact on air quality. Ambient air quality refers to the quality of outdoor air in our surrounding environment. It is typically measured near ground level, away from direct sources of pollution. There are many factors that affect air quality, making the search for clean air quite a complicated issue.

For determining air quality of a particular area, Air Quality Index is determined. Air Quality Index is a scale reporting the air pollution [1]. Different indices have been developed and refined timely for a better analysis of air quality by different agencies all over the world. Central Pollution Control Board of India has proposed several regulations and guidelines for the calculation of Air Quality Index [2-3]. NAAQS proposed by CPCB regulates the emission of air pollutants over an area. Other than this many cities are using Air Quality Indices governed and issued by US Environmental protection Agency [4]. The criteria and regulations used by these indices are nowhere related to the level of air pollution in an area [9].

Looking over the Dhanbad city, coal mines are prominent in this area and the mining activities going there contribute much to the air pollution [6]. SO_2, NOx and Particulate Matter are the most important emissions during coal mining. These emissions are a result of drilling, blasting, overburden loading and unloading, coal loading and unloading, haul roads, transport roads, stock yards, exposed overburden dumps, coal handling plants, exposed pit faces, presence of fire, exhausts from heavy earth moving machinery, crushing of coal to a convenient size in the feeder breaker and workshop [6]. Burning of coal also results in disturbing the air quality.

The primary objective of this study is to calculate the AQI of Dhanbad city by the EPA method and evaluating the results for better health.

2. AIR QUALITY INDEX

Air pollution is a well-known environmental problem associated with urban areas around the world. For determining the quality of air, we use different air quality indices. Air Quality Index, in general, is defined as a number stating the air quality over an area and depicting its effect on the human health [1]. Broadly speaking, AQI is a mathematical expression which uses various pollutant concentration to reach at a number. In India, the most common index used is the NAAQS, given by Central Pollution Control Board. In this 12 various pollutants are set under different categories in respect to their emissions and time of contact. USEPA is considered as a valuable index throughout the world in taking consideration of Air Quality. PSI, was established in 1976 by USEPA rating the air quality from 0-500 with 100 equal to National Ambient Air Quality Standards (NAAQS). The daily PSI is determined by the highest value of one of the five main air pollutants: PM10, O3, SO2, CO and NO2 (EPA, 1997; EPA, 1999). Various researchers have done study on USEPA and the results were much clearer. The factor analysis in the USEPA shows aa very wide range in comparison to NAAQS which make it more approachable [9]. USEPA revised their AQI in 1999 for better analysis. Lohani (1984) applied factor analysis approach to find environmental index for Taiwan Indian context, the studies on AQIs have been carried out for the city of Lucknow[10], Delhi [7] and Kanpur [8]

3. AQI BY USING EPA METHOD (EPAQI)

The EPA method is based on concentrations of five criteria pollutants: carbon monoxide (CO), nitrogen dioxide (NOx), ozone (O_3), particulate matter (PM) and sulphur dioxide (SO_2). The concentration values are converted into numerical indexes. The overall AQI is calculated by considering the maximum AQI among the monitored pollutants corresponding to a site or station.

The AQI measures daily pollution index of the pollutants for which EPA has established National Ambient Air Quality Standards (NAAQS). The index combines the NAAQS with an epidemiological function to determine a descriptor of human health effects due to short-term exposure (24 hour or less) to each pollutant (EPA, 1994, 1997). The index for a pollutant is calculated using the mathematical expression (EPA, 1999):

$$I_{P=} \frac{Imax - Imin}{BPmax - BPmin}(C_P - BP_{min}) + I_{min} \quad (1)$$

Where, IP=the index value for pollutant, P; CP=the truncated concentration of pollutant, P; BPmax=the breakpoint that is≥ CP; BPLO=the breakpoint that is≤ CP; Imax =the AQI value corresponding to BPmax, Imin=the AQI value corresponding to BPmin. The indexes for each of the pollutants NO_2, O_3, PM_{10}, CO and SO2 were obtained from Eq. (1) using their respective break points and associated AQI values (EPA, 1999). Having calculated Ip of each pollutant, the EPAQI is evaluated by considering the maximum index value (Ip) of the single pollutant. Mathematically, it is expressed as EPAQI=Max (Ip)

Table 1: Proposed sub-index and breakpoint pollutant concentration for Indian – AQI

S. No.	AQI	Category	SO_2(24 hr)	NO_2 (24hr)	$PM_{2.5}$ (24hr)	PM_{10} (24hr)
1	0-100	Good	0-80	0-80	0-400	0-100
2	101-200	Moderate	81-367	81-180	401-500	101-150
3	201-300	Poor	368-786	181-564	501-700	151-350
4	301-400	Very Poor	787-1572	565-1272	701-900	351-420
5	401-500	Hazardous	>1572	>1272	>900	>420

These breaking points are obtained on the basis of human health effects.

The entire population is more likely to be affected. [8]

- **Good**: Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. It is represented in green colour.
- **Moderate:** Members of sensitive groups may experience health effects. It is represented in yellow colour.
- **Poor:** Members of sensitive groups may experience more serious health effects. It is represented in orange colour.
- **Very Poor:** Triggers health alert, everyone may experience more serious health effects. It is represented in red colour.
- **Critical:** Triggers health warnings of emergency conditions. It is represented in maroon colour.

Here we use AQIs to assess the status of ambient air quality near five cites in the Dhanbad city of Jharkhand, India. The AQIs for the criteria pollutants such as Suspended Particulate Matter (SPM), Oxides of Nitrogen (NOx), Sulphur dioxide (SO2) and Respirable Particulate Matter (RPM) are calculated by the procedure suggested by the EPA.

4. STUDY AREA AND MONITORING

As stated earlier the study area was Dhanbad District. The area under study included one of busiest roads in Dhanbad with vehicles moving around all the time. In addition, there are numerous commercial and industrial activities along. In order to monitor the air pollution status in Dhanbad district, five monitoring stations were selected keeping in view the general characteristics of the areas, care in monitoring i.e. location, availability of round the clock electricity, safety of monitoring equipment etc. The monitoring stations thus selected were as listed below.

Table 2: Geographical Description of Cites

Location	Latitude (in degree)	Longitude (in degree)
ISM Main Gate	23.8091932	86.4425194
ISM Admin Block	23.8097472	86.4423806
Bank More	23.7888694	86.4198583
Kusunda	23.7774535	86.3756867
Steel Gate	23.8219694	86.4829139

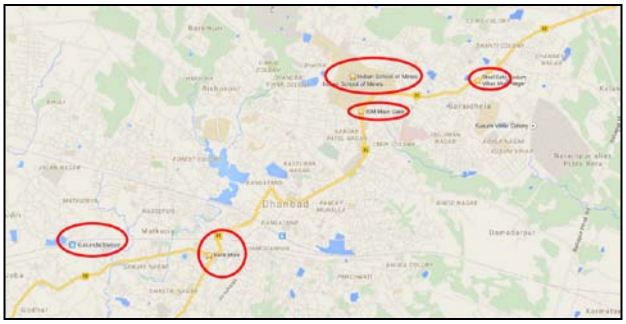


Fig. 1: Pictorial Description of Monitoring Sites

1) Main Gate Indian School of Mines(ISM),Dhanbad: It is a site representing purely commercial activities and road traffic.

2) Bank more: It is one of the busiest marketing centres of the district and is surrounded by residential areas. All the vehicles going to Bokaro passes by this place and thus the traffic density is pretty high.

3) Kusunda: It is a place 10.9 kilometres from Dhanbad main city. It is just beside coal mine, all vehicles going to mine passes through this place.

4) Steel Gate: It is site consisting of small market. Trucks and other heavy vehicle numbers are more during night since this road connects to highway.

5) ISM Admin Block: It can be considered as a sensitive area since it is a very calm place where the usage of vehicles is minimum throughout the day. As we see, the monitoring stations selected represent the various mixes of air pollution source situations.

5. COLLECTION OF SAMPLE AND ANALYSIS

Suspended Particulate Matter (SPM), Oxides of Nitrogen (NOx), Sulphur dioxide (SO2) and RespirableParticulate Matter (RPM) were sampled by high volume sampler (HVS); capacity of which is 1.26-1.42 cu.m. per minute; 2350 cu.m. of air may get filtered in 24 hours. The collected particulate matter was dried and weighed. The ambient air monitoring was carried out at 24 hours in a day in each station. The weight of material collected is determined by weighing the filters before and after collection. For the estimation of Sulphur dioxide (SO_2) Modified West &Gaeke method, 1956 was employed using sodium tetra chloromercurate as absorbent by spectrometric analysis and for the estimation of oxides of nitrogen (NOx), we used Modified Jacobs &Hochheiser Method in which 0.1 N sodium hydroxide (NaOH) solution is mixed with 0.4 % of sodium arsenate and was used as absorbing solution where it converts into nitrite ions. The nitrite content is again estimated using spectrophotometer by the method of IS: 5182 (Part-VI).

6. OBSERVATION

Table 3. Observation Table of the Monitored Pollutants

Location	SPM (24 hrs)	RPM (24 hrs)	SO_2 (24 hrs)	NO_x (24 hrs)
ISM Main Gate	310	253	49	100
ISM Admin Block	25.575	78	11.25	8.25
Bank More	435.5	355	16.85	124.5
Kusunda	467.5	467.5	15.95	120.5
Steel Gate	355	323	39	87.5

7. RESULTS & DISCUSSION

AQI at different location was calculated by USEPA method.

Table 4: Result Obtained (AQI)

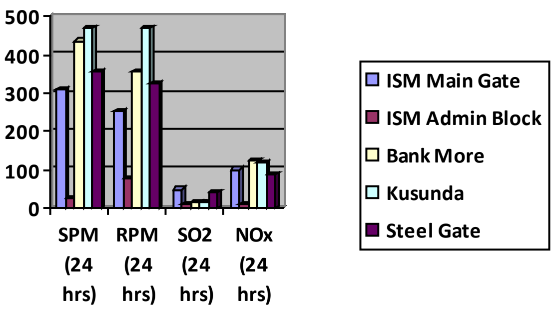
Location	SPM	RPM	SO_2	NO_x
ISM Main Gate	77.5	251	61.25	120
ISM Admin Block	6.4	78	14.0625	10.3125
Bank More	135.5	306.7	21.0625	144.5
Kusunda	167.5	459.78	19.94	140.5
Steel Gate	88.75	286.57	48.75	107.5

From above result of AQI these pollutants at different location come under different categories which are as follows:

Table 5: Categorical Description of the Monitored Pollutants

Location	SPM	RPM	SO_2	NO_x
ISM Main Gate	Good	Poor	Good	Moderate
ISM Admin Block	Good	Good	Good	Good
Bank More	Moderate	Very Poor	Good	Moderate
Kusunda	Moderate	Critical	Good	Moderate
Steel gate	Good	Poor	Good	Moderate

Bar Chart Representation



8. DISCUSSION

1) The AQI of SPM came under "Good" category in three locations namely ISM Main Gate, ISM Admin Block and Steel Gate. Henceforth, the air quality comes satisfactory at these location in the terms of SPM while it was moderate in other two locations, Bank More and Kusunda. This effects more to sensitive people with respiratory or heart disease and the groups comprising elders and children are most at risk. It is recommended that other people should consider reducing prolonged or heavy exertion at these location.

2) The AQI of RPM at ISM Main Gate and steel gate came under "Poor" category. Henceforth, sensitive people with respiratory disease are the most at risk. Due to that, respiratory symptoms and aggravation of lung diseases are increasing such as asthma, bronchitis etc. It was good at ISM Admin Block but at Bank More it was very poor and at Kusunda it came under critical situation. Due to that respiratory symptoms and aggravation of lung diseases increased at these locations. Therefore, it is recommended that everyone should avoid any outdoor exertion; people with respiratory diseaseshould remain indoors.

3) The AQI of SO_2 at these locations were good. So there is no tension of any disease.

4) The AQI of NOx at ISM Admin Block was good while moderate at rest of the locations. At these locations sensitive people suffers with asthma or other respiratory diseases. It was also seen that healthy individuals also experience respiratory symptoms in these locations.

9. RECOMMENDATION

From the above observations and results of the areas which were studied, the observed sites should be considered as polluted prone and suitable action should be taken to reduce the concentration of SPM,RPM and NOX.

On the basis of this situation, the following suggestions are made:

1. The roads has a large number of bad patches which increase dust generation and slow down the traffic. Hence, this condition is the main contribution to air pollutants which can be minimized by repairing the road and maintaining the proper smooth condition.

2. Due to high traffic density in busy roads, vehicles invariably go out to the unpaved side of the road which causes huge amount of dust generation which become airborne. One solution for this is to increase the width of the road to accommodate high traffic density and if this is not possible we advise to make footpaths or some raised platforms by the side of the road so that vehicles cannot move to the aisle of the road and generate dust.

3. It is advisable to use unleaded petrol since the petrol driven vehicles emit lead from their exhaust which is very harmful.

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