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Urban Air Pollution Caused of Particulate Matter and Lead in the City of Chittagong-Bangladesh

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Abstract: Chittagong city is one of the largest and commercial cities of Bangladesh. Many industries are continuously producing particulate matters by their daily activity. Air pollution due to the PM has significant effects on asthma, allergy and other respiratory diseases. There is a great need to implement control measures in most of the megacities of the world to improve air quality and hence protect public health. Like many megacities in the world the ambient air quality of Chittagong is also being deteriorated day by day. Main sources of air pollution are particulate matter in this city are arising out emitted directly from a source, such as construction sites, unpaved roads, fields and fires. Most particles form in the atmosphere as a result of complex reactions of chemicals from sulfur dioxide and nitrogen oxides, which are pollutants emitted from power plants, industries and automobiles. Considering that, the current study plan was undertaken to measure the pollutants level in the air of different urban locations of Chittagong, the second largest city of Bangladesh. Atmospheric pollutants such particulate matters (PM2.5, PM10 and PM) and lead (Pb) were determined in Chittagong city. Eight different sampling stations, Muradpur Circle, WASA Circle, G.E.C Circle, Proborthak Circle, Chawk Bazar Circle, Alongkar Circle, New Market Circle and Oxygen Circle were selected for sample collection and observations. The objective of the study was to determine the concentrations of particulate matters and heavy metal lead (Pb) pollution to find out the variation of air pollutants in different locations of Chittagong city. The concentration of particulate matter pollutants was found more at highly traffic areas. The highest average concentration value of PM2.5, PM10, PM and Pb was observed at G.E.C Circle, Proborthak Circle Chawkbazar Circle and Oxygen Circle respectively. The lowest average concentration value of PM2.5, PM10, PM and Pb was found at Chawkbazar Circle, Alongkar Circle, Muradpur Circle and Proborthak Circle. The average results of particulate matters and trace metals have been compared to national and international standards. The value of PM2.5, PM10 in air of Chittagong city is higher than that of TLV value recommended by WHO and ECR’97 and 2005 amendment suggested standard. The elemental concentrations of lead (Pb) of ambient air that collected at different locations in Chittagong city is in the TLV. A strategic air quality management plan has been proposed.

Keywords: Chittagong City, Air Pollution, Control, Particulate Matter, Lead, ECR 1997, Amendment 2005

1. Introduction

Air pollution is a complex mixture of gaseous and particulate components, each of which has detrimental effects on human health. While the composition of air pollution varies greatly depending on the source, studies from across the world have consistently shown that air pollution is an important modifiable risk factor for significantly increased morbidity and mortality. Moreover, clinical studies have generally shown a greater impact of particulate matter (PM) air pollution on health than the gaseous components [1]. Particles in the size range 0.1-1.0 micrometer (µm) have the greatest influence on the absorption and scattering of solar radiation in the atmosphere. Therefore, concentrations of these particles in the atmosphere are of special important to the planetary heat budget [2]. However, recently pollutants in micro-environments (vehicle inside, footpath, corridors etc.) are very much different from that in local monitoring stations [3]. Particle pollution exposure to a variety of problem including-increased respiratory symptoms, such as irritation of the airways, coughing or difficult breathing, decrease lung function, aggravated asthma, development of chronic bronchitis, irregular heartbeat, non-fatal heart attacks, premature death in people with heart and lung disease, people with heart and lung disease, children and older adults are the most likely to be attacked by particle pollution exposure [4]. It has been estimated that exposure to fine particulate matter in outdoor air leads to about 100 000 deaths (and 725 000 years of life lost) annually in Europe [5]. In addition, if the particle consists of a mixture of purely scattering material such as ammonium sulfate and partially absorbing material such as stool, the cooling versus heating effect depends on the manner in which two substances are mixed throughout the particle pollution [6, 7]. Accumulation in air is one major way through which heavy metals may find their way into soils and subsequently living tissues of plants, animals and human beings [8]. The reduction in PM levels have led to gradual reduction in PM-associated morbidity and mortality; however, recent epidemiologic studies still consistently show a link between PM exposure and cardiopulmonary mortality [1]. Lead is well established as an environmental health problem due to its neurotoxic effects in both children and adults. Children are especially vulnerable to the neurotoxic effects of lead exposure due to their developmental state, body weight, and behaviors that increase risk of exposures. Exposures in childhood have been shown to have significant long-term ramifications on both neurological and cognitive health and socioeconomic status over the life course [9]. Testing in 397 children aged 2–3 years from a birth cohort in the Munshiganj District of Bangladesh found that over 85% had blood lead concentrations above the Centers for Disease Control and Prevention's (CDC) current reference level of 5 µg/dL nearly 35% of these had concentrations above the previous CDC action level of 10 µg/Dl [10].

Airborne lead (Pb) is a constituent of atmospheric particulate matter (PM), and as such it may be transported to great distances before being removed in deposition processes (Mirjana Ristić, 2013) [11]. The size distribution of Pb in particulate matter has a unimodal mode that peaks at approximately 0.154–1.59 µm particle diameter, indicating that Pb is mainly concentrated in fine fraction. Lead in the fine fraction is enriched by a factor of 103–104 relative to Pb abundance in crust. Eight categories of Pb pollution sources were identified in the PM2.5 in the winter of 2007 in Shanghai. The important emission sources among them are vehicle exhaust derived from combustion of unleaded gasoline, metallurgic industry emission, and coal combustion emission [12]. Lead concentration in ambient air in Central European countries in the last 20 years significantly declined as a result of phasing out leaded gasoline, measures of air pollution policy, and also contraction of economic activities. This decline significantly reflected in human exposure to lead [13].

In high-income countries (HICs) the legacy of lead exposure keeps populations continuously exposed. In lower- and middle-income countries (LMICs), in addition to the legacy of lead exposure, lack of regulations or the inability to enforce regulations keeps populations exposed [14]. Airborne lead was a major concern but the phase-out of lead in gasoline implemented throughout South Asia in the year 1999 and the early 2000s has contributed greatly to reducing the lead concentration in ambient air [15]. Trace metals like lead are percolated into the soil and are eventually transferred into plants and eventually human through the consumption of this plants [16]. They thus enter the food chain as a result of their uptake by edible plants [17].

Two stroke engines three-wheeler vehicles have already been withdrawn from the city roads to protect the urban environment. These three-wheeler vehicles were responsible for majority (around 60%) of the air pollution in the city. Infect, these three wheelers were popular vehicles among the middle class and upper middle-class people of Chittagong city. By this time, Government of Bangladesh has imposed a ban on these 2 (two) strokes three wheelers and invited new 4 (four) stroke engine three-wheeler compressed natural gas (CNG) vehicles to replace Two stroke vehicles. As a result of which, the city and the urban dwellers got rid of around 60% of air pollution by this time [18].

1.1. Material and Methodology

1.1.1. Selection of Sampling Locations

Chittagong City is not only the principal city of the district of Chittagong but also the second largest city of Bangladesh. It is situated within 22°-14' and 22°-24'-30" N Latitude and between 91°-46' and 91°-53' E Longitude and on the Right Bank of the river Karnafuli.[25] [16]. Eight important sampling locations in Chittagong city had been chosen for the collection of the air sample. Locations are:

Table 1. *Study area and GPS coordination.*

Sampling Location	latitude	longitude
Chawkbazar Circle	22°21'26.42"N	91°50'14.15"E
Proborthak Circle	22°21'38.48"N	91°49'43.51"E
Chittagong WASA Circle	22°21'4.31"N	91°49'18.64"E
Muradpur Circle	22°22'6.99"N	91°49'58.55"E
Alongkar Circle	22°21'33.33"	91°46'54.49"E
G.E.C Circle	22°21'33.65"N	91°49'17.69"E
New Market Circle	22°20'1.31"N	91°49'57.37"E
Oxygen Circle	22°23'36.32"N	91°49'15.91"E

Figure 1. *Sampling Spot.*

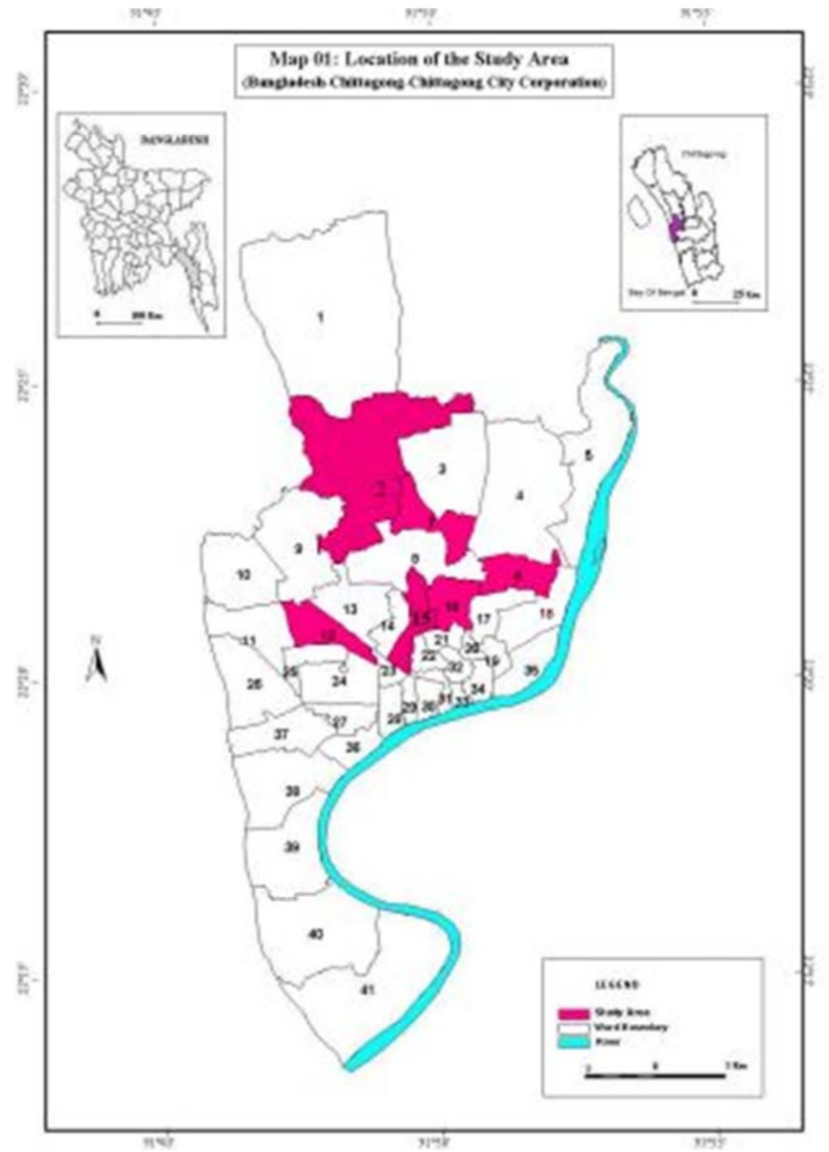

Figure 2. *Map of Bangladesh showing the location of Chittagong. Insert show's locations of Sampling Spot.*

1.1.2. Sample Collection and Preparation

The sampling operation was carried out from morning to evening for eight hours. Weather condition was sunny in all sampling locations. Envirotech APM 250 Combined Dust Sampler was used for the collection of PM2.5 and PM10. High purity quartz microfiber was used for air sampling to analysis PM2.5 and Glass fiber filter paper were used for analyzing PM10. PM2.5 carried filter was further used for determining Lead (Pb) concentration in the environment.

Envirotech APM 250 Combined Dust Sampler in the selected areas from morning to evening (8 hours) was placed for the purpose. Respirable dust sampler was used for the collection of atmospheric particulate matters and was determine by gravimetric analysis.

1.1.3. Procedure for the Determination of PM2.5, PM10 and PM

Combined Dust Sampler (Envirotech APM 250) used to collect the air sample. The particulate samples collected during the monitoring period and analyzed as per the below procedures [19].

PM2.5 Analysis:

The equation of the mass of the fine particulate matter is

$$M_{2.5}=(M_f - M_i) \times 10^3$$

Were,

$M_{2.5}$=total mass of fine particulate collected during sampling period (mg)

Mf=final mass of the conditioned filter after sample collection (mg)

Mi=initial mass of the conditioned filter before sample collection (mg)

10^3=unit conversion factor for milligrams (mg) to micrograms (μg)

PM2.5 samplers are required to provide measurements of the total volume of ambient air passing through the sampler (V) in cubic meters at the actual temperatures and pressures measured during sampling.

$$V=Q_{avg} \times t \times 10^{-3}$$

where,

V=total sample volume (m^3)

Qavg=average flow rate over the entire duration of the sampling period (L/min)

t=duration of sampling period (min)

10^{-3}=unit conversion factor for liters (L) into cubic meters (m^3)

$$Q_{avg}=(\text{Initial Flow Rate} + \text{Final Flow Rate})/2$$

Hence the Final Equation for measuring $PM_{2.5}$ is-

$$PM_{2.5}=(M_f - M_i) \times 10^3/ Q_{avg} \times t \text{ X } 10^{-3}$$

$$\text{Or, } PM_{2.5}=(M_f - M_i) \times 10^6/ Q_{avg} \times t$$

For PM_{10} it is same. i.e $PM_{10}=(M_f - M_i) \text{ X} 10^6/ Q_{avg} \times t$

To determine PM mass,

$$PM=PM10 - PM\ 2.5$$

1.2. Procedure for Collecting Weather Date

Portable MS6508 Digital Temperature and Humidity Meter Hygrometer was used to collect the temperature, humidity and weather condition during air sampling.

1.3. Procedure for the Determination of Trace Metals Lead (Pb)

Hot Block Digestion System capable of maintaining a temperature of 95°C within±2°C were set up. This temperature will heat the samples to a temperature of ~85°C (±5°C).

Extraction Fluid of 1.5% HCl and 5.55% HNO_3 were prepared for digestion of PM2.5 carried filter paper. The extraction fluid is prepared in a 1,000 mL volumetric flask by adding 15 mL of HCl and 55.5 mL of HNO_3 to ~900 mL grade 3 distilled water. Dilute to 1000 mL with distilled water and mix thoroughly.

Carefully fold the PM2.5 exposed filter paper and pour it into a 250mL beaker. Push all the way to the bottom using a pre-cleaned Teflon stirring rod for each sample to be sure the filter is below the 10 mL line. Add 10 mL of extraction fluid (1.5% HCl, 5.55% HNO_3) to the extraction beaker. Samples will be extracted for a total time of 2.5 hours with the Hot Block temperature set to 95°C (±2°C). This temperature will heat the samples to a temperature of ~85°C (±5°C). After 1.5 hours of extraction, add 1.8 mL of H_2O_2 and allow to effervesce for 0.5 hours. Add an additional 1.8 mL of H_2O_2 after 2 hours of extraction and allow to effervesce again for 0.5 hours. This completes the extraction process. After extraction is complete, remove the rack of samples and allow them to cool to room temperature. Add 20 mL of distilled water and allow to stand for 0.5 hours. This critical step must not be omitted; it allows the acid to diffuse from the filter into the rinse. After this time period, bring the sample volume to the 50 mL line on the volumetric flask with a wash bottle filled with distilled water prior to filtering. Carefully filter the sample extract with a 2 μm Filter Mate filter. Homogenize the sample by inverting three times and then the extract is ready to be analyzed.

Metal concentration in the air sample should be calculated as follows

$$C_M=[Cr \times V \times 1]/Vstd$$

Where:

C_M=concentration, μg metal/m^3

Cr=metal concentration determined from ICP/MS method, μg metal/L

V=total sample extraction volume from extraction procedure (i.e., 0.05 L)

1=[Usable filter area] / [Exposed area of one strip ((1"×1") × 1) representing a strip that has been folded)]

Vstd=standard air volume pulled through the filter, m^3

1.4. Calibration Curves for Metal Determination

1000 mgL^{-1} of stock standard Pb solution was prepared. For the preparation of 10 mgL^{-1} intermediate Pb standard, 5mL stock Pb standard was taken in a 500mL volumetric flask and diluted up to the mark with deionized water containing 10mL HNO_3. 0.5, 1, 2 and 4 mgL^{-1} working standard was prepared from 10 mgL^{-1} intermediate standard for carrying out the analysis. 2.5mL for 0.5, 5mL for 1.00, 10mL for 2, 15 ml for 3 and 20mL for 4mgL^{-1} was taken from the 10 mgL^{-1} intermediate standard solution in separate 50mL volumetric flask. 1mL HNO_3 acid was added to each dilute up to the mark with deionized water. Working standard solution was prepared daily.

1.5. Results and Discussion

The Particulate matters PM2.5 were measured in different traffic locations in Chittagong city ambient air. The average concentration of particulate matter PM2.5 was found 83.14μgm^{-3} for all sampling locations in Chittagong city which was higher than the daily average given by WHO and BDS. The average concentration of PM2.5 was found in Muradpur Circle, WASA Circle, G.E.C Circle, Proborthak Circle, Chawkbazar Circle, Alongkar Circle, New Market Circle and Oxygen Circle was 76.13μgm^{-3}, 80.15μgm^{-3}, 83.14μgm^{-3}, 83.06μgm^{-3}, 67.03μgm^{-3}, 68.74μgm^{-3}, 69.20μgm^{-3}, 69.17μgm^{-3}, respectively in air of Chittagong city. The highest concentration of PM2.5 was found at G.E.C Circle. The PM2.5 concentrations were varying from 83.14μgm^{-3} G.E.C Circle to 67.03μgm^{-3} Chawkbazar Circle. The concentration of PM2.5 in all sampling station in Chittagong city is higher than the D_OE value. The concentration of PM2.5 in Chittagong city air has shown in Table 1.

The Particulate matters PM10 were measured in different traffic locations in Chittagong city ambient air. The average concentration of particulate matter PM10 was found 171.43μgm^{-3} for all sampling locations in Chittagong city which was higher than the daily average given by WHO and BDS by DoE. The average concentration of PM10 was found in Muradpur Circle, WASA Circle, G.E.C Circle, Proborthak Circle, Chawkbazar Circle, Alongkar Circle, New Market Circle and Oxygen Circle was 153.4μgm^{-3}, 163.44μgm^{-3}, 166.07μgm^{-3}, 171.43μgm^{-3}, 163.73μgm^{-3}, 153.36μgm^{-3}, 153.82μgm^{-3}, 153.79μgm^{-3}, respectively in air of Chittagong city. The highest concentration of PM10 was found at Proborthak Circle. The PM10 concentrations were varying from 171.43μgm^{-3} at Proborthak Circle to 153.36μgm^{-3} at New Market Circle. The concentration of PM10 in all sampling station in Chittagong city is higher than the DoE value. The concentration of PM10 particulate matter in Chittagong city air has shown in Table 1.

The Particulate matters (PM Coarse) were measured in different traffic locations in Chittagong city ambient air. The average concentration of Particulate matters (PM Coarse) was found 96.69μgm^{-3} for all sampling locations in Chittagong city which was higher than the daily average given by WHO and BDS by DoE. The average concentration of Particulate matters (PM Coarse) was found in Muradpur Circle, WASA Circle, G.E.C Circle, Proborthak Circle, Chawkbazar Circle, Alongkar Circle, New Market Circle and Oxygen Circle was 77.27μgm^{-3}, 83.29μgm^{-3}, 82.93μgm^{-3}, 88.37μgm^{-3}, 96.69μgm^{-3}, 84.62μgm^{-3}, 84.62μgm^{-3}, 84.62μgm^{-3}, respectively in air of Chittagong city. The highest concentration of Particulate matters (PM Coarse) was found in highly traffic area New Market Circle. The Particulate matters (PM Coarse) concentrations were varying from 96.69μgm^{-3} Chawkbazar Circle to 77.27μgm^{-3} Muradpur Circle. The concentration of Particulate matters (PM Coarse) in all sampling station in Chittagong city is higher than the DoE value. The concentration of particulate coarse matter in Chittagong city air has shown in Table 1.

The cause of higher value of Particulate matters in Chittagong city air are incomplete combustion of fossil fuel of vehicles included car, jeep, bus, minibus, truck, human holler, microbus, four stroke engine driven vehicles like auto rickshaw, CNG etc and motorbikes. railway engines, industrial plants, power plants, brick fields, open burning incineration, solid waste disposal sites, road side dust particles, road diggings, constructions and other development activities are also contributing to the higher value of suspended particulate matter in air of Chittagong city.

The average concentration of lead was 0.44 μgm^{-3} at Muradpur Circle. The average concentration of lead was 8.44 μgm^{-3} at WASA Circle. The average concentration of lead was 0.31 μgm^{-3} at G.E.C Circle. The average concentration of lead was 0.09 μgm^{-3} at Proborthak Circle. The average concentration of lead 7.73 μgm^{-3} at Chawkbazar Circle. The average concentration of lead was 0.10 μgm^{-3} at Alongkar Circle. The average concentration of lead was 5.66 μgm^{-3} at New Market Circle. The average concentration of lead was 8.77 μgm^{-3} at Oxygen Circle. Lead pollution in Chittagong City most probably occurred due to lead content petrol and diesel use in vehicles. Table 2.

Concentration of particulate matters and lead of found value compared with standard value provided by DoE and other international organization are shown in Table 4.

Table 2. *The PM2.5, PM10 and PM Coarse particle concentration (24-Hourse calculated value) of different locations in Chittagong city.*

Sampling Id	Location	Temperature	Humidity	Weather	Sampling hour	Concentration of PM2.5	Concentration of PM10	Concentration of PM Coarse
		(°C)	(%RH)			(μgm^{-3})	(μgm^{-3})	(μgm^{-3})
AQ1	Muradpur Circle	24	51	Scattered Cloud	24 hours	74.02	150.09	76.07
AQ2		29	52	Sunny	24 hours	76.19	152.03	75.84
AQ3		30	58	Partly Sunny	24 hours	78.18	158.08	79.9
Average		27.7	53.7	--	--	76.13	153.4	77.27

Sampling Id	Location	Temperature (°C)	Humidity (%RH)	Weather	Sampling hour	Concentration of PM2.5 (μgm^{-3})	Concentration of PM10 (μgm^{-3})	Concentration of PM Coarse (μgm^{-3})
AQ1	WASA Circle	24	68	Sunny	24 hours	84.15	168.14	83.99
AQ2		30	62	Sunny	24 hours	80.11	164.1	83.99
AQ3		30	55	Sunny	24 hours	76.19	158.09	81.9
Average		28.0	61.7	--	--	80.15	163.44	83.29
AQ1	G.E.C Circle	25	71	Partly Sunny	24 hours	86.17	171.09	84.92
AQ2		30	65	Haze	24 hours	82.09	168.01	85.92
AQ3		32	60	Haze	24 hours	81.15	159.1	77.95
Average		29.0	65.3	--	--	83.14	166.07	82.93
AQ1	Proborthak Circle	25	64	Haze	24 hours	81.08	168.01	86.93
AQ2		30	65	Sunny	24 hours	81	168.09	87.09
AQ3		27	81	Fog	24 hours	87.11	178.19	91.08
Average		27.3	70.0	--	--	83.06	171.43	88.37
AQ1	Chawkbazar Circle	25	76	Fog	24 hours	86.02	177.14	91.12
AQ2		31	40	Sunny	24 hours	54.07	156.01	101.94
AQ3		32	54	Scattered Clouds	24 hours	61.01	158.03	97.02
Average		29.3	56.7	--	--	67.03	163.73	96.69
AQ1	Alongkar Circle	26	43	Scattered Clouds	24 hours	55.01	157.05	102.04
AQ2		32	53	Sunny	24 hours	76.11	152.01	75.9
AQ3		33	50	Haze	24 hours	75.11	151.03	75.92
Average		30.3	48.7	--	--	68.74	153.36	84.62
AQ1	New Market Circle	26	46	Scattered Clouds	24 hours	55.54	157.65	102.11
AQ2		32	57	Haze	24 hours	76.91	152.68	75.77
AQ3		33	50	Scattered Clouds	24 hours	75.16	151.13	75.97
Average		30.3	51.0	--	--	69.20	153.82	84.62
AQ1	Oxygen Circle	28	45	Sunny	24 hours	55.34	157.25	101.91
AQ2		31	57	Scattered Clouds	24 hours	76.31	152.18	75.87
AQ3		34	54	Partly Sunny	24 hours	75.86	151.93	76.07
Average		31.0	52.0	--	--	69.17	153.79	84.62

Table 3. *The trace metal (Pb) concentrations of different locations in Chittagong city.*

Sampling Id	Location	Units in μgm-3
AQ1	Muradpur Circle	0.61
AQ2		0.4
AQ3		0.31
Average		0.44
AQ1	WASA Circle	8.63
AQ2		8.28
AQ3		8.41
Average		8.44
AQ1	G.E.C Circle	0.35
AQ2		0.32
AQ3		0.26
Average		0.31
AQ1	Proborthak Circle	0.08
AQ2		0.08
AQ3		0.1
Average		0.09
AQ1	Chawkbazar Circle	8.11
AQ2		7.68
AQ3		7.41
Average		7.73
AQ1	Alongkar Circle	0.07
AQ2		0.06
AQ3		0.16
Average		0.10
AQ1	New Market Circle	5.91
AQ2		5.87
AQ3		5.21
Average		5.66
AQ1	Oxygen Circle	9.12

Sampling Id	Location	Units in µgm-3
AQ2		8.54
AQ3		8.65
Average		8.77
*BDL=Less than 0.01 μgm^{-3}		

Table 4. *Comparison of trace metal (Pb) concentration of current study with other cities data.*

City	Locations	Units in μgm^{-3} Pb	References
Beijing, China	---	0.046	*I. Mori, M. Nishikawa, T. Tanimura, and H. Quan [20]*
Islamabad, Pakistan	---	0.214	*N. Shaheen, M. H. Shah and M. Jaffar [21]*
Vienna, Austria	---	0.017	*H. Puxbaum, B. Gomiscek, M. Kalina, H. Bauer, A. Salam, S. Stopper, O. Preining and H. Hauck [22]*
	---	0.012	
Teheran, Iran	---	1.02	*S. Rostami, M. Sohrabpour, H. Mirzaee and M. Athari [23]*
Bangladesh (Chittagong City)	Bahaddarhat	0.42	*Ahmed, Mohammed Jamaluddin; Ali, Mohammed Khorshed; Hossain, Muzammel; Siraj, Shajahan; Ahsan, Mohammed Aminul [16]*
	Newmarket	0.745	
	Nasirabad	0.3	
	G.E.C Circle	0.16	
	Director's Office	0.55	
Bangladesh (Dhaka City)	Dhaka City	4.63	*M. Habibur Rahman, A. Al-Muyeed [15]*
	Locations	Units in μgm^{-3}	References
Current study	Muradpur Circle	0.44	Current Study values
	WASA Circle	8.44	
	G.E.C Circle	0.31	
	Proborthak Circle	0.09	
	Chawkbazar Circle	7.73	
	New Market Circle	5.66	
	Alongkar Circle	8.77	

Table 5. *Comparison of particulate maters and lead concentration with standard data.*

Location	PM2.5 (μgm^{-3})	PM10 (μgm^{-3})	PM (μgm^{-3})	Lead (μgm^{-3})
Muradpur	76.13	153.4	77.27	0.44
WASA	80.15	163.44	83.29	8.44
G.E.C	83.14	166.07	82.93	0.31
Proborthak	83.06	171.43	88.37	0.09
Chawkbazar	67.03	163.73	96.69	7.73
Alongkar	68.74	153.36	84.62	0.10
New Market	69.2	153.82	84.62	5.66
Oxygen	69.17	153.79	84.62	8.77
ECR, Amendment [26]	65	150	--	0.5
WHO [24]	15	45	--	0.5
EPA, U.S [25]	12 (Primary Standard) 15 (Secondary Standard)	150	--	0.15/3-month average
Sampling Hours	24	24	24	24

1.6. Graphical Present on Humidity and Temperature Effect on Particulate Matter

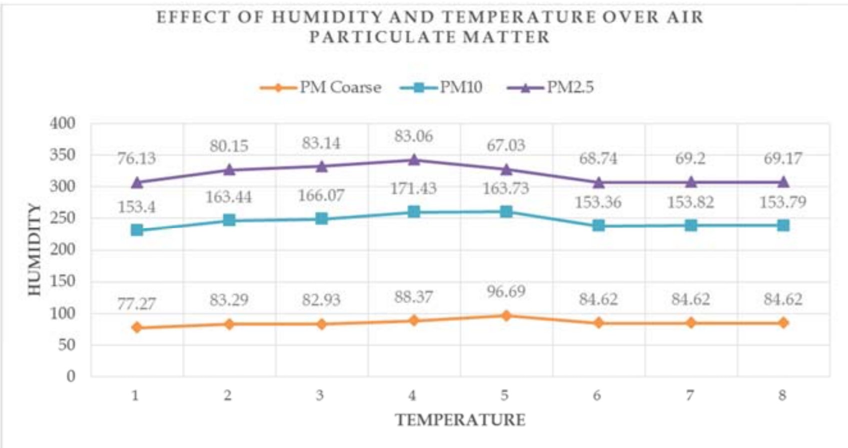

Figure 3. *Effect of Humidity and Temperature Over Air Particulate Matter.*

It had found that the average concentration value of particulate matter is increase with increase of ambient humidity where temperature has mixed effect on it.

1.7. Graphical Present of Lead Pollution Level at Different Location in Chittagong City

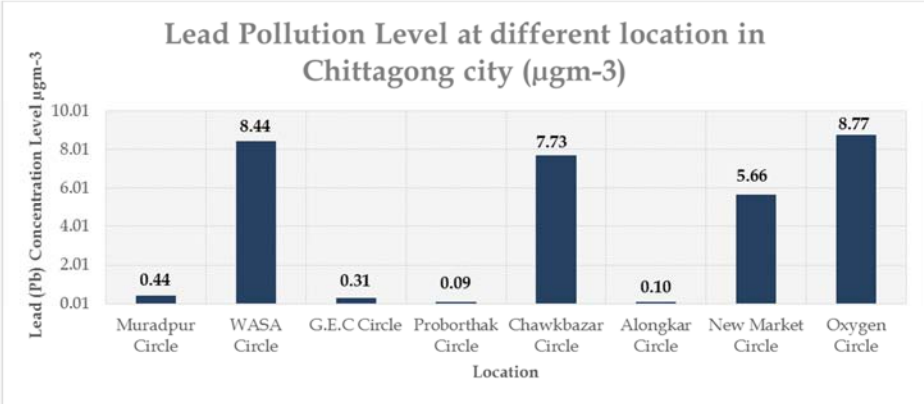

Figure 4. *Lead Pollution Level at different location in Chittagong city (μgm^{-3}).*

2. Conclusion

Particulate matter is an important constituent of the atmosphere. In the environment it may enter from natural or manmade sources. There are a number of natural sources that inject millions of tons of PM into the atmosphere. In Bangladesh main natural sources are wind, dust storms, firing, salt spray and soil erosion. Man-made activities such as fuel combustion, industrial processes, steel industry, petroleum foundries, glass manufacturing industry, smelting and mining operations, fly-ash emissions from power plant, burning of coal, agricultural refuse and most importantly cement industries in Bangladesh also contribute to particulate matter in the atmosphere. Exposure to particulate matter is linked to long and short time cardiovascular and respiratory health problems, reduced activity days, and premature death. Governments of Bangladesh can take action to reduce the environmental damage caused. For their policies to work effectively and for their targets to be achieved the actions of the individual are required. The cumulative energy reductions by individuals would reduce the need for energy consumption, conserve stocks of raw materials such as coal, oil and gas, and bring about a reduction in pollutant emissions. Human especially child health is at high risk because of lead poisoning. Vehicle which are using lead content of petrol and diesel contribute in lead pollution in the environment. Natural gas operated vehicle may take the place of it.

3. Recommendation to Reduce Air Pollution

i. Tree plantation may one of the best ways to reduce air pollution. Chiara Letter and Georg Jäger has shown in their study that a large enough area of a well-suited tree species is a feasible way to increase air quality and, in some cases, even to reduce the particulate matter pollution to an acceptable level [27].
ii. By controlling speed of the vehicle and spraying dust suppressant on the road particulate matter concentration in the air can be reduce. One could reduce emissions caused by traffic, by limiting the allowed maximal speed in areas affected by PM pollution or using dust suppressants [28].
iii. By implementing the laws of government such as for Bangladesh it's "The Bangladesh Environment Conservation Act".

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