# Evaluation of Ambient Air Particulate Matter (PM) Concentration in Urban Context and Its Public Perception

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Urban air pollution has become a global issue and vehicle emissions, rapid industrialization, and urbanization are known to be the main contributing factors for air pollution. Therefore, air quality monitoring is essential for detecting air pollution levels mainly in urban areas. Among the main air pollutants, particulate matters (PM) play major roles as an urban air pollutant. The objectives of this research study were (a) to evaluate and compare the PM concentration on ambient air in selected locations in Colombo urban area (b) to calculate air quality index (AQI) to identify the pollutant levels of ambient air in selected study sites and (c) to identify the public perception and awareness regarding the PM-related air pollution. In this research, ambient PM concentrations were measured by ambient fine dust air sampling techniques in selected locations in Colombo urban area representing commercial, construction, and residential sites. Evaluation and comparison of PM concentration and questionnaire survey were analyzed by using suitable statistical approaches and softwares. Results of the study indicated that residential areas having significantly low PM concentrations while both commercial and construction areas having high PM concentrations. The highest $PM_{2.5}$ concentration was 101.08 µg/m$^3$ and it was recorded in Maradana area which came under the commercial category. The lowest PM concentration was recorded in Kotte representing the residential area. There was no any significant difference of PM concentration between commercial and construction sites mainly including Borella, Maradana, Peliyagoda areas. In addition, there was a significant difference between PM concentrations of selected commercial and residential areas and construction and residential areas. $PM_{2.5}$ concentrations were varied into the range of 17.23 - 101.08 µg/m$^3$ in commercial and construction areas and 5.68- 26.08 µg/m$^3$ in residential areas. Calculated AQI by using mean PM concentration values in air sampling locations indicated that commercial and construction areas with moderate air quality level under the AQI category of 51-100 and residential areas with good air quality level under the AQI category of 0-51.

**Keywords:** Air quality index, particulate matter, urban air pollution

## Introduction

Globally, more people live in urban areas than in rural areas. Approximately 55 % of the world's population residing in urban areas. Urban air pollution is a growing concern for many cities in the developed and developing countries of the world due to urbanization and industrialization. This air pollution is recognized as one of the most serious environmental problem worldwide and is known as one of the silent killer of the people (Nandasena *et al*., 2010). The most common air pollutants of ambient air are included Particulate matters (PM), Ozone ($O_3$), Nitrogen dioxide ($NO_2$), Carbon monoxide (CO), Sulphur dioxide ($SO_2$). In Asia region PM is the main air pollutant. People and the environment are gradually harmed by air pollution due to PM as they are unable to see and understand the pollution until it affects them badly (Kularatna & Sudantha, 2008). High concentrations of air pollutants including mainly PM in many developing countries lead to increase illnesses, particularly among individuals suffering from respiratory problems and cause premature death. Along with health effects, there are many effects of air pollution. These include the effects on vegetation, soil and water, man-made materials, climate and visibility (Smog

formation) (Kularatna & Sudantha, 2008). Common sources of PM are automotive combustion, solid fumigation, and industrial emissions and manufacturing and construction activities. Fossil fuel burning is a major cause of air pollution and very difficult to manage and emit hazardous gases and a considerable amount of PM. Most developing countries reporting large contributions from biomass burning, coal combustion, and road dust that are highly contributed to emit the PM into the atmosphere (Mayer, 1999). PM levels create serious problems in the developing countries. The urban areas of developing countries are highly susceptible to increased PM levels of the air (Chauhan *et al*., 2010).

Sri Lanka is one of the developing countries of Asia region that also facing the problem in quality of the air severely due to increasing the PM concentration (Illeperuma and Abeyratne, 2002). Most of the air quality researches, air quality monitoring and management activities in Sri Lanka have been conducted for $SO_2$ and $NO_2$ in city areas. But only a few studies have been focused on the PM concentration of ambient air quality. Therefore, the present research was conducted to study the variation of PM concentration and PM-related air quality index in urban ambient air and evaluate the public perception on PM-related ambient air pollution in Colombo urban area. The main objectives of this study are to compare of PM concentration in selected study sites that representing residential, commercial and construction areas, to assess PM-related Air Quality Index (AQI) to identify the pollutant levels of ambient air in selected study sites within the study period and to evaluate the public perception and awareness about PM related ambient air pollution.

**Methodology**

Colombo urban area was selected as the study area. This area including Colombo city, the capital of Sri Lanka, one of the most dynamic area of Sri Lanka with one of the fastest growth rate. This area is highly polluted due to high traffic congestion during peak hours, higher vehicle population, and low priority for vehicle maintenance and fuel efficiency, improper releasing of harmful air pollutants from the factories and various construction activities. The sampling sites were selected to represent commercial, construction and residential areas in Colombo. The study sites were chosen after proper investigation based on basic site selection criteria and reduced interference of the local public with the devices used for the experiments. A 24 hours air sampling for successive days from each site were conducted during the experimental period. PM concentrations were monitored by using ambient fine dust sampler (Model No: INSTRUMEX-IPM
–FDS). This instrument provides continuous concentrations of PM suspended in the ambient air for 24 hours by sucking approximately 24$m^3$ of air with operated at the average flow rate of 1 $m^3$/hr or 16.67 LPM (Figure 1). This system can store the values in its memory automatically and calculate minimum, mean and maximum ambient air temperature, sampling time, and total volume of the air sample and average flow rate and power interruptions during the sampling time period.


Figure 1: Ambient Fine Dust Sampler

Glass fiber filter papers were used to detect PM. Pre-weighed glass fiber filters of What-man were used as per standard methods. The mass concentration of PM particles in ambient air was computed as the total mass of collected particles divided by the volume of air sampled and was expressed in micrograms per cubic meter of air.
After compiling the results, the concentration of each pollutant was converted into an AQI. The criteria pollutants namely PM has been considered for determining the AQI of selected area based on EPA method. Numerical AQI values are often accompanied by color schemes, category and health based descriptions to provide meaningful information to the public. Survey study was carried out to identify the public perception on PM related air pollution. Survey was performed through discussions and interviews with the people who are living or working around the selected sample sites. Approximately 12 interviews for each study sites were conducted to evaluate the public perception of PM-related air pollution. The comparisons were made with appropriate WHO standards and its related Sri Lankan standards for air quality guidelines. One sample T-test was used to compare the monitored PM concentration with the standard PM concentration .One way ANOVA test and Tukey pair wise comparison test were used to evaluate the significant difference between each category. All the statistical analysis was done by using Mini Tab18.0 version. SPSS 16.3 version was used to analyze the survey.

**Results and Discussion**

Some air samples of Peliyagoda, Maradana and Borella areas were exceeded the standard ambient PM level and all the collected air samples of residential areas including Kotte have not exceeded the standard PM Concentration level. With the publication of WHO air quality guidelines in 2006 (WHO, 2006), air quality standards for Sri Lanka, including standards for PM, were amended and gazetted in August 2008 (National Environmental Act, 2008). One sample t- test was used to evaluate the significant difference between means of the air samples in each study site with the hypothesized mean. According to one sample t-tests, mean PM concentration of air samples in selected areas were not greater than the standard guideline PM value derived from the national environmental ambient air quality regulations in Sri Lanka. According to performed one way ANOVA tests for PM concentration, observed p- value for the test was less than the 0.05. Therefore means were not equal and there was a significance difference between PM concentrations between the sampling sites. $PM_{2.5}$ concentrations were varied in the range of 20.76 to 101.08 to $\mu g/m^3$ in Maradana area, 17.23-69.45 $\mu g/m^3$ in Peliyagoda, 20.25-65.54 $\mu g/m^3$ in Borella, and 5.68-16.80 $\mu g/m^3$ in Kotte respectively.

Adjusted p-values of Tukey pair wise tests for difference of means were proved, there was no significant difference between PM concentration of commercial and construction areas. There was a significant difference between residential areas with commercial and construction areas. The quality of air in the study area can be estimated from the air quality index. The higher the AQI value, greater is the level of air pollution and greater the damage to health (Chaurasia et al., 2013). According to calculated AQI for PM, Moderate AOI levels of health concern were observed in commercial areas and construction areas (AQI range from 51-100). Air qualities of those areas were acceptable. However, some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution. Good AQI for PM were observed in selected residential areas and air quality is considered satisfactory in those areas, and air pollution poses little or no risk (AQI range from 0-51).

According to the survey results, most of the participants (71 %) have no awareness about the PM related air pollution. 29 % of people have moderate awareness and there were no people that have highly aware about the PM-related air pollution. Other research studies concluded that both awareness of the links between PM related air pollution and an understanding of air quality information are lacking amongst the public (Bickerstaff and Walker, 2001; Semenza *et al*., 2008).

Majority of people (74 %) mentioned the air quality is little worse. 26 % of people mentioned the air quality is much worse in Colombo urban area. There were no votes for better air quality levels in Colombo. Most of the people were not affected to consequences of PM related air pollution in Colombo urban area. But 34% of people were affected and 5% of people were highly affected. Globally, it is estimated that outdoor air pollution accounts for over 800,000 premature deaths and 6.4 million years of life lost, 65% is from Asia alone (Cohen, 2005). WHO has estimated that 1,000 deaths in 2004 being attributable to outdoor air pollution in Sri Lanka (WHO, 2006). Majority of the people are having health problems such as irritation to the eyes, nose, and throat (81 %) and having more difficulties in breathing (19%), respectively. Interviewed people were not faced to the skin problems, poor visibility and asthma incidents due to the exposure of PM in Colombo urban area. There are a range of mobile (road vehicles, railway trains) and stationary (industries) sources of particulate matter (WHO, 2006). Mayer, (1999) revealed that air quality in cities is getting worse as the population, traffic, industrialization and energy use increase. The results were observed as 50 % motor vehicle emissions, 23 % construction emissions, and 12 % burning of waste, 9 % manufacturing facilities and 4 % waste disposal are main PM emission source in the surveyed area based on the public perspectives.

## Conclusion

Residential areas having significantly low concentrations of PM concentrations while both commercial and construction areas having high concentrations of PM concentration. The highest concentration was recorded in Maradana and in Borella which came under commercial category, possibly related to high levels of vehicle movement within the area. The lowest PM concentration was recorded in Kotte representing residential areas. Further, there was no significant difference of concentration between commercial and construction sites including mainly Borella, Maradana and Peliyagoda areas and there was a significant difference between commercial and residential areas and construction and residential areas. Calculated AQI by using mean PM concentration values in air sampling locations indicated that commercial and construction areas have moderate air quality levels and residential areas have good air quality level. Public awareness about the PM related air pollution is considerably low and majority of the people mentioned that the air quality is not good in Colombo urban area. Approximately half of the interviewed people were affected to the poor air quality and its related health effects. According to public perception, vehicular emission is the main particulate matter emission source in Colombo area.

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