

ASSESSMENT OF PARTICULATE MATTER AND NOISE POLLUTION AT DIFFERENT ROAD INTERSECTIONS IN KHULNA CITY

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ABSTRACT

Air is a crucial element of the atmosphere which may affect all the living creatures and the environment. Air with high particulate matter (PM) is most harmful to public health and environment. Noise is also one of the most extending environmental problem. Characteristics of airborne particulate matter and noise generated from the movement of traffic have been studied at different road intersections in Khulna City. PM and noise data were collected from five locations named as Fulbarigate, Shiromoni, Daultapur, Shibbari More and Notun Rasta. Different fractions of PM and sound level found to be closely correlated with the number of heavy traffic as like busses, trucks, auto-rickshaws, three-wheelers and two-wheelers as counted at the study area. The maximum noise level found as 87 decibel at Daultapur and minimum was 79 decibel at Fulbarigate. Maximum concentration of PM_{1.0}, PM_{2.5}, PM₁₀ were reported at Duk Bangla as 27.0 (µg/m³), 43.0 (µg/m³), 63.0 (µg/m³). PM_{2.5} found to contribute to the total concentration of PM₁₀ about 69 % at Duk Bangla location while the maximum value of PM_{1.0}/PM_{2.5} ratio obtained as 0.63 at Shibbari More which indicates the dominancy of fine particles at these locations. The highest air quality index (AQI) value was found as 67 at Duk Bangla which indicates the moderate air quality of this location whereas other four intersections exhibited the air quality according to AQI as good. Recorded noise level found to be exceeded the national standard for all monitoring locations.

Keywords: Particulate matter, Noise pollution, Air quality index, PM_{2.5}/PM_{10.0}.

1. INTRODUCTION

Air quality is degrading rapidly all over the world and as well as Noise level is becoming intolerable to human beings. These problems arise mainly for urbanization, industrialization, high density of population and increasing level of vehicular concentrations. Khulna is the third largest city of Bangladesh. It is one of the most traffic congested city with a large number of population about 0.63 million. The number of population in Khulna city is expected .990 million by 2020 (Population Stat, 2019). The rapid growth of population and industries making as increasing scenario of number of vehicles and the limited roadways causing heavy traffic concentration. Therefore the emissions from vehicles specially Particulate Matter have been identified as the most responsible pollutant causing air pollution. The traffic generated emissions are accounting more than 50% of the total PM emissions in the urban areas (Wrobel et al., 2000). About more than 30% respiratory problems are related to personal exposure to high level PM concentrations (WHO, 2000).

At present, over 600 million people living in urban areas worldwide are being exposed to dangerous levels of traffic-generated air pollutants (Cacciola et al., 2002). In developed countries, PM emissions are mainly responsible for respiratory health problems (Yang, 2002; Shendell and Naeher, 2002; Wang et al., 2003). Vehicular exhausts, emission from tire and brake wear and re-suspension of road dusts are the major sources of Ambient PM concentrations. During recent years, Khulna city is experiencing a rapid growth of industrialisation due to easily navigation transport of raw materials by Mongla Port. The government of Bangladesh has banned thousands of two-stroke three-wheelers, sometimes known as baby taxis, from the streets of Dhaka. Because of this Banning, vehicles took place in some divisional cities, also in Khulna. According to the daily air quality index (AQI) report of 29th November, 2019 the Air quality index of Khulna city was recorded as 184 which indicates unhealthy conditions. A lot of peoples are suffering from respiratory problems due to Air pollution.

Noise is derived from the Latin word “nausea” implying unwanted sound or sound that is loud, unpleasant or unexpected (Sing et al., 2004). Noise pollution is defined as form of air pollution that is an audible unwanted sound that poses a threat to a person’s health and well-being (Goines et al., 2007). In Khulna city, the noise level is also increasing rapidly specially for vehicular movements. Large amount of buses and trucks are moving through this city because of different industrial activities situated in this city. Vehicles moving between Dhaka to Khulna for passenger purpose are also responsible for generating noise. As per the December 2018 report of Department of Environment, Khulna, most of the populous places in the city have crossed the allowable limit 60dB. The noise level at Rupsha Traffic intersection was 70dB and Daulatpur, Sonadanga and Boyra bus stands stood at 73, 82 and 72 respectively. According to World Health Organization (WHO), generally 60dB sound can make a person deaf temporarily and 100dB sound can cause complete deafness. Road users in Khulna city such as drivers, helpers, shop keepers, students etc. are suffering from heart attack, bed temper, hearing problem because of noise pollution (Begum et al., 2011). In Khulna city area, there are 49 rice mills, 7 jute mills and 32 other mills and lots of trucks are moving to carry their raw materials and products. In recent years, it is shown that , the roadway of Khulna city is frequently submerging with water ,as a result these road surface getting cracked easily. For this reason, the friction between tyre and roads are increasing and it increases PM Mass concentrations. So improvement of traffic management system and besides roadway environment may have a direct consequences on Air quality and noise level. The objectives of this study to asses the concentration of Particulate matter and Noise level at some road intersections and to compare the value with Bangladesh National Air Quality Standards and Standard set by the government of Bangladesh.

2. METHODOLOGY

2.1 Selection of Locations

Five road intersections were selected carefully for achieving the purpose of this study. These intersection points have more populated traffic congestion than other points. The first point was Fulbarigate, which is about 6m North of Fulbarigate Police box. The second point was Daulatpur

about 2m South of Akankha Tower. The third intersection point was Notun Rasta about 2m east of Mosque. Shibbari More was taken as fourth intersection point about 2m apart from Sundarban Currier Service office. Duk Bangla was taken as fifth intersection points. These points were selected very close to intersections. Description of selected locations are presented in Figure1.

2.2 Particulate Matter (PM) Monitoring

Handheld 3016 IAQ laser particle counter, a real time particulate matter monitoring equipment was used in this study. After finalizing the monitoring locations, with the help of the monitoring equipment as shown in Figure 2, PM data was measured. Air data monitoring campaigns were conducted frequently at different dates for at least 1-hour duration at every intersection point from June to September, 2019. Particulate matter concentration data were recorded per min by PM counter as per their sizes. The concentration of different PM fractions (0.3, 0.5, 1.0, 2.5, 5.0, 10.0) were recorded by this equipment.

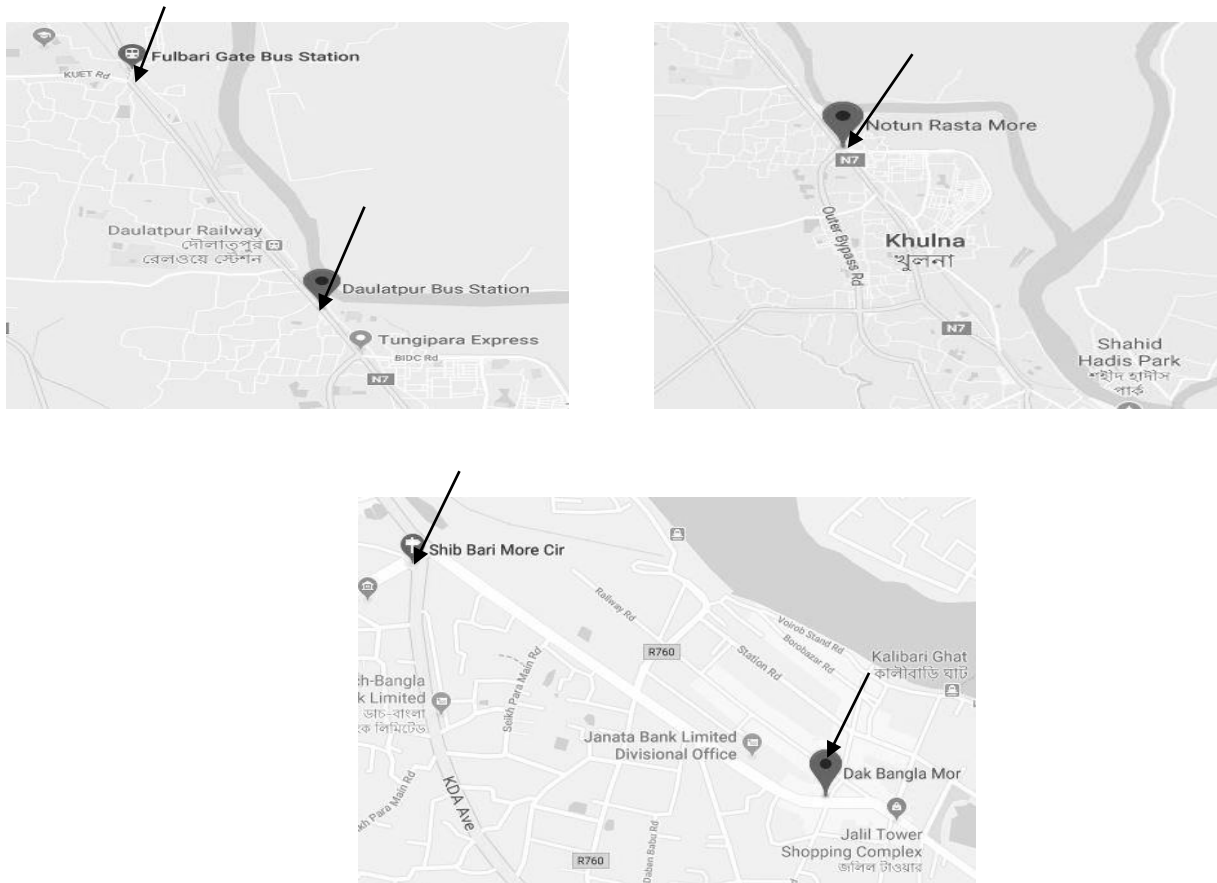


Figure 1: Monitoring locations in Map



Figure 2: Particulate Matter Monitoring at Shibbari More

2.3 Monitoring of Sound

Noise measurements were conducted with the PM concentration data at the selected locations by using a calibrated Sound Level Meter (SLM). The Sound Level Meter was placed a specified distance from the source of sound and kept it at a height of ear level shown in Figure 3. The distance between the source of sound or traffic and Sound level meter was 1.5m for all intersection points. Sound data were recorded per minute intervals from this equipment. All points from where sound data was collected at the same conditions. All intersection points were open, no obstacles to sound such as buildings, trees, poles etc. It was maintained that there was no contribution of noise from other sources. After using this collected data, the Noise level of this point was reported with the help of standard set by the government of Bangladesh.



Figure 3: Noise Data sampling by Sound Level Meter

2.4 Traffic Monitoring

From all selected intersection points, traffic data was collected simultaneously with PM concentration and Noise data by video recording of moving vehicles. Mobile camera was used for recording the movement of vehicles. After that, the video was analysed and vehicles were counted with respect to time. By using this data, the variation of PM concentration with Traffic volume was reported. At the same time variation of Noise level with traffic volume was reported.

2.5 Calculation of Air Quality Index

Air Quality Index is a communication to easily and effectively describe the air quality of a certain location. AQI values are derived from air quality data readings, which allows for more meaningful comparison of pollutants affecting air quality. The index is derived using the below depicted formula 1.

$$\text{AQI}_{\text{pollutant}} = \frac{\text{Pollutant data reading}}{\text{Standard}} * 100 \quad \dots\dots \quad \dots (1)$$

3. RESULTS AND DISCUSSION

3.1 PM Mass Concentration and Air Quality Index

Average PM concentration at selected road intersections are presented in Table 1. Concentrations of PM_{2.5} and PM_{10.0} found within the BNAAQS for all considered intersection. Duk Bangla location found to carry the highest concentration of PM_{1.0}, PM_{2.5} and PM_{10.0} as 26.64 µg/m³, 43.47 µg/m³ and 63.02 µg/m³ consecutively. This can be happened due to the larger vehicular movement at this location. Notun Rasta location showed lowest average concentration of PM_{1.0}, PM_{2.5} and PM_{10.0} as 5.82 µg/m³, 13.33 µg/m³ and 34.91 µg/m³ respectively. Highest PM_{1.0}/ PM_{2.5} appeared at Shibbari More as 0.63 and lowest was at Fulbarigate as 0.43 indicating the contribution of PM_{1.0} to the concentration of PM_{2.5}. Highest PM_{2.5}/ PM_{10.0} found at Duk Bangla as 0.69 indicates 69 % presence of fine particles in total particle concentration. Air Quality Index of 1-hr averaging PM concentration data at selected road intersections are presented in Table 2. AQI of PM_{2.5} and PM_{10.0} found as good for four locations named as Fulbarigate, Daulatpur, Natun Rasta and Shibbari more while the location named as Duk Bangla found to exhibit the AQI value as moderate. It can be evidenced from the larger vehicular movement at this location as tremendous amount of people used to come to this location for purchasing different goods.

Table 1: 1-hour average PM concentration at selected road intersections

Description		Fulbarigate	Daulatpur	Notun Rasta	Shibbari More	Duk-Bangla
PM Mass concentration (µg/m ³)	PM _{1.0}	6.0	7.0	6.0	15.0	27.0
	PM _{2.5}	14.0	15.0	13.0	24.0	43.0
	PM _{10.0}	36.0	39.0	35.0	41.0	63.0
PM Mass Ratio	PM _{1.0} / PM _{2.5}	0.43	0.44	0.44	0.63	0.62
	PM _{2.5} / PM _{10.0}	0.39	0.40	0.40	0.60	0.69

Table 2: Air Quality Index of 1-hr averaging PM concentration data at selected road intersections

Location	Standard ($\mu\text{g}/\text{m}^3$)	AQI of PM for Respective Locations				
		Fulbarigate	Daulatpur	Notun Rasta	Shibbari More	Duk Bangla
PM _{2.5}	65 (24h avg)	21	23	21	37	67
PM ₁₀	150 (24h avg)	24	26	23	28	42
AQI	-	24	26	23	37	67
Category	-	Good	Good	Good	Good	Moderate

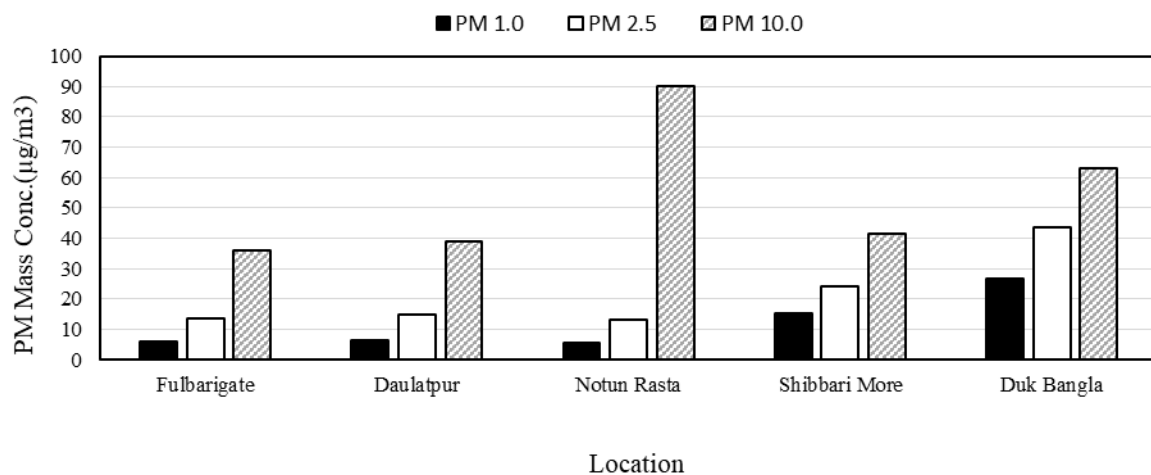


Figure 4 : PM Mass concentration at different road intersections

PM Mass concentration at different road intersections presented in Figure 4. Bar diagram represented the variation of PM Mass Concentration at five road intersection points. In the diagram it was seen that the concentration of PM₁₀ at Notun Rasta is higher than other intersection points. It was due to high traffic volume and more traffic congestion. Vehicles movement at new market were very slowly because in this intersection a lot of traffic came from two sideways one of Notun Rasta –Khalipur link road and another is Notun Rasta-Sonadanga link road. Also, concentration of PM_{2.5} and PM₁₀ was very high at Duk Bangla because of a large number of 3W vehicles and auto-rickshaw were moving and contributing particulate matter.

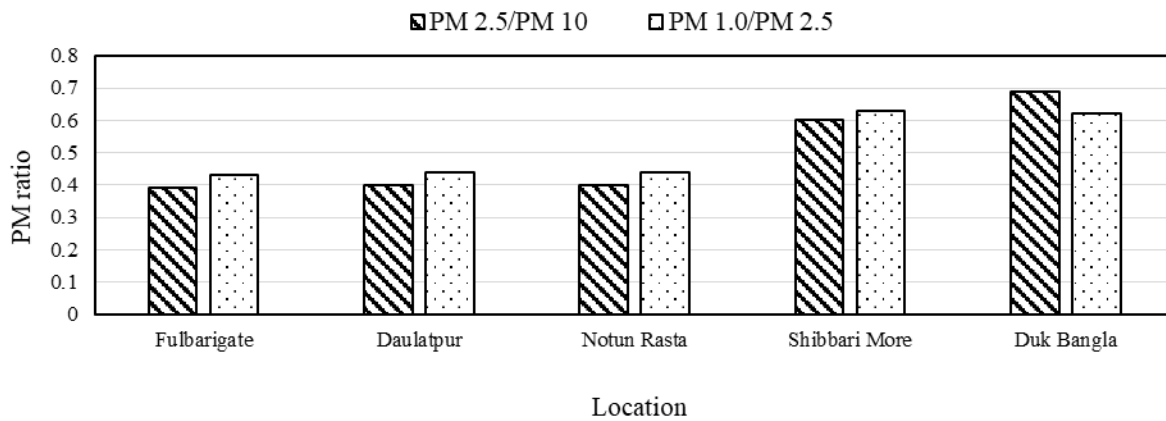


Figure 5: PM ratio at different road intersections

At four intersection points the value of $PM_{1.0}/PM_{2.5}$ was larger than the value of $PM_{2.5}/PM_{10.0}$ indicated that Particulate matter sizes less than $1 \mu m$ contributing higher than other particle sizes for polluting the air of Fulbarigate, Daulatpur, Notun Rasta and Shibbari More. At Duk Bangla location, $PM_{2.5}/PM_{10.0}$ value was higher than $PM_{1.0}/PM_{2.5}$ indicated that the particulate matter sizes less than $2.5 \mu m$ contributing more for air pollution of that intersection point.

3.2 Traffic Concentration

Vehicles moving through the intersection points were classified as 2W (motor cycle), 3W (auto rickshaw, CNG), 4W (small trucks, private cars) and HCV (large buses and trucks). Vehicles moving through all the selected road intersection points were counted manually for one-hour duration with four minutes intervals as presented in Table 3. From this data, average traffic moving at Fulbarigate, Daulatpur, Notun Rasta, Shibbari More and Duk Bangla were 84, 96, 106, 84 and 79 nos for per four minutes respectively. It was found that the number vehicles crossing Notun Rasta was highest than then other points which was the major reason of higher concentration of Particulate matter at that location. Also, the location Duk Bangla contained the average traffic flow as high which supports the higher concentration of PM at this location. Among all intersection points the amount of HCV was higher at Fulbarigate (12%) that contributes huge amount PM emissions.

Table 3: Percentages of motor vehicle plying on monitoring intersections

Location	2W	3W	4W	HCV
Fulbarigate	23%	51%	12%	14%
Daulatpur	17%	68%	9%	6%
Notun Rasta	21%	59%	7%	13%
Shibbari More	23%	57%	11%	9%
Duk Bangla	20%	52%	12%	16%

3.3 Noise Level at Five Selected Road Intersections

Noise level of five road intersections is shown in Figure 6. It was reported that the highest value of noise level belongs to Daulatpur as 85.95 dB at high value weighted A and 83.09 dB at low value weighted A. Daulatpur road intersection was also near the three-wheeler station and bus station. Large number of shops are situated near this point that contributes more sound value. Duk Bangla is one of the most congested place of Khulna city having three-wheeler stand and lots of shop in the footpath. It is also a business centre of Khulna City. Because of these reasons a large number of people are gathering there and as a result the sound level of this intersection poses higher than tolerable limit. It is seen that in each intersection points the sound value exceeds the standard value set by the government (70dB).

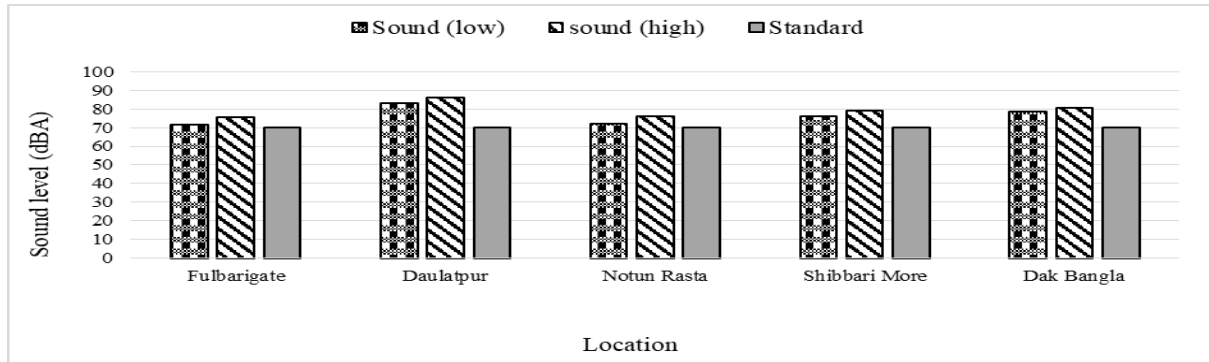
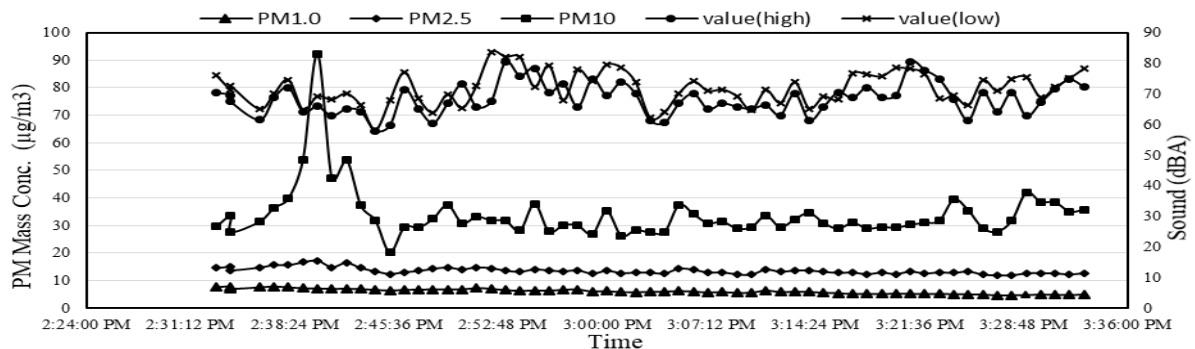


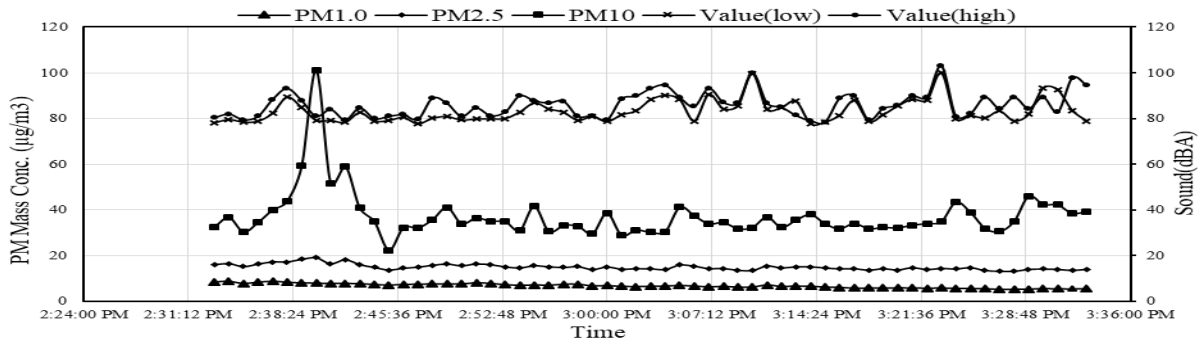
Figure 6: Variation of Noise level at road intersections

Variation of PM Mass concentration and Sound level for all monitoring locations are shown in Figure 7(a) to Figure 7 (e).

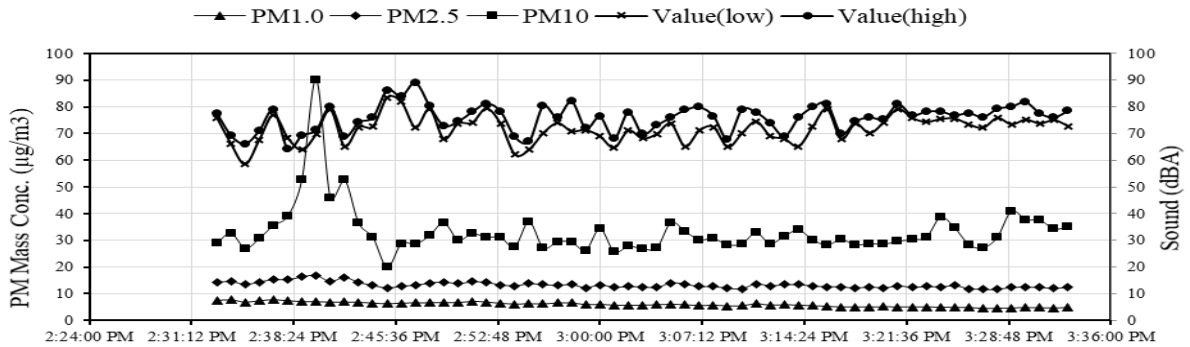
The nature of PM mass concentration and noise level curve with respect to time poses similarity. Most of the cases it is shown that, Particulate matter increasing with the increasing of noise level. Both of these data are generated from vehicular movement. PM concentration and noise level pose high pick when the concentration of vehicular movement increases. Sometimes it was observed that the concentration of PM increases abruptly specially at Fulbarigate because of occurring traffic congestion when train was crossing through Dhaka –Khulna highway. At that time Vehicular emission increases due to fuel combustion although vehicle concentration is not increased and sound data also poses peak in that curve due to sound contribution by moving train. At other road intersections, fluctuation of PM concentration and sound level was reported. The main reason for showing that fluctuation could be the gathering of people with motorized vehicle at the respective locations affecting the PM concentration and Noise level.



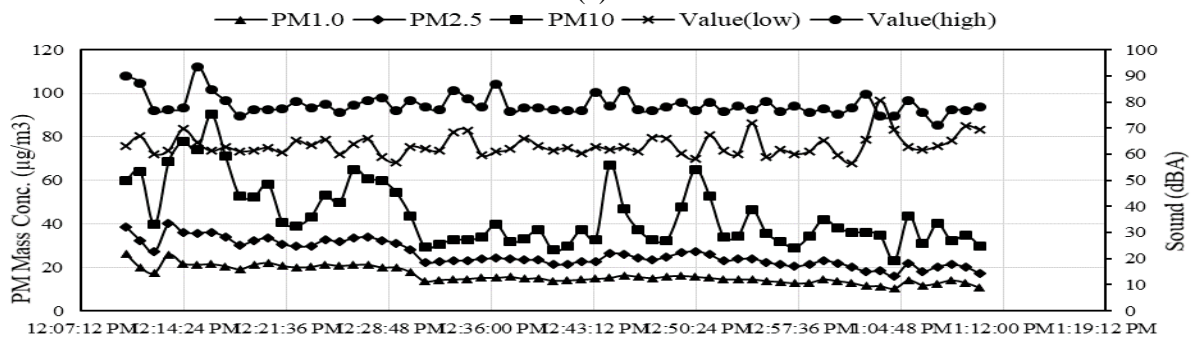
(a)



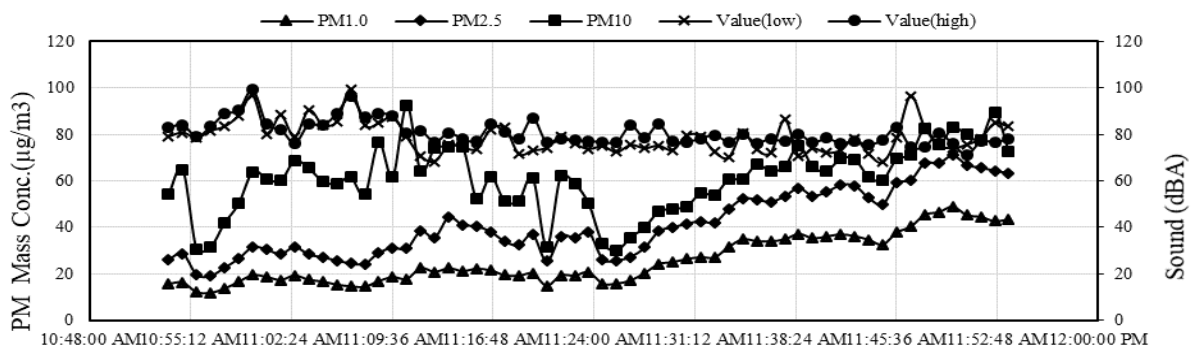
(b)



(c)



(d)



(e)

Figure 7: Variation of PM Mass concentration and Sound level; (a) Fulbarigate, (b) Daulatpur, (c) Natun Rasta, (d) Shibbari More and (e) Duk Bangla

4. CONCLUSIONS

In this present study, the concentration of PM₁₀, PM_{2.5}, PM_{1.0} and Noise level due to heterogeneous traffic movement at five road intersection points of Khulna city was investigated. Major findings of this study are as follows:

- Maximum concentration of PM_{1.0}, PM_{2.5} and PM₁₀ were reported at Duk Bangla as 27.0 µg/m³, 43.0 µg/m³, 63.0 µg/m³.
- The maximum Noise level was 87 decibels at Daultatpur location and minimum was as 79 decibels at Fulbarigate location.
- The maximum value of PM_{2.5}/PM_{10.0} ratio was 0.69 obtained at Duk Bangla and minimum value found as 0.43 found at Fulbarigate.
- The maximum value of PM_{1.0}/PM_{2.5} ratio was obtained as 0.63 at Shibbari More while minimum value was found as 0.39 at Fulbarigate.
- The highest air quality index (AQI) value was found at Duk Bangla as 67 which indicates moderate air quality of this location. The condition of air quality found good for rest four locations according to the AQI of PM.

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