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AIR POLLUTION IN KARACHI
Part I. Survey of Smoke Concentration

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The level of smoke concentration, lead and tarry deposit on tree leaves has been determined during the surveys carried out in 1975, 1982 and 1983 along the main roads of Karachi. The highest smoke concentration is found at the Tibet Centre, where it was 270 $\mu g/m^3$ in 1975, 598 $\mu g/m^3$ in 1982 and 623 $\mu g/m^3$ in 1983. The maximum amount of tarry deposits on leaves is 4.987 g/sq. ft. containing 0.019% lead, found in the Burns Road Area near the KMC School. The results have been compared with the previous surveys in this context and it has been noted that at all the sampling points, the smoke level during the last 14 years has alarmingly increased by about 5 times.

Key words: Pollution Air; Smoke Concentrations; Environmental Survey.

INTRODUCTION

Air pollution has emerged as a major ecological problem among the scores of environmental degradation processes initiated by automobile transportation. It poses a threat to the normal function of the ecosystem as well as to the health of urban and rural dwellers.

There has been a hundredfold increase in the number of automobiles in the country. In 1983 alone 30,000 cars were imported; this was the largest import on record for one year upto that time. With the Suzukis coming into local production, the number of small cars is likely to increase many times in not too distant a future.

Karachi is the main industrial centre and the only port city of Pakistan. Consequently it requires large fleet of vehicles for the transportation of approximately 1.5 million persons, raw material as well as products. Cars are used to meet the demand of easy living of the middle and high income group of a pseudo-affluent society and rickshaws and Suzukis as a cheap transport for middle class families. In Karachi alone there are three times as many vehicles now as there used to be in the whole of Pakistan in 1968-69; the total number during recent times is one third of that in the country.

There were 486,000 registered auto vehicles in Karachi upto August 1985. Table 1. records the tremendous growth in the population of auto vehicles during the past seven years in Karachi. The growth of various categories of vehicles from 1977 to 1984 was cars/jeeps/station wagons 173.3 %, motor cycles/scooters 137 %, taxies 78.9 %, rickshaws 30.6 %, buses and mini buses 140.2 %, trucks 94.6 % and others 289.2 %. The present rate of growth, i.e. 20.8 % per year, suggests that there would be more than two million vehicles by the end of the century in the city.

The city traffic comprises old as well as new vehicles with the former being more abundant than the latter. The auto exhaust from old vehicles contains more unburnt fuel, carbon monoxide and smoke, particularly in the case of diesel run engines than the new ones [9]. The total amount of petroleum for transport used in the country is approximately 3 million tons and as per estimates, Karachi consumes over one million tons a year.

Vehicles like buses, minibuses and trucks run on diesel engines give off much less carbon monoxide and unburnt fuel than petrol engines, if well maintained. However, they are liable to emit black smole with the passage of time and particularly due to poor maintenance [7]. Genuine spare parts availability and the cost of their replacement are prohibitive factors in maintenance and consequently once imported, the vehicles are kept running as long as possible with the worn-out machinery and parts and thus create nuisance. They are withdrawn only when totally road unworthy. Alongwith the exhaust emission in the form of smoke, carbon monoxide, nitrogen oxides etc., a substantial quantity of lead and tarry material is pumped into the air of 135 miles of major arterians, 115 miles minor arterians and 142 miles distributors of the city every year. Thus the air besides being depleted of oxygen is simultaneously contaminated by toxic and unwanted gases. The quantity of foul emission is increasing every year because

Table 1. Motor vehicles registered in Karachi*.

Year	Cars, Jeeps Station Wagons	Motor cycles/ Scooters	Taxies	Motor Rickshaws	Buses and Minibuses	Trucks	Other	Total
1977	65,415	85,091	5,801	12,691	4,294	5,615	7,672	1,86,585
1978	81,222	1,03,078	7,148	12,999	5,150	6,367	9,652	2,25,616
1979	96,639	1,18,796	8,054	14,170	6,129	7,207	13,262	2,64,257
1980	1,13,133	1,38,648	8,497	15,571	7,500	7,999	16,521	3,07,869
1981	1,26,454	1,54,798	9,029	16,185	8,227	8,960	20,331	3,43,984
1982	1,41,297	1,71,162	9,878	16,482	8,747	9,815	23,828	3,81,209
1983	1,57,594	1,86,809	10,296	16,529	9,351	10,401	26,248	4,17,218
1984	1,78,786	2,02,042	10,301	16,579	10,312	10,924	29,864	4,58,808
1985 Up to June	1,88,901	2,10,468	10,366	16,609	10,609	11,319	30,768	4,79,040
1985 Up to Aug.	1,92,587	2,13,196	10,396	16,616	10,658	11,409	31,043	4,85,905

*Source: Traffic Engineering Bureau (KDA)

the rate of replacement of the old vehicles continues to be very low.

The city of Karachi is therefore faced with two major problems from the exhaust of the automobiles: one is smoke and tar from diesel engines and two-stroke engines respectively and the other is the dispersion of decomposition products of lead additives used in gasoline [6]. This paper describes the result of survey carried out during the last few years to determine the extent of pollution due to particulate matter.

EXPERIMENTAL

Measurement of smoke. There portable appartuses were used for carrying out the survey. Each appartus consisted of a filter clamp and a battery operated pump attached to an air pollution gas meter to record the volume of the air sampled.

Smoke stain was obtained by drawing a known volume of air through Whatman No. 1 filter paper. Very dark stains resulting from heavy pollution were avoided by using a larger diameter clamp and appropriate size filter paper or by reducing the duration of sampling since calibration of intensity against concentration of smoke is reliable only for light stains [8].

An EEL smoke stain reflectometer designed by Evans Electroselenium Ltd. England, was used for the assessment of smoke concentration in air by the calibration formula reported earlier [2]. Air velocity, temperature and humidity at the site were recorded by standard methods.

Samples of leaves were collected from road side trees. The tarry substance deposited on the leaves was analysed by the usual solvent extraction method. A Bausch and Lomb Spectronic – 21 spectrophotometer was used for lead determination from tarry material by the dithiazone method [10].

Regular surveys were carried out by collecting air samples during working hours from the following points:

(1) Sabil Masjid, (2) Numaish,
(3) Tibet Centre, (4) Burns Road,
(5) Jamia Cloth Market, (6) Lakshmi Building,
(7) Mereweather Tower, (8) Regal Bus Stop, and
(9) Empress Market.

Description of sampling points. Sampling point No. 1 is located at the confluence of traffic from North Karachi, F.B. Area and Liaquatabad via Jehangir Road; from Nazimabad and Gulbahar through Business Recorder Road and from district east of Karachi via Bahadur Yar Jang Road. This place is open with only few multi-storeyed buildings but the volume of traffic is so large that traffic jams are a common feature which gives rise to a high degree of pollution at this point.

Sampling point No. 2 is the Numaish roundabout which is a fairly open place, but it has to handle a traffic from east merging into the already large volume coming from north to pass on to Saddar and the commercial areas on M.A. Jinnah Road. The west of Quaid-i-Azam's Mausoleum faces this point and is therefore exposed to the pollutants coming along with the westerly wind.

Point No. 3 located near the Tibet House is the most congested spot of the city; here the road is quite narrow and multistoreyed buildings like Charnia Hospital and Tibet House have been constructed which do not allow the pollutants to disperse easily. Moreover, there is a traffic light at this point so that at each stoppage the concentration of pollutants starts building up.

Sampling point No. 4 is a very narrow portion of Burns Road where traffic slows down due to traffic light and also the sharp turn which the traffic from Shahrah-e-Liaquat has to take. This point is not quite open and is surrounded by buildings and a few trees. The pollutants do not get much chance to disperse here also.

Sampling points No. 5 and 6 are fairly open and at these points the traffic on M.A. Jinnah Road is one way, thus reducing the volume.

Point No. 7 is the terminus of most of the buses coming from all over the city areas. The vehicles are generally kept idling here for ten to fifteen minutes and for this reason the smoke concentration is quite high; the sampling point is open.

Sampling point No. 8 is the main commercial area of Saddar which receives traffic from all over the city. Being near a bus stop as well as a traffic light, it is faced with the build up of pollutant level at each stoppage of the large traffic volume.

Sampling point No. 9 is near the main market, commercial area as well as a bus stop. The traffic flow distributes from here to all parts of the city and hence there is a usual accumulation of pollutants.

RESULTS AND DISCUSSION

Periodic surveys carried out in 1969, 1972 [1] and 1973 [2] have shown that the air in Karachi Metropolitan area contains carbon monoxide, smoke and particulate matter beyond permissible limits [3, 4, 5]. In 1975 it was reported that the emission of smoke and tarry materials has not only started damaging the Quaid-i-Azam's Mausoleum but also important monuments such as Mereweather Tower etc.

Monthly average smoke concentration together with air velocity, temperature, humidity and the average number of vehicles per hour operating during each month for the year 1975, 1982 and 1983 are presented in Tables 2-10. The monthly average concentration of smoke for the said years is shown in Figs. 3-11. It has been observed that during working hours a cloud of smoke usually hangs over traffic congestion spots. A photograph of M.A. Jinnah Road taken from Quaid's Mausoleum shows the extent of pollution.

It may be seen from the data reported here that at all sampling points, the smoke level during the last 14 years has increased by about five times from 1969 to 1983.

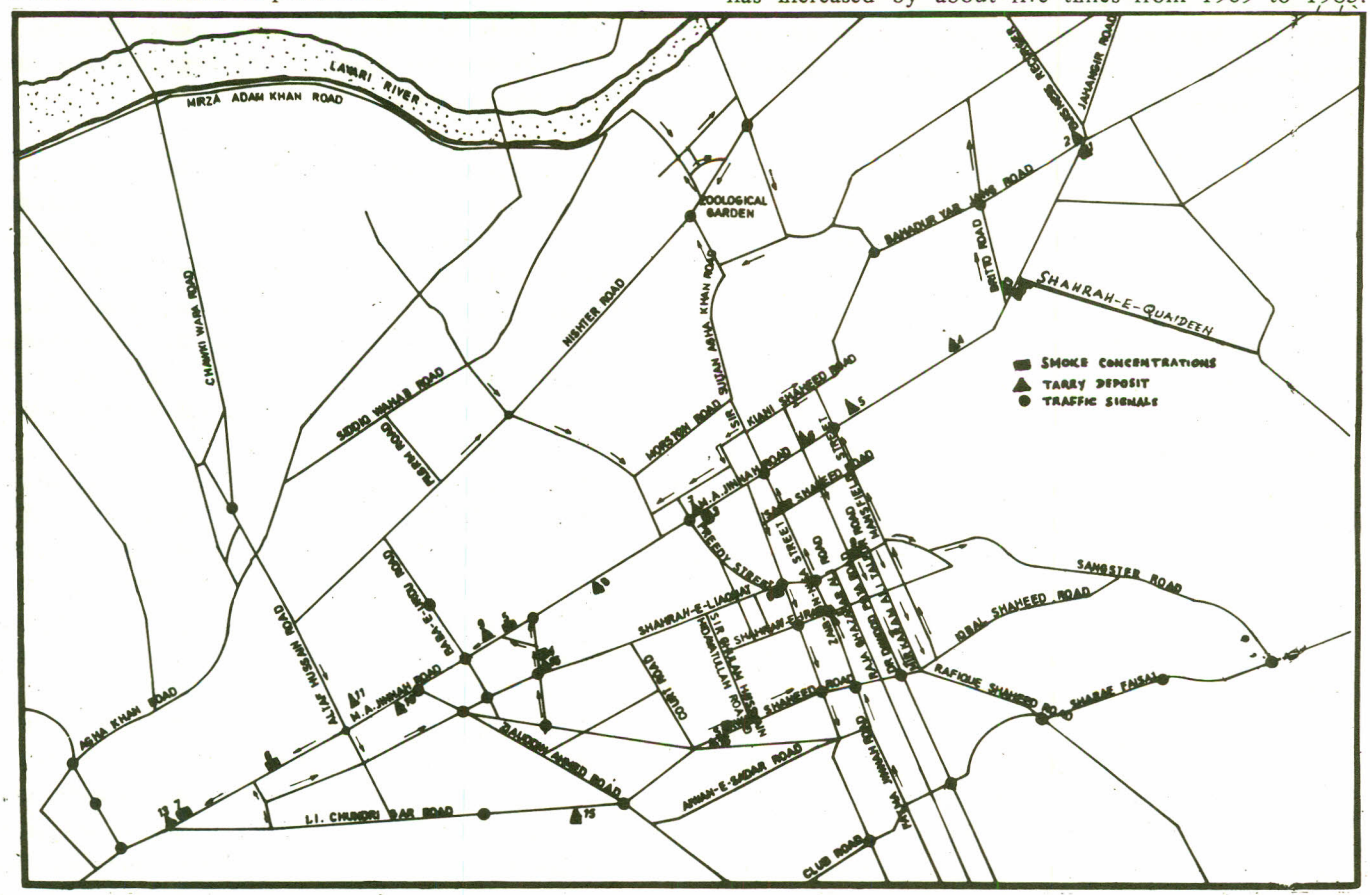

Fig. 1

At the Tibet Centre, sampling point No. 3, for example, the maximum average smoke concentration was 122 $\mu g/m^3$ in 1969. It was 270 $\mu g/m^3$ in 1975, 598 $\mu g/m^3$ in 1982

Fig. 2. A view of air pollution on M.A. Jinnah Road, Karachi.

and in 1983 it was the maximum of any point viz. 623 $\mu g/m^3$. Similarly at Empress Market, the maximum monthly average smoke concentration in 1969 was 64 $\mu g/m^3$, in 1975 it was 308 $\mu g/m^3$, and in 1982 it was 465 $\mu g/m^3$.

There are a number of factors which could be responsible for the tremendous increase in pollution level, some of the major ones being rise in traffic volume and the "tunnel effect" as a result of construction of multistoreyed buildings along the busy roads of the city.

As pointed out earlier, there has been a continuous increase in the number of motor vehicles in the city at an average rate of 20.8% per year during the last seven years while the road conditions have changed for the worse. Multistoreyed buildings have been constructed along the already congested roads. The city roads could easily handle approximately 20,000 cars and a few hundred buses and tram cars in 1947, at which time Karachi could be placed among the cleanest cities in the world. As is apparent from Table 1, the volume of traffic has undergone 20 fold increase. The number of vehicles operating during the day in 1969 was 400 to 800 vehicles per hour [1]. Table 2 shows that the flow of traffic has gone from 2,000 to 4,000 vehicles per hour. The pollutant values now being obtained are therefore not surprising. As regards the high level of smoke and particulates at open spaces like Numaish and Empress Market, it may be mentioned that the smoke concentration does not depend on the number of vehicles alone. On a main road of a small town in England for

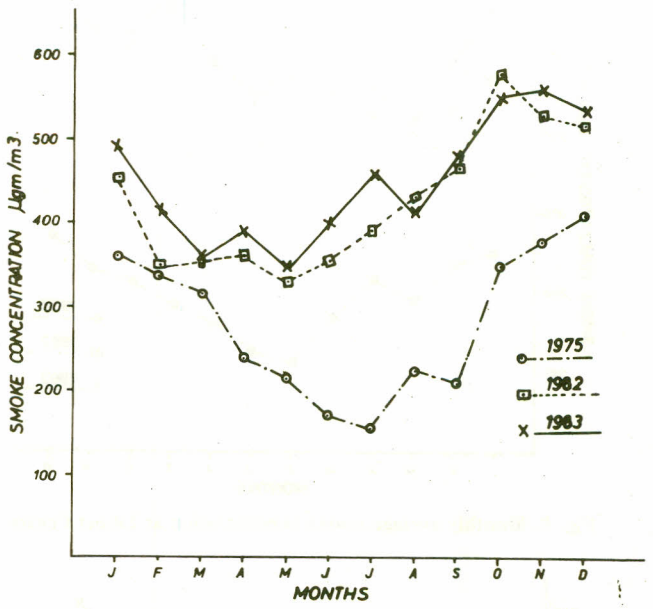

Fig. 3. Monthly average smoke concentration at Sabil Masjid.

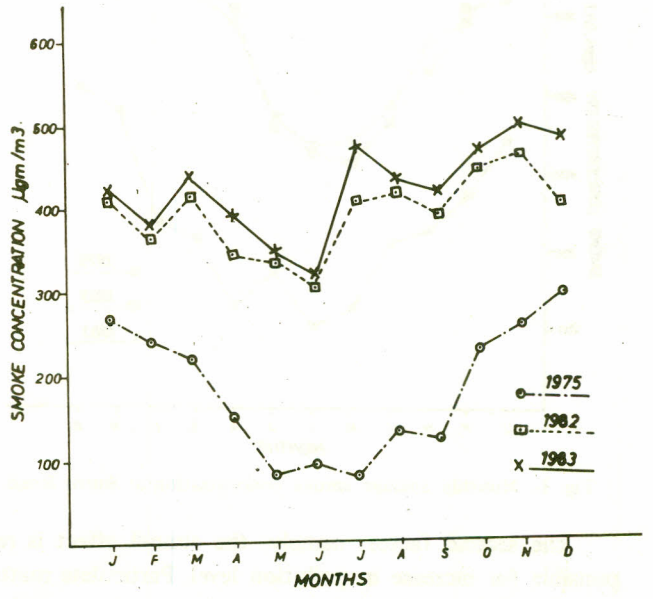

Fig. 4. Monthly average smoke concentration at Numaish

example, the smoke from road traffic was 50 $\mu g/m^3$ in spite of its fair width. Similarly in a narrow congested section of the same road, there was four times as much of smoke in

the wider part i.e. 200 $\mu g/m^3$. Similar measurements made at a place in London showed concentration upto 900 $\mu g/m^3$ with the same volume of traffic. This high figure occurred at a site where traffic was held up at traffic lights while going uphill [6].

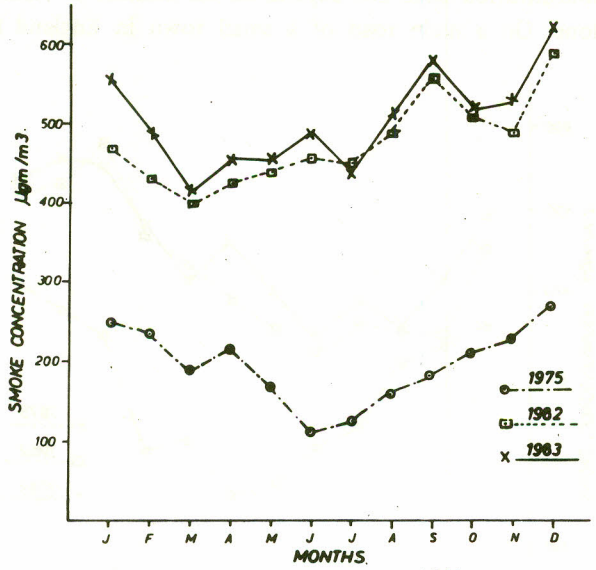

Fig. 5. Monthly average smoke concentration at Tibbet Centre.

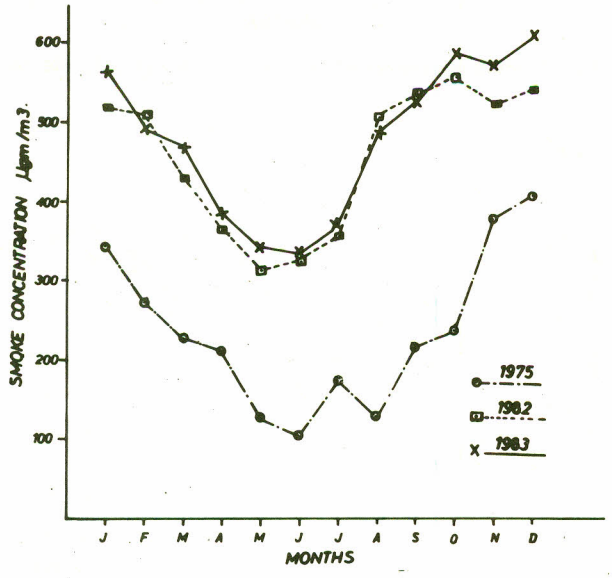

Fig. 6. Monthly average smoke concentration at Burns Road.

The second factor, namely, the tunnel effect is responsible for increase in pollution level. Particulate matter generated by vehicles continues to hang and accumulate and its dispersal is not rapid.

It may be observed from the data presented here that the level of smoke concentration is quite high in winter compared with that during summer time. It may be due to high air velocity during summer in Karachi when the usual wind direction is from west to east with high humidity. In winter the air velocity is low and the average temperature during day time is 18° to 22°C with low humidity. It is well known that the concentration of pollutants at

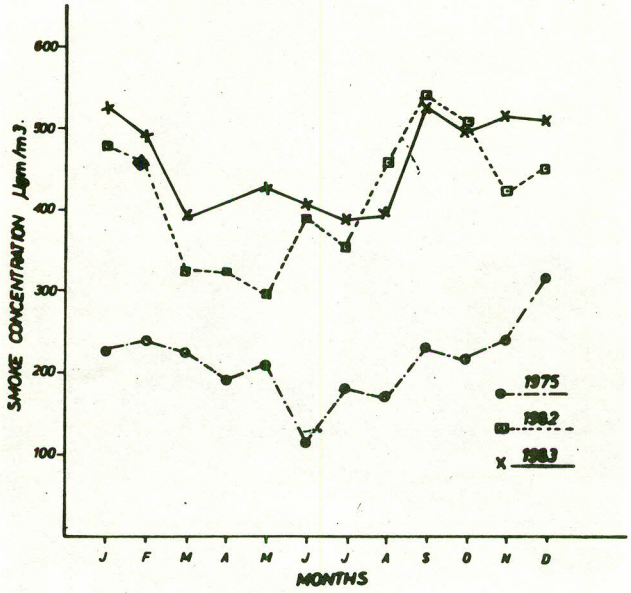

Fig. 7. Monthly average smoke concentration at Jamia Cloth Market.

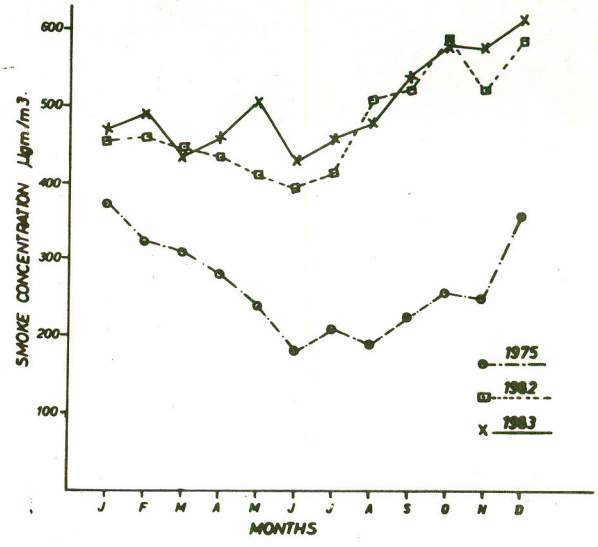

Fig. 8. Monthly average smoke concentration at Lakshmi Building.

ground level is the balance between the amount emitted and the extent to which it is diluted and dispersed by the atmospheric currents. Dispersal of pollutants depends on variation in air temperature with height and the wind velocity. In summer the wind speed is moderately high and due to dispersion effected by it, the pollution level is low. In winter on the other hand, fog is formed because of

Table 2. Air quality data at Sabil Masjid.

Year	1975					1982					1983				
Parameters*	I: Smoke Concentration	II: Temperature	III: Humidity	IV: Air Velocity	V: No. of Vehicles	I: Smoke Concentration	II: Temperature	III: Humidity	IV: Air Velocity	V: No. of Vehicles	I: Smoke Concentration	II: Temperature	III: Humidity	IV: Air Velocity	V: No. of Vehicles
	$\mu g/m^3$	°C	%	m/min.	No./hr	$\mu g/m^3$	°C	%	m/min.	No./hr	$\mu g/m^3$	°C	%	m/min.	No./hr
January	360	19	22.6	48	1820	452	19.8	26	78	2902	489	19.7	30.1	102	2996
February	336	20.5	29.1	98	1904	345	18.8	38	87	2713	410	20.9	26.2	130	3077
March	315	21.0	38	85	1850	352	28	45	104	2642	360	24.6	25.8	115	3566
April	240	22.0	46	110	1720	360	33.2	46.5	94	2802	391	24.0	36.1	108	3817
May	216	28	54	115	1632	328	31.9	55.8	80	2791	347	28.1	45.2	143	3753
June	170	31	49	130	1830	352	32.8	62.1	107	2879	407	33.4	53.1	98	3901
July	156	29.5	51	107	1806	392	31.6	53.5	133	2894	460	32.6	46.0	127	3712
August	225	31	39	78	1792	428	30.9	57.5	63	2790	412	31.5	41	98	3656
September	210	28.5	29.2	80	1765	468	28.5	52	121	2641	480	30.0	38.5	72	3212
October	350	30	32.4	67	1784	580	31.5	46	89	2932	550	33	39.5	97	3986
November	380	20.3	24	36	1812	530	25.7	43	68	2962	560	24.7	37.2	48	3735
December	410	19.1	23	28	1615	570	21.5	28	35	2881	536	22.9	35.3	58	3912

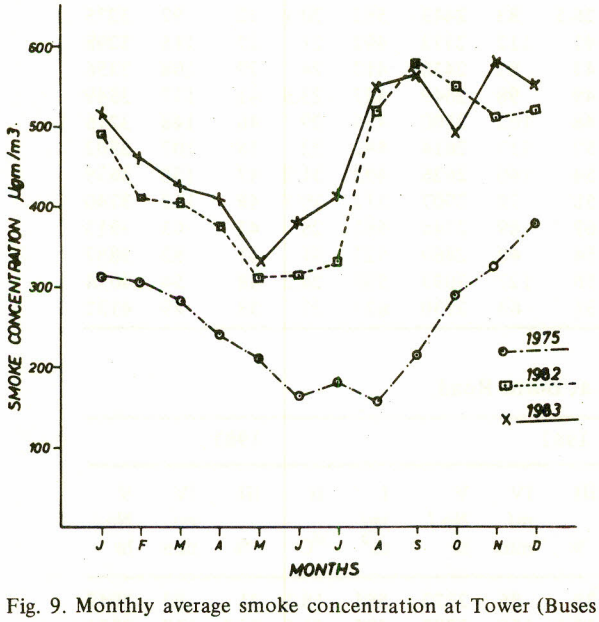

Fig. 9. Monthly average smoke concentration at Tower (Buses terminus).

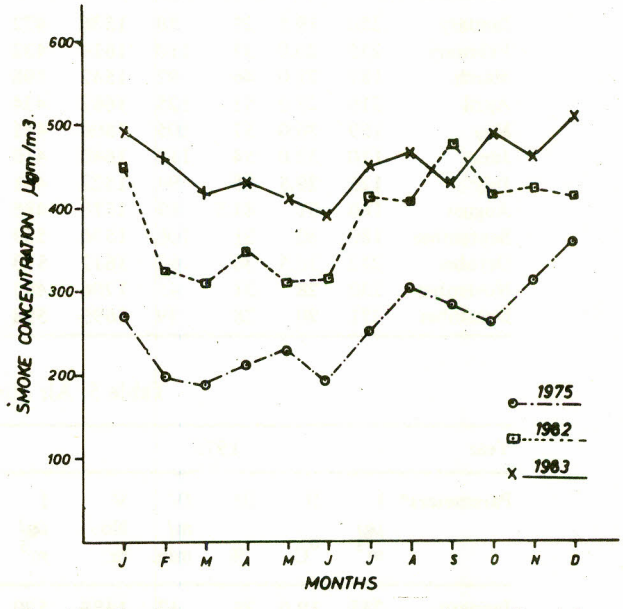

Fig. 10. Monthly average smoke concentration at Regal Bus Stop.

humid air from the sea and if radiation inversion is produced due to a deep stable layer of air with low velocity winds, the fog in the area is mixed up with smoke to form smog and there is a continuous tendency to bring the pollutants down to ground level, till such time as a complete change in weather occurs.

The third factor is the composition of smoke which in the case of Karachi is not just soot particles but is a mixture of carbon with tarry matter. This is mainly because of the presence of rickshaws and to a certain extent other two stroke engines which use a lubricant along with fuel. The former use higher quantities of lubricants than recommended. Furthermore, they use tinny exhaust pipes for unretarded flow of gases being discharged and to obtain high speed without getting the engine heated up. It has been found that the automobile exhausts spread lead, tar

Table 3. Air quality data at Numaish

Year	1975					1982					1983				
Parameters*	I μg/m³	II °C	III %	IV m/min.	V No./hr	I μg/m³	II °C	III %	IV m/min.	V No./hr	I μg/m³	II °C	III %	IV m/min.	V No./hr
January	270	20	23	53	1627	410	19.1	28.1	96	3112	417	21.2	28.9	112	3431
February	241	20.6	29.8	102	1705	365	19.7	42.8	89	2917	387	23.1	25.1	134	3211
March	220	21.8	41	78	1651	416	26.8	44.7	92	2887	440	26.8	27.2	108	3464
April	150	22	48	119	1521	345	34.6	49.2	106	2715	390	25.1	36.7	127	3608
May	80	29	56	130	1695	335	31.6	52	115	2890	346	27.7	46.1	132	3790
June	92	32	50	112	1752	304	32.3	59.3	112	2949	315	34.2	57.1	107	3886
July	78	28	53	80	1602	408	32.8	51.2	86	2987	473	33.1	44.5	113	3812
August	130	30	46	69	1593	418	31.0	54	54	3015	428	30.2	42.1	89	3679
September	120	29.2	31	61	1627	389	28.7	56	49	2790	413	31.3	35.2	97	3825
October	281	30.3	29	73	1685	445	32.2	54	42	2681	469	34.1	37.1	102	3872
November	254	27	30	38	1643	464	26.2	44	47	2864	492	25	31.1	54	3995
December	295	18.5	26	35	1516	405	22.6	29	81	2778	480	21.5	33.8	67	4086

Table 4. Air quality data at Tibet Centre.

Year	1975					1982					1983				
Parameters*	I μg/m³	II °C	III %	IV m/min.	V No./hr	I μg/m³	II °C	III %	IV m/min.	V No./hr	I μg/m³	II °C	III %	IV m/min.	V No./hr
January	250	19.5	29	58	1536	472	18.5	26.5	83	2443	552	20.1	32	97	3275
February	235	20.0	37	110	1614	432	19.9	41	112	2372	492	21	27	115	3298
March	187	21.0	46	97	1542	398	26.1	43	82	2430	413	24	29	108	3356
April	216	23.0	51	125	1662	424	32.6	49	98	2649	457	23.5	41	117	3549
May	169	30.0	57	105	1506	441	30.5	48	102	2500	456	29	46	148	3216
June	110	33.0	54	117	1640	410	31.0	57	117	2614	442	32	58	107	3502
July	125	29.5	56	94	1522	401	30.8	54	140	2626	492	31.2	47	138	3639
August	160	31	41.5	89	1570	488	31.2	58	79	2907	512	29.7	48	112	3740
September	180	30	31	106	1536	569	29.2	69	89	2748	581	28	42	63	3913
October	212	30.5	30	63	1612	513	32.2	54	48	2869	522	31	41	83	3887
November	230	28	31	45	1706	495	26.7	58	127	3093	530	24.2	38	54	4014
December	271	20	28	39	1695	598	22.1	31	63	3130	623	21	33	49	4132

Table 5. Air quality data at Burns Road.

Year	1975					1982					1983				
Parameters*	I μg/m³	II °C	III %	IV m/min.	V No./hr	I μg/m³	II °C	III %	IV m/min.	V No./hr	I μg/m³	II °C	III %	IV m/min.	V No./hr
January	345	19.0	25	43	1488	520	19.2	32	86	2372	565	18.1	31	93	3042
February	270	21.1	39	87	1372	510	20.5	49.5	108	2287	495	21.5	26.5	118	3171
March	225	20.7	48	91	1380	430	26.45	46.1	78	2200	470	24.3	27.4	95	3190
April	210	25	53	117	1440	365	28.2	51	127	2296	380	23.7	38.5	112	3329
May	125	29.5	56.5	112	1464	315	31.2	52.2	91	2334	340	28.5	47	120	3412
June	105	32.2	58	128	1536	325	30.2	59	112	2449	330	32.7	55.5	101	3477
July	170	28.5	55	100	1498	360	33	56	136	2388	370	32	48.3	115	3544
August	127	31.2	43	65	1659	510	32	53.9	106	2645	490	30.6	45	121	3756
September	215	30.1	38	81	1732	540	29	55.5	97	2812	530	29	39.7	81	3994
October	235	29.0	31	55	1697	560	32	46	52	2866	590	32	38.8	90	4069
November	380	27.3	33	40	1713	525	26.2	48	49	2841	575	23.3	39.6	59	3884
December	410	19.5	24	34	1768	545	21	20.5	56	2592	610	20.2	32	53	3927

Table 6. Air quality data at Jamia Cloth Market.

Year	1975					1982					1983				
Parameters*	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V
	µg/m³	°C	%	m/min.	No./hr	µg/m³	°C	%	m/min.	No./hr	µg/m³	°C	%	m/min.	No./hr
January	225	19.6	24	51	1586	480	19.7	28.1	64	2297	525	19.8	30.5	83	3086
February	240	20.5	36	99	1632	462	19.2	43	99	2281	488	21.6	26.2	98	3172
March	225	22.0	44	87	1468	327	26.8	44.7	89	2460	389	26.7	28.1	118	3015
April	190	24	52	107	1398	325	33	49.0	108	2331	410	24.0	38.0	106	2986
May	210	30	57.5	115	1502	388	31.3	52.1	98	2232	435	28.3	46.0	132	3157
June	110	32.6	56	121	1497	390	32.0	59.3	92	2297	405	33.0	55.9	98	3267
July	180	30.1	58	95	1531	355	33.1	54.0	123	2378	376	32.2	46.5	117	3298
August	170	32	40.1	76	1677	460	32.5	55.5	76	2532	488	30.5	44.0	94	3302
September	230	30.5	32.5	78	1625	545	29.2	58.1	92	2571	531	29.6	38.95	110	3369
October	216	32	30.2	65	1689	510	33	50.0	49	2497	492	32.5	39.1	87	3421
November	240	29	31.2	40	1721	426	27	48.2	93	2562	516	24.3	35.9	67	3567
December	315	20.1	28	34	1732	450	22	27.5	51	2541	510	21.4	33.5	74	3506

Table 7. Air quality data at Lakshmi Building.

Year	1975					1982					1983				
Parameters*	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V
	µg/m³	°C	%	m/min.	No./hr	µg/m³	°C	%	m/min.	No./hr	µg/m³	°C	%	m/min.	No./hr
January	375	20.1	34	67	1602	455	18.5	31	53	2306	470	19.7	31.1	72	3227
February	325	21.0	42	88	1637	460	19.8	46	64	2295	495	21.3	26.8	87	3297
March	310	24.1	49.5	92	1588	448	26.2	48	77	2376	435	25.1	29.1	79	3286
April	280	25.0	51	127	1495	435	32.8	46	84	2317	460	24.2	41	97	3368
May	240	29	58	112	1512	410	30.9	52	97	2286	510	28.6	49	112	3417
June	180	31.8	59	109	1617	397	31.5	61	112	2392	430	33.7	57	127	3458
July	210	30.0	55	106	1591	415	32.5	56	102	2418	460	32.0	45.6	123	3527
August	190	33.5	41.5	96	1632	510	31.8	58	64	2576	480	30.8	42	84	3498
September	225	32.1	40.2	82	1678	525	30.0	49	72	2617	540	29.5	40.2	102	3568
October	260	33	37.6	61	1692	590	31.6	52	92	2714	585	31.9	42	110	3572
November	250	27	36	49	1726	525	26.2	51	45	2651	580	24.8	36	82	3609
December	360	19.2	34	54	1776	590	22.5	30	38	2886	615	20.8	32	44	3587

Table 8. Air quality data at Tower (Buses Terminus).

Year	1975					1982					1983				
Parameters*	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V
	µg/m³	°C	%	m/min.	No./hr	µg/m³	°C	%	m/min.	No./hr	µg/m³	°C	%	m/min.	No./hr
January	315	21	44	68	1184	490	19	33	75	2296	515	19.5	34	84	3176
February	310	21	48	93	1218	410	20.2	48	94	2286	460	21.0	29	82	3261
March	285	22	55	107	1266	405	25.8	51	87	2384	425	23.2	31	95	3328
April	240	23	50	138	1248	375	31.5	49	102	2327	410	22.5	44	102	3517
May	210	27	57	121	1280	310	31.0	54	107	2279	330	29.2	51	124	3498
June	160	29	62	119	1216	315	30.5	67	126	2395	380	31.6	62	115	3525
July	180	28	52	110	1197	330	33.1	59	141	2428	412	30.5	56	134	3622
August	155	29	43	89	1220	520	32	62	62	2464	550	31.0	51	98	3526
September	216	27	48	76	1390	570	29.2	52	46	2527	565	30.2	40.5	110	3517
October	290	29	45	84	1270	550	30.1	51	57	2517	490	32.2	44	68	3591
November	325	26	43	64	1330	510	28	43	48	2588	585	23.5	38	78	3627
December	380	20	40	72	1425	520	21.8	38	62	2610	550	22.1	31	38	3735

Table 9. Air quality data at Regal Bus Stop.

Year	1975					1982					1983				
Parameters*	I $\mu g/m^3$	II °C	III %	IV m/min.	V No./hr	I $\mu g/m^3$	II °C	III %	IV m/min.	V No./hr	I $\mu g/m^3$	II °C	III %	IV m/min.	V No./hr
January	272	20.0	25.0	68	1508	450	19.0	26.5	97	2317	490	21.0	30.5	83	3167
February	197	20.5	32.1	103	1517	325	20.1	43.2	88	2294	460	21.5	26.6	72	3232
March	186	22.0	36.5	95	1567	310	27.5	46.2	103	2357	416	26.0	27.8	89	3394
April	210	23.1	49.0	126	1613	350	33.5	52.1	112	2364	430	25.1	38.6	106	3463
May	230	28.6	51.5	114	1642	310	31.5	50	124	2395	410	27.6	46.2	117	3496
June	190	34.5	55.0	121	1702	315	32.0	56.1	98	2372	390	34.1	56.5	112	3542
July	251	32.5	54.0	98	1625	415	32.6	52.2	109	2429	450	33.2	47	108	3626
August	305	33.1	45.1	86	1591	410	30.5	53	62	2401	465	31.0	36.3	74	3597
September	285	30.6	32.6	74	1586	480	29.5	57	72	2567	425	30.5	34.7	104	3626
October	265	32.1	33.5	84	1592	417	32.0	51	45	2631	490	32.7	35.2	72	3686
November	315	25.5	27.5	52	1672	425	25.5	49	42	2615	460	26.6	33.4	49	3624
December	360	19.5	26.2	45	1652	495	22.5	32	62	2672	510	21.5	28.6	37	3692

Table 10. Air quality data at Empress Market.

Year	1975					1982					1983				
Parameters*	I $\mu g/m^3$	II °C	III %	IV m/min.	V No./hr	I $\mu g/m^3$	II °C	III %	IV m/min.	V No./hr	I $\mu g/m^3$	II °C	III %	IV m/min.	V No./hr
January	285	19.6	24.8	57	1417	390	18.8	27.3	84	2287	430	20.6	30.6	78	3127
February	240	20.3	31.9	97	1556	375	19.8	41.9	105	2215	385	22.0	26.3	85	3194
March	220	21.2	36	86	1513	370	27	43.6	87	2347	410	25.4	27.8	97	3364
April	210	22.6	48.3	118	1672	355	33.6	49.1	102	2384	390	24.3	38.5	98	3423
May	180	29.3	51	116	1607	330	31.0	50	114	2319	400	28.5	46.8	114	3532
June	170	34	55.6	108	1693	315	31.5	58.1	108	2386	380	33.1	56.1	109	3592
July	175	31.2	53.3	94	1588	290	32.0	52.6	113	2372	415	32.5	46.5	126	3619
August	240	32.0	42.1	79	1564	395	31.1	56	67	2429	430	30.5	38.2	112	3621
September	255	30.2	30.4	83	1584	380	29.0	82	69	2476	405	29.5	36.2	72	3592
October	225	31.5	31.2	68	1598	370	32.5	53	45	2531	450	32.6	33.4	69	3616
November	280	26	28.3	42	1627	405	26.5	51	56	2525	410	26.0	36.5	51	3672
December	308	19.2	25.6	38	1617	465	21.6	36	52	2612	480	22.0	33.5	42	3652

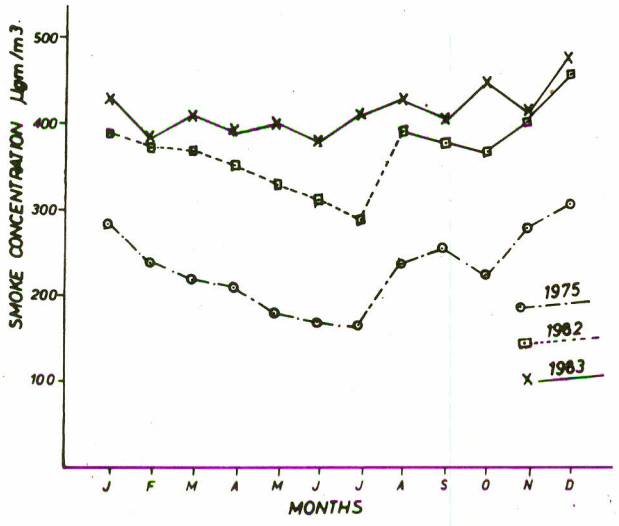

Fig. 11. Monthly average smoke concentration at Empress Market.

and smoke on the side walks as also on the leaves of the trees. When the smoke stain was analysed, it was found to contain lead on an average upto 0.013 to 0.79 $\mu g/m^3$. It is also a common sight to note that tree leaves, from one end of the city centre to the other are black or greyish green instead of green. It is also commonly noted that young trees and shrubs have lost their growth and are dwarfed. The tarry substances as well as lead deposit on the leaves, make them initially greyish green and finally black.

The tar deposited on tree leaves has been analysed and it was found that the matter deposited on the leaves is not simply unburnt fuel but it contains dust, tar and lead therein. Table 11 shows the amount of tarry deposit along the main roads of the city. The maximum amount of tarry deposit was 4.987 g/sq. ft with 0.019% of lead found in the Burns Road area near KMC School sampling point No. 15. The samples were collected from a large banyan

Table 11. Tarry and lead deposits on the leaves of main roads of Karachi city.

S. No.	Location	Height (feet)	Tarry deposit g/sq. ft.	Lead (μg/sq. ft.)	Organic matter in tarry deposit (%)	Organic Carbon in tarry deposit (%)	Lead in tarry deposit (%)
1.	Teen Hatti	6	0.265	40	64.9	38.1	0.0151
		12	0.127	22	63.5	27.6	0.018
2.	Sabil Masjid	6	0.974	178	66.1	39.6	0.0182
		12	0.521	93	63.2	34.8	0.0178
3.	Numaish	6	0.291	53	64.8	39.3	0.018
	Roundabout	12	0.342	60	62.9	36.3	0.017
4.	M.A. Jinnah Road Near Bundu Khan Restaurant	6	0.711	130	59.2	35.1	0.0168
5.	M.A. Jinnah Road Near Capri Cinema (Centre of Road)	6	0.350	42	60.5	36.0	0.012
6.	M.A. Jinnah Road/ Garden Road	6	0.531	90	62.7	39.3	0.017
7.	M.A. Jinnah Road Tibet Centre	10	1.610	309	69.3	42.3	0.019
8.	M.A. Jinnah Road Near Radio Pakistan	6	0.921	162	63.2	35.4	0.017
9.	M.A. Jinnah Road Sind Govt. Hospital	8	0.401	60	61.1	31.5	0.149
10.	M.A. Jinnah Road	6	0.523	92	66.2	35.7	0.0175
	Near KMC Building	12	0.497	89	60.1	27.6	0.0179
11.	City Court	6	0.699	106	55.7	21.6	0.0152
12.	Denso Hall	6	0.247	44	63.8	39.3	0.0178
		12	0.293	46	64.1	35.7	0.0156
13.	Tower Bus Terminus	6	0.151	14	61.2	38.4	0.009
		12	1.275	179	64.1	39.3	0.11
14.	Burns Road	12	4.987	952	69.7	44.4	0.019
15.	Abdullah Haroon Road	6	0.1613	29	59.7	27.3	0.0173
	Near Printing Press	12	0.283	35	55.2	26.1	0.123
16.	Near Goethe Institute	6	0.0397	4	48.3	24.3	0.0092
		12	0.1895	76	42.7	25.5	0.011

tree covering a narrow portion of the road from the top. At this point the maximum smoke concentration was 610 $\mu g/m^3$. The high values obtained may, as mentioned earlier, be due to the slowing down of traffic at the intersection. The other congested area near the Tibet Centre where smoke concentration was found highest viz. 623 $\mu g/m^3$ had 1.61 g/sq. ft tarry deposits on tree leaves with 0.019% of lead; here also the traffic is held up by traffic lights. The minimum tarry deposit of 0.1895 g/sq. ft with 0.011% lead was found near Goethe Institute, where the traffic volume is comparatively low and the area is quite open.

It may be seen from the same Table that both particulate matter and lead vary according to volume of traffic, and the higher the number of vehicles, the larger is the smoke and lead concentration. The smoke particles are carried away by the air to far off distances. When the dust, deposited on the top window on the west of Quaid's Mausoleum at a height of about 200 ft. was analysed, it was found to contain black particles of smoke and lead upto 0.0096%. The smoke particulates and tarry deposits have thus started decolourising the marble of the Mausoleum.

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