Assessment of Ambient Air Quality Using Air Quality Index: A Case Study for Urban and Rural Area in Palghar District of Maharashtra (India)

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Abstract: ***Most of the research of air pollution has focused on assessing the urban landscape effects of pollutants in megacities, very less is known about their associations in small to mid - sized cities or towns. Air Quality Index (AQI) is a tool for identify the status of air quality, as in the last few years, national and international issues have been brought up about the health impacts caused by deteriorating air quality mainly due to large - scale industrialization, urbanization, and many other factors. In order to assess the AQI, five pollutants effect viz., PM_{10}, $PM_{2.5}$, NOx, SO_2, and CO were used to assess the prevailing ambient air quality in the urban and its associate rural areas, the ambient air quality was continuously monitored and studied. Results of AQI are observed to be satisfactory as per CPCB at urban and rural sites, shows not much variation and suggested the sources that are responsible. Maximum PM_{10}values are observed higher at 4 rural sites and at 1 Boisar urban location. This is due to the construction of road works, nearby building and township constructions ongoing along with resuspension dust on the road side. Thus, measures are suggested to reduce PM levels so that, AQI should be in good category and thereby helps to reduce the health impacts. The study helps to assist the supplementary suggestion to the strategy plan to reduce pollution levels with respect to rural region.***

Keywords: Air Quality Index, PM_{10}, $PM_{2.5}$

1. Introduction

Ambient air pollution is a global environmental problem that effects regularly to the health hazards of urban as well as rural public. The effects from ambient air pollution in combination with indoor air pollution cause approximately seven million early deaths every year, mainly due to the result of increased in mortality of stroke, Ischemic Heart Disease (IHD), Chronic Obstructive Pulmonary Disease (COPD), lung cancer and acute respiratory infections (WHO, 2020). Air pollution can occur in both outdoor and indoor environments. Cook stoves in rural homes, motor vehicles, industrial facilities and forest fires are common sources of ambient air pollution.

Cities, towns, rural areas and even national parks are sometime covered by polluted air. Air pollution impacts on human health could be the most drastic since human lungs, containing very sensitive tissues, receive daily around 15 kg of air compared to 2.5 kg of water and 1.5 kg of food (Veetil, 2012). India suffers from high levels of air pollutant concentrations. Six of the ten most polluted cities worldwide in year 2020 were in India (IEA, 2021). Particulate matter is one of the crucial contributors to urban and rural air pollution (Kuldeep et al, 2022). Tian et al, (2019) and Tobias et al, (2020) stated that $PM_{2.5}$ (aerodynamic diameter less than/equal to 2.5 μm) and PM_{10} (aerodynamic diameter less than to 10 μm) with significant health issues including chronic respiratory disease (Khaniabadi et al, 2017), premature mortality (Kermani et al, 2020), aggravated asthma (Manojkumar, 2021), acute respiratory (Afghan, 2020), emergency visits, and hospital admissions symptoms (Markandeya et al, 2021; Goel et al., 2021) and decrease in lung function (Rovira et al, 2020).

Exposure to outdoor and indoor air pollution has become one of the main reasons for children's death with increase in mortality and disease rate among children less than five years old. Between 2015 and 2016, the number of total deaths among children less than five - year - old, increased from 2, 37, 000 to 5, 43, 000 due to outdoor air pollution with highest deaths in Africa (1, 27, 900) and Asia (1, 06, 800) as disclosed by Lelieveld et al., (2018).

Indoor and ambient air pollution account for 6% and 3%, respectively, of the total national burden of disease and together, they exceed the burden from any other risk factor of the more than 60 observed. This burden, borne disproportionately by poor populations who are dependent on solid fuels for cooking, poses an enormous challenge for air quality management within public health programs in India. There is a need to integrate research and intervention across indoor as well as ambient air pollution exposures in India with respect to reduce disease burdens and to efficiently improve health by using intervention efforts.

Presently, the National Ambient Air Quality Standards (NAAQS) remain focused in Indian cities with very limited rural monitoring take place, even though two - thirds of people in India living in rural region. With about one - fourth of primary ambient $PM_{2.5}$ in India attributed to solid household cooking fuels, and thus, it will be difficult and, in some areas, not possible, to meet current NAAQS without reducing household emissions as compared to addressing vehicular, industrial, and other various emissions from known urban sources (CPCB, 2011). City/Town air quality is not only affected by emission sources but also related to meteorological conditions. Lot of studies had analyzed the influences of wind, temperature, and relative humidity on the concentrations of air pollutants (Fung and Wu, 2014; Wang et al., 2001). Moreover, air quality is affected by temporary weather conditions, and it might also be influenced by the variability of climate systems as well as pollutant sources in rural and urban region. So, it needs to monitor the ambient air quality of urban and adjoining rural residential areas of Boisar, Palghar and DahanuTown. Hence, it is very important to study about the air quality of India and help to formulate/contribute for relevant policies to reduce/control the air pollution with respect to rural areas.

2. Method and Materials

Palghar district is an administrative district in the state of Maharashtra in India. The district headquarters are located at Palghar Town/City. The district occupies an area of 9, 558 km² and has a population of 29, 90, 116 (Census, 2011). The climate of Palghar district is hot and humid with maximum and minimum temperature being 40.6^{o} Celsius and 8.3^{o} Celsius respectively. Average rainfall received is 2293 mm (CIDCO, 2016). Palghar district hosts many industrial activities at Boisar, Vasai, Palghar and Wada. The average wind speed in Palghar is 3.4 m/s with the maximum wind speed of around 10 m/s. The average ambient temperature remains 27.3°C, varies from 17.1°C to 36.4°C. The average relative humidity remains around 70.4%, varies from 26.9% to 97.1% respectively. The station pressure varies from 1000 hPa to 989 hPa, averaged around 1010 hPa. The average annual wind rose of Palghar shows that predominantly wind blow from the WSW, almost 20.92% of all wind directions as shown in **Figure 1** (Indian Climate. com, 2023). The study was carried out at thirteen sites, out of which three are located on urban and ten on rural as shown in **Table 1**.

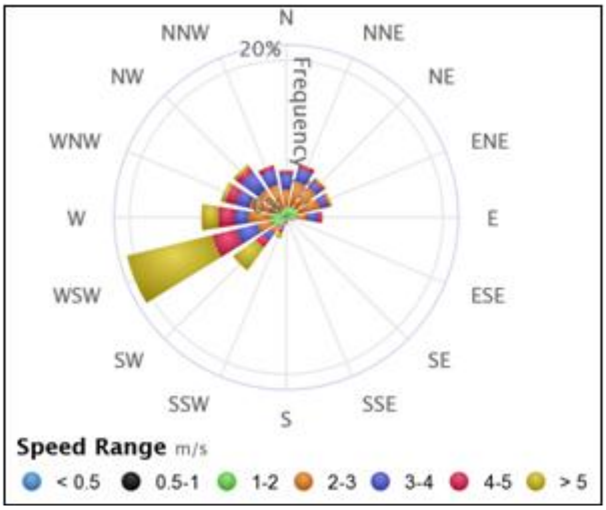

Figure 1: Annual Windrose of the Palghar

Table 1: Monitoring Locations for Urban and Rural Air Study

Sr. No.	Site/Locations	Latitude	Longitude
Urban Air Monitoring Sites			
1	Dahanu	19°59'23.49"N	72°44'22.87"E
2	Palghar	19°41'47.87"N	72°46'10.92"E
3	Boisar	19°47'47.17"N	72°45'25.00"E
Rural Air Monitoring Sites			
1	Bordi	20°06'52.91"N	72°44'23.51"E
2	Sakhare	19°54'37.37"N	72°48'31.71"E
3	Kosbad	20°03'17.67"N	72°045'8.54"E
4	Vilatpada	20°02'36.33"N	72°43'45.92"E
5	Kainad	20°01'35.88"N	72°46'27.77"E
6	Narpad	20°00'54.30"N	72°43'10.37"E
7	Nandore	19°44'08.15"N	72°48'37.23"E
8	Murbe	19°44'30.97"N	72°42'31.05"E
9	Kumbhwali	19°46'18.68"N	72°42'55.65"E
10	Asangaon	19°54'22.61"N	72°45'11.46"E

2.1 Sample Collection

Air monitoring samples was collected for twice a week for four months period. Thus, for one site, thirty - four samples are collected for air monitoring. 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 (NOx), Sulphur Dioxide (SO_2), and Carbon Monoxide (CO). Samples of PM_{10} and $PM_{2.5}$ were collected at all the 13 sites from both rural and urban sites, at 24 hours for twice a week. PM_{10} and $PM_{2.5}$ samples were collected on Whatman GF/A and Teflon - Millipore filter papers by respirable dust sampler (Asha Enviro, New Delhi) and Wins - Anderson impactor (Asha Enviro, 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.

2.2 Analysis Method

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 assess the mass concentration of the PM_{10} and $PM_{2.5}$. The weighed filter papers were preserved in freezer for chemical analysis.

Parameters assessed are SO_2, and NOx with help of AEE/C - 0147 (Asha Enviro) with gaseous attachment by suction of air into appropriate reagent for 48 hours, every week at 24 - hourly intervals and after monitoring, the samples transported to laboratory for analysis. $SO_2$and NOx were collected by bubbling the ample in a specific absorbing (Sodium tetrachloromercurate for SO_2, Sodium hydroxide for NOx,) 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 NOx was measured with standard method of Modified (Jacobs, 1958), and SO_2 was measured by modified (West & Gaeke, 1956).

The instrument was kept at a height of 2 to 2.5 mts from the surface of the ground. CO samples collected in polyteadlar bags using low volume sampler for 8 hours at respective locations. Samples were transferred to laboratory and analyzed using Thermo Scientific Analyzer (Model 48i CO).

3. Air Quality Index (AQI)

AQI is an important tool, introduced by Environmental Protection agency (EPA) to assess the pollution levels due to major air pollutants present in the ambient air. Mukesh Sharma (2003) defined the AQI as an overall system that changes weighted values of individual air pollution linked parameters into a single number or set of numbers. The AQI was calculated using AQI described by CPCB. This AQI has divided into six categories with associated health impact as shown in **Table 2**.

Table 2: AQI Categories and Its Associated Health Impacts (CPCB, 2014)

AQI Value	Air Quality	Associated Health Impacts	Colour Code
0 - 50	Good	Minimal Impact	
51 - 100	Satisfactory	May cause minor breathing discomfort to sensitive people	
101 - 200	Moderate	May cause breathing discomfort to the people with lung disease such as asthma and discomfort to people with heart disease, children and older adults	
201 - 300	Poor	May cause breathing discomfort to people on prolonged exposure and discomfort to people with heart disease with short exposure	
301 - 400	Very Poor	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases	
401 - 500	Severe	May cause respiratory effects even on healthy people and serious health impacts on people with lung/heart diseases. The health impacts may be experienced even during light physical activity	

4. Results and Discussions

Overall, based on the analysis results of the air monitoring, PM_{10} values on urban locations shows maximum at Boisar (130.6 µg/m^3), followed by Dahanu (95.65 µg/m^3) and Palghar (94.65 µg/m^3) respectively and minimum at Boisar (36.47 µg/m^3), Palghar (34.77 µg/m^3) and Dahanu (27.77 µg/m^3) respectively. Values of $PM_{2.5}$ was observed maximum in the range of 104.6 - 92.22 µg/m^3 and minimum range 27.34 - 24.07 µg/m^3 respectively for urban. SO_2 and NOx concentration levels at urban location are observed maximum atBoisar (52.81 µg/m^3) followed by Dahanu (49.61 µg/m^3) and Palghar (30.21 µg/m^3), minimum values at Dahanu (18.61 µg/m^3), Boisar (17.43 µg/m^3) and Palghar (16.82 µg/m^3) respectively. NOx values observed in the range of 95.47 µg/m^3 (Boisar) to 20.9 µg/m^3 (Palghar) respectively. Similarly, CO values are observed in the range of 2.44 mg/m^3 (Boisar) to 0.94 mg/m^3 (Palghar) respectively. **Figure 1** to **Figure 5** shows the minimum, maximum, average, and 98percentile for PM_{10}, $PM_{2.5}$, SO_2, NOx and CO respectively. Average PM_{10}, $PM_{2.5}$, SO_2, NOx and CO are observed in the range of 76 - 82 µg/m^3, 52 - 59 µg/m^3, 30 - 33 µg/m^3, 46 - 59 µg/m^3 and 1.6 - 1.8 mg/m^3 respectively and observed within the standard limits of CPCB, which is 100, 60, 80, 80 and 04 respectively. Average values of all parameters are found to be higher at Boisar location as compared to other two locations in urban region and shown in **Figure 6**. Maximum values of all parameter's studies are found to be high at Boisar as compared to the Dahanu and Palghar (**Figure 7**). AQI values are observed in the range of 97 (Boisar) to 87 (Dahanu) and air quality found to be satisfactory (51 - 100) which indicates minor breathing discomfort to sensitive people as per AQI categories and its associated health impacts (CPCB, 2014).

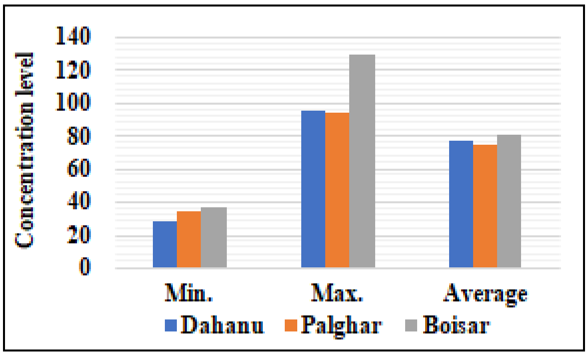

Figure 1: PM_{10} Concentration Level for Urban Locations

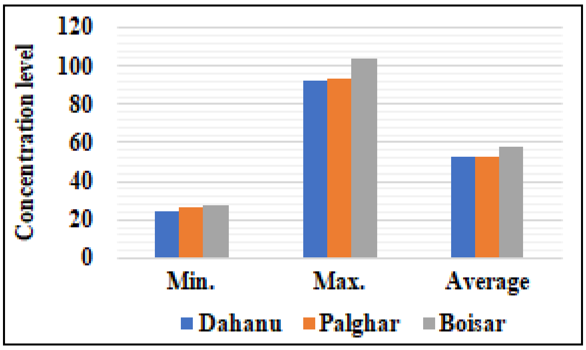

Figure 2: $PM_{2.5}$ Concentration Level for Urban Locations

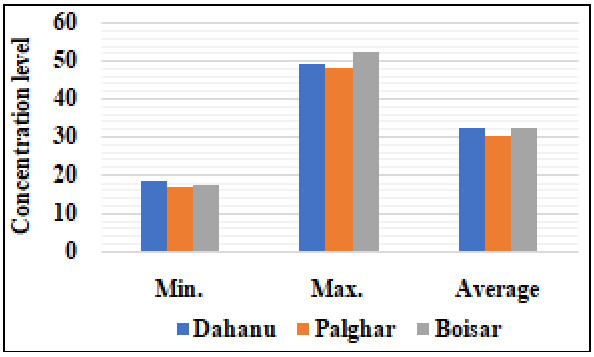

Figure 3: SO_2 Concentration Level for Urban Locations

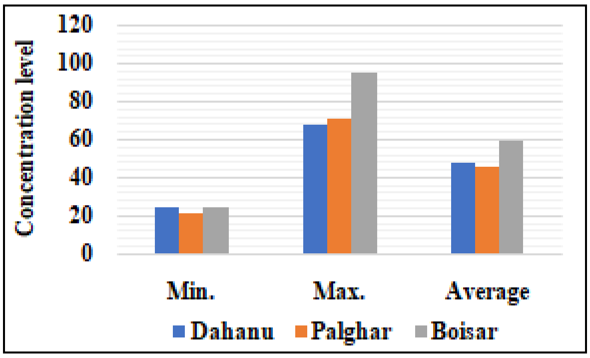

Figure 4: NOx Concentration Level for Urban Locations

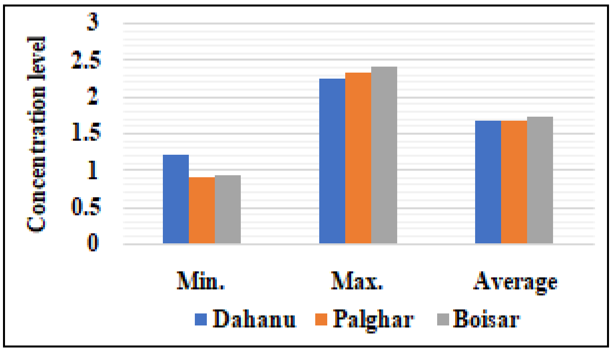

Figure 5: CO Concentration Level for Urban Locations

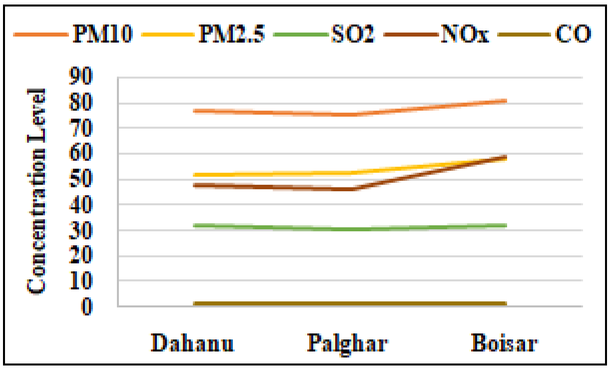

Figure 6: Average Concentration Level for Urban Locations

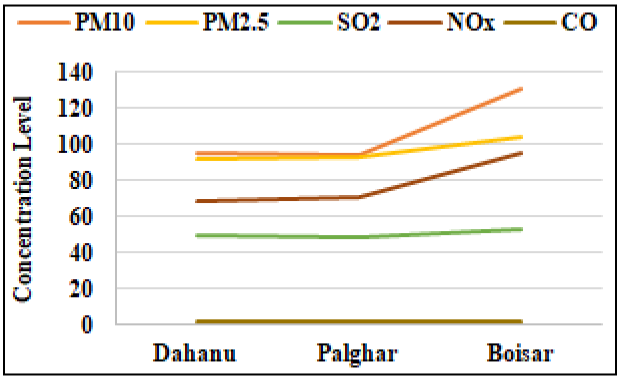

Figure 7: Maximum Concentration Level for Urban Locations

Maximum PM_{10}values for rural sites was observed at Kumbhwali (105.31 µg/m^3) and Kosbad (105.30 µg/m^3) village whereas minimum at Asangaon village (28.72 µg/m^3) respectively and shown in **Figure 8**. These may be due to the air monitoring locations are located near the KosbadDhanue road and thus PM_{10} values are higher due to the heavy vehicular movement during day and night. Maximum $PM_{2.5}$ values are found to be at Narpad (97.48 µg/m^3) and minimum at Murbe (16.23 µg/m^3) site and shown in **Figure 9**. Maximum SO_2 values are found at Sakhara (66.35 µg/m^3) and minimum at Asangaon (12.9 µg/m^3) respectively. Maximum NOx values are observed high at Kainad (89.43 µg/m^3) and low at Asangaon (13.7 µg/m^3) respectively. CO are observed in the range of 2.49 – 0.27 mg/m^3 respectively. AQI were also calculated using CPCB formula and found highest at Vilatpada (92) and lowest at Kumbhwali (60) respectively.

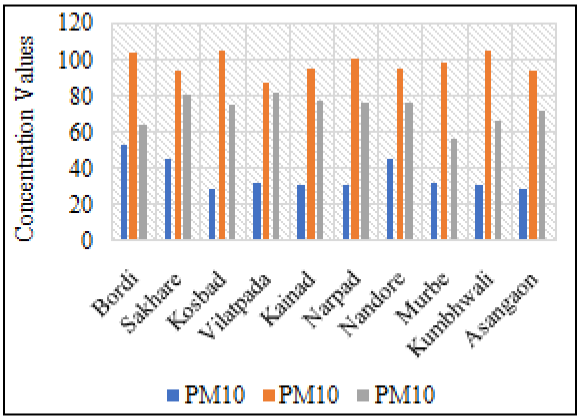

Figure 8: PM10 Concentration Values at Rural Sites

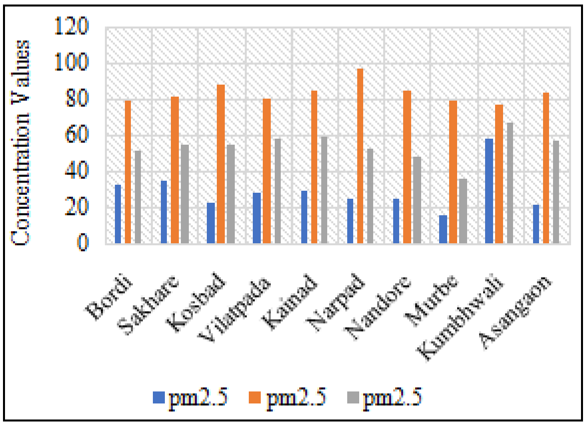

Figure 9: PM2.5 Concentration Values at Rural Sites

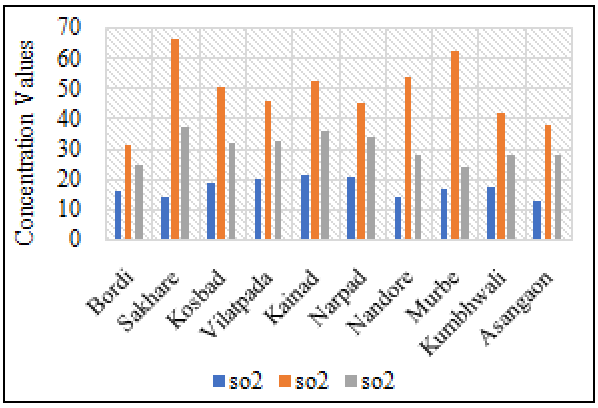

Figure 8: SO2 Concentration Values at Rural Sites

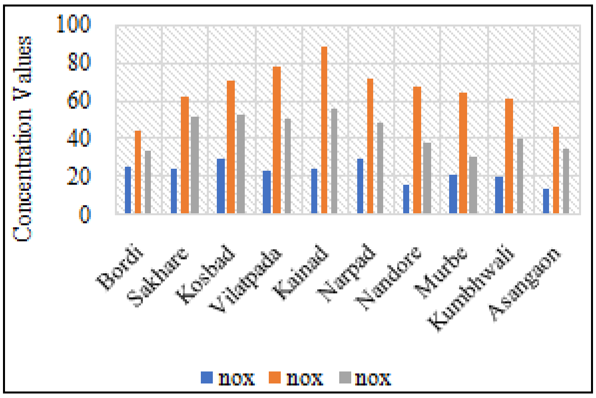

Figure 9: NOx Concentration Values at Rural Sites

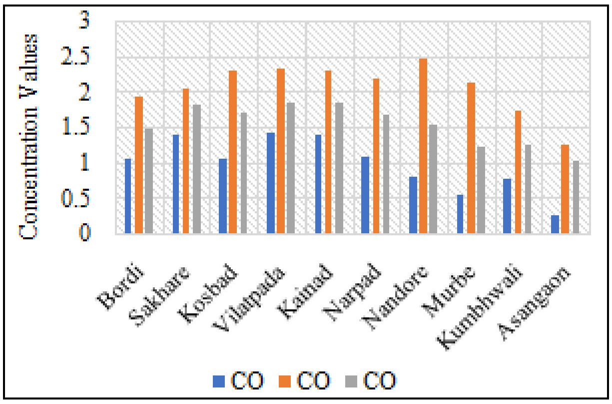

Figure 10: CO Concentration Values at Rural Sites

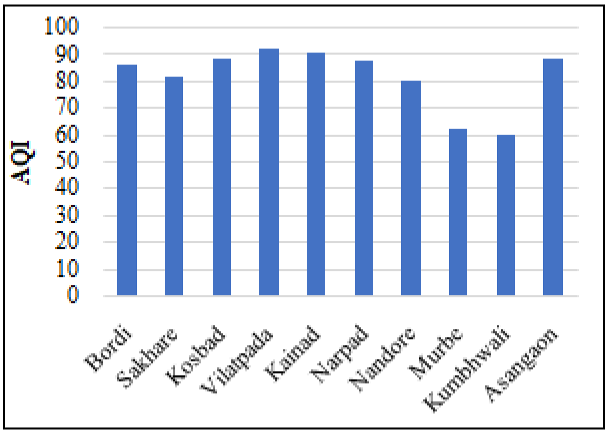

Figure 11: AQI for Rural Sites

All the 24 hrs average parameters for PM_{10}, $PM_{2.5}$, SO_2, NOx and CO calculated at urban and rural sites are found within the standard limit of CPCB. AQI for rural sites are found to in the range 92 - 60 and as designated as Satisfactory as per CPCB stated.

Average 24 hrsPM_{10} values are observed to be high at Boisar and Vilatpada due to the vehicular pollution and resuspension of the road dust. Sometimes repairing and widening of road is also the responsible for higher value. Average 24 hrs PM2.5 shows highest values found at Kumbhwali (rural site) may be due to the emissions that include biomass combustion for cooking, lighting, and heating (firewood, charcoal, manure, crop residues). Avg 24 hrs SO2 values shows higher at Sakhare (rural site) due to the burning of domestic emissions from fossil fuel and diesel vehicles. Similarly, NOx values are found to be high at Boisar (Urban site) due to the heavy traffic, combustion of fossil fuels (coal, gas and oil) especially fuel used in cars, etc. CO level was found high at Vilatpada, and is produced by the combustion of carbonaceous materials and contribution to air pollution derives mainly from increased motor vehicle use and from road congestion. **Figure 12** revels the average 24 hrs parameters studied in urban and rural region.

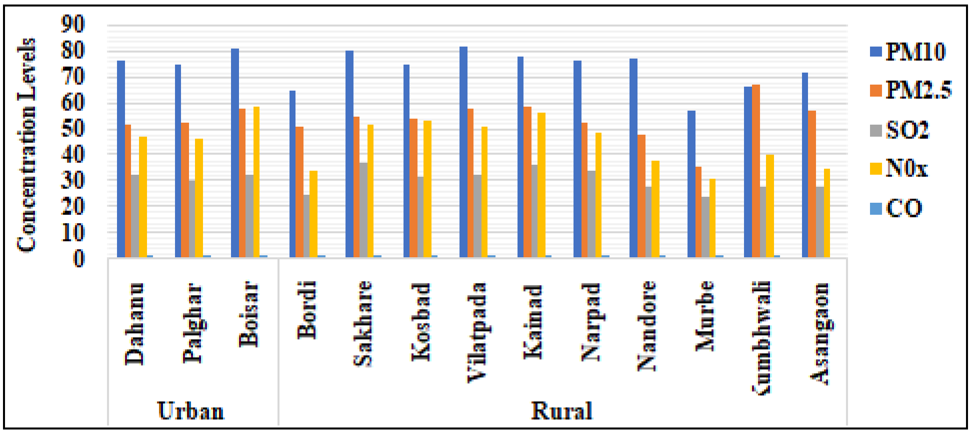

Figure 12: Average 24 hrs Values at Urban and Rural Sites

5. Conclusion

With a growth in population and increasing in settlements, the need for baselines and a start to tackle air pollution is crucial and urgent. The overall AQI can give clear idea about the ambient air pollutant primarily accountable for the quality of air quality which can be easier for a common man to understand. The AQI study reveals that particulate matter (PM) was mainly responsible for maximum times in all sites for urban and rural region. The majority of AQI values of

PM_{10}, $PM_{2.5}$, SO_2, NOx and CO fall under the category of satisfactory. This could be due to rapid increase in urban population, growth of vehicular population, frequent dust storms, and resuspension of dust. Not much difference in pollutant parameters were observed between urban and rural sites except Boisar. Boisal site is located nearest to the industrial region and thus, PM_{10} was observed higher value. PM levels may be higher due to the construction of buildings, road works repair, and resuspension of the dust (on road). To reduce the PM pollution, awareness program along with regularly cleaning of roads, proper fencing/ sprinking of water for building and town construction works to be implemented.

Implementation of modern and clean energy sources can reduce air pollution and deliver major health benefits, but also significantly reduce GHG emissions lead to the benefit for climate change. Reducing the use of traditional biomass in residential can also significantly reduce air pollutants, but only fully switching to modern, clean cooking technologies by 2030 can nearly fully abate indoor $PM_{2.5}$ emissions by 2040, whereas reducing emissions from NO_X and SO_2 by 65 - 75% in the same period (IEA, 2021). Emissions inventory followed by a dispersion modeling exercise to evaluate the particulate pollution trend and identify source contributions. Simply publishing or studying such numbers will not reduce pollution, but in the absence of any other existing data, results from such study can support the policy makers to establish baselines and plan a roadmap to improve air quality in the long run. To accomplish this, supplementary policy efforts are essential. A changeover to clean cooking fuel could further help mitigating climate change.

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Author Profile

Sandeep TTayade, pursuing PhD from University of Mumbai and completed Master Degree in Environmental Science, from University of Mumbai and presently working with EcoFoot Forward on EIA project in different sectors. Also, work with various organizations (CSIR - NEERI, WTERT, WERG, SWM - NEERI) on environment sector. Having national and international patents on wastewater treatment.

Amey V Gawade, pursuing PhD on Environmental Science from University of Mumbai, and founder of Eco foot forward Environmental Consultancy and Engineers at Mumbai from 2013 onwards. Presently, he is a QCI - NABET EIA Coordinator for Sector 38, 39, 33, 21 and 1 along with Functional Area Experts (FAE) for various sectors. Worked with Environment Department, Government of Maharashtra as Project Coordinator and Project Officer of SEAC & SEIAA, Maharashtra.

Shrutika Bhute completed the M. Tech Degree in Environmental Engineering from Y. C. C. E (Year: 2016 - 2018), Nagpur. During 2018 - 2022, she worked with Environmental Consultancy and carried out works related to Environmental Impact Assessment and monitoring of environmental components (air, water, noise, soil etc.). Presently, now working with EFRD Environmental Consultancy & Engineers Pvt. Ltd., Mumbai

Surekha S Jamdar, currently working as **Technical Manager with** Parykshan Laboratories and completed Master Degree in Chemistry from Vinayakamission University. Previously worked with Netel, Vardhman Export, Envirocare Labs, as Laboratort Manager and having experience more than 12 years. Also, expert in handling AAS, GCMS, HPCL with analytical and leadership skills.