# Urban Air Pollution – Source Significance

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***Abstract*— Particulate matter is a group of fine particles which has varying range of diameter i.e., the particle size varies from 0.05µm to 10µm. Among all the pollution emission found in the atmosphere, particulate matter represents a complex group of air pollutants whose properties and impact vary depending on their size and composition. They are generally made up of elemental carbon, organic compound, sulphate and nitrate ions, trace metals, soil particles and sea salt. These emissions are basically fine carbonaceous matter which finds their way into the atmosphere due coal burning, vehicular movement, open burning of municipal solid waste, agricultural land management activities, construction operations and other such activities. To understand the impact of particulate matter on the environment, it is necessary to understand the sources of emission.**

***Keywords*— Air quality, source, vehicle, lung spaces, Road, industrial growth**

## I. INTRODUCTION

Urban Air pollution is one of the most serious problems faced by the people in urban areas of developing countries. These urban centers, not only experience a rapid growth of population, but also industrialization, accompanied by growing number of vehicles. According to the World Development Indicators report, 1.5 billion people are exposed to dangerous levels of air pollution about 15 to 18 million children in developing countries are affected by high levels of lead in their blood, which could be the result of emissions from vehicle exhaust and suffer from respiratory/lung related illness [1]. United Nations Development Programme and World Health Organization estimated that, air pollution kills about 2.7 million to 3 million people every year- i.e., 6% of all deaths annually. The Air pollution kills an estimated 673 thousand people in India, out of which 589 thousand people from indoor pollution and 84 thousand, from outdoor pollution. India is one of the environmentally degraded countries and is paying heavy health and economic price for it. According to a World Bank sponsored study, estimated environmental damage in the year 1992 amounts to US $ 10 Billion or Rupees 34,000 Crores, which is 4.5 % of total GDP of the country [2] [3].

### *A. Air Pollution as Economic Problem*

Air Pollution is an economic problem, because it reduces the value of natural resources that, the society has at its disposal. Whatever the trends in pollution level, they are justified in treating pollution as a problem. For this reason, much of the economic analysis is concerned with the comparison of the cost associated with the various methods of abating pollution. The economists view pollution as a negative externality. Economic system withdraws resources from the natural environment and returns the waste materials generated by the production and the consumption activities to the environment [4].

### *B. Description of Study area*

Bangalore is a rapidly growing mega-city, in the State of Karnataka, located in South India. High-tech industries have agglomerated in the recent past. The city has attracted policy makers to establish a new growth model to increase the people's quality of life (PQL) by mitigating the negative impacts. Bangalore had the reputation of "Garden City of India" with tree-lined avenues and well-laid extensive gardens and parks. Subsequently, the character of the city has also been marked by strong influence of globalization, and rapid growth of information technology has earned it the title "Silicon Valley of India".

However, the existing urban infrastructure is far behind than what is required for the efficient promotion of such growth. There are constraints on the expansion of the city and there is a need for immediate and consistent urban environmental management. There is a 10-fold increase in the vehicular population, since 1996, after globalization with an average annual growth of 10 per cent. The Bangalore urban public transport system is not sufficient to cater to the need for foster economic development. Traffic problems are acute, and local authorities are developing many improvements plans such as construction of highways, flyovers, subways, metro and improvement of road network. The major means of motorized transport is road-based. On an insufficient road network, the average driving speed of the vehicle has reduced and resulted in long travel time (the average speed in the city area is as low as 10–13 km/h, which is very low compared with many other growing Asian cities).

### *C. Demographic Characteristics*

There is an exponential growth of population over decades in the city. During 1880, the population of the city was approximately 100,000 and it became 300,000 in 1935. In 1971, the city had a population of 1,600,000 and now it is one of India's largest cities with a population of 9.531 million (Census, 2011). The demographic characteristic of the population of Bangalore is presented in Table 1. The total population of Bangalore had grown from 0.8 million in 1951 to around 8.7 million in 2011. The decadal growth rates of the

population are increased from 0.78 percent in 1901 to 39.88 percent in 2011. The ration of population to 1901 is 56.75 percent, which is huge when compared to the limited land & water resources to any growing urban centers.

TABLE 1: Demographic characteristics of the population of Bangalore, 1901-2011

| Year | Population in Lakhs in BBMP | Decadal growth rate of population in BBMP | Ratio of population to 1901 population |
|---|---|---|---|
| 1901 | 1.59 | -- | -- |
| 1911 | 2.37 | 0.78 | 0.9834 |
| 1921 | 2.89 | 0.52 | 0.9752 |
| 1931 | 3.07 | 0.18 | 0.9679 |
| 1941 | 4.06 | 0.99 | 0.9576 |
| 1951 | 7.78 | 3.72 | 0.9188 |
| 1961 | 12.06 | 4.28 | 0.8742 |
| 1971 | 15.40 | 3.34 | 0.8393 |
| 1981 | 24.76 | 9.36 | 0.7417 |
| 1991 | 41.30 | 16.54 | 0-5692 |
| 2001 | 56.00 | 14.70 | 0.4159 |
| 2011 | 95.88 | 39.88 | 1.00 |

Source: Bangalore city development plan for JNNURM.

### *D. Vehicle growth and road congestion*

The number of registered vehicles has increased from 7.33 lakhs in 1990–91 to 68.32 lakhs in 2016–17 showing almost a tenfold increase over the past 25 years. According to 2011, the vehicle population has increased to 36.86 lakh with an addition of 3-4 lakh vehicles from other places coming in and going out every day. These vehicles are accommodated on 7,200 km road network in the city. On an average, the vehicular population is growing at the rate of 10 per cent per annum [5].

Out of the total number of vehicles in Karnataka, about 38.22 per cent of vehicles are plying in Bangalore urban area alone and problems emerging from the traffic are uniquely different from that of other districts in Karnataka. About total vehicles, two-wheelers constitute 71.81 per cent, followed by cars (9.50 per cent) and other vehicles (9.57 per cent). Approximately 39.58 per cent of the state's two-wheelers are registered in Bangalore. The total number of different type of registered vehicles in Bangalore since 1970-71 to 2016-17 are tabulated in the Table 2.

TABLE 2: Total number of different types of registered vehicles in Bangalore, since 1970-71 to 2016-17.

*In Lakhs*

| Year | Two-Wheeler | Three-Wheeler | Car/Jeep/ Taxi | Bus | Goods Vehicles | Others |
|---|---|---|---|---|---|---|
| 1970-71 | 0.23 | 0.08 | 0.33 | 0.03 | 0.08 | 0.01 |
| 1980-81 | 1.12 | 0.10 | 0.36 | 0.05 | 0.127 | 0.01 |
| 1990-91 | 4.59 | 0.17 | 0.91 | 0.05 | 0.23 | 0.04 |
| 2000-01 | 22.29 | 1.25 | 4.59 | 0.44 | 1.05 | 0.23 |
| 2010-11 | 25.47 | 0.93 | 7.44 | 0.73 | 1.51 | 0.78 |
| 2016-17 | 47.31 | 1.73 | 15.80 | 0.92 | 1.72 | 0.84 |

Source: RTO, Bangalore.

Transport activities contribute to wide range of effects on the environment such as air pollution, re-suspended road dust and noise pollution from road traffic. In Bangalore, the percentage of two wheelers have increased from 0.23 percent in 1970-71 to 47.31 percent in 2016-17, recorded a yearly average increase of 63.87 percent followed by cars 53.68 percent and buses 41.44 percent (Table 3). In India two wheelers are getting popular due to the greater fuel economy, better specific power and lower operational, maintenance and production costs.

The environmental effects of fuels like oil and petroleum products are of growing concern owing to increasing consumption levels. The combustion of these fuels in vehicles has been a major source of pollution. With the increasing vehicles in country, the vehicular pollution has also increased, and it accounts for a considerable share of air pollution in India. The different factors contributing for urban air pollution are the types of engines used, the age of the vehicles, poor road conditions and congested traffic.

TABLE 3: Percentage distribution of different type of vehicles on road in Bangalore from 1970-71 to 2016-17.

| Year | Two-Wheeler | Three-Wheeler | Car/Jeep/ Taxi | Bus | Goods Vehicles | Others |
|---|---|---|---|---|---|---|
| 1970-71 | 30.26 | 10.52 | 43.42 | 3.94 | 10.52 | 1.31 |
| 1980-81 | 63.38 | 5.65 | 20.37 | 2.82 | 7.18 | 0.56 |
| 1990-91 | 76.62 | 2.83 | 15.19 | 0.83 | 3.83 | 0.66 |
| 2000-01 | 74.67 | 4.18 | 15.37 | 1.47 | 3.51 | 0.77 |
| 2010-11 | 69.09 | 2.52 | 20.18 | 1.98 | 4.09 | 2.11 |
| 2016-17 | 69.24 | 2.53 | 23.12 | 1.34 | 2.51 | 1.22 |

Source: RTO, Bangalore.

The Transport infrastructure has expanded considerably in terms of network and services including the Metro in the recent past. However, the road transport accounts for a major share of air pollution in the city, in most traffic junctions, the air pollution has worsened due to traffic congestion, narrow roads, unscientific one ways, encroachment of roads and garbage accumulation, which is a major cause of respiratory diseases. The Table:4 gives the major sources of air pollutants particularly PM10, in the city. Road dust, industry and construction activities takes the following steps with 11%, 7.85 and 7.7 % respectively.

TABLE- 4: Major sources of air pollution in Bengaluru City

| Sl. No. | Particulars | Source PM10 (TPD) | % Contribution |
|---|---|---|---|
| 1. | Transport | 22.4 | 42 |
| 2. | Road dust | 10.9 | 20 |
| 3. | Domestic | 1.8 | 3 |
| 4. | DG Set | 3.6 | 7 |
| 5. | Industry | 7.8 | 14 |
| 6. | Hotel | 0.1 | - |
| 7. | Construction | 7.7 | 14 |
| 8. | Total | 54.3 | 100 |

Source: Source Apportionment study by TERI, 2014.

### *E. Industrial Growth and its Impact on Ambient Air Quality*

In Bangalore urban and rural district, 22 industrial estates have been developed by Karnataka Small Scale Industries Development Corporation (KSSIDC) in an area of 241.69 ha and 16 industrial areas developed by Karnataka Industrial Area Development Board (KIADB) in an area of 8726.19 ha. The first industrial area was established at Ramanagara during 1957 in an area of 5 acres and then in Rajajinagar during 1959 in an area of 37 acres. Subsequently, there was development of substantially larger industrial areas with Dyavasandra in 1968 with an area of 525 acres and Peenya Phase I–IV in 1971 with an area of 1,197 acres. Developed areas have also expanded rapidly at an average rate of about 282 acres per year.

The KSPCB has classified the industries as Red, Orange and Green based on the pollution potential to the surrounding environment. Approximately 40 per cent of the registered operating industries are classified as Red and Orange. Together these two groups comprise 2,900 industries accounting for the major polluters in the region. Table 5 gives the classification of operating industries registered with KSPCB in the region.

TABLE 5: Classification of operating industries in Bangalore registered with KSPCB

| Sl. No | Size | Red | Orange |
|---|---|---|---|
| 1 | Large | 462 | 387 |
| 2 | Medium | 371 | 562 |
| 3 | Small | 815 | 521 |
| 4 | Total | 1648 | 1470 |

Source: KSPCB, 2016.

Sources of industrial air pollution include single-point sources such as furnaces, boilers, incinerators and diesel generator (DG) sets. The prominent air pollutants emitted into the atmosphere includes Sulphur oxides ($SO_2$), oxides of nitrogen (NOX), carbon monoxide (CO) and PM. Apart from industrial emission, the uncontrolled burning of municipal solid waste is a very significant additional source of air pollution within the city region [6].

The air quality monitoring results reveal that the PM10 (called SPM) levels are almost three to four times (160–210 $\mu g/Nm^3$) that of the NAAQS of 60 $\mu g/Nm^3$, which has raised the concern over growing pollution and health risks.

### *F. Reduction of Lung Spaces*

Lung spaces which were part of Cities earlier, have vanished due to real estate boon and migration. Open spaces like lakes, parks, playgrounds, unbuilt government and private lands, have become either slums or gated communities. But both migrants and original residents of the city suffered due to air pollution. Reduction in the green cover due to cutting of trees due to infrastructure is also contributing for increase in Dust concentration in the ambient air of Bangalore [7].

The WHO has recommended a minimum green space of 9.5 $M^2$/person considering the services like Oxygen, moderation of micro climate etc., and goods of an urban environment. Estimates indicate that about 6 Tons of carbon is sequestered by 1 Ha of forest annually, and this averages out as the carbon sequestration of 6 kg/tree/year. Per capita respiratory carbon ranges from 192 – 328 kg/year depending on the physiology of human. Generally, the carbon dissipated through respiration varies from 525 – 900 gm/day/person.

The number of trees required to sequent the $CO_2$ is 32 to 55 number/person, however a study by KSPCB has revealed that there are 17 trees/100person in Bangalore. The percentage of Green cover during 1973 was 68.27 but reduced to 16.32 in 2009. The Change of Land Use from Industrial/ Agricultural area in to Residential Area since 1970 to till date is tabulated in the Table 6.

TABLE 6: The Percentage Change of Land Use to Residential Area since 1970 to till date

| Class | Urban | | Vegetation | | Water | | Others | |
|---|---|---|---|---|---|---|---|---|
| Year | Ha | % | Ha | % | Ha | % | Ha | % |
| 1973 | 5448 | 7.97 | 46639 | 68.27 | 2324 | 3.4 | 13903 | 20.35 |
| 1992 | 18650 | 27.3 | 31579 | 46.22 | 1790 | 2.6 | 16303 | 23.86 |
| 1999 | 24163 | 35.37 | 31272 | 45.77 | 1542 | 2.26 | 11346 | 16.61 |
| 2006 | 29535 | 43.23 | 19696 | 28.83 | 1073 | 1.57 | 18017 | 26.37 |
| 2012 | 41570 | 58.33 | 16569 | 23.25 | 665 | 0.93 | 12468 | 17.49 |

Source: ENVIS technical Report (May 2014)

Bangalore was once branded as the Garden city due to its dense vegetation cover, but the amount of vegetation has declined from 68.27% (in 1973) to less than 23% (in 2012). Bangalore had also been known as a city of lakes once upon a time for the numerous lakes that were present in it. The impact of urbanization has reduced the number of water bodies now (which is 93 lakes as per 2011). Additionally, there has also been a reduction in the number of feeder canals (Rajakaluve/ storm water drains). The water bodies have reduced from 3.4% (1973) to less than 1% (2012). Other land uses have changed from 20.35% (1973) to 17.49% (2012).

*G. Ambient Air Quality Status*

The Karnataka State Pollution Control Board (KSPCB) is monitoring the Ambient Air Quality (AAQ) in various places of Karnataka. Bangalore is highly polluted city in Karnataka due to increased concentration of PM in the ambient air. It is monitored at 13 different locations (Table 7) [8].

TABLE 7: Annual average values of air pollutants at 13 locations in Bangalore City during the 2015-16

| Sl. No | Name of the Station | Zone | SO2µg /m3 | NO2µ g/m3 | PM10 µg/m 3 | PM10 exceeded to the National Standards |
|---|---|---|---|---|---|---|
| 1 | Export promotional park ITPL, White field, premises of Graphite India Ltd, Bangalore | Industrial | 3.8 | 21.1 | 189.0 | 215.0 % |
| 2 | K.H.B Industrial Area, Yelahanka | Industrial | 3.6 | 15.5 | 109.0 | 82.0 % |
| 3 | Peenya Industrial Area (RO) | Industrial | 3.9 | 20.2 | 127.0 | 112.0 % |
| 4 | Swan Silk Peenya Industrial Area | Industrial | 2.0 | 36.0 | 117.0 | 95.0 % |
| 5 | Yeshwanthpura Police Station | Mixed Urban zone | 3.6 | 22.6 | 105.0 | 75.0 % |
| 6 | AMCO Batteries, Mysore Road | Mixed Urban zone | 4.0 | 20.2 | 119.0 | 98.0 % |
| 7 | Central Silk Board , Hosur Road | Mixed Urban zone | 3.9 | 21.1 | 165.0 | 175.0 % |
| 8 | DTDC House Victoria Road | Mixed Urban zone | 3.7 | 17.5 | 135.0 | 125.0 % |
| 9 | Kajisonnenahalli , | Mixed Urban zone | 3.6 | 12.6 | 75.0 | 25.0 % |
| 10 | City Railway Station | Mixed Urban zone | 9.0 | 45.6 | 104.0 | 73.0 % |
| 11 | CAAQMS at S,G,Halli | Mixed Urban zone | 3.7 | 25.7 | 72.0 | 20.0 % |
| 12 | Victoria Hospital | Sensitive | 4.0 | 23.0 | 99.5 | 66.0 % |
| 13 | Indira Gandhi Institute of child health | Sensitive | 3.8 | 17.5 | 113.0 | 88.0 % |
| Standards/National limits | | | 50.0 | 40.0 | 60.0 | |

Source Annual Report, 2016.

The salient features of AAQ status in Bangalore are:

- The concentration of PM10has exceeded the national AAQ standards.
- The concentration of NOx is within the national AAQ Standards for the year 2012-2015 except for the year 2015-16.
- The concentration of $SO_2$ are well within the national AAQ Standard.
- The concentration of CO is well within the national AAQ standard.

## II. CONCLUSION

Rapid and unplanned expansion of Bangalore is one of the serious problems, as it has manifold effects, one of the most important being air pollution. Rapid population growth and urbanization is adversely affecting the Bangalore environment in terms of Water scarcity, water quality deterioration, air quality deterioration, mis -management of solid waste etc. All these in turn led to an increase in the air pollution levels. However, air pollution not only leads to deteriorating environmental conditions, but also have adverse effects on the health of people. Increase in automobile emission has resulted in serious Impact on the urban air pollution in the city. The relevant empirical data for the study has been taken from various sources like census of India, annual report of transport department, Karnataka State Pollution Control Board, TERI, CPCB and compendium of environment statistics. Technical pollution parameters suggest that two wheelers are more polluting, as compared to other motor vehicles.

The total pollution load into the ambient air environment in Bangalore during 2007 is estimated to be 54.4 TPD, 217.4TPD for NOx and 14.6 for SO2. at the city level, the major source of PM 10 is transport (42%), road re-suspension (20%), construction (14%), industry (14%), DG Set (7%) and domestic (3%). likewise, at the city level, the major source of NOx is transport (68%), industry (8%), DG Set (23%) and domestic (1%). In case of SO2, at the city level, the major source is transport (16%), industry (56%), DG Set (23%).

Increase in urban air pollution in Bangalore is one of the greatest menaces to the health of people, which in turn causing threat to the survival. There is a need to control urban air pollution in the city. Measures to control air pollution should be intensified and a shift in the movement of personal vehicles should be encouraged to public transport bus system. State Transport bus service sector should comply with better vehicular standards and the fuel burning efficiency should be increased with more R and D in vehicle technology. The air pollution should not be a responsibility of government alone, but mass and local people should be encouraged to make dedicated efforts to eradicate the air pollution problems. It is the need of time to protect environment for the present and future generation.

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