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Ambient Air Quality Assessment in Karachi, Sindh Pakistan

Muhammad Idress,[1] Yasmin Nergis,[1*] Jawad Abdullah Butt,[2]Mughal Sharif[2]

[1]Department of Earth and Environmental Science, Bahria University Karachi Campus, Pakistan
[2]Environmental Research Center, Bahria University Karachi Campus, Pakistan

*Email: nergisyasmin.bukc@bahria.edu.pk

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Abstract: Pakistan's urban air pollution is amongst the utmost severity in the world that causes acute damage to the economy and human health. This study was designed for the assessment of ambient air quality in different areas of Karachi. The data were collected as pre-monsoon and post-monsoon season from main industrial zones of Karachi, S.I.T.E area, North Karachi industrial area, Korangi industrial area and Landhi industrial area in the year of 2017-2019. These zones are also a blend of industrial, residential, commercial and heavy traffic zones with dense populations. Ambient air data were collected for different pollutants like Nitrogen Oxides (NOx), Carbon Monoxide (CO), Sulfur Dioxide (SO_2) and Particulate Matters (TSPM, PM_{10} and $PM_{2.5}$). It is observed that in pre-monsoon, there is quite high intensity of particulate matter (TSPM, PM_{10} & $PM_{2.5}$) present in the air, whereas CO and NO_2 values found in all four zones are moderate in the air samples as prescribed by Sindh Environmental Protection Agency (SEPA) standards. It is observed specifically in Landhi, S.I.T.E Area and Korangi industrial area which are more prone to the exposure of these pollutants. In post-monsoon, the intensity of particulate matters (TSPM, PM_{10} & $PM_{2.5}$), CO and NO_2 values in all four zones are less to moderate than the values of pre-monsoon due to the seasonal effects. Study data shows that three major zones; Landhi, Korangi and S.I.T.E. industrial areas are at a high exposure to gases and other toxic elements. North Karachi is at the least risk because of having a small scale of industries present. The PM_{10} & $PM_{2.5}$ levels average about 2 - 3-fold greater than the SEPA standards. High levels of ambient air pollutants cause severe health problems and chronic diseases on human health. Therefore the implementation of rules and regulations regarding ambient air pollutants should be more rigorous. .

Keywords: Urban air quality, Karachi city, pollutants, industrial area.

Introduction

Air Pollution is the most critical global challenge with a significant impact on food production, water supply, health, etc being faced by humanity. The disastrous impact of air pollution is already being felt around the globe in the form of weather extremes, floods, cyclones, droughts, etc. (IPCC Report, 2007).

Air pollution is one of the emerging environmental risk factors, with devastating environmental, deteriorating health and adverse economic impacts on society. Since decades, Asian countries have experienced extensive growth in urbanization and development together with motorization and a rise in energy usage. A significant increase is seen in the forms and quantity of emission sources of air pollutants in the constituency (Gurjar et al. 2008). Extreme trade movement, growing population and exceptional increase in vehicle usage are the major reasons of spartan environmental influence in the constituency (Hopke et al. 2008). As a product, air pollution has emerged as an intense hazard to the environment, negatively impacting the health of the populace and environmental quality of South Asia specifically where pollution control technology and approaches are not continually being accurately made or accepted (Ian et al., 2009).

Pakistan's urban air pollution is amongst the desolate problems in the world and it causes major impairment to the economy and human health. Karachi, the city of Pakistan, is the twelfth-largest populated city in the world (Wikipedia, 2021). It is the capital of the Pakistani province of Sindh. Karachi is the most growing city in the world with an estimated population in 2021 at 16,459,472 (World Population Review, 2021) located at 24°51′36″ North and 67°0′36″ East, situated at an elevation of 38 meters above sea level (Wikipedia, 2021). This city is a subtropical coastal lowland area. Its terrestrial position is not advantageous to obtain even enough seasonal monsoonal rain. In summer, the mean maximum is 38°C while winter's mean daily temperature is 23°C in the year 2020 (FFD, 2020).

Karachi has a greater and diverse economy. It is the industrial hub of a wide range of industries in different areas of the city such as Korangi Industrial & Trade Estate, Sindh Industrial & Trading Estate (SITE), North Karachi Industrial & Trade Estate, FB Area, Port Qasim, etc. (Zehra et al. 2009). The overall trend of industries in the country contributes further towards polluting the environment. Due to the spread of industrial zones in the rural area as well as in the far and near vicinity of cities, the problem of air pollution is penetrating the clean and healthy rural zones, thus degrading the environment (Manisalidis et al. 2020). On the other hand, the burning of solid and municipal waste also causes a great threat to both environment and humans (Mustafa Z., 2011).

This study focuses on emissions of CO, NO2, SO2 and Particulate Matters (TSPM, PM10, PM2.5) in the main four industrial zones of Karachi city, emphasizing degenerating air quality because of unswerving

detrimental emissions, its unfavorable impact on climate change and precautionary measures that should be taken by the authorities to minimize the adverse effects on humans and environment in the major Industrial Zones in Karachi (JICA Report, 2012).

Sindh Industrial Trading Estates (SITE): There are more than 2000 industrial units on 4500 acres (1800 ha) of land west of the Lyari River. Main industries include textile, steel, pharmaceutical, automobile, chemical, engineering, beverage and flour mills. The town grew as worker colonies were established around the industrial estate.

Korangi Industrial Area: It is spread over an area of 8500 acres. Korangi Industrial Area houses provide approximately 3000 facilities for various industries including textile, steel, pharmaceutical, automobile, chemical, engineering, food and flour mills, etc.

Landhi Industrial Area: It comprises about 11,000 acres (4,500 ha) of land and consists of medium and large size industries. The industrial area housing has many industries including textile, steel, pharmaceutical, automobile, chemical, engineering and flour mills, etc.

North Karachi Industrial Area: It came into existence in 1974. It is scattered over an area of 725 acres with more than 2000 commercial, industrial and service units containing automobile, textile, engineering and food, etc.

Material and Methods

Ambient air data was collected from four major industrial zones of Karachi city that was further subdivided into 24 geographical locations (Fig. 1). These zones include Sindh Industrial and Trading Estate area (S.I.T.E), North Karachi Industrial Area, Korangi Industrial Area and Landhi Industrial Area (Table 1 and Fig. 2). In these areas, small and large industries are available in bulk without any consideration of residential and industrial zones (Table 1). These industries are mostly textile, chemical, pharmaceutical, glass, plastic and food products etc. The pollutants were analyzed for Nitrogen Oxides (NOx), Carbon Monoxide (CO), Sulfur Dioxide (SO_2), Particulate Matters (TSPM, PM_{10} and $PM_{2.5}$). For data collection, a random sampling technique was used by the mentioned site areas, visited mostly at peak working hours (0800-1800hrs). The samples were collected by visiting the sites at random time slots and days on a seasonal basis i.e. pre-monsoon (May to June) and post-monsoon (October to November) season for three years (2017-2019). The apparatus used for the collection of data is HAZ- SCANNER (Model: HIM-6000) the USA, which is a complete air monitoring station. The Haz-Scanner measures and documents trace level (ppb) gases and particulates parameters in real-time calibration. Haz-Scanner provides direct readings in real-time with data logging capabilities.

Haz-Scanner can be configured to provide up to 12 simultaneous critical air measurements with true simultaneous PM-2.5, PM-10 and TSP readings in one easily portable battery-operated instrument. Particulate reading was recorded with Infra-Red Light Scattering method and toxic Gases with Electrochemical sensor.

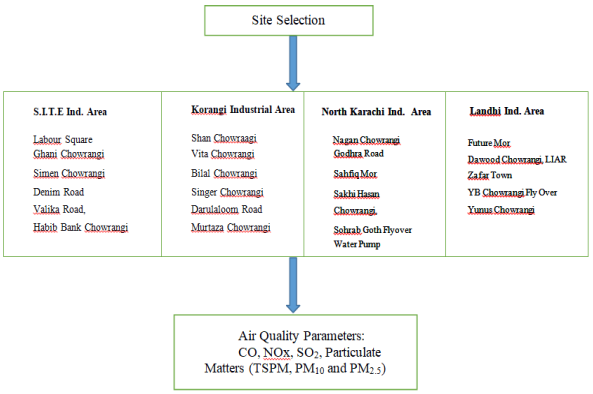

Fig. 1 Industrial Zones, Sampling Areas and Parameters.

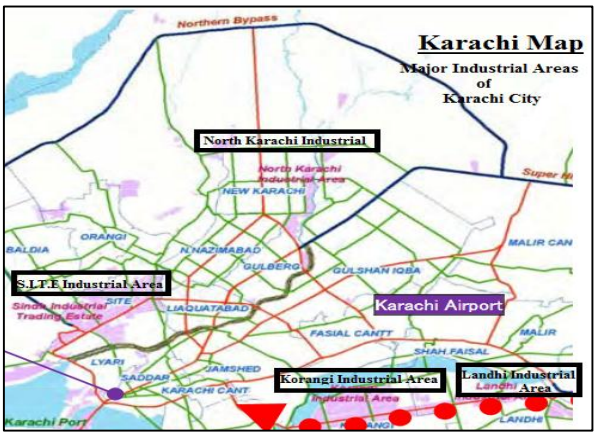

Fig. 2 Study area map.

Results and Discussion

Escalation of pollution due to industrial activity is one of the main sources of air quality deterioration. It has not been conceivable to evaluate the enormousness of industrial air contamination since industrial releases have considerably spread over the previous years. Ambient Air data collected were compared with available Sindh Environmental Quality Standards (SEQS) guidelines.

Mean Ambient Air Data Pre-Monsoon (2017-2019)

Table 2. S.I.T.E Area Data.

Sampling Site	Parameters (µg/m³)					
	CO	NO_2	SO_2	TSPM	PM_{10}	$PM_{2.5}$
SEQS	10 (mg/ m³)	80	120	500	150	75
Habib Bank Chorangi	1.12	35	25	394	168	92
Siemen Chorangi	1.91	40	28	580	192	101
Ghani Chorangi	1.61	42	43	340	155	83
Valika Road	2.26	47	37	572	178	96
Labour Square	2.13	52	32	417	160	89
Denim Road	2.38	55	36	317	149	83

Table 3 Korangi industrial area data.

Sampling Site	Parameters (µg/m³)					
	CO	NO_2	SO_2	TSPM	PM_{10}	$PM_{2.5}$
SEQS	10 (mg/ m³)	80	120	500	150	75
Bilal Chorangi	0.35	51	30	386	187	97
Vita Chorangi	0.98	30	24	324	148	81
Singer Chorangi	1.85	27	38	567	201	117
Murtaza Chorangi	2.12	38	24	745	409	238
Darulaloom Road	0.52	22	26	367	136	64
Shan Chorangi	0.77	42	35	288	138	67

Table 4 North Karachi industrial area data.

Sampling Site	Parameters (µg/m³)					
	CO	NO_2	SO_2	TSPM	PM_{10}	$PM_{2.5}$
SEQS	10 (mg/ m³)	80	120	500	150	75
Nagan Chorangi	0.61	64	51	648	292	173
Sohrab Goth	2.89	73	42	607	281	166
Shafiq Morr	1.19	23	31	468	148	73
Godhra Road	3.98	32	30	311	145	72
Sakhi Hassan Chorangi	2.83	22	23	273	129	67
Water pump Chorangi	0.29	22	25	317	137	55

Table 5 Landhi industrial area data.

Sampling Site	Parameters (µg/m³)					
	CO	NO_2	SO_2	TSPM	PM_{10}	$PM_{2.5}$
SEQS	10 (mg/ m³)	80	120	500	150	75
Yunus Chorangi	3.58	69	39	656	371	198
Dawood Chorangi	2.12	49	37	762	329	197
LIAR	0.29	32	26	376	194	93
YB Chorangi FLY	0.92	58	42	294	148	67
Zafar Town	0.59	76	34	262	129	63
Future Morr	1.99	42	39	407	173	98

Mean ambient air data post-monsoon (2017-2019)

Table 6. S.I.T.E area data.

Sampling Site	Parameters (µg/m³)					
	CO	NO_2	SO_2	TSPM	PM_{10}	$PM_{2.5}$
SEQS	10 (mg/ m³)	80	120	500	150	75
Habib Bank Chorangi	1.77	30	29	298	144	67
Siemen Chorangi	1.21	36	24	514	162	78
Ghani Chorangi	1.07	32	35	531	187	85
Valika Road	0.99	28	22	259	142	69
Labour Square	1.14	40	26	260	128	51
Denim Road	1.01	29	28	228	107	42

Table 7. Korangi industrial area data.

In pre-monsoon, Table 2 to 5 show very high mean values of particulate matter (TSPM, PM_{10} & $PM_{2.5}$) in all four industrial zones such as Sohrab Goth, Godhra Road, Yunus Chorangi, Denim Road, Labour square, Bilal Chorangi and Mutraza Chorangi. Carbon Monoxide (CO), Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2) values are found at reasonable levels in all locations such as Labour Square, Denim Road, Yunus & Dawood Chorangi, Mutraza Chorangi and Sohrab Goth.

Sampling Site	Parameters (µg/m³)					
	CO	NO_2	SO_2	TSPM	PM_{10}	$PM_{2.5}$
SEQS	10 (mg/ m³)	80	120	500	150	75
Bilal Chorangi	0.30	42	25	272	133	59
Vita Chorangi	2.58	35	23	297	131	70
Singer Chorangi	2.94	46	29	228	113	54
Murtaza Chorangi	3.76	53	37	514	197	92
Darulaloom Road	1.94	42	31	219	103	41
Shan Chorangi	2.34	38	23	201	104	32

Table 8. North Karachi industrial area data.

Sampling Site	Parameters (µg/m³)					
	CO	NO_2	SO_2	TSPM	PM_{10}	$PM_{2.5}$
SEQS	10 (mg/ m³)	80	120	500	150	75
Nagan Chorangi	0.41	41	30	431	145	70
Sohrab Goth	1.27	49	26	532	171	95
Shafiq Morr	0.97	36	20	210	102	56
Godhra Road	2.11	52	25	212	118	49
Sakhi Hassan Chorangi	2.65	25	28	202	112	38
Water Pump Chorangi	0.27	29	19	236	114	32

Table 9. Landhi industrial area data.

Sampling Site	Parameters (µg/m³)					
	CO	NO_2	SO_2	TSPM	PM_{10}	$PM_{2.5}$
SEQS	10 (mg/ m³)	80	120	500	150	75
Yunus Chorangi	2.90	60	35	569	212	131
Dawood Chorangi	1.61	36	30	599	226	148
LIAR	0.82	27	21	256	135	63
YB Chorangi FLY	0.51	30	28	209	117	42
Zafar Town	0.77	47	25	237	115	48
Future Morr	1.70	53	31	357	146	66

In post-monsoon, Table 6 to 9 show moderate to some high mean values of particulate matter (TSPM, PM_{10} & $PM_{2.5}$) in all four industrial zones such as Ghani Chorangi, Yunus and Dawood Chorngi, Murtaza Chorangi, Nagan Chorangi and Sohrab Goth. Carbon Monoxide (CO), Nitrogen Oxide (NO_2) and Sulphur Dioxide (SO_2) were found at less to moderate level in different locations such as Yunus Chorngi, Dawood Chorngi, Singer Chorngi, Murtaza Chorangi and Sohrab Goth.

It is observed that there is a high intensity of particulate matter PM_{10} & $PM_{2.5}$ present in the air samples of all locations which are not as prescribed by Sindh Environmental Protection Agency (SEPA) standards 150 and 75 µg/m3 for PM_{10} & $PM_{2.5}$, specifically in Landhi, S.I.T.E Area and Korangi industrial areas which are more prone to the exposure of these pollutants. High variations of PM_{10} & $PM_{2.5}$ in all zones are due to industrial and traffic factors contributing to the

increasing pollution. Higher values of particulate matter (PM_{10} & $PM_{2.5)}$ have spatial bonding with open areas in nearby industrial activities that attract heavy traffic for transporting raw materials and manufactured products.

In the pre-monsoon season, the intensity of particulate matter (TSPM, PM_{10} & $PM_{2.5}$) values in all four zones are too high, whereas some even exceed the standard limits provided by SEPA. CO and NO_2 values are found at a moderate level that contributes to polluting the environment. In post-monsoon, the intensity of particulate matters (TSPM, PM_{10} & $PM_{2.5}$), CO and NO_2 values in all four zones are less to moderate than the values of pre-monsoon due to the seasonal monsoon effects.

Besides natural processes, NO2 is formed when combustion occurs at a very high temperature. Nitrogen dioxide was found in all four zones because of fuel combustion in nearby industries. It enters the atmosphere in approximately equal amounts from auto-emissions and power plants (Nadakavukaren, 1990). The presence of nitrogen dioxide is highlighted, which is not only negatively affecting the human respiratory system but also promoting photochemical pollution such as surface ozone (O_3). Nonetheless, in Karachi, prevalent bronchitis and eye diseases are common because of the presence of NO2 in the atmosphere (Mudassar et al., 2012).

From the above analysis, it is determined that S.I.T.E, Korangi and Landhi industrial areas are more vulnerable to the exposure of the toxic ambient air pollutants mainly PM_{10} & $PM_{2.5}$ and NO_2 because there are many large and small industries available and are functional. The industrial areas are mostly aligned with heavy traffic zones, noncompliance with SEPA standards, therefore increasing the risks of health impact. Moreover the frequent diseases, according to the Physician's analysis, were Airway and lung irritation, Bronchitis, Eye Irritations, Sleeplessness and Headaches (Mudassar et al. 2012; Manucci and Franchini, 2017).

Conclusion

The findings of this research demonstrate the potential importance of industrial activity, manufacturing and pollutant emissions to the significant concentration in ambient air. As an intense industrial activity of all sorts is present in Karachi, the ambient air of Karachi is a house for holding toxic elements and gases, creating extremely adverse impacts on the environment and its residents of Karachi. Study data shows the three major zones S.I.T.E, Korangi and Landhi industrial areas at a high exposure to gases and other toxic elements. Whereas North Karachi is at the least risk because of having a small scale of industries present. It is also noted that in the industrial areas, there is no proper implementation of laws provided by the responsible authorities like SEPA.

This study examined the association between particulate air pollution in a megacity of Karachi where particulate altitudes are enormously high. The PM_{10} & $PM_{2.5}$ levels averaging about 2 - 3 fold are greater than the SEPA standards. Studies in advanced countries revealed that greater levels of PM_{10} & $PM_{2.5}$ are related to a prominent elevation in rates of hospitalizations for hypertension, cardiovascular syndromes (myocardial infarction, ischemic heart disease). Due to the conspicuous levels of air pollution that are acknowledged, it is imperious that additional research on pollution repercussions in the megacity of Karachi be performed.

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