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Full Length Research Article

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# Application of GIS for Detection of Ambient Air Pollution of Industrial Area of Gujarat

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## ABSTRACT

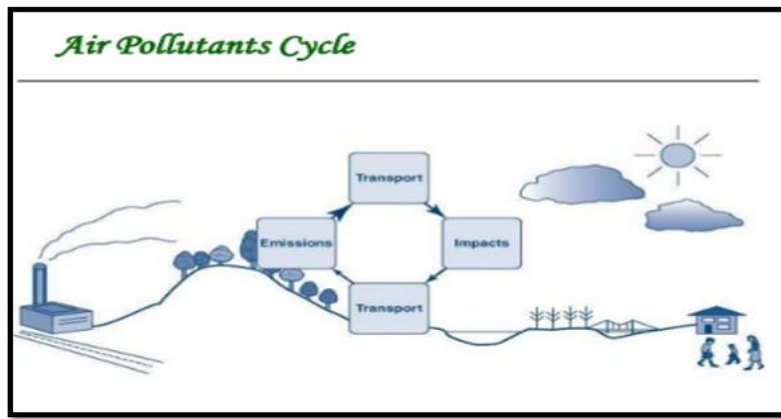
Air quality is important to our health and environment, but sources of contamination are often difficult to monitor. GIS technology manages statistical and spatial data to provide a tool that shows the relationship between poor air quality and occurrences of deficient human and environmental health. In this way, a GIS aids in monitoring pollutant emissions. A GIS can be used to track the EPA regulated pollutant emissions by delineating the effects of ozone, smog, dust, and other harmful airborne pollutants on plant and human life. By monitoring those relationships, a GIS becomes a tool conservationists can use to ensure that no further ambient dust occurs. The main aim of study is to analyse variability of pollutants selected industrial area of Gujarat and correlated with occupational health hazard indicator.

**Keywords:** GIS, AQI, Tracking, Human health, Pollutant emission, Monitoring

## INTRODUCTION

Throughout the world, air pollution is a matter of concern at all levels. The worldwide epidemiological study on the effect of air pollution had revealed that gaseous pollutants and particulate matter had enough potential to cause severe health effect like respiratory, cardiovascular diseases and cardio pulmonary mortality [1,2]. Being a serious matter of concern now-a-day, a systematic monitoring programme all over the world especially in industrial area urgently needed [3]. The World Health Organization (WHO) listed six major

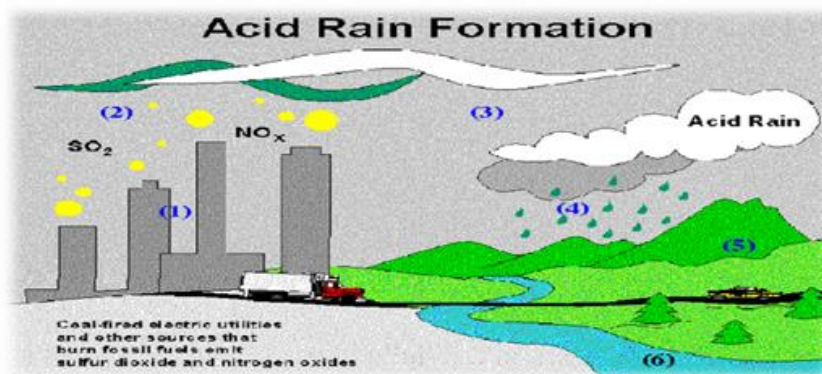
substances which are termed "classic" air pollutant-namely Lead (Pb), Total Suspended Particles (TSP), Ozone (O<sub>3</sub>), Carbon monoxide (CO), Sulphur dioxide (SO<sub>2</sub>), Nitrogen dioxide (NO<sub>2</sub>) and other air toxic elements[3]. Recent development in the study of air pollution have heightened and also established relationships between deaths caused by chronic obstructive pulmonary disease, lung cancer and heart disease (Figure 1) [4,5].



**Figure 1:** Air pollution cycle.

In India, air pollution had also become a topic of intense debate at all levels mainly because of the enhanced anthropogenic activities. Today India is

one of the first ten industrial countries of the world [6,7].



**Figure 2:** Acid rain formation.

**GIS application in Pollution detection**

Geographic Information Systems (GIS) is an essential scientific tool for data processing, analysis of geographical distribution and variations, mapping, monitoring and management. The implementation of technological improvements is considered one of the most important remedial measures to cope with increased risk to human health due to road transport. The sources of air pollution are generally multiple and depend not only upon geography of the location but also changing meteorological conditions, and increasingly climate.

Systematic air quality-monitoring programme with GIS approach was reported from this own. Hence the quality of ambient air deserved a systematic as well as scientific investigations so that proper strategies could

be taken to mitigate in case of any pollution was found. The objective of this study is to evaluate the distribution of selected gaseous pollutants i.e. sulphur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>) and respiratory suspended particulate matter (RSPM) by using GIS techniques in an industrial area of Gujarat.

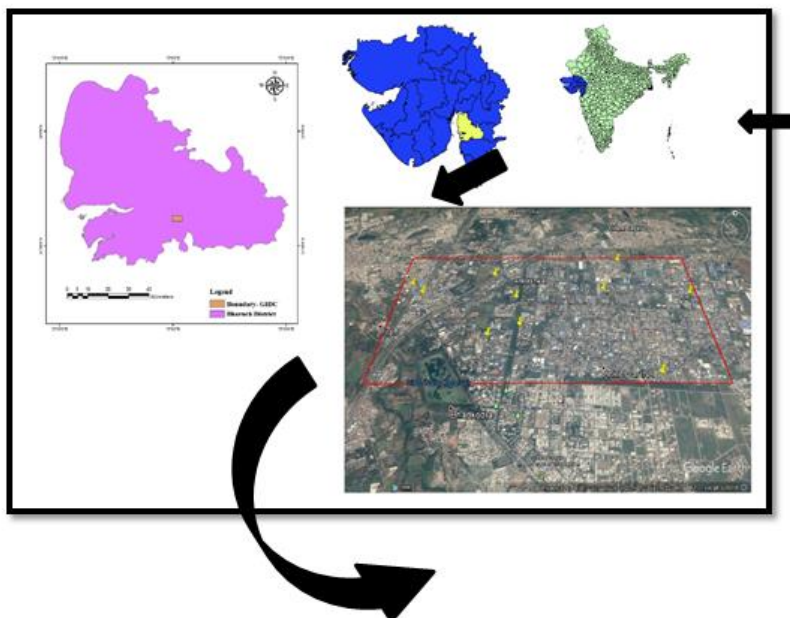
**Scope of study:** NAAQS prescribe standards to study impact of air pollution on human health. Due to presence of primary pollutants and secondary pollutants, composition of air altered which give systematic persistent and chronic impact on human health. Prolong exposure of pollutants leads to occupational health issues. For this we require predicted models and cumulative study of all ambient parameters which can be study with help of geospatial information approaches.

## MATERIALS AND METHODS

### Study area

Ankleshwar, (sometimes written Anklesvar) is a city and a municipality in the Bharuch district of the state of

Gujarat, India. The city is located ten kilometres from Bharuch at 21.6180° N, 73.0228° E, which is spread over an area of 1600 hectares in close proximity to NH-8 and the town is known for its industrial township called GIDC (Gujarat Industrial Development Corporation) (Figure 3).



**Figure 3:** Sample location map.

Ankleshwar has over 1500 chemical plants, producing products such as pesticides, pharmaceuticals, CETP, TSDF sites, chemicals and paints. GIDC has started

organising Trade fair and Industrial expo occasionally to attract large number of industries all over from India (Figure 4).



**Figure 4:** Combo Sampler.

**Sampling (6:00 A.M. to 6:00 A.M.) and Analysis of Gaseous Pollutants and Particulate Matter**

In both the seasons the sampling was done for twenty- four (24) hours at each site. The seasonal classification was followed as per specification laid by Indian meteorological department [26]. Air monitoring parameters such as PM 2.5, PM 10, SOx and NOx has been collected by Yash Combo Sampler. Analysis of all pollutants as per CPCB manual [3].

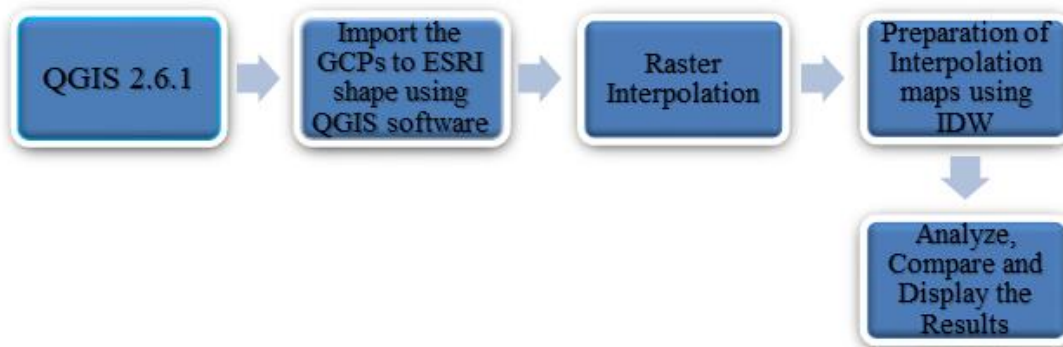
**Interpolation methods**

Commonly used interpolation approaches have been evaluated with reference to the study area and adopted methodology is summarized in Fig. 5. Global Positioning System (GPS) survey has been conducted over the study area during the collection of sample.

The data (GCPs) have been imported in the GIS environment (QGIS 2.6.1) and plotted to a shape file. Interpolation maps have been generated for all four parameters individually from the shape file using interpolation method of Inverse Distance Weighted (IDW).

**Inverse distance interpolation:**

Inverse Distance Weighted (IDW) interpolation explicitly makes the assumption those things that are close to one another are more alike than those that are farther apart. To predict a value for any unmeasured location, IDW uses the measured values surrounding the prediction location. The measured values closest to the prediction location have more influence on the predicted value than those farther away. IDW assumes that each measured point has a local influence that diminishes with distance (Figure 5).

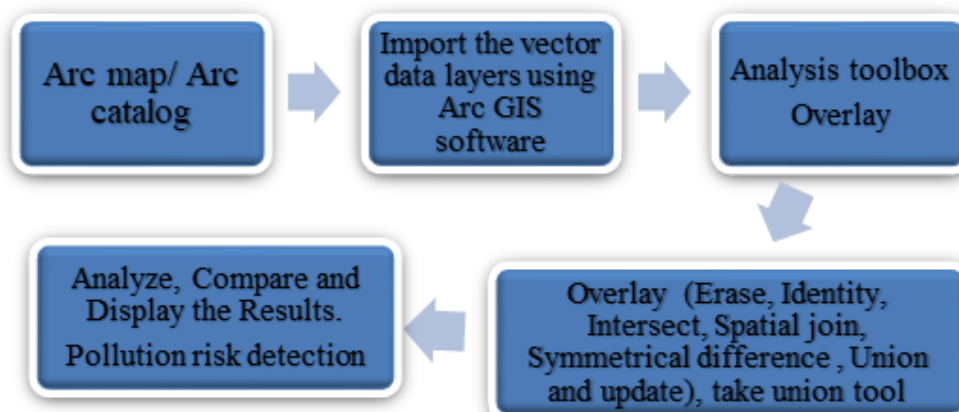


**Figure 5:** Inverse distance Interpolation technique flow diagram.

**Overlay analysis**

The map overlay operation is the building block for various analysis operations in GIS. A typical two map overlay involves unions and intersections of large no of polygons of each map. In many applications there is a need for overlying more than two maps. Feature overlay tools are located in the Analysis toolbox,

Overlay toolset (Fig. 6). Conceptually, the tools are similar-they differ by the feature types that allows to overlay multiple layers at one time, and by which input and overlay features are maintained in the output layer (Figure 6).

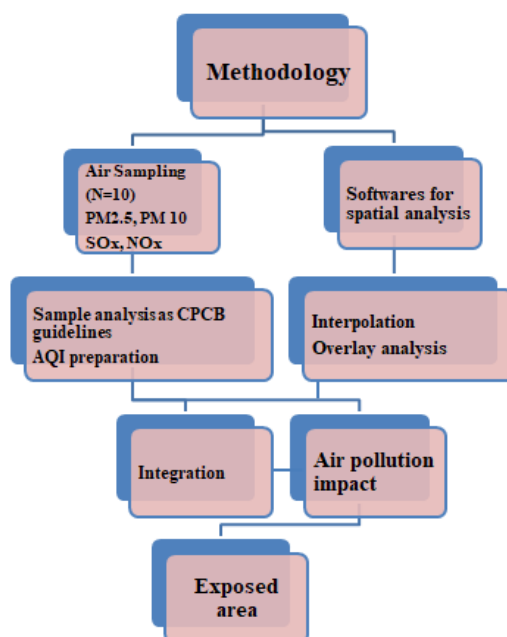


**Figure 6:** Overlay analysis method flow diagram.

**Air Quality Index (AQI)**

An AQI could be defined as a scheme that transforms the (weighted) values of individual air pollution related parameters into single number. Air quality index is also measured here for each place in each zone.

The flow of work is divided in two major input as wet lab work; sampling and analysis whereas dry lab work requires spatial analysis tools as interpolation and overlay tools (Figure 7).



**Figure 7:** Flow chart of Methodology.

**RESULTS AND DISCUSSION**

Results of ambient air quality status of different monitoring sites of study area encompassing industrial are represented in Tables 1 which is the

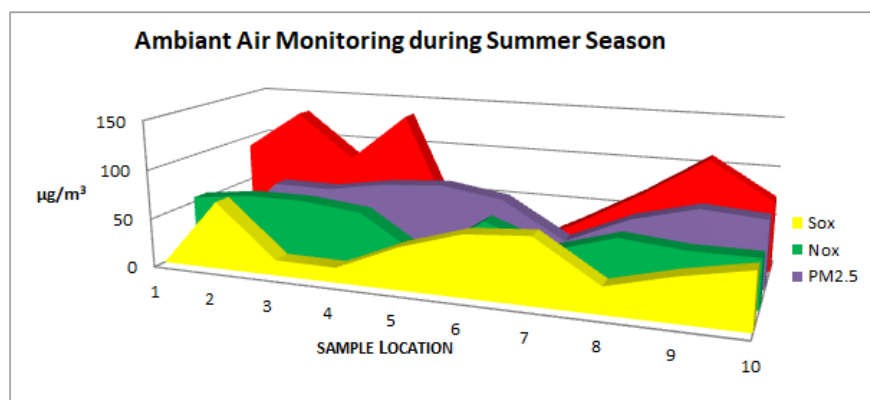
average summer season values of RSPM, SOx and NOx. Table 2 represents Air Quality Index standards and Table 3 represents national ambient air quality standards India (Graphs 1 and 2).

**Table1:** concentration of seasonal ambient air pollutant.

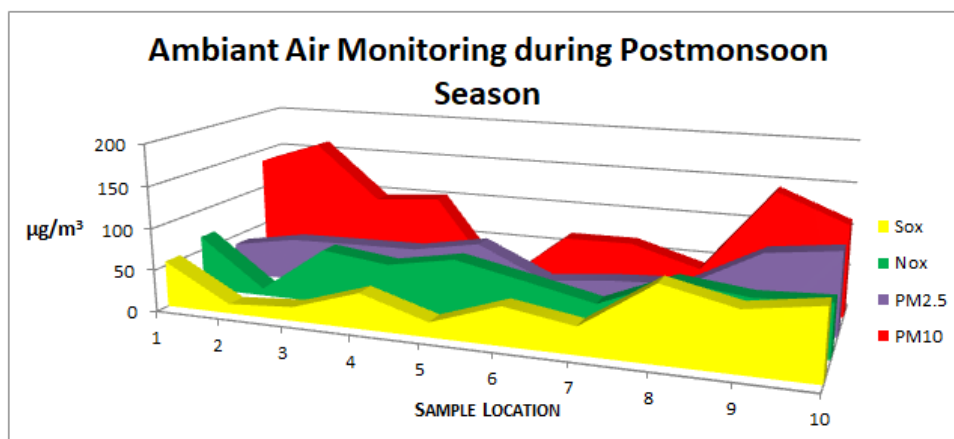
Location	Sox (ppm)		Nox (ppm)		PM2.5 (ppm)		PM10 (ppm)	
	Summer	Post-monsoon	Summer	Post-monsoon	Summer	Post-monsoon	Summer	Post-monsoon
1	69.2	55.1	54.8	67	0	38.74	89.1	135.6
2	15.8	11.3	62.1	8.9	61.8	52.2	130	162.3
3	15.33	16.9	62.1	65.2	61.5	53.9	83.8	95.7
4	42.5	42.5	55.3	55.3	71.5	55	134.2	102.3
5	61.8	17.6	15.8	69.5	75.8	69.2	0	0
6	66.4	45.5	58.9	52.5	66.2	32	0	65.5
7	26.8	32.3	36.2	34.6	29.5	40.1	33.5	66.2
8	43.5	88.36	55.3	69.4	57.9	44.8	69.5	42.5
9	56.2	69.9	49.5	59.7	74.2	89.5	110.5	143.5
10	66.8	82.6	49.5	63.4	69.5	99.4	72.6	110.5

**Table 2:** Ambient air quality index table.

Category	AQI of ambient air	Description of effect
I	Good (0-50)	Minimal Impact
II	Satisfactory (51-100)	Minor breathing discomfort to sensitive people
III	Moderate (101-200)	Breathing discomfort to the people with lung, heart disease, children and older adults
V	Poor (201-300)	Breathing discomfort to people on prolonged exposure
VI	Very Poor (301-400)	Respiratory illness to the people on prolonged exposure
VII	Severe (>401)	Respiratory effects even on healthy people



**Graph1:** Ambient air monitoring during summer season 2016.



**Graph 2:** Ambient air monitoring during post-monsoon season 2016.

**Table 3:** National Ambient Air Quality Standards.

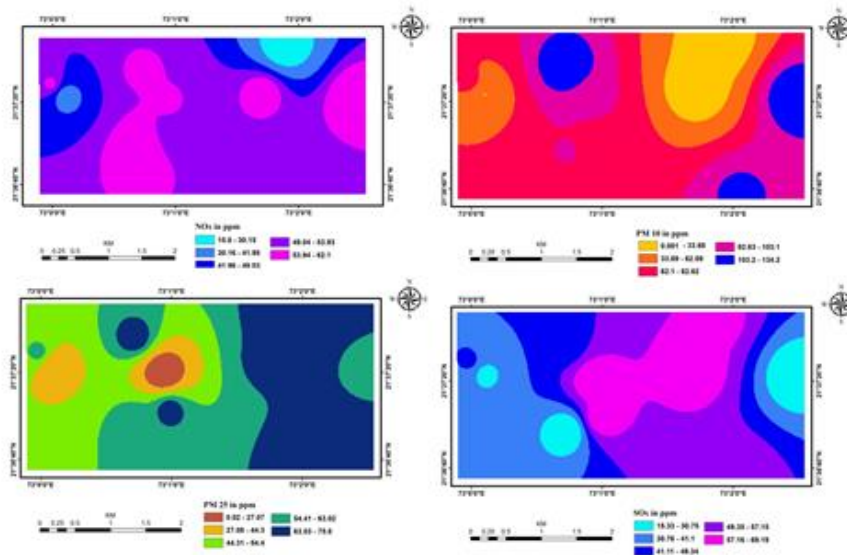
Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and Other Areas	Ecologically Sensitive Area (notified by Central Government)
Sulphur Dioxide (SO <sub>2</sub> ), µg/m <sup>3</sup>	Annual*	50-80	20-80
	24 hours**		
Nitrogen Dioxide (NO <sub>2</sub> ), µg/m <sup>3</sup>	Annual*	40-80	30-80
	24 hours**		

Particulate Matter (size less than 10 $\mu\text{m}$ ) or $\text{PM}_{10}$ $\mu\text{g}/\text{m}^3$	Annual*	60-100	60-100
Particulate Matter (size less than 2.5 $\mu\text{m}$ ) or $\text{PM}_{2.5}$ $\mu\text{g}/\text{m}^3$	Annual*24 hours**	40-60	40-60

**RSPM Scenario**

During summer season all the industrial sites had high level of RSPM than the standard prescribed by NAAQS. This might be due to re-suspension of road dust, soil dust, and vehicular traffic and nearby industrial emission [7]. In RSPM level exceeded its standard in every monitoring site except 1, 3, and 9 where the level of RSPM lied very near to the standard. Looking to entire GIDC area (Fig.8), North East and some of northern area having highest  $\text{PM}_{10}$  whereas central area of GIDC is affected with  $\text{PM}_{2.5}$  which may lead to

systematic upper respiratory diseases in reference to occupational health issue. But in post-monsoon phenomenon was more critical with  $\text{PM}_{10}$  compare to  $\text{PM}_{2.5}$ , in general it is found that most of the post-monsoon RSPM concentration was significantly higher than the summer concentration (Graph 1 and 2). This might be due to their locational disadvantages as because all these two areas are located in the region where majority dye, dye intermediate, pesticide intermediate factories of the GIDC situated (Figure 8).



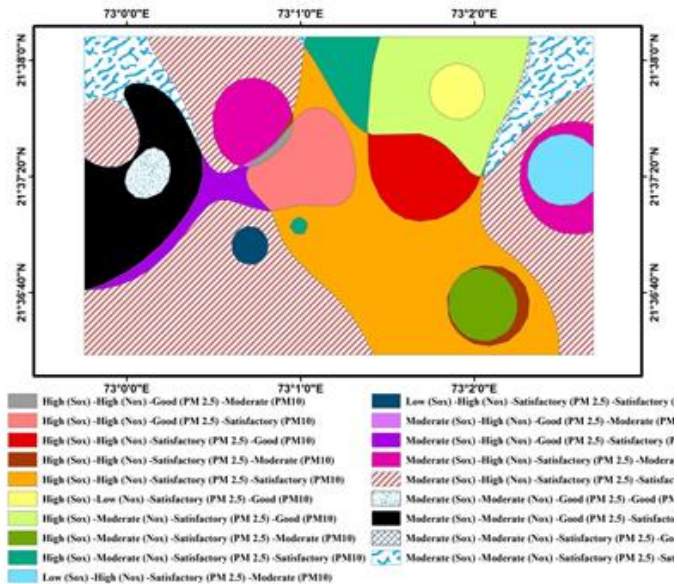
**Figure 8:** Interpolation diagram for  $\text{SO}_x$ ,  $\text{NO}_x$ , RSPM.

**$\text{SO}_x$  and  $\text{NO}_x$  scenario**

The concentration of  $\text{SO}_x$  was comparatively lower in both the seasons than the prescribed standard of NAAQS in all the monitoring sites. Similar kind of  $\text{NO}_x$  status is also highlighted, among industrial and sensitive sites maximum  $\text{SO}_x$  level was observed in industrial sites 9 during post monsoon season i.e.  $88.36 \mu\text{g}/\text{m}^3$  a during summer season  $43.5 \mu\text{g}/\text{m}^3$  (Graph 1 and 2) This might possibly be due to emission from industrial boiler, process stacks and vehicle sources. At glance of whole GIDC area with

interpolation tool  $\text{SO}_x$  is more concentrated in central area whereas  $\text{NO}_x$  is highly dispersed in entire GIDC (Figure 8), cumulative impact of both concentration may leads to endemic upper respiratory diseases in entire part.

To identify areas of high concentration of air pollutants with geospatial technology we have used overlay technique as an analysis tool in GIS software which helps to categorized the area into highly as well as less polluted (Figure 9).



**Figure 9:** overlay diagram of pollutants to study impact.

## CONCLUSION

Central portion of GIDC has cumulative effect of SO<sub>x</sub>, NO<sub>x</sub>, and RSPM which leads Moderate AQI impact with breathing discomfort to people with lung and heart diseases (NAAQS). Entire south west region having low impact (Fig. 9), AQI-category-II, as minor breathing problem which may be temporary but if for longer exposure leads to chronic effect. Middle-west portion of the GIDC is having minimal impact with all pollutants the reason behind its open

space where no industrial plot available and due to vegetation effect of all cumulative pollutants is minor. On the basis of AQI rating and using overlay analysis tool these seasonal images can be useful to interpretation of occupational health issues.

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