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ENVIRONMENTAL PROBLEMS OF KARACHI
Part III. Estimation of Dustfall

MIRZA ARSHAD ALI BEG, S. NAEEM MAHMOOD AND A.H.K. YOUSUFZAI

PCSIR Laboratories Complex, Karachi, Pakistan

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Micro-climatics and dustfall data and their correlation at two locations of Karachi city are presented. It is found that the dustfall has contributions from construction activity, particulate emission from automobile exhausts comprising soot and hydrocarbons, besides the chimneys from two cement factories in the city. On an average the dustfall in Karachi ranges from 4.5 to 5.5 gm/(m^2month).

Key words: Environmental problem, Dust fall, Pollutants.

Introduction

Particulates are one of the typical air pollutants such as CO, NO_x and various hydrocarbons. Particulates may be of various sizes ranging from 0.1 to 100 micron but dust may be defined as solid particles ranging between 1 to 100 micron in diameter and capable of temporary suspension in air.

The nuisance caused by dust-fall [1,2] and grit is a common feature in urban areas of arid zones, since they are faced with a combination of industrial, construction and transportation activities such as in Karachi and Lahore. Karachi is additionally confronted with the problem of cement dust emanating from two factories, *viz*. Javedan Cement located close to and National Cement within the residential areas.

Particulates emitted from faulty vehicles comprise smoke, unburnt fuel and tarry material due to the inappropriate mix of gasoline with lubricants in two stroke engines and their impact on vegetation on city streets is simply distressing [3-5].

The estimate of the quality and quantity of dust which settles per square mile in a given time indicates the degree and kind of air pollution in a city [6]. As a part of the comprehensive survey of the quality of air undertaken in the city of Karachi for the last 20 years, the monthly measurements of dustfall were also recorded continuously for a period of six years. The present paper describes the rate, composition and quantity of dust-fall in the city of Karachi at two locations namely the PCSIR Laboratories Complex, Karachi (KL), 18 km on the east of the centre and the Quaid-e-Azam Mausoleum (QM) in the centre. Data for 1982 forms part of the KDA (1982) 'Environmental Pollution: A Status Report on the City of Karachi' and is included in the Environmental Profile of Pakistan [7].

Materials and Methods

The estimation of dust-fall was carried out by exposing dustfall containers of standardized shape and size at the two sites for a period of one calender month corrected to 30 ± 2 days [8]. At the end of the sampling period, the containers were sealed and returned to the laboratory for analysis. One dust collector each was installed at the (QM) and (KL) sites. The latter could have been treated as control sample point because of its location outside the city limits and the non-significant industrial activity within its radius of about 7 km, but for National Cement Factory, located about 8 km to the SSW and Javedan Cement Factory, 16 km to its WWN which discharge copious dust from their exhaust system. QM on the other hand, is located in an open area with no multistoried buildings around but on one of the busiest roads of the city where the average traffic flow in peak hrs is over 3,000 vehicles/hr [4]. As shown in the location map of Karachi city (Fig. 1), National Cement Factory is located about 9 km NE and Javedan Cement Factory about 20 km N from this point.

The chemical analysis of the total settleable particles (dustfall) was carried out by standard chemical and physical methods [9]. Air velocity and direction were determined by a Woelfe type model 1405-315 mechanical wind recorder. Maximum and minimum temperatures and humidity were recorded on the hydrograph/temperature recorders installed at the site of location of the dust collectors.

Results and Discussion

The survey was conducted over a period of 6 years starting from 1980 to 1985. Data on dust-fall and other matereological parameters such as air direction, air velocity, maximum and minimum temperature, and humidity obtained for KL are recorded in Tables 1-6 while those for QM are listed in Tables 7-12. Typical analysis and particle size distribution of the dust deposited in the dust collectors are listed in Tables 13 and 14 respectively. Table 15 shows the analysis of the chimney dust emanating from the two cement factories.

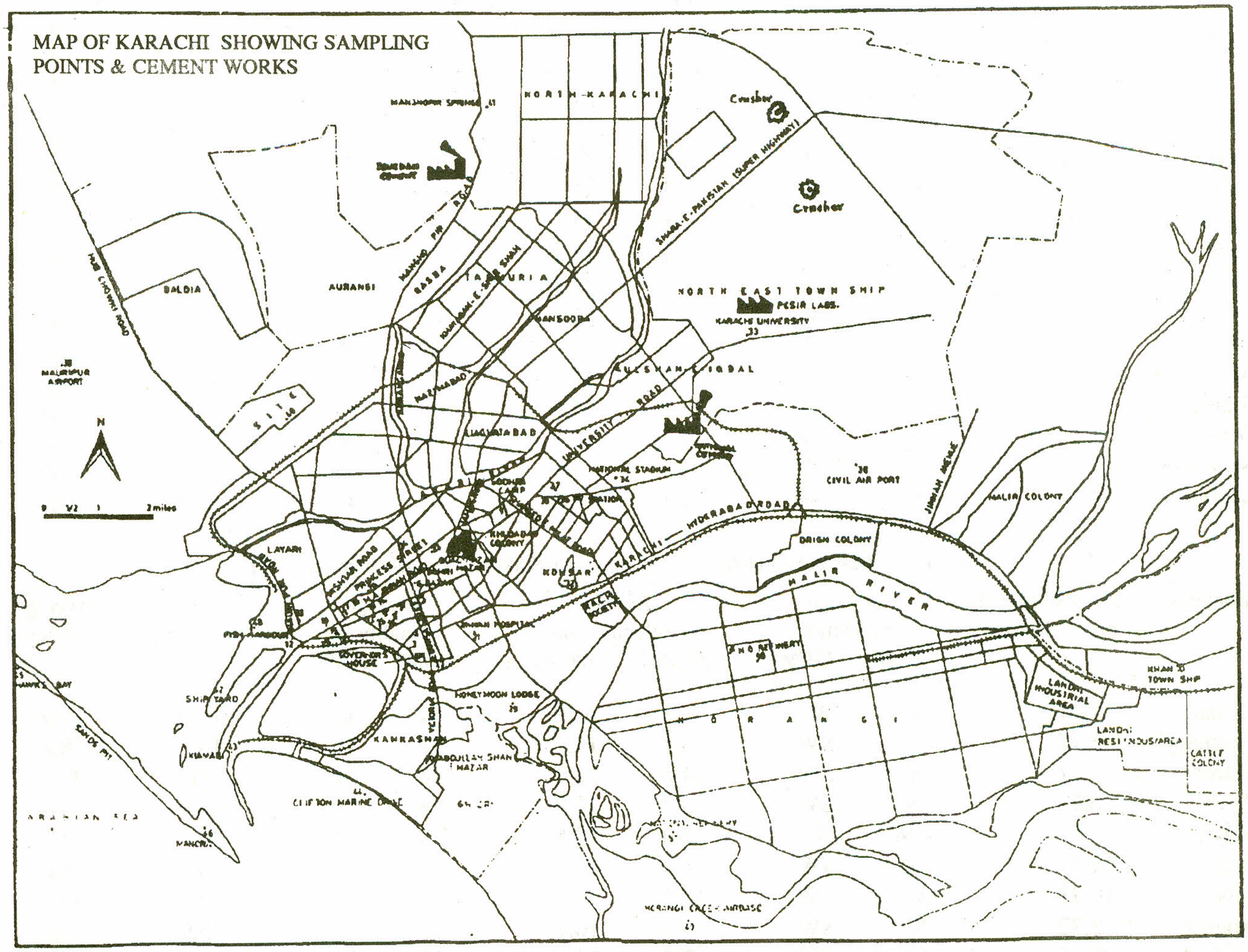

Fig. 1. Location map of Karachi city.

Dust fall and micro-climatics at KL. It may be observed from the six years data for KL that the highest dust-fall 12.04gm/(m^2month) was recorded in the month of June 1985 and the lowest 0.87gm/(m^2month) in the month of Nov. 1980. It would be noted from Tables 1-6 that dust-fall was usually high during the May to Aug. period ranging between 6.46 and 12.04gm/(m^2month) at the KL. It was significantly low during the months of Nov. and Dec. ranging between 0.87 and 2.90gm/(m^2month).

Tables 1-6 show that the air direction at KL site at 03 GM time during the period under study was 52.8%W, 16.7%NE, 8.3%NW, 6.9%SW, 1.4%N, 1.4%W and 2.8% calm while at 12 GM time the direction of air was 81.9%SW, 13.9%W and 4.2%S. These observations suggest that during the nights the wind direction was mostly westerly for 8 months of summer, northerly or north easterly for four months of winter and was south westerly throughout the 1980- 85 period during day time.

At 03 GM time the air velocity at KL is low in winter from Nov. to Feb. ranging between a recorded minimum of 0.0 km/hr. in Nov. 1985 and a recorded maximum of 13.9 km/hr. in Jan. 1981. At 12 GM time it ranged between a low of 1.8 km/hr. recorded in Dec. 1985 and a high of 23.7 km/hr. in Feb. 1985. It was high during the summer and monsoon seasons extending over the eight months period from March to Oct. At 03 GM time it ranged between a low of 0.0 in Nov. 1985 and a high of 20.2 km/hr. recorded in June 1985. At 12 GM time it ranged between a low of 5.6 in Nov. 1984 and a high of 23.7 km/hr. recorded in June 1985.

It may be observed from Tables 1-6 that variation in temperature also affected the rate of dust-fall. It was high during the May to Aug. period when there was an increase in temperature particularly at 03 GMT. It is known that the increase in atmospheric temperature creates a low pressure area which causes sea breeze and brings humid air to inland locations such as the sampling stations mentioned above. It is thus responsible for an increase in wind velocity from morning to evening. It also causes natural convention currents which increase the amount of dust deposition during summer months.

TABLE 1. MONTHLY AVERAGE DUST FALL AT KARACHI LABORATORIES 1980.

Months	Settleable particles gm/m²/30 days	Average air direction		Average air velocity(km/hr.)		Average humidity %		Average min. temp.	Average max. temp.
		03GMT	12GMT	03GMT	12GMT	03GMT	12GMT		
January	1.84	N	SW	0.9	11.5	69	40	10.7	25.3
February	3.94	NE	SW	0.9	10.9	67	40	13.5	28.6
March	2.62	NW	SW	2.8	13.1	72	47	18.3	31.2
April	5.32	W	SW	3.3	11.5	77	49	24.2	35.9
May	10.21	W	SW	10.5	17.2	74	62	27.9	34.9
June	7.47	W	SW	9.3	13.7	77	66	28.4	35.0
July	8.32	SW	SW	11.5	18.7	80	73	27.6	32.7
August	8.17	W	SW	12.0	16.1	76	66	26.5	32.0
September	7.00	W	SW	11.8	14.4	78	64	25.5	31.8
October	2.90	W	SW	4.1	10.7	75	50	22.1	34.3
November	0.87	N	SW	1.7	7.6	60	35	16.8	31.2
December	1.26	N	SW	1.3	8.7	68	41	12.0	26.6

TABLE 2. MONTHLY AVERAGE DUST FALL AT KARACHI LABORATORIES, 1981.

Months	Settleable particles gm/m²/30 days	Average air direction		Average air velocity(km/hr.)		Average humidity %		Average min. temp.	Average max. temp.
		03GMT	12GMT	03GMT	12GMT	03GMT	12GMT		
January	2.01	N	W	3.3	11.7	64	37	12.6	25.7
February	3.17	N	SW	0.7	11.7	72	34	13.3	28.4
March	4.21	NW	SW	4.6	12.2	77	51	18.6	30.3
April	6.27	W	SW	5.2	14.2	78	51	22.9	34.8
May	9.62	SW	W	12.0	20.5	73	57	26.1	35.5
June	11.21	W	SW	12.8	19.4	75	62	28.2	35.6
July	10.71	W	SW	12.9	18.7	78	69	27.4	33.1
August	8.72	W	SW	8.9	10.1	81	73	25.9	31.2
September	5.15	W	SW	7.8	14.6	79	59	25.8	33.9
October	3.96	NW	SW	2.6	12.5	71	41	21.0	35.1
November	2.76	NE	SW	0.7	10.4	72	46	15.6	30.4
December	2.31	NE	SW	1.5	7.8	67	40	11.5	28.3

TABLE 3. MONTHLY AVERAGE DUST FALL AT KARACHI LABORATORIES, 1982.

Months	Settleable particles gm/m²/30 days	Average air direction		Average air velocity(km/hr.)		Average humidity %		Average min. temp.	Average max. temp.
		03GMT	12GMT	03GMT	12GMT	03GMT	12GMT		
January	2.21	NS	S	2.6	11.3	64	35	10.0	25.5
February	2.18	NE	SW	2.2	11.1	70	47	12.9	26.0
March	3.07	NW	SW	1.9	14.3	69	37	16.5	30.8
April	6.25	W	Sw	6.9	14.6	75	47	22.1	34.1
May	8.63	W	W	8.3	15.9	68	51	25.4	36.3
June	11.19	W	SW	13.5	18.8	77	66	28.1	35.5
July	10.07	W	SW	12.1	15.8	78	67	27.6	34.5
August	7.99	W	SW	10.8	15.4	81	73	27.1	32.6
September	4.97	W	SW	7.6	16.5	78	61	25.4	34.1
October	3.00	W	SW	3.2	10.2	76	56	22.4	34.7
November	2.04	NW	SW	2.0	10.0	63	43	16.1	31.3
December	2.28	NE	SW	2.2	8.5	65	40	13.2	27.3

TABLE 4. MONTHLY AVERAGE DUST FALL AT KARACHI LABORATORIES, 1983.

Months	Settleable particles $gm/m^2/30$ days	Average air direction		Average air velocity(km/hr.)		Average humidity %		Average min. temp.	Average max. temp.
		03GMT	12GMT	03GMT	12GMT	03GMT	12GMT		
January	2.25	Ne	SW	3.3	11.7	64	35	11.4	26.3
February	4.11	NE	W	2.0	13.5	70	47	12.5	26.4
March	3.71	SW	W	5.7	16.5	69	37	16.8	30.2
April	5.67	W	SW	6.8	14.0	75	47	21.3	32.2
May	9.57	W	SW	9.3	16.6	68	51	26.3	34.7
June	7.20	W	SW	9.1	15.4	77	66	28.1	35.6
July	8.29	W	W	10.7	16.1	78	67	28.1	33.7
August	9.01	W	W	11.5	14.1	81	73	26.6	32.2
September	5.27	W	SW	8.7	13.5	78	61	26.0	33.3
October	2.89	NW	SW	1.1	10.2	76	56	20.5	34.9
November	2.52	N	Sw	0.2	9.6	63	43	14.3	31.9
December	1.99	NE	S	0.4	9.1	65	40	10.9	27.7

TABLE 5. MONTHLY AVERAGE DUST FALL AT KARACHI LABORATORIES, 1984.

Months	Settleable particles $gm/m^2/30$ days	Average air direction		Average air velocity(km/hr.)		Average humidity %		Average min. temp.	Average max. temp.
		03GMT	12GMT	03GMT	12GMT	03GMT	12GMT		
January	2.23	NE	SW	0.7	9.1	68	36	8.6	25.8
February	1.85	N	W	3.1	11.8	56	27	9.5	26.6
March	4.16	W	SW	1.5	13.3	77	47	17.9	32.9
April	6.53	W	SW	5.0	13.5	78	48	23.1	35.8
May	11.13	W	SW	13.3	19.2	78	63	25.9	34.4
June	11.11	W	SW	13.1	20.0	77	65	28.1	35.2
July	10.36	W	SW	12.6	18.7	80	70	27.0	32.2
August	6.46	W	SW	7.4	11.1	88	81	25.4	30.3
September	4.32	SW	SW	7.4	16.1	83	71	24.9	32.5
October	3.86	SW	SW	0.6	10.4	74	42	18.1	34.1
November	2.19	Calm	SW	0.2	5.6	78	49	15.1	31.6
December	2.90	NE	SW	0.2	6.8	68	54	11.5	28.3

TABLE 6. MONTHLY AVERAGE DUST FALL AT KARACHI LABORATORIES, 1985.

Months	Settleable particles $gm/m^2/30$ days	Average air direction		Average air velocity(km/hr.)		Average humidity %		Average min. temp.	Average max. temp.
		03GMT	12GMT	03GMT	12GMT	03GMT	12GMT		
January	3.36	NE	S	0.9	9.0	72	39	10.1	26.2
February	2.73	E	SW	1.5	21.2	73	46	11.8	29.7
March	5.14	W	W	3.7	12.2	74	44	18.8	33.7
April	6.13	W	SW	8.7	13.1	79	59	22.1	32.9
May	8.00	W	SW	9.8	9.8	75	55	26.0	36.2
June	12.04	W	SW	13.9	23.7	76	65	27.8	34.3
July	7.75	W	SW	12.6	17.0	80	72	26.6	31.9
August	6.79	W	SW	10.9	14.8	78	72	24.7	30.9
September	7.89	W	SW	10.9	16.3	81	68	23.8	31.7
October	4.91	W	SW	0.6	6.3	74	43	21.1	35.5
November	2.77	Calm	SW	0.1	6.1	76	44	16.1	32.9
December	2.38	NE	W	0.2	1.8	62	34	10.6	29.9

Dust Fall and Micro-Climatics at QM. Tables 7-12 list the data observed at QM and suggest that at 03 GMT the wind direction was 41.7%SW, 30.6%NE, 22.2%NW, 2.8%W, 1.4%N and 1.4% calm while at 12 GMT it was 86.1%SW, 2.8%NW, 2.8%SE, 6.9%W and 1.4%S. In general the direction is SW during the summer months and NE during winter in the night but mostly SW during the day. The south-westerly, north- easterly and north-westerly winds are the main contributors during winter nights and therefore it is possible that the dust-fall here is not only from the desert areas on the SE to NW region but also from both the cement factories in the north and north east. In the summer it is contributed mainly by the desert areas.

The air velocity at 03 GMT ranged between 0.0 km/hr. recorded in Nov. 1985 and 13.5 km/hr. in June 1985 and between 2.1 km/hr. in Dec. 1985 and 22.06 km/hr. in June 1985 at 12 GMT. The average minimum temperature was higher at QM than at KL by at least 0.3 to 0.8° while the maximum was higher at KL by 0.2 to 0.8°. The pattern of humidity changes at the two sites is of similar nature.

The maximum dust-fall at QM was 10.1gm/(m²month) recorded in the month of March, 1983 and the minimum 0.92g/(m²month) in Dec. 1983. Higher amount of dust was deposited during March and April ranging between 5.5 and 10.1 gm/(m²month) and comparatively low during Nov. and Dec. ranging between 0.9 and 2.9gm/(m²month). It may be noted from Fig. 2 that there are two maxima: one in March-April region and the other in the Sept.-Oct. region.

These maxima seem to be related to the maximum temperature which also has two maxima. They do not seem to have any relation with rainfall wind velocity or humidity which have maxima in the June to Aug. period and not those mentioned above.

General observations on dust-fall at Karachi. It may be observed from Tables 1-12 that air direction is the main factor causing variation of the deposition of dust. The prevalent directions of winds in Karachi are westerly, south-westerly and north-westerly but westerly winds are dominant; westerly and south-westerly winds bring the sea breeze while the north-easterly bring land breeze.

Karachi has westerly winds in summer and north-easterly in winter. If the rate of deposition is compared with air direction, it may be observed that the amount of dust-fall at KL sampling point is high during the May to Aug. period when the air direction is westerly or south-westerly. This suggests that the dust is contributed by the adjacent arid area of Sindh and a significant amount of the dust-fall is attributed to the two cement factories, although the sampling sites are not directly under the direction of plume emanating from the chimney of the cement factory kilns.

Figures 2 and 3 show the monthly average dust-fall during the six years of observation at the two sampling sites. It would be noted that the pattern of dust-fall was not identical at the two sites; at QM the rate of dust-fall was higher from Feb. to April whereas at KL the higher values were recorded during the April to Sept. period. This suggests that the change in air direction affects the rate of dust-fall since it brings the two sites under the plume of the cement factories and the excess deposition could be attributed to this industrial activity. Additionally, there are at least three stone crushers which also raise considerable quantities of dust and contribute to dustfall at KL sampling site.

Air velocity is also a major factor which affects dust-fall because high winds are usually dust raising in character. Ad-

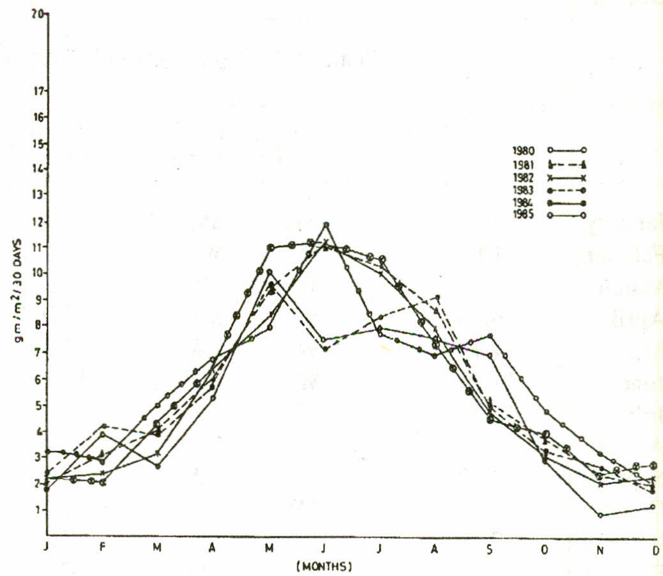

Fig. 2. Dustfall at Karachi Labs (Monthly average).

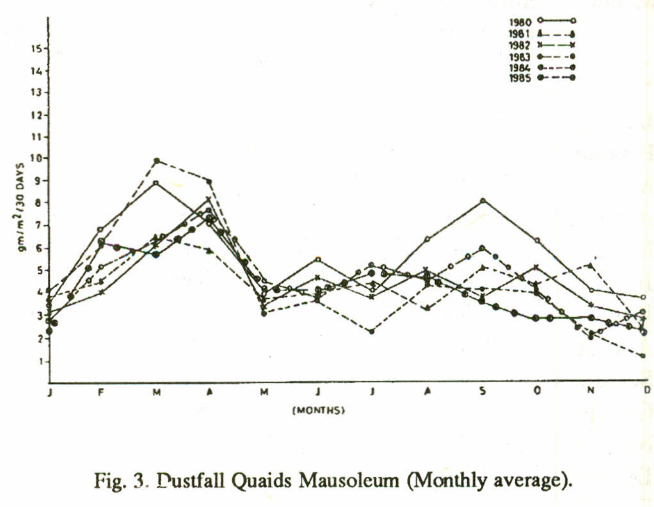

Fig. 3. Dustfall Quaids Mausoleum (Monthly average).

TABLE 7. MONTHLY AVERAGE DUST FALL AT QUAID'S MAZAR, 1980.

Months	Settleable particles gm/m²/30 days	Average air direction		Average air velocity(km/hr.)		Average humidity %		Average min. temp.	Average max. temp.
		03GMT	12GMT	03GMT	12GMT	03GMT	12GMT		
January	3.61	NE	SW	3.3	8.7	65	37	11.8	24.8
February	6.92	NW	SW	2.3	11.2	70	44	14.6	27.8
March	9.11	NW	SW	3.8	14.9	73	50	18.6	30.2
April	7.22	NW	SW	5.2	15.2	80	62	24.3	34.5
May	3.73	SW	SW	13.4	19.2	78	71	26.4	35.1
June	5.65	SW	SW	13.3	17.6	75	68	27.2	34.4
July	4.21	SW	SW	12.2	17.8	78	72	27.0	32.1
August	6.44	SW	SW	12.6	17.2	76	71	26.4	31.2
September	8.13	NW	SW	11.8	17.3	77	69	25.2	31.4
October	5.96	NW	SW	6.1	13.4	78	57	22.8	33.2
November	2.24	NE	SW	4.2	9.8	62	36	17.6	30.4
December	3.92	NE	SW	4.7	8.9	68	41	13.0	26.1

TABLE 8. MONTHLY AVERAGE DUST FALL AT QUAID'S MAZAR, 1981.

Months	Settleable particles gm/m²/30 days	Average air direction		Average air velocity(km/hr.)		Average humidity %		Average min. temp.	Average max. temp.
		03GMT	12GMT	03GMT	12GMT	03GMT	12GMT		
January	3.61	NE	SW	5.6	12.2	66.5	41	13.3	25.6
February	4.32	NE	SW	2.1	12.2	73.0	37	14.5	27.0
March	6.26	NW	SW	4.7	12.8	76.0	51	18.4	30.5
April	5.92	NW	SW	5.5	14.9	76.5	57	22.6	33.2
May	4.12	SW	SW	11.7	19.6	72.0	58	25.6	34.4
June	4.26	SW	SW	12.9	18.9	76.0	63	27.8	35.1
July	4.35	SW	SW	13.1	18.4	79.0	70	27.5	33.5
August	3.15	SW	SW	9.9	13.2	81.0	73	26.6	31.6
September	4.92	SW	SW	7.6	15.3	78.0	62	26.6	33.6
October	4.33	NW	SW	2.6	11.8	73.0	42	25.6	34.1
November	2.29	NE	SW	1.4	10.1	70.0	46	22.4	30.2
December	2.11	NE	SE	2.1	8.1	64.0	38	17.3	27.5

TABLE 9. MONTHLY AVERAGE DUST FALL AT QUAID'S MAZAR, 1982.

Months	Settleable particles gm/m²/30 days	Average air direction		Average air velocity(km/hr.)		Average humidity %		Average min. temp.	Average max. temp.
		03GMT	12GMT	03GMT	12GMT	03GMT	12GMT		
January	2.92	NE	SW	3.2	10.4	63	35	10.8	25.15
February	3.67	NE	SW	2.9	11.6	66	45	13.5	25.7
March	7.21	NW	SW	3.3	13.9	66	37	17.5	29.8
April	8.40	SW	SW	6.3	15.1	75	52	2.3	33.0
May	3.56	SW	SW	9.9	15.7	67	53	25.6	35.5
June	4.96	SW	SW	12.5	18.8	76	67	27.5	35.6
July	3.62	SW	SW	13.1	15.1	78	69	27.2	33.6
August	2.35	SW	SW	10.1	14.8	82	74	26.5	31.9
September	3.96	SW	SW	7.3	15.0	78	59	25.3	33.4
October	5.32	NW	SW	3.0	10.6	75	53	22.8	33.9
November	2.91	NE	SE	3.3	9.4	59	41	17.2	30.9
December	2.26	NE	SW	3.5	8.4	63	40	13.9	26.7

TABLE 10. MONTHLY AVERAGE DUST FALL AT QUAID'S MAZAR, 1983.

Months	Settleable particles gm/m²/30 days	Average air direction		Average air velocity(km/hr.)		Average humidity %		Average min. temp.	Average max. temp.
		03GMT	12GMT	03GMT	12GMT	03GMT	12GMT		
January	4.1	NE	SE	3.8	10.2	58	36	12.5	25.9
February	6.62	NE	SW	2.9	12.9	67	44	13.3	25.6
March	10.1	NW	SW	5.9	14.5	65	38	17.4	29.6
April	8.96	SW	SW	7.3	12.9	75	52	21.2	31.8
May	2.89	SW	SW	9.7	15.0	73	61	26.1	34.0
June	3.35	SW	SW	8.0	14.0	77	65	28.0	35.1
July	2.02	SW	SW	10.1	14.7	78	68	27.9	33.8
August	4.52	SW	SW	10.4	13.1	83	74	26.5	32.0
September	4.21	SW	SW	8.5	12.1	81	66	25.8	32.8
October	3.6	NW	SW	1.5	9.9	76	53	21.1	34.2
November	2.01	NE	SW	0.8	8.6	68	41	12.2	31.0
December	0.92	NE	SW	1.5	7.8	62	37	11.7	27.5

TABLE 11. MONTHLY AVERAGE DUST FALL AT QUAID'S MAZAR, 1984.

Months	Settleable particles gm/m²/30 days	Average air direction		Average air velocity(km/hr.)		Average humidity %		Average min. Temp.	Average max. Temp.
		03GMT	12GMT	03GMT	12GMT	03GMT	12GMT		
January	2.13	NE	SW	2.0	8.7	66	34	8.2	25.4
February	6.12	NW	SW	3.0	11.3	55	26	9.8	26.2
March	5.52	SW	SW	2.0	12.5	79	52	11.7	31.9
April	7.21	SW	SW	7.7	12.9	78	52	21.0	34.7
May	4.41	SW	SW	12.4	17.3	77	64	24.5	34.3
June	3.71	SW	SW	12.3	17.5	76	67	26.8	34.3
July	5.11	SW	SW	11.7	16.9	79	70	27.2	32.0
August	4.91	SW	SW	7.8	11.7	87	79	17.2	30.2
September	3.21	SW	SW	7.1	14.4	83	70	25.2	31.6
October	2.65	SW	SW	0.9	10.1	74	42	21.1	33.7
November	2.72	NE	SW	0.5	6.9	76	49	17.0	30.9
December	2.33	NE	NW	1.3	7.7	65	45	13.4	27.9

TABLE 12. MONTHLY AVERAGE DUST FALL AT QUAID'S MAZAR, 1985.

Months	Settleable particles gm/m²/30 days	Average air direction		Average air velocity(km/hr.)		Average humidity %		Average min. temp.	Average max. temp.
		03GMT	12GMT	03GMT	12GMT	03GMT	12GMT		
January	2.52	NE	SW	0.9	8.6	71	38	9.8	27.1
February	5.10	NE	SW	1.5	20.1	74	43	10.9	28.4
March	6.21	NW	W	4.1	11.9	71	46	19.1	34.1
April	7.49	NW	SW	7.9	12.6	78	57	22.3	33.1
May	4.31	W	SW	9.4	9.32	75	55	26.4	36.3
June	5.67	W	SW	13.5	22.6	77	63	28.2	32.4
July	5.11	W	SW	11.5	16.9	81	71	26.1	34.4
August	4.67	W	SW	10.5	13.6	70	73	24.3	31.5
September	6.03	NW	SW	11.2	15.9	80	67	24.1	32.2
October	3.81	NW	SW	0.5	5.7	71	40	21.6	35.1
November	1.91	Calm	SW	0.0	6.0	76	42	16.4	33.2
December	2.71	NE	W	0.1	2.1	64	37	10.2	30.1

TABLE 13. TYPICAL COMPOSITION OF DUST FALL.

Constituents (% by weight)	Quaid'sMazar (QM)	Karachi Laboratories (KL)
Loss on ignition	26.24	21.56
Silica (SiO_2)	39.06	42.81
Combined oxides ($Al_2O_3 + Fe_2O_3$)	12.01	11.04
Calcium oxide (CaO)	17.74	18.43
Magnesium oxide MgO	1.99	2.26
Sodium oxide (Na_2O)	1.27	1.12
Potassium (oxide K_2O)	0.56	0.34
Sulphur trioxide SO_3	1.03	2.52
Lead (Pb)	0.0096	—

TABLE 14. TYPICAL PARTICLE SIZE DISTRIBUTION OF THE DEPOSITS.

Grade size	Fraction (% by weight)	
	Laboratories (%)	Quaid's Mazar (%)
125	8.49	39.94
74	12.19	15.26
53	22.86	18.15
37	26.07	16.75
Below 37	30.37	9.88

TABLE 15. TYPICAL ANALYSIS OF CHIMNEY DUST*.

Constituents (% by weight)	National Cement Factory	Javedan Cement Factory
Loss on ignition	23.32	18.27
Silica (SiO_2)	20.30	17.35
Aluminium oxide (Al_2O_3)	3.66	7.6
Iron oxide (Fe_2O_3)	2.64	2.55
Calcium oxide (CaO)	47.01	46.00
Magnesium oxide (MgO)	2.23	2.30
Sulphur trioxide (SO_3)	—	2.33

* Source—Quality Control Managers of National and Javedan Cement Facotories.

ditionally, background values of both settled and suspended winds can be quite high during high winds [10]. It may be noted from Tables 1-12 that the wind velocity at Karachi is generally high in summer compared with that in winter. It is the highest during monsoon season; it increases from March to Aug. and decreases from Sept. to Nov. November has usually the lowest wind speed in Karachi. On a day to day basis it increases from morning to evening. It may be noted from the Tables that the higher quantities of dust-fall were observed during the high air velocity period of eight months compared with the rest during the same year. The highest air velocity i.e. 13.9 and 23.7 km/hr. was recorded at 03 GMT and 12 GMT respectively during June, 1985, which contributed to the maximum deposition of 12.04gm/(m^2month) dust-fall during the same month.

The dust-fall was significantly high at QM during the March to April period which was not the pattern at KL. The windy months i.e. May to July apparently did not cause high deposition of particulate matter at QM sampling site possibly because of the location of this point at the centre of the city where the surrounding area has metalled roads and has residential building around it. In order to test this hypothesis four sampling dishes were placed on the top base of the dome of QM in four directions NEWS, and it was observed that the deposition was almost the same on all dishes. This apparently suggests that it is the dust bearing wind which is responsible for the dust-fall. KL on the other hand is located in an unpopulated and barren area with no metalled roads or buildings around. The region is semi-arid comprising rocks of limestone, sandstone and clay. The winds carry high quantities of particulate matter due to loose soil and sand.

Karachi lies between two prominent deserts, Baluchistan in the west and Thar-Rajputana in the east. The soil of Karachi is partly residual, calcareous, derived from limestone, sandstone and dolomite, which are the dominant rock formations, and partly alluvial being drifted from the high land deposits in the region. Table 13 shows the typical composition of the dust-fall collected at the two sampling points. The higher concentrations of SiO_2 42.81% CaO 18.43% and MgO 2.26% at KL suggest that in addition to cement dust it also contains dust particles from the surrounding desert area.

The grey coloured dust having 26.24% loss on ignition 12.01% combined oxides and 1.03% SO_3 and also significant amount of Pb shows that the collected dust at QM is a mixture of cement dust, smoke and unburnt fuel whereas the high content of Na_2O and K_2O is due to salinity of the moist air on the coast.

National and Javedan Cement Factories together discharge over 70,000 tonnes of cement dust annually out of their total cement production (10% from Javedan + 7% from National) into the environment of Karachi during various operations. The two cement factories are located at two different sites, Javedan Cement on the north and National Cement at NE of QM and are surrounded by populated areas. The air direction during most of the year is such that a good proportion of cement dust emitted by the chimneys is spread over vast residential areas and contributes to the dust- fall in the city throughout the year.

Analysis of data in Tables 13 and 15 suggests that the dust-fall collected at the two sampling sites contains a significant amount of cement dust. It has been reported [11] that the chemical composition of the total aerosol mass of the Karachi city contains 20% limestone (cement), 28% silicates (soil, dust), 12% sea salt, 3% fossil fuel sulphate and 1% NO_3. The remaining 36% undetermined component has been suggested to be a mixture of soot, vehicular traffic aerosols, water vapour and other undetermined aerosol constituents.

The particle size distribution of the deposits listed in Table 15 indicates that at QM about 40% particles are of 125 micron size whereas at KL site more than 30% are below 37 micron size. A critical examination of the particle size of the collected dust-fall suggests that at QM site, dust-fall is mainly due to construction activity, cement kilns, and transport vehicles whereas the dust collected at KL site comprised cement dust and soil and sand particles of the surrounding area.

Conclusion

The foregoing description suggests that the kiln dust from the two cement factories, one located in the residential areas and the other on the outskirts of the city contributes to the extra amount of dust-fall being deposited throughout the city all round the year, and poses a major health hazard. The measurements carried out during the survey reveal that the monthly average dust-fall during the period of six years *viz*. 1980 to 1985, is 5.5gm/(m^2month) or (15.7 tons/sq. mile) and 4.57gm/(m^2month) or (13.0 tons/sq. mile) at KL and QM respectively whereas the natural rate of dust-fall as a rough estimate, should not exceed 5 tons/km^2/ 30 days [12].

It is suggested that appropriate measures such as wet scrubbers, electrostatic precipitators, fabric filters or mechanical collectors be installed to check the dust discharged from the chimneys of cement works. In addition, the construction activities be also monitored so that the rate of emission and deposition of particulates could be minimized and population of Karachi could be protected from this potential health hazard.

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