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Determination of Ambient Air Quality in Peenya Industrial Area of the Bangalore City, India

Ganesh Babu Kn[1*], Vasanthy Muthunarayanan[2], Selvi K.G[3]
[1]Research Scholar, Department of Environmental Biotechnology, Bharathidasan University, Thiruchirappalli, TamilNadu, India - 620 024.
[2]Associate Professor, Department of Environmental Biotechnology, Bharathidasan University, Thiruchirappalli, TamilNadu, India - 620 024.
[3]PG and Research Department of Zoology, ADM College for Women, Nagapattinam , Tamilnadu, India.
E-mail: **biotech25phd@gmail.com**

ABSTRACT
Particulate matter is a major air contaminant in the ambient air and wide information is assessable on its concentrations from various parts of the world. Air pollutants with the strongest evidence for public health concern, include particulate matter (PM), ozone (O_3), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2). Air pollutants are reported to be harmful to human health if their concentrations exceed certain acceptable levels. Industries have contributed substantially to the air pollution problem as point source of emissions. Understanding the current status of ambient air quality in and around Peenya in Bangalore will help to identify the probable sources of pollutants to facilitate the effective control measures. The aim of the present work is to determine the ambient air quality of Peenya region in terms of PM_{10}, PM_{100}, $PM_{2.5}$, SO_2, NO_x and CO levels to identify the probable sources of pollutants to facilitate the effective control measures.
Key words: *PM_{10}, PM_{100}, $PM_{2.5}$, SO_2, NO_x and CO levels, Peenya city.*

1.INTRODUCTION

Air pollution may be described as any atmospheric condition wherein certain substances are found in such concentrations that they able to produce unwanted effects on man and his surroundings. These substances consist of gases (SO_2, NO_2, CO, hydrocarbons), particulate matter (smoke, dust, fumes, and aerosols), radioactive materials and many others. Most of these substances are naturally present in the atmosphere in low concentrations and are commonly considered to be harmless (Rao, 1996).

Figure 1. Peenya Industrial Area in Bangalore

Bangalore is located in the south Eastern quadrant of the state of Karnataka at 12^0 58' North latitude and 77^0 35' East longitudes at an altitude of 921m above (MSL) Mean Sea Level. The Bangalore city is to be found about 450km from the Bay of Bengal and the Arabian Sea and about 700km from the Indian Ocean. It is noticeable that different physical features such as its elevation, climate, beauty of its rolling

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countryside, its red earth and its granite hillocks and rock outcrops which contrast with the greenery of cultivated fields have all contributed to Bangalore city becoming a major city of modern India.

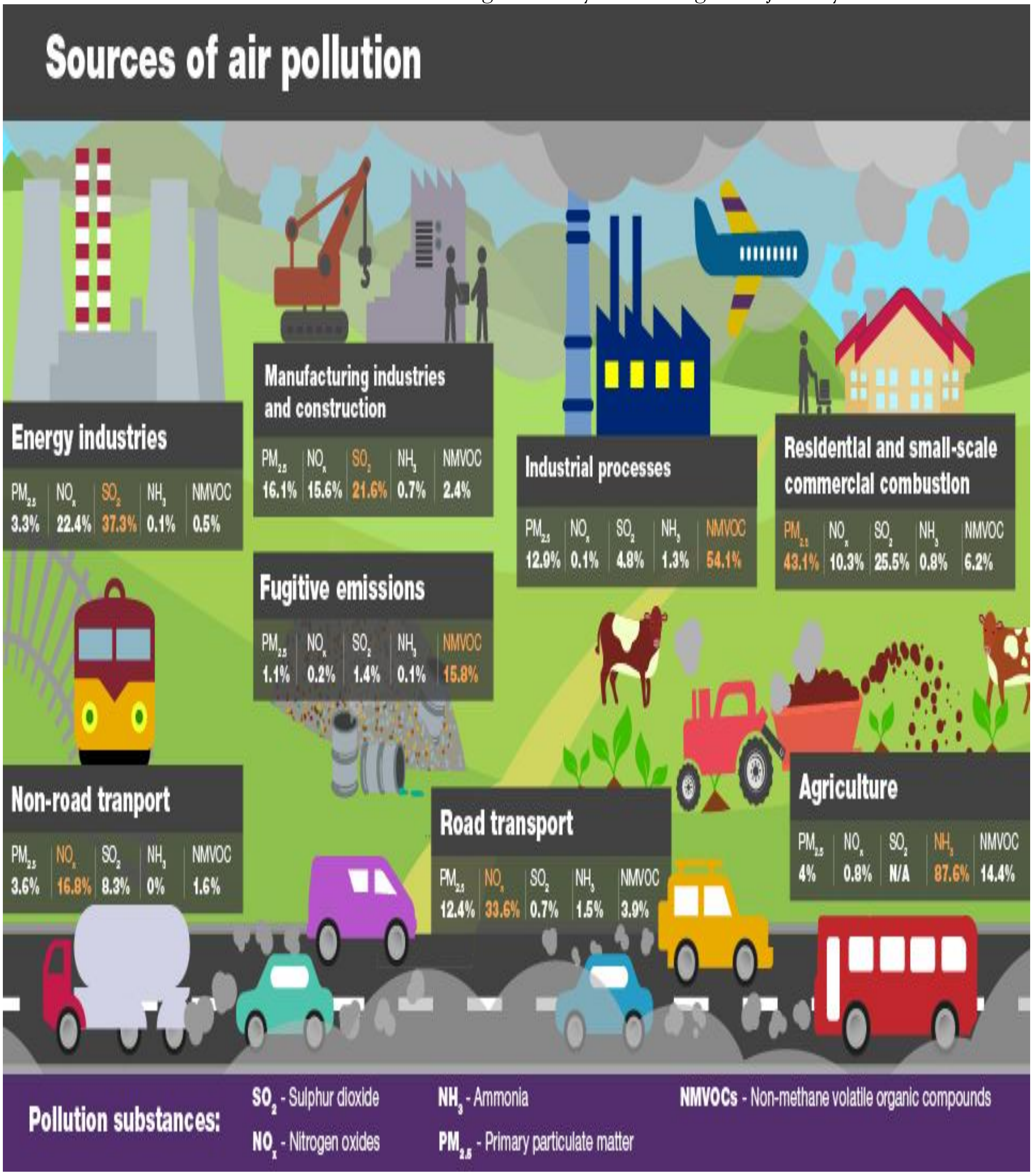

Figure 2. Air pollutants sources in Bangalore city

At the global level, rapid development in motor vehicle activity has severe energy security and climate change implications. The transport sector already consumes nearly half of the world's oil. But in urban areas both developing and developed countries, it is predominately mobile and vehicular pollution that contributes to air quality troubles. The sources of pollutants consist of emissions from the combustion of fossil fuels in motor vehicles and for industrial processes, domestic cooking and heating, energy production and high dust levels due to local construction, smoking, unpaved roads, sweeping, hotels long-range transport. The present study to estimate the PM_{10}, PM_{100},$PM_{2.5}$, SO_2, NOx and CO levels concentration in the sampling stations in the period of January to June 2025.

Table – 1: National ambient air quality standards

Pollutants	Time-weighted average	Concentration in Ambient Air		
		Industrial Areas	Residential, Rural & other Areas	Sensitive Areas
Sulphur Dioxide (SO_2)	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3
Oxides of Nitrogen as (NO_2)	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3
Suspended Particulate Matter	Annual Average*	360 µg/m^3	140 µg/m^3	70 µg/m^3

(SPM)	24 hours**	500 µg/m^3	200 µg/m^3	100 µg/m^3
Respirable Particulate Matter (RPM) (size less than 10 microns)	Annual Average*	120 µg/m^3	60 µg/m^3	50 µg/m^3
	24 hours**	150 µg/m^3	100 µg/m^3	75 µg/m^3
Lead (Pb)	Annual Average*	1.0 µg/m^3	0.75 µg/m^3	0.50 µg/m^3
	24 hours**	1.5 µg/m^3	1.00 µg/m^3	0.75 µg/m^3
Ammonia	Annual Average*	0.1 mg/ m^3	0.1 mg/ m^3	0.1 mg/m^3
	24 hours**	0.4 mg/ m^3	0.4 mg/m^3	0.4 mg/m^3
Carbon Monoxide (CO)	8 hours**	5.0 mg/m^3	2.0 mg/m^3	1.0 mg/ m^3
	1 hour	10.0 mg/m^3	4.0 mg/m^3	2.0 mg/m^3

2.MATERIALS AND METHODS

To assess the ambient air quality, station were identified in the population density areas. Calibrated Respirable Dust Samplers (Enviro tech APM 460) with flow rate ranging between 1.2 - 1.45 m^3/min were used for monitoring of SPM and RPM. Gaseous samples were collected by integrated gas sampling assembly (Envirotech APM 411). A tapping provided in the hopper of the sampler was utilized for sampling of SO_2, NO_X and CO, with proper flow controller and a flow 1.0l/min. Envirotech Organic Vapour Sampler (APM 850) and a digital imported personnel sampler Drager Multiwarm II BD were used for monitoring CO. The pollutants were monitored on 24 hourly basis in twice in month or season wise.

PM_{10}

Calibrated Respirable Dust Sampler is used with Whatman GF/A microfibre filter paper for the determination of PM_{10}. PM_{10} is a measure of particulate matter having size <10 microns. Respirable Dust Sampler (RDS) is attached with a cyclone. Air enters a vertical cylinder with swirling (Vortex) motion and particle larger than design cut-off are deposited on the on the inner surface of the cylinder, whereas particles below 10 microns are deposited on the Whatman GF/A microfibre filter paper. PM_{10} was calculated by taking the difference between final and initial weight of the filter paper and dividing volume of the air sampled.

$PM_{2.5}$

Fine particulate matter ($PM_{2.5}$, particles smaller than 2.5 µm in aerodynamic diameter) has been associated with a variety of adverse health effects, visibility reduction, as well as changes in the Earth's radiation balance. Fine $PM_{2.5}$ may be formed directly from a primary source, such as, motor vehicles, industrial facilities, biomass burning, or indirectly through the conversion of gaseous emissions to the atmosphere from anthropogenic or natural sources.

Estimation of SO_2

Sulphur dioxide is collected in a scrubbing solution of sodium tetrachloro-mercurate and is allowed to react with HCHO and then with Para-rosaniline hydrochloride. The absorbance of the product red-violet dye is measured using digital spectrophotometer at a wavelength of 560nm.

Estimation of NO_2

A nitrogen oxide as nitrogen dioxide is collected by bubbling air through sodium hydroxide solution to form a stable solution of sodium nitrite. The nitrite ion produced during sampling is determined using digital spectrophotometer at a wavelength of 540nm by reacting the exposed absorbing reagent with phosphoric acid, sulfanilamide and N (1-naphthyl) ethylamine di-hydrochloride (IS: 5182 Part IV, 1975).

Estimation of CO

An imported digital CO detector (Drager' s Mini Warn) is used for monitoring of CO.

SAMPLING STATIONS

The natural environment, around Peenya in Bangalore, is regularly contaminated with heavy deposition of dust by emitting through the smokestacks. The entire vegetation and buildings almost seems to be grayish white in appearance within the rations of 5 km around the study area. With the overall observation, it is clear that a different place of Peenya describes the probability of increase of the SPM concentration.

1. Dasarahalli (N)
2. Jalahalli (NE)
3. Yeshwntpur (E)

4. Rajajinagar (S)
5. Nandhini layout (SE)
6. Vijayanagar(SW)
7. Laggere (W)
8. Nagasandra(NW)

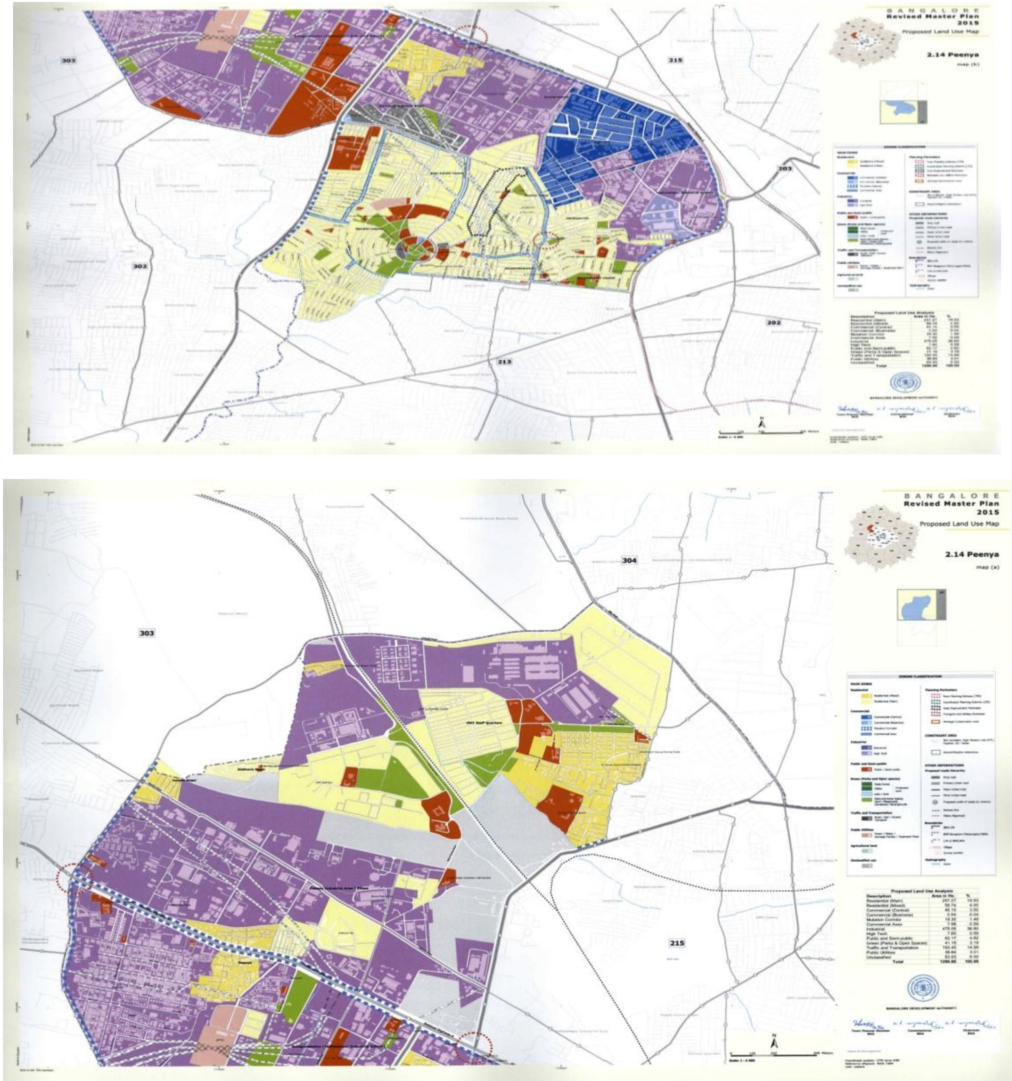

Fig 1. Study area

The height about 6 m above the ground level to avoid the contamination effect of the local dust lifted from ground level. The frequency of sampling for (PM_{10}) was four times a month and the sampling was carried out for a period January to June 2025.

Calculations

Determination of respirable particulate matter (PM_{10})

$$\text{Concentration of } PM_{10} = \frac{W \times 106}{V \times T} \ \mu g/m^3$$

Where
V = Flow rate in cubic meter per minutes
T = Total period of sampling in minutes
W = Difference in final and initial weight of filter paper in grams.

Determination of Non respirable particulate matter (PM_{100})

$$\text{Concentration of } PM_{100} = \frac{W \times 106}{V \times T} \ \mu g/m^3$$

Where
V = Flow rate in cubic meter per minutes

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T = Total period of sampling in minutes
W = Difference in final and initial weight of hopper in grams.

Determination of Particulate matter $PM_{2.5}$

$$\text{Concentration of } PM_{2.5} = \frac{W \times 106}{V \times T} \mu g/m^3$$

Where
V = Flow rate in cubic meter per minutes
T = Total period of sampling in minutes
W = Difference in final and initial weight of filter paper in grams

3.RESULTS AND DISCUSSION

The overall observation, it is clear that a different place of Bangalore city region describes the probability of increase of the particulate matter concentration (Table 2-7).

Table 2: Summary of Ambient Air Quality Data in and around Peenya during January 2025 (mean values $\mu g/m^3$)

AREA	PM_{10} (Mean value)	PM_{100} (Mean value)	$PM_{2.5}$ (Mean value)	SO_2 (Mean value)	NO_2 (Mean value)	CO (Mean value)
Dasarahalli (N)	112	278	88	21.0	33	720
Jalahalli (NE)	162	317	97	24.3	37	620
Yeshwntpur (E)	316	360	117	29.8	42	612
Rajajinagar (S)	328	475	160	27.3	51	1240
Nandhini layout (SE)	124	370	71	21.3	38	1100
Vijayanagar(SW)	91	114	49	9.4	19.6	112
Laggere (W)	64	72	34	6.8	17.3	140
Nagasandra(NW)	147	129	58	12.6	25.9	210

Table 3: Summary of Ambient Air Quality Data in and around Peenya during February 2025 (mean values $\mu g/m^3$)

AREA	PM_{10} (Mean value)	PM_{100} (Mean value)	$PM_{2.5}$ (Mean value)	SO_2 (Mean value)	NO_2 (Mean value)	CO (Mean value)
Dasarahalli (N)	112	216	112	12.3	26.2	305
Jalahalli (NE)	120	216	51	9.4	31.6	340
Yeshwntpur (E)	102	142	48	9.8	34.3	240
Rajajinagar (S)	312	424	124	17.3	51.4	710
Nandhini layout (SE)	212	342	114	12.6	30.1	610
Vijayanagar(SW)	316	420	77	19.6	51.3	940
Laggere (W)	142	214	80	24.7	31.6	980
Nagasandra(NW)	417	518	151	21.6	41.6	510

Table 4: Summary of Ambient Air Quality Data in and around Peenya during March 2025 (mean values $\mu g/m^3$)

AREA	PM_{10} (Mean value)	PM_{100} (Mean value)	$PM_{2.5}$ (Mean value)	SO_2 (Mean value)	NO_2 (Mean value)	CO (Mean value)
Dasarahalli (N)	150	188	94	13.4	31.8	270
Jalahalli (NE)	114	154	44	14.8	27.4	210
Yeshwntpur (E)	94	108	40	13.7	37.8	170
Rajajinagar (S)	224	624	124	19.4	47.6	840
Nandhini layout (SE)	210	138	84	15.4	41.2	520
Vijayanagar(SW)	224	212	74	21.7	51.6	720

Laggere (W)	314	164	64	16.8	47.3	370
Nagasandra(NW)	478	724	125	20.1	50.3	470

Table 5: Summary of Ambient Air Quality Data in and around Peenya during April 2025 (mean values µg/m^3)

AREA	PM_{10} (Mean value)	PM_{100} (Mean value)	$PM_{2.5}$ (Mean value)	SO_2 (Mean value)	NO_2 (Mean value)	CO (Mean value)
Dasarahalli (N)	114	142	74	14.3	29.4	210
Jalahalli (NE)	132	138	54	15.8	31.8	140
Yeshwntpur (E)	142	142	34	17.6	38.2	210
Rajajinagar (S)	148	414	112	20.1	51.3	640
Nandhini layout (SE)	174	148	94	17.6	44.3	540
Vijayanagar(SW)	138	162	78	13.8	40.6	240
Laggere (W)	114	188	88	13.6	34.3	430
Nagasandra(NW)	840	628	134	13.5	41.3	940

Table 6: Summary of Ambient Air Quality Data in and around Peenya during May 2025 (mean values µg/m^3)

AREA	PM_{10} (Mean value)	PM_{100} (Mean value)	$PM_{2.5}$ (Mean value)	SO_2 (Mean value)	NO_2 (Mean value)	CO (Mean value)
Dasarahalli (N)	132	112	54	14.3	28	270
Jalahalli (NE)	89	132	62	16.8	34.8	310
Yeshwntpur (E)	84	84	54	13.8	31.7	460
Rajajinagar (S)	169	220	114	19.8	51.4	842
Nandhini layout (SE)	174	210	68	14.8	48.4	514
Vijayanagar(SW)	112	214	86	15.3	37.3	510
Laggere (W)	148	208	74	14.3	38.8	528
Nagasandra(NW)	295	462	134	21.4	51.3	864

Table 7: Summary of Ambient Air Quality Data in and around Peenya during June 2025 (mean values µg/m^3)

AREA	PM_{10} (Mean value)	PM_{100} (Mean value)	$PM_{2.5}$ (Mean value)	SO_2 (Mean value)	NO_2 (Mean value)	CO (Mean value)
Dasarahalli (N)	82	128	54	14.3	27.4	216
Jalahalli (NE)	94	110	62	14.6	22.3	274
Yeshwntpur (E)	51	79	31	9.8	45.8	308
Rajajinagar (S)	152	240	124	18.6	41.8	516
Nandhini layout (SE)	112	140	84	14.3	41.6	460
Vijayanagar(SW)	108	138	108	13.6	34.9	308
Laggere (W)	96	144	74	14.3	27.8	428
Nagasandra(NW)	214	416	138	24.8	49.8	716

Particulate matter which includes PM_{10}, PM_{100}, $PM_{2.5}$ serves as an important tool to determine the ambient air quality. This study reveals the concentration of PM_{10}, PM_{100} and $PM_{2.5}$ at all the sampling stations to be dangerous to plants, animals and human beings. The sampling stations fall under the category of industrial zones.

In the Nagasandra, minimum PM_{10}, PM_{100}, $PM_{2.5}$ noticed was 218, 416 and 102 µg/m^3 for the period of January 2025. This value slightly exceeds the standard value.

The industrial zone such as Nagasandra lies at around 4 kms from the industry and does not face any mining activities. Comparatively the PM_{10}, PM_{100}, $PM_{2.5}$ from the industry has made the area severely polluted during the period of April and June. As the wind direction dominates in the north east with

respect to the industry during the monsoon months. That may be a reason for the severe pollution of this region where as the monsoon brings rain to the region during June to July.
But these months have not recorded higher number of rainy days, where as the wind speed is higher during these days. Not only these factors are associated with pollution, the other factors such as the plume behavior must also be considered. Due to humidity there may be inversion during this period there by resulting in increase in the ground level concentration of PM_{10}, PM_{100}, $PM_{2.5}$.
Air pollution caused by automobiles has been described as the 'disease of wealth'. Sulphur dioxide, nitrogen dioxide and particulate matter (PM) are regarded as major air pollutants in India (Agarwal and Bhatnagar, 1991). In the developing countries, air quality crisis in cities is attributed to vehicular emission which contributes to 40-80% of total air pollution (Ghose et al., 2005). A major part of Particulate matter existing in the air also comes from natural sources, including ground, oceans and volcanoes (Limaye and Salvi, 2010). Furthermore, Particulate matter can travel over long distances and even remain suspended in the atmosphere over time (Londahl et al., 2007).

Pandey et al. (1999) has studied the ambient air quality of Lucknow city in India, in terms of SPM which ranges from 583 $\mu g/m^3$ to 3450$\mu g/m^3$, the authors have mentioned the vehicular pollution also acts as a source of pollution.

Agarwal and khanam (1997) have monitored the air quality near by Dala cement factory in Uttarpradesh in India. They have reported that the SPM concentration has exceeded within 2km from the source, and also higher values have been recorded during summer periods that is about 752$\mu g/m^3$, where the sampling site is 0.5km from the source.

Similar results have been cited by Mohanty, (1999), Joshi and Jain (2000), Jayanthi and Krishnamoorthy (2006), Gupta and Sunita (1997), Agarwal and Khanam (1997) further discuss the effect of transportation of cement bags and raw materials as source for SPM. So we can justify the mere pollution of this region may be influenced by not only from the source but also the meteorological condition along with the stack height, plume behavior could contribute to the severity of pollution. (Rao and Rao, 1989).

From the observation, it was clear that the chief industrial activity responsible for such PM_{10} pollution must be the cement industry and the limestone quarries. PM_{10} must be controlled in order to safeguard the health of the future generation and to achieve sustainable development. Similar results have been reported by Chandrasekaran et al. (1996) and Prasad et al. (1997). Hence, the Vehicular pollution, industrial pollution coupled with domestic activities result in an increased pollutant concentration in the ambient air. Fly ash comprises divided particles of ash entrained in flue gases arising from combustion of coal. The size of fly ash particles may vary from 0.02μm to over 300μm. It contains incompletely burned coal and the carbon content of fly ash may vary from 5 to 20%, though some samples may contain as high as 50 %. Also a large number of minerals, originally present in the coal, may also occur in fly ash (Thangarasu, 2002). Cement manufacturing industries have found to contribute substantially to the air pollution problem as point source of emission. Fall out of cement factory emission was determined by several factors such as variations in cement manufacturing process, efficiency of emission control devices, meteorological and topographical conditions, vegetation and soil are also important sinks for air borne pollutants. In India, high dust fall rates around cement factories have been reported by several workers (Manju et.al., 2000, Sundar et.al., 2000, Anandan et.al., 2019, Ashok et.al., 2018, 2019, Vasanthy and Jeganathan 2008, 2009).
Pandey et al. (1999) has studied the ambient air quality of Lucknow city in India, in terms of SPM which ranges from 583 $\mu g/m^3$ to 3450$\mu g/m^3$, the authors have mentioned the vehicular pollution also acts as a source of pollution. The sampling station namely Sample 3 is severely polluted during January, February, and November and the area seems to be fairly clean during, April and during most of the months namely June, August, September, October and December it is moderately polluted. And in this area not much variation is seen during the day and night values.

CONCLUSION

Air pollution is a global issue, therefore, can't be addressed only locally, moreover local actions are irreplaceable and crucially necessary. The main cause of air pollution is mainly due to fast growing population of automobiles and poor traffic control, congested roads. To overcome this development and planning of city and public awareness play very important role to reduce the ambient air pollution. From the study, it is clear that the anthropogenic activities especially industrial, mining activities and vehicular pollution are responsible for the higher concentration of particulate matter in Bangalore region. Increased monitoring can play an important role as a health advisory system and as a means of increasing pressure on polluters to comply with existing regulations. There is an urgent need of development of a sustainability index to bench mark using these components strong environmental governance guidelines/ violators.

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