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Research Article

STATUS OF AMBIENT AIR QUALITY IN SELECTED STATE CAPITALS AND METROPOLITAN CITIES OF INDIA

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A B S T R A C T

Air pollution is a major environmental concern around the whole world. Over last decades increase in industrialization, urbanisation and rapid growth in population has led to retrogression environmental conditions. Due to the challenge of strengthening the economy of the country, India is facing issues in protecting its environment. India ranked ninth most polluted country in the world as per2014 WHO report. According to this report, 80% of the urban population is exposed to the air quality levels which exceeded the standard limits. Major polluted cities in India contains high-level criteria of pollutants like Sulphur Dioxide(SO2), Nitrogen Dioxide(NO2), Particulate Matter(PM), Greenhouse gases, Ozone precursors and aerosols etc. which deteriorate the environment. In this assessment, three air pollutants are monitored for air quality evaluation from 7 topographical different cities (Chandigarh, Ahmedabad, Bhopal, Chennai, Kolkata, Shillong, Thiruvendrum) which are SO2, NO2 and PM10.There are various health risks of these air pollutants like higher respiratory illness rates, heart diseases, chronic bronchitis, pulmonary emphysema, Pneumonia, cancer, eye irritation,. The air quality data generated at various monitoring stations of selected cities from 2005 to 2015 is compiled and analyzed. The study shows fluctuating trends which indicates the level of pollutants from 2005 to 2015 where SO2 and NO2 are more or less stable and coming under the NAAQS limits whereas PM10 shows increment in its levels until 2013, then decrement in 2014 and 2015.The analysis of the data collected indicates that, there is need to focus on non-exhaust emission including municipal waste and biomass burning, a rapid decrease in vehicles, the decrease in forest area etc. it has been also seen that topographical and meteorological conditions also play an important role in increment or decrement of air pollution rate over the areas.

INTRODUCTION

The air of earth is a layer of gases encompassing the planet. Atmospheric air comprises of nitrogen, oxygen, argon, carbon dioxide, and some other gases in small quantity. Air also contains a variable measure of water vapor, by and large around 1% (Fenner *et al*., 1973).This composition determines its quality and is being changed in the recent past due to emission of large amount of un-natural materials in the atmosphere by industries and automobiles (CPCB,2006). This changed quality became a great threat to survival of life, properties, materials and ecosystem as a whole (Leonard, 1989). Urbanization in India is faster around the major cities. Increment in modern industrial activities, population, vehicular population and so forth have prompted various ecological issues, one of them being air contamination.

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(Ahmad and Sharma,2014;Chauhan *et.al*.,2010).Different contaminants consistently enter the climate through natural and man-made procedures and they interface with nature to cause infection, toxicity, ecological decay and are marked as contaminant. Fast urbanization and industrialization has included different components/mixes to the unadulterated air and along these lines caused the expansion in contamination. (Chauhan *et.al*. 2010; Saravanan, 2007). Air pollutants can be **natural** or might be the aftereffect of different **anthropogenic** exercises. Encourage of the air contaminations can be primary or secondary relying on their development mechanism (Volkamer *et. al*., 2006). **Primary pollutants** are specifically produced/emitted from the source and **Secondary pollutants** are framed in the atmosphere. Meteorological variables assume a basic part in surrounding centralizations of air pollutants (Nazaroff and Weschler, 2004). Despite the fact that the aggregate release of air contaminations into the air may stay consistent, the encompassing groupings of air toxins may change contingent on the meteorological conditions.

Air contamination incorporates an assorted exhibit of natural and anthropogenic emissions, including gaseous constituents, volatile chemicals, aerosols (particulate) and their atmospheric reaction products(Chauhan *et.al*.,2017). Surrounding air goes about as an atmospheric sink, where all outflows are dissipated and absorbed (Saravanan, 2007; Volkamer *et. al*., 2006). Numerous such emissions are in such little amounts that they get promptly dispersed and retained at such rates that ceaseless arrival of these toxins develop noticeable all around and possess hazards to human wellbeing. Not withstanding contamination control endeavors, the air quality has been undermined to disturbing levels in a few urban areas all through the world. The World Health Organization (WHO) gauges that upwards of 1.4 billion urban inhabitants on the planet inhale air surpassing the WHO air quality rules.On a worldwide premise, increase mortality rate because of open air contamination is evaluated to be around 2.0 to 5.7 lakhs, speaking to around 0.4 to 1.1 percent oftotal annual deaths (Nazaroff and Weschler, 2004). The antagonistic impacts of air contamination are more pronounced in the developing nations. On the one hand, the developing countries are grappling with the environmental problems associated with inadequate economic developments, the hallmarks of which are malnutrition, poor sanitation, and lack of basic human needs (WHO, 2016; Biermann, 2017). On the other hand, in their pursuit for rapid economic development, the developing countries are confronted with a newer set of environmental problems due to increasing air pollution on account of industrialization, urbanization, and motorization (Shaik and Hossain, 2013). The air has a relative constant composition of gases and is utilized by most of the living organisms in respiration to liberate chemical energy for their survival.

Sources of Pollutants

Sources of air pollution vary with the various locations, activities or factors which are responsible for the releasing of pollutants into the atmosphere. These sources can be classified into two major categories which are anthropogenic sources (Stationary sources, Mobile sources) and Natural sources (Dust, Methane from digestion of food, radon gas from radioactive decay, smoke and fog from wildfires etc)(Volkamer *et. al*., 2006; Chauhan *et.al*.,2017).

MATERIALS AND METHODS

Study Areas: In this research paper 7 topographically different cities are selected and analyzedthe trend of SO_2, NO_2 and PM_{10} concentration in their environment from year 2005 to 2015. In table 2, the selected state capital's and metropolitan city's geographical location, climate, population and air monitoring stationhave been discussed. There were different monitoring station in cities which give real time data of pollutants concentration.

Methods of Measurement of Sulphur Dioxide (SO_2) in Ambient Air

Modified West and Geake method method was used to measure sulphur content present in the surrounding area. 0.04M solution of sodium tetrachloromercurate absorbs sulphur dioxide with an average flow rate of 1 litre per minute and results in the formation of dischlorosulphitomercurate complex. (West and Gaeke, 1956)

Sulphamic acid acts as reducing agent which prevents interference from nitrogen and converts oxygenated nitrogen to gas. EDTA also prevents interference from trace metals when added to unexposed absorbing solution. For analysis, treatment of exposed air is done with formaldehyde, sulphamic acid and acid bleached parasaniline containing HCl. Pararosaniline, formaldehyde and bisulfite anion react to form violet red colored pararosaniline methyl sulphonic acid. The intensity of the color is measured on a spectrophotometer at 560 nm wavelength. The detection range of the SO_2 concentration is 4 – 1050 μg/m^3 (Westand Gaeke, 1956; CPCB,2014)

Table 1 Sources of Air pollution and pollutants present .

Source Category	Types of Sources
Area Sources	Domestic cooking: Fossil fuel combustion Open burning (refuse/biomass/tyre etc. burning) Paved & unpaved roads Construction/Demolition/Alteration activities for buildings
Point Sources	Large scale industries and Power plants (Fossil fuel combustion). Medium scale industries; Fossil fuel combustion Small scale industries (28 industrial estates); Fossil fuel combustion
Line Sources	Heavy duty commercial vehicles (Diesel, CNG) Variety of fossil fuel (combustion) has been taken place in fuel specifications/types in all above categories.

Methods of Measurement of Nitrogen dioxide (NO_2) in Ambient Air

Solution of sodium hydroxide and sodium arsenite is used to absorb NO_2 from air as it's the major interfering compound. Adding hydrogen peroxide serves the purpose of eliminating SO_2 by converting it to sulphuric acid and hence prevents interference. The absorbed nitrogen dioxide is then reacted with sulphanilamide in the presence of phosphoric acid at a pH <2 and coupling it with N-(1Nepthyl) ethylene diaminedihydrochloride. The absorbance of the highly colored azo dye is measured on spectrophotometer at a wavelength of 540 nm. The detection range of the NO_2 concentration is 9 – 750 μg/m3 (Jacobsand Hochheiser, 1958).

Methods of Measurement of Respirable Suspended Particulate Matter (RSPM/ PM10) in Ambient Air

PM10 are the particulate matter having aerodynamic diameter less than or equal to 10 μm size suspended in air and representing the fraction that is considered to enter the respiratory system. PM10 may also be formed from other pollutants (acid rain, NOx, SOx, organics) and from incomplete combustion of any fuel (Marcazzan*et.al*, 2001) Monitoring of RSPM is carried out for 24 hours with 8-hourly sampling. RSPM is measured gravimetrically with GFA/EPM 2000 filter paper using respirable dust sampler. In a gravimetric method, air is drawn at a flow rate which is typically 1.1 m3/min through a size-selective inlet wherein the particulate matter is fractionated in two aerodynamic diameter size ranges, 0-10 micro meter called RSPM of PM_{10} and above 10 micro meter called coarse fraction. The PM_{10} is collected on a 20.3 X 25.4 cm (8 X 10 in) filter. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The concentration of PM_{10} is calculated by dividing the weight gain of the filter by the volume of air sampled (Rodrıguez *et.al*. 2004).

Table 2 Information regarding selected State capitals and metropolitical cities of India

City name	State	Air monitoring stations	Climate	Geographical Location	Population (census 2011)	References
Ahmedabad	Gujarat	6 (4 residential, 2 industrial)	Semi Arid Climate. There are three main seasons: summer, monsoon and winter. Aside from the monsoon season, the climate is dry	The city sits on the banks of the River Sabarmati, in north-central Gujarat. falls under seismic zone-III.	60,439,692.	(Mahadevia et.al,2014;Metro,2011;Ahmedabad2015)
Chandigarh	UT	2 (4 residential, 1 industrial)	Tropical type characterized by three distinct seasons	Chandigarh is located near the foothills of the Sivalik range of the Himalayas in northwest India . The city, lying in the northern plains, has vast fertile and flat land.	1,025,682.	(Metro,2011;Gov. Chandigarh,2015;Indian Meterological Department IMD,2015)
Shillong	Meghalaya	2(1residential, 1 other)	The city features a subtropical highland climate. Its summers are cool and very rainy, while its winters are cool and dry	The city lies in the center of the plateau and is surrounded by hills, three of which are revered in Khasi tradition: LumSohpetbneng, LumDiengiei and LumShillong	143,229.	(Bilham and England,2001;IMD 2015;Meghalaya,2011)
Bhopal	Madhya Pradesh	4 (2 residential, 2industrial)	Humid subtropical climate, with mild, dry winters, a hot summer and a humid monsoon season	Located in upper limit of the Vindhya mountain ranges, on the Malwa plateau. The area is occupied alluvial formations	1,883,381.	(Metro,2011; Bakshiand Ralhan,2007;IMD2015)
Chennai	Tamil Nadu	11 (7 residential, 4 industrial)	Tropical wet and dry climate. The weather is hot and humid for most of the year	Situated on the eastern coastal plains. Drained by Cooum River (or *Koovam*) through the centre, Adyar River to the south and Kortalaiyar on the northern fringes. Soil is mostly clay, shale and sandstone	8,696,010.	(Metro,2011;Chennai District,2012;IMD, 2012)
Thiruvanathapuram	Kerala	4 (2 residential, 1 industrial, 1 sensitive)	Tropical savanna climate and a tropical monsoon climate.	Thiruvananthapuram is built on seven hills by the sea shore on the west coast, near the southern tip of mainland India	1,687,406.	(Metro,2011;IMD 2014)
Kolkata	West Bengal	10 (7 residential, 3 industrial)	Tropical wet-and-dry climate. Summers are hot and humid.	Spread linearly along the banks of the River Hooghly in a north-south direction	14,112,536 7.	(Metro,2011; Dutta,2003; Ray Chaudhuriand Thakur,2006)

Table 3 Revised National Ambient Air Quality Standards, 2009, (Naaqs)

S. No.	Pollutants	Time Weighted Average	Concentration in Ambient Air: Industrial, Residential, Rural and other Areas	Concentration in Ambient Air: Ecologically Sensitive Area (notified by Central Government)	Methods of Measurement
1	Sulphur Dioxide (SO_2), µg/m³	Annual*	50	20	1. Improved West and Gaeke 2. Ultraviolet Fluorescence
		24 Hours**	80	80	
2	Nitrogen Dioxide (NO_2), µg/m³	Annual*	40	30	1. Modified Jacob & Hochheiser 2. Chemiluminescence
		24 Hours**	80	80	
3	Particulate Matter (Size <10µm) or PM_{10} µg/m³	Annual*	60	60	1. Gravimetric 2. TEOM 3. Beta attenuation
		24 Hours**	100	100	

Data Analysis

The air quality data generated at the monitoring stations are entered into data bank of CPCB known as Environmental Data Bank (EDB) by respective SPCBs and PCCs, where the data is scrutinized for outliers and gaps in input of data (CPCB-MOEF, 2014). In case of any gaps the matter is discussed with the respective agencies and later the data is checked, scrutinized, compiled, processed and analyzed statistically to get the information on the annual mean, standard deviation etc. of the pollutants and payment is also made to the respective agencies. Figure 3.1 shows the data flow in NAMP (CPCB-MOEF, 2003).In the present Paper, results of PM_{10}, SO_2 and NO_2, form the year 2005 to 2015 are presented.

RESULT AND DICSCUSSION

In order to set environmental requirement of ambient air quality the CPCB also adopted National Ambient Air Quality Standards (NAAQS) in 1982 for different land-uses, which were revised from time to time to make them more comprehensive and practicable. The NAAQS are based on safe level of different air pollutants which rely on the scientific evidence on adverse impacts of air pollutants. Here following trends of SO_2, NO_2 and PM10 in selected state capitals and metropolitan cities.

Figure 4.1 revealed the ambient air quality trend in Ahmedabad city. Analysis of ten-year air quality data of Particulate Matter having aerodynamic diameter less than or equal to 10 µm size (PM10) shows a declining trend but above the National Standard whereas, both SO_2 and NO_2 are showing more or less a stable trend but well within the National Ambient Air Quality Standard (NAAQS), 2009.

Figure 4.2 analyze the Ambient air quality trend in Chennai city over a period of ten years, It shows a decreasing but fluctuating trend with respect to Particulate Matter having aerodynamic diameter less than or equal to 10 µm size (PM_{10}). However, both SO_2 and NO_2 are showing more or less a stable trend but well within the National Ambient Air Quality Standard (NAAQS), 2009.

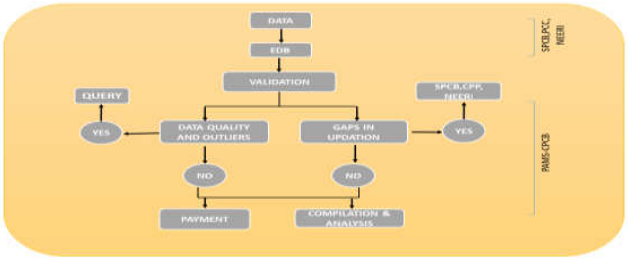

Figure 3.1 Data flow chart under NAMP.

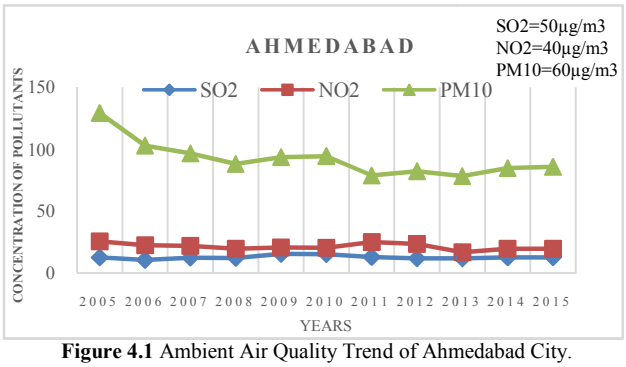

Figure 4.1 Ambient Air Quality Trend of Ahmedabad City.

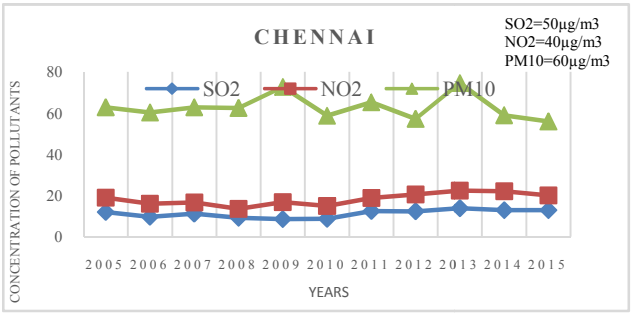

Figure 4.2 Ambient Air Quality Trend of Chennai City.

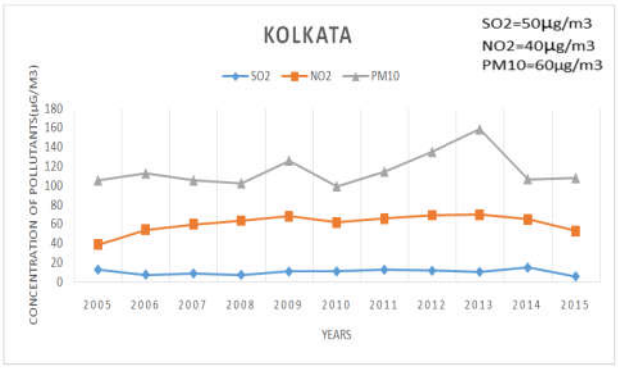

Figure 4.3 Ambient Air Quality Trend of Kolkata City.

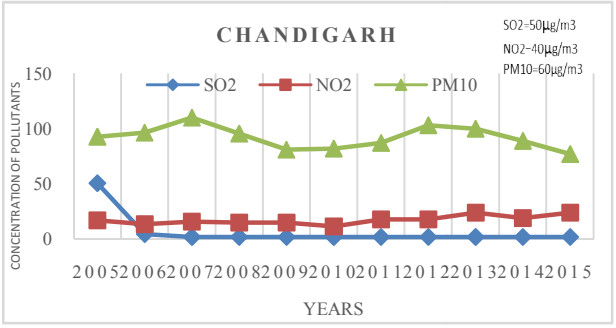

Figure 4.4 Ambient Air Quality Trend of Chandigarh City.

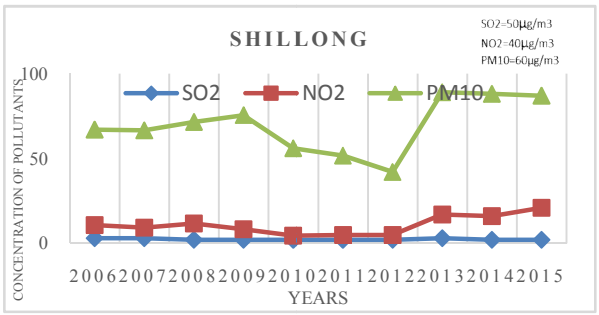

Figure 4.5 Ambient Air Quality Trend of Shillong City.

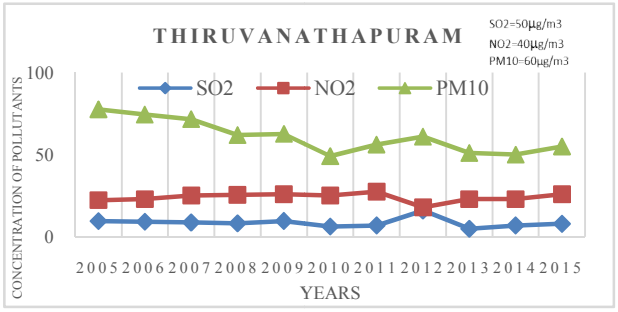

Figure 4.6 Ambient Air Quality Trend of Thiruvananthapuram City.

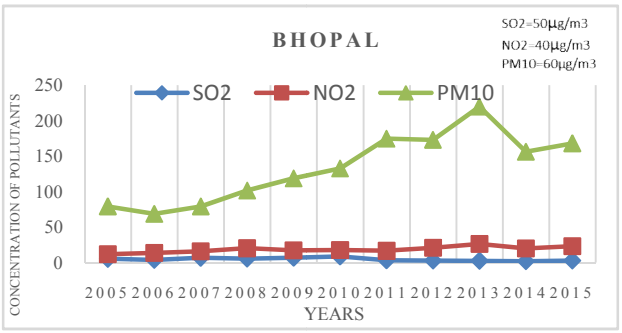

Figure 4.7 Ambient Air Quality Trend of Bhopal City.

Figure 4.3 showing the Ambient air quality trend in Kolkata city over a period of ten years, reveals that the Particulate Matter having aerodynamic diameter less than or equal to 10 µm size (PM10) follows a fluctuating trend but slight increase in concentration can be observed from 2010 - 2013. NO_2 also shows an increasing trend with concentration exceeding the National Standards over the years 2006 - 2013. SO_2, however, shows more or less a stable trend but well within the National Ambient Air Quality Standard (NAAQS), 2009.

Figure 4.4 shows the ambient air quality trend in Chandigarh city over ten years period (2005 – 2011). As evident from the figure, Particulate Matter having aerodynamic diameter less than or equal to 10 µm size (PM_{10}) indicates a fluctuating trend with decrease in concentration from 2012 – 2015, but above the National Standards. Further, SO_2 and NO_2 are showing more or less a stable trend but well within the National Ambient Air Quality Standard (NAAQS), 2009.

Analysis of ten-year ambient air quality data of Shillong city,Figure 4.5, indicates an increase in concentration of Particulate Matter having aerodynamic diameter less than or equal to 10 µm size (PM10) till 2009 followed by decrease in 2012, a sudden increase in 2013 and then stabilizing by 2015. NO_2 shows a slightly increasing trend but well within the limits while SO_2 shows a stable trend over the period of study. Figure 4.6 shows the ambient air quality trend in Thirruvanathapuram city over ten years period (2005 – 2015).

As evident from the figure, Particulate Matter (PM_{10}) indicates a decreasing trend in concentration over the period of study, also below the National Standards from 2013. Further, SO_2 and NO_2 are showing more or less a stable trend but well within the National Ambient Air Quality Standard (NAAQS), 2009.

The ambient air quality data of Bhopal city from 2005 – 2015 (Figure 4.7) indicates an increase in concentration of Particulate Matter having aerodynamic diameter less than or equal to 10 µm size (PM_{10}) from 2005 to 2013, followed by sudden decrease from 2014 onwards but above the National Standards. Furthermore, SO_2 and NO_2 are showing more or less a stable trend but well within the National Ambient Air Quality Standard (NAAQS), 2009.

CONCLUSION

According to the result observed, we can conclude that $SO_2$and NO_2 levels are in NAAQS 2009 limits in selected cities but there is a mega difference in PM10 concentration with respect to their permissible limits. Maximum PM10 concentration over a decade was is observed in Bhopal and then in Chandigarh and Kolkata. This increased level of PM10 is due to the reduce size of forest from 94,689 km^2 (2005) to 77,462 km^2 (2015) and18 new industrial area were set up increase in Madhya Pradesh. Similarly reduction in forest area from 33 km^2 (2005) to 22.03 km^2 (2015) was documented in Chandigarh .and there was exponential increase from 81.1 million to 210 million in no of automobile registration from 2005 to 2015 respectively in India. Due to all these issues pollutant levels are increasing exponentially. So, the concern for preserving the quality of life and promoting environment while undertaking the industrialization and other developmental activities was stressed by the government under its planning processes, policy percept and regulatory mechanisms. Improving air quality through prevention and control of air pollution in Indian cities has been focus of Indian policies and regulations. Some of the important initiatives like legal and institutional mechanisms to regulate pollution, introduction of clean fuel in urban areas, fuel quality specifications, environmental auditing, promotion of clean technologies, regulation of hazardous wastes and chemicals, promotion of voluntary schemes like Corporate Responsibility on Environment Protection (CREP were established . The major policy initiatives include “National Conservation Strategy and Policy Statement on Environment and Development, 1992”, “Policy Statement for Abatement of Pollution, 1992”, National Environment Policy, 2006. These directives sought to incorporate environmental concerns into all forms of developmental activities, government planning, environmental education, strengthening the enforcement of environmental regulations, need to develop clean technologies, regulatory reform, focus on prevention of pollution, adoption of best available technology, implementation of polluter pays principle and public participation in decision making.

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