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MEASUREMENT OF MAJOR AMBIENT AIR POLLUTION COMPONENTS AT SUB- URBAN AREA OF KARACHI

A H K Yousufzai and Durdana Rais Hashmi

PCSIR Laboratories Complex, off University Road, Karachi- 75280, Pakistan

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Base line study for the measurement of major ambient air pollution components such as O_3, SO_2, CO, NO, NOx, PM10, methane, non-methane along with the meteorological parameters was carried out by Air pollution Monitoring Mobile Laboratory at an urban back ground site of Karachi. The average concentration of O_3 was found to be between 4.62 and 20.36 ppb, SO_2 0.73 and 4.69 ppb, CO 0.14 and 0.77 ppm, NO 0.92 and 2.73 ppb, NOx 3.1 and 7.5 ppb, PM10 142 and 251 $\mu g\ m^{-3}$, methane 1.09 and 2.7 ppm, non-methane hydrocarbon 0.41 and 0.96 ppm.

Key word: Ambient air pollution components, Photochemical oxidant, Baseline data, Ozone.

Introduction

Air pollution is generally the most widespread and obvious kind of environmental damage. Around two billions metric tons per year of air pollutants (CO_2 and wind blown soils not included) are released into the atmosphere. In USA alone some 147 million metric tons of air pollutants are released every year (Parker 1991). Major cities of the world are facing the environmental problems and their air quality is constantly deteriorating. Growing urban population and levels of industrialisation in Karachi are the main causes of air pollutants. The most common air pollutants in 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), and methane and non methane hydrocarbons. Nitrogen dioxide and ozone are regarded as secondary photochemical pollutants, both are dependent on the emissions of NO.

The principal source of NO in urban areas is motor vehicles. In cities where traffic density is high, the emission of NO in presence of sun shine and hydrocarbons produce high concentrations of NO_2 and O_3 as the product of their reaction with hydrocarbons. These photochemical oxidants are also the main constituents of photochemical smog. It has been estimated that each resident of Los Angeles suffers 17 days per year from ozone related symptoms and that attaining air quality standards in this city may cost US 10 billions which would save approximately 1,600 lives each year (Zarski 1993). Sulphur dioxide contributes to acid rain and sulphate aerosol. Particulate matter smog, dust, ozone, and carbon monoxide, all have proven adverse health effects. Over the past twenty years the number of motor vehicles on the road have increased enormously. In Karachi alone there are 650 thousand registered motor vehicles which are increasing at the rate of 11 % per year (Yousufzai 1991). The motor vehicle has inevitably brought with it a host of problems, including atmospheric pollution, noise, death and injuries amounting world wide to several million per year.

Experimental

The measurements of ambient air quality were made by Air Pollution Monitoring Mobile Laboratory, fully equipped with ambient air and particulate monitors designed to measure the low concentration of SO_2, NO, NO_2, NOx, CO, O_3, HC and particulate matter (PM10). The mobile laboratory is also equipped with meteorological sensors mounted on a telescopic mast. These advanced technology instruments are microprocessor regulated and define a homogenous and coherent range. An intelligent data logger SAM32 records spot concentrations every second and accumulates these to provide 15 min averages. The logger also monitors instrument alarm and diagnostic functions and controls daily instrument zero/span response checks. Calibrations were made automatically by NO_2 permeation tube oven and zero gas generator.

Following are the main characteristics of the instruments.

UV Photometric ozone analyser model O3 41M. Ozone computerised analyser with UV energy, temperature and pressure compensation, based on Beer Lambert Law. It has its own zero gas and ozone generator for calibration. A barometric sensor is used inside the measurement chamber for pressure compensation and a gas temperature sensor for temperature compensation. The instrument is microprocessor controlled and automatically calibrated.

*NO-NOx analyser model AC 31M.*Chemiluminescent AC 31M analyser is of two channels type. Measurements of NO and NOx are carried out on practically the same sample. The air sampled by a pump placed at circuit end, is led, 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 into NO). The analyser is coupled with serial R232 output, signal processing and continuous zero control by the microprocessors.

*UV fluorescent SO_2 analyser model AF 21M.*Sulphur dioxide analyser consists of zinc ray UV lamp with stabilised power supply, continuous energy monitor and compensation for measurement at constant energy level, and integrated carbon "KICKER" for continuous removal of interfering hydrocarbons.

Gas filter correlation CO analyser model CO 11M. Based on the NDIR correlation photometry principle for CO measurement together with high sensitive and interference rejection and insensitive to vibration.

DANI TNMH 451 methane non-methane hydrocarbons. DANI TNMH 451 determines the total methane non-methane hydrocarbons contents in the ambient air by means of flame ionisation detection principle (FID), after catalytic subtraction. A built-in pump in the instrument aspirates the air to be analysed and a small part of it is conveyed to the analyser at a constant flow rate, whereas the rest is vented through a precision back pressure regulator. The ambient air to be analysed is sent to FID through a special scrubber which removes all the hydrocarbons except methane. While the other portion of the gas is sent directly to FID which gives the result for total hydrocarbons. The operative parameters are managed by a microprocessor which controls all the operative phases of the instruments.

*Ambient suspended particulate beta gauge monitor model MPSI 100.*The monitor is based on the principle of beta absorption by 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.

OBSERMET CM5 (Pyranometer). The pyranometer CM5 is designed for measuring the irradiance on a plane surface, which results from the direct solar radiation and from the diffuse solar radiation incident from the hemisphere above. It complies with the specifications for a "first class" pyranometer, as published in the "Guide to Meteorological Instruments and Methods of Observation" WMO-Geneva, Switzerland.

*OBSERMET OMC-506 (Barometric pressure sensor):*The OMC-506 is a high accuracy, signal conditioning unit, taking a differential input signal and offering a variety of different output options. The sensitivity of the unit is continuously variable over a 5:1 turn down range without recourse to soldering etc.

*OBSERMET OMC-160 (Wind speed/direction sensor).*The OBSERMET wind sensor combination OMC-160 consists of wind speed sensor and wind direction sensor. The wind speed sensor is a rotary -cup type unit made from stainless steel. Rotating of the cup unit generates pulses which are converted by microprocessor transmitter into a digital current-loop signal The wind direction sensor is a wind vane type unit. The wind vane drives a resolver, from which the reference coils are connected to the microprocessor transmitter housed in the sensor. Thus, the output signals of wind direction and wind speed are combined into digital serial signals. (Serial current-loop, 300 band, ASCII Code).

OBSERMET OMC-402 (Humidity and temperature sensor). The humidity sensor, a solid state device, changes its electrical characteristics at extremely small changes in humidity. These changes are detected, linearized and amplified as an analogue output by electronic circuitry. The temperature sensing system also uses integrated circuit technology in combination with an accurate temperature element (PT-100) to produce high quality data.

Fifteen minutes average data of ten days from the KDA Filter Plant , COD Hills Karachi is presented in Table 1.

Results and Discussion

The urban back ground site Filter plant COD hills was selected by PCSIR, EPA Sindh and EEC consultants to obtain base line data with the air pollution monitoring mobile laboratory. The site is some distance away from main sources of pollution and is more representative of levels of general background exposure. This site may be used to demonstrate the impact of control strategies on air packets over Karachi. The generated data would lay the foundation for implementation of appropriate air quality standards and can be used in future by scientists and technologists for references in air pollution modelling and in studying the trends in pollution level and effectiveness of pollution control measures.

Karachi Development Authority water supply Filter plant COD hills is located at Lat:67° 06′ Long 24°53′ with an elevation of 160 feet. Figure 1 shows the location of Karachi Development Authority water supply works. The sampling site is relatively elevated and is an open place. The site is surrounded on either side by residential area. In 320 NW to 240 SW there is main university road about 1 Km away from sampling site having traffic density of 3,23,245 vehicles per day (Anon 1993). The population living around the

Table 1

Average concentration of major ambient air pollutants at filter plant, COD hills, Karachi

HH:MM	OZONE ppb	SO2 ppb	CO ppm	NO ppb	NOX ppb	PM10 ug/m3	METH ppm	N.METH ppm	W.Speed m/sec	W.Dir Deg	Humidity %	Temp °C	BARO m.Bars	Solar W/Sq.m
0 0:15	7.52	1.04	0.50	0.97	4.48	137.66	1.81	0.55	3.45	68.64	71.90	25.90	1005.4	1.95
00:3 0	7.49	1.02	0.49	0.99	4.44	137.78	1.84	0.54	3.44	60.73	73.90	25.70	1005.4	2.18
0 0:45	7.58	1.00	0.49	1.01	4.42	137.94	1.85	0.54	3.46	45.73	74.10	25.60	1005.3	2.40
01:00	7.47	1.08	0.52	0.98	4.41	138.03	1.97	0.61	3.38	74.20	70.40	25.50	1005.2	2.18
01:15	6.94	1.01	0.47	0.98	4.48	138.16	2.01	0.58	2.94	86.18	70.60	25.40	1005.2	2.63
01:30	7.26	1.02	0.43	1.01	4.19	134.20	2.03	0.54	3.01	54.73	69.70	25.40	1005.1	2.18
01:45	7.66	1.01	0.35	0.98	3.99	115.31	1.93	0.54	2.93	45.36	69.50	25.50	1004.9	2.52
02 :00	7.66	0.99	0.34	0.96	4.00	116.09	1.99	0.58	3.03	62.64	69.70	25.40	1004.7	2.40
0 2:15	6.61	0.79	0.14	1.00	3.59	116.69	2.08	0.68	2.97	65.64	73.40	25.40	1004.6	2.51
0 2:30	7.55	0.96	0.33	0.95	3.54	116.69	2.18	0.68	2.88	67.00	73.20	25.60	1004.6	2.63
0 2:45	7.83	0.94	0.37	0.92	3.47	116.65	2.21	0.67	2.85	75.00	73.60	25.50	1004.5	2.51
0 3:00	7.72	0.89	0.36	0.98	3.38	116.65	2.16	0.69	2.81	91.82	71.60	25.40	1004.4	2.40
0 3:15	7.60	0.86	0.34	0.92	3.15	116.83	2.14	0.71	2.55	96.91	72.30	25.30	1004.4	2.74
0 3:30	7.29	0.86	0.34	0.96	3.10	118.95	2.13	0.72	2.50	125.09	72.80	25.30	1004.4	2.51
0 3:45	7.24	0.83	0.35	0.95	3.13	124.39	2.19	0.77	2.58	89.73	73.70	25.20	1004.3	2.40
0 4:00	6.96	0.84	0.34	0.98	3.17	124.36	2.12	0.67	2.59	102.45	74.40	25.00	1004.2	2.70
0 4:15	6.97	0.80	0.31	0.95	3.18	126.86	2.24	0.69	2.58	101.00	74.40	25.10	1004.2	2.69
0 4:30	6.89	0.79	0.32	0.97	3.24	126.90	2.31	0.79	2.25	98.27	72.90	25.00	1004.2	2.91
0 4:45	6.59	0.79	0.36	1.01	3.35	124.68	2.31	0.79	2.18	135.91	73.40	24.90	1004.2	2.82
0 5:00	6.29	0.79	0.37	1.00	3.36	124.70	2.17	0.74	2.36	100.55	74.50	24.90	1004.2	2.88
0 5:15	6.12	0.73	0.34	1.01	3.40	124.73	2.40	0.82	2.25	113.09	74.90	24.70	1004.4	3.28
0 5:30	5.84	0.76	0.37	1.07	3.68	123.41	2.61	0.92	2.35	104.82	75.20	24.40	1004.4	11.73
0 5:45	5.88	0.80	0.36	1.04	3.52	119.05	2.46	0.96	2.50	92.00	75.60	24.70	1004.5	12.38
0 6:00	5.69	0.80	0.40	1.02	3.54	118.95	2.46	0.95	2.41	87.91	75.70	24.70	1004.6	24.63
0 6:15	5.53	0.83	0.40	1.08	3.91	118.91	2.30	0.81	2.55	115.09	78.30	24.70	1004.7	23.72
0 6:30	5.41	0.84	0.48	1.14	4.66	118.94	2.24	0.75	2.45	101.09	78.70	24.60	1004.9	25.99
0 6:45	5.28	0.87	0.61	1.28	5.45	118.90	2.43	0.85	2.34	69.18	78.20	24.60	1005.2	32.78
0 7:00	4.80	0.95	0.64	1.53	5.95	118.90	2.70	0.88	2.48	83.36	78.70	24.60	1005.3	62.66
0 7:15	4.62	0.96	0.70	1.84	6.58	120.06	2.67	0.90	2.42	81.55	78.90	24.70	1005.5	88.79
0 7:30	4.62	1.02	0.75	1.96	6.66	129.78	2.44	0.88	2.74	109.45	80.50	24.80	1005.7	132.33
0 7:45	4.86	1.03	0.77	2.43	7.23	152.25	2.19	0.85	2.85	76.82	79.40	25.20	1005.9	189.46
0 8:00	4.87	1.10	0.73	2.73	7.55	152.34	1.98	0.71	2.97	92.45	78.60	25.10	1006.1	251.85

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(Table 1 Contd ....)

0 8:15	5.21	1.05	0.65	2.55	7.29	152.34	1.87	0.55	3.19	86.82	77.80	25.50	1006.3	320.76
0 8:30	5.45	1.05	0.62	2.39	7.10	152.05	1.83	0.57	3.53	102.27	75.50	25.90	1006.6	367.37
0 8:45	5.82	1.12	0.66	2.10	6.25	152.02	1.83	0.57	3.38	102.55	73.40	26.20	1006.7	428.14
0 9:00	6.00	1.16	0.61	1.77	5.45	151.42	1.64	0.51	3.30	115.91	70.70	26.60	1007.1	473.50
0 9:15	6.80	1.24	0.56	1.59	5.06	151.51	1.64	0.49	3.49	106.64	68.40	27.00	1007.1	513.75
0 9:30	7.04	1.33	0.52	1.48	4.95	157.56	1.61	0.51	3.42	105.72	66.80	27.60	1007.1	560.17
09:45	7.45	1.39	0.53	1.55	4.94	173.55	1.65	0.51	3.17	144.02	64.90	28.00	1007.4	595.73
10:00	8.21	1.43	0.50	1.59	5.08	173.59	1.58	0.51	3.35	131.96	62.40	28.50	1007.5	637.91
10:15	9.50	1.46	0.49	1.55	5.07	173.62	1.59	0.48	3.55	113.88	59.60	28.90	1007.5	677.90
10:30	10.75	1.48	0.45	1.46	4.74	173.62	1.55	0.47	3.55	122.05	57.60	29.40	1007.6	720.91
10:45	11.65	1.46	0.40	1.35	4.41	173.28	1.52	0.48	3.43	120.40	55.20	29.90	1007.5	762.22
11:00	12.26	1.47	0.43	1.41	4.24	173.30	1.53	0.46	3.27	162.85	53.30	30.40	1007.4	796.64
11:15	13.62	1.47	0.42	1.47	4.18	173.32	1.46	0.48	3.63	134.98	50.70	30.70	1007.4	832.63
11:30	14.72	1.48	0.46	1.31	4.25	186.01	1.45	0.48	3.63	101.05	50.80	31.20	1007.2	851.75
11:45	15.70	1.58	0.44	1.40	4.38	228.40	1.57	0.57	3.58	123.12	49.90	31.40	1007.1	873.55
12:00	16.23	1.59	0.47	1.25	4.23	229.52	1.52	0.51	3.73	84.35	46.60	31.70	1006.8	892.60
12:15	16.11	1.61	0.43	1.22	3.96	229.48	1.54	0.51	3.86	139.45	45.10	32.00	1006.7	914.35
12:30	17.61	1.65	0.40	1.17	3.88	229.52	1.52	0.49	4.28	161.27	44.50	32.20	1006.5	928.19
12:45	18.36	1.63	0.44	1.26	4.03	229.60	1.53	0.52	4.28	179.73	46.00	32.30	1006.3	927.30
13:00	19.29	1.63	0.43	1.27	4.27	229.59	1.54	0.53	4.38	189.98	45.30	32.50	1006.1	925.50
13:15	19.90	1.61	0.40	1.22	4.21	229.52	1.54	0.51	4.73	188.27	44.40	32.60	1005.8	920.83
13:30	19.98	1.42	0.38	1.25	4.07	236.96	1.55	0.52	4.63	183.45	43.70	32.60	1005.6	909.35
13:45	20.36	1.36	0.42	1.18	4.02	251.72	1.56	0.51	4.79	221.00	42.90	32.70	1005.4	892.17
14:00	20.09	1.36	0.40	1.29	4.09	251.76	1.55	0.49	4.82	252.36	42.80	32.70	1005.2	872.19
14:15	20.09	1.35	0.41	1.25	4.06	251.80	1.42	0.51	4.99	262.64	43.70	32.60	1005.3	846.74
14:30	19.34	1.31	0.40	1.24	3.84	251.80	1.27	0.43	4.92	250.36	43.90	32.50	1004.8	812.53
14:45	18.93	1.35	0.38	1.24	3.79	251.84	1.25	0.42	4.91	249.18	43.90	32.40	1004.6	777.05
15:00	18.68	1.34	0.37	1.17	3.70	251.80	1.26	0.41	4.85	284.91	43.60	32.40	1004.5	732.97
15:15	18.82	1.43	0.37	1.20	3.60	251.84	1.24	0.43	5.09	196.36	43.30	32.30	1004.4	688.08
15:30	18.86	1.61	0.36	1.28	3.92	246.04	1.14	0.41	4.87	196.18	42.90	32.30	1004.3	638.09
15:45	18.25	1.54	0.35	1.21	3.95	225.56	1.12	0.41	5.03	228.64	42.40	32.20	1004.2	591.85
16:00	18.50	1.42	0.36	1.23	3.75	225.60	1.11	0.42	5.09	164.64	42.40	32.10	1004.1	545.85
16:15	18.23	1.31	0.38	1.15	3.65	225.64	1.11	0.43	4.97	228.45	43.10	32.00	1004	497.41
16:30	18.34	1.24	0.39	1.15	3.75	225.60	1.09	0.44	4.99	259.36	43.70	31.80	1004	442.98
16:45	17.61	1.24	0.42	1.19	4.03	225.64	1.13	0.45	4.89	192.18	44.80	31.50	1004	384.56
17:00	16.94	1.24	0.46	1.22	4.33	225.69	1.14	0.45	4.96	186.27	46.10	31.20	1003.9	331.71
17:15	15.19	1.25	0.52	1.28	4.73	225.72	1.22	0.46	4.77	248.91	48.10	30.90	1004.1	271.05

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(Table 1 Contd ....)

17:30	13.98	1.30	0.55	1.21	4.65	219.52	1.22	0.46	4.67	254.09	48.30	30.60	1004.1	222.18
17:45	13.21	1.33	0.60	1.28	5.29	205.08	1.21	0.46	4.68	221.45	49.70	30.10	1004.1	172.52
18:00	11.84	1.38	0.66	1.27	5.47	205.08	1.25	0.49	4.72	193.91	52.00	29.60	1004.2	122.54
18:15	9.59	1.38	0.69	1.23	5.62	205.08	1.25	0.51	4.38	259.73	55.80	29.10	1004.3	77.43
18:30	8.95	1.32	0.70	1.29	5.48	205.04	1.27	0.51	4.53	230.64	59.10	28.50	1004.4	40.82
18:45	7.64	1.29	0.69	1.23	5.65	205.04	1.23	0.47	4.55	226.18	62.70	28.00	1004.5	16.27
19:00	7.35	1.30	0.75	1.21	6.20	205.00	1.25	0.46	4.60	164.18	64.60	27.60	1004.7	5.02
19:15	6.36	1.27	0.77	1.25	6.15	205.00	1.25	0.47	4.55	137.09	65.80	27.40	1004.9	2.29
19:30	6.27	1.38	0.73	1.29	6.20	205.36	1.25	0.47	4.63	111.73	66.30	27.20	1004.9	2.17
19:45	6.85	1.37	0.68	1.17	5.48	204.20	1.26	0.47	4.95	82.64	66.70	27.00	1005.1	2.40
20:00	6.65	1.36	0.72	1.13	5.28	204.16	1.27	0.48	4.73	80.36	67.40	27.10	1005.3	1.95
20:15	6.42	1.34	0.72	1.13	5.42	204.16	1.25	0.48	4.49	84.27	68.20	26.80	1005.4	2.06
20:30	6.29	1.33	0.67	1.14	5.08	204.12	1.23	0.47	4.60	81.73	69.60	26.70	1005.5	2.06
20:45	5.77	1.26	0.69	1.07	5.15	204.08	1.24	0.48	4.39	59.00	70.90	26.50	1005.6	2.07
21:00	5.73	1.28	0.69	1.15	5.31	204.08	1.21	0.44	4.11	56.45	71.60	26.40	1005.7	2.07
21:15	6.36	1.21	0.61	1.12	4.95	204.08	1.22	0.45	4.42	54.18	71.90	26.40	1005.8	1.95
21:30	6.13	1.27	0.67	1.10	5.23	185.00	1.23	0.46	4.25	24.45	71.90	26.30	1006.1	1.95
21:45	5.50	4.69	0.71	1.10	5.04	147.96	1.21	0.49	4.31	33.09	72.70	26.30	1006.2	2.17
22:00	5.42	3.18	0.68	1.05	4.67	148.20	1.21	0.46	4.17	36.55	73.90	26.10	1006.3	2.08
22:15	5.46	2.21	0.71	1.10	4.78	148.10	1.23	0.44	4.10	30.45	73.90	26.00	1006.4	2.18
22:30	5.43	1.64	0.70	1.16	5.08	148.64	1.21	0.42	3.96	65.28	73.10	26.00	1006.5	2.19
22:45	5.42	2.03	0.69	1.05	5.10	148.64	1.22	0.45	3.93	39.92	73.00	26.00	1006.6	2.21
23:00	5.62	1.70	0.72	1.16	5.13	148.44	1.29	0.44	3.80	64.55	73.90	25.90	1006.6	2.10
23:15	6.37	1.40	0.58	1.08	4.59	148.96	1.26	0.41	4.06	72.10	74.40	25.90	1006.7	2.10
23:30	6.87	1.30	0.53	1.08	4.35	143.09	1.36	0.46	3.87	39.59	75.30	25.80	1006.7	2.57
23:45	6.67	1.25	0.60	1.15	4.55	143.63	1.42	0.47	3.88	70.21	75.40	25.80	1006.7	2.31
2 4:00	7.00	1.19	0.57	1.10	4.61	142.71	1.41	0.46	3.93	96.57	74.80	26.00	1006.5	2.39
Total Averag	9.89	1.29	0.51	1.26	4.60	174.13	1.65	0.56	3.75	124.66	63.71	27.81	1005.44	278.81
Maximum	20.36	4.69	0.77	2.73	7.55	251.84	2.70	0.96	5.09	284.91	80.50	32.70	1007.6	928.19
Minimum	4.62	0.73	0.14	0.92	3.10	115.31	1.09	0.41	2.18	24.45	42.40	24.40	1003.9	1.95

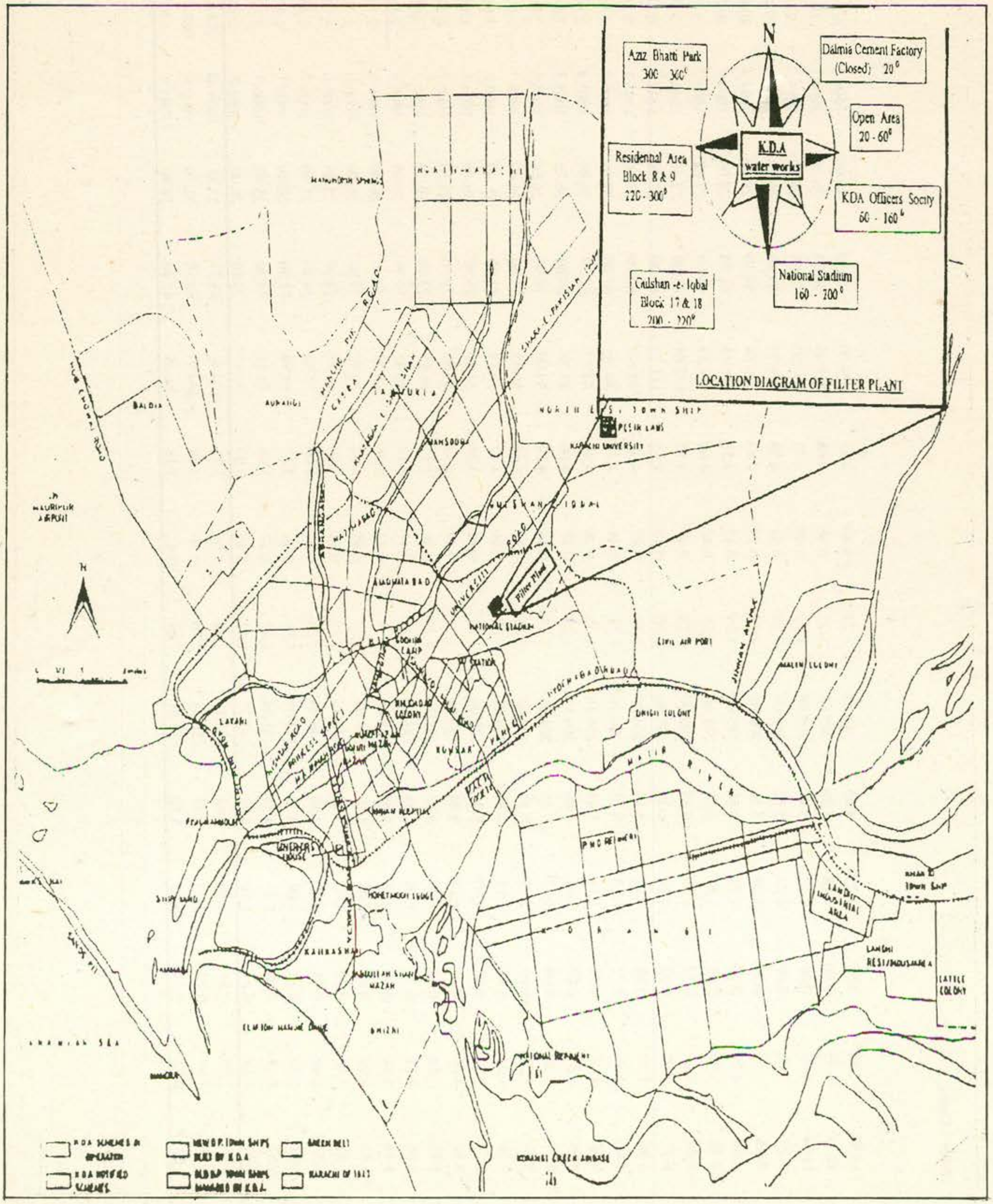

Fig 1. Key plan of Karachi.

site belongs to the middle and high income groups.

Measurements of major ambient air pollutants such as O_3, SO_2, CO, NO, NOx along with meteorological data were recorded round the clock for ten days at this location and total average concentration is presented in Table 1. The fifteen minutes average concentration of O_3 was found to be between 4.62 and 20.36 ppb, SO_2 0.73 and 4.69 ppb, CO 0.14 and 0.77 ppm, NO 0.92 and 2.73 ppb, NOx 3.1 and 7.5 ppb, PM10 142 and 251 $\mu g\ m^{-3}$, methane 1.09 and 2.7 ppm, non-methane hydrocarbon 0.41and 0.96 ppm.

The maximum average concentration of PM10 was found to be around 251.8$\mu g\ m^{-3}$ at filter plant COD Hills from 14:45 to 21:45 h local time. The average variation in wind direction during this period was 180° to 250°. It seems that the pollutants were coming from the main university road which was about 1 Km away from the sampling site.It is also worth noting that vehicles plying on the roads of Karachi tend to be older and poorly maintained, making them a significant source of air pollution specially of particulate matter.

Particulate matter coming out of the vehicle contains elemental carbon, unburned hydrocarbons and toxic base metals. Detailed inventory of organic and elemental emissions of carbon in Los Angeles, attributed approximately 25 percent of emissions to petrol engine vehicles and 25 percent to diesel vehicles . Black elemental carbon is the dominant fraction of diesel (Spengeler *et al* 1990). Health effects of SPM are usually associated with those of SO_2 as traditionally these pollutants have been attributed to the same sources. Particles in respirable range i.e. less than 10 μm, are of particular interest as regards human health.

Chemical composition of air borne particulate matter also plays an important role in determining the effect on health. Several studies have documented the effect of particulate air pollution on health in virtual absence of SO_2 (Anon 1996). It has also been reported that effect on lung functions, acute respiratory symptoms, and medication use have been found at 24 h average of PM10 level even below 115$\mu g\ m^{-3}$ (WHO 1987).

Methane is considered to be one of the green house gases. Studies of C^{14} content of atmospheric CH_4 suggest that about 20 percent of the total annual emissions (i.e. 100 x 106) are from fossil fuel carbon sources. It has been reported that the average concentration of methane has been doubled from the pre industrial period value of 0.8 ppm, to present day values of 1.7 ppm(Houghton and Varney 1992). The maximum concentration of methane 2.7 ppm was found at 07: 00 local time and minimum concentration of 1.09 ppm at 16:30 in evening. Total average concentration was found to be 1.65 ppm. The high values of methane may be due to the residential area around the sampling site. Natural gas (99% methane) is being used in almost every house for cooking and other household purposes. According to Stockholm Environmental Institute (SEI) inventory, rice cultivation and live stock collectively account for almost 60 percent of man made flux of methane to atmosphere. Energy related sources contribute the bulk of remainder (23 %), with just three countries, China, USA and the former USSR accounting for 60 percent of the emission of this source (UNEP 1993-94).

The maximum average concentration of SO_2 was found to be 4.69 ppb (12.5$\mu g\ m^{-3}$)once in ten days. The total average concentration was observed to be 1.29 ppb (3.43$\mu g\ m^{-3}$) which is relatively very low .The SO_2 concentration found at this location is well with in WHO limits (40-60 $\mu g\ m^{-3}$) (WHO 1987). The low level of SO_2 observed may be due to the fact that the use of coal in the urban area of Karachi is negligible and 100 % population in this area is using natural gas (Sui gas) which is sulphur free.

In the last six years, it has been reported in many epidemiological studies that daily variation in exposure to the major air pollution components such as ozone, particulate matter and SO_2 are associated with health effects ranging from increased mortality and hospital admissions to subtle changes in lung function at low to very low concentration (Brunekreef *et al* 1995). It has also been observed that vast majority of hospital admissions in Canada occured when the 24 h average of SO_2 were below 200 $\mu g\ m^{-3}$. Respiratory and asthma visits were found to be correlated with SO_2 in both the winter and summer seasons (Bates *et al* 1990).

Maximum average concentration of carbon monoxide (CO) was found to be 0.77 ppm in this area. The total average concentration was recorded to be 0.51 ppm. The WHO guidelines for carbon monoxide exposure are just 10 mg m^{-3} over 8h and 30 mg m^{-3} over any 1h. The carbon monoxide found in this area is relatively very low (0.6 mg m^{-3}). This may be because of the relatively fewer number of motor vehicles plying in the residential area close to the monitoring site. Percentage contribution of anthropogenic emission sources in 1987 attributed 90% of carbon monoxide present in Los Angeles to transport (Anon 1991). The low values observed here are also due to low traffic density.

Nitrogen oxides are highly reactive gases formed when nitrogen in fuel or combustion air is heated to temperature above 650 °C in presence of oxygen. The initial product nitric oxide (NO) is oxidised further in atmosphere to nitrogen dioxide (NO_2) which is an active compound in photochemical smog formation. Vehicle emissions are of particular significance because of low emission heights. Seventy percent of NO_2 concentration in urban area can be attributed to vehicle pollutants (Varey and William 1988; Simpson 1987). Maximum concentration of NO 2.73 ppb and NOx 7.5 ppb was found at 8:00 h. The total average concentration of NO was 1.26 ppb and that of NOx 4.60 ppb. Figure 2 shows the variation of NO, NOx and O_3. The formation of ozone was evident during day time and higest concentration of ozone was found when the solar radiation was also

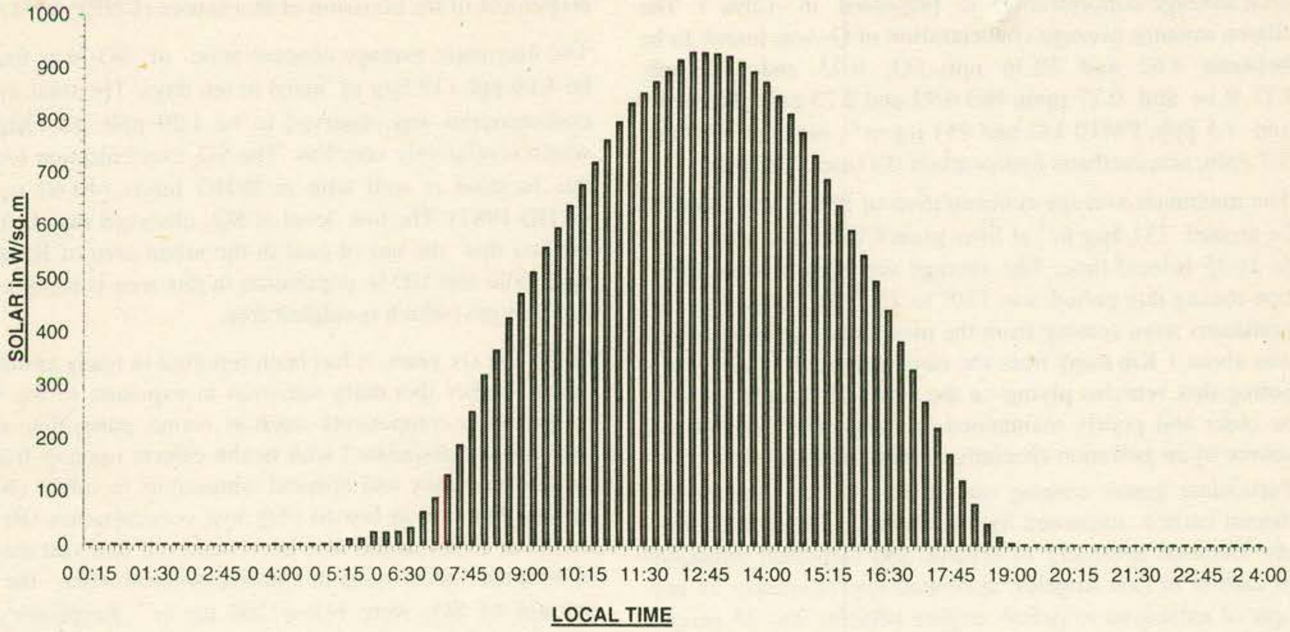

Fig. 2. Average variation of solar energy.

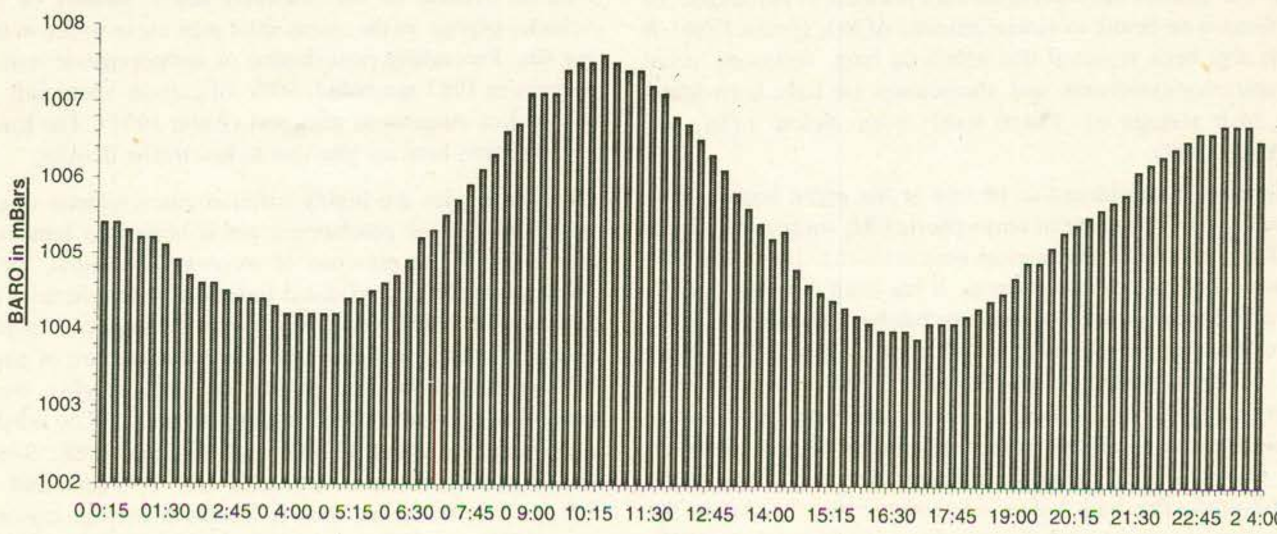

Fig. 3. Average variation in baro.

high (Fig. 3). The study was carried out in winter and the atmospheric conditions were more stable. It can be seen from the graph that the balance between NO, NOx and O_3 shifted in favour of ozone production due to photochemical dissociation of NO_2, resulting in the maximum concentration of ozone in mid afternoon. The ozone level decreased in the evening as the level of ultraviolet radiation from the sun also declined during this period. Ozone concentrations were often elevated in the down wind direction of urban area because of the time lag involved in photochemical processes and NO scavenging in polluted atmosphere. The air masses were coming from the university road at this location. The main contribution of photochemical oxidants may be due to motor vehicles. Long range transport of air pollution can also have national and regional impacts. Oxides of nitrogen and sulphur in the "urban plume" can contribute to acid deposition at great distances from the city.

The effect of air pollutants on health, published after a large number of epidemiological studies, have demonstrated the effects of major air pollutants on health at concentrations below existing WHO guidelines and standards. These studies suggest that health effect can occur at levels far below the US EPA standards. For example effects of ambient ozone level on lung function of subjects exercising out door have now been documented at one hour maximum level not exceeding 120 $\mu g\ m^{-3}$ i.e. half the current US EPA standards (Brunekreef *et al* 1995).

Conclusion

The baseline data generated for major ambient air pollutants at sub urban area of Karachi shows that all the values obtained for O_3, SO_2, CO, NO, NOx, methane, non-methane, are within WHO threshold limits. The generated data will play a part in laying the foundation for implementation of appropriate ambient air quality standards for Pakistan.

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