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Particulate Matter Concentration in Ambient Air at Gulshan e Iqbal, Karachi

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ABSTRACT

The aim of this study is to measure the PM concentration ($PM_{2.5}$, PM_{10}) at different times and at different locations of the Gulshan-e-Iqbal town and comparison of the obtained results with the permissible limits of Pak-EPA for assessment of the air quality. A total of 12 sampling locations were selected in different blocks of Gulshan-e-Iqbal town. The PM 2.5 concentration in the study area ranged from 47 to 81.3 µg/m^3, with a mean value of 65.4 µg/m^3. The results revealed that values of PM2.5 at all the sampling stations were above the permissible limits (35 µg/m^3) set by Environmental Protection Agency Pakistan (Pak-EPA). The PM 10 concentration in the study area ranged from 55.6 to 99.0 µg/m^3, with a mean value of 79.9 µg/m^3. The results revealed that values of PM10 at all the sampling stations were within the permissible limits (150 µg/m^3) set by Environmental Protection Agency Pakistan (Pak-EPA). The concentration of PM ($PM_{2.5}$, PM_{10}) was found to vary with time at all the sampling stations. Maximum concentrations were recorded at 2 PM and 7 PM while minimum concentrations were recorded at 12 AM. The worst air quality in terms of particulate matter concentration in the study area was observed at Block 11 of Gulshan-e-Iqbal, whereas better air quality in terms of PM was recorded at Block 7.

Key Words: Air Quality, Particulate Matter, PM2.5, PM10, Gulshan-e-Iqbal Town, Karachi

1. INTRODUCTION

Karachi also known as the city of lights is the largest city of Pakistan in terms of area. It is also the most populous city of the country having an estimated population of about in 2020 of 16 million with annual population growth rate of 4.5 percent (Hasan et. al, 2016). A United Nations report suggests that the population of Karachi will nearly double i.e., become 23 million in the time span of 15 years from now(Desa et. al, 2018).The city accommodates 1.81 million vehicles and has a huge network of roads, having a total length of about 9500 km. In addition to that the number of vehicles in the city is constantly increasing on monthly basis by a figure of 16,562 (Qureshi et. al, 2007).

Due to its significant health impacts, the air quality has been receiving attention by the scientific community and is considered as the most serious environmental issue in both the developed and developing nations of the world. Air quality is a serious issue in the urban areas of the world (IAQP, 2010).The increasing population and industrialization in the urban areas has caused a significant rise in air pollution emissions(Reddy et. al, 2004, Khandelwal et. al, 2018). The human health and quality of life is worsened by these high emissions of air pollutants (Tandon et. al, 2008). Resultantly, the disorders of pulmonary functions, cardiovascular disease, neurobehavioral effects, and mortality arise due to the high level of air pollutants in urban areas (Gupta et. al, 1999).

Air pollutants can be categorized into two major categories i.e. gaseous air pollutants and particulate matter. The mixture of both solid and liquid droplets present in air are collectively called as particulate matter (PM) (Cheng et. al, 2000, Tucker et. al, 2000). Density and size of particles also help to characterize the category of airborne fine particulate matter. They can travel to long distances in the atmosphere and generally have long residence time in the atmosphere (CEPA, 1999). The increasing concentration of particulate matter in the air is the major contributor of air pollution in Karachi city. The main reason of this air pollution is the increasing traffic and over population in the city (Hashmi et. al, 2018).

Out of all the sources of air pollution, the vehicular emissions are the most detrimental to the air quality due its associated health impacts, as they are ground-level sources of air pollution and have the maximum impact on the general population (Ali et. al, 2010). Studies have shown increase in morbidity and mortality due to PM exposure. The World Health Organization estimates that PM 2.5 concentration contributes to approximately 800,000 premature deaths per year, ranking it the 13th leading cause of mortality worldwide (Mutangadura et. al, 2004).

Anjum et.al. in his study investigated the particulate matter concentration in Lahore City. The average PM 2.5

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concentrations were recorded as 118 µg/m3. The study revealed that there are five main sources of particulate matter in the, which include diesel combustion, industrial emissions, biomass burning, two-stroke vehicles and coal combustion (Rasheed et. al, 2015).

Alam Khan et.al. in his study investigated the particulate matter concentration in Peshawar City. The author has reported that the PM 10 and PM 2.5 concentrations in the ambient air was increasing with the passage of time due to increasing rates of industrialization and urbanization in the city. The average PM 2.5 and PM 10 concentrations were recorded as 172 µg/m3 and 480 µg/m3 respectively. The study revealed that there are five main sources of particulate matter in the, which include, vehicular emissions, household combustion emissions, industrial emissions, resuspended soil/road dust and brick kiln emission (Alam et. al, 2015).

For this research study the study area has been selected as Gulshan-e-Iqbal town, which is one of the largest towns of Karachi city. It is bordered by Gadap town, Faial and Malir cantonments, Jamshed town, Gulberg and Liaqatabad to its North, east, southwest, and west respectively. According to the 1998 census the population of Gulshan Town was estimated to be about 6, 50,000, and the recent population of Gulshan Town is estimated to be nearly one million (Hussain et. al, 2016). The main objective of this study is to ascertain the change of the air quality in terms of particulate material at different points in Gulshan-e-Iqbal town. The details of the study include the measurements of these PM particles that were carried out at different times and at different locations of the city after which the obtained results were evaluated and assessed. Mental issue in both the developed and developing nations of the world. Air quality is a serious issue in the urban areas of the world(IAQP, 2010). The increasing population and industrialization in the urban areas has caused a significant rise in air pollution emissions (Reddy et. al, 2004, Khandelwal et. al, 2018). The human health and quality of life is worsened by these high emissions of air pollutants (Tandon et. al, 2008). Resultantly, the disorders of pulmonary functions, cardiovascular disease, neurobehavioral effects, and mortality arise due to the high level of air pollutants in urban areas (Gupta et. al, 1999).

2. MATERIALS AND METHODS

2.1 Study Area

This research study is focused on the air quality of the Gulshan-e-Iqbal town of Karachi. It is mainly a residential neighborhood located in the East district of Karachi having residents belonging to mainly the middle to upper middle-class residents. The town is bordered by Gadap Town towards its north, the Faisal and Malir Cantonments towards its east, Jamshed Town towards its southwest and Gulberg town and Liaquatabad towards its west. The geographical coordinates of this town are 24°55’38” N and 66°05’21” E respectively. This town with population exceeding 0.85 million people (as reported in 2017) is an important part of the largest metropolitan city of Pakistan (Karachi).

Figure 1: Map showing location of Study Area (Gulshan-e-Iqbal Town)

2.2 Air Monitoring Locations

Gulshan-e-Iqbal town is divided into 19 blocks by the town administration. For the purpose of this research, the total twelve sampling sites were selected. These sampling sites are in different vicinity blocks of Gulshan e Iqbal town namely blocks 1to 13 respectively. Locations of sampling stations are provided in figure 2.1 and table 2.1 given below.

Table 1: Locations of Sample Collection Sites

Sampling Station #	Location	GPS Coordinates	
		Northing	Easting
1	Block 1	24°55'11.2"	67°05'07.6"
2	Block 2	24°55'16.2"	67°05'13.8"
3	Block 3	24°55'38.6"	67°05'21.3"
4	Block 4	24°55'59.8"	67°06'10.0"
5	Block 5	24°54'59.4"	67°05'42.4"
6	Block 6	24°55'32.1"	67°06'24.9"
7	Block 7	24°55'32.1"	67°06'24.9"
8	Block 8	24°54'46.1"	67°05'26.0"
9	Block 9	24°54'38.1"	67°05'14.0"
10	Block 10	24.914347	67.101371
11	Block 11	24°54'42.9"	67°06'17.8"
12	Block 13	24°55'09.6"	67°05'05.6"

Figure 2: Map of Sample Collection Sites

2.3 Air Monitoring Instrument and Method

The Particulate matter monitoring was done by using instruments and following standard method for air monitoring of particulate matter. The air monitoring was performed on regular days of the week (from Monday to Thursday) with daily time duration of 15 hrs. (from 9 am to 12 am). The high-volume air samplers with glass filters (203× 254 mm) was used to collect the air samples. The high-volume air sampler is considered as a reliable for measuring the concentration of PM10 in ambient air. Accordingly, the high-volume air sampler was used for sampling particulate matter in ambient air. These samples were collected at a height of about 10 meters above ground level.

3. RESULTS AND DISCUSSION

3.1 Spatial Variability of Ambient PM 2.5 Concentration in the Study Area

The concentration of $PM_{2.5}$ as measured at the different sampling locations are provided in table 3.2 given below. The value of this air quality parameter ranged between 47 and 81.3 µg/m^3, and the average concentration was recorded as 65.4 µg/m^3. Minimum concentration was observed in block 7 of Gulshan-e-Iqbal town, whereas maximum concentration was observed in block 11 of the same town. Elevated concentration of PM 2.5 in block 11 sampling site can be attributed to the fact that this particular locality is located near a very busy road that leads from NIPA flyover to Rashid Minhas Road. Relatively concentration of PM 2.5 in block 7 sampling site can be attributed to the fact that this particular block of Gulshan-e-Iqbal is mostly a residential locality with minimal vehicular movement. The results revealed that values of PM2.5 at all the sampling stations were above the permissible limits (35 µg/m^3) set by Environmental Protection Agency Pakistan (Pak-EPA).

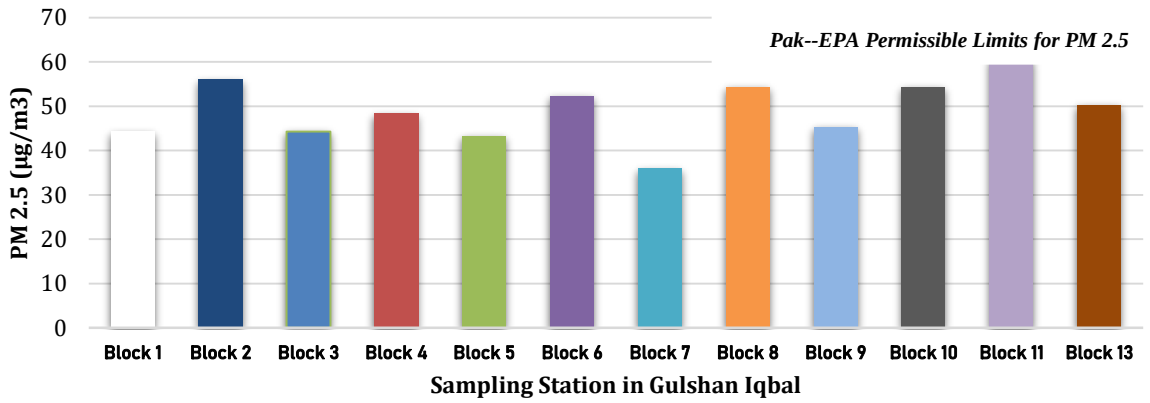

Figure 3: Mean concentration of PM2.5 at all the sampling stations

3.2 Spatial Variability of Ambient PM 10 Concentration in the Study Area

The concentration of $PM_{2.5}$ as measured at the different sampling locations are provided in table 3.2 given below. The value of this air quality parameter ranged between 55.6 and 99.0 µg/m^3, and the average concentration was recorded as 79.9 µg/m^3. Minimum concentration was observed in block 7 of Gulshan-e-Iqbal town, whereas maximum concentration was observed in block 11 of the same town. Elevated concentration of PM 2.5 in block 11 sampling site can be attributed to the fact that this particular locality is located near a very busy road that leads from NIPA flyover to Rashid Minhas Road. Relatively concentration of PM 2.5 in block 7 sampling site can be attributed to the fact that this particular block of Gulshan-e-Iqbal is mostly a residential locality with very minimal vehicular movement. The results revealed that values of PM10 at all the sampling stations were within the permissible limits (150 µg/m^3) set by Environmental Protection Agency Pakistan (Pak-EPA).

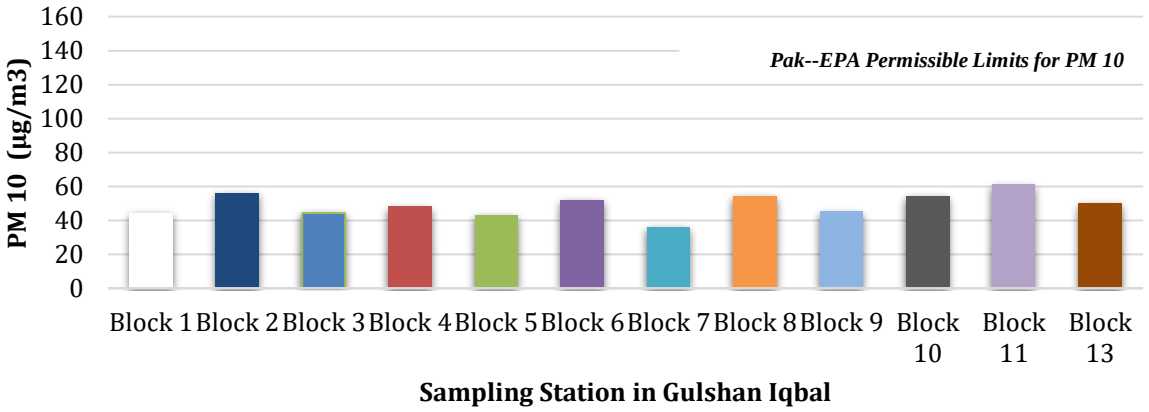

Figure 4: Mean concentration of PM2.5 at all the sampling stations

3.3 Temporal Variability of Ambient PM 2.5 Concentration in the Study Area

The most prominent feature of the temporal variation of ambient concentration of PM 2.5 is that there is a variation in the concentration of PM 2.5 with change in timings at the sampling locations. Highest mass concentrations of PM 2.5 were recorded at 2 PM and 7 PM, which also coincide with the peak traffic periods in Gulshan-e-Iqbal town. Lowest mass concentrations of PM2.5 were recorded at 12 AM, which coincide with the light traffic in Gulshan-e-Iqbal town during these timings. A strong correlation between the concentration of PM 2.5 in the ambient air and the no. of vehicles at the sampling locations was observed as shown in figure given below:

Table 2: Temporal variation in the concentration of PM2.5 at all the sampling stations

Sampling Station	Location	Concentration of PM $_{2.5}$ (µg/m^3)				No. of Vehicles per hour at Sampling Site			
		9 AM	2 PM	7 PM	12 AM	9 AM	2 PM	7 PM	12 AM
1	Block 1	77	92	88	18	220	380	350	44
2	Block 2	97	100	109	15	325	400	52	425
3	Block 3	54	102	99	19	280	420	450	64
4	Block 4	62	90	110	26	300	430	480	80
5	Block 5	50	90	84	19	274	400	420	74
6	Block 6	62	96	105	15	180	380	550	54
7	Block 7	54	89	70	17	174	350	325	64
8	Block 8	78	99	120	35	270	370	440	160
9	Block 9	88	91	101	37	274	390	444	150
10	Block 10	72	86	110	57	320	400	524	210
11	Block 11	96	80	105	43	320	360	524	210
12	Block 13	70	105	71	23	294	450	470	84
Mean		72	93	98	27	269	394	419	135

3.4 Temporal Variability of Ambient PM 10 Concentration in the Study Area

The most prominent feature of the temporal variation of ambient concentration of particulate matter is that there is a variation in the concentration of PM 10 with change in timings at the sampling locations. Highest mass concentrations of PM 1.0 were recorded at 2 PM and 7 PM, which also coincide with the peak traffic periods in Gulshan-e-Iqbal town. Lowest mass concentrations of PM10 was recorded at 12 AM, which coincide with the light traffic in Gulshan-e-Iqbal town during these timings. A strong correlation between the concentration of PM 10 in the ambient air and the no. of vehicles at the sampling locations was observed

Table 3: Temporal variation in the concentration of PM10 at all the sampling stations

Sampling Stations	Location	Concentration of PM $_{10}$ (µg/m^3)				No. of Vehicles per hour at Sampling Site			
		9 AM	2 PM	7 PM	12 AM	9 AM	2 PM	7 PM	12 AM
1	Block 1	89	106	102	20	220	380	350	44
2	Block 2	112	110	122	17	325	400	52	425
3	Block 3	62	150	126	22	280	420	450	64
4	Block 4	74	122	165	30	300	430	480	80
5	Block 5	70	105	110	22	274	400	420	74
6	Block 6	70	166	144	17	180	380	550	54
7	Block 7	60	123	88	19	174	350	325	64
8	Block 8	109	113	146	39	270	370	440	160
9	Block 9	98	100	116	41	274	390	444	150
10	Block 10	84	103	118	66	320	400	524	210
11	Block 11	112	88	136	49	320	360	524	210
12	Block 13	90	160	108	26	294	450	470	84
Mean		86	121	123	31	269	394	419	135
SEQs						-	-	-	-

4. CONCLUSIONS

From the results of this study it can be concluded that concentration of particulate matter (PM2.5, PM10) varied with time and location in the study area. The PM 2.5 concentration in the study area ranged from 47 to 81.3 $\mu g/m^3$, with a mean value of 65.4 $\mu g/m^3$. The results revealed that values of PM2.5 at all the sampling stations were above the permissible limits (35 $\mu g/m^3$) set by Environmental Protection Agency Pakistan (Pak-EPA). The PM 10 concentration in the study area ranged from 55.6 to 99.0 $\mu g/m^3$, with a mean value of 79.9 $\mu g/m^3$. The results revealed that values of PM10 at all the sampling stations were within the permissible limits (150 $\mu g/m^3$) set by Environmental Protection Agency Pakistan (Pak-EPA). The concentration of all the three measured types of particulate matter (PM2.5, PM10) peaked at block 11 of Gulshan-e-Iqbal, lowest concentration of PM was observed at Block 7 of Gulshan-Iqbal town. The concentration of all the three measured types of particulate matter (PM2.5, PM10) was also found to vary with time at all the sampling stations with PM concentrations peaking in the afternoon (2 PM) and the evening and lowest concentration of PM was observed at 12 AM.

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