Study of Ambient Air Quality in Urban and Rural Residential Areas of Kalyan City in Maharashtra

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Abstract: ***Major issues and increasing risk factor due to the air pollution, causes for ill health in India and to the country's burden of disease. Rural and urban towns of India are both affected by poor air quality. Urban activities create more pollution as compare with rural activities. This paper assesses the status of ambient air quality in urban and rural residential area of adjoining village of Kalyan city. For assessment purpose, three monitoring sites were selected for urban as well as nearby adjourning residential rural to understand the present status of the air quality of this region. The ambient air quality was studies using assessing the air pollutants parameters, namely, Particulate matter less than 10 microns (PM_{10}), Particulate matter less than 2.5 microns ($PM_{2.5}$), Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), Ammonia (NH_3), and Carbon Monoxide (CO). After assessing, it has been observed that PM_{10} and $PM_{2.5}$ valves found high at Urban as comparison to Rural site at all locations, exceeded the prescribed standard. Gaseous pollutants are found to be in prescribed standards at urban and rural sites. Air Quality Index were observed as heavily polluted at all urban sites and also at one rural site (Koregaon). It is recommended that particulate matter should be reduced at urban as well as rural areas.***

Keywords: Risk factor, ambient air quality, particulate matter, microns

1. Introduction

Today, air pollution is considered as one of the utmost problems affecting humans, with significant consequences on the environment as well as health of the population. In metros or megacities such as São Paulo, Los Angeles, and Beijing, the industrial processes, fuel combustion, transportation and urbanization are major causes of contamination sources [1]-[3]. Subsequently, air pollutant determinations have attracted great concern over the last decades due to the evidence as they are associated with respiratory and cardiovascular diseases in humans [4]-[5]. Increase in the concentration of traffic particles by 1 $\mu g/m^3$, could be associated with about 7,000 additional early deaths per year in the United States [6].

Exposure to air pollution has shown to slow lung development in children [7], affect cognitive development [8], and has resulted in high levels of mortality from respiratory infections [9]. The older aged is more likely to develop chronic respiratory and cardiac illnesses as a result of long-term exposure and are more susceptible to heart attacks and strokes during episodic high pollution events. Susceptible also are those of a lower socio-economic status with results of studies shows they are more vulnerable to insults from air pollution exposure for a various reason including occupation, housing, cooking fuel use, the common link being poverty [10].

Worldwide, it is observed that air pollution is now widely known to have impacts over human health, agriculture, ecology, buildings, and climate. It affects the respiratory, cardiovascular, cardiopulmonary and reproductive systems and that can also lead to cancer [11]. International Agency for Research on Cancer (IARC) has classified outdoor air pollution as carcinogenic to humans [12]. Lim et al. (2012) estimated 0.62 million mortalities annually in India that could be attributed to $PM_{2.5}$ pollution in 2010 [13]. This makes air pollution the fifth largest killer in India. TERI [14] projected the mortalities to increase to 1.1 million in 2031 and 1.8 million in 2051, in a business as usual scenario. IHME (2013) also lists air pollution among the top 10 health risks in India [15].

Other than ambient outdoor air pollution, biomass used in rural areas and urban slums for cooking and kerosene for lighting is also associated indoor air pollution and with a many health disease such as Chronic Obstructive Pulmonary Disease [16], tuberculosis [17], cataract [18] and adverse pregnancy results [19]. Carbon monoxide (CO) is one of the significant sources of motor vehicle exhausts in megacities of the developing countries [20]-[21]. A study by Sathitkunarat et al. (2006) show that traffic can contribute with up to 90% of total CO emissions in a city. CO reduces the oxygen-carrying capacity of the blood and health-based guidelines for maximum ambient CO-levels are; 86 ppm for 15 min, 52 ppm for 30 min, 26 ppm for 1 hour and 9 ppm for 8 hours exposure [22]-[23].

In rural areas, air quality is being measured but no action was taken to reduce the pollutant level. Thus, in other words, options available in paper/reports only not implemented. The common belief is that rural areas are free from air pollution. On the contrary, air quality in the rural areas all over the world and particularly in the developing countries may be more polluted than some of the urban areas. Major sources of air pollution in rural area are indiscriminate use of insecticides/pesticides sprays and burning of wheat and paddy straw. The major air pollutants include gases like sulphur dioxide, oxides of nitrogen, suspended particulate matter and respirable suspended particulate matter. These air pollutants in the atmosphere have an adverse effect on human life and are contributed by various sources. The direct effect of air pollutants on plants, animals and soil can influence the structure and function of ecosystems, including self-regulation ability, thereby affecting the quality of life [24].

Air quality of a city is not only affected by local emission sources but also related to meteorological conditions. Various studies have analyses the influences of wind, temperature, and relative humidity on the concentrations of air pollutants [25]-[26]. Furthermore, air quality is affected by temporary weather conditions, and it might also be influenced by the variability of climate systems. So, it needs to monitor the ambient air quality of urban and adjoining rural residential areas of Kalyan City.

2. Method and Materials

Kalyan Dombilivi Municipal Corporation is located in Thane district, situated on the western coast and comes under the Konkan division of the Maharashtra state. The climate of the district is distinctly different on the coastal plains and on the eastern slopes. Being fully tropical, the climate on the coast, the coastal strip including Thane, Vasai, Palghar and Dahanu Tahsils is very humid and warm. On the other hand, the climate on the eastern slopes and in the plains at the foot of the slopes is comparatively less humid. The maximum temperature varies from 28.0^{0}C to 35.2^{0}C and the minimum temperature varies from 16.3^{0}C to 26.5^{0}C. The district receives average rainfall of 2000 to 4000 mm from the South-West monsoons during the months June to September (https://thane.nic.in/district-profile/). The study was carried out at six sites, out of which three each site located at rural and urban city as shown in Table 1.

Table 1: Details of Monitoring Locations at Urban and Rural Site

Urban Air Monitoring Locations		*Rural Air Monitoring Locations*	
Sr.No	*Site*	*Sr.No*	*Site*
U1	Dombivali	R1	Konegaon
U2	Kalyan	R2	Bhalgaon
U3	Vithallwadi	R3	Golavali

Air monitoring samples was collected for twice a week in a month for twelve months. Thus, for one site, twelve weeks samples are collected for air monitoring. Monitoring was carried out during the month of March 2018 to February 2019. The ambient air quality was measured for Particulate Matter less than 10 microns (PM_{10}), Particulate matter less than 2.5 microns ($PM_{2.5}$), Nitrogen Dioxide (NO_X), Sulphur Dioxide (SO_2), Ammonia (NH_3) and Carbon Monoxide (CO). Samples of PM_{10} and $PM_{2.5}$ were collected at all the 6 sites that include rural and urban sites, at 24 hours for twice a week. PM10 and PM2.5 samples were collected on Whatman GF/A and Teflon-Millipore filter papers by respirable dust sampler (APM 460DX, Envirotech, New Delhi) and Wins-Anderson impactor (APM 550, Envirotech, New Delhi) with sharper cut point of 10μm and 2.5μm, respectively. The high-volume sampler and Wins- Anderson impactor was operated at flow rates of 1.0 m^3/min and 16.67 l/min, respectively.

Filter papers used for the instruments were pre-weighed on analytical weighing balance before the sampling and desiccated for 24 hours. To avoid the contamination, the conditioned and weighed filter papers were placed in filter holder cassette for $PM_{2.5}$ and zip lock polybag for PM_{10} and were taken to the field for sampling. Before loading the filter papers on the samplers, initial volume and timer readings were noted for $PM_{2.5}$ and the manometer reading for PM_{10} sampler. Filter papers were loaded on respective samplers and starting the samplers. After sampling, the loaded filter of $PM_{2.5}$ was removed with forceps and placed in cassette and wrapped with aluminum foil. Similarly, the PM_{10} filter paper was covered in aluminum foil and placed back in zip lock polybag and both the filter papers were transferred to laboratory as soon as possible. In laboratory, filter papers were conditioned and weighed again to determine the mass concentration of the PM_{10} and $PM_{2.5}$. The weighed filter papers were preserved in freezer for chemical analysis.

Parameters such as SO_2, NO_2 and NH_3 were measured with help of RDS APM 460DX with gaseous attachment APM 411 by sucking air into appropriate reagent for 48 hours every week at 24-hourly intervals and after air monitoring it procured into laboratory and analysis for the concentration level. SO_2, NO_2 and NH_3 were collected by bubbling the ample in a specific absorbing (Sodium tetrachloromercurate for SO_2, Sodium hydroxide for NO_2, and 0.1N Sulphuric acid for NH_3) solution at an average flow rate of 0.2-0.5 l/min. Impinge samples were placed in the ice boxes immediately after sampling and placed immediately to a refrigerator and analyzed within 24 hrs. The concentration of NO_2 was measured with standard method of Modified [27], SO_2 was measured by modified [28] and NH_3 was measured by using Nessler method. The instrument was kept at a height of 2 to 2.5 mts from the surface of the ground. CO samples collected in poly-teadlar bags using low volume sampler for 8 hours at respective sites. Samples were transferred to laboratory and analyzed using Thermo Scientific Analyzer (Model 48i CO).

2.1 Air Quality Index

Air Quality Index (AQI) is used to study the air quality in cities across the country on a real time basis and also to enhance the public awareness. Air Quality Index (AQI) is one such tool for effective dissemination of air quality information to people [29]-[30]. AQI will help the people know about the level of pollution in the ambient air on daily basis. The AQI is a measure of the ratio of the pollutant's concentration to the status of ambient air in monitoring places. Indices of air pollutant or air quality have been used for about 25 years [29]. The following computation was used to drive the air quality index of the sites under consideration:

$$AQI=1/4 \times (I_{PM10}/S_{PM10} + I_{PM2.5}/S_{PM2.5} + I_{SO2}/S_{SO2} + I_{NO2}/S_{NO2} + I_{NH3}/S_{NH3} + I_{CO}/S_{CO}) \times 100 \quad (1)$$

Where:

I_{PM10}, $I_{PM2.5}$, I_{SO2}, I_{NO2}, I_{NH3} and I_{CO} = Individual values of particulate matter (10 and 2.5), Sulphur dioxide oxides of nitrogen, ammonia and carbon monoxide respectively.

S_{PM10}, $S_{PM2.5}$, S_{SO2}, S_{NO2}, S_{NH3} and S_{CO}= Standards of ambient air quality.

The indices [31] use health-based descriptions to provide

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meaningful information to the public. The five levels of AQI are represented in Table 2.

Table 2: Index Values of Air Quality Index calculation

Sr No.	*Index Value*	*Remarks*
1	Between 10 - 25	Clear air
2	Between 26 - 50	Light air pollution
3	Between 51 - 75	Moderate air pollution
4	Between 76-100	Heavy air pollution
5	More than 100	Severe air pollution

(Source: Rao and Rao, 1989)

3. Results and Discussion

PM_{10} values observed at Urban sites are in the range of 146 µg/m^3 (U2) to 527 µg/m^3(U1) respectively. Average PM_{10} values are found highest at U1. i.e. Dombivali site (420 µg/m^3) followed by Vithallwadi (U3) and Kalyan (U2) respectively. All PM_{10} valves of Urban sites are found to be higher than standard prescribe by National Ambient Air Quality (Table 4). Table 3 and Figure 1 shows the concentration levels of PM_{10} at Urban sites. Maximum and minimum values of PM_{10} at Rural sites are observed at 333 µg/m^3 (R1) and 26 µg/m^3 (R2) respectively. Average PM_{10} values are found higher at Konegaon (R1) as compare to other sites as well as higher than standard (Table 4) as shown in Figure 2. Urban area found more polluted (420 µg/m^3) with PM_{10} compared to the rural residential area (247 µg/m^3). PM_{10} is most associated with vehicular exhausts, road dust and construction activities. Wear and tear of brakes and tyres on vehicles and crushing activities at construction sites can all contribute to a rise in PM_{10}.

Table 3: Concentration Levels of PM_{10}& $PM_{2.5}$ at Urban & Rural sites

Area	*Sampling sites*	*PM_{10} (µg/m^3)*			*$PM_{2.5}$ (µg/m^3)*		
		Avg	*Min*	*Max*	*Avg*	*Min*	*Max*
Urban	Dombivali (U1)	420	250	527	107	83	190
	Kalyan (U2)	315	182	430	129	56	286
	Vithallwadi ((U3)	324	146	459	142	52	428
Rural	Konegaon (R1)	247	75	333	89	56	133
	Bhalgaon (R2)	135	26	253	51	17	78
	Golavali (R3)	105	49	234	51	42	60

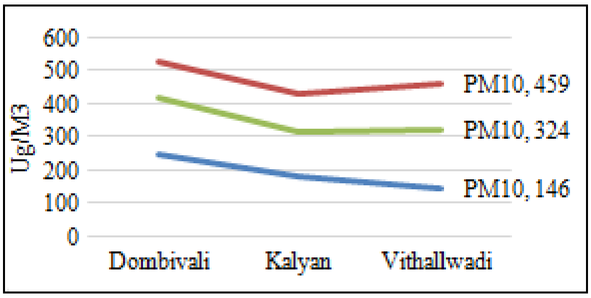

Figure 1: Concentration of PM10 at Urban Sites

Table 4: Standard for National Ambient Air Quality (CPCB, 2009)

Pollutants Parameters	*Time Weighted average*	*Residential Concentration in ambient air*	*Method of Measurement*
Particulate Matter (size less than 10µm) or PM10, µg/m3	24 hrs	100	Gravimetric
Particulate Matter (size less than 2.5 µm) or PM2.5, µg/m3	24 hrs	60	Gravimetric
Sulphur Dioxide (SO2), µg/m3	24 hrs	80	Improved West & Gaeke
Nitrogen Dioxide (NO2), µg/m3	24 hrs	80	Modified Jacob & Hochheiser
Carbon Monoxide (CO), mg/m3	8 hrs	02	NDIR spectroscopy
Ammonia (NH3), µg/m3	24 hrs	400	Indophenol blue method

Source: CPCB, 2009

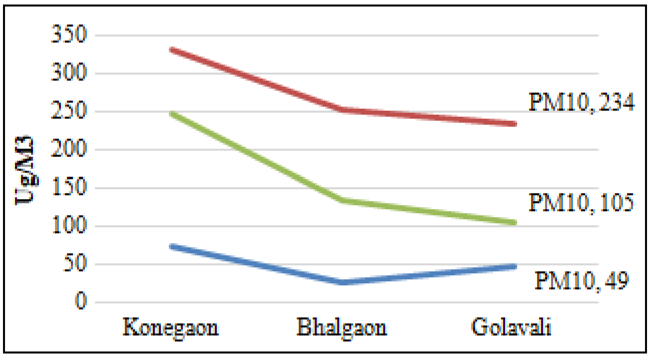

Figure 2: Concentration of PM10 at Rural Sites

$PM_{2.5}$ values found at urban sites are in the range of 52 µg/m^3 (U3) to 428 µg/m^3 (U3) respectively. Average $PM_{2.5}$ values are found highest at U3. i.e. Vithallwadi site (142 µg/m^3) followed by Kalyan (U2) and Dombivali (U1) respectively as shown Average $PM_{2.5}$ valves of urban sites are found to be higher than standard prescribe by National Ambient Air Quality (Table 4). Table 3 and Figure 3 shows the concentration levels of $PM_{2.5}$ at rural sites. Similarly, average value of $PM_{2.5}$ is higher at Konegaon (R1) and more than standard prescribe by National Ambient Air Quality (Table 4). Alternatively, $PM^{2.5}$ is more associated with fuel burning, industrial combustion processes and vehicle emissions.

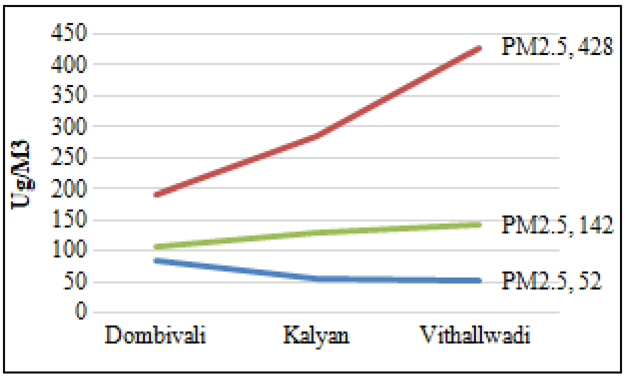

Figure 3: Concentration of PM2.5 at Urban Sites

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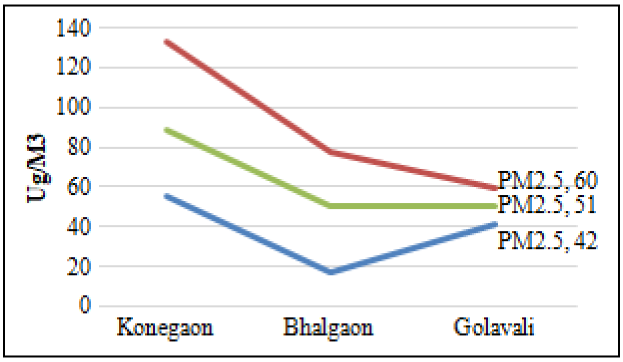

Figure 4: Concentration of PM2.5 at Rural Sites

SO_2 values are found in the range of 53 µg/m^3 to 2 µg/m^3 and 33 µg/m^3 to 2 µg/m^3 at Urban and Rural site respectively as shown in Table 4. Average SO_2 values are highest at Dombivali (U1) i.e. 17.6 µg/m^3 and Konegaon (R1) i.e. 8.0 µg/m^3 for Urban and Rural sites as shown in Figure 5 and Figure 6 respectively and within the standard limits (Table 4).

Table 4: Concentration Levels of SO_2 at Urban and Rural Sites

Area	*Sampling sites*	*SO_2 (µg/m^3)*		
		Avg	*Min*	*Max*
Urban	Dombivali (U1)	17.6	2.0	53.0
	Kalyan (U2)	8.8	2.0	43.0
	Vithallwadi ((U3)	3.3	2.0	15.0
Rural	Konegaon (R1)	8.0	2.0	33.0
	Bhalgaon (R2)	2.3	2.0	4.0
	Golavali (R3)	2.2	2.0	4.0

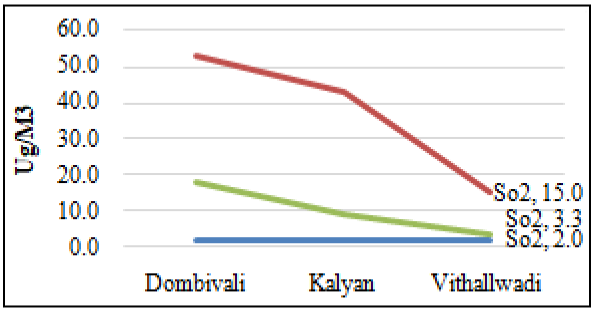

Figure 5: Concentration of SO2 at Urban Sites

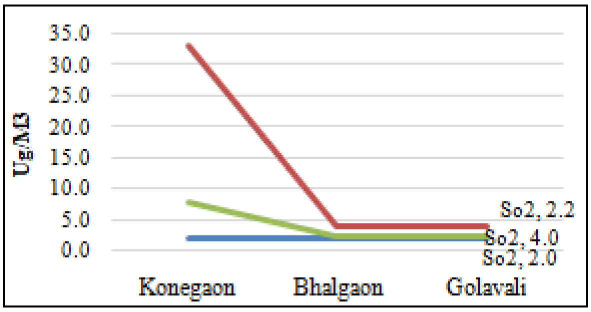

Figure 6: Concentration of SO2 at Rural Sites

NO_2 values are found in the range of 86 µg/m^3 to 5 µg/m^3 and 32 µg/m^3 to 2 µg/m^3 at Urban and Rural site respectively as shown in Table 5. Average NO_2 values are highest at Vithallwadi (U3) i.e. 86.0 µg/m^3 and Konegaon (R1) i.e. 32.0 µg/m^3 for Urban and Rural sites as shown in Figure 7 and Figure 8 respectively. All average NO_2 values within the standard limits (Table 4).

Table 5: Concentration Levels of NO_2 at Urban and Rural Sites

Area	*Sampling sites*	*NO2 (µg/m3)*		
		Avg	*Min*	*Max*
Urban	Dombivali (U1)	19.4	5.0	55
	Kalyan (U2)	23.0	5.0	39
	Vithallwadi (U3)	19.7	5.0	86
Rural	Konegaon (R1)	13.4	5.0	32
	Bhalgaon (R2)	10.1	5.0	23
	Golavali (R3)	6.0	5.0	11

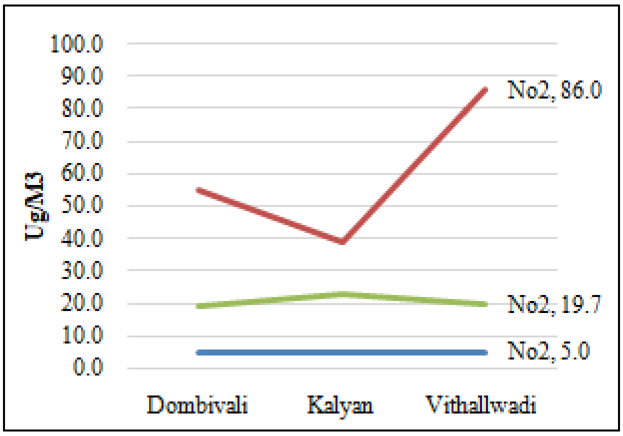

Figure 7: Concentration of NO2 at Urban Sites

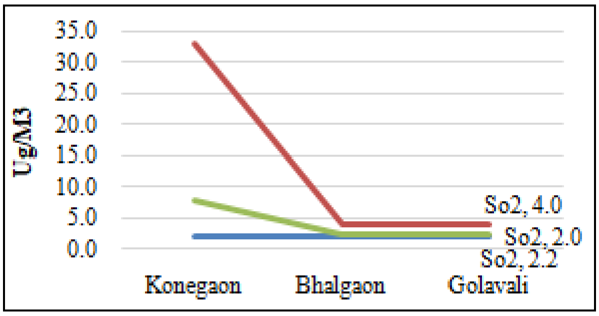

Figure 8: Concentration of NO2 at Rural Sites

NH_3 values are found in the range of 159 µg/m^3 to 5 µg/m^3 and 177 µg/m^3 to 2 µg/m^3 at Urban and Rural site respectively as shown in Table 5. Average NH_3 values are highest at Dombivali (U1) i.e. 44.8 µg/m^3 and Konegaon (R1) i.e. 48.3 µg/m^3 for Urban and Rural sites as shown in Figure 9 and Figure 10 respectively. All average NH_3 values within the standard limits (Table 4).

Table 6: Concentration Levels of NH3 at Urban and Rural Sites

Area	*Sampling sites*	*NH3 (µg/m3)*		
		Avg	*Min*	*Max*
Urban	Dombivali (U1)	44.8	5.0	110
	Kalyan (U2)	40.1	5.0	134
	Vithallwadi (U3)	37.7	5.0	159
Rural	Konegaon (R1)	48.3	5.0	177
	Bhalgaon (R2)	22.5	5.0	152
	Golavali (R3)	19.3	5.0	39

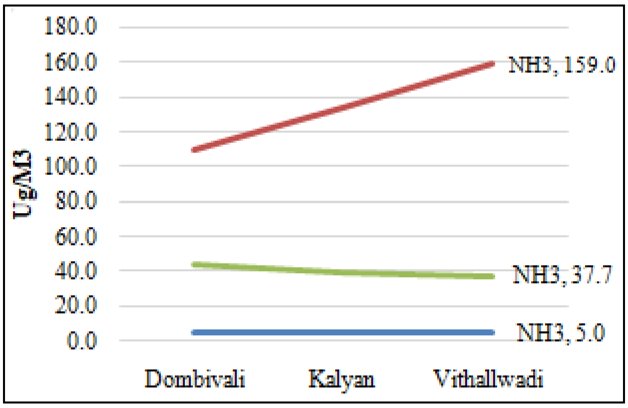

Figure 9: Concentration of NH3 at Urban Sites

CO values are found in the range of 2.5 mg/m^3 to 0.3 mg/m^3 and 1.2 mg/m^3 to 0.3 mg/m^3 at Urban and Rural site respectively as shown in Table 7. Average CO values are highest at Vithallwadi (U3) i.e. 1.0 mg/m3 and Golavali (R3) i.e. 0.9 mg/m^3 for Urban and Rural sites as shown in Figure 11 and Figure 12 respectively. All average COvalues within the standard limits (Table 4).

Table 7: Concentration Levels of CO at Urban and Rural Sites

Area	*Sampling sites*	*CO (mg/m3)*		
		Avg	*Min*	*Max*
Urban	Dombivali (U1)	0.5	0.4	0.9
	Kalyan (U2)	0.8	0.5	1.2
	Vithallwadi (U3)	1.0	0.3	2.5
Rural	Konegaon (R1)	0.7	0.3	1.2
	Bhalgaon (R2)	0.8	0.5	1.1
	Golavali (R3)	0.9	0.4	1.2

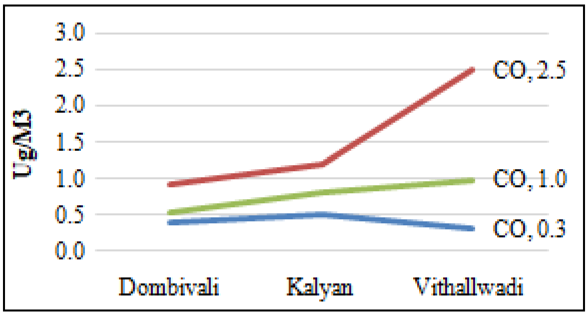

Figure 11: Concentration of CO at Urban Sites

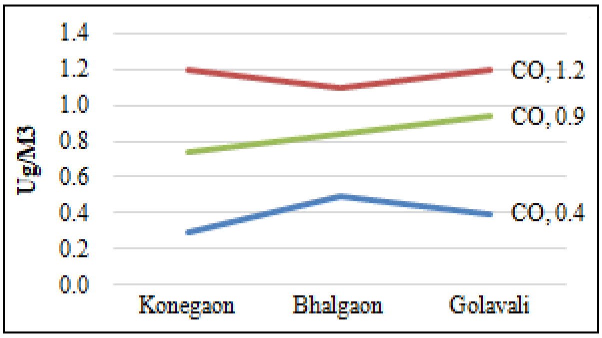

Figure 12: Concentration of CO at Rural Sites

Ambient air quality with respect to the average parameters and respective AQI is presented in Table 8. On the basis of AQI, it can be seen that the Dombivali, Kalyan, Vithallwadi, and Konegaon were heavily polluted (AQI above 100) whereas the Bhalgaon and Golavali were moderately polluted (AQI 51-75) as per Table 2.

Table 8: Ambient air quality with respect to the average parameters and respective AQI

Sites	*PM_{10}*	*$PM_{2.5}$*	*SO_2*	*NO_2*	*NH_3*	*CO*	*AQI*
Dombivali	420	107	17.6	19.4	44.8	0.5	168
Kalyan	315	129	8.8	23.0	40.1	0.8	150
Vithallwadi	324	142	3.3	19.7	37.7	1.0	156
Konegaon	247	89	8.0	13.4	48.3	0.7	113
Bhalgaon	135	51	2.3	10.1	22.5	0.8	66
Golavali	105	51	2.2	6.0	19.3	0.9	57

All values in µg/m3 except CO in mg/m3

Table 9: Ambient air quality with respective AQI

Sites	*AQI*	*Quality of Ambient air*
Dombivali	168	Severe air pollution
Kalyan	150	Severe air pollution
Vithallwadi	156	Severe air pollution
Konegaon	113	Severe air pollution
Bhalgaon	66	Moderate air pollution
Golavali	57	Moderate air pollution

4. Conclusion

Average monitoring data of urban and rural sites clearly showed lower concentrations of gaseous pollutants (SO_2, NO_2, NH_3, and CO) and higher concentrations of PM_{10} and $PM_{2.5}$ in the ambient air. At all urban and rural the monitoring sites, PM_{10} and $PM_{2.5}$ concentrations exceeded the permissible limits specified by CPCB while SO_2, NO_2 NH_3 and CO were within the standard specified by CPCB. In India, the major factors for increasing Air pollution are growing number of cars in cities, private & commercial vehicles are the major factor for causing air pollution. Low standards for vehicle emissions & fuel have resulted in increased levels of Nitrogen Oxides & Sulphur dioxide.

Kerosene lanterns used in rural areas are a primary source of emission of black carbon soot and cause significant health impact, particularly in the case of women and children. Agricultural burning of residues is another factor which contributes to the problem seasonally. A business model needs to be developed for waste to energy conversion using biomass gasification technology. Dusty construction sites have multiplied, outdoor air pollution has become a major healthhazard. Heavy duty vehicles such as trucks and interstate buses have the highest share in vehicular emission. Many steps to reduce air pollutants in terms of introducing many policies and increasing awareness towards clean energy have taken place, however lot needs to be done for active implementation. A shift towards renewable energy is part of the plan to reduce dependency on fossil fuels as well as provide clean energy to households that are currently using kerosene for lighting purposes.

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