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AIR QUALITY STATUS IN MANIKGANJ DISTRICT TOWN, BANGLADESH: A WINTER TIME OBSERVATION

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ABSTRACT

Introduction: Air pollution is the biggest threat to human survival, particularly in emerging nations.

Objective: The objective of this study is to estimate the Particulate Matters (PM_1, $PM_{2.5}$ and PM_{10}) and Carbon Monoxide (CO) concentration in Manikgonj district town.

Methods: This study was conducted on 60 locations based on seven land use in Manikgonj district town, by using portable Air Quality Monitor and portable CO meter.

Result: It is found that average concentrations of PMs of 60 places in Manikgonj district town were 61.96, 101.95 and 132.19 µg/m^3 respectively which were 4 and 2.5 times higher than World Health Organization (WHO) standard level. It is estimated that the average $PM_{2.5}/PM_{10}$ was 77.25% and $PM_1/PM_{2.5}$ was 60.80%. The average concentration of $PM_{2.5}$ of different land-use were found higher which is 1.57 folds than the daily Bangladesh National Ambient Air Quality Standard (NAAQS) level. average concentration of CO found 1.1 to 2.15 times higher than level. Further found that the changes in the concentration of all the selected parameters within land uses were significant. Average concentration of $PM_{2.5}$ which follows as commercial area > road intersection area > village area > sensitive area >mixed area > industrial area > residential area.

Conclusion: Air pollution can reduce by making people aware about it as well as implementing the law.

Keywords: Air Pollution, Particulate Matter, Concentration, Manikgonj District town, Distribution, Pollutants.

1.Introduction

Air pollution may be defined as an atmospheric condition in which various substances are present at concentrations high enough above their normal ambient levels to produce a measurable effect on people, animals, vegetation, or materials. 'Substances' refers to any natural or manmade chemical elements or compounds capable of being airborne, which may be in gaseous, liquid or solid form (Harrison et al., 2014). It includes any substance whether noxious or benign; however, the term 'measurable effect' generally restricts attention to those substances that cause undesirable effects. Air Quality has deteriorated both due to human activities and natural phenomena such as windblown dust particles etc. Recently, air pollution has received priority among environmental issues in Asia as well as in other parts of the world (HEI., 2020). Exposure to air pollution is the main environmental threat to human health in many towns and cities. Bangladesh is in the top position in the Air Quality Report of 2019 and 2020 in terms of air pollution (IQAir, 2020; IQAir, 2021). According to the Report, about 7 million people die every year in the world due to air pollution. In 2018, about 1 lakh 58 thousand people died of air pollution in Bangladesh (HEI, 2020). Pollutants are increasing in suburban area with urban areas, especially surrounding areas of Dhaka city. With reference to that study area particulates matters pollution arisen in Manikganj district town (Mondol et al., 2014). Gazipur, Manikganj, Barisal, Noakhali, Chittagong, Faridpur and Kustia and Pabna are being polluted where PMs concentration in 3-6 times higher than standard level (Mondol et al., 2014; Hossain et al., 2019). Rana et al., 2015 found that during the colder months, the PM_{10} levels in Dhaka, Gazipur, and Narayanganj were, respectively 257.1,

240.3, and 327.4 g/m^3. Another study found that Joydebpur (Gazipur) has higher $PM_{2.5}$ and PM_{10} levels than Farmgate (Dhaka) because to long-distance transportation and brick kilns. Different study found that in different location has others types of PM ranges 0.3µm to 5 µm (Hasan et al., 2016). Air pollution seriously affects the respiratory tract and can causes' high respiratory disease, headache, asthma, high blood pressure, and even cancer. One of the most difficult problems is irritation of the eyes or throat, coughing, sneezing; high fever (Rana et al., 2016; Ahmed et al., 2016; Alam et al., 2018; Woo et al., 2018). The mental faculty of children will be adversely affected by PMs pollution, which can also affect the central nervous system and cause renal damage and hypertension (Ahmed et al., 2016; Tusher et al., 2018). Pollutants, especially $PM_{2.5}$ considered as more harmful due to its characteristics and it is capable to travel deeper part of the respiratory system and also pass through the alveoli into the bloodstream that causes premature mortality, lung cancer and increase the risk of respiratory and heart disease. Developing countries like Bangladesh suffer $PM_{2.5}$ exposures that are four to five times more than developed countries and worldwide, air pollution is the fifth risk factor for mortality (Tusher et al., 2018; HEI, 2019; Hill, 2010). Majumder et al., 2020 found that PM levels changed periodically, increasing during the winter and decreasing during the wet seasons. also mention that annual $PM_{2.5}$ concentration was 5-6 times and PM_{10} concentration was 3 times the Bangladesh National Ambient Air Quality Standard (BNAAQS) level. The effects of long-term exposure to elevated ambient concentrations of CO are often associated with cardiovascular problems amongst exposed individuals. Acute exposure to high concentrations of CO may result in CO poisoning with an onset of symptoms including nausea, vomiting, headaches, shortness of breath, confusion, and can quickly lead to death (Tasnuva et al., 2014; Tusher et al., 2018).

The objectives of the Study:

- To identity the status of air pollution in Manikganj District Town.
- To assess the relationship between land use and all parameters (PM_1, $PM_{2.5}$, PM_{10}, and CO).
- To identify AQI of Manikganj based on $PM_{2.5}$ and do the spatial map.
- Geospatial mapping on the concentration of PM_1, $PM_{2.5}$, PM_{10}, and CO.

2. Methodology

2.1 Study area:

Manikgonj Sadar is an upazila of Manikgonj District in the division of Dhaka, Bangladesh. Manikganj District town is located at 23.8644° N, 90.0047° E. (Wikipedia, 2021).

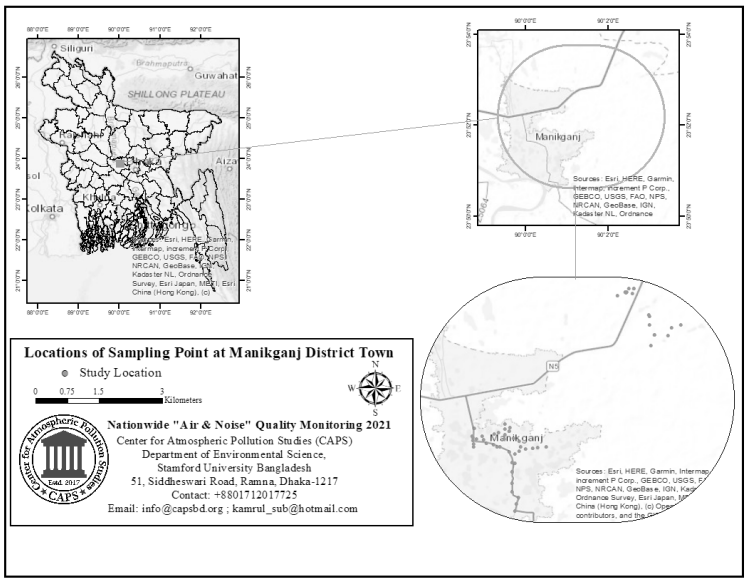

Figure 1: Study Area (Manikganj) District Town Area and Data Collection Locations Point

2.2 Research Methods

In this study, we considered 4 important parameters. Theses 4 parameters are Particulate Matter ($PM_{1.0}$, $PM_{2.5}$ and PM_{10}) and Carbon monoxide (CO) along with that 60 locations were selected on basis of the use of land. After that, all locations were divided according to the use of land into seven types, which are sensitive, residential, mixed, commercial, road intersection, industrial and village Area. There is total 10 sensitive area were select that includes hospitals and clinics, schools, colleges, mosques, madrasas, temples, churches, and administrative Bhaban. On the other side, mixed areas contain bazars, buildings, main roads etc. Rest 50 locations were categorized as residential areas;10 locations, mixed areas; 4 locations, commercial areas;8 locations, road intersection or busiest road junctions and bends; 8 locations, industrial area; 10 locations and village area; 10 locations.

2.3 Data Collection

As part of the survey, Air Quality was measured in different location of Manikganj district town area with the help of various automated portable instruments name Air Quality Monitor and Handheld Carbon Monoxide Meter and GPS data was also collected by an android software name as “GPS Location Camera”. Four individual data of PM_1, $PM_{2.5}$, PM_{10} and CO was collected from each location. Data was collected from 60 different locations by CAPS team. Data was collected in different times in seven days from morning to late evening.

2.4 Data Processing

Collected data was input in an IBM SPSS V20 and MS Excel 2020, analyzed it where descriptive statistics done to know the dispersion of every parameter of land use and do an ANOVA for significance test between land use and parameters. In study, used a formula for conversion of concentration of $PM_{2.5}$ and PM_{10} to AQI. Also used different color for understanding the concentration of particulates matters and gaseous pollutants. Formula for Conversion- To convert from concentration to AQI this equation was used.

3. Result and Discussion

Figure 2 (a, b, c, d and e) shows the PM concentration (µg/m^3) of some locations in mixed, residential, road intersection and commercial areas in Manikgonj district town. among these 10 sensitive places, in front of Government Debendronath Collage and outside of Aftabia Jame Masjid with the concentration of PMs 82.25, 141.50 and 179.00 µg/m^3 and75.50, 122.75 and 159.75µg/m^3 two were highly polluted followed by Manikganj Govt. High School with $PM_{2.5}$ concentration of 105 µg/m^3 where comparatively less polluted places were outside of Govt. Debendro Collage, outside of Manikganj Sorkari Mohila Collage and near Sadar Thana Manikganj with $PM_{2.5}$ concentration of 67.25, 80.75 and 85.75 µg/m^3 respectively. However, it was also noted that the concentrations of $PM_{2.5}$ and PM_{10} found in the most polluted place were 2.18 and 1.19 times higher than Bangladesh National Ambient Air Quality Standards (NAAQS) level which are 65 and 150 µg/m^3 set by the Department of Environment (DoE). As we could see, 4 mixed places, two polluted places were Belayet Hossen road and near Bitul Mamur Jame Mosque with the $PM_{2.5}$ concentration of 97.75 and 96.00 µg/m^3 respectively and comparatively less polluted places were near Government women Organization and outside of Dutch Bangla Manikganj with the $PM_{2.5}$ concentration of 89.50 and 90.50 µg/m^3 respectively. It has been observed that concentration of PM_1, $PM_{2.5}$ and PM_{10} of Belayet Hossen road and near Government women Organization were 60.50, 97.75 and 127.50 µg/m^3 and 53.00, 89.50 and 114.00 µg/m^3 respectively. In the year 2016, the highest $PM_{2.5}$ concentration was found 152.0, 181.0, 178.7 µg/m³ at Nawabganj, Manikganj, and Dhaka city respectively (Hossain et al, 2019). Presence of Power plant in different area may be the cause of increasing pollution. It was also noted that the concentrations of $PM_{2.5}$ found in the most polluted place was 1.50 times higher than NAAQS. Also, in the most polluted location, concentration of $PM_{2.5}$ was 3.91 times and PM_{10} was 2.55 times higher than WHO standard level. The Air Quality Standard (24-hour) set by the WHO for $PM_{2.5}$ and PM_{10} are 25 and 50 µg/m^3 respectively. It has been found that out of 10 residential places, three polluted places were Nimtoli, Bonogram

residential area and Durgamondir road with $PM_{2.5}$ concentration of 109.25, 100.00 and 98.25µg/m^3 respectively and comparatively less polluted places were Professor Housing Society, North Bonogram and West Bonogram with $PM_{2.5}$ concentration of 79.50, 82.50 and 82.50 µg/m^3. It has been observed that concentration of PM_1, $PM_{2.5}$ and PM_{10} of Nimtoli and Professor Housing Society were 69.25, 109.25 and 140.50µg/m^3 and 49.50, 79.50 and 104.00µg/m^3 respectively. It was also noted that the concentrations of $PM_{2.5}$ found in the most polluted place was 1.68 times higher than NAAQS level. Also, the concentrations of $PM_{2.5}$ and PM_{10} found in the most polluted location were 4.37 and 2.81 times higher than WHO standard level respectively. Again it has been found that out of 8 road intersection places, one highly polluted place was Chouraster mor with the PMs concentration of 75.75, 127.00 and 162.75 µg/$m^3$and two polluted places were Singgail road, Chowrasta and Begam Jarina Collage mor with the $PM_{2.5}$ concentration of 110.25 and 109.00 µg/m^3 respectively and comparatively less polluted places Khilpar, Manikganj Bus Stand and Department of Agricultural Extension, Bazar Bridge mor with the $PM_{2.5}$ concentration of 96.25, 100.00 and 102.25 µg/m^3 respectively. The concentrations of $PM_{2.5}$ and PM_{10} discovered in the most polluted place were 1.95 and 1.085 times higher than NAAQS level in road intersection area. In this study among 8 Commercial places, three highly polluted places were Shahid Rofiq Road, Manikgonj Bazar and Dudh Bazar with the PMs concentration of 123.50, 216.00 and 271.25 µg/m^3, 110.75, 180.50 and 234.25 µg/m^3 and 67.75, 114.75 and 162.67 µg/m^3 respectively and comparatively less polluted places were Customs, near Shonali Bank Manikgonj and Pubali Bank Manikganj with the $PM_{2.5}$ concentration of 86.75, 97.00 and 97.50 µg/m^3 respectively. For commercial area, $PM_{2.5}$ and PM_{10} concentrations found in the most polluted place were 3.32 and 1.81 times higher than NAAQS level.

Figure 2 (f and g) displays the concentration (µg/m^3) of PM_s of some locations in industrial and village areas in Manikgonj district town. Selected 10 industrial places, Corbel International with the PMs concentration of 113.50161.75 and 241.50 µg/m^3 was highly polluted place and Iron & Arsenic removal water treatment plant and Eraton with the $PM_{2.5}$ concentration of 111.00 and 95.25 µg/m^3 were in 2nd and 3rd position and comparatively less polluted places were Kalam cotton enterprise, Family Products and Nayeem Enterprise with the $PM_{2.5}$ concentration of 68.75, 69.00 and 69.50 µg/m^3. The concentrations of $PM_{2.5}$ and PM_{10} found in the most polluted place were 2.49 and 1.61 times higher than NAAQS level. Tasnuva et al., (2014) investigate that the concentration of air pollutants at Kushtia sugar mills, it is found maximum concentrations of PM_{10} was 380.339 µg/m^3. It has been selected that, among 10 village places, one highly polluted place was Golora Jame Mosque with the PMs concentration of 129.00, 212.75 and 274.50 µg/m^3 and two polluted places were Daira, Vhobanipur and Khanbari mor, Chandipara with the $PM_{2.5}$ concentration of 129.75 and 116.75 µg/m^3 respectively and comparatively less polluted places were Middle Golora, Golora and Chandi guora with the $PM_{2.5}$ concentration of 70.25, 74.25 and 76.75µg/m^3 respectively. It was also established that the concentrations of $PM_{2.5}$ and PM_{10} found in the most polluted place were 3.27 and 1.83 times higher than NAAQS level. *Among average* concentration of PMs of seven lands uses in Manikgonj district town the highest was found in commercial area (76.16, 125.91 and 164.52 µg/m^3) followed by road intersection area (63.97, 106.81 and 137.19 µg/m^3) and village area (63.95, 105.43 and136.08 µg/m^3) respectively.

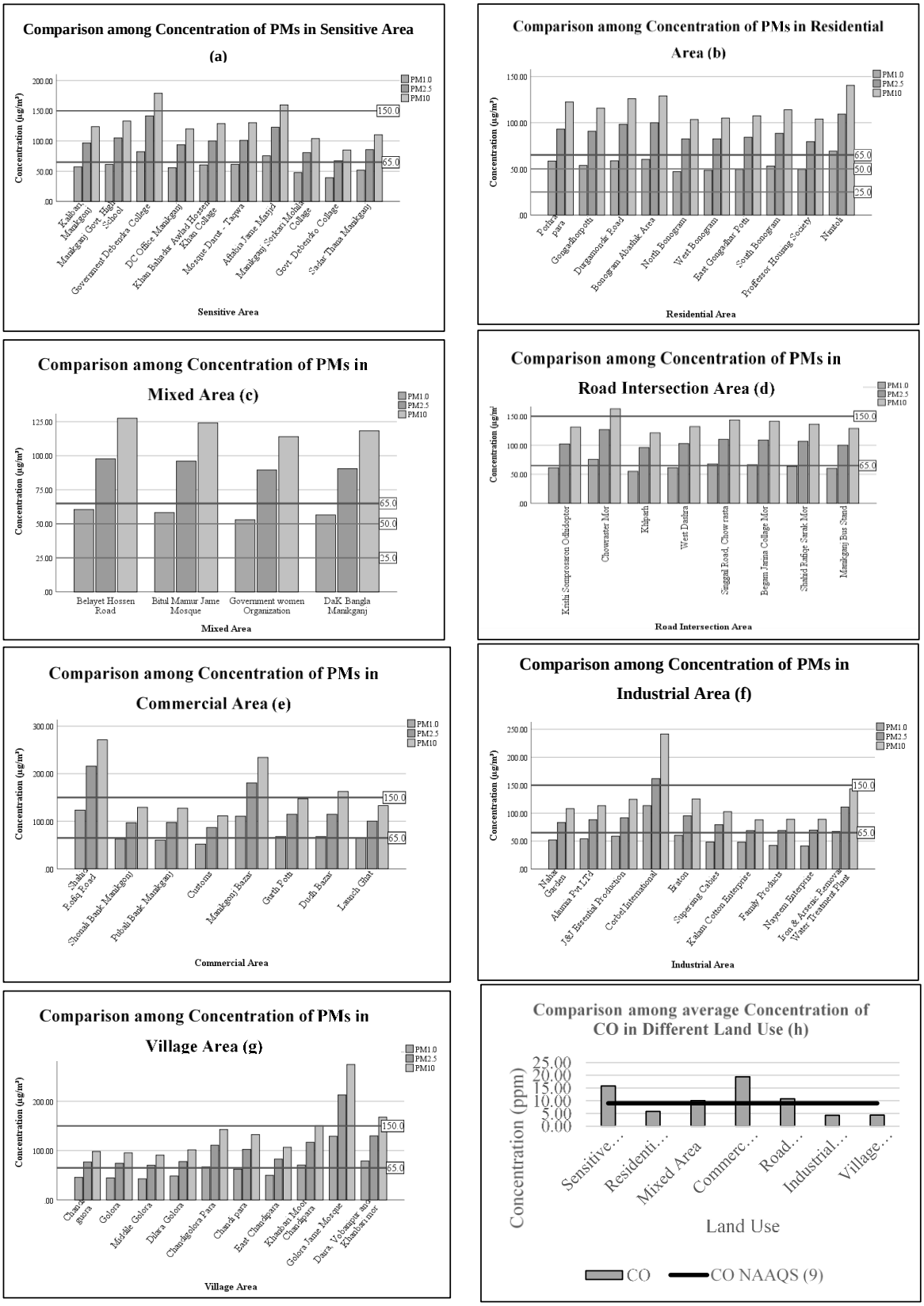

Figure 2: Comparison among Concentration of PMs and CO in Different Land Use

Mondol et al., 2014 estimated that in Dhaka, Noakhali, Chittagong, Faridpur and Kustia the average values of total suspended particulate matter were 413.02,671.65, 292.63, 301.13 and 184.09 g/m^3 respectively. It was also noted that the concentrations of $PM_{2.5}$ and PM_{10} found in the most polluted area were 1.94 and 1.0968 times higher than NAAQS level. Here, concentrations of PMs were found

relatively lower in residential area, industrial area and mixed area. Moreover, the average concentrations of PM_1 (54.80 µg/m^3), $PM_{2.5}$ (90.85 µg/m^3) and PM_{10} (116.78 µg/m^3) were found to be least in residential area. In the Figure 2(h) illustrate the comparison of average CO concentration among seven land use in Manikgonj district town. In this study, the graph shows that the average of CO was found to be higher in the commercial area, sensitive area, road intersection area and mixed area which are also higher than the standard level. The average concentration of CO of commercial area, sensitive area, road intersection area and mixed area were found 19.38, 15.80, 10.75 and 10.00 ppm respectively. The CO concentration was 1.1 to 2.15 times higher than NAAQS level, being 9 ppm (8-hour) set by the Department of Environment (DoE). Whereas, the average concentration of CO of residential area, village area and industrial area where the concentration did not exceed the standard level. The average concentrations of CO found least in industrial area.

3.2 Dispersion of PM_1, $PM_{2.5}$, PM_{10} and CO

The following table 1 shows the descriptive statistics for PM_1, $PM_{2.5}$, PM_{10} and CO of the studied seven land uses. The highest range was found in village area (86.25, 142.50 and 183.25 µg/m^3) for the PMs and sensitive area (48 ppm) for CO and lowest range was found in mixed area for all the parameters. Among all those land uses the highest mean value of PMs and CO were found in commercial area (167.16 µg/m^3, 125.91 µg/m^3, 164.52 µg/m^3 and 19.38 ppm) and the lowest mean was found in residential area (54.80, 90.85, 116.78 µg/m^3) for PMs. Study found average mean value for PMs 61.96, 101.95 and 132.20 µg/m^3 respectively. Study found the highest standard deviation was in village area for PM_1 and commercial area for $PM_{2.5}$, PM_{10} and CO and the lowest was seen in mixed area for all the parameters. Average stand. deviation was found (14.52, 23.05 and 10.06 µg/m^3), average stand. deviation value was found ± 42.41 and ±58.91 for $PM_{2.5}$ and PM_{10} at Manikganj in 2016 (Hossain et al., 2019). Table also shows that; the highest coefficient of variation was seen in village area and the lowest was seen in mixed area for all the parameters. The whisker box plot displays in figure 3 (a), (b), (c) and (d) that the average of PM_s and CO concentrations in seven land uses. A horizontal black line within the box marks the median; the lower boundary of the box indicates the 25th percentile, the upper boundary of the box indicates the 75th percentile. The whisker represents the maximum (upper whisker) and minimum value (lower whisker) for each land use. Following whisker box plot of PMs revealed that commercial area had the highest dispersion with extreme positively skewed distribution which is contradicted to descriptive statistics where village area had shown highest variation. The higher values observed in Shahid Rofiq Road due to economic activities was the reason behind the higher dispersion in commercial area. The village area, industrial area and sensitive area had moderate distribution with normally skewed values along with one distant outlier in each; these episodes were found in Golora Jame Mosque in village area due to burning of dry leaves and biomass, Corbel International in industrial area due to industrial activities and in Government Debendronath Collage in sensitive area due to sudden vehicular movements.

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Table 1: Descriptive Statistics for PM_1, $PM_{2.5}$, PM_{10} and CO

S. N.	Land Use	No L	PM_1				$PM_{2.5}$				PM_{10}				CO			
			Range (µg/m³) (Min-max)	Mean (µg/m³)	Std. Deviation (µg/m³)	Coefficient of Variation (%)	Range (µg/m³) (Min-max)	Mean (µg/m³)	Std. Deviation (µg/m³)	Coefficient of Variation (%)	Range (µg/m³) (Min-max)	Mean (µg/m³)	Std. Deviation (µg/m³)	Coefficient of Variation (%)	Range (µg/m³) (Min-max)	Mean (µg/m³)	Std. Deviation (µg/m³)	Coefficient of Variation (%)
1.	SA	9	43.00	59.25	12.50	21.11	74.25	99.45	20.97	21.09	94.00	127.38	26.79	21.03	48	15.80	14.47	91.61
2.	MA	9	7.50	57.06	3.16	5.55	8.25	93.44	4.05	4.34	13.50	120.94	5.99	4.96	4	10.00	2.00	20.00
3.	RA	6	22.25	54.80	6.90	12.60	29.75	90.85	9.42	10.37	37.00	116.78	12.49	10.69	23	5.80	8.51	146.70
4.	RIA	5	20.50	63.97	6.13	9.58	30.75	106.81	9.39	8.79	41.50	137.19	12.49	9.10	13	10.75	4.65	43.28
5.	CA	12	71.50	76.16	26.00	34.14	129.25	125.91	46.59	37.0	159.75	164.52	57.33	34.85	55	19.38	18.51	95.53
6.	IA	9	72.25	58.55	20.93	35.75	93.00	91.75	28.02	30.54	153.50	122.48	45.63	37.25	11	4.30	4.62	107.44
7.	VA	10	86.25	63.95	26.03	40.70	142.50	105.43	42.93	40.72	183.75	136.08	55.39	40.71	18	4.40	6.67	151.59
Average				61.96	14.52	Average		101.95	23.05	Average		132.20	30.87	Average		10.06	8.49	

SA-Sensitive area, MA-Mixed area, RA-Residential area, RIA- Road Intersection Area, CA-Commercial area, IA-Industrial area, VA- Village area and NoL- Number of Locations.

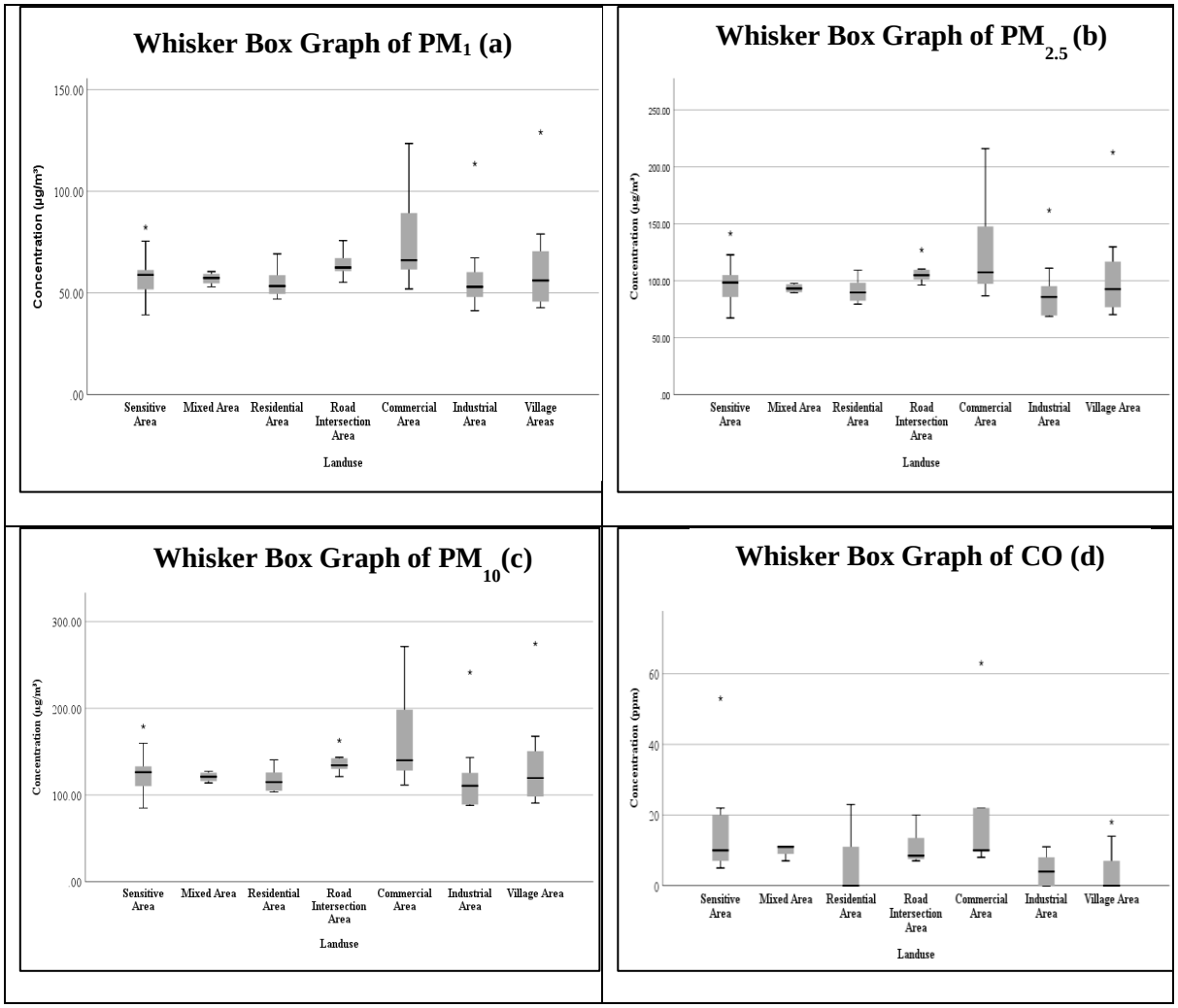

Figure 3: Whisker box plot for concentration of PM_1, $PM_{2.5}$, PM_{10} and CO in Different Land use

The residential area and road intersection area had less dispersed concentration with negative to extreme negative skewness with one outlier in road intersection area in $PM_{2.5}$ and PM_{10} whisker box due to heavy traffic. The mixed area had the least dispersed concentration with normal distribution. Whisker box plot of CO revealed that sensitive area, commercial area and residential area had higher dispersion with positive to extreme positively skewed distribution. Which is contradicting to descriptive statistics where village area had shown the highest variation. The sensitive area and commercial area had one distant outlier in each; these episodes were found in Manikganj Sorkari Mohila Collage in sensitive area due to sudden vehicular movements and Launch Ghat in commercial area due to sudden vehicular movements and economic activities.

3.3 Significance Test

Table 2 shows ANOVA for the significant test. ANOVA has been performed to find whether the changes in the concentration of all the parameters between and within land uses are significant. Here the F value of found to be 1.297 for PM_1, 1.502 for $PM_{2.5}$, 1.438 for PM_{10} and 2.879 for CO respectively. P values found for PM_1, $PM_{2.5}$, PM_{10} and CO are 0.275, 0.196, 0.218 and 0.017 respectively. The following tables revealed that the concentrations of none of the parameters change significantly except of CO as the p values are greater than 0.05. For CO it is less than 0.05. Therefore, the concentration of CO might change significantly between and within in the land uses.

Table 2: Significance Test

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
PM_1	Between Groups	2482.334	6	413.722	1.297	.275
	Within Groups	16900.769	53	318.882		
	Total	19383.103	59			
$PM_{2.5}$	Between Groups	7525.214	6	1254.202	1.502	.196
	Within Groups	44269.764	53	835.279		
	Total	51794.978	59			
PM_{10}	Between Groups	12770.534	6	2128.422	1.438	.218
	Within Groups	78422.023	53	1479.661		
	Total	91192.557	59			
CO	Between Groups	1854.658	6	309.110	2.879	.017
	Within Groups	5691.075	53	107.379		
	Total	7545.733	59			

3.4 Land Use Based Cluster Analysis

Figure 4 (a, b, c and d) shows the dendrogram plot obtained from cluster analysis in terms of PM_1, $PM_{2.5}$ and PM_{10} with Z-score normalization. For this analysis average linkage between groups has been considered. At very primary level two clusters have been found from below PMs graph. In PM_1 graph, first cluster is consisting of road intersection area and village area; second cluster consist of sensitive area, industrial area and mixed area. The residential area individually joined with the second cluster at the approximate distance of 3. This grouping joined with first cluster at the approximate distance of 5. These large grouping joined with the commercial area at the approximate distance of 25. Along with that, first cluster is consisted of residential area, industrial area and mixed area; second cluster includes road intersection area, village area, and sensitive area; and third cluster includes commercial area only. Therefore, first and second cluster joins at the approximate distance of 5 which joins with third cluster the approximate distance of 25. Consequently first cluster is consisted of road intersection area and village area, mixed area, industrial area, residential area and sensitive area; and second cluster includes commercial area only. Two clusters join at the approximate distance of 25. However, three clusters have been found from the dendrogram for CO. Where First cluster is consisted of industrial area, village area and residential area; second cluster includes mixed area and road intersection area. Third cluster consisted of sensitive area and commercial area. First cluster and second cluster joined at the approximate distance of 7 and these two large grouping joined with third cluster at the approximate distance of 25.

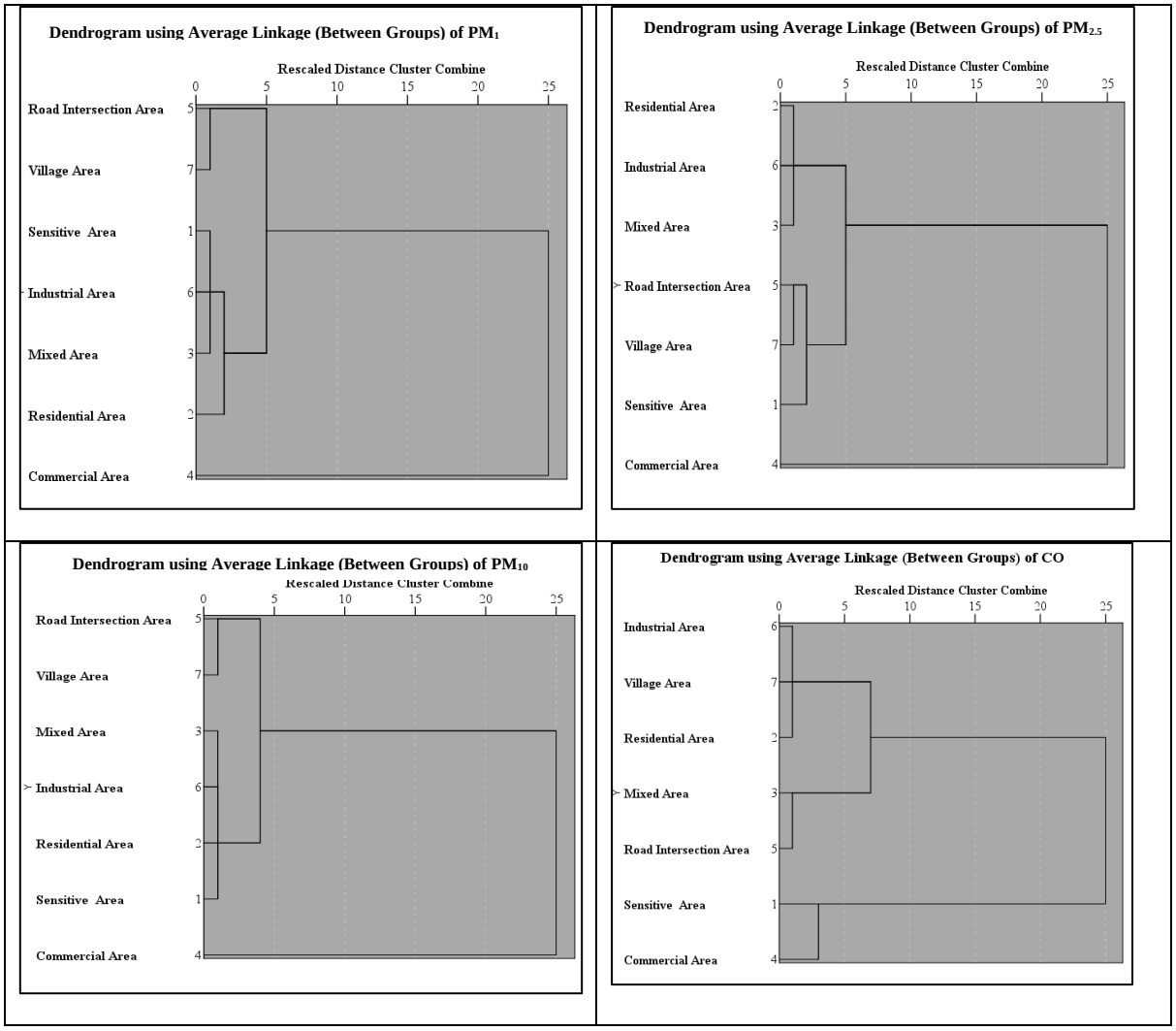

Figure 4: Land Use Based Cluster Analysis for PM_1, $PM_{2.5}$, PM_{10} and CO

3.5 Concentration Map on PM_1, $PM_{2.5}$, PM_{10} and CO

Figure 5, 6, 7, 8 show the concentration of Particulate Matter (PM_s) and CO at various location of Manikjong district town in the year of 2021. Concentrations of Particulate Matter (PM_1) are expressed in $\mu g/m^3$. The concentration of $\mu g/m^3$ means one-millionth of a gram of PM_1, $PM_{2.5}$ and PM_{10} per cubic meter of air. The maximum concentration of PM_1, PM_{10} and CO was found in outside of Golora Jame Mosque and $PM_{2.5}$ concentration map showed maximum concentration was found in Shahid Rofiq Road and the least concentration of PM_1 was found in Middle Golora area and $PM_{2.5}$ and PM_{10} was found in font of Govt. Debendronath Collage and minimum concentration of CO was found in near to Launch Ghat.

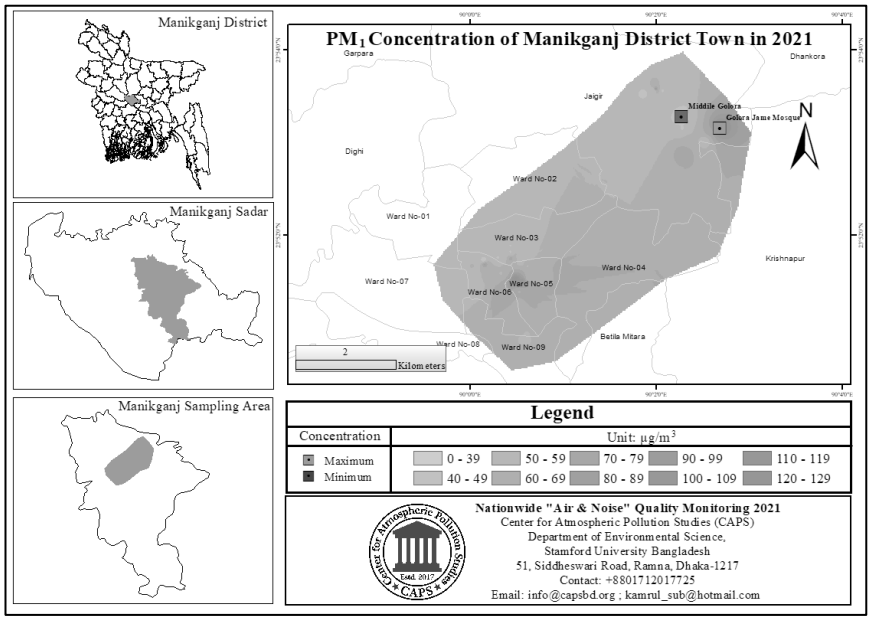

Figure 5: PM_1 Concentration of Manikgonj District Town in 2021

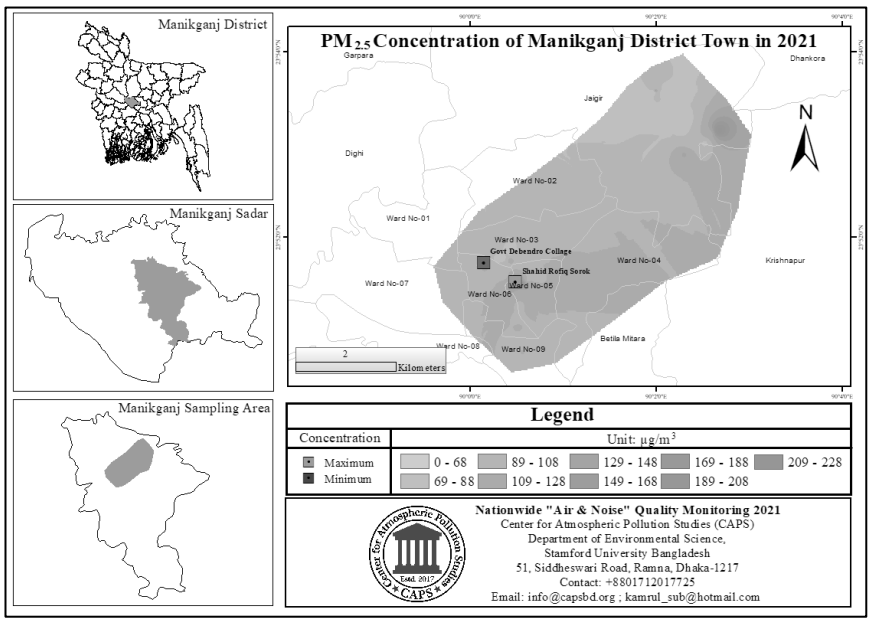

Figure 6: $PM_{2.5}$ Concentration Map of Manikgonj District Town in 2021

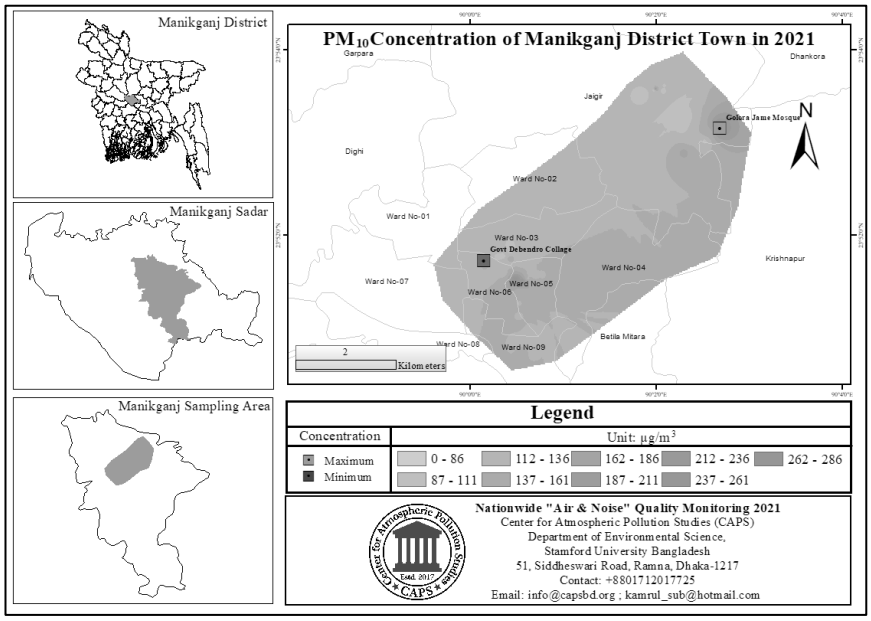

Figure 7: PM_{10} Concentration Map of Manikgonj District Town in 2021

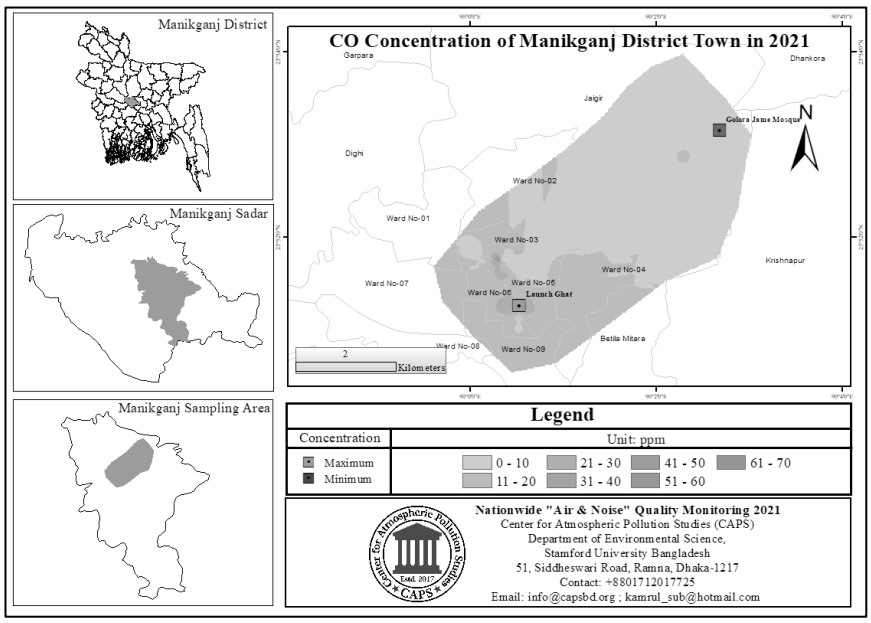

Figure 8: CO Concentration Map of Manikgonj District Town in 2021

3.7 AQI on $PM_{2.5}$ Concentration of Manikgonj District Town in 2021

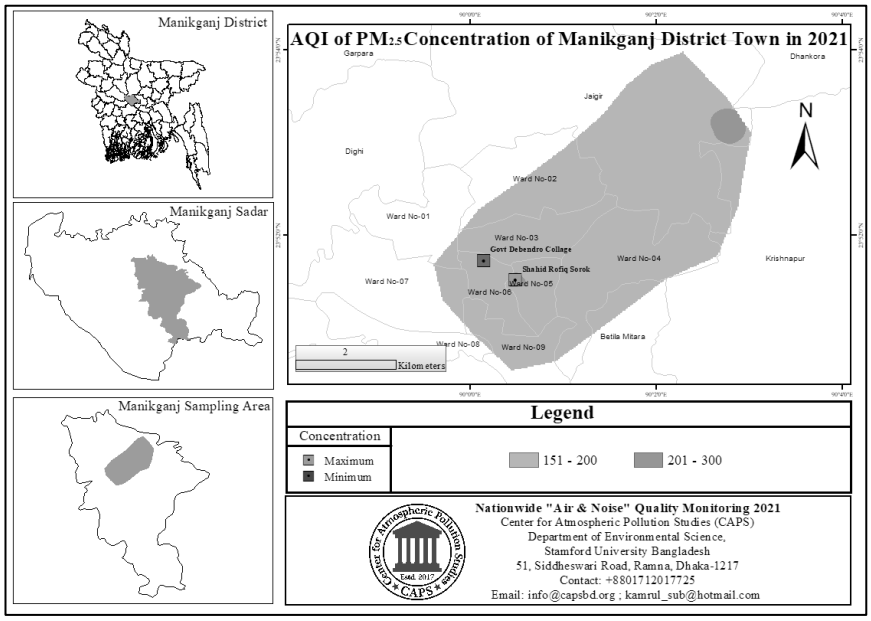

Figure 17: AQI on $PM_{2.5}$ Concentration Map of Manikgonj District Town in 2021

Figure 17 Shows the Manikgonj district town based on $PM_{2.5}$. In this map, different colors represent the category of AQI according to Bangladesh National Ambient Air Pollution Standard. The map shows that AQI (201-300) was very unhealthy condition and also shows that, the whole sample area was around the AQI was (151-200). The maximum concentration shows with red flag and minimum concentration with green flag. The maximum concentration was found in Shahid Rofiq Road and the least concentration was found outside of Government Debendronath Collage.

4.Conclusion

Study found that the average concentration of PM_1, $PM_{2.5}$ and PM_{10} of60 places in Manikgonj district town were 61.96, 101.95 and 132.19µg/m^3 respectively. From the outcome of this research the studied land uses are arranged in descending order based on average concentration $PM_{2.5}$ which follows as commercial area (125.91µg/m^3)> road intersection area (106.81 µg/m^3)> village area (105.43 µg/m^3)> sensitive area (99.45µg/m^3)>mixed area (93.44 µg/m^3)> industrial area (91.75µg/m^3)> residential area (90.85 µg/m^3). The Concentration of $PM_{2.5}$ (212.75µg/m^3) of different land use was found to be very high which was nearly 3.27 times higher than the standard level. The National Air Quality Standard (Daily) set by the Department of Environment (DoE) for $PM_{2.5}$ is 65 µg/m^3. On, the basis of $PM_{1.0}$, $PM_{2.5}$ and PM_{10} dispersion among all those land uses the maximum range was found in village area followed by commercial area while minimum was found in mixed area. Std. deviation and coefficient of variation of PMs and CO among all those land uses was found higher in commercial area and village area followed by least in mixed area. Moreover, whisker box graph of PM_1, $PM_{2.5}$ and PM_{10}revealed that commercial area had the highest dispersion with extreme positively skewed distribution.

4.1 Recommendations

It is impossible to completely eradicate air pollution. Because it is created naturally and at a time when all types of cars use diesel and gasoline. The continuous development of motor transportation is linked to the need to lessen its negative environmental impact. The authorities should have started cleaning up the city sooner. People should also be concerned about air pollution, which can help to limit the number of pollutants in our daily lives. For personal protection from corrosion using improved quality, masks could be a temporary solution for the individual. To reduce air pollution, the coordination of governmental bodies is mandatory. Encouraging people for Rooftop Gardening in the area, May, help to improve the air quality. The number of surface water bodies should be increased in the nearness of the area. The Clean Air Act-2019 needs to be implemented as soon as possible. The annual budget

allocation of the Ministry of Environment needs to be increased to create environmental protection and awareness.

4.2 Limitation of the Study

- Need more locations data for better understanding of data.
- Need more scattered data of each Location.
- Need weekly or monthly data then we will do specific and more detailed research.
- Need more locations for specific land use.

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