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PRELIMINARY DETERMINATION OF AIR QUALITY INDEX (AQI) ALONG BUSY ROADS IN KARACHI METROPOLITAN, PAKISTAN

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ABSTRACT

Present study was carried out to determine the concentration of ambient air quality in terms of air born particulate matter (PM10) at 10 different locations on the busy roads in the commercial, residential and industrial areas of Karachi city. Concentrations of particulate matter were used to calculate the results in the form of Air Quality Index (AQI). At each location, the study was carried out continuously for a period of 24 hours in summer and winter season during the year 2014. Results along the selected sites show that at most of the sites have very poor to hazardous AQI categories. Level of ambient air quality is aggravated at traffic congested sites and the sites proximal to industries where pollution level is highly worsen and exceeding the proposed standard limits of US-EPA. Diesel driven heavy duty vehicles (buses and trucks) and two stroke auto rickshaws are the most polluting vehicle emitting high concentration of pollution in the atmospheric air. The results show that the level of PM10 at all the selected sites excluding residential area of PIB colony and Gulshan-e-Iqbal, exceeds the permissible limits as specified by US-EPA. This high concentration of pollution is very harmful for human health to the residents.

KEYWORDS: Karachi city, Air Quality Index, Ambient air, particulate matter.

INTRODUCTION

Air pollution is a global hazards and has immense effects on human health, metrology, climatic changes and ecosystem. In developing countries modernization and industrialization increases the use of fossil fuel in many ways and producing environmental damages especially in rapidly growing megacities [1,2]. The proportion of the world population living in the large town or cities has grown about 5 to 50% during past two decades. Demographers estimate that by the year 2030, approximately two third of the world population will live in large towns or cities [3]**.** The most common air pollutants in the urban environment are Sulphur dioxide (SO_2), nitrogen oxides (NO and NO_2 collectively represented as NOx), carbon monoxide (CO), Ozone (O_3), suspended particulate matter (SPM), methane and non methane hydrocarbons and trace metals. In developing countries like Pakistan, a 'no care' attitude and total neglect along with ever growing demands over the years have made air pollution as a most alarming and hazardous issue.

Nowadays Particulate matter pollution is one of the most concerning problems in urban cities, due to the adverse health effects, reducing atmospheric visibility and cultural heritages [4]. Particulate pollution produce serious short-term and long-term effects on health hazards, even at low concentrations, because it can be absorbed into the lung tissues during breathing. short-term health effects link with airborne particulate matter (PM) concentrations cause lung function disorder, hospital admissions and mortality, whereas long-term health effects shows the incidence of mortality due to respiratory diseases. A number of epidemiological studies [5,6,7] have indicated a strong association between elevated concentrations of inhalable particulate (PM_{10}) and increased mortality and morbidity due to increase in hospitalizations, lung function disorder, asthma, bronchitis, other respiratory diseases and premature deaths [8]**.**

The air quality index (AQI) is a scale to show or characterize the degree of ambient air pollution at a particular monitoring location during a certain monitoring period (e.g., one, 8 or 24 h) due to the concentration of human activities that occur in cities. The main aim of AQI calculation is to aware the public about the risk of pollution level day to day and to prepare for precautionary measurement and to regulate the safety measures for health

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hazards. Generally it is related with the pollutants range and category describe as good, moderate, poor or hazardous in order to understand the meaning of AQI easily. In a simple way AQI shows that ambient air is how much polluted and what are the health hazards for the citizens [9].

Environmental Protection Agency (EPA) is using the AQI for five major "criteria pollutants" viz. ground level ozone, particulate matter, carbon monoxide, sulphur dioxide and nitrogen dioxide. For each of these pollutants EPA has set National Ambient Air Quality Standards (NAAQS) against the risk of pollution on human health and environment [10].

The present study was carried out to determine the effect of urbanization, industrialization and automobile emission on the atmospheric air of Karachi city. The two main sources of air pollution in Karachi city are vehicular emission and industrial emission. This situation of air quality degradation has been increased due to unplanned urbanization and an increase in the number of vehicles. In this study it was going to access the status of ambient air quality of Karachi city in terms of AQI in winter and summer season for the year of 2014.

MATERIAL AND METHODS

Study area

The present research has been focused on Karachi city, the provincial capital of Sind, Pakistan. Karachi has an area of 3,640 Km² and is located along the cost of Arabian Sea. Karachi is 5th largest of Pakistan. Its geographical co-ordinates are 24°45'N and 66°37'E. It is the largest metropolitan city of Pakistan, has an estimated population of over 23.5 million people as reported by "World Population Report" in 2013.

Karachi has moderately temperate climate with a generally high relative humidity that varies from 58% in December (the driest month) to 85% in August (the wettest month). In winter, the average temperature of the city is about 21°C while in summer it reaches up to 35°C. Karachi receives about 256 mm of average annual rainfall [11].

Karachi is the financial and commercial capital of Pakistan as well as the major sea port. It plays an important role in the economy of Pakistan and is considered as the economic and financial gateway of Pakistan. Karachi has several large industrial zones such as Karachi Export Processing Zone, Sindh Industrial Trading Estate, Korangi Industrial Area, Landhi Industrial Trading Estate, Northern By-pass Industrial Zone, Bin Qasim and North Karachi industrial zone, located on the fringes of the main city [11]. Its primary industries are textiles, pharmaceuticals, steel, and auto-mobiles. Due to industrialization, business activities and employment opportunities Karachi has been facing mass scale rural-urban migration from all over the Pakistan.

The main object of this study was to estimate the level of particulate pollutants in the atmospheric environment of Karachi city for the year of 2014. In this study it was going to access the status of ambient air quality of some location in commercial, residential and industrial areas of Karachi in terms of Air Quality Index (AQI). Sampling has been done at ten different areas in summer and winter season. Details of sampling areas are presented in Table - 1.

Air monitoring Locations:

Locations for sampling have been selected at ten different areas of Karachi city marked as Commercial (C), residential (R) and industrial (I) areas. The samples have been collected along the major road, side road and round about.24 h continuous air sampling was carried out in, Commercial areas C-1, C-2 and C-3 (Karimabad, Liaquatabad and Tibet centre), residential areas R-1, R-2 and R-3 (PIB Colony, Nazimabad and Gulshan-e-Iqbal), Industrial areas in East I-1E and I-2E (Siemens Chorangi and Naurus chorangi), Industrial areas in West I-3W and I-4W (Singer Chorangi and Chamra Chorangi) respectively.

The air sampling areas were located in all directions and represented predominant urban areas associated with high, medium and low human activities. This was done with an intention to get better representation of the city. C-1, C-2 and C-3 (Karimabad, Liaquatabad and Tibet centre) located the city core area having high rise commercial buildings and heavy vehicular traffic characterize at these areas. R-1, R-2 and R-3 (PIB Colony, Nazimabad and Gulshan-e-Iqbal) air monitoring areas located almost in the central region of the city represented the residential areas with high vehicular traffic. Industrial areas in East I-1E and I-2E (Siemens chorangi and Naurus chorangi) represents with high vehicular traffic and industrial emission whereas, Industrial areas in west

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I-3W and I-4W (Singer chorangi and Chamra chorangi) represent industrial emission with moderate vehicular traffic.

Air monitoring instrument and method

Analysis had been carried out by using Hi-Volume air sampler installed by Centre for Environmental Studies, PCSIR Labs complex, Karachi. Samples have been collected according to USEPA method Number US 40 CFR. 120 Samples of particulate matter (PM_{10}) have been collected from the selected locations in summer and winter season during the year of 2014.

High Volume Sampler, Andersen Inc. Atlanta Georgia

High Volume Air Sampler collect particles over a wide size range up to approximately 50 micron. The collection efficiency is affected by both wind speed and direction. On a windy day in the presence of fugitive dust sources such as roads, unpaved parking lots or mineral and coal piles, significant and varying quantities of large particles are collected by Hi-volume Sampler. Because such large particles usually do not constitute a human health hazards and because they seriously affect the stability and accuracy of the high volume sampling method, EPA plans to promulgate a new size – specific primary ambient air quality standard. Most likely, the new standard will apply to PM-10 particles smaller than 10 microns in size. EPA states and industry are now intensively monitoring for size specific particulates in preparation for new standard.

Air Quality Index (AQI)

In this study AQI has been calculated with reference to the concentration of particulate pollution proposed by US-EPA [10]. These AQI values predict, evaluate and explained the air quality status and health concerns at the selected sites. As the air pollution increases, adverse health effect also increases.

Following equation was used to calculate the AQI values by using the pollutant concentration data.
After compiling the data, the concentration of PM_{10} pollutant was converted in to an AQI value for each location, higher the AQI value, higher the level of air pollution and describe the associated health hazards, providing meaning full information to the citizens.

The Table - 2 shows the air quality index with the category of health risk. The air quality index zero to fifty is good for human health and indicate clean air, 50 to 100 indicate moderate air quality, 101 to 150 point toward unhealthy for sensitive group, 151 to 200 express unhealthy for all people, 200 to 300 very unhealthy, 301 to 500 hazardous and > 500 indicate sever hazardous (Table - 2).

RESULTS AND DISCUSSION

Present study was carried out for the assessment of the concentrations of ambient air pollution with PM_{10} size fractions by using Air Quality Index (AQI) at ten different locations in Karachi. The average concentrations of airborne PM_{10} at all selected sampling points along the busy road were measured in summer and winter season, presented in Table – 3 & 4. Results show that the average concentrations of PM_{10} in summer season at different sites in Karachi city, i.e. in Commercial areas were found 177.0 $\mu g/m^3$ at C-1, 271.0 $\mu g/m^3$ at C-2, 218.0 $\mu g/m^3$ at C-3, in Residential areas were 106.2 $\mu g/m^3$ at R-1, 132.0 $\mu g/m^3$ at R-2, 87.4 $\mu g/m^3$ at R-3 and in industrial areas were 204.3 $\mu g/m^3$ at I-1E, 213.9 $\mu g/m^3$ at I-2E, 154.0 $\mu g/m^3$ at I-3W and 135.0 $\mu g/m^3$ at I-4W respectively whereas, the average concentrations of PM_{10} in winter season i-e. in Commercial areas were found 204.3 $\mu g/m^3$ at C-1, 294.0 $\mu g/m^3$ at C-2, 257.8 $\mu g/m^3$ at C-3, in Residential areas were 206.3 $\mu g/m^3$ at R-1, 213.9 $\mu g/m^3$ at R-2, 118.4 $\mu g/m^3$ at R-3 and in industrial areas were 282.2 $\mu g/m^3$ at I-1E, 267.5 $\mu g/m^3$ at I-2E, 218.0 $\mu g/m^3$ at I-3W and 205.3 $\mu g/m^3$ at I-4W respectively.

In general, the average PM_{10} concentrations were higher in commercial and industrial areas with high traffic density than the residential sites. Most of the sites have PM_{10} concentrations exceeded the specified permissible limits by US-EPA [10]. The highest mean concentration of PM_{10} was observed at I-1E followed by C-2. Location I-1E is an industrial site having industrial clusters on both sides of the road. This site also exhibited high traffic congestion mainly due to heavy duty diesel vehicles like trucks, tractors, trailers, vans, buses and minibuses. At this location I-1E the roads are also poorly maintained, unpaved and dusty with limited vegetation along the sides. The industrial processes especially combustion boilers fueled by heavy duty diesel, and heavy electric generators also fueled by diesel are the main source of PM_{10} pollution, Whereas, location C-2 is commercial area having narrow road with heavy traffic density and surrounded by high rise buildings for commercial activities on both side of the road producing tunnel effect where the pollutants are suspended for long time and it is associated with

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potential health effects for the resident specially for infant and old age group/ sensitive residents. The ambient AQI values in summer and winter season has been calculated with the recorded pollutant concentration data of the sampling sites presented in Table – 3 and 4, graphically represented in Figure - 1. The calculated Air Quality Index values in summer season at the selected sites vary between a maximum of 159.0 and a minimum of 67.0 respectively whereas in winter season vary between a maximum of 170.0 and a minimum of 82.0 respectively. Results of the calculation of AQI values at the sampling locations show moderate pollution in residential areas and poor or unhealthy pollution in commercial and industrial areas.

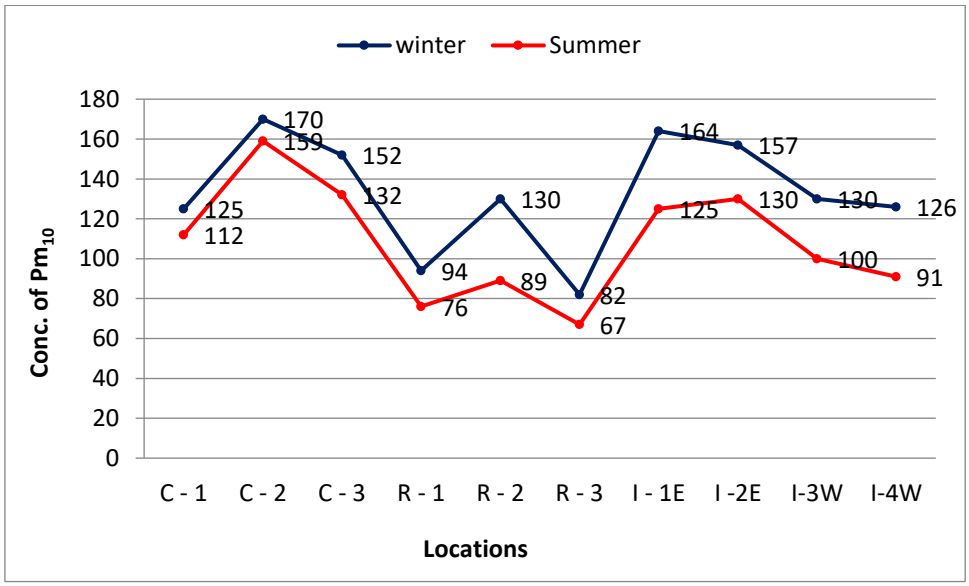

Figure – 1:- Observed AQI values at selected locations

The results of collected air quality data also show that the concentration of the pollution at each sampling sites were highly variable. This may be depends on the level of air quality at that site due to meteorological condition and influence of mobile and stationary sources. It can also be seen that the concentration of particulate PM_{10} pollutants exceeded the allowable standard limit at all the location except Gulshan-e-Iqbal in purely residential area due to average traffic density with low vehicular emission.

CONCLUSION

It can be concluded from this study that the concentration of particulate matter in the atmospheric environment along the road shows deterioration of air quality in the city. Observed values exceeding the permissible limits in commercial areas, industrial areas and in those residential areas, having both commercial and residential status of the city. The main source of the pollution appears to be traffic congestion and vehicular emission. In terms of Air Quality Index (AQI), as most of the sites have very poor to hazardous AQI categories. Results of this AQI value reveals that high concentration of pollution may cause negative impact on the atmospheric environment and potential health hazards to residents. Government and local bodies should take immediate measures, planning and social awareness to reduce the pollution load and improving the status of air quality in the city.

Formula:

$$I_p = \frac{IHi - Ilo}{BPHi\ BPLo}(C_p\ BPLo) + ILo\ .$$

Where;

Ip = the index for pollutant p
Cp = the rounded concentration of pollutant p
BPHi = the breakpoint that is greater than or equal to Cp
BPLo = the breakpoint that is less than or equal to Cp
BPHi = the breakpoint that is greater than or equal to Cp
IHi = the AQI value corresponding to BPHi
ILo = the AQI value corresponding to BPLo

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Tables:

Table – 1:- Relevant Features of Air Monitoring Locations

S. #	Locations	Cod #	Lat	Long	Activities
	Commercial Areas				
1	Karimabad	C – 1	24.9165	67.0576	Heavy Traffic Density with commercial activities etc.
2	Tibet Centre	C – 2	24.8628	67.0218	
3	Liaquatabad	C – 3	24.9018	67.0405	
	Residential Areas				
4	PIB Colony	R – 1	24.9248	67.0315	Moderate Traffic Density, exposed dump/exposed pit surface, domestic waste burning and residential activities.
5	Nazimabad	R – 2	24.8909	67.0505	Heavy Traffic Density with transport on paved road and unpaved road, haul road and exposed dump/exposed pit surface, domestic waste burning and residential activities.
6	Gulshan-e-Iqbal	R – 3	24.9294	67.1284	Average Traffic Density with residential activities
	Industrial Areas in East				
7	Siemens Chorangi	I-1E	24.9029	67.0028	Vehicular emission due to heavy traffic density, waste incineration, Stack emissions and other industrial activities.
8	Naurus Chorangi	I-2E	24.9055	67.0163	
	Commercial Areas in West				
9	Singer Chorangi	I-3W	24.8467	67.1594	Vehicular emission due to average traffic density, waste incineration, Stack emissions and other industrial activities.
10	Chamra Chorangi	I-4W	24.8615	67.0091	

Table - 2-: AQI Criteria and Quality Category.

AQI	Category
0 – 50	Good
51 – 100	Moderate
101 – 150	Unhealthy for sensitive
151 – 200	Poor (Unhealthy)
201 – 300	Very Poor OR Very Unhealthy
301 – 400	Hazardous
401 – 500	Very Hazardous
➢ 500	Very Critical
US EPA Standards	150

Source: US-EPA (2012) and Gurjar et al. (2008)

Table - 3: Air Quality Index and Air Quality Category of PM_{10} in Summer Season at Selected areas

S. #	Locations	Cod #	AQI	PM_{10} (µg m^3)	AQI Category
	Commercial Areas				
1	Karimabad	C – 1	112	177.0	Poor / unhealthy for Sensitive
2	Tibet Centre	C – 2	159	271.0	Unhealthy
3	Liaquatabad	C – 3	132	218.0	Poor / unhealthy for Sensitive
	Residential Areas				
4	PIB Colony	R – 1	76	106.2	Moderate
5	Nazimabad	R – 2	89	132.0	Moderate
6	Gulshan-e-Iqbal	R – 3	67	87.4	Moderate

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	Industrial Areas in East				
7	Siemens Chorangi	I-1E	125	204.3	Poor / unhealthy for Sensitive
8	Naurus Chorangi	I-2E	130	218.0	Poor / unhealthy for Sensitive
	Commercial Areas in West				
9	Singer Chorangi	I-3W	100	154.0	Moderate
10	Chamra Chorangi	I-4W	91	135.0	Moderate

Table - 4: Air Quality Index and Air Quality Category of PM_{10} in Winter Season at Selected areas

S. #	Locations	Cod #	AQI	PM (µg m-3)	AQI Category
	Commercial Areas				
1	Karimabad	C – 1	125	204.3	Poor / unhealthy for Sensitive
2	Tibet Centre	C – 2	170	294.0	Unhealthy
3	Liaquatabad	C – 3	152	257.8	Unhealthy
	Residential Areas				
4	PIB Colony	R – 1	94	206.3	Moderate
5	Nazimabad	R – 2	130	213.9	Poor / unhealthy for Sensitive
6	Gulshan-e-Iqbal	R – 3	82	118.4	Moderate
	Industrial Areas in East				
7	Siemens Chorangi	I-1E	164	282.2	Unhealthy
8	Naurus Chorangi	I-2E	157	267.5	Unhealthy
	Commercial Areas in West				
9	Singer Chorangi	I-3W	130	218.0	Poor / unhealthy for Sensitive
10	Chamra Chorangi	I-4W	126	205.3	Poor / unhealthy for Sensitive

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