SPATIAL AND TEMPORAL VARIATIONS OF PM_{10} IN CHITTAGONG CITY

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Abstract - Healthy environment is precondition of good health. Fresh air, pure water and soil are the main component of a healthy environment. Contaminants from different anthropogenic activities and natural sources such as, particulate matter (PM), Oxides of Sulphur (SO_x), oxides of Nitrogen (NO_x), carbon dioxide (CO_2) etc. contaminate and pollute this natural fresh air and threaten human life as well as environment.Every year the morbidity due to Particulate matter (PM) is about 50% of the total premature morbidity because of air pollution. World Health Organization's (WHO) International Agency for Research on Cancer classified it as group 1 human carcinogen. Considering its importance, in most of the country, monitoring of particulate matter has been given priority in assessing air quality monitoring. Analyzing the concentrations of particulate matter measured by high volume air sampler from six sampling sites of the city, differences in the concentrations of PM_{10} were observed in this study. The monthly mean concentration of PM_{10} hardly remain within the standards of Bangladesh while, the mean annual average of PM_{10} at all sampling sites was many times higher than the standard of Bangladesh and WHO. As, the concentration of PM_{10}in Chittagong is not praiseworthy enough and indicate a serious threat to human health, strategic air quality management and monitoring system are recommended in this study.

Keywords - Suspended Particulate matter,high volume air sampler

INTRODUCTION

With the rapid urbanization and industrialization, Bangladesh has started to experience different environmental problem especially atmospheric pollution.every 10 µg m^3 increase in PM_{10} concentrationis associated with up to 0.6% increase in daily premature mortality(Lim et al., 2012; Pope III et al., 2002).

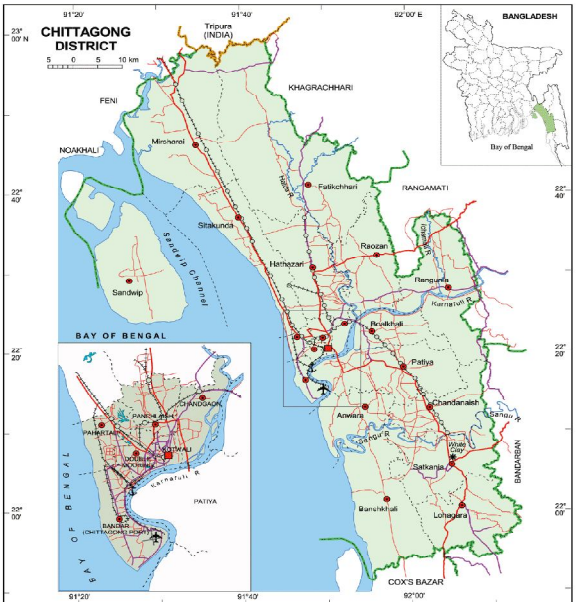


Figure1. Chittagong city (below inset) (District in map; Chittagong, 2015)

Chittagong is the financial center in south eastern Bangladesh having about 4600 small and medium scale, 410 heavy industries and a seaport. Contributing around 12% of Bangladesh's GDP, Chittagong holds the status of being the second-largest economy in Bangladesh (The Chittagong Chamber of Commerce & Industry, 2017).Department of Environment (DoE) is the only organization which records the monthly air monitoring data of Chittagong city and they did not publish their mobile air monitoring data, so, temporal and spatial distribution of particulate matter is not analyzed yet. Knowledge on SPM concentrations on the monthly and seasonal basis, as well as their spatial distributions is essential for better management and protection of the public health, while inter-annual variations give an insight into changes in levels of pollutants over the past years.

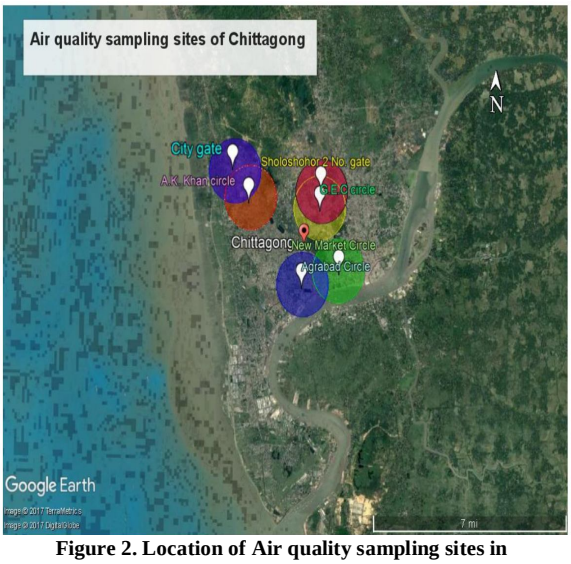


Figure 2. Location of Air quality sampling sites in Chittagong(white locator) showing with their coverage area (circle).

II. METHODOLOGY

2.1 Study Area

It is situated within 22°14' and 22°24' N Latitude and between 91°46' and 91°53' E Longitude covering an area of 155.4 km² and Density of population is 16,617.8 inhabitant /km² (BBS, 2011). Under the Köppen climate classification, Chittagong has a tropical monsoon climate (Am)(Peel, Finlayson and McMahon, 2007). From the climatic point of view, three distinct seasons can be recognized in Bangladesh –

The cool dry season from November through February, the pre-monsoon hot season from March through May, and the rainy monsoon season which lasts from June through October. (NOAA, 2012).

2.2 Sampling framework

The concentrations of SPM were collected and measured by high volume air sampler from 2011 January to 2016 December. This air sampler was placed at 6 sampling sites in arbitrary 5 days in every month for 8 hours at a stretch to measure the concentration of Particulate Matter.

III. RESULTS AND DISCUSSION

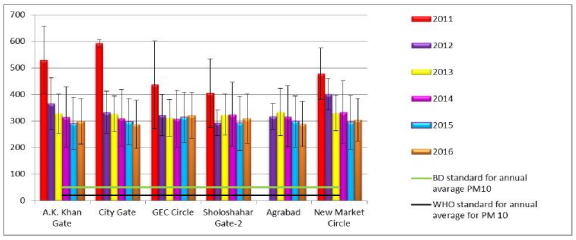
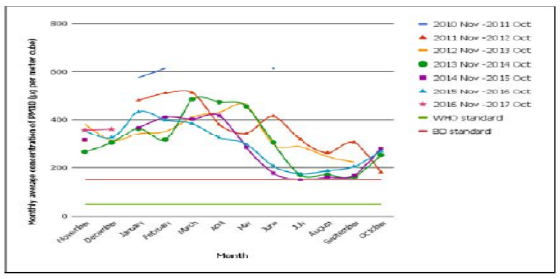
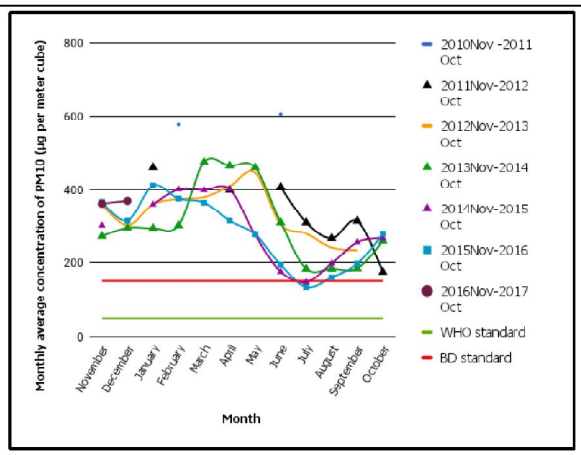


Figure 3. Inter-annual and spatial variations of PM_{10} in Chittagong City

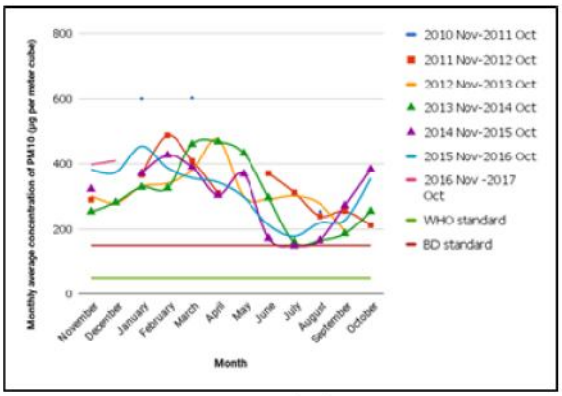
Figure 3 shows that in 2011, the annual average concentration of PM_{10} was highest at all sampling sites under Mobile Air Monitoring System. Here, the standard deviation for each year has been represented by the error bar. The standard annual average concentration of Bangladesh is 20 µg/m^{3}and the annual average concentration at entire sampling sites are unexpectedly higher than the standard annual average maximum limit for PM_{10}. From 2011 to 2016, there is no significant difference among the annual average PM_{10} concentration of the entire sampling site.



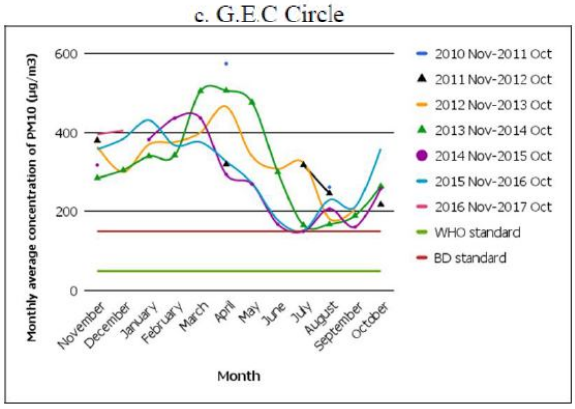
a. A.K. Khan Gate



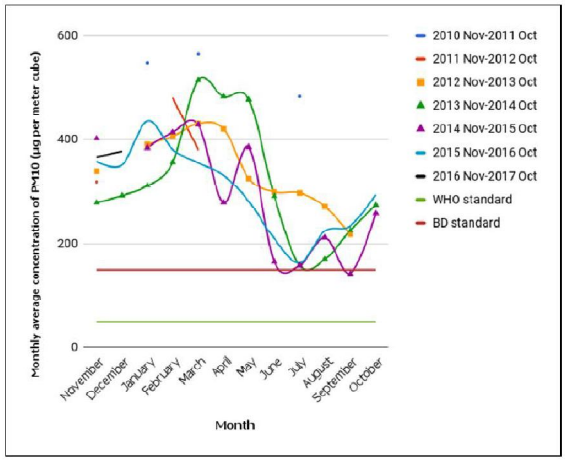
b. City gate



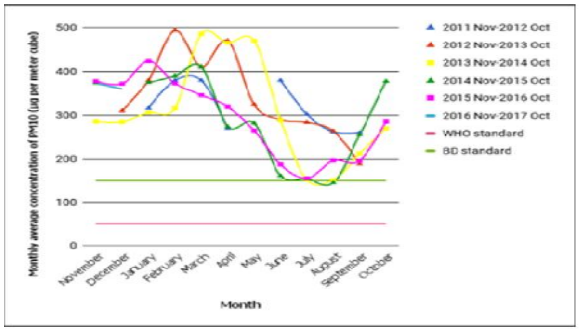
c. G.E.C Circle



d.Sholoshohor 2 no. gate



e. Agrabad Circle



f. New Market Circle

Figure 4: Monthly variation of monthly average PM_{10} concentration at (a) A.K. khan circle (b) City gate (c) G.E.C Circle (d)Sholoshohor 2 No. Gate (e) Agrabad circle (f) New market circle

Figure 4 demonstrates that the monthly average concentrations of PM_{10} at A.K.Khan gate and city gate are higher in dry winter (November to February) and hot summer (March to June) than in rainy monsoon season (July to October).The monthly average concentrations of PM_{10} at G.E.C. Circle, Sholoshohor 2 No. Gate, Agrabad circle and New market circle from the end of the dry winter till the mid of the hot summer (February-April) are the higher than the rainy season. Highest concentration of PM_{10} was observed in 2011in A.K. khan gate which is located near Shagorika industrial zone. The standard limit of PM_{10} concentration of Bangladesh for average 8 hour is 150µg/m^3, where this standard of WHO is 50µg/m^3. No average concentration is found within the standard limit of WHO. This average PM_{10} concentration is higher than the standard of Bangladesh, while these concentrations hardly remain within the standard limit of Bangladesh only in rainy season.

Source of Variation	SS	df	MS	F	P-value	F crit
Month	6479684	71	91263.16	7.476149	4.62379E-39	1.331454
sites	144158.1	5	28831.61	2.361845	0.039663437	2.239414
Error	4333571	355	12207.24			
Total	10957413	431				

Table 1: Anova table for monthly and spatial variation of PM_{10} concentration

From the ANOVA table, the P value for the site =0.03966 < 0.05, It depicts that at 95% level of confidence there is significant difference in the Monthly average concentration of PM_{10} among these six sites under Mobile Air Monitoring System.

CONCLUSIONS

The aim of the study was to analyze of the temporal variations of PM_{10} from monthly to inter-annual scale based on monitoring sites of Chittagong city. This study has revealed that there was significant spatial variation in the monthly average of PM_{10} among the sites. The findings of this study are:

- Within-city differences in the monthly average concentrations of PM_{10} were observed in this study. There is significant difference in the monthly average concentration of PM_{10} among these six sites.
- The mean annual average PM_{10} at all sampling sites were many times higher than the standard of Bangladesh and WHO.

An integrated management system can be the best solution to reduce the concentration of particulate matter. Based on this study, the recommendations are given below:

- Musk has to be used to reduce the risk to be exposed to Particulate matter as most the measured concentration are found higher than the standard limit which is harmful for health.
- Judicious use of vegetationhave to be popularize to reduce the Particulate matter movement, as 60 percentstreet level PMconcentration at can be reduced by the planned plantation of grass, climbing ivy and other plants in urban canyons(Pugh et al., 2012)
- The sampling plan has to be updated for well representation of particulate matter condition in Chittagong.

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