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Assessment of Ambient Air Quality in Rural Area of Palghar District in Maharashtra State

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ABSTRACT: Rapid increase in population, economic development, urbanization, transportation, and energy consumption, are major dynamic forces of air pollution in large and growing cities. Emissions from biomass utilization and combustion are major sources of outdoor and indoor air pollution and are estimated to cause millions of premature deaths worldwide annually. The present paper assesses the ambient air quality status in rural residential area of Wada, Mokada, Vikramgad, Shahapur and Jawhar Taluka of Palghar District of Maharashtra. Ten sites under rural area were selected to assess the ambient air quality of the region. The air quality was assessed based on measuring five parameters air pollutants namely Particulate Matter (PM₁₀ and PM_{2.5}), Oxides of Nitrogen (NO_x) and Sulphur-di-oxide (SO₂) and Ammonia (NH₃). Mean values of particulate matters i.e PM₁₀ and PM_{2.5} are found to be higher than the prescribed limits of CPCB, New Delhi at all sites except Waki and Balivali sites. NO_x, SO₂ and NH₃ average levels are within the prescribed limits of CPCB. The AQI value of Sakhare, Belwad and Suryamal sites are found to be heavily polluted; Malwada, Waki, Walvande, Parli, Mangrul, and Dhaipatpada are observed as moderate polluted whereas Balivali site found as lighter polluted. Thus, heavily polluted villages need to take immediate steps to reduce the pollution levels of particulate matters.

KEYWORDS: CPCB, PM₁₀, PM_{2.5}, heavily polluted, AQI.

I. INTRODUCTION

Population growth has been enhanced in urban cities due to migration of rural population [1]. Increase in industrial activities, population both endemic and floating with vehicular population has led to a rapid increase in environmental problems like air pollution, sound pollution, etc [2,3]. Pollution has become a major issue of debate and especially the air pollution because of the anthropogenic activities such as burning fossil fuels, natural gas, coal and oil to power industrial processes and motor vehicles emissions. Clean air is one of the basic requirements and essential of health and well-being of humans [4]. Levels of air pollutants are rapidly increasing in urban and rural areas in many megacities (urban population greater than 10 million) of the developing world [5]. Most of Asian cities cannot comply with the WHO air quality guidelines or the US Environmental Protection Agency standard, exempted cities in more developed countries such as Singapore, Taiwan, and Japan. Various Asian cities in China, India, and Vietnam have the highest levels of outdoor air pollution in the world [6].

A widespread range of adverse effects of air pollution on health has documented by studies conducted in various parts of the region [7,8,9,10,11,12]. Also, air pollution causes environmental degradation such as acid rain, eutrophication, haze, ozone depletion, crop and forest damage and global climate change [12,13,14]. WHO estimated that 3 million deaths from PM_{2.5} exposure for the year 2012, while the most recent Global Burden of Disease estimate was 4.2 million for the year 2015. Exposure to pollutants levels of PM_{2.5} that leads the environmental risk factor for death, accounting for about 4.2 million deaths which ranks 5th worldwide among all risks, including smoking, diet, and high blood pressure [11]. The most obvious is urban ambient air pollution that causes approximately 8,00,000 deaths per year worldwide [17]. Particulate matter (PM), SO₂, NO₂ and O₃ are considered as air pollutants and commonly used as indicator pollutants for fuel combustion and traffic related air pollution [18]. In South Asia, air pollution ranks among the leading risk factors contributing to the global and regional burden of disease [19,20].

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It has been stated that more than 70% of the population in India depends on traditional fuels that includes firewood, crop residue, cow dung, coal and lignite, etc for cooking and almost 32% depend on kerosene for lighting purposes mostly at rural regions. About, 3 billion people in the world (more than 40% of the global population) rely on traditional biomass for the purpose of cooking and an estimated 500 million households rely on kerosene and similar for the purpose of lighting [21]. In rural regions of India, for instance, only 11.4% of the households use LPG for cooking purposes as per Census 2011 [22].

Fuel from biomass remains a widely used as a source of energy in rural India whereas nearly 80% of households use them as the primary cooking fuel. In contrast, the majority of urban households use liquefied petroleum gas as the primary cooking fuel however, about 19% of urban households use biomass fuel for cooking purposes. Poverty, inaccessibility to improved cooking fuel and lack of awareness about harms of biomass emissions are among the major factors that drive their widespread use [23]. Use of biomass fuel leads to harmful health effects due to the emission, during its incomplete combustion of a large number of air pollutants such as carbon monoxide (CO), sulfur dioxide (SO₂), respirable particulate matter (PM_{2.5} and PM₁₀), poly-cyclic aromatic hydrocarbon (PAH), benzene, and metals like lead and copper [24, 25,26].

Air quality in rural areas remains a neglected issue so far. It is commonly belief 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 [27]. Rural areas suffer from air pollution caused by both natural as well as because of human activities.

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, and 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 [28]. Thus, it needs to monitor the ambient air quality of rural region of residential areas.

II. MATERIAL AND METHODS

The study was carried out at 10 villages located in the Palghar District of Maharashtra state in Konkan Division. New Palghar District was engraved out of the old Thane District, it comprised the talukas of Palghar, Vada, Vikramgad, Jawhar, Mokhada, Dahanu, Talasari and Vasai-Virar. The district is bounded by Thane and Nashik Districts on the east and north east, and by Valsad District of Gujarat state and Union Territory of Dadra and Nagar Haveli on the north. Air quality in region is the result of complex interaction between natural and anthropogenic environmental condition [29].

For the present study, sites were selected near the main roads where vehicles move continuously in the vada, vikramgad, Jawhar and Mokhada Taluka of Palghar District. Most of the villages are of the scheduled tribes, persons are Katkaris, Kolams and Madia Gonds are the considered Primitive Tribes of the state. The other more known tribes are Warli, Bhils, Gonds, Mahadeo kolis, and Malahar kolis, Koknas, Thakurs etc. Tribals are usually referred as backward, meaning their lack of capacity to utilize the opportunities of development offered to them. The crucial issues in their development are therefore not related only to providing infrastructure and schemes of development but to develop their capacity to utilize them on par with other citizens of the District or state.

Ambient air monitoring was carried out for twice a week in a month for 12 months. Thus, for one site, 12 weeks data is collected for ambient air monitoring. It was carried out during the month of January 2016 to December 2016. Locations of ambient air monitoring sites are mentioned in table 1 with respect to their talukas.

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Table 1: Sites for Ambient Air Monitoring at Palghar District

| Sr.No | Site in Village | Talukas |
|-------|-----------------|-----------|
| 1 | Malwada | Vikramgad |
| 2 | Waki | Vikramgad |
| 3 | Sakhare | Jawhar |
| 4 | Walvande | Jawhar |
| 5 | Belwad | Shahapur |
| 6 | Balivali | Shahapur |
| 7 | Parli | Wada |
| 8 | Suryamal | Mokada |
| 9 | Mangrul | Wada |
| 10 | Dhaipatpada | Wada |

Samples of PM₁₀ and PM_{2.5} were collected at all the 10 sites. PM₁₀ and PM_{2.5} samples were collected for 24 hours at 10 different sites for twice a week. PM₁₀ and PM_{2.5} 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 were operated at flow rates of 1.0 m³/min and 16.67 l/min, respectively. All the filter papers 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 PM₁₀ 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 PM₁₀ 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 aluminium foil. Similarly, the PM₁₀ filter paper was wrapped in aluminum foil and placed back in zip lock polybag and both the filter papers were transferred to laboratory. In laboratory, filter papers were conditioned and weighed again to determine the mass concentration of the PM₁₀ and PM_{2.5}. The weighed filter papers were preserved in freezer for chemical analysis.

SO₂, NO_x and NH₃ were measured with help of RDS APM 460DX with gaseous attachment APM 411 by sucking air into appropriate reagent for 48 h every week at 24-hourly intervals and after air monitoring it procured into lab and analysis for the concentration level. SO₂, NO_x and NH₃ were collected by bubbling the ample in a specific absorbing (Sodium tetrachloromercurate for SO₂, Sodium hydroxide for NO_x, and 0.1N Sulphuric acid for NH₃) 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 until analyzed. The concentration of NO_x was measured with standard method of Modified [30], SO₂ was measured by modified [31] and NH₃ was measured by using Nessler method. The instrument was kept at a height of 2 to 2.5 m from the surface of the ground.

Air Quality Index

Air Quality Index (AQI) is used to monitor 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 [32]. AQI will help the people know about the level of pollution in the ambient air on daily basis. The air quality index (AQI) is a measure of the ratio of the pollutants concentration to the status of ambient air in places. Indices of air pollutant or air quality have been used for about 25 years [33,34]. The following computation was used to drive the air quality index of the sites under consideration:

$$AQI = \frac{1}{4} \times (IPM_{10} / SPM_{10} + IPM_{2.5} / SPM_{2.5} + ISO_2 / SSO_2 + INO_x / SNO_x + INH_3 / SNH_3) \times 100$$

Where:

IPM₁₀, IPM_{2.5}, ISO₂, INO_x and INH₃ = Individual values of particulate matter (10 and 2.5), sulphur dioxide oxides of nitrogen, and ammonia respectively.

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IPM₁₀, IPM_{2.5}, ISO₂, INO_x and INH₃ = Standards of ambient air quality.

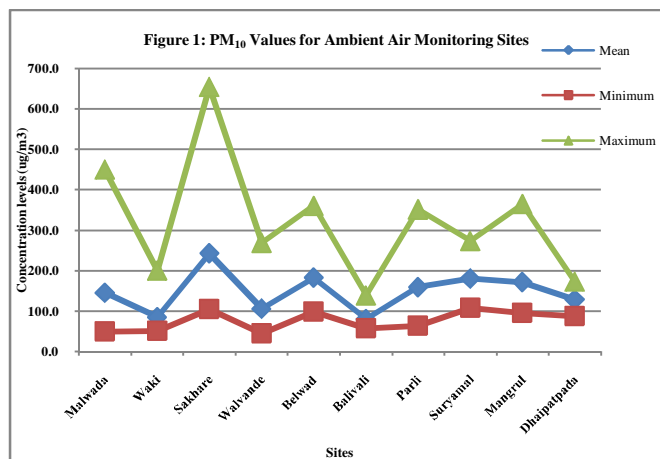
The indices use health based descriptions to provide meaningful information to the public. The five levels of AQI are given in table 2.

Table 2: Index Values of air quality index calculation [35].

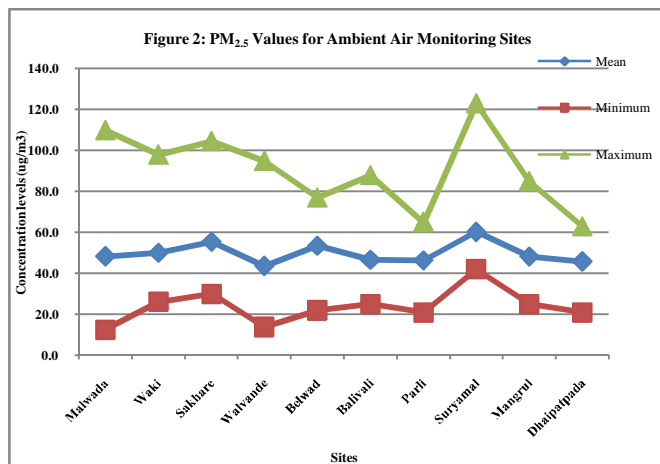
| Value of Index | Remarks |
|----------------|------------------------|
| Between 10-25 | Clean air |
| Between 26-50 | Light air pollution |
| Between 51-75 | Moderate air pollution |
| Between 76-100 | Heavy air pollution |
| Above 100 | Severe air pollution |

III.RESULTS AND DISCUSSIONS

Mean PM₁₀ values at all sites are observed in the range of 81.00 ug/m³ (Balivali site) to 243.2 ug/m³ (Sakhare site) respectively. Minimum and maximum values are found at Walvande site (45.6 ug/m³) and Sakhare site (654.2 ug/m³) respectively. It has been observed that all the maximum values at all sites exceeds the Air Quality Standards (i.e. more than 100 ug/m³) NAAQS, 2009 due to the local burning of fuel woods, burning of leaves/dried waste materials and resuspension of road dust in the atmosphere. Figure 1 shows average, minimum and maximum values of PM₁₀ values at all monitoring sites.



Mean PM_{2.5} values at all sites are observed in the range of 48.2 ug/m³ (Mangrul site) to 60.3 ug/m³ (Suryamal site) respectively. Minimum and maximum average values observed at Malvade site (12.5 ug/m³) and Suryamal site (123.0 ug/m³) respectively. It has been observed that maximum values at all sites exceeds the Air Quality Standards (i.e. more than 60 ug/m³) NAAQS, 2009. The high values of PM_{2.5} found due to the biomass burning for heating and cooking activities and resuspension of road dust. Figure 2 shows average, minimum and maximum values of PM_{2.5} values at all monitoring sites.



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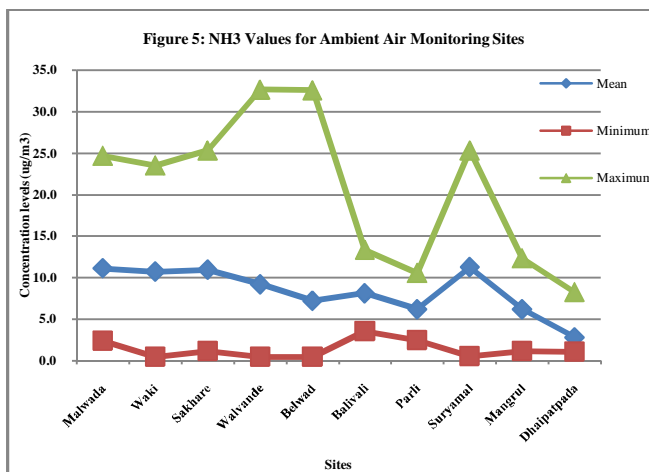
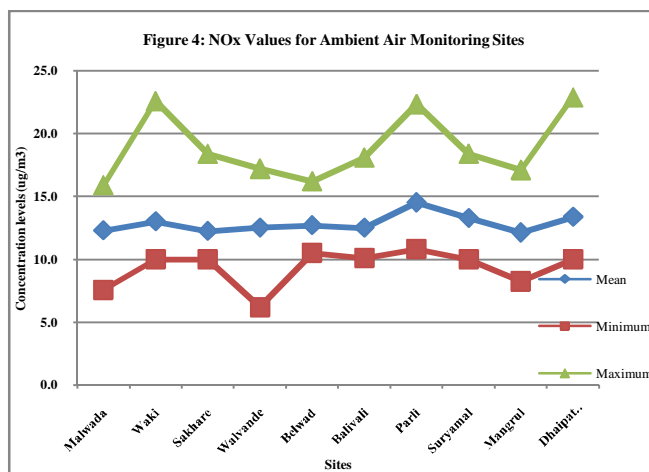
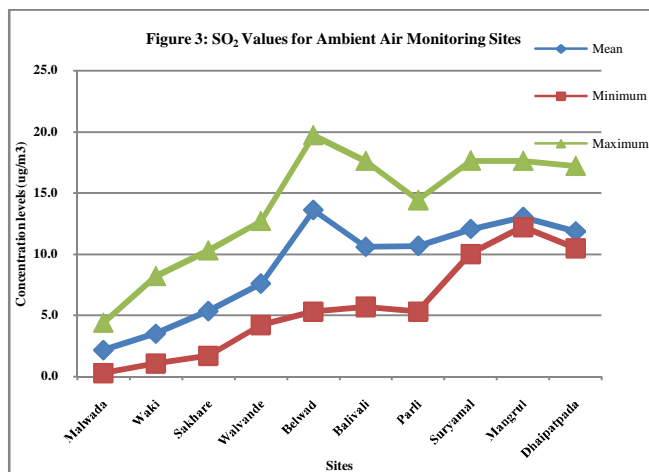
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Mean SO₂ values at all sites are observed in the range of 2.2 ug/m³ (Malwada site) to 13.6 ug/m³ (Belwad site) respectively. Minimum and maximum average values observed at Malwade site (0.3 ug/m³) and Mangrul site (12.2 ug/m³) respectively. It has been observed that values at all sites are within the limits of the Air Quality Standards (i.e. more than 80 ug/m³) NAAQS, 2009. Figure 3 shows average, minimum and maximum values of SO₂ values at all monitoring sites. SO₂ sources are generally from the burning of fossil fuels and industrial emissions (WHO, 2002).

Mean NO_x values at all sites are observed in the range of 12.1 ug/m³ (Mangrul site) to 14.5 ug/m³ (Parli site) respectively. Minimum and maximum average values observed at Walvande site (6.2 ug/m³) and Dhaipatpada site (22.9 ug/m³) respectively. It has been observed that values at all sites are within the limits of the Air Quality Standards (i.e. more than 80 ug/m³) NAAQS, 2009. Figure 4 shows average, minimum and maximum values of NO_x values at all monitoring sites. Nox sources are generally from the part of PM_{2.5} and O₃, found in nitrate aerosols, produced by burning fuels, electricity generation plus vehicle engines (WHO, 2002).

Mean NH₃ values at all sites are observed in the range of 2.9 ug/m³ (Dhaipatpada site) to 11.2 ug/m³ (Malwada site) respectively. Minimum and maximum average values observed at Waki site (0.5 ug/m³) and Belwad site (32.6 ug/m³) respectively. It has been observed that values at all sites are within the limits of the Air Quality Standards (i.e. more than 80 ug/m³) NAAQS, 2009. Figure 5 shows average, minimum and maximum values of NH₃ values at all monitoring sites. Sources of Ammonia is also emitted from non-agricultural sources such as catalytic converters in petrol cars, landfill sites, sewage works, composting of organic materials, combustion, industry and wild mammals and birds [36,37].

Ambient air quality with respect to the average parameters and respective AQI is presented in Table 3. On the basis of AQI, it can be seen that the Sakhare, Belwad, and Suryamal were heavily polluted (AQI 76-100) whereas the Malwada, Waki, Walvande, Parli, Mangrul, and Dhaipatpada were moderately polluted (AQI 51-75).



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Table 3: Ambient air quality with respect to the average parameters and respective AQI

| Sites | PM ₁₀ | PM _{2.5} | SO ₂ | NO ₂ | NH ₃ | AQI | Quality of Ambient air |
|-------------|------------------|-------------------|-----------------|-----------------|-----------------|------|------------------------|
| Malwada | 146.1 | 48.3 | 2.2 | 12.3 | 11.2 | 64.7 | Moderate air pollution |
| Waki | 85.7 | 50.0 | 3.5 | 13.0 | 10.8 | 50.8 | Moderate air pollution |
| Sakhare | 243.2 | 55.4 | 5.4 | 12.3 | 11.0 | 92.8 | Heavy air pollution |
| Walvande | 106.7 | 43.6 | 7.6 | 12.5 | 9.3 | 54.0 | Moderate air pollution |
| Belwad | 183.5 | 53.4 | 13.6 | 12.7 | 7.3 | 78.6 | Heavy air pollution |
| Balivali | 81.0 | 46.6 | 10.6 | 12.5 | 8.2 | 49.4 | Light air pollution |
| Parli | 159.7 | 46.3 | 10.7 | 14.5 | 6.2 | 69.1 | Moderate air pollution |
| Suryamal | 181.0 | 60.3 | 12.0 | 13.3 | 11.3 | 81.8 | Heavy air pollution |
| Mangrul | 172.3 | 48.2 | 13.0 | 12.1 | 6.3 | 73.0 | Moderate air pollution |
| Dhaipatpada | 129.3 | 45.8 | 11.9 | 13.4 | 2.9 | 60.2 | Moderate air pollution |

IV. CONCLUSION

Average monitoring data of all the sites clearly showed lower concentrations of gaseous pollutants (SO₂, NO_x and NH₃) and higher concentrations of PM₁₀ and PM_{2.5} in the ambient air. At all the monitoring sites, PM₁₀ and PM_{2.5} concentrations exceeded the permissible limits specified by CPCB while SO₂, NO_x and NH₃ were within the standard specified by CPCB. In order to protect human health, property and environment from the adverse effects of air pollution, the National ambient air quality standards have been set by the central pollution control board. The problems associated with air pollution in selected village areas are mostly due to the large number of privately owned motor vehicles, vehicles of obsolete two stroke technologies, road congestion, poor public transit system, bad maintenance, etc. Over the years, there has been a dramatic increase in the number of vehicles particularly the two wheelers. Increasing public awareness of air quality and the burden of disease caused by air pollution is an essential step in reducing air pollution and improving public health.

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