Measurement of Traditional Air Pollutants in Industrial Areas of Karachi, Pakistan

D. R. HASHMI AND M. I. QAIM KHANI
PCSIR Laboratories Complex, Karachi- 75280 Pakistan

(Received 7th Feburary, 2002, revised 10th December, 2002)

Summary: Continuous measurement of traditional air pollutants alongwith meteorological parameters was carried out by air pollution Mobile Monitoring Laboratory at industrial areas of Karachi. Average concentration of SO_2 at Sindh Industrial Trading Estate was found to be 24.9 $\mu g/m^3$ and PM10 (Particulate matter) was 176.5 $\mu g/m^3$, whereas the average concentration of SO_2 at Korangi Industrial Area was 7.4 $\mu g/m^3$ and PM10 was 147.2 $\mu g/m^3$ respectively. These data were compared with the uptown area of Karachi. The result suggested that SO_2 and PM10 found in these areas shows similar variation, which indicates that, these pollutants originate from the same source. Effect on human health is also discussed.

Introduction

The rapid growth of population has given rise to many common problems, such as air pollution and environmental degradation, pressure for land space, traffic congestion, lack of adequate drainage & waste disposal and destruction of trees and green areas to accommodate urban development [1]. Air pollution is one of the major concerns, which is affecting the urban and rural areas. The pollutants are being discharged into the atmosphere from a number of sources but vehicular traffic and industries are the major contributors. Industrialization introduces uncontrolled pollution into atmosphere and is a threat to human environment. Karachi is the largest city of Pakistan. Tremendous increase in the population, factories, processing industries and transport fleet has adversely affected the quality of air in Karachi.

The most common air pollutants in urban environment are ozone (O_3), Sulphur dioxide (SO_2), Carbon monoxide (CO), Nitrogen oxide (NOx), Particulate matter (PM10), methan and non-methan hydrocabons. Sulphur dioxide and particulate matter are regarded as traditional pollutants as they generally attributed from the same source.

The main natural sources of SO_2 in the atmosphere include evaporation of sea spray, erosion of sulphate containing dust from arid soils, fumes

from volcanoes and bio-genic emission of hydrogen sulphide and organic sulphur containing compounds such as dimethyl sulphide, carbonyl sulphide and carbon disulphide. The SO_2 in the atmosphere lasts only a few days, the residence time at the most being 4 days. This is the reason that the SO_2 mass in atmosphere is so small as compared to annual emission by man. Atmospheric background concentration of SO_2 is 0.2 ppb [2].

Anthropogenic emission of particulate matter results from sources such as traffic, steel mills, cement plants, ceramic industry and solid waste incineration. Particulate matter includes dust, soot, ash, lint and many other suspended materials. Sulphur dioxide and PM10 usually occur together representing a complex mixture of by products of combustion of fossil fuels. On the basis of observation, SO_2 and PM10 are evaluated jointly by WHO in air quality guidelines [3]

The main objective of this study was to collect baseline data for ambient air quality and to determine the trend of traditional air pollutants in industrial areas of Karachi. The generated data could be used by future planners, scientists and technologists for taking appropriate measures against hazardous effects of air pollution.

Results and Discussion

Karachi is located in a semi arid zone on the coast of Arabian Sea between latitude 25^0 North and longitude 67^o East. The city is growing rapidly because it is the biggest industrial and commercial centre in Pakistan and offers immense employment and business opportunities. According to 1998 census Karachi has a population of 9.2 million [4]. It has also been declared as Megacity among 20 megacities of the world [5].

Karachi has well defined industrial base, there are about 20,000 small and large industrial units working only in various industrial areas of Karachi [6]. There are some planned industrial estates in Karachi, namely Sindh Industrial Trading Estate (SITE), Korangi Industrial Area (KIA), Landhi Industrial Trading Estate (LITE) and Federal Industrial Area (FIA).

Continuous measurements of traditional air pollutants were carried out at SITE and KIA. The data was collected continuously for eight days in the month of February 1998. A Scanair software was used for acquisition, editing and recording logical and analogical data from data logger. Fifteen minutes average concentration of traditional air pollutants alongwith meteorological parameters are presented in the form of graphs I, II & III.

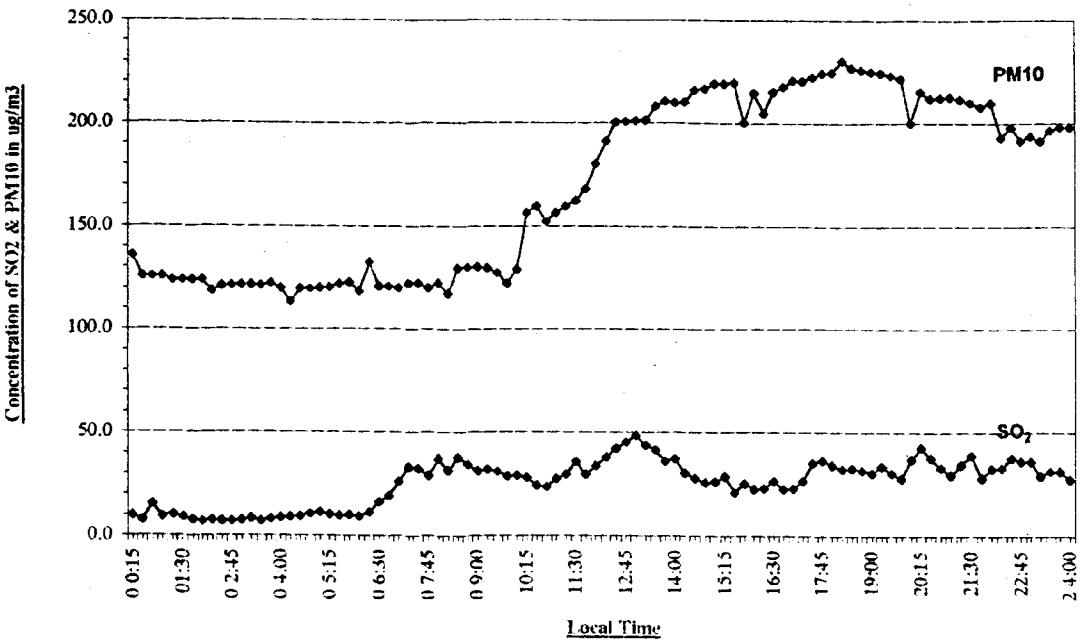
SITE of Karachi is one of the largest and oldest industrial estates of Pakistan. It was established in 1953 and is located at Latitude $24^0.54'$ and Longitude $67^0.10$ in the district South, Karachi. Nearly 2000 various types of industries are located in this area. Approximately 60% of these industries are textile mills while others deal with pharmaceutical, chemical, detergent, iron and steel, vegetable oils, beverages and food products etc.

Shortage and frequent break down of electric power in industrial areas has compelled the industries to install their own power generation units. These units are mostly diesel and Sui gas (Natural gas having 99.9 % methane) fired which emit significant amount of particulate matter and sulphur dioxide. Growing number of small power plants being installed in this areas motivate us to collect baseline data of traditional air pollutants and to study their trend in ambient air.

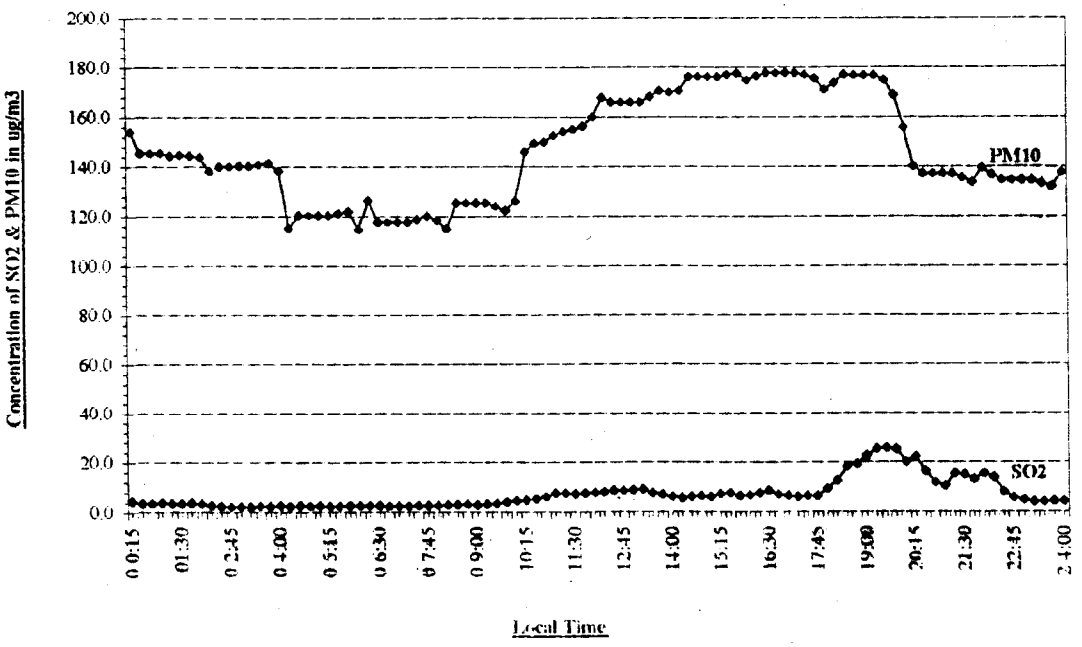
During measurement period the average concentration of SO_2 at SITE was found to be 24.9 $\mu g/m^3$, maximum concentration was 54.9 $\mu g/m^2$ and minimum concentration was 7.1 $\mu g/m^3$. Whereas the average concentration of PM10 at SITE was 176.5 $\mu g/m^3$, maximum concentration was 230.7 $\mu g/m^3$ and minimum concentration was 75.5 $\mu g/m^3$ respectively.

Sulphur dioxide has a natural global biogeochemical cycle, but man made emission interferes with this cycle. 80 % of all sulphur dioxide emission is due to fossil fuel combustion. Refineries and smelters also produce significant amount of sulphur dioxide. The effect of SO_2 on human health has been widely studied. The short-term exposure to SO_2 may increase the mortality in the sensitive part of the population specially children and elderly people. In a study in Marseilles, a significant effect of SO_2 pollution was observed in the form of mortality from respiratory diseases among the peoples of 65 years of age or over [7].

Graph I shows the average variation in SO_2 and PM10 at SITE of Karachi. The maximum



Graph-I: Average Concentration of SO_2 and PM10 at SITE



Graph-II: Average Concentration of SO_2 and PM10 at KIA

average concentration of SO_2 was recorded as 54.9 $\mu g/m^3$ between 17:45 to 19:30 hours local time. The wind direction during this period was 150^0 to 170^0 SE and wind speed was between 3 to 4 m/s. The major contributor of SO_2 during this period may be from the boiler and power generation unit of near by pharmaceutical industry. Whereas the minimum average concentration of SO_2 was recorded as 7.1 $\mu g/m^3$ between 01:45 to 02:45 hours local time during this period wind direction was between 140^0 to 150^0 SW. All the industries in this area used natural gas for boilers and other combustion purposes. The natural gas (Sui gas) supplied is almost free from sulphur. This may be one of the causes of low level of SO_2 found in the atmosphere of Sindh Industrial Trading Estate of Karachi. WHO has established guidelines of 40-60 $\mu g/m^3$ for SO_2 [8]

Particulate matter arises either from condensation process or from erosion, grinding & spraying etc. Worldwide emission amount to about 1 million metric tons/year. This inventory shows that the industrial stationary sources account for 59 % of anthropogenic suspended particulate matter emission [6]. Several studies have documented the effect of particulate air pollution on health in virtual absence of SO_2 [9] WHO estimate that 70 % of global urban population in developing countries breathe air that has unhealthy particulate concentration [10]

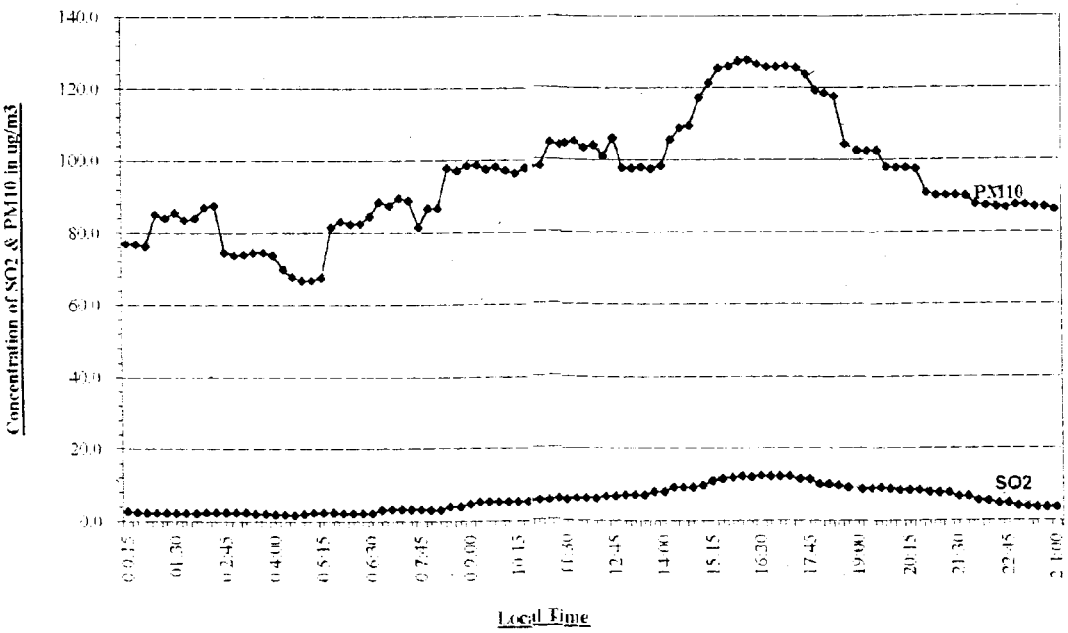
The average variation in PM10 at Sindh Industrial Trading Estate of Karachi can also be seen in graph I. The maximum average concentration of PM10 was found to be around 230.7 $\mu g/m^3$ between 17:45 to 19:45 hours local time. The average variation in wind direction during this period was between 150^0 to 170^0 SE and wind speed was between 3.1 to 4.0 m/s. It seems that the pollutants are coming from boiler and power generation units of nearby pharmaceutical industry, which is about 50-75 m away from the sampling site. WHO has established guideline of 150-230 $\mu g/m^3$ for suspended particulate matter [8].

The data was also collected from Korangi Industrial Area (KIA), which is the second largest industrial area of Karachi. KIA is located in South of Karachi at Latitude 24^0. 51and Longitude $67^0.11'$ in district East. Approximately 2000 various types of industries are located in this area, which include tanneries (more than 100 units), pharmaceuticals, textile, chemical and refineries etc. The data of KIA was also generated in the month of February.

Graph II shows the concentrations of sulphur dioxide and PM10 at KIA. Maximum average concentration of SO_2 at KIA was recorded as 25.8 $\mu g/m^3$ between 18:15 to 20:15 hours local time. The microclimatic condition during this period shows that wind direction was between 200^0 to 251^0 SW and average wind speed was between 2.34 to 3.96 m/s. whereas minimum average concentration of SO_2 recorded as 2.4 $\mu g/m^3$ at 03:00 hours local time, during this period wind direction was 106^0 SW and wind speed was 1.6 m/s. The main source of SO_2 observed here may be due to refinery which is about 1km away in SW direction of sampling site. Low observed values of SO_2 may be due to the fact that the use of coal in Karachi is negligible and almost all of the population and factories using natural gas (sui gas) as a fuel, which is almost sulphur free. Average variation of PM10 in KIA can also be seen in graph II. During the survey the maximum average concentration of PM10 at KIA was 177.9 $\mu g/m^3$ between 16:30 to 19:30 hours local time, whereas the average concentration was observed to be 147.2 $\mu g/m^3$. The average variation in wind direction during this period was between 200^0 to 251^0 SW, which shows that the major contributor of the pollutants may be the refinery.

Traditional air pollution measurements were also carried out at uptown area of Karachi. The sampling site is located at Latitude $24^0.71'$ and Longitude $67^0.08'$ in the uptown area of Karachi. The sampling site is about 1 km away from the super high way and 20 km down wind from the city centre. The area around the sampling site is very sparsely populated. Air masses reaching the sampling site were generally coming from main super highway. The data at uptown area was also generated in the month of February.

Graph III shows the average concentration of SO_2 and PM10 at uptown area. The maximum average concentration of SO_2 was recorded as 12.5 $\mu g/m^3$ between 15:45 to 17:45 hours local time. The microclimatic condition shows that during the measurement period wind direction was between 180° to 250° NE and wind speed was 4.2 to 5.0 m/s. whereas the maximum average concentration of PM10 at uptown area was found to be 127.9 $\mu g/m^3$ between 15:30 to 17:30 hours local time. The wind direction during this period was between 190° to 260° NE and wind speed was 4 to 5 m/sec, which shows that the pollutant source may be due to vehicular emissions, which were coming from the main super



Graph-III: Average Concentration of SO_2 and PM10 at Uptown Area

highway that has very high traffic density. Low values of SO_2 and PM10 observed here may be due to the fact that the air masses which were coming from the sampling site were diluted and well mixed due to very stable atmospheric condition.

Health effects

Effect of air pollution of human health vary according to the intensity, duration of exposure and health status of exposed population. The effect of SO_2 on human health has been widely studied. The short-term exposure to SO_2 may increase the mortality in the sensitive parts of the population specially children and elderly people. A significant correlation was found between measured SO_2 and specific morbidity recorded by emergency calls. The relation between cases of illness of respiratory tract, especially among children, and unfavorable air pollution was particularly marked [11]. Health effects of suspended particulate matter are usually associated with those of sulphur dioxide as traditionally these pollutants have been attributed to the same sources. Particles in the respirable range, that is smaller than 10μ are of particular interest.

The chemical composition of air born particulate matter also plays an important role in determining the effects on health. Elemental carbon, polynuclear aromatic hydrocarbons (PAHs) and toxic base metals are amongst the constituents of particulate matter which are of particular interest in this regard. In the year 1995 Environmental Protection Agency Quality Standard (EPAQS) recommended the standard of PM10 as 50 $\mu g/m^3$ [9]. The health effect study carried out for EPAQS in UK observed that 10 $\mu g/m^3$ rise in PM10 would result in 2.4 % increased in respiratory admission, 2.1 % in Cardiovascular disease admissions and 1.1 % increase in all causes of mortality [11].

Experimental

The data presented here was collected with the help of Air Pollution Monitoring Mobile Laboratory designed and fabricated by Environmental S.A., France. The laboratory is fully equipped to measure low concentrations of pollutant gases such as SO_2, NO, NO_x, CO, O_3, HC and inhalable particulate matter (PM10) in ambient air. It is also equipped with meteorological sensors mounted on a telescopic mast, data acquisition and processing system. These advanced technology sophisticated instruments are microprocessor regulated and define homogeneous and coherent range. This range of automatic and continuous analyzers enables to monitor ambient air continuously.

An intelligent data logger SAM32 records spot concentration every second and accumulates these to provide 15 minute averages. The logger also monitors instrument alarm and diagnostic functions and controls zero/span response checks of every analyzer. A SCANAIR software was used for acquisition, editing and recording logical and analogical data from SAM32. Fifteen minutes average data of eight days for every site is presented in the form of graphs.

Following are the characteristic of the instrument used for the monitoring.

UV Fluorescent SO_2 Analyzer Model AF 21M

Sulphur dioxide analyzer consists 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.

Characteristics:

Measurement ranges	:0.1,0.25,0.5,1.0,10.0 ppm
Units	: ppm or mg/m^3, ppb or $\mu g/m^3$
Noise	: 0.5 ppb (response time 90")
Minimum detectable	: 1 ppb (response time 90")
Response time	:12-120" (programmable)
Zero drift	:<1%/7 days with
	:automatically zero-ref
Span drift	:<1% / 7 days
Relative Linearity	: 1%
Influence of temperature	: 0.3 ppb/°C
Sample flow rate	:0.5 liters/m
Temperature chamber	: 43 °C

Ambient Suspended Particulate Beta Gauge Monitor Model MPSI 100

The monitor is based on the principle of beta absorption by a particulate, sampled through the instrument and collected on a fiber glass filter tape. An internal microprocessor handles all sequences and automatically calculates the concentration in function of measurement cycles and of sampled air volume. It is fitted with PM10 sample head for suspended particulate sampling.

Characteristics:

Measurement principle: -	beta ray absorption standardized method: AFNOR NFX 43017 concentration measurement in g/m^3 little dependence upon physico chemical composition of dust
Measurement capacity:	1350 samples with a 30 m filter tape.
Measurement cycle	:Range of 7 values:1/2-1-2-4-8-12-24 hrs.
Scan period	4 programmable
positions:	0-1/2-1-2 hours
Results	Mean concentration one cycle and mean concentration on a scan period. Out put Analog 0-10V or 0- 20mA current Loop upon request: 0-1 V50 ohms. Plus train-Frequency 30 or 300Hz (for telephone transmission) Microprocessors printer
Measurement time	: Ts = 200 s
Clean filter tarring	: Automatic at each measurement
Calibration	:To be checked once per year with standard foil gauge delivered with unit.

Conclusion

The measurement of sulphur dioxide and PM10 carried out at Sindh industrial trading estate, Korangi industrial area and Uptown area of Karachi. Both the pollutants at every location was mostly

within WHO threshold limits. During the measurement period at SITE and KIA the air masses were usually coming from the sea and the emissions from the industries and power generation units were also diluted because of topographical conditions. Whereas at uptown area the air masses coming from super highway become diluted and well mixed due to very stable atmospheric condition. Measurement of SO_2 and PM10 at all locations show similar trend through out the measurement period, which indicates that both the pollutants are originated from same sources.

References

1. R. Web, Urban forestry in Kuala Lumpur, Malaysia Arborie. J, 22: 287. (1998).
2. Kenneth Work/Cecil.F, Warmer. Air Pollution, its origin and control, Harper & Paw Publication, New York. 103. (1976).
3. WHO (World Health Organization). Air Quality guidelines for Europe. WHO Regional publication. European Series No.23, WHO. Regional Office for Europe. Copenhagen. Denmark. (1987)
4. Pakistan in Figures. Federal Bureau of Statistics, Statistical Division, Government of Pakistan. (1998).
5. Zarski Lyuba. *World environment*, **36**, 2, 5. (1993).
6. Beg. M. M. A et al. "Survey of polluted stream of Sindh Industrial Trading estate Manghopir Area". Proceeding in Pakistan Academy of Science. **15**, 1 & 2, (1978).
7. Klea Katsouyanni. Environmental Health Perspective. **103**, 2, 23, (1995).
8. Global Pollution and Health. WHO, UNEP & Global environmental monitoring system (GEMS) publication. 6, (1987).
9. Air Health Strategy. "PM10 standard unlikely to show health benefits" Ridgway London. S.W 194 Q.N, England. 1, 18 & 20, (1996).
10. Encyclopedia of Environmental Science. Editor in-chief Fybil P - Parker. Paragon Press, Harper & Row Publication. New York. 470, (1991).
11. Wordley J. et al short-term health effect of Particulate air pollution Thorax 50 (suppl 2) A34, (1995).