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URBANIZATION AND ITS ENVIRONMENTAL HEALTH HAZARDS OF BANGALORE CITY, KARNATAKA, INDIA

D. Rajasekaran
Associate Professor of Geography, Govt. Arts College, Bangalore, India
Email: drdrajsekaran@gmail.com

Abstract: *Bangaluru (earlier known as Bangalore) is the capital of Karnataka and is the primate city of South India - one of the largest growing metropolitan regions of the world. With the Information Technology (IT) and Bio-Technology (BT) boom, Bangalore is one of the fastest growing cities in India and Asia. Bangalore serves as the global example of the potentials and problems facing mega-cities in the developing nations. – Bangalore is among the top 10 polluted cities in the country as found by the Ministry of Environment. The prime cause for pollution is by emissions of motor vehicles. But, there is no mechanism as such to check the increasing vehicular pollution that is affecting the air quality and health of people in the so-called Garden City. Earlier, commuters had to inhale a lot of petrol and diesel exhaust smoke at signals, but now because of increasing LPG-fuel vehicles, they complain of inhaling more gaseous substances, dust from paved roads and soils, building construction dustier leads hazards to health. – Bangalore city along with the problem of Air Pollution, there is an acute shortage of piped drinking water; therefore city has 3.12 lakhs bore wells. Bangalore's urban future is grave - because of heavy mineral/metals found in groundwater are fluoride, zinc copper, lead, manganese, chromium, iron, nitrate and aluminium which are hazards to health. Therefore, the study reveals to focus on the effects of the Bangalore City's air pollution especially Particulate Matter (PM10) – exceeds recommended standards levels and the contaminated ground water – chemicals which lead to various health hazards are analysed and some of the suggestions are dealt in it.*

Key words: Ambient Air Quality, Emissions, Particulate Matter, Water Contamination

Introduction

Bengaluru (earlier known as Bangalore) is the capital of Karnataka and is the primate city of South India - one of the largest growing metropolitan regions of the world. With the Information Technology (IT) and Bio-Technology (BT) boom, Bangalore is one of the fastest growing cities in India and Asia. Bangalore serves as the global example of the potentials and problems facing mega-cities in the developing nations. The Bangalore has the highest demography and the only metropolitan city, of Karnataka, which it has 95 lacks of population as per the 2011 census. Presently 2015 Bangalore has a population of 10,839,725. The intensity, quantity, and frequency of both urban, suburban and movement with other cities are same factor of increasing transportation problem and acute shortage of piped drinking water in the Bangalore area; particularly in transportation utility development could not comply with the demand. The dependency of urban population on transportation systems on fossil fuels is quite high and same manner dependency on bore well water also quite high.

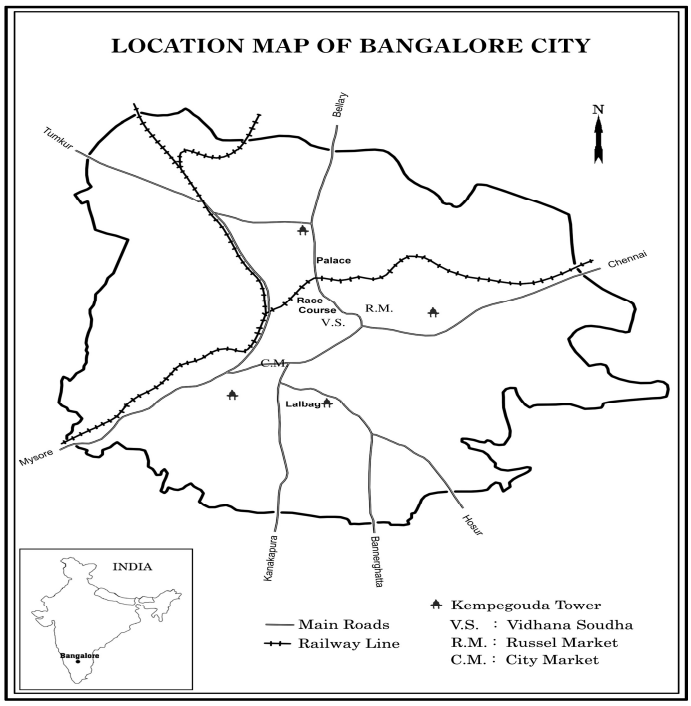
Bangalore is among the top 10 polluted cities in the country as found by the Ministry of Environment. The prime cause for pollution is by emissions of motor vehicles. But, there is no mechanism as such to check the increasing vehicular pollution that is affecting the air quality and health of people in the so-called Garden City. Earlier, commuters had to inhale a lot of petrol and diesel exhaust smoke at signals, but now because of increasing LPG-fuel vehicles, they complain of inhaling more gaseous substances, dust from paved roads

and soils, building construction dust are leads hazards to health. Bangalore city along with the problem of air pollution, there is an acute shortage of piped drinking water; therefore city has 3.12 lakhs bore wells. Bangalore's urban future is grave - because of heavy mineral/metals found in ground water are fluoride, zinc copper, lead, manganese, chromium, iron, nitrate and aluminium which are hazards to health. Therefore, the study reveals to focus on the effects of the Bangalore City's air pollution especially Particulate Matter (PM10) – exceeds recommended standards levels and the contaminated ground water – chemicals which lead to various health hazards are analysed and some of the suggestions are dealt in it.

Study Area

Bangalore is emerged as the third largest metropolis in India with a population of about 8.4 million as per the Census 2011, and is among one of the fastest growing cities in Asia. It is also the capital of the state of Karnataka. The name Bangalore is an Anglicized version of the city's name in Kannada language, Bengaluru. The Bangalore city is considered as the principal administrative, industrial, commercial, educational and cultural capital of the state of Karnataka, in the South-Western part of India. Blessed with a strong educational and technological base and agreeable climate, Bangalore is witnessing a tremendous growth in industry, trade and commerce leading to a rapid growth of the city and large scale urbanization. It is globally recognized as IT capital of India and also as a well-developed industrial city. The city which was originally developed as a Garden City has slowly transformed into an industrial and software hub of India.

Bangalore City is located in Bangalore District of south east of Karnataka State. It is located in the heart of the Deccan Plateau. The area lies between 12^{o} $58^{'}$ to 13^{o} $0^{'}$ North Latitude and 77^{o} $37^{'}$ to 78^{o} $18^{'}$ East Longitude and at an average elevation of 949 meters (3,113 feet) above mean sea level. It covers an area of about 2190 sq. kms. It has a maximum temperature of 33^{o} C to lowest minimum of 14^{o} C. Climatic conditions are March to May warmest, June to September rainy and December to January cold. It has a moderate and pleasant climate. Summers are mild and winters are cool. Bangalore is accessible by air, road, and rail.



Problems

The main problems that are overlooked across the globe are pollution. The Pollution is evident in many different forms, such as, water, sound, light, radioactive, land, and air. The Toxic mix of unbridled vehicular growth, dusty constructions and chemical emission triggers unprecedented air pollution. Rising traffic congestion is a serious issue confronting Bangalore. The combination of population and economic growth of Bangalore contributes to the increased number registered vehicles and miles/kilometres driven. The only way is to reduce the problem of air pollution is the elimination or reduction of fossil fuels used by vehicles. Added to this problem is the fact that there is no rail-based commuter system, which only compounds the situation.

Thus, the increases in population, migration, uncontrolled urban expansion, income, economic growth, energy consumption and mobility have created a serious for air pollution problems, in cities throughout the world. The study is to find the emissions from the vehicles and their impact on the environment. This deals with the present scenario of air pollution and the effects on environment in Bangalore city. The worst thing about vehicular pollution is that it cannot be avoided as the vehicular emissions are emitted at the near ground level where we breathe and the polluted air - especially Particulate Matter (PM10) – exceeds recommended standards in all wards contributed from vehicles, dust from paved roads and soil, reveals a study on the effects of air pollution leads to diseases.

Objectives

- To know the history of growth of increasing population in Bangalore city.
- To know the effects of rapid urban growth, urbanization on land use and to that of Transportation in Bangalore city.
- To study the impact of vehicular population on the environment.
- To identify the types of pollutants released from vehicles in Bangalore city.
- To identify the type of Chemicals found in groundwater in Bangalore city.
- To identify the types of diseases caused by pollutants released in Bangalore city.
- To forecast and suggestion for controlling measures of air pollution in Bangalore.

Methodology

In the present study of Urbanization and its Environmental Health Hazards of Bangalore City, Karnataka – South India data from secondary as well as primary sources like Bangalore District Census Hand Book, data from Bangalore Road Transport office. And data of Bangalore Metropolitan Area (BMA) covered area has been collected and analysed. As the study is qualitative in nature simple tables and suitable maps have been generated. Since Bangalore City is a dynamic metropolis there are a series of popular articles published in leading dailies from which information has been elicited.

Urban Growth

The population of Bangalore city stands at 6.5 million in 2001 and 9.5 million as per 2011, and continuing with this growth rate, the city's population is expected to reach around 21 and 32 million in 2021 and 2041 respectively. With the Information Technology (IT) boom, Bangalore is one of the fastest growing cities in India and Asia. With the emerging Bio-Technology (BT) boom, Bangalore's population growth may be even faster in the forth-coming decades. Bangalore is booming with other growth which is evident from its nicknames viz. "India's Silicon Valley", "Fashion Capital of India", "The Pub City of India", and so on. All these factors contribute to the growth of population of city. The table 1 below shows the growth trends.

Table 1: Population Growth of Bangalore City, 1901-2011

Year	Area (in km2)	Population	Sex Ratio	Density	Decadal Variation in Percent
1901	NA	163,091	982	NA	--
1911	60.35	189,485	958	NA	8.47
1921	NA	240,054	931	NA	12.25
1931	NA	309,785	928	NA	22.79
1941	NA	410,967	922	NA	25.11
1951	NA	786,343	895	NA	69.77
1961	501.21	1,206,961	890	2,408	19.61
1971	177.30	1,664,208	886	9,386	46.55
1981	365.65	2,921,751	900	7,991	59.08
1991	445.91	4,130,288	903	9,263	38.44
2001	531.00	6,537,124	908	2,985	35.09
2011	800.00	9,588,910	908	4,378	46.68

Source: Census of India, District Census Handbook -2001 & 2011.

Land Use Analysis

This was carried out using data of Landsat satellite using supervised pattern classifier - Gaussian maximum likelihood algorithm using GRASS. Four major types of land use classes were considered: built-up area, forestland, open area, and water body. The results of the analysis are shown in tabulated in table 2.

Table 2: Land Use- Changes &Projected in Bangalore City

Class →	Urban	Vegetation	Water	Others
Year ↓	Percent	Percent	Percent	Percent
1973	7.97	68.27	3.40	20.35
1992	27.30	46.22	2.60	23.86
1999	35.37	45.77	2.26	13.61
2002	37.75	38.72	1.84	21.69
2006	43.23	28.83	1.57	26.37
2010	54.42	23.41	0.90	21.27
2020	70.64	13.55	0.74	15.07

Source: Data Collected from District Census Handbook -2001 & 2011 and BDA (Bangalore Development Authority) and Compiled by Author.

This showcased sprawl in the region, hence greater Bangalore with 10 km buffer was also analysed for years 2008, 2010, 2012 and land use is as tabulated in table 3. This data was further considered for modelling of urban growth for the year 2020.

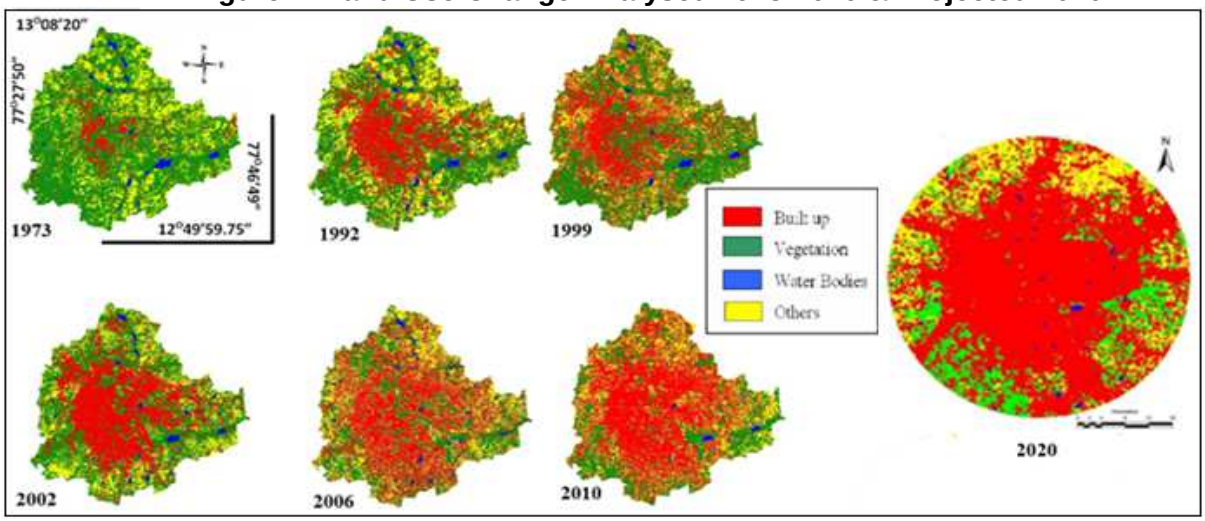
Table 3: Land Use during 2008, 2010 and 2012

Class →	Built up Area	Water	Vegetation	Others
Year ↓	Percent	Percent	Percent	Percent
2008	24.85	0.53	38.35	36.27
2010	28.48	0.78	36.57	34.17
2012	29.33	0.58	33.68	36.41

Source: Data Collected from District Census Handbook -2001 & 2011 and Bruhat Bangalore Mahanagara Palike (BBMP)

Urban density is computed for the period 1973 to 2010 & projected 2020 land use and is depicted below, which illustrates that there has been a linear growth in almost all directions shows the Figure below.

Figure 1: Land Use Change Analysed 1973-2010 & Projected 2020



With this increase in rapid urban growth, which is likely to increase travel demand significantly in Bangalore city. Given current trends, by 2020 the Bangalore city will have a 1.3 crore population will reach 2 largest city including the nearby cities of other states capital such as, Hyderabad, Chennai, Thiruvananthapuram in south India by 2030.

Air Pollution

Bangalore is among the top 10 polluted cities in the country as found by the Ministry of Environment. The prime cause for pollution is by emissions of motor vehicles. But, there is no mechanism as such to check the increasing vehicular pollution that is affecting the air quality and health of people in the so-called Garden City. Air pollution is addition of any harmful gaseous, liquid or solid particles or substances to the atmosphere, which causes the damaging of the environment, human health on quality of life in urban area that can endanger the health of human beings, plants animals, or damage materials reduce visibility or release undesirable odors. By this one of the great problems faced in urban areas throughout the world is the increase in vehicles due to imbalance between the public transport and the increase in population, mobility and last mile connectivity. This increase in the number of vehicles has led to increase in congestion and the increase in pollution by the private vehicles polluting such a natural resource by various human activities will substantially change the composition of air. This may lead to many short term and long term implications on the life of plants and animals. Besides the change in composition, the pollution may directly add some poisonous and harmful gases - which may cause series of health complications.

Transportation is one of the important of economic activity and beneficial social interactions. While the transportation sector is also a major source of air pollution in Bangalore, estimated to account for nearly all of carbon monoxide (CO), more than 80 percent of nitrogen oxides (NOx), 40 percent of volatile organic compounds (VOC), 20 percent of sulphur dioxide (SO2), and 35 percent of PM10. The growing problems related to the increase in the number of vehicles from transportation sector presents a wide range of issues viz. air pollution, noise, congestion, accidents and increased travel time and delays. It was evident from the existing information that air pollution controls and lacks of security are also very worrisome. The key question is how to reduce the adverse environmental impacts and other negative effects of transportation without giving up the benefits of transportation. The table no.4 shows the number of registered and share of different modes of vehicles in Bangalore city on December 31, 2013.

Table 4: Vehicles Registered in Bangalore (As on December 31, 2013)

Types of Vehicles	2013
Two Wheelers	33,85,343
Cars	9,61,740
Three wheelers (Auto Rickshaws)	1,36,871
Trucks / Lorries	53,606
Total	49,20,035

Source: Deccan Herald News Paper and RTO Bangalore.

Table 5: Registered Number of Vehicles, Bangalore and Forecast

Vehicles Types	1980	1990	2000	2010	2020	2030
Two Wheelers	1,11,750	4,58,860	10,67,430	29,51,520	48,35,610	67,19,700
Three wheelers	10,044	17,379	61,424	1,15,401	1,69,378	2,23,355
Cars	31,738	82,205	2,01,052	6,97,745	11,94,438	16,91,131
Jeeps	3,554	6,376	6,827	9,104	11,381	13,658
Taxi	1,120	2,511	6,299	32,818	59,337	85,856
Buses	4,671	4,516	20,656	35,723	50,790	65,857
Trucks	8,236	19,149	41,887	1,39,573	2,37,259	3,34,945
Tractors	1,929	1,993	6,158	20,555	34,952	49,349
Trailers	1,734	1,723	5,544	12,487	19,430	26,373
Maxi cab	*	*	4,238	23,153	42,068	60,983
Others	549	3,574	16,542	84,018	1,51,494	2,18,970
Total	1,75,325	5,98,286	14,38,057	41,22,097	68,06,137	9,490,177

Source: RTO's, District Census Hand Book, Bangalore

The urban air pollution is contributed generally by a variety of sources such as industrial, commercial and transportation sectors. However, at Bangalore air pollution problems which are quite severe are mainly compounded by the transportation sector while the other sources such as industrial etc. are contributing less. As the core transportation sector presently consists mainly of petrol and diesel driven vehicles operating throughout the city, the major air pollutant components are contributed by the automobile exhaust emissions, which consist of; Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Oxides of Nitrogen and Sulphur, Carbon Monoxide etc. Presently many of these air pollutant concentrations are being monitored by the Karnataka State Pollution Control Board (KSPCB) at some locations and by the Central Pollution Control Board (CPCB) at some selected important intersections of the city.

Table 6: Choking Lungs-Air quality comparison of Bangalore City 2010 – 2013

Pollutant Areas	Pollutant *	2010	2011	2012	2013	Standard
White Field	Sulphur dioxide	16	50	16.5	16.1	19.3
	Nitrogen oxide	37.9	30.4	30.1	31	40
	Dust particles	122	122	86	162	60
City Railway Station	Sulphur dioxide	29.5	40	72.6	83	65.8
	Nitrogen oxide	19.9	15.4	8.9	8.3	50
	Dust particles	72	61	55	99	60
Mysore Road	Sulphur dioxide	15	50	1402	13.9	16.1
	Nitrogen oxide	34.5	29	31.3	31	40
	Dust particles	65	80	58	169	60
Victoria Hospital	Sulphur dioxide	13	20	13.3	12.7	12.6
	Nitrogen oxide	33.4	27.2	28.1	30	30
	Dust particles	59	64	51	152	6

*Pollutants measured as micrograms/metre/cube

Source: Data Compiled from Daily News Paper-Deccan Herald.

Supplementary data relating to the vehicle demography- i.e. statistics of vehicle population over the years to the present day, vehicle category data, annual fuel consumption for the city vehicle population, pollution emission factors for various types of automobile fuel uses were collected to evaluate precisely the air pollution status at the proposed, the accepted criteria for Air Quality Index are given in Table 7.

Table 7: Generally accepted criteria for AQI

Range	Criteria
0 to 25	Clean Air
26 to 50	Light Air Pollution
51 to 75	Moderate Air Pollution
AQI > 75	Heavy pollution
AQI > 100	Severe Air Pollution

Source: Karnataka State Pollution Control Board (KSPCB).

Table 8: Details of AQI values and Criteria at Metro Corridors

Name of Stations	*AQI Values	Air Quality Criteria
Yeshwanthpur	256	Severe Air Pollution
Navarang Junction (Rajajinagar)	148	Severe Air Pollution
Seshadripuram / Swastik Circle	140	Severe Air Pollution
Anand Rao Circle	189	Severe Air Pollution
National College / Vanivilas Circle	238	Severe Air Pollution
South End Circle	173	Severe Air Pollution
KIMS Circle	146	Severe Air Pollution
Sri Aurobindo Circle (Jayanagar 5th block)	178	Severe Air Pollution
KIMCO Junction Vijay Bus Depot Mysore Road	256	Severe Air Pollution
Vijayanagar Tollgate (Magadi Junction)	140	Severe Air Pollution
Okalipuram	310	Severe Air Pollution
Anil Kumble Circle	76	Heavy Air Pollution
Shanthala Silks (Majestic)	314	Severe Air Pollution
Trinity Circle	232	Severe Air Pollution
Cauvery Bhavan (Mysore Bank Circle)	241	Severe Air Pollution
Old Madras Road	194	Severe Air Pollution

*AQI - Air Quality Index

Source: Karnataka State Pollution Control Board (KSPCB).

Emission Inventory

Emission inventory is an estimate of the amount of pollutants emitted into atmosphere. Characterized by the following aspects:

(i) Type of activities that cause emissions.
(ii) Chemical or physical identity of the pollutants included.
(iii) Geographic location, and
(iv) Time period over which emissions are estimated.

Transport sector is the major contributor of emissions of PM_{10}–Particulate Matter and NO_x-Nitrogen Oxide in Bangalore whereas Industrial sector is the number one emitter for SO_2 -Sulphur dioxide emissions. Over the years, PM_{10} emissions have fallen mainly due to a shift away from coal and wood for both domestic heating and industrial use, and are

predicted to fall in future with change in fuel use trends and technology improvements. As shown in Table 3.16, transport sector of Bangalore is the major source for PM_{10} emissions contributing nearly 45 percent of total. The main source of NO_x emissions in Bangalore is motor vehicles (75 percent), while DG sets contribute about 20 percent. Domestic and commercial sector combustion is only minor sources of NO_x. The main source of SO_2 emissions is industry. This source contributes 60 percent of the total SO_2 emissions in Bangalore. The other major sources are transport and domestic sources.

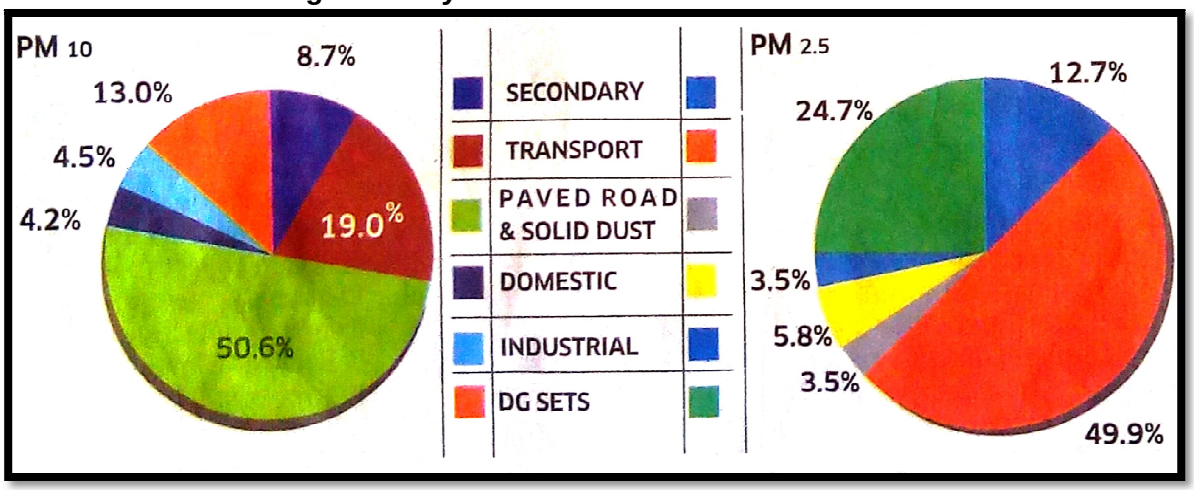
Table 9: Emission Inventory in Bangalore (t/day)

Sources	PM_{10}	NO_x	SO_2
Transport	22.4	146.36	2.31
Road Dust	10.9	0	0
Domestic	108	2.73	0.68
Industry	7.8	1.2	8.2
Commercial	0.1	0.2	0.02
Construction	2.7	0	0
Others (DG set)	3.6	51	3.35

Source: TERI, 2011a

PM-Particulate Matter, **NO_x**-Nitrogen oxide, **SO_2**-Sulfur dioxide

Bangalore City's Air Pollution – Particulate Matter



Environmental Health Hazards lead to high levels of Air Pollution - Bangalore City

Environmental pollution in its many forms has affected human health - Cancer, asthma, skin diseases, neuro and coronary problems, vision and even foetal illnesses. And all are fatal. Air pollution is by far the most harmful form of pollution in our environment. Air pollution is cause by the injurious smoke emitted by cars, buses, trucks, trains, and factories, namely sulphur dioxide, carbon monoxide and nitrogen oxides. Even smoke from burning leaves and cigarettes are harmful to the environment causing a lot of damage to man and the atmosphere. Evidence of increasing air pollution is seen in lung cancer, asthma, allergies, and various breathing problems along with severe and irreparable damage to flora and fauna. Even the most natural phenomenon of migratory birds has been hampered, with severe air pollution preventing them from reaching their seasonal metropolitan destinations of centuries.

Increasing air pollution levels, shrinking greenery and shrinking of lung spaces over the past few years has made Bangalore City the Asthma capital of India. Due to rapid urbanization and pollution has led to increase incidence of Asthma - children are most vulnerable to asthma. According to Paediatric Pulmonologist – "Though asthma can be

hereditary, the Environment plays a key role in causing the disease". Changing lifestyle, eating habits and rise in traffic congestion are some of the reason leading to asthma among the urban population. It confirms that 50 per cent of PM10 is a result of paved road and soil dust and 19 per cent due to vehicles. Vehicular pollution, on the other hand, contributes to 50 per cent of PM2.5, which is more hazardous to health. PM consists of aerosols, smoke, fumes, dust, ash and pollen. While PM2.5 is particles smaller than 2.5 micrometers, PM10 is particulate matter up to 10 micrometers in size. In certain areas, PM10 exceeded up to three times the recommended permissible limit of 60 microgram/m3. To analyse the effects of air pollutants on Cardiovascular Disease (CVD) in Bangalore, it obtained in excess of one million death records and found that the CVD deaths contributed to almost 40 per cent of total mortality. Sulphur Dioxide (SO2), however, was found to be well under permissible limits, due to the various measures taken by the government such as reduction of sulphur content in diesel fuel and wider use of liquefied petroleum gas (LPG), instead of coal as domestic fuel. An Environmental Health Information System Model (ENVHIS) based on Geographic Information System (GIS) was designed specifically to conduct a spatiotemporal analysis of the effects of air pollution on CVD. With support from various authorities such as BBMP, KSPCB (Karnataka State Pollution Control Board) and Transport department, data including demographic, air pollution data, vehicular data and mortality data was obtained and used for analysis."Particulate matter can penetrate the respiratory tract initially, by entering the nasal passages and into the alveoli. Due to their excessive penetrability, they then enter deep into the lungs and are deposited within the tracheobronchial tree, respiratory bronchioles and the alveoli where gas exchange occurs. The particulates then enter the bloodstream resulting in significant health problems". Rising pollution levels in Bangalore City over a period have led to an increase in the number of health ailments among citizens. Skin diseases, allergies, respiratory problems, etc, are on the rise. Fine dust particles are potential triggers for skin diseases. With the depleting ozone layer, sun burns are quite commonly reported among the people say dermatologists.

Those travelling often are at higher risk of suffering from clogged skin pores. Due to exposure to pollution, causes related to pimples and eczemas are on the rise, and possibilities of scalp-related problems like dandruff and itching increased with suspended dust particles. Hence, it is important to take good care of hair and scalp. The same can also lead to critical conditions like skin cancer if ignored in the long run. Extra care is advised for those with sensitive skin.Long-term exposure to particulate air pollution may not only lead to respiratory and cardiovascular diseases, but also causes damage to the Kidneys. On average, the livelihood of developing membranous nephropathy, an immune disorder of the kidneys that can lead to kidney failure, it increase 13 percent annually over 11 years a study says by researchers from Southern Medical University in China. The latest study says that due to Air Pollution children's loss their memory power and also the IQ. The life of the human being will reduce to three to three and half years.

Environmental Health Hazards Lead to Water Contamination- Bangalore City

Rapid urbanization, mindless development, erratic industrialization coupled with poor sewage and solid waste management has not only depleted the groundwater levels, but has also irreversibly contaminated the water table in Bangalore. With the Bangalore Water Supply and Sewerage Board (BWSSB) distributing River Cauvery water to only six lakh-odd households, a large population depends on groundwater for potable and non-potable purposes. Most of residents, especially those living in the fringe areas, either buy water or adopt reverse osmosis or RO (a filtration methodology) for purifying drinking water, as groundwater is unsafe for direct consumption.

In fact Bangalore City has only 30 per cent is open area, and has a normal annual rainfall in the city is 830 mm. Bangalore City receives 66,400 hectare meter per annum (hhm/pa) of water, out of which 17,000 hhm/pa is the surface run-off of the total rainwater. Bangalore City exploits 12,450 hhm/pa of groundwater, but only 2,100 hhm/pa of water is recharged in the groundwater annually. Evaporation-transpiration water loss is 47,235

hhm/pa. Water consumption in Bangalore City is 140 litres per day per head. The total requirement of water in the city is 48,600 hhm/pa. But city receives only 35,605 hhm/pa of water is tapped from distant river sources like Cauvery and other sources. The shortfall in water requirement of about 13,000 hhm/pa will be managed through bore wells. Presently Bangalore City has 3.12 lakh bore wells.

Suggestions

1. Air Quality of the urban "pollution dome" due to fuel driven vehicles as expected to be diffused to a large extent by improving the air quality (CO2, SO2, NOX, Pb reduction).
2. While constructions of buildings it should be cover, so that dust will be avoided.
3. The rain water will be drained properly on both sides of the roads so that soil dust will avoided.
4. Huge reduction due to reduction of fueled vehicles and opting for electrical traction.
5. The noise along corridors will be reduced as on-road vehicular population density goes down and the noise in other areas can be marginal due to overall reduction of density.
6. Quality of life improved by reduced vehicles on road, lesser pollution, lesser road accidents, quicker and comfortable mode of transport.
7. CO2 fixing by increased potential for growing trees both along corridors and other selected areas of forestation.
8. With traffic decongestion being the key, the primary aim of the Bangalore Metro should be to encourage commuters to leave their vehicles in their garages and use public transport. Positioned as a complementary, rather than competitive mode of transport, the Bangalore Metro should work in tandem with other transport system like buses and mono rails.
9. The city bus corridors will not run parallel to Bangalore Metro corridors; instead buses will act as feeders. The mono rail network planned for the city will not overlap with that of the metro, but will connect at major junctions as feeders.
10. On certain high density corridors, three wheelers will be regulated. Feeder bus services will be provided to all the metro stations. Bus bays and parking facilities for private vehicles will be available at all major stations. State-of-the-art satellite bus-cum-metro terminals are being planned in the city outskirts, to control the entry of inter-city buses.
11. Rainwater harvesting should be made compulsory for all residents.
12. Maintaining sanitation is a must both while collecting garbage as well at the disposal points and stringent laws should be enforced to treat and dispose of effluents safely.

Conclusion

The Bangalore City with rapid urbanization and its environmental issues focused problems could be to some extent reduced by creating and concentrating on developing suburbs; reduce the traffic congestion and air pollution through Metro project being an infrastructure project for Bangalore city designed to promote an efficient and commuter friendly transport sector for the benefit of the urban community is also expected to bring in a number of positive impacts on the environment and the general public. Depending upon their significance and magnitude, some of them could be considered as tangible while others could be viewed as intangible benefits. The positive impacts of metro would be steadily realized during sustained running operations of the metro system. The Bangalore Metro comes with a package deal. Comfortable, quick, safer and economical, its energy requirement per passenger km. is only one-fifth of that of road based systems. Commuters and children can breathe easy; there will be no air pollution as the system runs on electric power. The economic rate of return is 22.3percent.To introduction of Monorail; (ELRTS) elevated rail system, BRTS Bus route transport system, fuel price etc.

Lake rejuvenation and rainwater harvesting are the recommended solutions to the growing groundwater contamination in the City. Technology must be adopted to tackle groundwater contamination. A de-nitrification plant can be a boon to remove nitrate in water. Lake rejuvenation must be campaigned for aggressively, which will also increase the groundwater table. Rainwater harvesting should be made compulsory for all residents. We have messed up with the industrial effluent discharge system in the City, which is the main reason for heavy metal contamination. Stringent laws should be enforced to treat and dispose of effluents safely. It is high time for both the government and the public to act to curb groundwater contamination.To improve the quality of air and water there is a need of strict enforcement and monitoring program by the Karnataka Pollution Control Board.

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