MAJOR PROJECT REPORT

ON

ANALYSIS OF GHAZIABAD AS CRITICALLY POLLUTED AREA USING CEPI

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE

OF

MASTER OF TECHNOLOGY

IN

ENVIRONMENTAL ENGINEERING

Submitted by

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2K17/ENE/09

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CANDIDATE'S DECLERATION

I, Medha Sharma, Roll No.2K17/ENE/009 of M.Tech (Department of Environmental Engineering), hereby declare that the project Dissertation titled "Analysis Of Ghaziabad As Critically Polluted Area Using CEPI " which is submitted by me to the Department of Environmental Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of degree of Master of Technology in Environmental Engineering, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of my Degree, Diploma Associate ship, Fellowship or other similar title or recognition.

Place: Delhi MEDHA SHARMA

Date:

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CERTIFICATE

I, hereby certify that the project Dissertation titled "Analysis of Ghaziabad as Critically Polluted Area Using CEPI" which is submitted by **Medha Sharma, Roll No. 2K17/ENE/09** (Department of Environmental Engineering), Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the Degree of Master of Technology, is a record of the project carried out by the Student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any degree or diploma to this University or elsewhere.

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ABSTRACT

Environmental pollution has been a challenging issue for the past few decades and it endangers the health of livings and it have been aggravated by industrialization across the country. Industrial developments could not be ignored as they are backbone of economics of a country.

The Study is typically based on the usage of data of monitored ambient air pollution, Surface water pollution and Groundwater pollution from various point locations in study area. The pollutant concentration is averaged over these selected locations by using GIS to know the spatial variations of pollutants over the study area and thus to estimate pollution exposure.

Environmental pollution index (EPI) is calculated by selecting 3 most critical pollutants depending on the concentration and exceedance for Air, Surface water and Groundwater. Thereafter, Comprehensive Environmental Pollution Index (CEPI) is calculated by selecting three parameters in air, water and Groundwater for 17 Air quality monitoring locations, 06 Surface water quality monitoring locations and 16 Groundwater quality monitoring locations in Ghaziabad. In industrialized urban areas, this approach may present critical issues due to the spatial complexities of air pollutants which are emitted by different sources. This study focused on the Ghaziabad District of Uttar Pradesh, India, which is one of the most highly industrialized cities in India.

Studies have revealed several critical situations in this area, in terms of short-term health effects of air pollution. The objectives of this project report are to study the variability of pollutants in Air, Surface water and Groundwater in the Ghaziabad and to interpret the results in relation to the applicability of the data in assessing population exposure. Meteorological and pollution data is studied for year 2009, 2011, 2013 and 2018 and analyzed. Relative and absolute spatial concentration variations were investigated by means of Inverse distance weighting (IDW), which is a type of deterministic method for multivariate interpolation with a known scattered set of points. The assigned values to unknown points are calculated with a weighted average of the values available at the known points. Results show significant differences among stations. The highest correlation between stations was observed for $PM_{10,}$ CO and $PM_{2.5}$ concentrations for air, Total Phosphorus, Phenol and BOD for Surface water and Total Hardness, Mercury and TDS for Groundwater. Results suggest evaluating the population exposure to pollutants in study area by taking into account the possible zones of influence of different emission sources. Present research forms important baseline for further research in this area.

ACKNOWLEDGEMENT

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ABBREVIATIONS USED

AAQ: Ambient Air Quality

BIS: Bureau of Indian Standards

CEPI: Comprehensive Environmental Pollution Index

CETP: Common Effluent Treatment Plant

CHWTSDF: Common Hazardous Waste Transfer Storage Disposal Facility

CPCB: Central Pollution Control Board

EPI: Environmental Pollution Index

ETP: Effluent Treatment Plant

FETP: Final Effluent Treatment Plant

GWQ: Groundwater Quality

SI: Sub Index

SPCB: State Pollution Control Board

SNLF: Surrogate Number Level Factor

SWQ: Surface Water Quality

TDS: Total Dissolved Solids

TH: Total Hardness

TP: Total Phosphorus

CHAPTER-1

INTRODUCTION

Environmental pollution has been a challenging issue for the past few decades and it endangers the health of livings. The problem of pollution and its corresponding adverse ecological impacts have been aggravated by industrialization across the country and affecting the life of billions of people, other living creatures and damaging the natural resources locating nearby. Industrial developments could not be ignored as they are backbone of economics of a country. The micro, small and medium enterprises sector has emerged as a highly vibrant and dynamic sector of the Indian economy over the last five decades and most of them are concentrated in Industrial areas. Industrial areas specifically concentrated with large, medium and small scale industries with different category are in alarming condition and there is a need to restore the quality of the environment. There is an urgent need to identify critically polluted areas and their problematic dimensions. The Government shall take measure to the purpose of protecting and improvement in quality of the environment. Accordingly, measures have to be taken to make our process of industrial development and economic growth more sustainable. The quality of the environment is studied by monitoring the environmental components such as water, air and land and health of human and other living creatures. The monitoring data does not help the policy makers and other public to understand the quality of environment system. An aggregated measurement of environmental performance or sustainability, which is usually in the form of a comprehensive environmental pollution index (CEPI) has evolved as a focus in environmental system analysis. CEPI quantifies the environmental health of polluted industrial areas by synthesizing available information on environmental status using quantity data. CEPI shall also be valuable as a vehicle for providing environmental information in a clear and succinct manner.

Environmental quality assessment, in the form of index is a complex process which has limited study. As the present method of assessment of pollution studies does not give clear picture on the quality of environment to the public and policy makers, there is a need to form a common code/number/description. In view of this, an index with description was needed and an innovative concept of CEPI has been developed by Central Pollution Control Board, Government of India. The index value will be derived

based on the available sources of pollution, presence of the pollution, level of the pollution and number of exceedance of the pollution, impact on health of human, ecosystem and the preventive action taken in controlling the environmental pollution are playing important role in establishment of the quality index value. To evaluate the CEPI scores of polluted industrial areas, a project on 'Monitoring, sampling and analysis for ambient air quality, surface water quality and ground water quality in 100 polluted industrial areas' has been carried out in 2018. The outcome of the project studies is presented in this report.

1.1 Objective of the Studies

The main objectives of the project are:

1. To identify critically polluted industrial clusters/areas from pollution point of view.
2. To facilitate the definition of critically polluted industrial clusters/ areas based on the environmental parameter index.
3. To rank the studied industrial clusters based on CEPI score.
4. To study the spatial distribution of varies pollutants in air, surface water and groundwater environment

CHAPTER-2

LITERATURE REVIEW

2.1 Associated History of CEPI Development

Comprehensive Environmental Pollution Index (CEPI) is a rational number to characterize the environmental quality at a given location following the algorithm of source, pathway and receptor. The concept of CEPI was developed by IIT, Delhi and CPCB. The comprehensive Environmental Pollution index was calculated on basis of various factors and three rounds of monitoring have been undertaken by CPCB in 2009, 2011, 2013 on basis of which, CEPI assessment was done.

Table 2.1 CEPI scoring

Sr. No.	CEPI SCORE	STATUS
1	ABOVE 70	CRITICALLY POLLUTED AREA
2	BETWEEN 60 AND 70	SEVERLY POLLUTED AREA
3	BELOW 60	OTHER AREA

Source : cpcb.nic.in

Initially, Central Pollution Control Board (CPCB) in collaboration with Indian Institute of Technology (IIT), Delhi had carried out comprehensive Environmental assessment of 88 prominent industrial clusters (In Uttar Pradesh, Gujarat, Orrisa, Maharashtra,West Bengal, Jharkhand, Himachal Pradesh, Chattisgarh, Karnataka, Rajasthan, Madhya Pradesh, Tamilnadu, Kerala, Assam, Punjab, Haryana. Delhi, Andra Pradesh) during 2009-10 based on comprehensive Environmental Pollution Index (CEPI) criteria. Total 88 prominent industrial clusters were assessed which were identified by State Pollution Control Boards of respective states, out of which, 43 industrial clusters in 16 States having CEPI score of 70 and above were identified as Critically Polluted Industrial

Clusters. Further, 32 industrial clusters with CEPI scores between 60 & 70 are categorized as severely polluted areas.

2.2 Initial Concept of CEPI

Four elements viz., A,B,C and D are evaluated to calculate Sub index for Ambient air quality, Surface water quality as well as Groundwater quality.

Finally, CEPI is calculated as:

$$CEPI = i_m + \{(100-i_m)\times(i_2/100)\times(i_3/100)\}$$

Where,

i_m: maximum sub index; and

i_2 and i_3 are sub indices for other media

$i_i = A+B+C+D$

i_1, i_2, i_3= EPI for Air quality, for surface water quality, for land quality respectively

OLD CRITERIA FOR CEPI EVALUATION

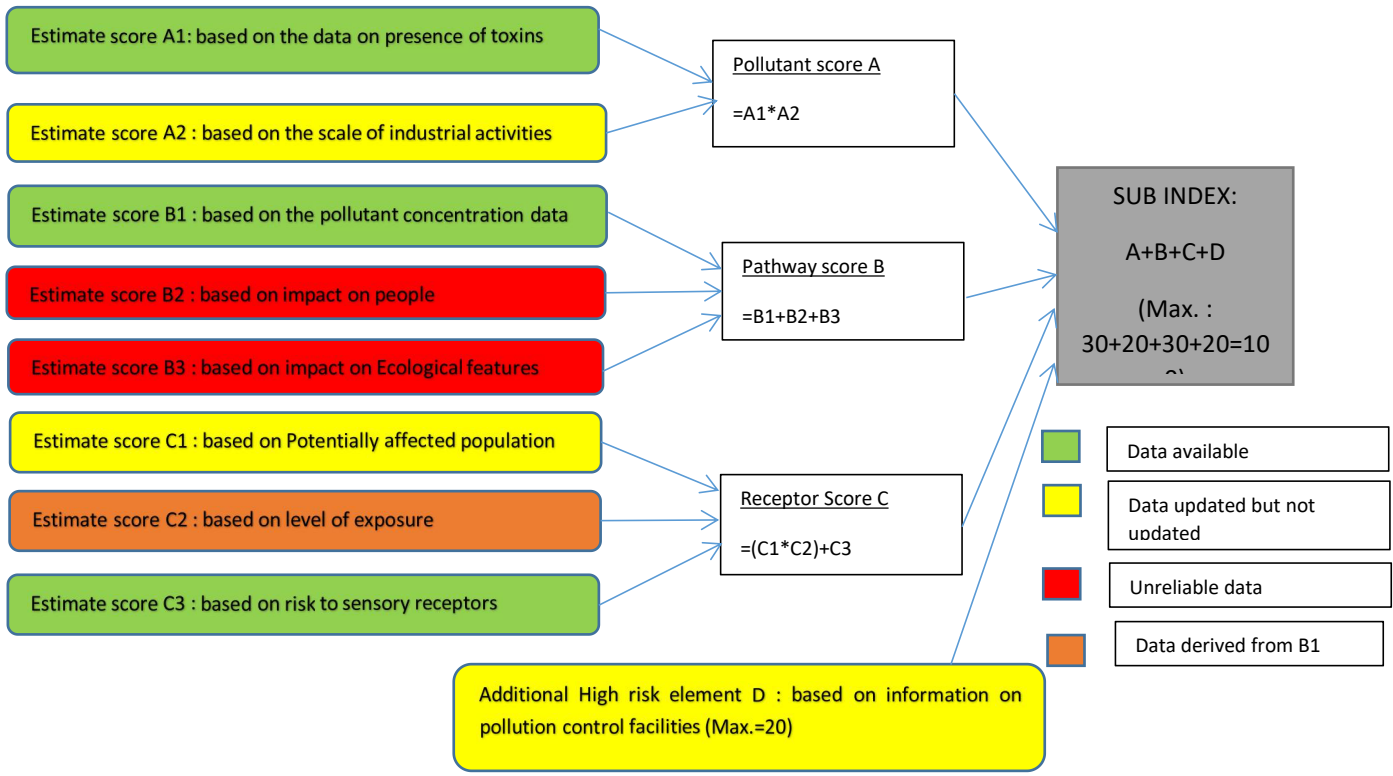


Figure 2.1 Flowchart describing older version of CEPI

There are many factors involved in CEPI which are difficult to measure objectively like potentially affected population and assessment of health impacts etc. Hence, proposals Environmental pollution index (EPI) is a rational number to characterize the Environmental quality of Air/ Surface water/ Groundwater of an area. Proposals were received from various Stakeholders for revisiting the concept of CEPI concept. The methodology till 2015 on evaluation of CEPI score has been a matter of discussion at various occasions including during the national level conferences as well as regular meetings with SPCBs and following issues were realized:

• Factors B2, B3, C1 and C3 of the existing CEPI concept require reliable health impact studies on humans, flora and fauna.

• These health studies require huge funds and time consuming as well as complex due to difficulty in finding truly representative data.

• Existing criteria of assigning values based on news reports, magazines, journals, NGO studies, published literature etc. is many times debated by various stakeholders.

• Existing criteria also lacks clarity with respect to potentially affected population.

2.3 Revised Concept of CEPI

In 2016, CEPI evaluation process was revised and accordingly, attempts were made to develop the 'Revised criteria of CEPI based on the following principles:

- Retaining the existing algorithm based on source, Pathway and receptor.
- Develop the revised CEPI considering the source of pollution, real time observed values of pollutant in ambient air.
- In revised concept the subjective debatable factors were eliminated and factors which can be measured precisely were retained.
- Component of Health was also retained in revised concept but with less weightage.

REVISED CRITERIA FOR CEPI EVALUATION

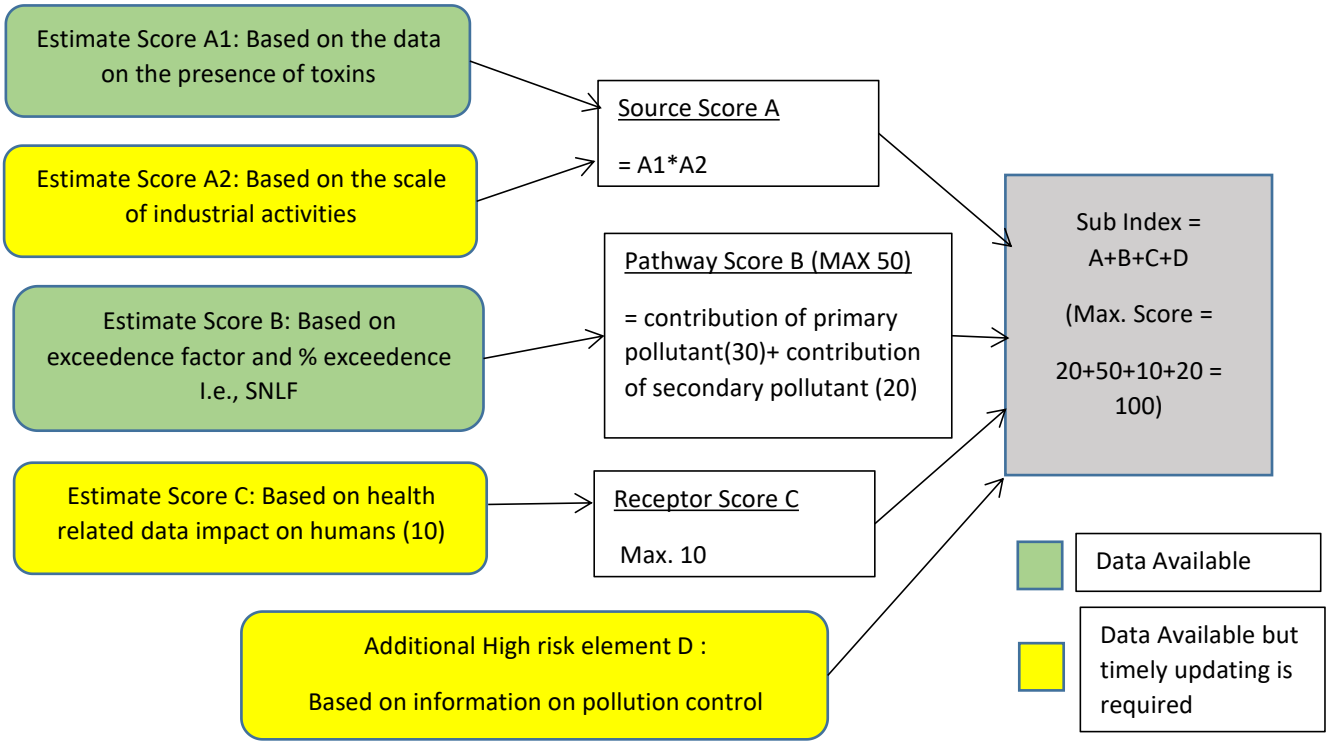


Figure 2.2 Flowchart describing Revised version of CEPI

2.4 Features of Revised CEPI Criteria

- It is proposed to develop the Comprehensive Environmental Pollution Index (CEPI) based on Sources of pollution, real time observed values of the pollutants in the ambient air, surface water and ground water in & around the industrial cluster and health related statistics.
- For assessment of the environmental quality of the area i.e. CEPI score, the concept of SNLF i.e. a surrogate number which represents the level of exposure (a function of percentage sample exceedence & Exceedence Factor) shall be used.
- Health component to be evaluated based on the health data available from major hospitals in the area was also retained in the revised concept.

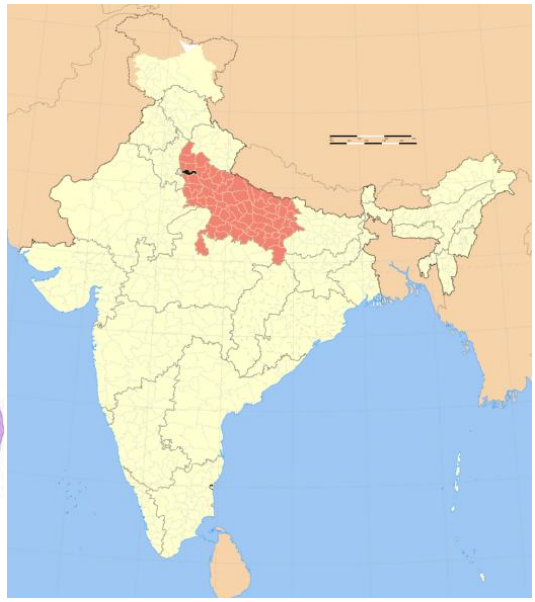
CHAPTER-3

STUDTY AREA AND METHODOLOGY

3.1 Study Area

Ghaziabad is a city in the Indian state of Uttar Pradesh with latitude of 28° 40' 4.2816" N and Longitude of 77° 26' 59.2476" E. Ghaziabad District is spread over an area of 133.3 KM^2 area and elevated at 219 m from mean sea level. Ghaziabad occupies important position in industrial map of U.P in India. The number of small-scale industries functioning in the district are 14,160. The number of medium/heavy industries functioning in the district are 145. These industries are discharging their effluents in water bodies. Currently there are total 21 surviving water bodies.

Source: Sericulturecouncil.com



Source: Creative Common

Figure 3.1 Study area

Table 3.1 Regions considered for sampling and monitoring in Ghaziabad

Cluster	Industrial Area
Sub-Cluster A	1.Mohan nagar/Mohan Meakin Industrial area
	2.Rajender nagar Industrial area
	3.Sahibabad Industrial area
	4.South side of Grand trunk road industrial area, sahibabad
	5.Sahibabad industrial area Site-4
Sub Cluster B	Pandav nagar Industrial area
	Kavi nagar industrial area
	Bulandshahar road industrial area
	Amrit nagar
	Arya nagar industrial area
Sub Cluster C	Meerut road industrial area
Sub Cluster D	Loni industrial area
	Loni road industrial area
	Roop nagar industrial area
Sub Cluster E	Hapur road industrial area
	Dasna
	Philkua
Sub Cluster F	South side of GT road
	Kavi nagar
	Tronica city
	Anand nagar
	Jindal nagar
	Prakash nagar
	Rural Industrial estate

3.1.1 Ambient Air Quality Monitoring Location

Table 3.2 Ambient Air Quality Monitoring Locations

Sr. No.	Name of monitoring location	Latitude	Longitude
A1	Shahi Export Pvt. Ltd 30/2, Loni road, Mohannagar	N: 28° 41' 1.3''	E:77° 22' 38.4''
A2	Krishna foods, Industrial area, main road, Loni	N: 28° 44' 37.8''	E: 77° 17' 53.5'
A3	Sambhav Automobiles, Arya nagar Industrial area, main road, Loni	N: 28° 44' 9.8''	E: 77° 15' 54.5''
A4	Mahadev Industries, Tronica city , Loni	N: 28° 47' 18.7''	E: 77° 17' 20.2''
A5	Mohan Meakin Limited, Mohan Nagar	N: 28° 40' 41.3''	E: 77° 22' 59.6''
A6	Times of India, Site IV, Sahibabad	N: 28° 39' 6.26''	E: 77° 19' 98.2''
A7	Siva Electronica Pvt Ltd, Rajendra nagar, Industrial area	N: 28° 40' 65.1''	E: 77° 22' 55.1''
A8	Raijade corrugating Industry, Prakash nagar industrial area, Ghaziabad	N: 28° 40' 51.6''	E: 77° 20' 61.4''
A9	Unichem Laboratories limited, Meerut road industrial area	N: 28° 41' 5.6''	E: 77° 26' 12.6''
A10	Eagle Continental, Hindon nagar, Dasna	N: 28° 41' 13.8''	E: 77° 26' 18.8''
A11	Jindal pipes Ltd., Jindal nagar	N: 28° 41' 68''	E: 77° 34' 81.5''
A12	Sathe Engineering Co. Pvt. Ltd., Kavi nagar Industrial area	N: 28° 39' 75''	E: 77° 27' 49.6''
A13	Astha medical center, Kavi nagar	N: 28° 39' 85.2''	E: 77° 27' 16.5''
A14	Sigma Enterprises, Pandav Nagar, Industrial area	N: 28° 39' 52.9''	E: 77° 27' 17.7
A15	Amko exports, Bulandshahar Road, Industrial area	N: 28° 39' 55.8''	E: 77° 27' 96.1''

A16	Rathi super steel Ltd., South side G.T. road	N: 28° 38’ 45.7’’	E: 77° 26’ 38’’

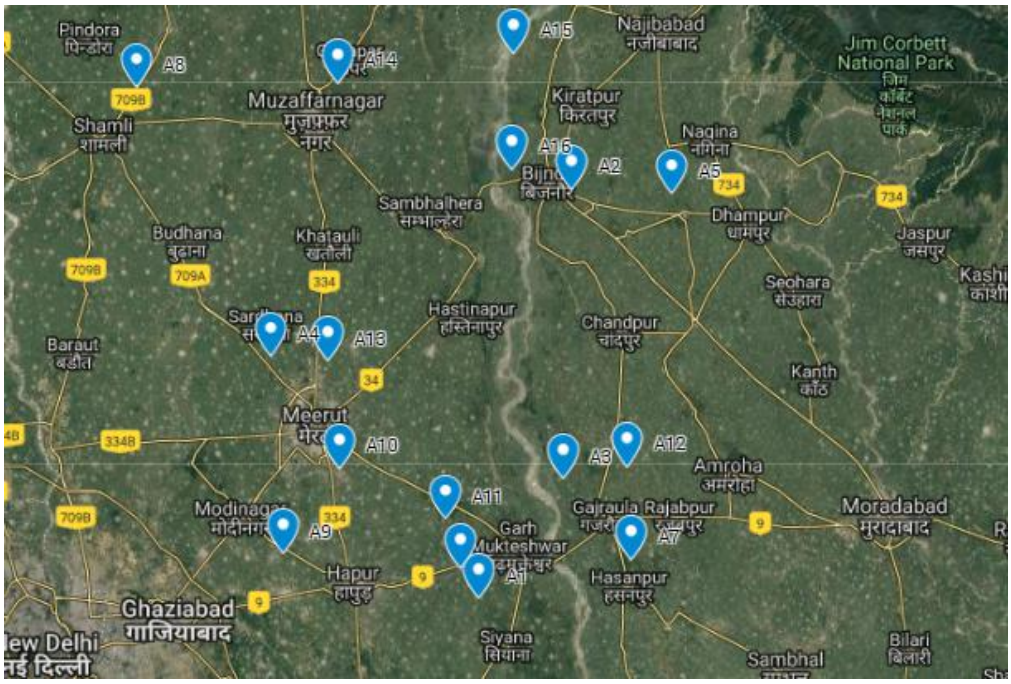


Figure 3.2 Satellite view of Air quality monitoring locations

3.1.2 Surface Water Quality Monitoring Locations

Table 3.3 Surface water Sampling Locations

Sr. No.	Name of monitoring location	Latitude	Longitude
SW1	Hindon river, Downstream, Near NH-24 Bridge	N: 28° 38’ 14.4’’	E:77° 24’ 4.5’’
SW2	Hindon river, Downstream, Near Gaur city	N: 28° 36’ 22.6’’	E: 77° 25’ 45.9’’
SW3	Hindon river, Middle Strea, Near Railway bridge, Near Mohan nagar	N: 28° 40’ 3.4’’	E: 77° 24’ 37.6’’
SW4	Hindon river, Upstream, Near bridge at karhera village	N: 28° 41’ 13.3’’	E: 77° 23’ 54.9’’
SW5	Gang nahar, Upstream, near Murad nagar regulator bridge	N: 28° 48’ 1.5’’	E: 77° 31’ 0.3’’
SW6	Gang nahar, Downstream, near Masoori bridge, at NH-24	N: 28° 41’ 43’’	E: 77° 33’ 44.2’’

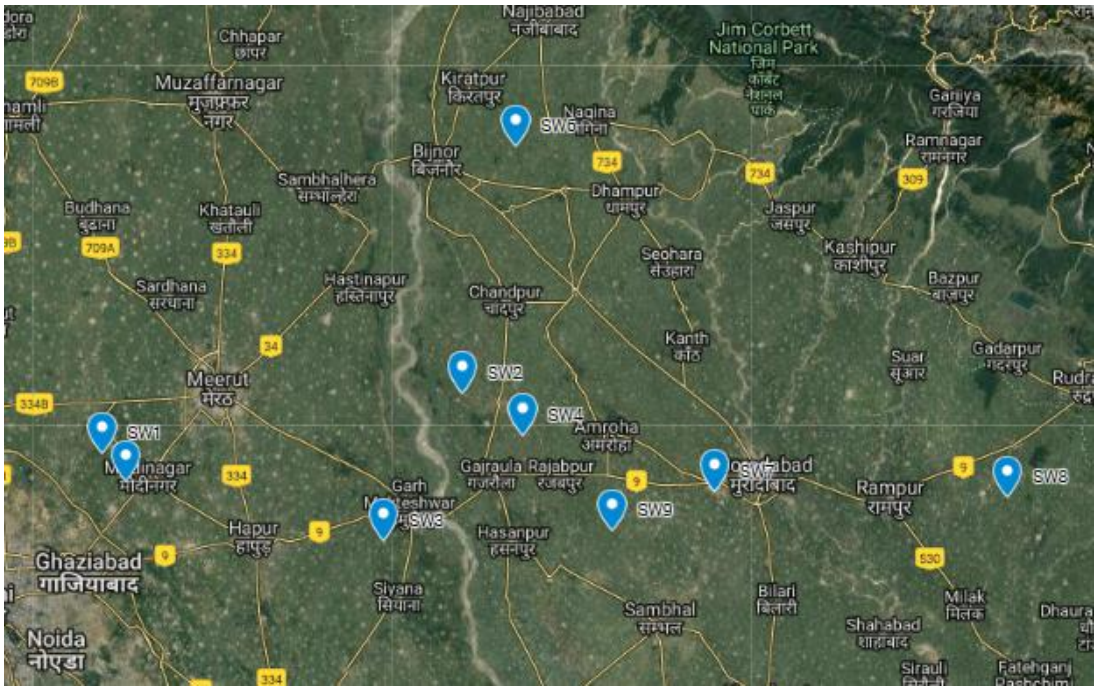


Figure3.3 Satellite view of Surface water quality monitoring locations

3.1.3 Groundwater Quality Monitoring Locations

Table 3.4 Groundwater Sampling Locations

Sr. No.	Name of monitoring location	Latitude	Longitude
GW1	Shahi Export Pvt. Ltd., Loni road, Mohan nagar	N: 28° 41’ 1.3’’	E:77° 22’ 38.4’’
GW2	Krishna foods, roop nagar industrial area, Loni	N: 28° 44’ 37.8’’	E: 77° 17’ 53.5’’
GW3	Sambhav Automobiles, Arya nagar industrial area, Loni	N: 28° 44’ 9.8’’	E: 77° 15’ 54.5’’
GW4	Mahadev Industries, tronica city, Loni	N: 28° 47’ 18.7’’	E: 77° 17’ 20.2’’
GW5	Mohan Meakin Ltd, Mohan Nagar	N: 28° 40’ 41.3’’	E: 77° 22’ 59.6’’
GW6	Times of India, Site IV, Sahibabad	N: 28° 39’ 6.26’’	E: 77° 20’ 38.2’’
GW7	Siva Electronica Pvt. Ltd., Rajendra nagar Industrial area	N: 28° 41’ 5.1’’	E: 77° 22’ 55.1’’
GW8	National Engineering works,	N: 28° 40’ 51.6’’	E: 77° 21’ 1.4’’

	Prakash nagar Industrial area		
GW9	Unichem Laboratories Ltd, Meerut road Industrial area	N: 28° 41’ 5.6’’	E: 77° 26’ 12.6’’
GW10	Albert David Ltd., Meerut Road Industrial area	N: 28° 41’ 13.8’’	E: 77° 26’ 18.8’’
GW11	Eagle continental, Hindon nagar, dasna	N: 28° 41’ 32.1’’	E: 77° 31’ 36.3’’
GW12	Jindal Pipes Ltd, Jindal nagar	N: 28° 42’ 8’’	E: 77° 35’ 31.5’’
GW13	Sathe Engineering Co. Pvt. Ltd., Kavi nagar industrial area	N: 28° 40’ 15’’	E: 77° 27’ 49.6’’
GW14	Astha medical center, Kavi nagar	N: 28° 40’ 25.2’’	E: 77° 27’ 16.5’’
GW15	Sigma Enterprises, Pandav nagar Industrial area	N: 28° 39’ 52.9’’	E: 77° 28’ 17.7’’
GW16	Amko exports, Bulandshahr Road industrial area	N: 28° 39’ 55.8’’	E: 77° 28’ 36.1’’
GW17	Rathi super steel Ltd., South side, G. T. road	N: 28° 38’ 45.7’’	E: 77° 26’ 38’’

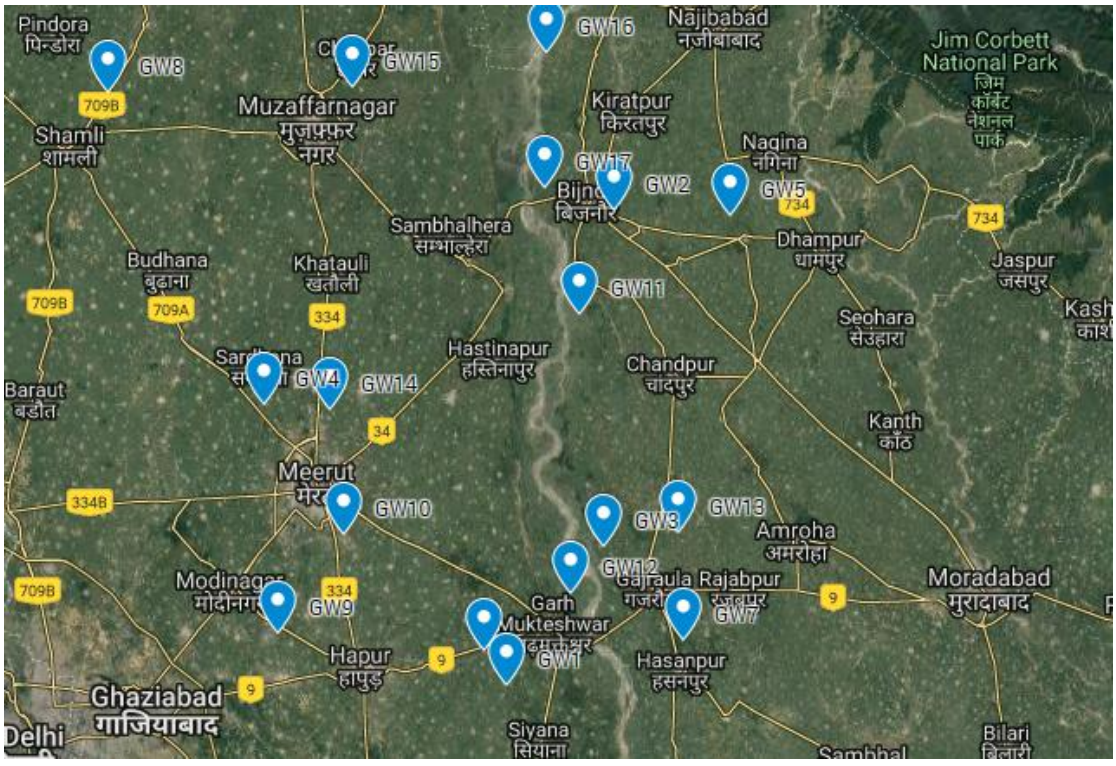


Figure 3.4 Satellite view of Groundwater quality monitoring location

Revised CEPI will comprise of following components:

Table 3.5 Scoring Scheme for CEPI

Component	Weightage
Scale of industrial activity	20
Scale of exceedance of Environmental Quality (Level of exposure)	50
Health related statistics	10
Compliance status of industries	20
TOTAL CEPI SCORE	**100**

Source : cpcb.nic.in

Salient features of revised CEPI criteria:

• Environmental Pollution Index (EPI) is a rational number to characterize the environmental quality of ambient Air/Surface Water /Ground Water of an Area.

• Air EPI, Surface Water EPI and Ground Water EPI will be calculated separately on a scale of 0-100.

• Overall CEPI will be evaluated using the existing formula, i.e., CEPI = i-max + [(100 – i-max) × (i2/100) × (i3/100)] Where, i-max – maximum index (which may be either Air EPI or SW EPI or GW EPI); and i2, and i3 are indices for other media.

3.2 Revised CEPI Evaluation Methodology

3.2.1 A: Source

• Factor #A1 - Presence of Toxin

- Group A – Pollutants / chemicals that are not assessed as acute or systemic = 1
- Group B – Organics / Pollutants / chemicals that are probable carcinogens (USEPA Class 2 and 3) or substances with some systemic toxicity. e.g. VOC's, PAHs, PCBs, air pollutants such as PM10 and PM2.5 = 2
- Group C - Known carcinogens or chemicals with significant systemic or organ system toxicity. E.g. vinyl chloride, benzene, lead, radionuclide, hexa-chromium, cadmium, organophosphate pesticides. = 3

Selection of criteria pollutants:

- Option 1: 3 pollutants relevant with the Area depending on the nature of industrial activity (preferable option /method)
- Option 2: up to 3 most critical pollutants depending on the concentration and exceedance

• Contribution of remaining two secondary pollutants will be based on the nature of the toxins as mentioned below:

Table 3.6 Classification on basis of toxicity

Group of toxicity of each of the Secondary Pollutants	Contribution Value for each of the pollutant
Group A	0.25
Group B	0.50
Group C	1.00

Source : cpcb.nic.in

Max. Contribution of secondary pollutants=2.00

Max. Score of A1=3+2 = 5

• **Factor #A2 – Scale of industrial activities**

– Large = 4 (if there are > 10 R17 per 10 sq km area or fraction OR > 2 R17 + 10 R54 per 10 sq km area or fraction OR > 100 R54 per 10 sq km area or fraction

– Moderate = 2.5 (if there are 2 to 10 R17 per 10 sq km area or fraction OR 10-100 R54 per 10 sq km area or fraction

– Limited = 1 (else there is any industry within 10 sq km area or fraction)

SCORE A = A1 x A2 (max score = 5 x 4 = 20)

3.2.2 B: Pathway Factor

B- Level of exposure

A surrogate number which will represent Level of Exposure (SNLF) is calculated using % violation of ambient pollutant concentration, which is calculated as:

SNLF = (No. of samples exceeded/ total no. of samples) x (Exceedance factor)

Table 3.7: Category classification on SNLF basis

Range of SNLF	Category	Value
(For EF > 0.75)	Low	0
7.5 < 0.50	Moderate	15
0.5 to < 1.0	High	22.5
1.0 and above	Critical	30

Source : cpcb.nic.in

Max. Contribution of primary pollutant=30

Table 3.8 Category classification on SNLF basis for secondary pollutants

Level of SNLF of each of the Secondary Pollutants	Contribution Value for each of the secondary pollutants
Low	2.5
Moderate	5.0
High	7.5
Critical	10.0

Source : cpcb.nic.in

Max. Contribution of secondary pollutants=20

Maximum value of B = 30 + 20 =50

3.2.3 C: Receptor Component

Table 3.9 Health impact score

C (Impact on Human Health) = 10	
Increase in cases	Marks
<5%	0
5-10%	5
>10%	10

Source : cpcb.nic.in

Percent increase is evaluated based on the total no. of cases recorded during two consecutive years. For Air Environment, total no. of case related to Asthma, Bronchitis, Cancer, Acute respiratory infections etc. are to be considered. For surface water / ground water Environment, cases related to Gastroenteritis, Diarrhea, renal (kidney) malfunction, cancer etc. are to be considered. For the above evaluation, the previous 5 years' records of 3-5 major hospitals of the area shall be considered.

3.2.4 D: Additional High Risk Element Factor

- Additional High Risk Element (Inadequacy of pollution control measures for large scale, medium and small scale industries and also due to unorganized sector). It is cumulative of ETPs, CETPs, Air Pollution Control Devises (APCDs) and unorganized waste disposal. Max. Score = 20 If all the industries in the area have adequately designed/ operated and maintained pollution control facilities and also common facilities such as CETP/ FETP/ CHWDF are having adequate capacity and are having state of art technology = 0.

- If all the large industries in the area have adequately designed/ operated and maintained pollution control facilities but small and medium industries are defaulting. Common facilities such as CETP/FETP/CHWDF are having adequate in capacity or operation/ maintenance = 5.

- If all the industries in the area have adequately designed/ operated and maintained pollution control facilities but the common facilities such as CETP/FETP/CHWDF are having inadequate in capacity or operation/ maintenance = 10.

- If all the large industries in the area have adequately designed/ operated and maintained pollution control facilities but small and medium industries are defaulting. Common facilities such as CETP/FETP/CHWDF are having inadequate in capacity or operation/ maintenance = 15.

- Inadequate Facilities of individual as well as common facilities, full penalty = 20.

Table 3.10 Score for Additional High Risk Element: Factor D

S. No	Large Scale Industries	Small/ Medium Scale Industries	Common Facilities for Pollution Control	Score
1	Adequate	Adequate	Adequate	0
2	Adequate	Inadequate	Adequate	5
3	Adequate	Adequate	Inadequate	10
4	Adequate	Inadequate	Inadequate	15
5	Inadequate	Inadequate	Inadequate	20

Source : cpcb.nic.in

Inadequate Facilities:

> 10% units deficient in terms of design/ operation and maintenance of pollution control in case of small and medium scale industries

OR,

> 2% unit's deficiency in terms of design/ operation and maintenance of pollution control in case of large scale industries or common facilities

The status report (last two years) shall be used for the purpose of deciding the score for adequacy. Evaluation of the Ambient Air Index / Surface Water Index / Ground Water Index After calculating A, B, C and D; calculate the sub index score (Air / Surface Water / Ground Water) as:

$$\text{Sub-Index Score} = (A + B + C + D)$$

Sub index scores are to be calculated for each of the individual environmental components that is,

Air Environment, Surface Water Environment and Soil & Ground Water Environment separately.

Calculation of the Aggregated CEPI

The aggregated CEPI Score can be calculated as.

$CEPI = i_m + \{(100 - i_m)*(i_2/100)*(i_3/100)\}$

Where, i_m: maximum sub index; and

i_2, and i_3 are sub-indices for other media.

To study the spatial variation of pollutant over the area, GIS is used.

Steps involved in creating the GIS images of spatial variation of pollutants over the study area are:

1. Creating the Base map of Study area (here, Ghaziabad) by Geo-referencing in GIS.

2. Adding base map in blank sheet.

3. Adding X-Y coordinates as respective latitudes and longitudes of the study area over its base map.

4. Exporting data of Ambient air pollutants, Surface water pollutants and groundwater pollutants one at a time over the base map.

5. Using Inverse Distance Weighing tool to calculate the assigned value to unknown points with a weighted average of the values available at the known points.

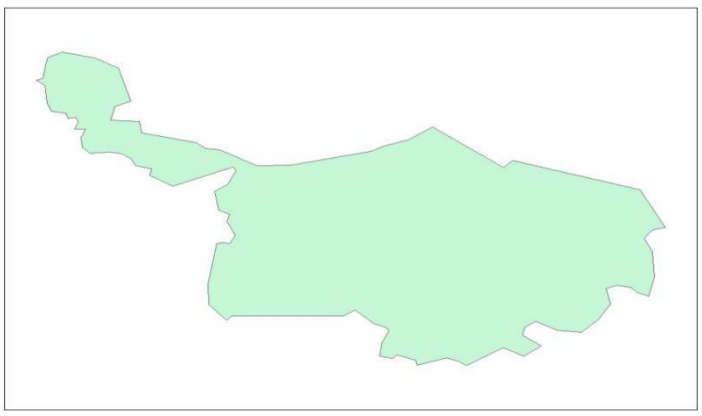


Figure 3.5 Basemap of Ghaziabad

CHAPTER-4

RESULTS AND DISCUSSION

4.1 Air quality analysis

Available data of air pollutants from sixteen monitoring locations is assessed, complied and analyzed over whole study area. Discrete data is used to create continuous variation of pollutants over basemap. IDW interpolation technique is used to map the spatial extent of pollutants to show the desired variation in simple and intuitive manner.

The result and discussion of air quality of Ghaziabad is based upon the monitored data for the year of 2018.

Spatial Variation of PM_{10} :

Location Code	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
PM_{10} (ug/m^3)	721	567	539	568	612	687	489	539	503	276	478	339	672	559	567	553

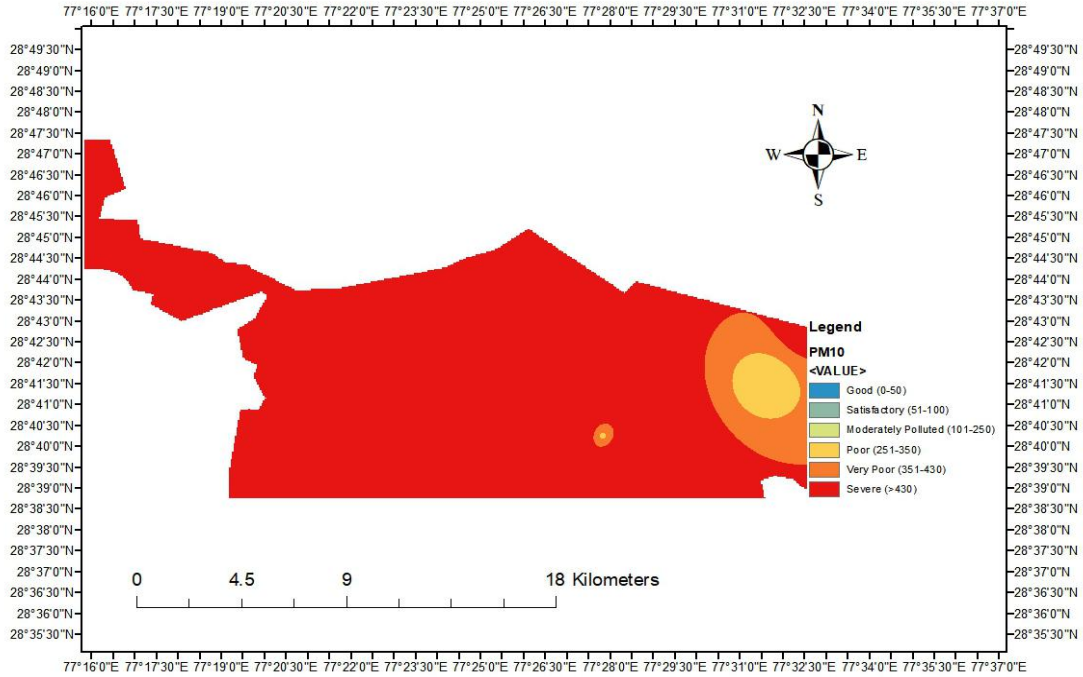


Figure 4.1 Spatial variation of PM_{10}

It can be seen that around 90% area of Ghaziabad district lies in severely polluted category in terms of PM_{10} and rest of the area is poor or very poor w.r.t air quality.

Prescribed standard by CPCB for PM_{10} is 100 µg/m^3 for 24 Hrs. Measured concentration of PM_{10} is exceeding the standard at all monitoring locations. Percent deviation of PM_{10} concentration against prescribed standard lies in range of 176% - 621%.

Spatial Variation of $PM_{2.5}$

Location Code	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
$PM_{2.5}$ (ug/m^3)	446	267	320	320	228	250	230	320	271	195	228	271	418	258	267	470

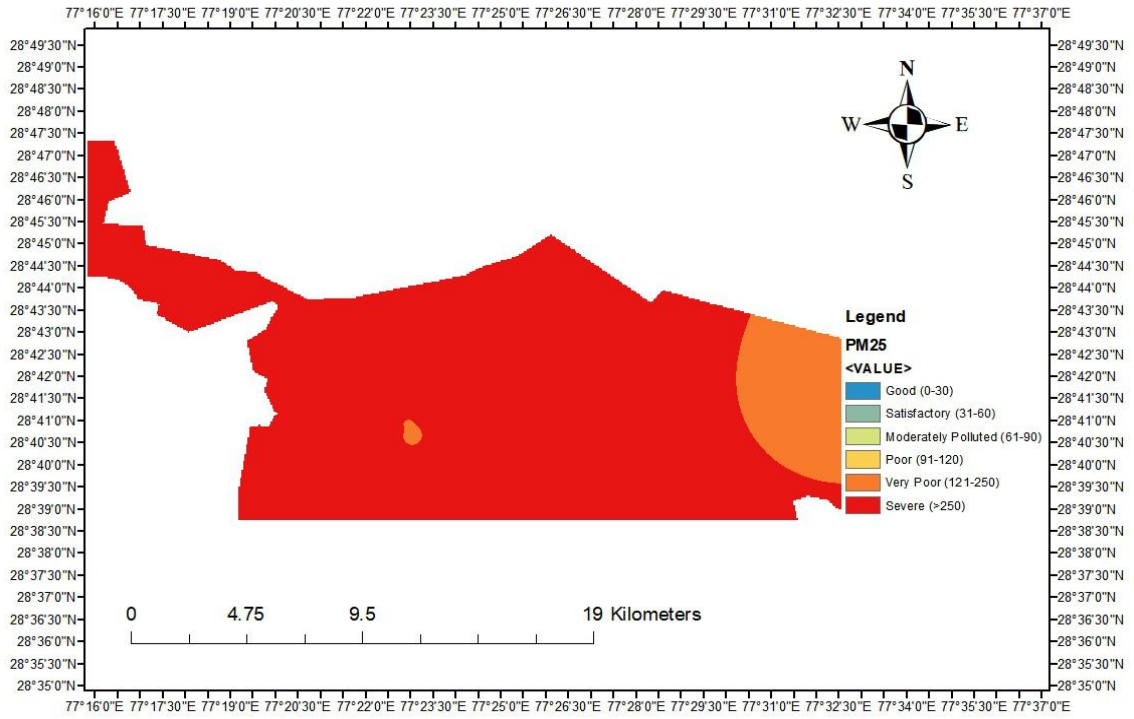


Figure 4.2 Spatial variation of $PM_{2.5}$

Most of the area of Ghaziabad district lies in severely polluted category in terms of $PM_{2.5}$ and rest of the area is very poor w.r.t air quality. Prescribed standard by CPCB for $PM_{2.5}$ is 60 µg/m^3 for 24 Hrs. Measured concentration of $PM_{2.5}$ is exceeding the standard at all monitoring locations. Percent deviation of $PM_{2.5}$ concentration against prescribed standard lies in range of 225% - 683%.

Spatial Variation of CO

Location Code	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
CO (mg/m³)	2.1	1.9	2.3	2.3	2.5	2.1	1.9	18	16	2.1	1.9	2.2	2.5	2.3	1.9	2.1

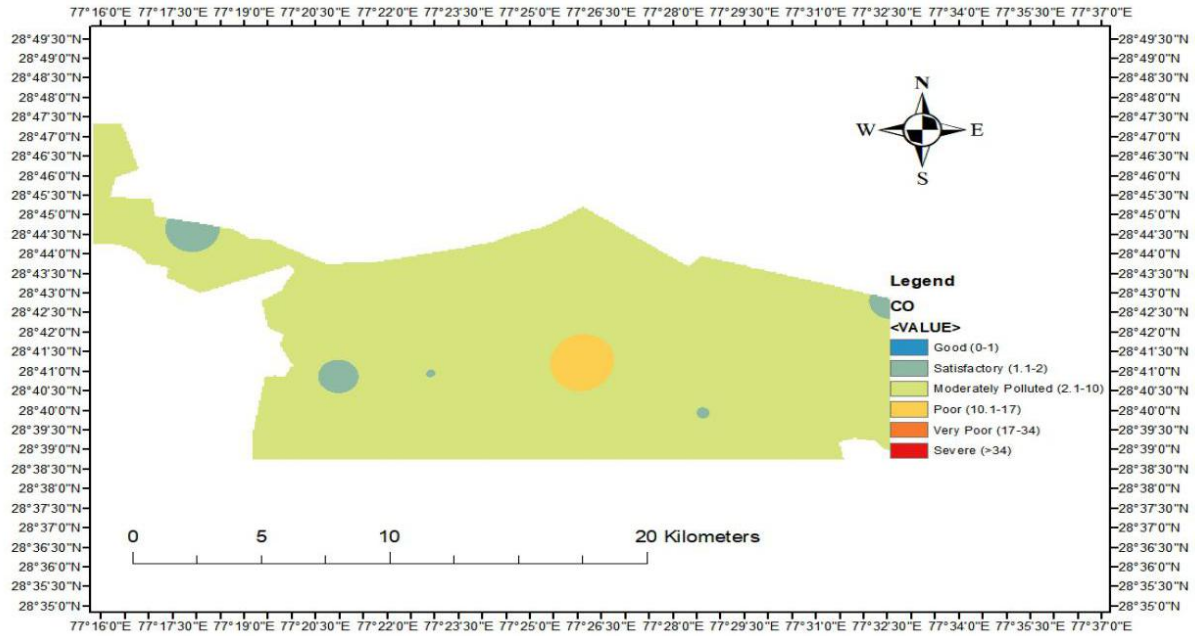


Figure 4.3 Spatial variation of Carbon Monoxide

Most of the area of Ghaziabad district lies in Moderately polluted category in terms of CO, a small patch of Satisfactory and Poor is also observed w.r.t CO. Prescribed standard by CPCB for CO is 2 mg/m^3 for 8 Hrs average value. CO concentration is exceeding the standard in four out of sixteen locations. Percent deviation of CO concentration against prescribed standard lies in range of 5% - 800%.

Spatial Variation of O_3

Location Code	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
O_3 (ug/m³)	18	11	17	28	1	11	11	17	12	24	18	18	12	10	11	20

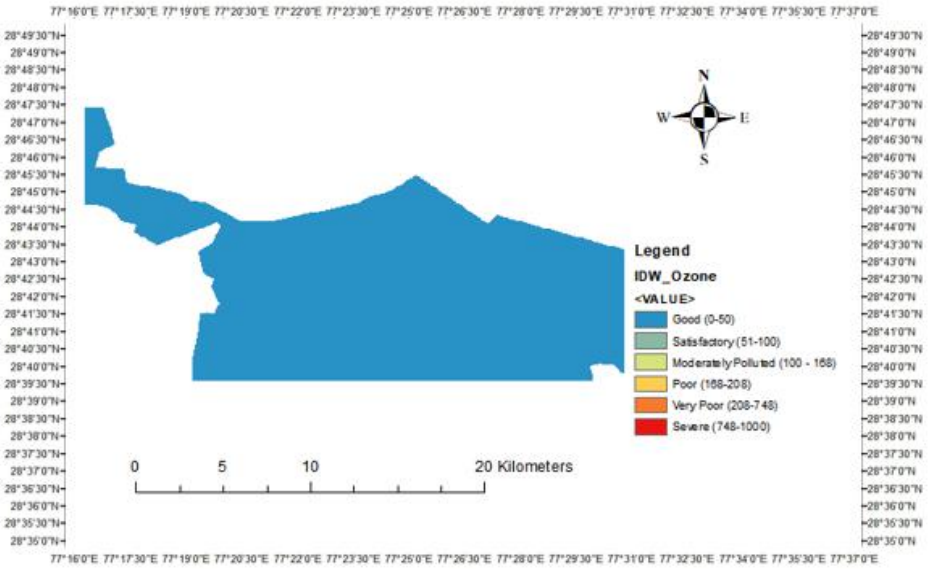


Figure 4.4 Spatial variation of ozone

At all monitoring location 8 hrs average value of ozone lies in range of whole area of Ghaziabad district lies in Good category in terms of O_3. Prescribed standard by CPCB for O_3 is 100 µg/m^3 for 8 Hrs average value.

Spatial Variation of SO_2

Location Code	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
SO2 (ug/m^3)	19	19	14	20	23	25	29	20	29	12	22	29	18	22	19	22

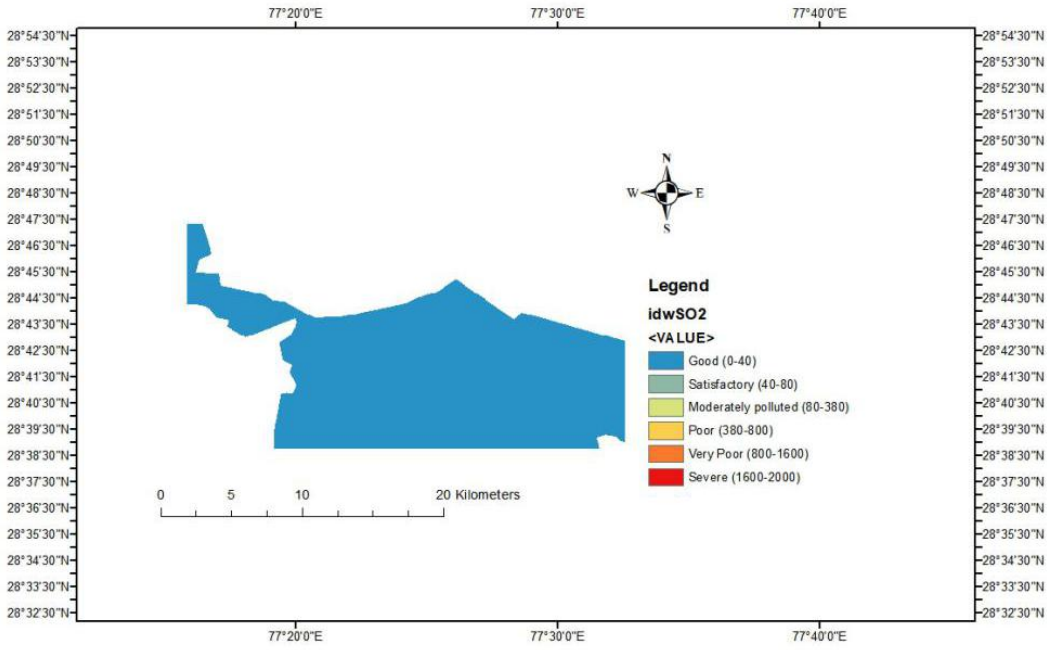


Figure 4.5 Spatial variation of Sulphur Dioxide

Whole area of Ghaziabad district lies in Good category in terms of SO_2. Prescribed standard by CPCB for SO_2 is 80 µg/m^3 for 24 Hrs.

Spatial Variation of NO_2

Location Code	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
NO2 (ug/m^3)	44	69	49	45	55	59	69	49	62	43	37	60	39	49	69	65

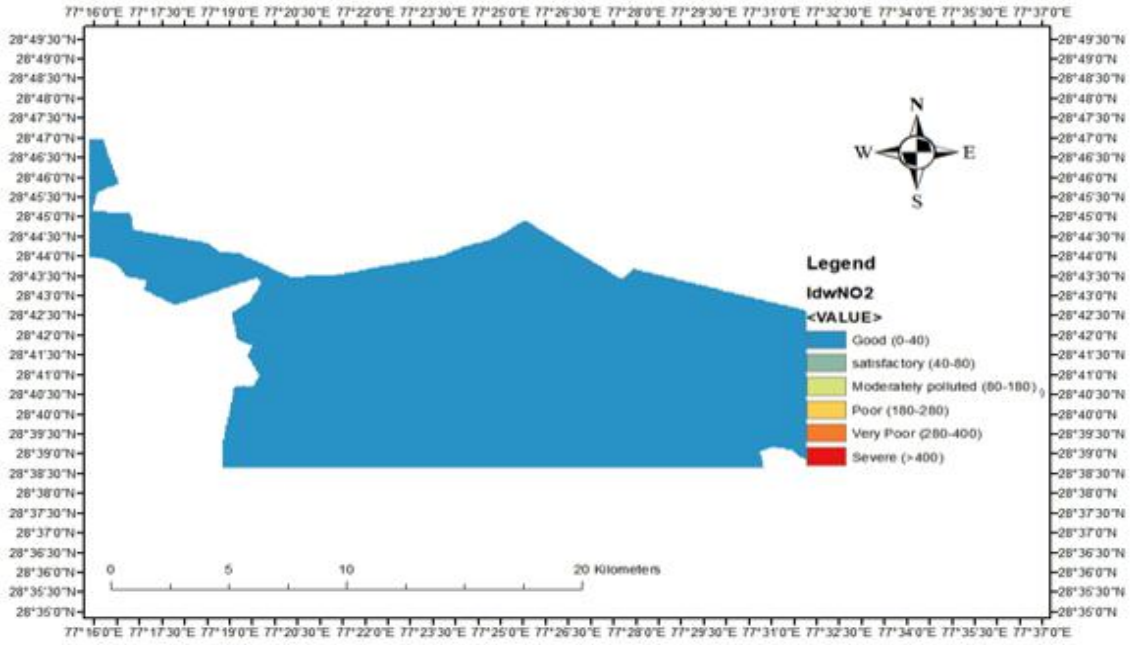


Figure 4.6 Spatial variation of NO_2

Entire area of Ghaziabad district lies in Good category w.r.t of NO_2. Prescribed standard by CPCB for NO_2 is 80 µg/m^3 for 24 Hrs average value.

4.2 Surface Water Quality Analysis

Spatial variation of pH

Location Code	SW1	SW2	SW3	SW4	SW5	SW6
pH	7.32	7.26	7.21	7.22	7.32	7.39

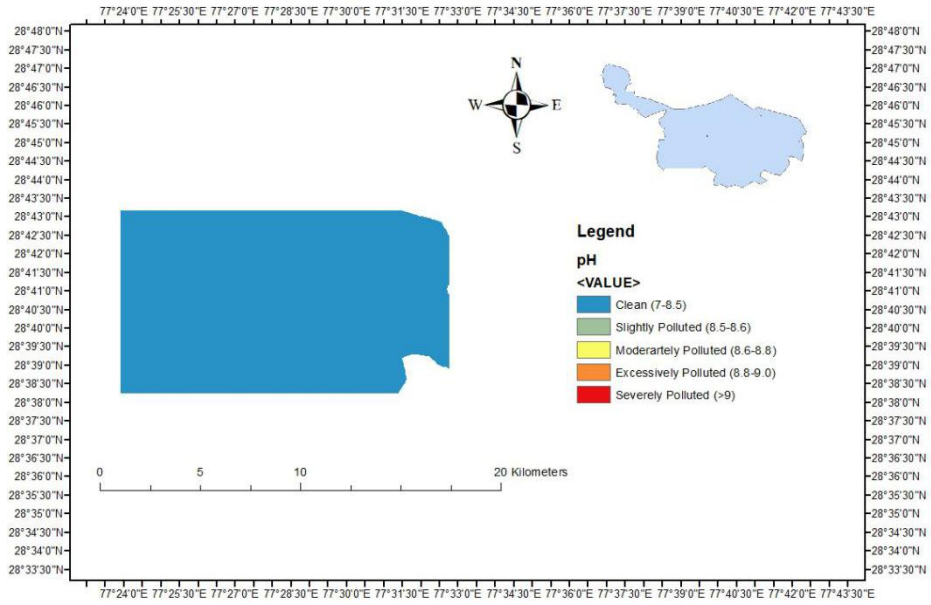


Figure 4.7 Spatial Concentration of pH

pH lies in group A i.e., Toxin not assessed as acute or systematic. Surface water quality standards for rivers, lakes and streams by BIS gives pH standard in range of 6.5-9. pH at monitoring locations lies within the range and surface water can be considered as good w.r.t pH.

Spatial variation of DO

Location Code	SW1	SW2	SW3	SW4	SW5	SW6
DO (mg/l)	2.1	0.9	2.5	0.7	5.4	6.4

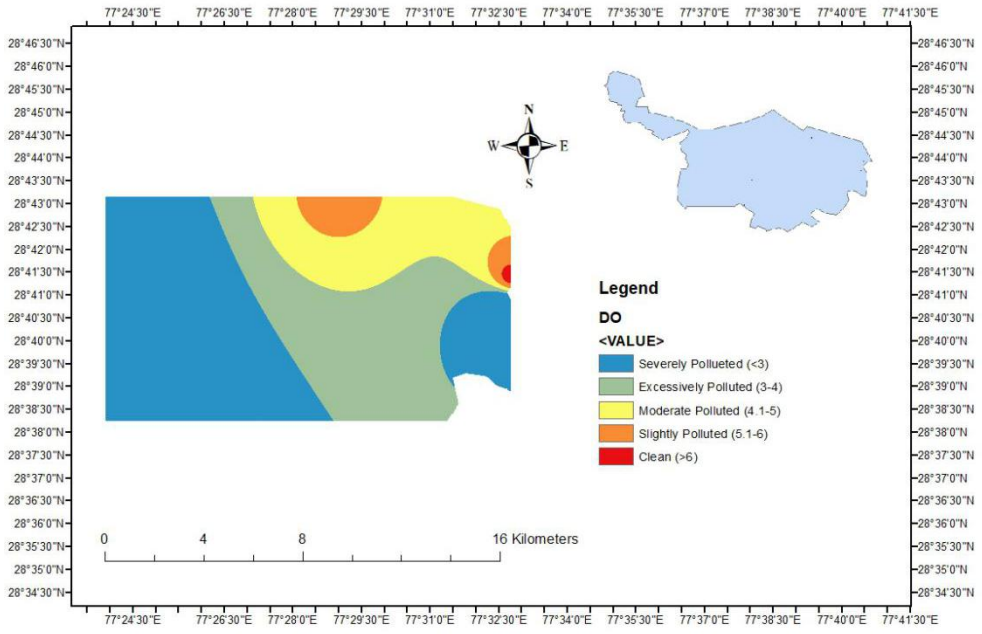


Figure 4.8 Spatial Variation of Dissolved Oxygen

Surface water quality standards for rivers, lakes and streams by CPCB gives DO standard as minimum 5mg/l. DO at monitoring locations shows percent deviation of 25% to 86%.

Spatial variation of BOD

Location Code	SW1	SW2	SW3	SW4	SW5	SW6	
BOD (mg/l)	30	80	22	70	5	8	

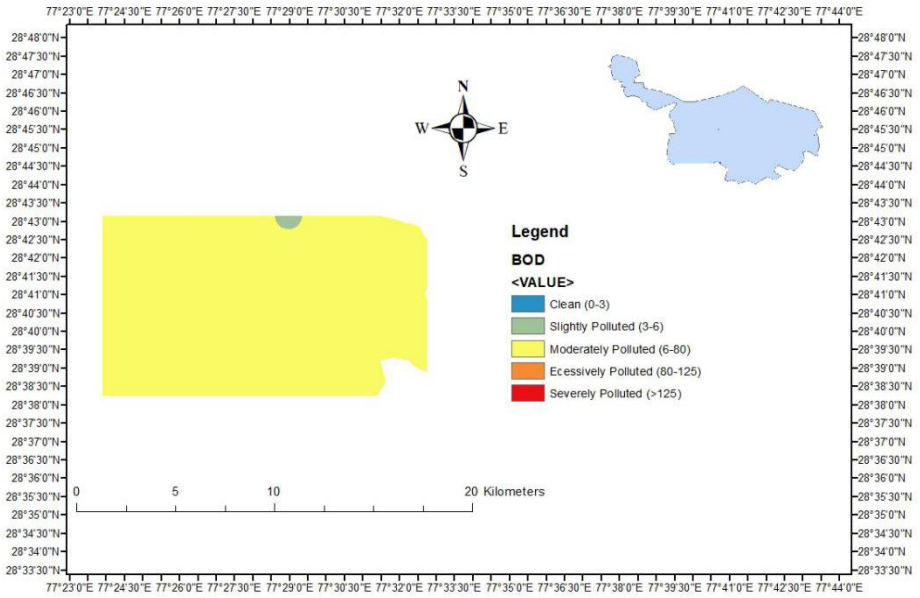


Figure 7.9 Spatial Variation of BOD

BOD lies in group B i.e., probable carcinogen or with some systematic toxicity. Surface water quality standards for rivers, lakes and streams by CPCB gives BOD standard as 8mg/l. Depending on the concentration and exceedance, BOD is considered as the primary pollutant for surface water monitoring.

Spatial variation of SAR

Location Code	SW1	SW2	SW3	SW4	SW5	SW6
SAR	14.6	4.4	0.86	0.49	0.08	0.15

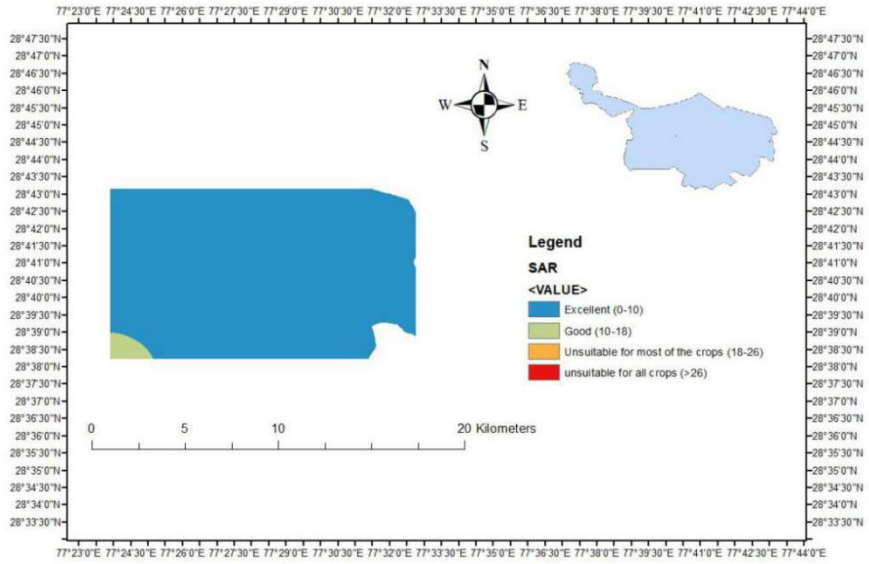


Figure 4.10 Spatial Variation of SAR

SAR or sodium absorption ratio is a water quality parameter. SAR is useful in management of sodium affected soils. By using SAR, suitability of water for agricultural purposes can be decided. At all monitoring locations SAR value is lying under excellent or good category thus and surface water can be considered safe w.r.t SAR and can be used for agricultural purposes.

Spatial variation of TP

Location Code	SW1	SW2	SW3	SW4	SW5	SW6
TP(mg/l)	8	8.2	2.4	10.2	2.4	2.8

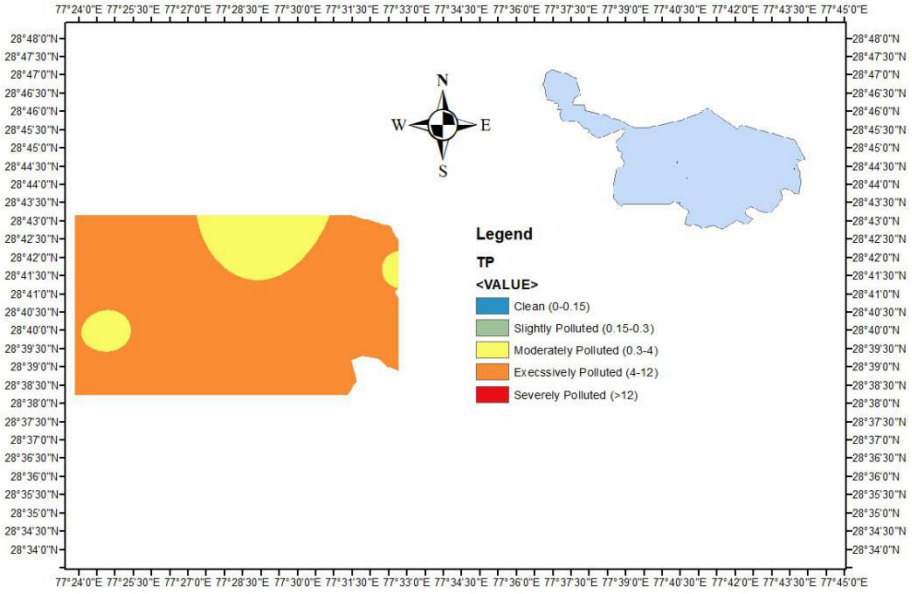


Figure 4.11 Spatial Variation of Total Phosphate

TP or Total phosphate lies in B category i.e., Probable carcinogen or with some systematic toxicity (List of parameters given by USEPA). Standard prescribed by CPCB for TP is 0.3 for surface water which is exceeding at all monitoring locations. Percent deviation ranges from 700% to 3300%. TP is considered as one of the critical parameter. TP is taken as secondary parameter

Spatial variation of Phenolic Compounds

Location Code	SW1	SW2	SW3	SW4	SW5	SW6
C_6H_5OH(mg/l)	14.6	4.4	0.86	0.49	0.08	0.15

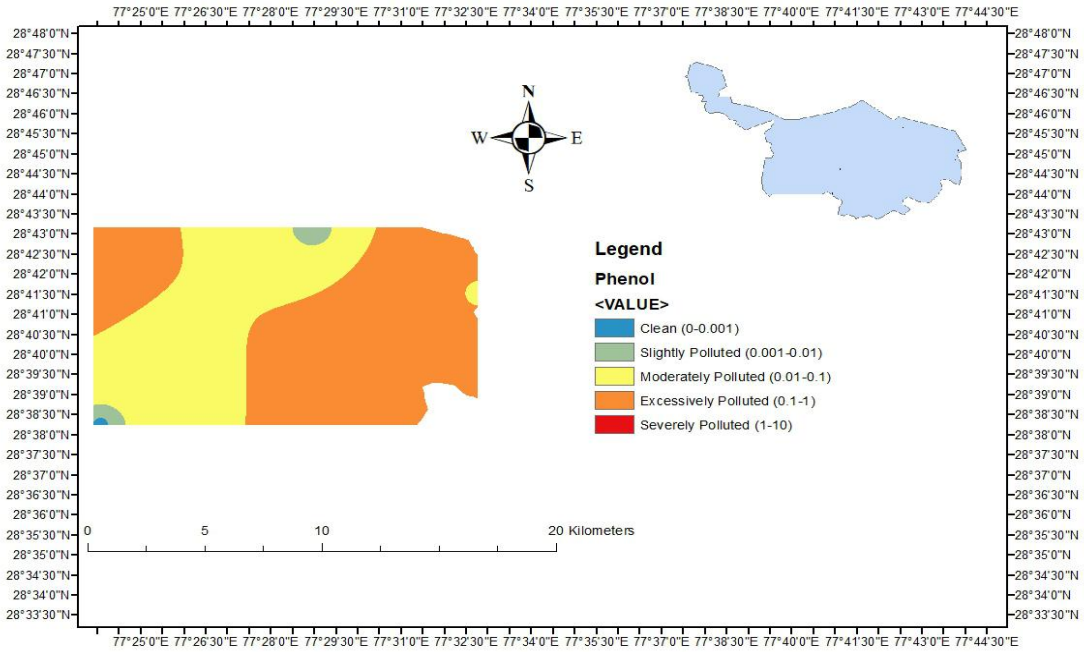


Figure 4.12 Spatial Variation of Phenolic compounds

Phenolic compounds lies in C category i.e., known carcinogen or chemicals with significant systematic or organ system toxicity (List of parameters given by USEPA). Standard prescribed by BIS for Phenolic compound is 0.01 for surface water which is exceeding at all monitoring locations. Percent deviation ranges from 700% to 3300%.

4.3 Groundwater quality analysis

Groundwater is an essential and vital component of any life support system. 27 samples of groundwater is collected for monitoring, sampling and analysis of various parameters from 16 locations. Some of the vital parameters studied and analyzed and are discussed in subsequent paragraphs.

Spatial Variation of pH

Location Code	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	GW10	GW11	GW12	GW13	GW14	GW15	GW16
pH	7.68	7.8	8.1	7.77	7.7	7.32	7.98	7.6	7.81	7.81	7.96	7.62	7.76	7.72	7.97	7.5

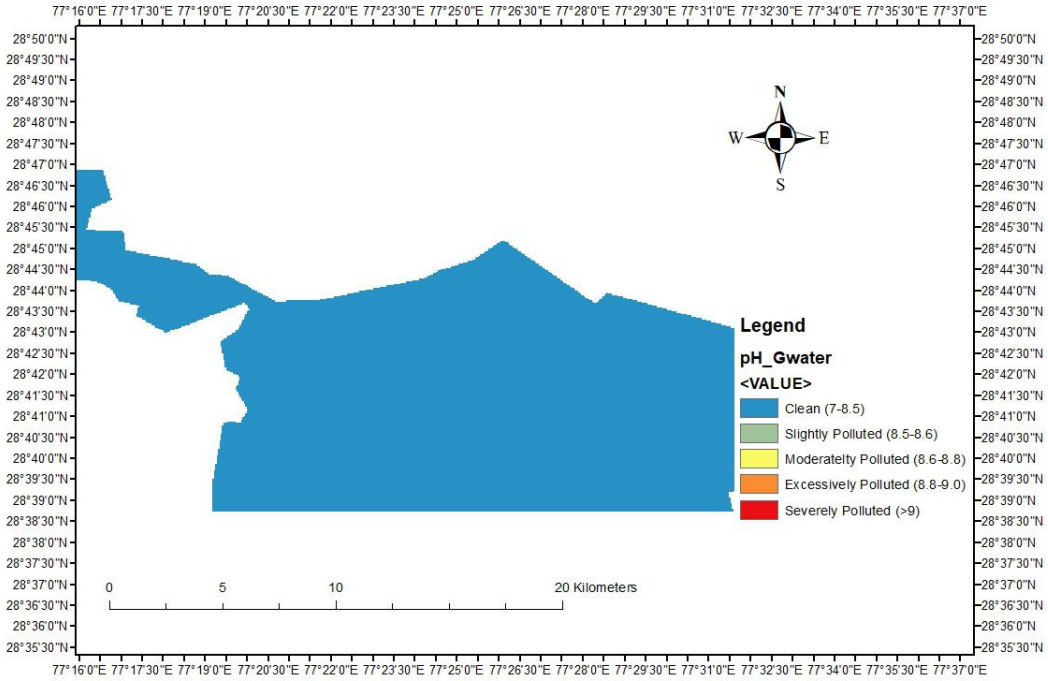


Figure 4.13 Spatial variation of pH in groundwater

Samples analyzed for pH shows that groundwater is under prescribed limits w.r.t pH and lying within the range of 7 - 8.5.

Spatial variation of SAR

Location code	GW1	GW2	GW4	GW5	GW6	GW7	GW10	GW11	GW14	GW15	GW16
SAR	17.39	3.42	4.62	6.84	5.21	9.36	1.42	1.01	1.01	1.16	3.62

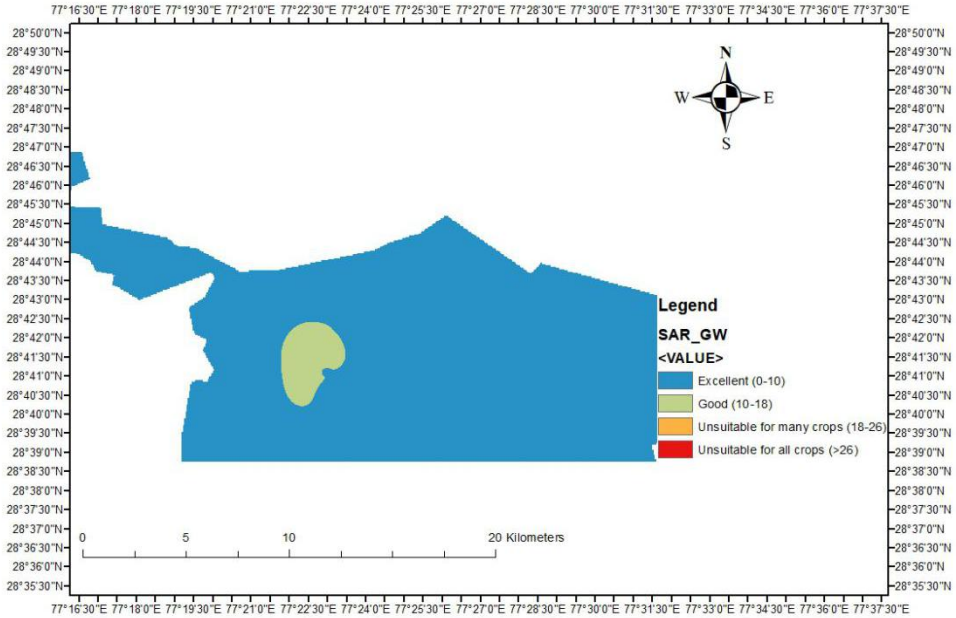


Figure 4.14 Spatial Variation of SAR in Groundwater

At all monitoring locations SAR value is lying under excellent or good category thus and Groundwater can be considered safe w.r.t SAR and can be used for agricultural purposes.

Spatial variation of TDS

Location code	GW1	GW2	GW4	GW5	GW6	GW7	GW10	GW11	GW14	GW15	GW16
TDS (mg/l)	2286	1678	894	512	2086	3016	352	342	622	708	1190

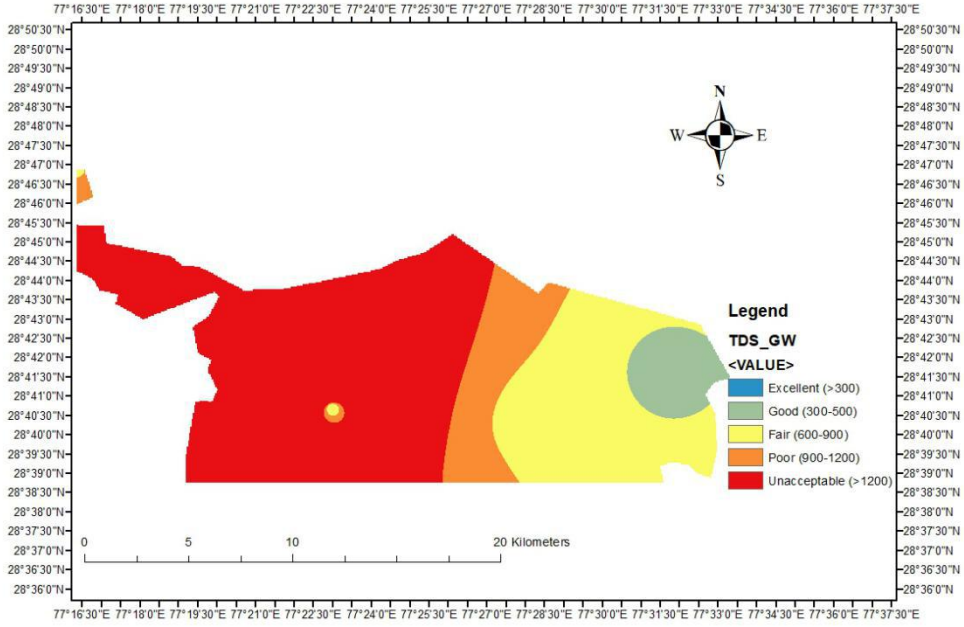


Figure 4.15 Spatial variation of TDS in Groundwater

TDS in water is the presence of inorganic and organic substances present. Anything other than pure H_2O molecules in water in dissolved form is considered as TDS.These are primarily minerals, salts, and organic matter that can be a general indicator of water quality. Unacceptable and Poor groundwater quality w.r.t TDS majorly observed.

Spatial Variation of Total Hardness

Location code	GW1	GW2	GW4	GW5	GW6	GW7	GW10	GW11	GW14	GW15	GW16
TH (mg/l)	440	724	482	320	860	758	184	330	340	366	522

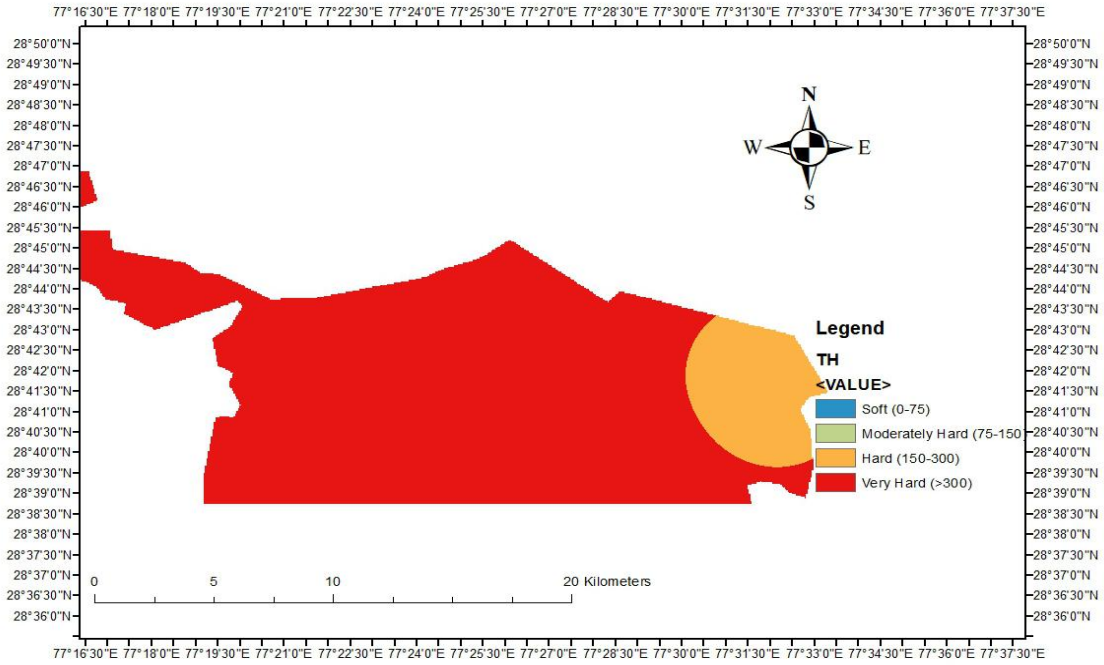


Figure 4.16 Spatial variation of total hardness in groundwater

4.4 CEPI calculation for Ghaziabad

Air EPI Calculation

For Ambient air quality analysis in Ghazibad area, PM_{10} is exceeding the standard of PM_{10} (80µg/m3 for 24-Hr average) prescribed by CPCB in all 36 samples out of 36 ambient air samples analyzed at 16 ambient air quality monitoring locations and considered as primary critical pollutant.

In similar fashion $PM_{2.5}$ is exceeding the standard of $PM_{2.5}$ (80µg/m^3 for 24-Hr average) prescribed by CPCB in all 36 samples out of 36 ambient air samples and Carbon Monoxide (CO) is exceeding in 20 samples out of 36 ambient air samples collected by the standard fixed by CPCB for CO (2mg/m^3 for 8-Hr, average). Since PM_{10} categorized as group B pollutant i.e., Probable carcinogen and thus scored 2 points in industrial activity calculation and $PM_{2.5}$ and CO being Secondary critical pollutant and categorized as Group B pollutant thus scored 0.5-0.5. as per the data collected, there are more than ten R17 category industries in Ghaziabad per 10 KM^2 area under the polluted industrial area considered. Thus Ghaziabad PIA categorized as Large on scale of industrial activities

Surrogate Number Level factor (SNLF) is a function of Exceedance factor and ratio of no. Of samples exceeding the standard to total no. Of samples analyzed. It is calculated as described in methodology giving B score as 45.5 with PM_{10} scored 30 as primary critical pollutants and $PM_{2.5}$ scored 10 as secondary critical pollutant SNLF is > 1 and CO being secondary critical pollutant with SNLF 0.56 scores 5.5 giving collective value of B as 45.5.

Score C corresponds to the health data received from at least major three to five hospitals situated in PIA. For Air EPI calculation, annual percent increment in the patients suffering from air Borne diseases like Asthma and Bronchitis received by hospital is calculated for past five years. Here for Air EPI calculation in year 2018, annual percent increment in no. of patients is less than 5% hence the Receptor score is given as 0.

For D score, the adequacy of large/medium/small scale industries and Compliance of CETP/STP/ETP/CHWTSDF and MSW management facilities is observed. For

Ghaziabad, in the demarcated PIA, industries as well as waste management facilities are complying thus resulting in D score as zero.

Ghaziabad- Uttar Pradesh- CEPI 2018

Air Quality Analysis Report

Pollutants	Group	A1	A2	A (A1xA2)
PM_{10}	B	2	large	
$PM_{2.5}$	B	0.5		
CO	B	0.5		
		3	4	12

Pollutants	Avg (1)	Std (2)	EF [(3) = 1/2]	No of samples Exceeding (4)	Total no. of samples (5)	SNLF Value [(6) = 4/5x3]	SNLF Score	(B)
PM_{10}	549.00	100	5.49	36	36	5.49	C	30
$PM_{2.5}$	271.22	60	4.52	36	36	4.52	C	10
CO	2.03	2	1.01	20	36	0.56	H	5.5
B Score = (B1+B2+B3)							B	**45.5**
C	**0**		**< 5%**					
D	**0**		**A-A-A**					
AIR EPI		**(A+B+C+D)**			**57.50**			

Water EPI Calculation

Phenolic compounds, Total Phosphorus and BOD are taken as Primary, secondary and secondary critical parameters respectively according to the surface water samples collected and tested further. BOD is exceeding the standard (5 mg/l) given by CPCB in 14 samples out of 27 samples collected from monitoring locations. Total Phosphorus is exceeding at all 27 locations and being a probable carcinogen it lies in group B scoring 0.5 points. Phenolic compounds exceeding the standard of Phenolic Compounds (0.01 mg/l) for surface water prescribed by BIS. Phenolic compound being the Carcinogenic compound lies in group C and scores 3 giving total score of A1 as 4 and A as 16.

For B score calculation, SNLF calculated is highest for Total Phosphorus and thus TP is taken as primary critical pollutant giving B1 score 30 (as SNLF is above 1) and marked as critical. Two runner ups with highest SNLF next to TP is considered as secondary critical pollutant and scored 10 points for having SNLF greater than 1 for each of them. B2 and B3 score for BOD and Phenolic compound is calculated in similar manner giving total B score as summation of B1, B2, and B3 as 50. Thus, total water EPI came out as 66 categorizing water in PIA as critical.

Water Quality Analysis Report				
Pollutants	**Group**	A1	A2	
BOD	B	0.5	**large**	**A (A1xA2)**
TP	B	0.5		
Phenolic Compound	C	3		
		4	**4**	**16**

Pollutants	Avg (1)	Std (2)	EF [(3)= 1/2]	No of samples Exceeding (4)	Total no. of samples (5)	SNLF Value [(6) = 4/5x3]	SNLF Score	
BOD	25.30	8	3.16	14	27	1.64	C	10
TP	5.50	0.30	18.35	27	27	18.35	C	30
Phenolic Compound	0.10	0.01	10.15	6	27	2.26	C	10
B value = (B1+B2+B3)							B	50
C	**0**		**< 5%**					
D	**0**		**A-A-A**					
WATER EPI		**(A+B+C+D)**			**66.00**			

Land EPI Calculation

Out of total 23 parameters tested for groundwater sample collected from 17 monitoring locations in demarcated PIA, three most critical parameters are selected on basis of exceedance.

For A score calculation mercury is found exceeding the standard prescribed by BIS for Mercury (0.001 mg/l) in groundwater and since C lies in group C category and is a known carcinogen thus it is considered ass primary critical pollutant and scored 3 points. For other two parameters Total Hardness and Total Dissolved Oxygen as group A parameter scored 0.25 points each.

For B score calculation SNLF calculated is highest for Total Hardness among three critical pollutants selected and considered for Primary critical pollutant and scored accordingly 11.25 points with Moderate label giving total B score of 18.25. Other two secondary critical pollutants scored 3.5 score with moderate label and Since health

related and adequacy score were zero thus total Land EPI came out as 32.25. Land is categorized as Normal.

Ground Water Quality Analysis Report				
Pollutants	**Group**	A1	A2	
T Hard.	A	0.25	Large	**A (A1xA2)**
Hg	C	3		
TDS	A	0.25		
		3.5	4	**14**

Pollutants	**Avg (1)**	**Std (2)**	**EF [(3) = 1/2]**	**No of samples Exceeding (4)**	**Total no. of samples (5)**	**SNLF Value [(6) = 4/5x3]**	**SNLF Score**	
T Hard.	468.97	600	0.78	9	36	0.20	M	11.25
Hg	0.003	0.001	3.13	2	36	0.17	M	3.5
TDS	1209.39	2000	0.60	9	36	0.15	M	3.5
B value = (B1+B2+B3)							B	**18.25**
C	**0**		**< 5%**					
D	**0**		**A-A-A**					
GW EPI		**(A+B+C+D)**			**32.25**			

AIR		**57.50**
WATER		**66.00**
GROUND WATER		**32.25**

$$CEPI = i_{max} + \{(100-i_{max}) \times (i_2/100) \times (i_3/100)\}$$

$$= 66+34 \times (57.5/100)\times(32.25/100)$$

$$=72.3$$

CEPI=72.3

CEPI score of Ghaziabad area coming out to be 72.3 thus Ghaziabad is categorized as Critically Polluted Area (CEPI Score >70)

4.5 Scenario of CEPI in all PIAs all over India

Details of CEPI Scores of Polluted Industrial Areas (PIAs) monitored during 2018

For monitoring and sampling purpose, India is divided in 5 zones *v.i.z.* East zone, West zone, North zone and South zone. Total 100 Nos. of Polluted industrial areas identified in 21 states of India were monitored for 12 parameters of ambient air quality and for 22 parameters of Surface water and Groundwater quality. CEPI scores based on the exceeding concentration pollutants categorized as primary and secondary pollutants are given below:

Table 4.1 CEPI Score for 100 PIAs

Sl. No.	Zone wise and State wise	Name of Polluted Industrial Areas (PIAs)	Environment		Criteria pollutants selected on the basis of monitoring carried out during 2018	EPI Score	CEPI Score
			EAST ZONE				
1.	Assam	Byrnihat		Air	**PM_{10}, $PM_{2.5}$, CO**	67.00	78.31
				Water	**T NH_4-N, TP, BOD**	70.50	
				Land	**As, Fe, BOD**	39.50	
2.		Digboi		Air	**BaP, PM_{10}, CO**	28.50	32.54
				Water	**BOD, T. Cr, Cd**	30.25	
				Land	**Fe, Mn, T. Hard.**	11.50	
3.	Bihar	Hajipur		Air	**PM_{10}, $PM_{2.5}$, CO**	77.00	85.45
				Water	**TP, T NH_3-N, Hg**	61.75	
				Land	**Fe, T. Cr, T. Hard.**	59.50	

4.	Jharkhand	Barajamda		Air	**PM_{10}, $PM_{2.5}$, NO_2**	62.75	70.31
				Water	**TP, Se, T. Hard.**	35.00	
				Land	**Fe, TP, TKN**	58.00	
5.		Dhanbad		Air	**PM_{10}, $PM_{2.5}$, CO**	43.00	59.78
				Water	**Hg, TP, TKN**	57.50	
				Land	**BOD, T. Hard., Fe**	12.50	
6.		Hazaribagh		Air	**PM_{10}, $PM_{2.5}$, NO_2**	81.00	85.64
				Water	**T. Hard., BOD, TDS**	40.00	
				Land	**Fe, Mn, BOD**	61.00	
7.		Jamshedpur		Air	**PM_{10}, $PM_{2.5}$, BaP**	46.00	48.10
				Water	**BOD, TKN, TP**	19.25	
				Land	**Fe, Free NH_4, T. Hard.**	20.25	
8.		Ramgarh		Air	**PM_{10}, $PM_{2.5}$, Pb**	56.75	66.75
				Water	**TP, TKN, BOD**	50.00	
				Land	**Fe, As, T. Hard.**	46.25	
9.		Saraikela		Air	**PM_{10}, $PM_{2.5}$, NO_2**	52.75	54.46
				Water	**T. Hard., T. Nit., TP**	12.50	
				Land	**Fe, T. Hard., TDS**	29.00	
10.		West Singhbhum		Air	**PM_{10}, $PM_{2.5}$, NO_2**	62.75	65.83
				Water	**TP, T NH_4-N, BOD**	36.75	
				Land	**Fe, Se, T. Hard.**	22.50	
11.	Orissa	Angul Talchar		Air	**PM_{10}, $PM_{2.5}$, CO**	44.75	45.37
				Water	**Se, T. Hard., BOD**	2.75	
				Land	**Fe, Free NH_3, T. Hard.**	40.50	
12.		Ib-Valley		Air	**PM_{10}, $PM_{2.5}$, CO**	48.75	66.35
				Water	**TP, T NH_4-N, BOD**	59.00	
				Land	**Fe, T. Hard., B**	36.75	
13.		Jharsuguda		Air	**PM_{10}, $PM_{2.5}$, CO**	36.00	36.40
				Water	**TP, T NH_4-N, BOD**	16.50	
				Land	**BOD, Fe, As**	3.75	
14.		Jajpur		Air	**PM_{10}, $PM_{2.5}$, CO**	43.50	49.62
				Water	**T. Hard., BOD, T. Nit.**	26.25	
				Land	**Fe, As, T. Hard.**	41.25	
15.		Paradeep		Air	**PM_{10}, $PM_{2.5}$, CO**	43.00	60.61
				Water	**Se, TDS, T. Hard.**	57.50	
				Land	**T. Hard., Fe, TDS**	17.00	
16.	West Bengal	Asansol		Air	**PM_{10}, $PM_{2.5}$, Ben.**	54.00	55.03
				Water	**TP, T. Hard., BOD**	16.25	
				Land	**T. Hard., Fe, BOD**	13.75	
17.		Durgapur		Air	**PM_{10}, $PM_{2.5}$, CO**	62.50	65.56
				Water	**TP, TKN, Fe**	43.50	
				Land	**T. Hard., Fe, TDS**	18.75	
18.		Bandel		Air	**PM_{10}, $PM_{2.5}$, BaP**	59.50	67.64
				Water	**T NH_4-N, BOD, TP**	47.00	
				Land	**Fe, Hg, T. Hard.**	42.75	

19.		Haldia		Air	**PM_{10}, $PM_{2.5}$, BaP**	45.00	45.72
				Water	**TSS, TDS, T. Hard.**	35.00	
				Land	**Fe, T. Hard., TDS**	3.75	
20.		Howrah		Air	**PM_{10}, $PM_{2.5}$, BaP**	60.50	61.76
				Water	**T. Hard., TDS, BOD**	20.00	
				Land	**Fe, T. Hard., TDS**	16.00	
	WEST ZONE						
21.	Gujarat	Ahmedabad		Air	**PM_{10}, $PM_{2.5}$, SO_2**	53.50	57.11
				Water	**TP, T NH_4-N, Phenol**	48.50	
				Land	**BOD, T. Hard., F**	16.00	
22.		Ankleshwar		Air	**PM_{10}, $PM_{2.5}$, CO**	68.00	77.51
				Water	**T NH_4-N, T. Hard., T. Cr**	58.25	
				Land	**T. Hard., Se, TDS**	51.00	
23.		Bhavnagar		Air	**PM_{10}, $PM_{2.5}$, NO_2**	56.00	57.06
				Water	**No sample**	15.50	
				Land	**Fe, T. Hard., TDS**	15.50	
24.		Junagarh		Air	**PM_{10}, $PM_{2.5}$, SO_2**	47.00	51.64
				Water	**TKN, BOD, T. Cr.**	25.00	
				Land	**T. Hard., Fe, TKN**	35.00	
25. ,		Morbi		Air	**PM_{10}, $PM_{2.5}$, NO_2**	51.00	54.24
				Water	**T. Hard., T. Nit., Phenol**	47.25	
				Land	**T. Hard., Phenol, TDS**	14.00	
26.		Rajkot		Air	**PM_{10}, $PM_{2.5}$, NO_2**	51.75	70.62
				Water	**T NH_4-N, T. Cr, BOD**	61.50	
				Land	**T. Nit., T. Cr, T. Hard.**	45.75	
27.		Surat		Air	**PM_{10}, $PM_{2.5}$, CO**	46.00	76.43
				Water	**T NH_4-N, BOD**, TP	68.25	
				Land	**T. Hard., TDS, Fe**	56.00	
28.		Vadodara		Air	**PM_{10}, $PM_{2.5}$, CO**	82.00	89.09
				Water	**BOD**, TP, **T NH_4-N**	80.75	
				Land	**T. Hard., TDS, Fe**	48.75	
29.		Vapi		Air	**PM_{10}, $PM_{2.5}$, NO_2**	61.00	79.58
				Water	**TP, TKN, TDS**	75.00	
				Land	**T. Hard., TDS, F**	30.00	
30.		Vatva		Air	**PM_{10}, $PM_{2.5}$, SO_2**	57.00	70.94
				Water	**T NH_4-N, BOD, TP**	66.00	
				Land	**T. Nit., T. Hard., TDS**	25.50	
31.	Maharashtra	Aurangabad		Air	**PM_{10}, $PM_{2.5}$, CO**	45.00	69.85
				Water	**TP, TKN, BOD**	65.38	
				Land	**Fe, T. Hard., TDS**	28.75	
32.		Chandrapur		Air	**PM_{10}, $PM_{2.5}$, BaP**	65.00	65.66
				Water	**T. Hard., TDS, Zn**	13.75	
				Land	**T. Hard., Fe, TDS**	13.75	

33.		Chembur		Air	**PM_{10}, $PM_{2.5}$, CO**	52.25	54.67
				Water	**TP, T. Hard., Chloride**	50.75	
				Land	**Fe, T. Hard., F**	10.00	
34.		Dombivali		Air	**PM_{10}, $PM_{2.5}$, CO**	62.00	69.67
				Water	**T NH_4-N, BOD, T. Hard.**	63.50	
				Land	**T. Hard., TDS, Fe**	27.25	
35.		Mahad		Air	**PM_{10}, $PM_{2.5}$, CO**	41.00	47.12
				Water	**Se, TDS, T. Hard.**	35.75	
				Land	**Se, Fe, T. Hard.**	29.00	
36.		Nashik		Air	**PM_{10}, $PM_{2.5}$, BaP**	56.50	69.49
				Water	**T. Nit., TP, T. Hard.**	60.00	
				Land	**T. Nit., Fe, T. Hard.**	42.00	
37.		Navi Mumbai		Air	**PM_{10}, $PM_{2.5}$, As**	46.00	66.77
				Water	**Chloride, T. Hard., TP**	65.00	
				Land	**T. Hard., Fe, TDS**	11.00	
38.		Pimpari-Chinchwad		Air	**PM_{10}, $PM_{2.5}$, CO**	52.00	52.16
				Water	**T. Hard., BOD, T. Nit.**	6.25	
				Land	**Fe, T. Hard., TDS,**	5.25	
39.		Tarapur		Air	**PM_{10}, $PM_{2.5}$, CO**	72.00	93.69
				Water	**Hg, TKN, T. Hard.**	89.00	
				Land	**T. Hard., Hg, Fe**	59.25	
			North Zone				
40.	Delhi	Najafgarh-Drain basin including Anand Parbat, Naraina, Okhla, Wazirpur		Air	**PM_{10}, $PM_{2.5}$, As**	90.25	95.83
				Water	**TP, T NH_4-N, BOD**	91.00	
				Land	**T. Hard., TDS, Fe**	59.50	
41.	Haryana	Faridabad		Air	**$PM_{2.5}$, PM_{10}, As**	87.25	95.08
				Water	**TP, T NH_4-N, Phenol**	90.00	
				Land	**T. Hard., TDS, Mn**	58.25	
42.		Gurgaon		Air	**PM_{10}, $PM_{2.5}$, CO**	70.00	85.15
				Water	**TP, Phenol, T NH_4-N,**	80.00	
				Land	**Fe, T. Hard., TDS**	36.75	
43.		Panipat		Air	**PM_{10}, $PM_{2.5}$, CO**	75.00	91.05
				Water	**TP, T NH_4-N , BOD**	81.00	
				Land	**Hg, Fe, T. Hard.**	70.50	
44.	Himachal Pradesh	Baddi		Air	**PM_{10}, $PM_{2.5}$, CO**	63.00	73.62
				Water	**Phenol, TP, T NH_4-N**	68.75	
				Land	**Mn, T. Hard., TDS**	24.75	
45.		Kala Amb		Air	**PM_{10}, CO, $PM_{2.5}$,**	17.00	65.70
				Water	**Phenol, TP, TKN**	64.00	
				Land	**TP, T. Hard., Fe**	27.75	
46.		Parwanoo		Air	**PM_{10}, $PM_{2.5}$, CO**	24.00	66.79
				Water	**TP, Zn, BOD**	61.88	
				Land	**Hg, Fe, Mn**	53.75	

47.	Punjab	Batala		Air	**PM_{10}, $PM_{2.5}$, CO**	63.00	68.92
				Water	**TP, T NH_4-N, BOD**	62.75	
				Land	**Fe, As., Mn**	25.50	
48.		Jalandhar		Air	**PM_{10}, $PM_{2.5}$, CO**	53.50	74.76
				Water	**TP, T NH_4-N, BOD**	66.88	
				Land	**Fe, B, Mn**	44.50	
49.		Ludhiana		Air	**PM_{10}, $PM_{2.5}$, CO**	53.50	73.48
				Water	**TP, T NH_4-N, BOD**	71.00	
				Land	**T. Hard., Fe, TDS**	16.00	
50.		Mandi Govindgarh		Air	**PM_{10}, $PM_{2.5}$, CO**	23.75	53.91
				Water	**T NH_4-N, TP, Phenol**	53.75	
				Land	**T. Hard., TDS, Fe**	1.50	
51.	Uttar Pradesh	Agra		Air	**PM_{10}, $PM_{2.5}$, Ben.,**	65.00	76.99
				Water	**TP, T NH_4-N, BOD**	66.88	
				Land	**TDS, T. Nit., T. Hard.**	47.00	
52.		Aligarh		Air	**PM_{10}, $PM_{2.5}$, CO**	56.25	64.42
				Water	**TP, T NH_4-N, BOD**	61.88	
				Land	**T, Hard., BOD, F**	11.88	
53.		Bulandsahar-Khurza		Air	**PM_{10}, $PM_{2.5}$, As**	79.50	85.23
				Water	**TP, T NH_4-N, BOD**	76.00	
				Land	**T. Hard., SO_4^{-2}, Se**	36.75	
54.		Firozabad		Air	**PM_{10}, $PM_{2.5}$, As**	86.00	90.04
				Water	**TP, T NH_4-N, BOD**	77.00	
				Land	**TKN, Fe, T. Hard.**	37.50	
55.		Gajraula Area		Air	**PM_{10}, $PM_{2.5}$, Ben.**	66.00	78.91
				Water	**Phenol, T. NH_4-N, BOD**	70.00	
				Land	**Mn, Se, T. Hard.**	45.00	
56.		Ghaziabad		Air	**PM_{10}, $PM_{2.5}$, CO**	57.50	72.30
				Water	**TP, Phenol, BOD**	66.00	
				Land	**T. Hard., Hg, TDS**	32.25	
57.		Kanpur		Air	**PM_{10}, $PM_{2.5}$, SO_2**	71.00	93.55
				Water	**TP, Phenol, T NH_4-N**	90.00	
				Land	**Fe, Mn, T. Hard.**	50.00	
58.		Mathura		Air	**PM_{10}, $PM_{2.5}$, As**	91.00	94.87
				Water	**OCP, TP, T. NH_4-N**	86.00	
				Land	**TDS, B, Fe**	50.00	
59.		Meerut		Air	**PM_{10}, $PM_{2.5}$, CO**	52.00	66.09
				Water	**TP, Phenol, T. NH_4-N**	65.00	
				Land	**T. Hard., TDS, Fe**	6.00	
60.		Moradabad		Air	**PM_{10}, $PM_{2.5}$, As**	76.75	83.20
				Water	**TP, T NH_4-N, BOD**	76.00	
				Land	**T. Hard., TDS, Mn**	36.50	
61.		Noida		Air	**PM_{10}, $PM_{2.5}$, As**	59.75	68.76
				Water	**BOD, TP, T NH_4-N**	62.75	
				Land	**T. Hard., TDS, Mn**	27.00	

62.		Singrauli (UP & MP)		Air	**PM_{10}, $PM_{2.5}$, CO**	50.00	68.43
				Water	**TP, Hg, BOD**	62.25	
				Land	**T. Hard., Fe, As**	32.75	
63.		Varanasi-Mirzapur		Air	**PM_{10}, $PM_{2.5}$, CO**	82.00	97.76
				Water	**Phenol, TP, BOD**	96.00	
				Land	**TP, T. Hard., F**	53.75	
64.	Uttarakhand	Haridwar		Air	**PM_{10}, $PM_{2.5}$, CO**	75.25	80.85
				Water	**Phenol, TP, TKN**	73.00	
				Land	**Fe, T. Hard., Mn**	31.00	
65.		Udhamsingh Nagar		Air	**PM_{10}, $PM_{2.5}$, CO**	43.00	91.13
				Water	**Phenol, TP, TKN**	89.50	
				Land	**T. Hard., Fe, Mn**	36.00	
			SOUTH ZONE				
66.	Andhra Pradesh	Vijayawada		Air	**PM_{10}, $PM_{2.5}$, As**	60.50	68.09
				Water	**Zn, TP, T. Nit.**	49.25	
				Land	**T. Hard., TDS, Fe**	39.00	
67.		Vishakhapatam		Air	**As, PM_{10}, $PM_{2.5}$**	27.25	44.74
				Water	**TP, BOD, Zn**	12.75	
				Land	**PAH, T. Hard., F**	42.75	
68.	Karnataka	Bhadravati		Air	**PM_{10}, $PM_{2.5}$, As**	45.00	58.48
				Water	**TP, Hg, Phenol**	52.00	
				Land	**TP, T. Hard., Pb**	30.00	
69.		Bidar		Air	**PM_{10}, $PM_{2.5}$, NO_2**	31.00	55.50
				Water	**Hg, T. Nit., T. Hard.**	50.00	
				Land	**Fe, TKN, Mn**	35.50	
70.		KIADB Industrial Area, Jigini, Anekal (Bengaluru)		Air	**PM_{10}, BaP, Pb**	52.00	70.99
				Water	**T NH_4-N, TP, BOD**	66.00	
				Land	**T. Hard., Mn, TDS**	28.25	
71.		Mangalore		Air	**PM_{10}, $PM_{2.5}$, As**	20.00	59.44
				Water	**PAH, Zn, T NH_4-N**	54.50	
				Land	**PAH, Fe, TKN**	54.25	
72		Peenya		Air	**PM_{10}, $PM_{2.5}$, NO_2**	41.00	78.12
				Water	**T NH_4-N, TP, BOD**	66.00	
				Land	**T. Cr, BOD, TKN**	70.00	
73		Raichur		Air	**PM_{10}, $PM_{2.5}$, Ni**	32.75	53.42
				Water	**Phenol, TP, Cu**	47.88	
				Land	**TKN, TDS, T. Hard.**	32.50	
74	Kerala	Greater Kochin		Air	**PM_{10}, $PM_{2.5}$, NO_2**	47.38	52.94
				Water	**SO_4, TP, BOD**	35.88	
				Land	**Fe, Mn, TKN**	29.50	
75	Tamil Nadu	Coimbatore		Air	**PM_{10}, $PM_{2.5}$, As**	47.25	63.64
				Water	**TP, Phenol, T NH_4-N**	53.75	
				Land	**Phenol, T. Hard., TDS**	45.25	
76		Cuddalore		Air	**PM_{10}, $PM_{2.5}$, As**	25.00	62.56

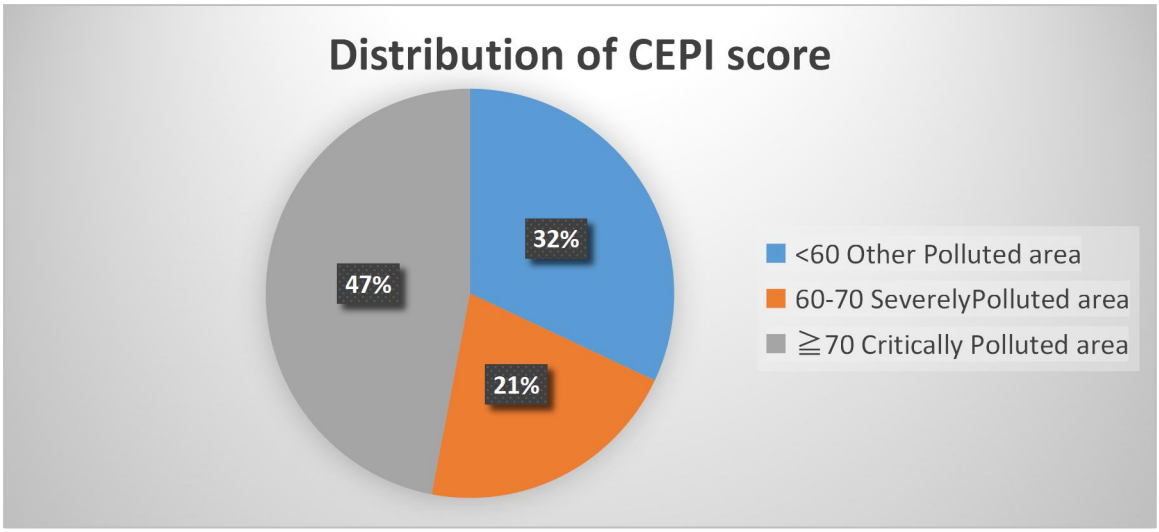
				Water	**Phenol, T. Hard., TDS**	58.25	
				Land	**Fe, TP, Phenol**	41.25	
77		Erode		Air	**PM_{10}, $PM_{2.5}$, NO_2**	39.13	72.25
				Water	**TP, TKN, T. Hard.**	47.00	
				Land	**Fe, TDS, T. Hard.**	66.00	
78		Manali		Air	**PM_{10}, $PM_{2.5}$, Ben.**	59.75	84.15
				Water	**PAH, Phenol, BOD**	72.25	
				Land	**PAH, Phenol, TP**	71.75	
79		Mettur		Air	**PM_{10}, As, $PM_{2.5}$**	41.25	73.31
				Water	**Se, TP, T. Hard.**	31.13	
				Land	**Phenol, BOD, TKN**	69.38	
80		Tiruppur		Air	**PM_{10}, $PM_{2.5}$, As**	58.00	97.73
				Water	**T NH_4-N, Phenol, BOD**	95.00	
				Land	**Phenol, TDS, T. Hard.**	94.00	
81		Tuticorin		Air	**As, PM_{10}, $PM_{2.5}$**	39.75	72.89
				Water	**TP, Zn, TKN**	51.00	
				Land	**T. Hard., TDS, TKN**	66.00	
82.		Vellore -North Arcot		Air	**Ni , PM_{10}, $PM_{2.5}$**	49.00	79.26
				Water	**T NH_4-N, BOD, T. Cr**	75.00	
				Land	**TP, Fe, TDS**	34.75	
83.	Telangana	Kattedan		Air	**PM_{10}, $PM_{2.5}$, As**	36.25	55.26
				Water	**TP, T NH_4-N, T. Hard.**	47.00	
				Land	**T. Hard., T. Nit., TDS**	43.00	
84.		Pattancheru Bollaram		Air	**PM_{10}, $PM_{2.5}$, NO_2**	56.00	75.42
				Water	**T NH_4-N, Phenol, BOD**	70.00	
				Land	**T. Hard., TDS, NO_3-N**	32.25	
85.		Kukatpally		Air	**PM_{10}, $PM_{2.5}$, NO_2**	53.75	77.55
				Water	**T NH_4-N, TP, BOD**	71.00	
				Land	**T. Hard., TKN, TDS**	42.00	
CENTRAL ZONE							
86.	Chhattisgarh	Korba		Air	**PM_{10}, $PM_{2.5}$, NO_2**	37.00	45.80
				Water	**TP, BOD, TKN**	11.00	
				Land	**Mn, SO_4, TKN**	43.50	
87.		Raipur		Air	**PM_{10}, $PM_{2.5}$, CO**	67.00	70.77
				Water	**TP, T NH_4-N, BOD**	45.75	
				Land	**T. Hard., TDS, F**	25.00	
88.		Bhillai-Durg		Air	**$PM_{2.5}$, PM_{10}, CO**	43.00	46.69
				Water	**TP, TKN, BOD**	32.75	
				Land	**Fe, T. Hard., F**	19.75	
89.		Siltara Industrial Area		Air	**PM_{10}, $PM_{2.5}$, Pb**	76.00	79.94
				Water	**TP, T NH_4-N, F**	51.75	
				Land	**T. Hard., TDS, F**	31.75	
90.	Madhya Pradesh	Indore		Air	**PM_{10}, $PM_{2.5}$, CO**	18.50	58.53
				Water	**TP, TKN, BOD**	56.88	
				Land	**T. Hard., SO_4^{-2}, F**	20.75	

91.		Dewas		Air	**$PM_{2.5}$, PM_{10}, Ni**	28.00	37.79
				Water	**TP, TKN, BOD**	31.63	
				Land	**T. Hard., TDS, F**	31.75	
92.		Mandideep		Air	**PM_{10}, $PM_{2.5}$, Ni**	56.00	58.43
				Water	**TP, BOD, T NH_4-N**	55.25	
				Land	**T. Hard., F, TDS**	10.00	
93.		Nagda–Ratlam		Air	**PM_{10}, $PM_{2.5}$, CO**	12.00	48.78
				Water	**TP, T. Hard., Zn**	47.00	
				Land	**T. Hard., TKN, TDS**	28.00	
94.		Pithampur		Air	**PM_{10}, $PM_{2.5}$, CO**	13.50	20.23
				Water	**TP, T. Hard., TKN**	19.50	
				Land	**T. Hard., TDS, Fe**	6.75	
95.		Gwalior		Air	**PM_{10}, $PM_{2.5}$, Ni**	50.00	51.67
				Water	**TP, BOD, TKN**	43.13	
				Land	**T. Hard., F, TDS**	7.75	
96.	Rajasthan	Bhiwadi		Air	**PM_{10}, $PM_{2.5}$, Pb**	66.50	79.63
				Water	**TKN, TP, BOD,**	71.00	
				Land	**T. Hard., T. Cr, F**	44.75	
97.		Jaipur		Air	**PM_{10}, $PM_{2.5}$, NO_2**	61.88	77.40
				Water	**TP, TKN, BOD**	71.88	
				Land	**T. Hard., F, TDS**	31.75	
98.		Jodhpur		Air	**PM_{10}, $PM_{2.5}$, CO**	67.00	81.16
				Water	**TP, BOD, TKN**	66.00	
				Land	**TP, TDS, T. Hard.,**	65.00	
99.		Pali		Air	**PM_{10}, $PM_{2.5}$, NO_2**	66.00	80.48
				Water	**TP, TDS, TKN**	65.00	
				Land	**TDS, B, T. Hard.**	65.50	
100.		Sanganer Industrial Area		Air	**PM_{10}, $PM_{2.5}$, As**	65.00	79.10
				Water	**BOD, TKN, TP**	71.88	
				Land	**B, Fe, T. Hard.**	39.50	

Source: Hon'ble NGT order in O.A No. 1038, dated 10/07/2019

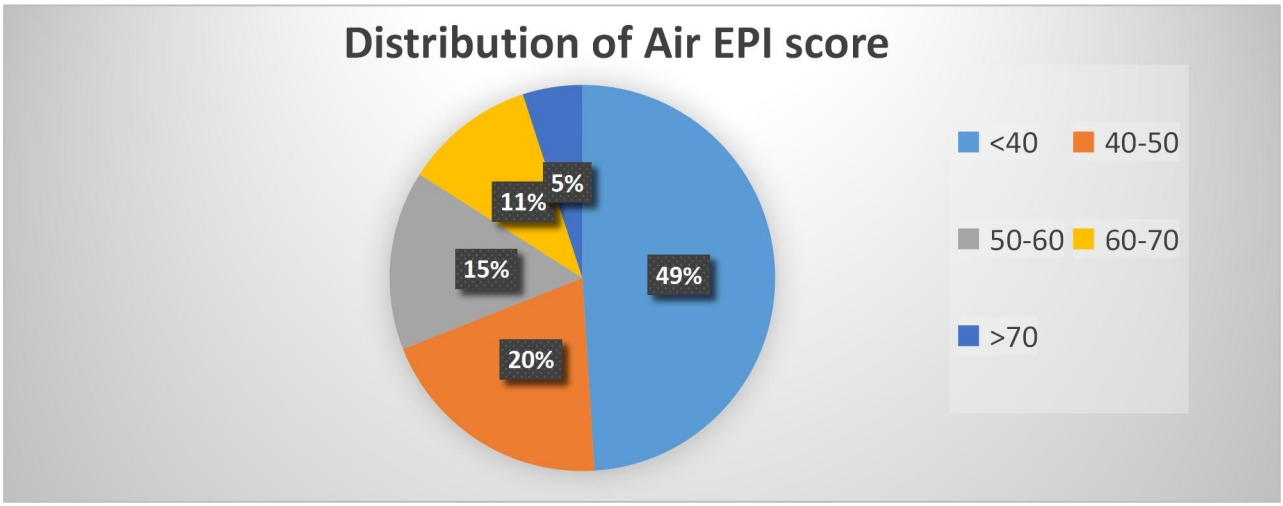
4.5.1 Distribution of CEPI score in India

Range of CEPI score	Status	No. Of PIA
≧70	Critically Polluted Area	47
60-70	Severely Polluted area	21
<60	Other Polluted Area	32
TOTAL	**100**	



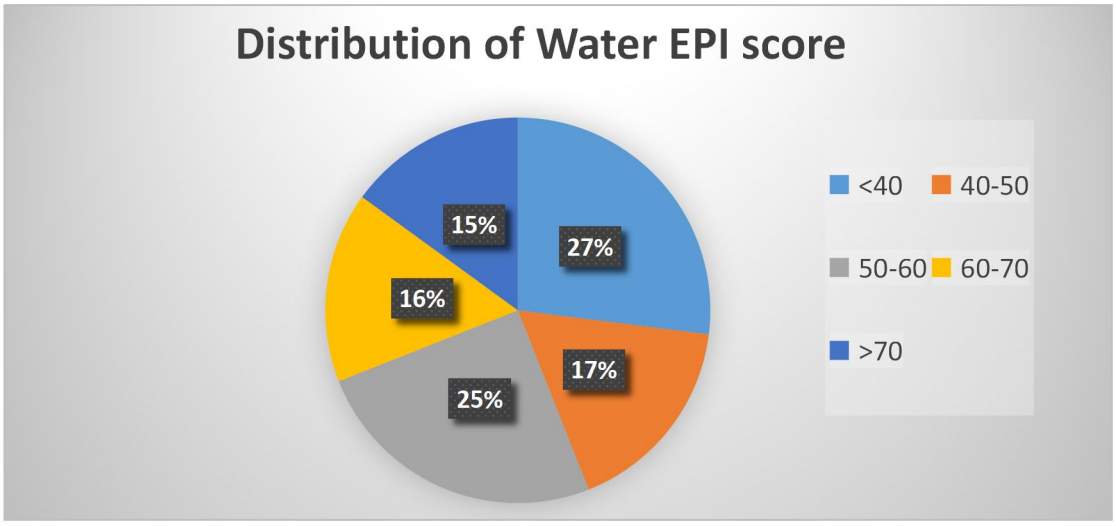
4.5.2 Distribution of Air EPI score in India

Air EPI score Range	No. Of PIAs
60-70	11
50-60	15
40-50	20
≧70	5
<40	49
TOTAL	**100**



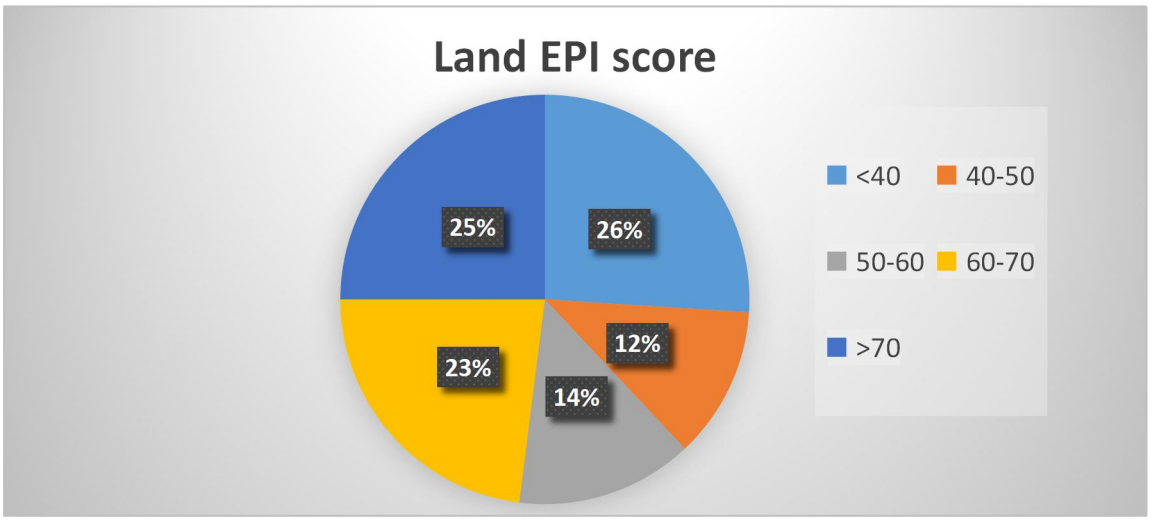
4.5.3 Distribution of Water EPI score

Water EPI score range	No. Of PIAs
<40	27
40-50	17
50-60	25
60-70	16
≧70	15
TOTAL	**100**



4.5.4Distribution of Land EPI score

Land EPI score range	No. Of PIAs
<40	26
40-50	12
50-60	14
60-70	23
≧70	25
TOTAL	**100**



CHAPTER-5

CONCLUSION AND RECOMMENDATION

CEPI is a tool which can give early warning. CEPI is designed so that it could be easily understood by common people and quick to use by the regulatory bodies. It helps in categorizing the industrial clusters/ areas in terms of priority of needing attention. In the study area, Ambient air quality of samples are analyzed for all the 12 notified parameters however the predominant pollutants identified were PM_{10}, $PM_{2.5}$ and CO as critical pollutants. At some locations benzene and heavy metals were also identified. It is interpreted that majorly vehicular movement and vehicular emission due to burning of fuel is responsible for $PM_{2.5}$ and PM_{10} and Recessively, emissions of SO_2, NO_2, ammonia and VOCs is a reason in formation of the inhalable particulate matter ($PM_{2.5}$) by photochemical reactions. Ambient air component has been observed severe in Ghaziabad Industrial area.

Similarly, in terms of water quality, the BOD, Phenolic Compounds, TP, Total Hardness, TDS and Hg are predominant parameters and most of the other parameters were not significant. The specific pollutants such as PAH and Hg are reported in some locations. Surface water is observed critical in Ghaziabad industrial areas with BOD, TP and Phenolic compounds as critical parameters. Whereas, ground water is in normal condition.

The CEPI analysis helps to categorize industrial areas/clusters into critically polluted area, severely polluted are and other polluted area with respect to one or more environmental component. The areas having aggregated CEPI scores of 70 and above are considered as critically polluted industrial clusters/ areas, whereas the areas having CEPI between 60-70 are considered as severely polluted areas and they are kept under surveillance and pollution control measures, whereas, for the critically polluted industrial clusters/ areas further detailed investigations in terms of the extent of damage and a formulation of appropriate remedial action plan. It is recommended that as the step II a comprehensive analysis of spatial and temporal data shall be done for the identified critical polluted industrial clusters/ areas so as to define the spatial boundaries and extent of damage to the eco-geological features.

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