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Measurement of Atmospheric Concentrations of CO, SO_2, NO and NOx in Urban Areas of Karachi City, Pakistan

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Abstract. In the assessment of variation trends in ambient air quality at five selected regions of Karachi city, four air pollutants namely carbon monoxide, sulphur dioxide, nitrogen oxide and nitrogen dioxide were monitored, along with metrological parameters, for eight consecutive days. The results suggested that all the pollutants were mainly due to the emissions from motor vehicles and industries, owing to the absence of regulatory laws/standards about ambient air quality in Pakistan. The results have been discussed with reference to recommendations of the World Health Organization for the same.

Keywords: air pollution, industrial emission, vehicular emission, atmosphere

Introduction

Karachi is the largest metropolitan city of Pakistan having an estimated population of above 10 million. Total amount and complexity of toxic pollutants in the environment of Karachi are increasing day by day with the rapid increase of population and proportional increase of industries, vehicular traffic and open air garbage burning. Rate of atmospheric pollution is 40 percent higher in Karachi than the other cities of Pakistan (Qureshi, 1997).

Typical major ambient air pollutants in the urban environment include CO, SO_2, NO, NOx, HC and PM10. CO is formed during combustion of carbon containing compounds. It is a toxic gas and its prolonged exposure, even at very low levels, may adversely affect central nervous system. When inhaled, it reacts with the haemoglobin of the blood stream to form carboxy-haemoglobin. CO attaches to haemoglobin roughly about 210 times more than the oxygen (All Refer.com, 2005). SO_2 is also generated by the combustion of high sulphur fuels. SO_2 is toxic to human body especially for persons having previous history of respiratory diseases, such as emphysema; besides, it also causes pneumonia. Nitrogen oxides are generated at high temperatures during combustion. Their ultimate effect on human beings is still not clearly understood, but they act as irritants to breathing and create discomfort to eyes and also destroy the celia in the respiratory system.

Present study was carried out in various industrial, residential/commercial and down-town regions of Karachi city to generate base-line data on these localities by air pollution monitoring analyzers, to identify major sources of air pollution and suggest their remedial measures. The data so generated may assist in the formulation of the country air quality standards. Information about the industries was obtained from different civic agencies and the Department of Industries.

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Materials and Methods

The subtropical city of Karachi is located in a semiarid zone. It is the largest industrial and commercial centre in Pakistan and declared as one of the twenty mega cities of the world (Mage *et al.,* 1996). Growing urban population, industrialization and traffic congestion are the main causes of air pollution in Karachi city. In order to assess the load of air pollutants in the environments of the city, monitoring of different air pollutants was carried out at five different locations (as shown in location map) of the city, categorized as follows:

1- Region A: the site with urban background, moderately populated, having low vehicular traffic density. It is one km distant from the main super highway. The area around the sampling site is sparsely populated.
2- Region B: a commercial site, densely populated, having high vehicular traffic density. This site is the busiest intersection of Karachi, surrounded by multistoried commercial as well as residential buildings. The population around this site mostly belongs to high income group.
3- Region C: an industrial area in district South of Karachi, with nearly 2000 different types of industries, approximately 60 percent comprising of textile mills, while

Location map: sample collection points

other industries are related to pharmaceuticals, chemicals, detergents, iron and steel, sulphur refining, vegetable oils, beverages and food products.

4- Region D: an industrial area in district East of Karachi with approximately 2000 various types of industries including tanneries (more than 100 units), pharmaceutical, textile and chemical units and refineries etc.

5- Region E: also an industrial area in district East of Karachi with 300 industrial units of different categories including textile, food, chemical, pharmaceutical and engineering units.

Measurement of major ambient air pollution components such as CO, SO_2, NO and NO_2 was carried out in summer season, for eight consecutive days at each of the five stations. Average variations of the pollutants were recorded for 11 hours at hourly intervals, at the selected regions (A-E).

Air quality measurements were performed, using air analyzer, designed and fabricated by Environmental SA, France. Average values of CO, SO_2, NO, NO_2 and NOx concentrations for 15 min were used for determining daily average hourly concentrations. The daily hourly average concentration values were further averaged for determining values for 8 days and for time weighted average (TWA) values for 1 h, 8 h and 24 h for each region.

UV fluorescent SO_2 Analyzer Model AF21 M consisted of zinc ray UV lamp with stabilized power supply, continuous energy monitor and compensation for measurement at constant energy level and integrated carbon kicker for continuous removal of interfering hydrocarbons.

The chemiluminescent NO-NOx Analyzer Model AC 31M was of two channel type coupled with serial R232 output signal processing and continuous zero control by the microprocessor. The air sampled by a pump placed at the circuit end, is carried, on the one hand *via* a converter oven towards the NOx chamber and on the other hand, directly into NO chamber. The radiation emitted in the NOx chamber is proportional to $NO+NO_2$ (reduced to NO).

Concentration of carbon monoxide was measured by Snift CO Analyzer (Model 50). The meter was kept at about 1.2 m

above the ground level and readings were taken at intervals of 15 minutes.

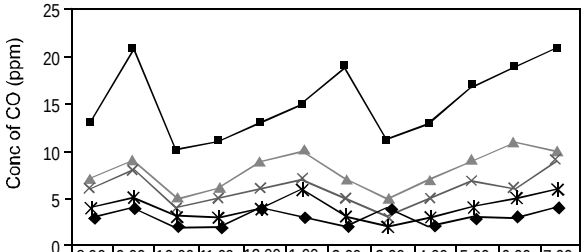
Results and Discussion

Hourly average variations of the pollutants, recorded at five selected regions A, B, C, D and E are graphically presented in Fig. 1 to 5. Table 1 gives the time weighted average (TWA) values for 1, 8, and 24 h, along with permissible ambient air quality limits, recommended by WHO.

Maximum average concentration of CO was found to be 4, 21, 11, 9, and 6 ppm in regions A, B, C, D and E, respectively (Fig. 1). The main source of CO at regions A and B may be motor vehicles plying on nearby main super highway and University Road, where traffic density is high, whereas, at regions C, D and E, the combustion of fuels in nearby industries and power generation plants.

Maximum hourly average concentrations of SO_2 were 5.7, 349.1, 74.5, 42.2 and 21.2 ppb at the regions A, B, C, D, and E, respectively, the highest concentration of SO_2 being 349.1, recorded at region B (Fig. 2). The main cause of this high concentration of SO_2 at this region may be very high traffic density due to narrow and congested roads, surrounded by high rising buildings. At region A, the main source of SO_2 is considered to be the vehicular traffic, whereas, at regions C, D, and E, the combustion of fuels in the nearby industries.

The highest average concentrations of NO were found to be 17.2, 231.3, 193.5, 157.4 and 132.5 ppb (Fig. 3), and those of NO_2, 9.8, 127.3, 122.2, 103.2 and 79.2 ppb (Fig. 4), whereas the highest average concentrations of NOx were found to be 27.0, 358.6, 315.7, 260.6 and 211.7 ppb (Fig. 5) in the selected regions A, B, C, D and E, respectively.



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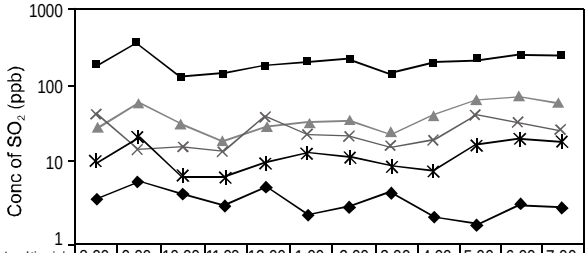
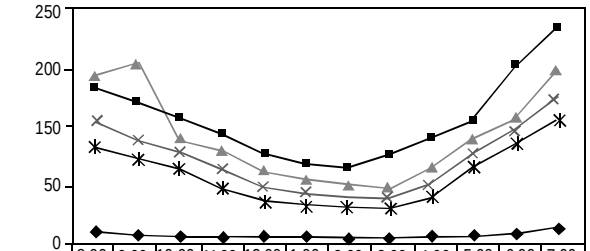
A	3	4	2	2	4	3	2	4	2	3	3	4
B	13	21	10	11	13	15	19	11	13	17	19	21
C	7	9	5	6	9	10	7	5	7	9	11	10
D	6	8	4	5	6	7	5	3	5	7	6	9
E	4	5	3	3	4	6	3	2	3	4	5	6

Fig. 1. Hourly average CO concentrations in regions A-E.



Local time in hr	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00
A	3.4	5.7	3.9	2.9	5.1	2.1	2.9	4.3	2.1	1.7	3.1	2.8
B	175.2	349.1	123.6	142.1	179.6	202.4	221.3	140.6	197.2	213.7	250.9	249.1
C	29.1	58.9	31.1	19.3	29.6	34.2	36.7	23.6	41.9	67.3	74.5	61.3
D	41.3	15.2	15.7	13.9	39.6	24.1	21.5	16.3	20.1	42.2	34.4	27.1
E	10.2	21.1	6.7	6.7	10.2	13.4	11.9	9.2	8.1	17.6	21.2	19.3

Fig. 2. Hourly average SO_2 concentrations in regions A-E.



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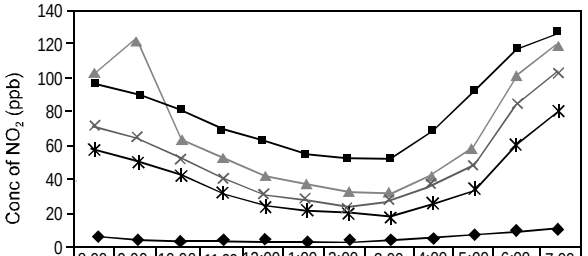
A	13.5	10.1	9.6	9	8.6	8.1	7.5	6.7	7.9	9.2	12.3	17.2
B	167.5	152.9	135.3	117.6	96.2	84.8	80.5	95.1	112.7	130.5	119.3	231.3
C	182.2	193.5	112.3	100.4	79.1	68.8	63.7	60.4	81.3	112.3	134.4	186.5
D	131.4	112.2	98.6	80.5	61.3	53.5	51.2	47.8	64.5	97.2	123.3	157.4
E	105.6	91.3	80.5	61.4	46.7	41.6	40.2	38.1	51.1	82.6	107.9	132.5

Fig. 3. Hourly average NO concentrations in regions A-E.

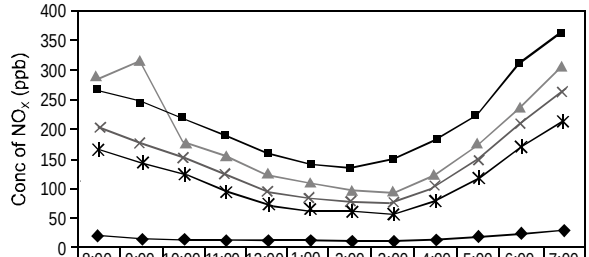
Table 1. Concentration of CO, SO_2 and NO_2 evaluated for 1, 8 and 24 h (TWA) and permissible limits of WHO.

Pollutants	Time weighted average (TWA) values							Averaging
	Region A	Region B	Region C	Region D	Region E	WHO	Unit	time
CO	3	12.25	6.7	3.7	3.5	30	mg/m^3	1 h
	2.1	15.75	8.8	4.1	3.8	10		8 h
SO_2	4	159.1	42.1	30.6	15.9	350	$\mu g/m^3$	1 h
						100-150		24 h
NO_2	5.6	79.4	47.7	35.9	32.9	400	$\mu g/m^3$	1 h
						150		24 h



Local time in hr	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00
A	5.2	4.1	3.3	3.1	2.7	2.1	1.8	3.1	4.2	6.4	7.9	9.8
B	96.4	90.1	81.2	69.1	61.6	54.5	52.1	51.5	67.7	91.3	116.5	127.3
C	103.5	122.2	63.3	52.5	41.6	36.8	32.1	30.6	41.4	58.2	101.2	119.6
D	71.2	64.2	98.6	40.3	30.5	27.6	23.2	27.1	36.7	47.6	84.7	103.2
E	57.5	50.3	80.5	31.4	23.7	20.8	20.1	17.2	24.6	32.7	59.9	79.2

Fig. 4. Hourly average NO_2 concentrations in regions A-E.



Local time in hr	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00
A	18.7	14.2	12.9	12.1	11.3	10.2	9.3	9.8	12.1	15.6	20.2	27
B	263.9	243	186.7	186.7	157.8	139.3	132.6	146.6	180.4	221.8	307.8	358.6
C	285.7	315.7	152.9	152.9	120.7	105.6	95.8	91	122.7	170.5	235.6	306.1
D	202.6	176.4	120.8	120.8	91.8	81.1	74.4	74.9	101.2	144.8	208	103.2
E	163.1	141.6	122.7	92.8	70.4	62.4	60.3	55.3	75.7	115.3	167.8	79.2

Fig. 5. Hourly average NOx concentrations in regions A-E.

Carbon monoxide is not easily detected by olfactory senses. High concentration of this pollutant in central parts of the cities due to traffic jams may creat serious problems. (ALA, 2000; WDNR, 2000). Exposure to carbon monoxide may lead to head ache, tiredness, dizziness, nausea, vomiting and drowsiness and in very acute situations, to unconsciousness and even death (Malakootian and Yaghmaeian, 2004). Exposure to elevated carbon monoxide level is associated with impairment of visual perception, work capacity, manual dexterity, learning ability and performance of complex tasks (Aziz and Qureshi, 2003).

In region A, the highest hourly average concentration of CO was recorded to be 4 ppm, from 7:00 to 9:00 a.m. and from 5:00 to 7:00 p.m. In the morning, the movement of traffic is down town and is reverse in the evening. Variations in the concentrations of carbon monoxide show that the concentration gradually increases till 9:00 a.m. and then comes down at 1:00 p.m. and again increases around 6:00 p.m. which are the rush hours. In region A, the air pollution was generated by vehicular traffic as the air currents were coming from main Super Highway that has quite high traffic density.

In region B, the pollution generation is mainly due to vehicular traffic. This site is the busiest intersection on M.A. Jinnah Road having high traffic density and traffic jams with high-rising buildings on both sides of the road creating tunnel effect. On the contrary, in regions C,D, and E, the pollution generation may be due to the emissions from nearby industries, power generation plants and boilers of the industries.

Sulphur dioxide originates mostly from the combustion of trace amounts of inorganic and organic sulphur, contained in the fuel. The estimated background concentration of SO_2 is 0.2 ppb and calculated atmospheric residence time is 4 days (Bhatia, 2005). Short term high level of SO_2 may enhance respiratory diseases, lung function disturbance and even mortality in adults and children (Nautiyal *et al.,* 2007). The maximum average concentrations of SO_2 at regions A and B were found to be 5.7 and 349.1 ppb, respectively, during 7.00 to 9.00 a.m. At these stations, the high concentration of SO_2 may be due to the fuel combustion by vehicular traffic. At regions C, D and E the highest values of SO_2 were 74.5, 42.2 and 21.2 ppb, respectively, at 6:00 p.m. The main source of SO_2 at station C may be power plants and boilers of the industries and at stations D and E, a large oil refinery, all located in SW directionof the areas. Relatively high concentration of SO_2 obtained at regions C, D, and E, during specified period may be due to emissions from the nearby industrial units.

Nitrogen oxides are of great concern, being precursors in ozone production in the presence of sun light. NO and NO_2 are emitted together from combustion sources and exist in equilibrium in the atmosphere; together, they are usually referred to as NOx. The diurnal pattern of NO and NOx has correlation with solar energy. A distinct photochemical relation between NO, NOx and solar energy has been established and as the solar energy increases during the day time, the level of NO, NOx decreases. The reaction of photochemical oxidants has a time scale of one to a few minutes (Clark, 1988). At region C, the highest concentrations of NO and NOx were found to be 193.5 ppb and 306.1 ppb, respectively, between 7.00 to 9.00 a.m. which may originate from the combustion of industries and power plants, about 45-60 meters away. The reaction is therefore, even more rapid here, having a time scale of only few seconds. The chemical reaction between the two mixing species was not completed due to time lag and shows high concentration of NO and NOx during the day time. However, at regions A, B, D and E, the highest values of hourly average concentration of NO and NOx were found before the sunrise which started decreasing as the ultra-violet radiations from the sun increased, and again increasing with the decrease of ultra-violet radiations from the sun. The main contributor of NO and NO_2 at regions A and B were the emissions from the vehicular traffic due to

combustion of fuel, whereas, at regions D and E, the combustion gases emitted by the industries.

A comparison of the time weighted average values of all the measured pollutants at the selected stations, with those of the WHO recommended air quality guidelines shows that the concentrations of ambient air pollutants found at these stations are well within the WHO limits.

Air pollution has become a world wide public health problem, particularly in large towns and cities of the developing countries where people are commonly exposed daily to very high levels of pollution for 3-7 hours for the last many years (Engel *et al.,* 1998). Effect of air pollution on human health varies according to the intensity, duration of exposure and health status of exposed population. Air pollution increases the risk of chronic obstructive pulmonary diseases and acute respiratory infections in childhood, lung and chest cancer, tuberculosis, prenatal outcomes including low birth weight and eye diseases. The worst affected age group had been between 50-60 years, followed by the lower age group of 45-55 years (Maddission, 1997).

Conclusion

The baseline data generated for major ambient air pollutants at different urban sites of Karachi show that the concentration of ambient air pollutants such as CO, SO_2, NO and NOx, are all within WHO threshold limits. The values recorded indicate that all the pollutants are emitted by the industries and motor vehicles. It is expected that the generated data will play a part in laying the foundation for developing appropriate ambient air quality standards for Pakistan and their implementation.

References

AllRefer.com 2005. Hemoglobin derivatives. Available at: http://health.allrefer.com/health/hemoglobinderatives-info.html.Accessed April 6, 2005.

ALA, 2000. *Carbon Monoxide and the Environment*, American Lung Association,USA, available at: http;// www.lunguas.org/air/carbon.

Aziz, J.A., Qureshi, T.A. 2003. Measurement of ambient particulate matter and carbon monoxide in Peshawar. *Science Technology and Development,* **22:** 1-4.

Bhatia, S.C. 2005. *Environmental Pollution and Control in Chemical Process Industry*, *Delhi*, pp. 104, published by Khanna Publishers, Nai Sarak, India.

Clark, .P.A. 1988. Mixing models for simulation of plume interaction with ambient air. *Atmospheric Environment*, **22:** 1097-1106.

Engel, P., Hortodo, E., Ruel, M. 1998. Smoke Exposure of women and young children in highland Guatemala, predictions recall Accuracy. *Human Organization,* **54:** 408-417.

Mage, D., Ozolins, G., Peterson, P., Webster, A., Orthofer, R., Vandeweerd, V., Gwynne, M. 1996. Urban air pollution in megacities of the world. *Atmospheric Environment,* **30:** 681-686.

Malakootian, Yaghmaeian, K. 2004. Investigation of carbon monoxide in heavy traffic intersections of Municipal districts. *International Journal of Environmental Science and Technology,* **1:** 227-231.

Maddission, D.A. 1997. *Meta Analysis of Air Pollution Epidemiological Studies,* London Centre for Social and Economic Research on the Global Environment, University College London, UK.

Nautiyal, J., Garg, M.I., Kumar, M.S., Khan, A.A., Thakur, J.S., Kumar, R. 2007. Air pollution and cardiovascular health in Mandi Gobindgarh, Punjab, India, -A pilot study. *International Journal of Environmental Research and Public Health,* **4:** 268-282. (doi10.3390/)

Qureshi, O.R. 1997. Atmospheric pollution in Karachi 40 percent higher than other cities. *Frontier Post,* June 07, Karachi.

WDNR, 2000. Carbon monoxide sources and health effects. Wisconsin Department of Natural Resources, USA, (http://www.dnr.state.wi.us).