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Air Pollution in India and Comparative Analysis of NAMP Monitored Pollutants

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Abstract: ***As India is moving towards industrialization across various sectors the need for industry, transport, housing, and infrastructural activities have surged to a new level. These grown-up activities have given the rise in the level of air pollution. While Pollution in few cities like New Delhi, Patna, Mumbai are the talk of the town many major and unpopular cities are overlooked but are more alarming for the entire nation. Industrialization and growing demand in the automobile sector have considerably increased the level of air pollution within a short period but it is the time to draw focus over more lethal air pollutants and pinpoint either it's the gaseous pollutant or the particulate one that is a threat to health and society. To know this our study has analysed four years data of National Air Quality Monitoring Programme (NAMP) monitored pollutants namely Nitrogen Oxide (NO_2), Sulphur Dioxide (SO_2), PM_{10} and $PM_{2.5}$. The analysis consists of recognizing Non-Attainment Cities, Correlation between all these pollutants and cluster analysis to know which city falls under which zone. The graphical analysis and Data visualization were analysed through python and tableau and other statistical analysis through excel and python.***
Keywords: ***Air Pollution, Nitrogen Oxide, Sulphur Oxide, PM_{10}, $PM_{2.5}$, NAMP, NAAQS, CPCB, Air Quality Management.***

I. INTRODUCTION

According to Report 15 out of 20 most polluted cities are in India. Gurgaon, Ghaziabad, Faridabad, Noida, and Bhiwandi are the top 5 most polluted cities. New Delhi is the most polluted capital in the World. Jharia, Jharkhand is the most polluted city in India [1]. Air Pollution in India is now a hot topic for the entire nation. The most shocking fact is that PM_{10} has violated the standard in about 80% of the Indian Cities as per National Ambient Air Quality Standard (NAAQS). The PM_{10} refers to all the particulate matter less than 10 micron-meter aerodynamic diameter, with the highest propensity to penetrate human lungs and result in aggregated respiratory and cardiovascular diseases and, in some cases, premature death [2] - [4].

The pollutants are mainly of two types Gaseous pollutants and Particulate Pollutants. Gaseous Pollutants comprises of NO_2, SO_2, O_3, CO_2, etc. and Particulate Pollutants are Mainly Particulate Matter (PM) with diameters of 10, 2.5 and 1. Here we talk about the four major pollutants and their comparative analysis (2015 and 2018) which is under the National Air Quality Monitoring Programme (NAMP). These pollutants have many health and environmental effects that should be discussed. Nitrogen Oxide (NO_2) is a type of primary air pollutant which causes health issues like Pulmonary disorders, increased susceptibility to respiratory infections and Precursor of ozone formation in the troposphere, Aerosol formation to the environment. Sulphur Dioxide (SO_2) is a secondary air pollutant which causes health issues like Respiratory problems, Heart and lung disorders, Visual impairment and Acid rain in the environment while Particulate Matter is an air pollutant which causes Respiratory problems, liver fibrosis, lung/liver cancer, Heart stroke, Bone problems and Visibility reduction in the environment.

This paper provides a better understanding of the level of air pollution in major cities of India through various data visualization tools and graphs and provides statistics about the real situation of India cities. This paper also accounts for the major contribution in this field and how these contributions have helped in formulating programmes. After that, we will discuss the methodology and the results and discussion about the paper that recognizes cities which are alarming to the nation and may cause serious health and environmental issues. Next, we will discuss the conclusion about the study and also provide some recommendation about what to be done in this field of study and how the surge in the air pollution level to be shunned.

II. LITERATURE SURVEY

Most of the researcher says that many urban cities of India are like a gas chamber. This research is an attempt to know the difference. Most of the analysis in this field of is study is related to health issues related to air pollution and others are related to the capital city Delhi. There are very few studies that cover the air pollution issues of the whole nation and this study is the one in the race. In New Delhi, research from 180 hours of real-time measurements of fine particle and black carbon mass concentration ($PM_{2.5}$, BC) and ultrafine particle number concentration (PN) inside a common vehicle, the auto-rickshaw. From these results, we estimate

that one's exposure during a daily commute by autorickshaw in Delhi is as least as large as full-day exposures experienced by urban residents of many high-income countries [5]. Major contribution in the field of Air pollution issues is mainly from the emission from industrial waste or fuel combustion and their respective health effect from vehicles especially in New Delhi [6]. Apart from that study suggest how to identifies issues related to measurement methods used to determine compliance with standards, describes current and future measurement methods and their limitations, and determines the extent to which existing technology can meet short-term and long-term needs for measuring compliance. [7]

Many studies also cover the science behind the nature of air pollutants and how to design the national networks and to employ the control mechanism are discussed [8]. All these studies include spatial analysis and analysis of AQI index and thus the holistic study of NAMP data are still in progress.

III. METHODOLOGY

This study is based on the information for which the NAMP data are available and incorporated all major cities of India and their air pollution level separately in terms of four major pollutants namely NO_2, SO_2, PM_{10}, and $PM_{2.5}$. There are many statistical methods are used that needs to be defined for a better understanding of the paper. The paper cover three major parts the data source and the statistical methods and the visual representation of data.

A. Data Source

The data are collected from the verified source that is Central Pollution control board (CPCB) There are no other sources taken into consideration and all the analysis are based on the only source. The data collected from CPCB are in Portable Document Format (PDF) which are a year-wise distribution of data for four pollutants. The data source contains the information regarding states, cities and monitoring station but for simplification of study, the average was taken of all station within a city. The most recent available data on CPCB website is of the year 2018.

B. Data Analysis

The study comprises of many data analysis tools like NAAQS Violation analysis, correlation analysis and cluster analysis. NAAQS violation analysis is done through excel, correlation analysis is done through python, and cluster analysis through tableau. The NAAQS violation analysis finds out how many cities have violated the NAAQS Standard while the correlation analysis has analysed all the four pollutants and find any correlation between them. The cluster analysis has not been analysed statistically but the information regarding the distance, iteration and ANOVA table was given by tableau. The cluster analysis in this study is K-Means clustering with distance considered is Euclidean distance. The number of clusters is determined through elbow graph with the help of python. There are three clusters as determined by elbow graph.

C. Data Representation

This paper includes many intuitive models with the help of charts, graphs and geographical maps. All the statistical analysis is represented in a visual form for the convenience of the reader. The study compares data of 2015 and 2018 for all the analysis and attempts to show how air pollution level has increased over time. This is a comparative study that takes the help of modern tools like python and tableau to compare the data about cluster analysis, correlation analysis and National Ambient Air Quality Standard (NAAQS) Violation analysis and attempt to recognise the most dangerous pollutants from the four major pollutants.

IV. RESULTS AND DISCUSSION

The study comprises of three major analysis mainly NAAQS Violation Analysis, Correlation Analysis and Cluster Analysis. These three analyses give the complete picture of the Air pollution across India. The NAAQS Violation Analysis gives an idea of how many cities have violated the standard set by NAAQS and update the list of Non-Attainment Cities that is not updated since 2012. Correlation analysis is about the correlation between pollutants. The most important analysis is cluster analysis which describes which city is under which zone which are alarming and which are not.

A. NAAQS Violation Analysis

Pollutants	National Ambient Air Quality Standard (Annual Mean)
Nitrogen Dioxide (NO_2), µg/m3	50
Sulphur Dioxide (SO_2), µg/m3	40
PM_{10} µg/m^3	60
$PM_{2.5}$ µg/m^3	40

(Source: CPCB Website)

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Table 1. National Ambient Air Quality Standard (NAAQS)

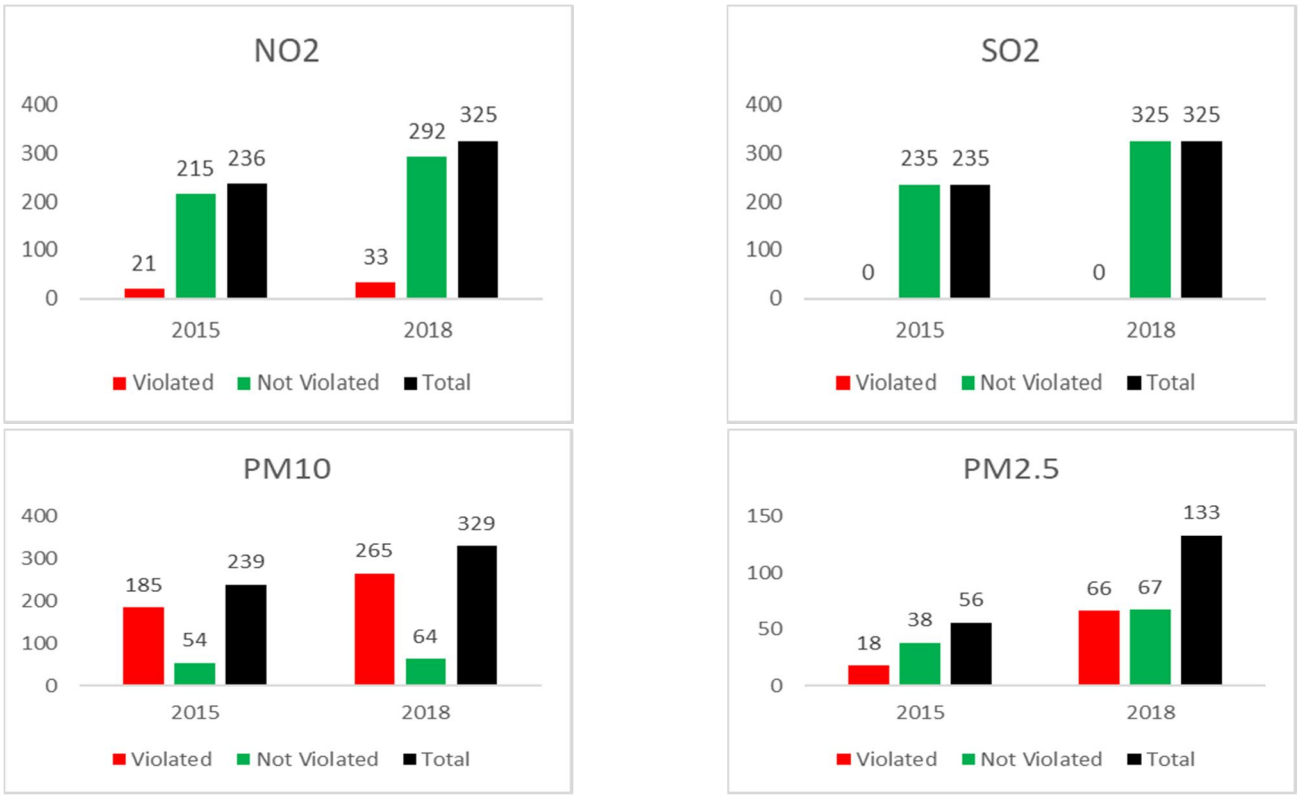


Figure 1. The number of cities violated the NAAQS Standard.

Figure 1 shows the number of cities that have violated the NAAQS standard. From this analysis, we can say that NO2 violation has increased from 9.77% in 2015 to 11.30% in 2018. SO2 doesn't show any violation of any city of India. PM_{10} violation has increased from 77.41% in 2015 to 80.55% in 2018. $PM_{2.5}$ Shows upward trend with 32.14% of violation in 2015 to 49.62% in 2018. PM_{10} and $PM_{2.5}$ are the most dangerous pollutants.

B. Correlation Analysis

	NO_2	SO_2	PM_{10}	$PM_{2.5}$
NO_2	1			
SO_2	0.306176474	1		
PM_{10}	0.56493302	0.300077856	1	
$PM_{2.5}$	0.584447198	0.170265565	0.808377052	1

Table 2. Correlation Analysis of all four pollutants.

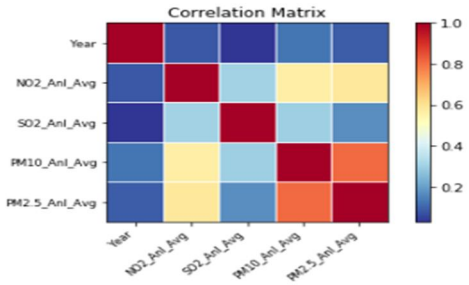


Figure 2. Correlation Matrix of Four Pollutants

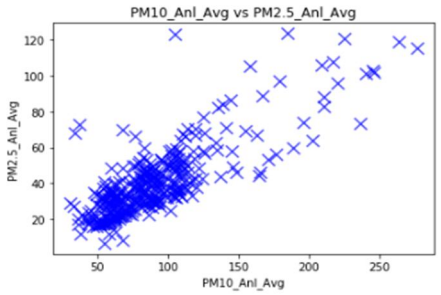


Figure 3. Scatter Plot Diagram of PM10 and PM2.5

From Table 2 and Figure 2 there is a high correlation between PM_{10} and $PM_{2.5}$. All other pollutants mark very low correlation. This high correlation of 0.8 shows that $PM_{2.5}$ is the smaller version of PM_{10} and $PM_{2.5}$ is the broken parts of PM_{10}. Never the less we can recognize that those cities which have a high level of PM_{10} also marks a high level of $PM_{2.5}$.

Figure 3 shows the scatter plot diagram of PM_{10} and $PM_{2.5}$ and it shows that there is a high level of correlation between values of 30 – 150 µg/m^3 of PM_{10} and 10 – 70 µg/m^3 of $PM_{2.5}$.

The PM_{10} and $PM_{2.5}$ is the reason for visibility reduction and the most common reason for an increase in Particulate Matter are construction work and fuel combustion.

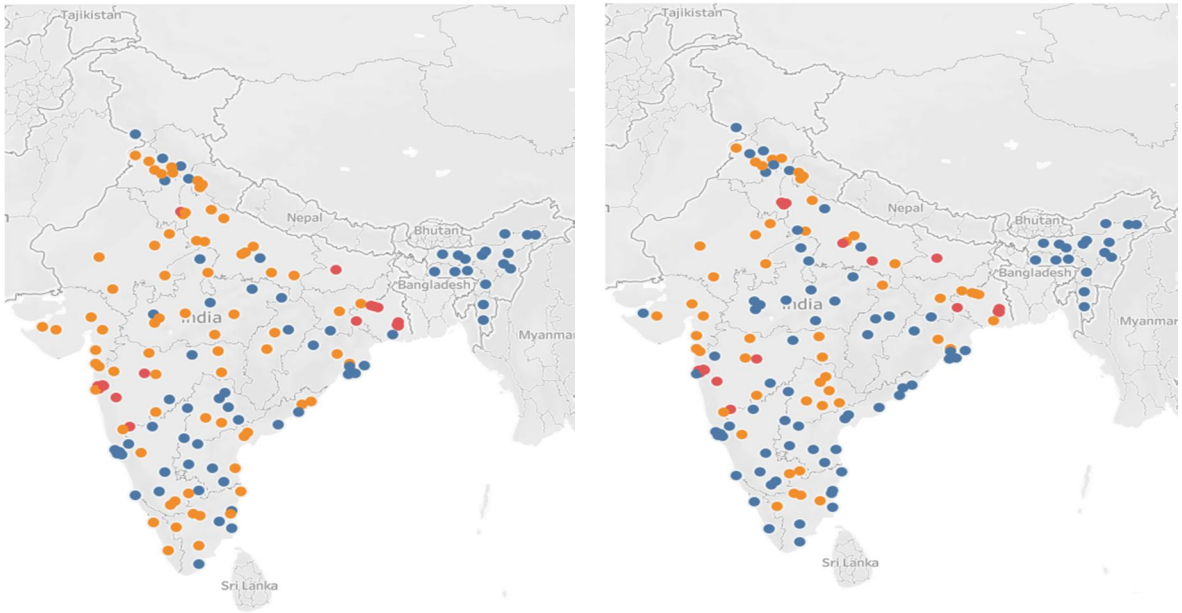
The death toll for 2017 is 1.2 Million with 0.6 million is due to Particulate Matter as per the report from Global Alliance on Health and Pollution. The average of 550 calls per day related to road accident due to smog is reported in wee hours in Delhi NCR.

The major sources of PM_{10} are due to building construction and fuel combustion in India. As per the report from the Business world [9]. Mumbai Metropolitan City (MMC) has topped the list with highest ongoing construction with 5.88 lakhs units are under construction that accounts for 31% of overall construction stock. National Capital Region (NCR) accounts for 5.40 Lakhs of units under construction that account for 29% of overall construction stock. Pune has more than 2.97 lakhs of the unit under construction followed by Bengaluru with 2.28 lakhs units, Hyderabad with 72,300 units, Chennai with 64,300 units are under construction Kolkata has 95,100 units under construction.

These seven cities are also those cities which are under threat of high level of PM concentration in air. These alarming figures point a finger on the rapid development or the mistakes undergoes during construction works that the builders overlook.

C. Cluster Analysis

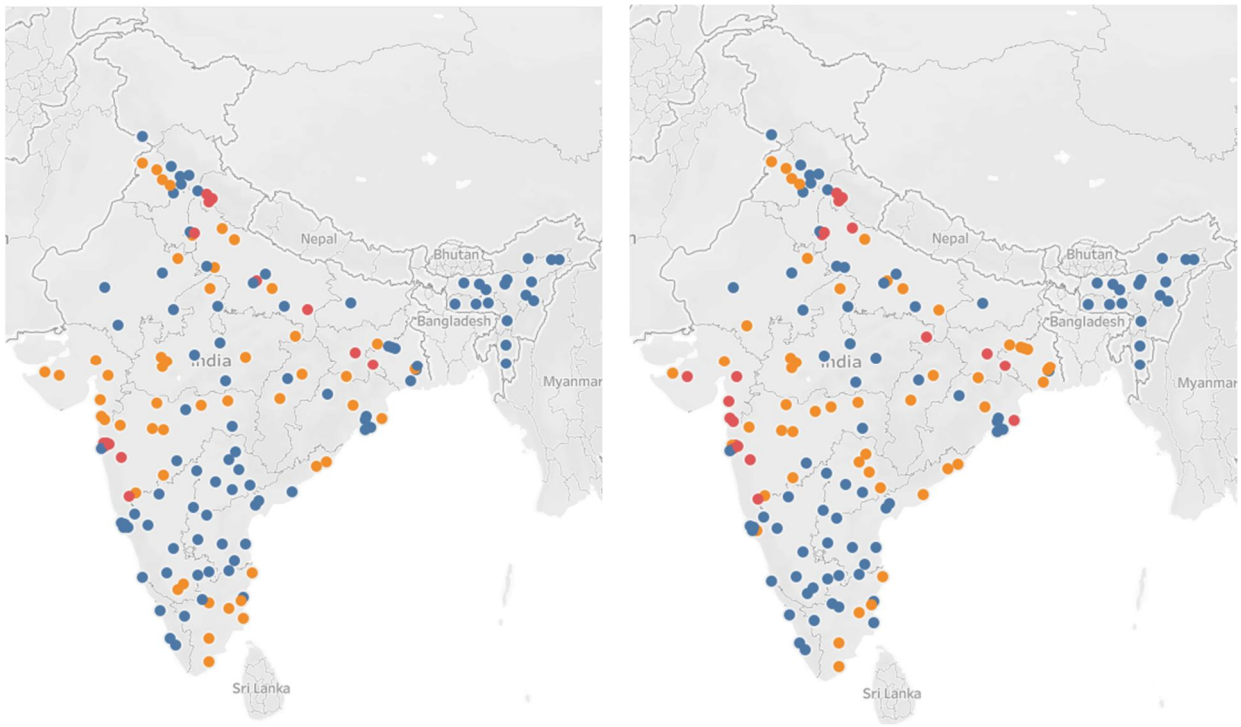
1) Nitrogen Oxide NO_2



2015 2018

Figure 4. Cluster Analysis of NO_2 for two years 2015 and 2018.

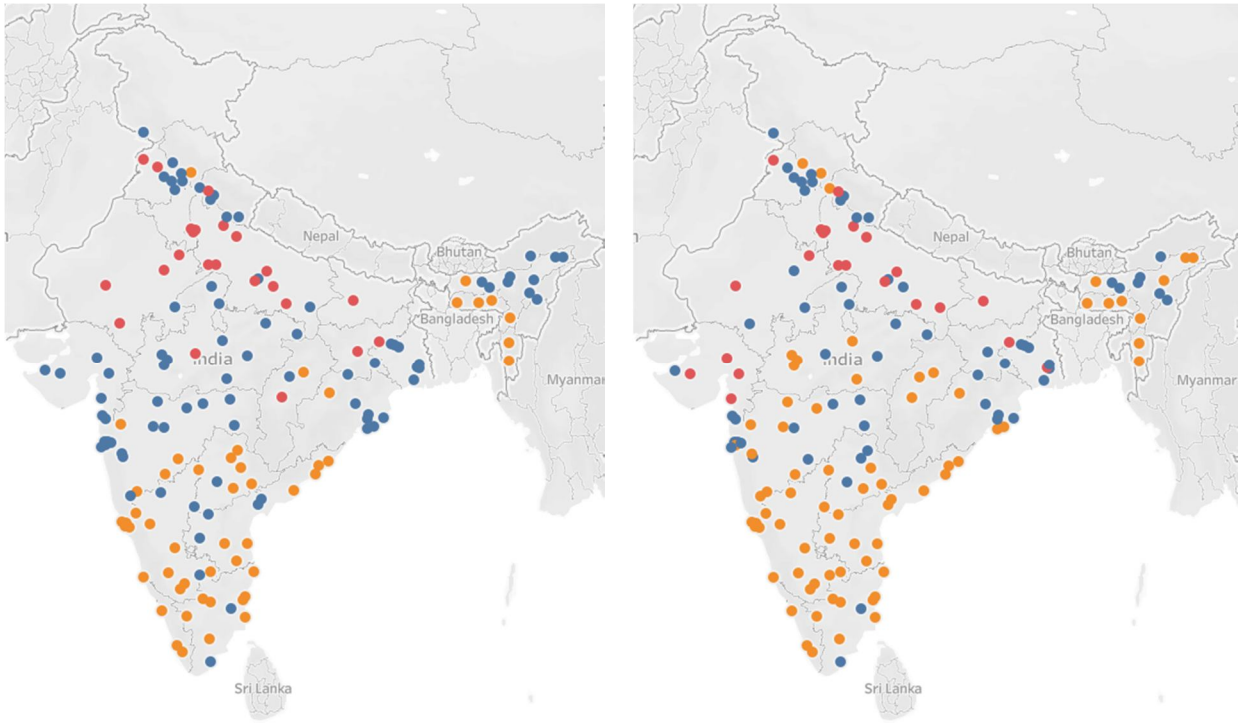
2) Sulphur Dioxide SO_2



2015 2018

Figure 5. Cluster Analysis of SO2 for two years 2015 and 2018.

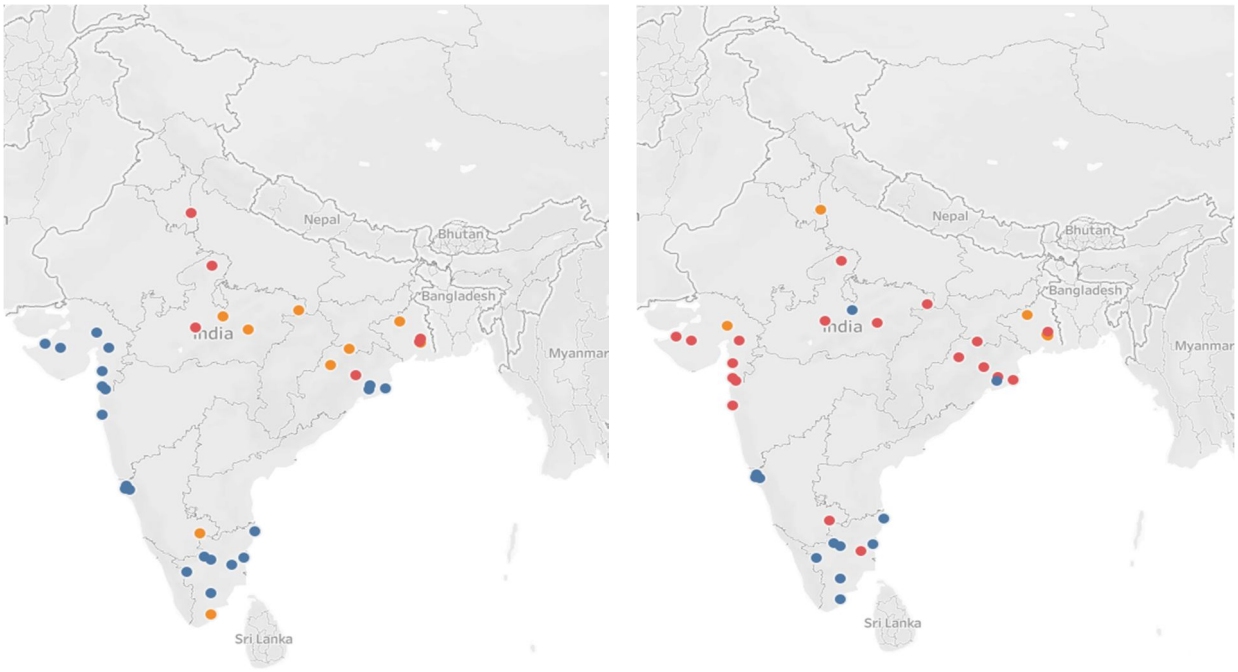
3) Particulate Matter 10 (PM_{10})



2015 2018

Figure 6. Cluster Analysis of PM10 for two years 2015 and 2018

4) Particulate Matter 2.5 ($PM_{2.5}$)



2015 2018

Figure 7. Cluster Analysis of $PM_{2.5}$ for two years 2015 and 2018

Figure 4, 5, 6, 7 Shows the cluster analysis of NO_2, SO_2, PM_{10} and $PM_{2.5}$ and comparative analysis of two years 2015 and 2018. From Geographical map, we can easily recognise those cities which has entered the red zone and which has left the red zone. States like Gujrat, Maharashtra, Karnataka, West Bengal, Orissa, New Delhi and Uttar Pradesh have shown a surge in pollution level. Although most of the metropolitan cities lie in these states. The cluster analysis recognises those cities where the pollution has surged and where the authority has failed to control the pollution while it also recognises those cities where the authority has succeeded in controlling pollution.

The state of Gujrat has severely deteriorated within three years and moved from least polluted to the most polluted cluster. These cities are Ahmedabad, Surat, Rajkot and Vadodara. Rapid Industrialization and making Gujrat a financial hub along with GIFT city project may be the reasons for this.

V. CONCLUSION

Coming back to a major threat to the cities are particulate pollutants that have covered almost 80% of Monitored cities by CPCB. PM_{10} has a major impact in metropolitan cities and those cities where fuel combustion is high. Another main reason for particulate matter is road dust thus cleaning of road and weighing it through water can help. From CPCB (2010) [10] study (and previously published studies like [11]-[13]), we know areas that need action. These include emissions from power plants and industrial plants units, waste burning, resuspension of road dust and dust from construction activities, etc. [14].

Pollution in India is a result of many sectors and focusing on only one sector will not improve air quality. Just looking into construction sites, fuel combustion and peak season stubble burn can never settle the issue. Curbing one sector may lead to a rise in another. A holistic approach is required so that it can address pollution across each sector.

VI. RECOMMENDATION

Over the past decade, everyone is concerned about the rising pollution level thus the government and many other institutions have taken many initiatives to shun the air pollution level. Many programmes and measures are taken are known but we recommend that these five major Innovative techniques are to be employed by the authority and also provide financial support to prevent air pollution, a report by Rene Van Berkel, Representative of India of the United Nations Industrial Development Organisation [15].

Chakr Innovation has developed the world's first retrofit emission control device for a diesel generator that captures over 90% of Particulate Matter emission from the exhaust of the generator without any adverse impact on the engine. The captured pollution is then converted into Ink. The Chakr shield was patented in 2016 [16].

Navalt Solar and electric boats Pvt. Ltd. has developed ADITYA India's first solar ferry that has 75-seater arrangement and takes 80% of its power from the sun and can cruise for 6 hours in sunny day. The boats are cost-efficient with on $2.5 as compared to $110 for diesel ferry. ADITYA has transported 500,000 people and travelled 20,000 Kms without a single drop of fuel and saved 35000 litres of diesel that converts to 94 tonnes of CO_2 and 8 tonnes of other harmful emissions [17].

Cellzyme Biotech uses engineered enzyme to make antibiotics at room temperature without using solvents – the main contributor to air pollution. This technique has reduced ecological footprints [18].

Agnisumukh uses radiant heat for cooking that saves around 30% of LPG and 29 tonnes of water, 110961 trees, 591 tonnes of oxygen and 2250 tonnes of CO_2 emission by eliminating charcoal-based traditional cooking [19].

Biomedical Waste Management with the help of Microwaves that eliminates POPs (Persistent Organic pollutants) - a toxic chemical having an adverse effect on health and environment.

These five innovative ideas aids in the recent development of air pollution management. Other major development is National Air Clean Development (NACP) in 2019 that covers 102 cities of India. Another breakthrough primarily for New Delhi City was Odd-Even rule [20] – [21]. I suggest these programmes to be appreciated and employed in other cities also.

VII. ACKNOWLEDGEMENT

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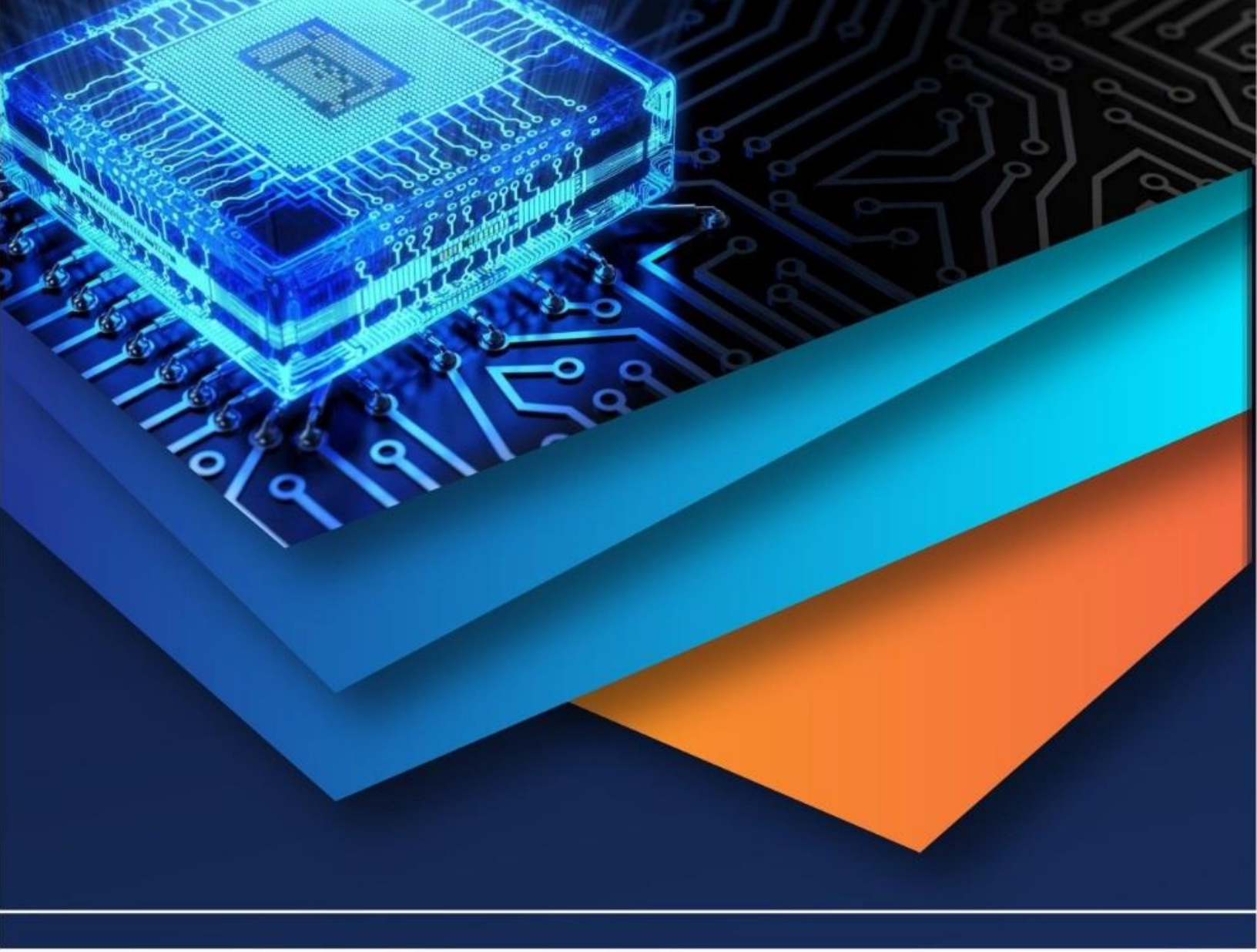

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