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Review of Air Quality Monitoring: Case Study of India

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Abstract

Air pollution is one of the foremost and grave public health and environmental anxiety in most of evolving countries.

Objectives: The objective of this paper is to provide insight details about current situation of air quality across various cities present in India, along with countless origins and effects of air pollution. An attempt is made to make people aware about various types of gases and particulate matter present in air highlighting their effects on environment along with the various ways of overcoming this situation. **Methods:** The National Air Quality Index (NAQI) ensures comparison amongst various cities so that new measures can be formulated in order to decrease the quantity of particulate matter present in air. In this paper concentration of various pollutants along with various harmful gases for various cities of India are analyzed based on past NAQI data thereby highlighting those areas which are under extensive menace of pollution. **Findings:** It has been perceived from past few years that the rate at which Urban Air Pollution across India has grown is alarming due to severe unsafe web of particulate matter (PM) and harmful gases present in air that living organism's breath. Levels of particulate matter are extremely higher in all cities of India. Only few cities are such that can be emphasized where Air Quality Monitoring (AQM) has started due to which they show some enhancement in quality of air but mostly affected areas are small and medium sized towns which suffer from phenomenal spurt in pollution in very critical manner. Due to increase in immense number of vehicles, industries and manufacturing units has resulted in excess assembly of pollutants in air making air pollution as a state of national emergency across various cities around the country.

Keywords: Air Quality Monitoring, Gaseous pollutants, National Air Quality Index, Particulate Matter

1. Introduction

For developing countries like India air pollution has tremendous impact on human vigor, agricultural practices, climatic variations and overall changes in ecosystem. Every year almost six lakh Indians die due to side effects of air pollution which has become fifth leading cause of death across the country after other causes like water pollution, nuclear pollution etc. Out of these, almost 35,000 death occur in national capital i.e. Delhi, rest 15,000 deaths are recorded in each industrial areas¹. Though almost complete key attention is paid towards national capital due to which other cities and towns are

suffering. Other cities that are suffering due to extensive threat of pollution are Ghaziabad, Punjab, Patna, Raipur, Agra and many more. Almost all the cities are suffering due to increase in concentration of Particulate Matter (PM) in air along with gaseous pollutants like oxides of nitrogen, sulphur along with other toxic materials that are already causing serious damage to environment. Only few cities are such that can be highlighted where Air Quality Monitoring (AQM) has started due to which they show some improvement in quality of air but mostly affected areas are small and medium sized towns which suffer from phenomenal spurt in pollution in very critical manner.

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The central pollution control board that has started a national air quality monitoring program since 1984 under which various air pollutants like sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and particulate matter having size less than 10 micron (PM_{10}), covering 254 towns and cities in 29 states and five union territories. This program operates 612 monitoring stations present at different places in various cities. From continuous monitoring it has been observed that 46 cities in India having population greater than one million are excessively polluted.

The aim of this paper is to provide comprehensive review of air quality monitoring practices in India with objectives: to identify critical problem areas suffering from severe air pollution by an objective assessment of state of practice and to recommend suitable measures for improvement were ever applicable. In this paper ten major cities have been taken into consideration for air quality monitoring, these cities have been so chosen bearing in mind the fact that these cities are major center for commercial, industrial and tourist activities due to which rate of environment worsening is high.

2. Materials and Methods

2.1 Air Pollutants

Major pollutants present in air are basically categorized into following types:

- Carbon Compounds: Oxides of carbon (Carbon dioxide (CO_2), carbon monoxide (CO)) mostly released from all vehicles and burning of fossil fuels.
- Sulphur Compounds: SO_2 , NO_2 , HNO_3 released from power plants and all industry units.
- Ozone: (O_3) its level in air rises due to change in.
- Chlorofluorocarbons: Released in excess from industries, insecticides sprays etc.
- Hydrocarbons: Mostly benzene, benzophrene etc. released from vehicles.
- Metallic Pollutants: In excess lead, nickel, arsenic beryllium, tin, vanadium, titanium, vanadium etc. present in all three basic states as solid, liquid or in gaseous form.
- Photochemical pollutants: Photochemical smog, PAN.
- Particulate matter: Fly ash, grit, dust and Suspended Particulate Matter (SPM) released from hydroelectric power plants and industries. It also can include bacterial cells, fungal spores and pollen in air.

2.2 Sources

There are numerous sources for occurrence of air pollution; some of these sources can be widely classified into following types.

2.2.1 Vehicles – A Major Cause

The toxic pollutants released from various vehicles are major source of air pollution. Due to rapid growth in use of personal vehicles rather than using private vehicles have not only increased extensive demand of vehicle oil but also have increased the concentration of particulate matter in air². This steady shift has also led to change of transport pattern as nowadays people prefer roadways rather than using railways. By the end of 2010 it was estimated that India has more than 5 million vehicles running out of which 65% vehicles are two wheelers working on petrol. Across major cities of country 800 to 1000 tons of pollutants are released into air daily out of which 50 percent come from vehicle exhausts. It has been estimated that by the end of 2035 the total Indian fuel demand will be six times the fuel demand recorded in year 2005. There is a wider shift in choice of persons personal vehicles as most of the people prefer bigger vehicles that are usually compact, medium in size and use high quantity of fuel. It has been estimated by the end of 2030-31 that if 50 percent of India's fuel efficiency is achieved by revising energy policies then India can save 65 percent of its total energy consumption and decrease CO_2 emissions equal to removing seven millions of four wheelers. Overall 15 percent of total CO_2 is released into air through transport sector in India. It has been found that 6 percent increase in quantity of CO_2 emissions occurs per year³. Table 1, gives the average data related to various pollutants released from vehicles for metropolitan cities

Table 1. Average Pollutant Percentages Released from Various Metropolitan Cities

Type of pollutant	Percentage value
carbon monoxide	70%
hydrocarbons	50%
oxides	30–40 %
SPM	30 %

For a vehicle without cleaning device on using 1000 gallons of petrol it releases 3200 lb. of CO , 2200–2400 lb.

of organic vapors, 25-75 lb of NO_x and 0.3 lb. of solid carbons. The chief sources of emission from any vehicles are:

- Exhaust System: Produces unburnt hydrocarbons, CO , NO_x , SO_x , lead oxides etc.
- Fuel tank and Carburetor: Produces hydrocarbons.
- Crankcase: 25% of hydrocarbons.

2.2.2 Industrial Wastes and Thermal Power Stations

Due to rapid industrialization and establishment of multiple factories, large number of industries have been running from past releasing chief pollutant gases SO_2 and NO_2 . It has been observed that Mathura based oil refineries are leading to deterioration of Taj Mahal and other monuments at Fatehpur Sikri². Along with industries there are numerous thermal power plants where coal consumption is in millions of tonnes and chief pollutants released are fly ash, hydrocarbons, SO_2 along with other gases⁴. Table 2 gives the data related to various pollutants released from a 200 MW thermal power plant where, total coal consumed is 1400 tonnes per day.

Table 2. Pollutants Emitted out from 200 MW Thermal Plant

Components	Emission factor Kg/ton of coal	Emitted quantity (tonnes per day)
Aldehydes	0.0025	0.0035
Carbon monoxide	0.25	0.35
NOX	0.01	0.14
Oxides of Sulphur	19(S)	13.34
Particulate matter	8(A)	369.6
Ash	2(A)	92.4

(A) Ash content in coal percent, (S) Sulphur content in coal per cent

2.2.3 Other Anthropological Sources

Apart from major sources given above, the following activities also play a vital role in causing air pollution:

- Burning up of crop wastes by farmers.
- Stoves and incinerators.
- Refrigeration activities and sprays of aerosol.
- Methane generation due to waste deposition in landfills.
- Verification of nuclear weapons by army personnel's.

- Dust particles generated from any natural sources.
- Uncertain volcanic activities producing high content of fumes, ash and other severe gases.
- Uncertain Forest fires.
- Decomposition of animals leading to production of methane.

2.3 Effects of Air Pollution

Air pollution causes wide range of side effects not only on environment but also on the various organisms dwelling in that environment. Some of those side effects have been summed up below⁵

- Enhanced ageing of lungs along with damage of lung capacity along with short term irritation in sense organs.
- Main cause of asthma, bronchitis, emphysema etc.
- Reduction in life span.
- Damage of shoots and upper vegetative cover of plants due to acid rain⁶.
- Depletion of soil nutrients due to reaction of nutrients with acid rain.
- Changes in physical appearance in vegetative cover due to intake of sulphur dioxide and ozone (flecking, tanning or bleaching)
- Eutrophication in rivers and other water bodies.
- Damage to constructed structures due to acid rain.

2.4 Research Facts about Air Pollution in India

- It has been observed that most of the established industries and factories do not obey environmental safety guidelines and laws⁷.
- From recent 2015 survey, India is labelled to be world's seventh environmentally unsafe country.
- Three parts of total pollution is caused due to automobiles running on daily basis emitting about 40 different types of pollutants⁷.
- Selling of adulterated fuels in India is so common in practice that in return environmental air quality is paying the price of using it?
- Bangalore city is termed as asthma city as about 30% children at that place suffer from asthma caused due to air pollution.
- Rate of cancer patients is also increasing in India, as per National Cancer Control Program (NCCP) by the year 2026 about 1.4 million people will be suffering from cancer.

- If considered hospitalized persons, 13% deaths occur due to acute respiratory disorders.

2.5. Current Status of Air Quality Monitoring in India

The National Air Quality Index (NAQI) has been announced as a regulatory body by government as a reporting standard to measure air quality levels to ensure comparison between various cities so that new measures can be devised in order to decrease the quantity of pollutants present in air⁸. No doubt the NAQI inadequately reveals that 23% of workstations across India are on alarming rate showing more than 70% of increase above permissible limits thus making air pollution as a state of national emergency across various cities around the country⁹. Comparison was done of Indian pollution levels with china due to the fact that population level of China is greater than India. On comparing the pollution levels between Indian cities and cities of China, it has been found that Indian pollution level is increased to a greater extent as compared to China clearly giving us an idea that these levels are ten times greater higher than WHO standards highlighting air pollution as a major concern in India. As per the analysis performed by Green Peace India, Figure 1 on data provided on NAQI interface it was observed that air pollution is not only a major concern in National Capital only but people need to focus on other areas also apart from capital of country as the rate of pollution is alarming across various regions of India. While the basic motive of the organization is to reduce the levels of particulate matter PM10 and PM2.5. As per World Health Organization, Figure 2 it was found that National Capital has pollution level 12 times higher than permissible limits along with other cities – Lucknow,

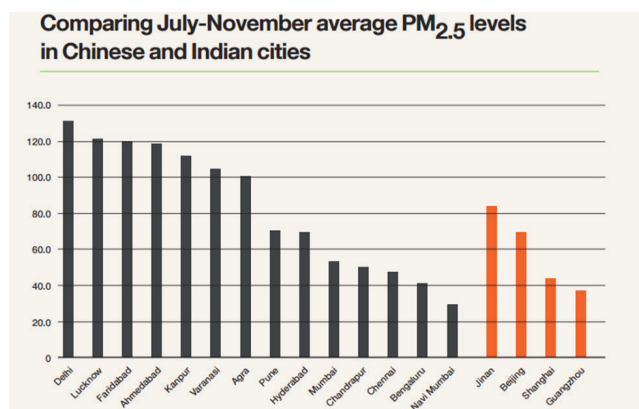


Figure 1. Source: Green Peace India: Comparison of Pollution Levels Across Various Indian Cities with Cities of China.

Faridabad, Kanpur, Agra and Varanasi whose levels have exceeded ten times. As per World Health Organization latest report of 2014, 20 cities were shortlisted as world's most air polluted cities out of which 13 were from India. No doubt the basic reason for such a situation is rapid industrialization and uncontrolled motorization thus attention is to be given towards such situation as it has become a global issue now¹⁰.

2.6 Current Scenario of Air Quality in Various Cities⁴

2.6.1 Agra

It is spread over an area of approximately 140 sq. km with population of 9.5 lakhs along with moving population of 20,000 as per 1991 census. Main causes of air pollution are foundry industries which practices coal as a fuel along with vehicular discharges as vehicular growth is high. As per National Ambient Air Quality Standards (NAAQS) level of SO₂ was found to be lower in all monitored periods but NO₂, RSPM and SPM levels were found to be cooperatively exceeding. The concentration of pollutants were found to be higher in winter seasons but were lower in summer and monsoon seasons. As per 2005 NAAQS survey, concentration of pollutants found is given in Table 3.

Table 3. Concentration of Pollutants Found at Agra

Pollutants	Concentration (µg/m ³)
SO ₂	10
NO ₂	27
RSPM	190
SPM	430

Percentage of days when pollution exceeded national standards

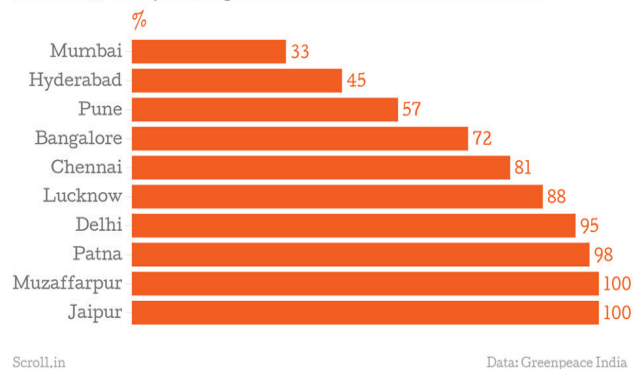


Figure 2. Source Green Peace India: Pollution Levels of Various Indian Cities.

2.6.2 Ahmadabad

It is also known as Manchester of East due to presence of large number of textile industries. Being one of industrial cities of India, main sources of pollution being industrial and vehicular sources along with coal fired hearth in slum units and bakery units. As per National Ambient Air Quality Standards (NAAQS) level of SO₂ and NO₂ was found to be lower in all monitored periods but RSPM and SPM levels were found to be cooperatively exceeding. The concentration of pollutants were found to be higher in winter seasons but were lower in summer and monsoon seasons as per 2005 NAAQS survey, concentration of pollutants found is given in Table 4.

Table 4. Concentration of Pollutants found at Ahmadabad

Pollutants	Concentration (µg/m ³)
SO ₂	12
NO ₂	28
RSPM	150
SPM	360

2.6.3 Bangalore

It is considered to be biggest industrial, commercial, educational, information technology and bio technology center in India, along with major sources diesel generator sets are continuous source of pollution. As per National Ambient Air Quality Standards (NAAQS) level of SO₂ was found to be very low and NO₂ was found to be moderate in all monitored periods but RSPM and SPM levels were found to be cooperatively exceeding. The concentration of pollutants were found to be higher in winter seasons and summer but were lower in monsoon seasons as per 2005 NAAQS survey, concentration of pollutants found is given in Table 5.

Table 5. Concentration of Pollutants found at Bangalore

Pollutants	Concentration (µg/m ³)
SO ₂	11
NO ₂	48
RSPM	73
SPM	140

2.6.4 Chennai

It is considered to be fourth largest city in India with surface, sea and air transport services with other sources of pollution being industrial boilers and generator sets. As per National Ambient Air Quality Standards (NAAQS) level of

SO₂ and NO₂ was found to be lower in all monitored periods but RSPM and SPM levels were found to be cooperatively exceeding. The concentration of pollutants were found to be higher in winter seasons but were lower in summer and monsoon seasons. As per 2005 NAAQS survey, concentration of pollutants found is given in Table 6.

Table 6. Concentration of Pollutants found at Chennai

Pollutants	Concentration (µg/m ³)
SO ₂	18
NO ₂	22
RSPM	74
SPM	130

2.6.5 Delhi

It is the capital of India considered to be most polluted in India with lot of vehicular emissions and thermal power plants releasing SPM, hydrocarbons, CO, sulphur, oxides of nitrogen and carbon monoxide¹¹. Air pollution load (tonnes/day) from thermal plants is given in Table 7. As per National Ambient Air Quality Standards (NAAQS) level of SO₂ and NO₂ was found to be lower in all monitored periods but RSPM and SPM levels were found to be cooperatively exceeding. In addition to these other pollutants found in the area was carbon monoxide (CO) whose level was very high in initial years but it has lowered to some extent due to follow up of pollution control measures in city. The concentration of pollutants were found to be higher in winter seasons but were moderate in summer and lower in monsoon seasons. As per 2005 NAAQS survey, concentration of pollutants found is given in Table 8.

Table 7. Concentration of Pollutants from Thermal Plants at Delhi

Thermal capacity	SO _x	NO _x	PM (without control device)	PM (without control device)
1083	61	91	3242	162

Table 8. Concentration of Pollutants found at Delhi

Pollutants	Concentration (µg/m ³)
SO ₂	11
NO ₂	48
RSPM	130
SPM	290

2.6.6 Hyderabad

It is known for wealthy Nizam's and reported to have 11 lakh vehicles around city. With vehicles as foremost cause of pollution subsidizing to bulk of unburnt hydrocarbon and carbon monoxide. Levels of SO_2 and NO_2 found to be lower but RSPM and SPM are found to be very high. The concentration of pollutants were found to be higher in winter seasons but were moderate in summer and very lower in monsoon seasons. As per 2005 NAAQS survey, concentration of pollutants found is given in Table 9.

Table 9. Concentration of Pollutants found at Hyderabad

Pollutants	Concentration ($\mu\text{g}/\text{m}^3$)
SO_2	8
NO_2	20
RSPM	60
SPM	230

2.6.7 Jharia

It is widely famous hub for coal mining activities with numerous mines operational from last 40 decades. Additions to it are about 103 small scale industries present in the town. As per National Ambient Air Quality Standards (NAAQS) level of SO_2 was found to be lower in all monitored periods along with moderate levels of NO_2 but RSPM and SPM levels were found to be cooperatively exceeding. The concentrations of pollutants were found to be higher in winter seasons but were moderate in summer and lower in monsoon seasons. As per 2005 NAAQS survey, concentration of pollutants found is given in Table 10.

Table 10. Concentration of Pollutants found at Jharia

Pollutants	Concentration ($\mu\text{g}/\text{m}^3$)
SO_2	16
NO_2	46
RSPM	160
SPM	290

2.6.8 Kanpur

It is considered to be main center of industrial and commercial activities and biggest producer of textiles and leather products. Levels of SO_2 and NO_2 found to be lower but RSPM and SPM are found to be very high. The concentration of pollutants were found to be higher in winter seasons but were moderate in summer and lower in monsoon seasons

As per 2005 NAAQS survey, concentration of pollutants found is given in Table 11.

Table 11. Concentration of Pollutants found at Kanpur

Pollutants	Concentration ($\mu\text{g}/\text{m}^3$)
SO_2	14
NO_2	17
RSPM	190
SPM	410

2.6.9 Kolkata

It is known for iron foundries, mills, metal furnishing units etc. apart from vehicles pollutants are generated from various large scale industries, power plants, domestic units. As per National Ambient Air Quality Standards (NAAQS) level of SO_2 was found to be lower in all monitored periods along with high levels of NO_2 but RSPM and SPM levels were found to be cooperatively high. As per 2005 NAAQS survey, concentration of pollutants found is given in Table 12.

Table 12. Concentration of Pollutants found at Kolkata

Pollutants	Concentration ($\mu\text{g}/\text{m}^3$)
SO_2	14
NO_2	45
RSPM	140
SPM	310

2.6.10 Lucknow

It is known as most populous state having silver, copper, brass and cotton small and medium industries. As per National Ambient Air Quality Standards (NAAQS) level of SO_2 and NO_2 was found to be lower but RSPM and SPM levels were found to be cooperatively high. As per 2005 NAAQS survey, concentration of pollutants found is given in Table 13.

Table 13. Concentration of pollutants found at Lucknow

Pollutants	Concentration ($\mu\text{g}/\text{m}^3$)
SO_2	11
NO_2	28
RSPM	190
SPM	410

3. Results and Discussion

On comparing concentration of levels of pollutants for various cities, as per Figure 3, 4, 5, 6 it was found that:

- SO_2 concentration of Hyderabad was found to be lowest and highest was of Chennai.
- NO_2 concentration of Kanpur was found to be lowest and highest was of Delhi and Bangalore.
- RSPM concentration was found critical in all cities among which low critical level was found in Hyderabad and extreme critical levels were found in Lucknow, Kanpur and Agra.
- SPM concentration was found very critical in all in all cities among which low critical level was found in Chennai and Bangalore and extreme critical levels were found in Lucknow, Kanpur and Agra.
- Mostly concentration of pollutants was found to be higher in winter seasons.

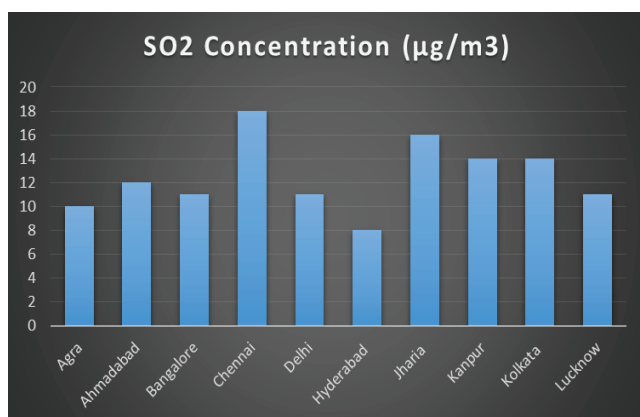


Figure 3. Comparison of SO_2 Concentration of 10 Cities.

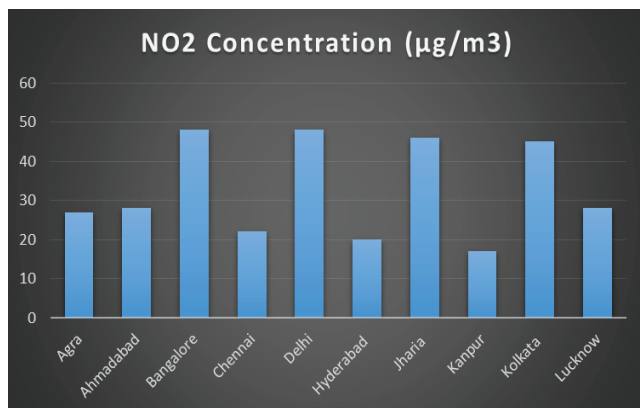


Figure 4. Comparison of SO_2 Concentration of 10 Cities.

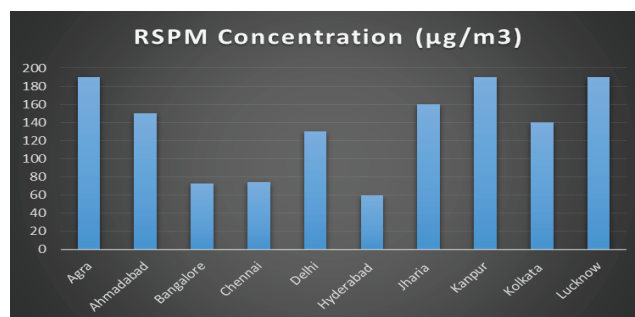


Figure 5. Comparison of RSPM Concentration of 10 Cities.

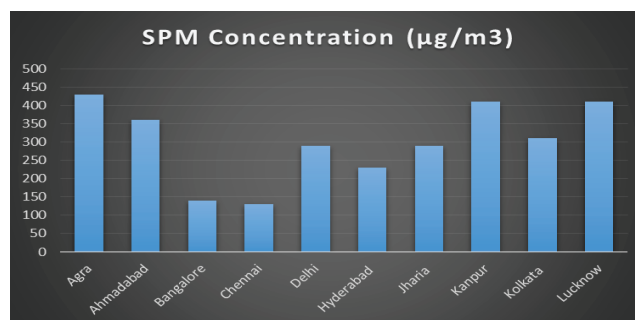


Figure 6. Comparison of SPM Concentration of 10 Cities.

3.1 Preventive Measures Followed in India

Air pollution and control act passed in 1981 and amended in 1987 to ensure prevention, control and abatement of air pollution in India. Supreme Court has taken air pollution prevention seriously by taking several initiatives like making use of compresses natural gas in public services mandatory due to which cumulative percentage of pollution has decreased. Reduction of pollution causing substances in fuels like extraction of excess sulphur and benzene from diesel, use of standardized fuels along with increased rate of use of LPGs replacing biomass fuels have also helped in decline of pollutants present in air in most parts of India¹²⁻¹³. Introduction of metro's have also helped in decrease in pollution rates as use of personal vehicles have decreased to larger extent⁷. In past shut down of hazardous gas emitting industries, hot mix plants and brick producing kilns being operated in Delhi have also made people to think about nature, extent and types of pollutants released in air, along with it introduction of unleaded petrol from year 1998 in vehicles have also helped in reduction of air pollutants. In most of cities in India a provision for vehicles is made in which vehicles is certified as "pollution under control" with validity of three months after proper testing under norms of Bharat Stage 2nd or higher emission norms, along with it

pollution control board present in every state perform ambient air quality monitoring at workstations present all over states across the country to keep continuous track about air pollution levels and applying corrective actions wherever necessary¹⁴. Many organizations have been established that work in hand with government to make necessary efforts to reduce air pollution for example Energy and resource institute, and Indian association for air pollution control, society of Indian automobile manufacturers etc are actively involved in prevention of air pollution.

4. Conclusion

From the given data it can be concluded that level of RSPM and SPM are extremely higher in all cities of India.

- Major cause of generation of pollutants was common in all monitored cities i.e. vehicles and automobiles.
- In past, several initiatives have been taken by Indian government to reduce air pollution across country but still lot of efforts need to be done to reduce it further.
- It is better to prevent air pollution rather than allowing it to increase and well known proverb 'charity begins at home' suits here, we need to understand the causes, effects and measures to reduce pollution then only we can decrease pollution levels to ensure better environment for future generations.
- More efforts are required for making air quality monitoring a national issue by creating more awareness and following certain laws and rules to decrease the level of pollutants in air.
- One needs to use public automobiles often and try to avoid use of excess personal automobiles as it will help to not only to decrease the excess vehicle congestion on roads but also help in decreasing pollution.
- Energy efficient commodities must be utilized wherever possible as they tend to save energy along with having low negative effects.
- Existing policies and strategies need to be strengthened more to ensure more positive results.
- People should prefer public transport rather than using personal vehicles.
- More vehicle evaluation on regular intervals needs to be done based on air pollutants emissions and proper certification should be given to vehicles.
- Awareness needs to be created among people related to health effects of air pollution so that people start taking it seriously and breathe a safer and pure air.

5. Acknowledgement

For all the work done in this review paper I would like to express my deepest gratitude to my mentor, Miss. Kirti Goyal Assistant Professor, Environment Department, Lovely Professional University whose contribution in stimulating suggestions, guidance and encouragement from initial to final level in collecting and analyzing various data helped me a lot in writing this review paper.

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