Asian Journal of Chemistry Vol. 3, No. 2 (1991), 197–205

DISTRIBUTION OF SOME AIRBORNE TRACE ELEMENTS IN ASWAN CITY

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Rubidium, barium and strontium together with zirconium and neodymium have been investigated in Aswan dustfall in twelve experimental sites. To reveal the relative metal distribution throughout the Aswan area, a contour and isometric map for each metal has been drawn using an advanced mainframe computer programme. With the exception of barium, strontium and zirconium in a few sites, the level of the remaining metals (Rb & Nd) contamination of the Aswan topsoils is limited. This will perhaps be the case until the end of the next century, provided there is no major change in anthropogenic sources.

INTRODUCTION

Continuing the series of the trace metal investigation in Aswan dustfallout,[1-5] the present paper reports on the detection of the annual distribution and accumulation of the airborne TM on topsoils in Aswan in comparison with other localities. As it has been mentioned before,[1-5] a network monitoring programme was established with the intention of studying the natural dustfall particles in Aswan city during the year 1982. These elements have been chosen for the present investigation due to the close similarity of the properties of Ba and Sr.[6] Together, these two alkaline earth metals resemble in many respects the chemical behaviour of Nd.[7] On the other hand, Aswan area is characterized by a wide exposure of granite, shale and sandstone.[7] However, Rb and Zr are found in trace concentrations in these types of rocks.[7]

EXPERIMENTAL

The general procedures and apparatus used in the present work are the same as those used in other recent publications from this laboratory.[5] In each of the twelve experimental sites of the dustfall (Fig. 1) sampling has been carried out regularly every quarter of a year by the use of six collecting buckets, each of five litres in size and with a base area of 139.56 cm^2. The annual bulk samples have been analysed using X-ray fluorescence. A representative dustfall sample from Aswan area for the year 1982 was prepared. It has been divided into two parts, one of which has been analysed for the TM composition by means of the atomic absorption, and the other used as a standard for XRF analyses. The twelve bulk samples were analysed (Table 1) and the relative element distribution throughout the Aswan area was plotted on two maps for each element, a contour and an isometric map (Fig. 2 and 3). In order to calculate the annual accumulation of the TM in the topsoil (Table 2) the base areas of the sampling buckets were taken into consideration.

RESULTS AND DISCUSSION

In the following section, the analytical results of the annual bulk samples will be discussed, with special emphasis on the local TM distribution in Aswan, and estimation of the annual values of the TM (trace metal) input to the topsoils.

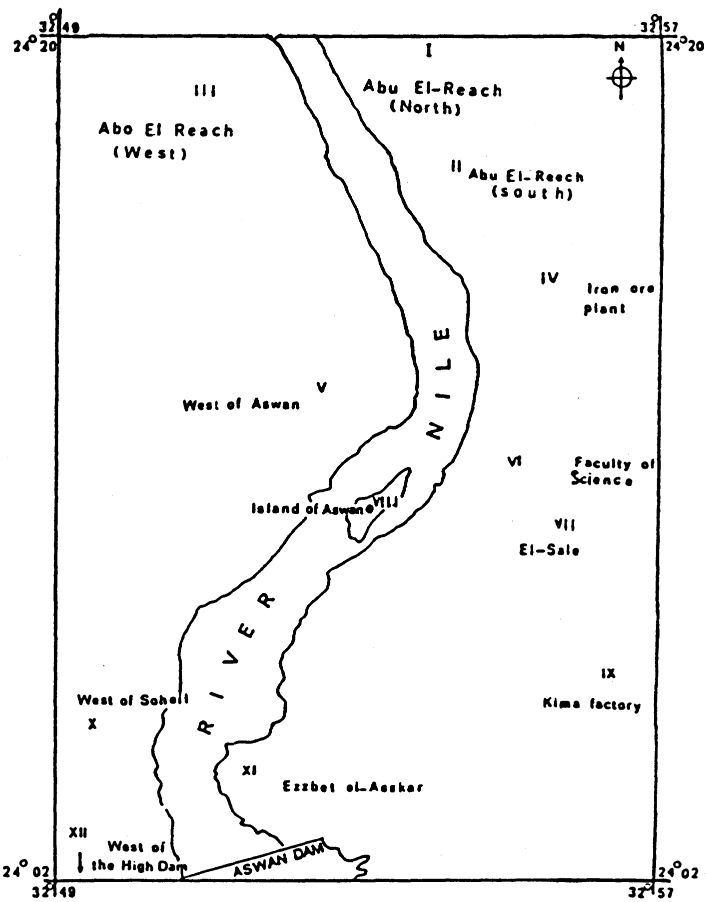

Fig. 1 Location of the experimental sites of the monitoring network dust materials in Aswan, Egypt

XRF ANALYSES OF THE BULK SAMPLES

Values of the TM detected are high and do not vary drastically in the different sites (Table 1); except for the Rb in almost all sites Sr, Zr and Ba in site IV are very low. Comparison of the contour and isometric maps with the location map has led to the following conclusion:

Barium and Strontium

The highest detected values of the Ba and Sr trace metals, 122 and 234 ppm respectively, occur in samples of site No. VI. Two other peaks for either Ba or Sr (28 and 43; 63 and 129 ppm) are noticed in site III and site VII. The general contouring pattern of the Ba trace metal shows a particular enrichment at the eastern part of the city (Fig. 2), whilst the isometric map exhibits a gradual decrease towards the south and west directions. However, the contouring pattern of Sr (Fig. 2) is

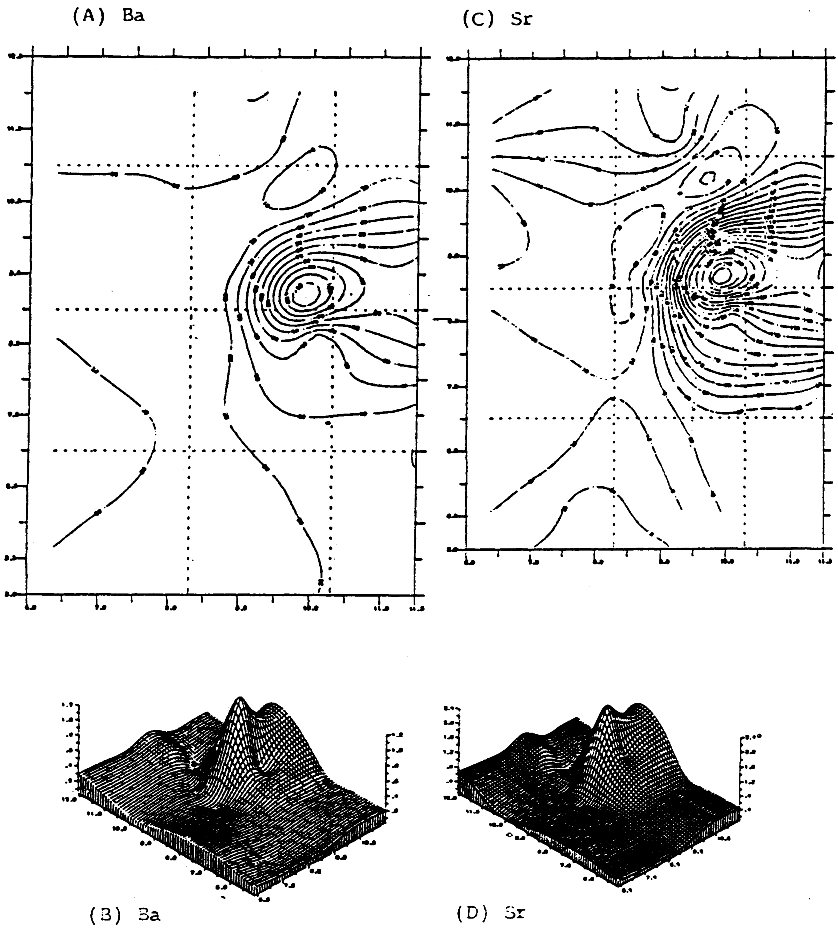

Fig. 2 Contouring map and isometric projection showing the distribution of barium (A & B) and strontium (C & D) in Aswan

compatible with that of Ba, implying shared provenance. The isometric distribution map of strontium shows a gradual decrease towards the south and west. Comparing the elemental composition of dustfall in Aswan with dust from air samples from Milan[8] and London[9] the Ba and Sr trace metal values in the Aswan fallout are rather high. However, the Sr values of Aswan fallout are dramatically increased in the northeast sector of the city with gradual decrease westwards across the Nile River.

Rubidium, Zirconium and Neodymium

The detected values of Rb trace element (Table 1) are lower than those of barium, strontium and zirconium. The highest value (18 ppm) was detected in a sample from Site No. VI. In comparison with other cities, the maximum quantities of Rb in Aswan dust are much less than those reported in London.[9] Site VI also revealed the highest peak of Zr (159 ppm). However, the isometric map shows a depression over the Nile trunk with increase in values at the periphery and

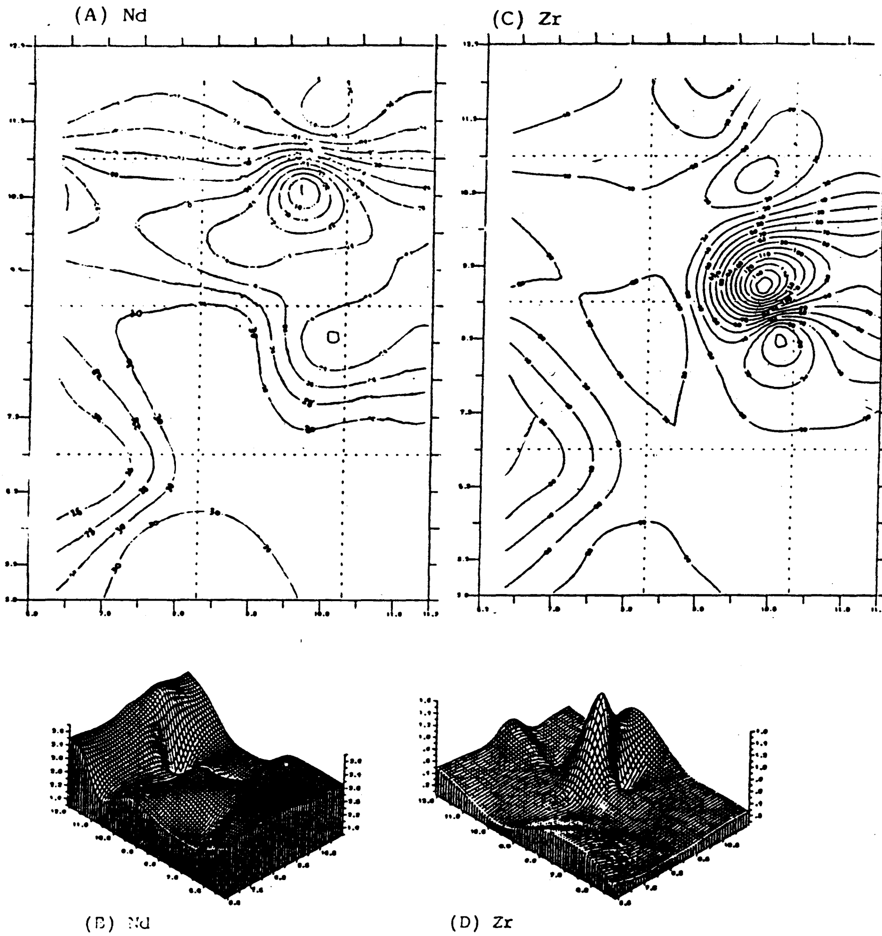

Fig. 3 Contour map and isometric projection showing the distribution of neodymium (A & B) and zirconium (C & D) in Aswan

outwards. It also shows a gradual decrease towards the north and northeast part of the city. The highest abundance of Nd occurred in the north and the south parts of the city (Site I, II and XII). The isometric map of Nd exhibits enrichment at the northern and the southern parts of the city, while it shows a gradual decrease towards the southeast and the southwest sectors. As with rubidium, the maximum concentration of Zr and Nd in Aswan dust fallout are much less than those reported in London.[9]

Accumulation of the trace elements in topsoils

As a consequence of the High Dam construction in Aswan, the seasonal transportation and deposition of fertile Nile River clay and silt over cultivated land has been reduced. Moreover, the addition of dustfall materials should influence the TM content of the topsoil in the long term. Enhancement of the level of potentially toxic TM in plants grown in the Aswan area could produce deleterious

TABLE 1
TRACE METAL CONCENTRATIONS (ppm) IN BULK SAMPLES OF DUST FALLOUT FROM TWELVE SITES IN ASWAN CITY DURING THE YEAR 1982

Element	Abu El Reesh			Iron ore plant	West Aswan	F. of Science	El-Sale	Island of Aswan	Kima	West Soheil	Ezzbet Assker	High Dam	Mean Values
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Rb	9	6	9	1	2	18	4	2	5	6	4	3	5.75
Ba	27	12	28	3	15	122	43	11	21	25	18	11	28.00
Sr	60	27	63	7	17	234	129	19	45	38	29	19	64.06
Zr	39	19	50	4	26	159	22	12	27	54	18	18	37.33
Nd	33	40	37	16	23	26	22	32	31	25	32	33	29.17

effects both on plants and on the animals and human beings who consume them. It has been reported[10] that, with the levels of metal contamination now characteristic of urban areas of the world, there is definitely enhanced entry of potentially toxic elements into food chains. An example of TM effects is a high incidence of dental caries in areas in the west of England contaminated by heavy metals.[11]

TABLE 2
CALCULATED MEAN ANNUAL ADDITION OF TRACE METAL TO THE SOIL SURFACE FROM ATMOSPHERE IN THE ASWAN AREA 1982 (gm/acre/annum)

Element	Site Number											
	I	II	III	IV	V	VI	VII	VII	IX	X	XI	XII
Rb	7.64	5.09	7.64	0.15	0.5	3.58	3.09	0.55	2.1	2.53	1.19	0.209
Ba	22.92	10.19	23.77	0.44	3.7	24.3	33.16	3.04	8.81	10.75	5.36	2.3
Sr	50.94	22.92	53.48	1.03	4.21	46.51	99.47	5.25	18.87	16.87	8.63	3.97
Zr	33.11	16.13	42.45	0.59	6.44	31.61	16.97	3.31	11.32	23.22	5.36	3.76
Nd	28.02	33.96	31.41	2.35	5.69	5.17	16.97	8.84	12.99	10.75	9.52	6.9

Accumulation of the trace elements in topsoils

As a consequence of the High Dam construction in Aswan, the seasonal transportation and deposition of fertile Nile River clay and silt over cultivated land has been reduced. Moreover, the addition of dustfall materials should influence the TM content of the topsoil in the long term. Enhancement of the level of potentially toxic TM in plants grown in the Aswan area could produce deleterious effects both on plants and on the animals and human beings who consume them. It has been reported[10] that, with the levels of metal contamination now characteristic of urban areas of the world, there is definitely enhanced entry of potentially toxic elements into food chains. An example of TM effects is a high incidence of dental caries in areas in the west of England contaminated by heavy metals.[11]

Effects of the trace elements upon the agricultural land

Together with the hazards to human beings and farm animals, natural dustfall materials and wind-blown dust are major harmful contributors to the agricultural lands in the arid regions. The mean annual addition of trace-metal to the topsoil of cultivated land is given in Table 3. If this level of contamination were sustained over 100 years, then the given data of Table 3 should be multiplied by 100. Consequently, according to current estimates of the median soil content,[11] the level of TM contamination of the Aswan topsoils is quite fair and will be so until the end of the forthcoming century.

Statistical Analyses

Correlation coefficient of the different TM has been computed from the analytical data given in Table 1, and listed in Table 4. From this table the following remarks can be delineated. There is a direct relation between each pair of TM (Sr & Ba, Sr & Nd, Sr & Zr, Rb & Sr, Rb & Zr, Rb & Ba, Rb & Nd, Zr & Ba).

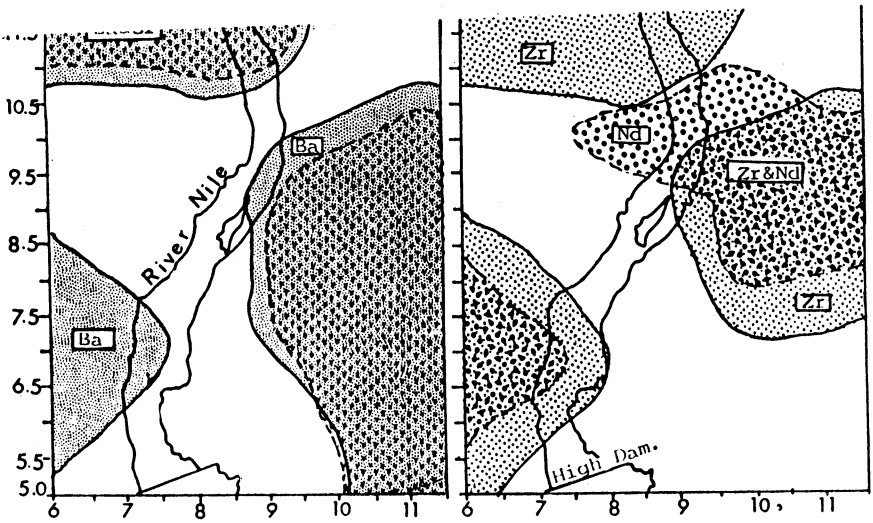

Fig. 4 Composite maps showing distribution-boundaries of the trace-materials detected in dustfall in Aswan during the yeat 1982. A: boundaries of Ba and Sr; B: boundaries of Nd and Zr.

TABLE 3
MEAN ANNUAL ADDITION OF TRACE-METAL (ppm)TO THE UPPER 20 Cm OF SOIL (TOPSOIL)

	Element				
	Rb	Ba	Sr	Zr	Nd
I	7.7×10^{-3}	0.023	0.051	0.034	0.028
II	5.2×10^{-3}	0.011	0.023	0.017	0.035
III	7.7×10^{-3}	0.024	0.054	0.043	0.032
IV	1.5×10^{-4}	$4.5ö10^{-4}$	1.1×10^{-3}	5.9×10^{-4}	2.4×10^{-3}
V	5.01×10^{-4}	3.76×10^{-3}	4.2×10^{-3}	6.5×10^{-4}	5.8×10^{-3}
VI	3.6×10^{-3}	0.025	0.047	6.5×10^{-3}	5.2×10^{-3}
VII	3.12x10	0.034	0.101	0.032	0.017
VIII	5.6×10^{-4}	3.07×10^{-3}	5.3×10^{-3}	0.017	8.5×10^{-3}
IX	2.12×10^{-3}	8.9×10^{-3}	0.019	3.4×10^{-3}	0.014
X	2.6×10^{-3}	0.011	0.017	0.024	0.011
XI	1.2×10^{-3}	4.42×10^{-3}	8.7×10^{-3}	5.4×10^{-3}	9.6×10^{-3}
XII	2.2×10^{-4}	2.33	4.1×10^{-3}	3.8×10^{-3}	6.98×10^{-3}
Medium soil concentration range (from Bowen 1979)	2.36×10^{-3} (1.5×10^{-2} - 0.0077)	9.96×10^{-3} (4.5×10^{-3} - 4.5×10^{-3})	0.018 (0.0011 - 5.56)	1.175×10^{-2} (5.9×10^{-3} - 0.043)	1.032×10^{-2} (2.38×10^{-3} - 0.039)

This indicates that each pair of TM might come from the same source. In order to assess the source of dustfall of Aswan area in terms of the interrelationship of the elemental constituent of the trace elements, a comparison between the present calculation (Table 4), and those representing the widely distributed soil, beds, and ores in Aswan area has been carried out. Kaolin soils[12,13], Nubian sandstone beds including oolitic iron ore and phosphate[14,15] deposits of Aswan, as well as dry-valley sediments east of Aswan[16] are considered. From the comparison it can be noticed that there is a direct relationship between Ba, Sr, Rb and Zr trace elements as well as Rb and Nd. That direct relationship among Ba, Sr, Rb, and Zr can possibly be attributed to their derivation from the same provenance (i.e. source rocks). The inverse coefficient between Zr on one hand and Ba and Nd on the other hand can be safely attributed to difference in specific gravities of these minerals and hence the soaring influence of the wind. However, the recent dry-valley sediments[17] are characterized by enrichments of Sr, Ba, Rb while Zr is enriched in the weathering products of the granitic rocks[17]. Moreover, the economic phosphate deposits which are produced by explosions and open-cast mining north of Aswan are also characterized by high constituents of Sr and Ba trace elements.

TABLE 4
CORRELATE COEFFECIENT VALUES OF TRACE METALS IN THE ASWAN DUSTFALL

Element	Rb	Sr	Zr	Ba	Nd
Nd	0.34	0.38	–0.34	–0.02	—
Ba	0.4	0.79	0.39	—	—
Zr	0.5	0.5	—	—	—
Sr	0.45	—	—	—	—

CONCLUSION

The distribution of dust fall-out in Aswan city indicated that the trace metals Ba and Sr (122 and 234 ppm) are concentrated in the eastern sector of the city, with a gradual decrease in the south and west across the Nile River. In spite of the high value of these two elements, it has no harmful effect on land plants or mammal muscle.[11] The remaining trace metals in this investigation (Rb, Zr, and Nd) behave similarly i.e. show a relative enrichment in the eastern part of the city. Consequently the author believes that the weathered granitic rocks and the Aswan iron-phosphate formations as well as the recent sediments of the dry-valley east of the city are the main sources of these trace elements.

REFERENCES

1. E. Khedr, *Aswan Sci. Tech. Bull*, **8**, 455 (1988).
2. E. Khedr and F. Hassan, *Aswan Sci. Tech. Bull.* (1988) (in press).
3. F.S.M. Hassan, *Asian J. Chem.*, **2**, 275 (1990).
4. ———, *Asian J. Chem.*, **2**, 399 (1990).
5. ———, *Intern. J. Environ. Anal. Chem.* (1990) (in press).
6. C.W. Wood and A.K. Holiday, Inorganic Chemistry, Butterworths, London, p. 75 (1967).
7. The Encyclopedia of Geochemistry and Environmental Sciences, V.VIA, Dowden, Hutchinson & Ross. Inc., Stroundsburg, Pennsylvania,. Fairbridge, R.W. (ed.) (1972).
8. R. Dams, J. Billiet, C. Block, M. Demuunck and M. Janssens, *Atoms. Envir.*, **9**, 1099 (1975), and P. Schutyser, A. Govaerts, R. Dams and J. Hoste, *J. Radioanal. Chem.*, **37**, 651 (1977).
9. I.E. Hamilton, *Sci. Total Envir.*, **3**, 8 (1974).

10. G.R. Anthony and R. Kozlovski, *J. Environ. Anal.*, **11**, 20–27 (1982).
11. H.J.M. Bowen, Environmental Chemistry of the Elements, Academic Press, London, p. 8 (1979).
12. E. Khedr, 13th Colloquium of African Geology, St. Andrews, Scotland, p. 355 (10–13 September 1985).
13. M.K. Sherif, R.M. Awadallah and F.S.M. Hassan, *Assuit Sci. Tech. Bull.*, II(1), 1–7 (1979).
14. E. Khedr, 14th Colloquium of African Geology, Technische Universitat Berlin, W. Germany, p. 121 (18–22 August 1987).
15. M.K. Sherif, R.M. Awadallah and F.S.M. Hassan, *Assuit Sci. Tech. Bull.*, II(1), 1–13 (1979).
16. G. Matheis and H. Schandelmeier, Current Research in African Earth Sciences, A.A. Balkema, Brookfield, pp. 467–471 (1987).
17. A.M. Abdel Salam, A.A. Khafaga, S. El Demerdashe and A.H. El Kadi, Reports of the Regional Planning of Aswan and the Desert Institute, Cairo (1974).

[Received: 27 March 1990; Accepted: 8 May 1990] AJC–170

APPENDIX I

WEIGHT OF DUSTFALL (TON/SQ KM) ON ASWAN CITY DURING THE FOUR SEASONS OF THE YEAR 1982 AND MEAN VALUE OF SEASONAL AND ANNUAL DEPOSITION, WIND VELOCITY AND TEMPERATURE (AFTER KHEDR, 1987)*

No.	Sites	Winter	Spring	Summer	Autumn	Mean Annual Deposition (MAD 82)
I	Abu El-Reech (rural)	229.75	268.39	161.23	189.43	212.22
II	Abu El-Reech (rural)	240.17	257.64	168.83	182.56	212.30
III	Abu El-Reech (desert)	237.78	279.59	154.97	177.69	212.26
IV	Iron-ore plant (desert)	16.67	23.66	72.15	34.16	36.66
V	West of Aswan (desert)	46.95	70.86	65.34	64.52	61.92
VI	Faculty of Science (urban)	34.80	41.65	66.52	55.79	49.69
VII	El-Sale (urban)	118.71	232.46	221.14	198.80	192.77
VIII	Nile Island of Aswan	34.83	120.43	94.74	26.04	69.01
IX	Kima Factory (industrial)	28.30	34.41	177.29	179.21	104.80
X	West of Soheil (desert)	17.44	192.12	161.40	59.02	107.50
XI	Ezzbet el-Assker (desert)	60.00	84.59	104.10	48.80	74.36
XII	High Dam, West (desert)	7.56	89.61	82.44	29.39	52.25
Mean Value		54.71	110.09	115.65	83.90	91.08
Mean Wind Velocity (Km/h)		15.66	17.00	17.33	15.00	16.25
Mean Temperature (°C)		18.00	32.00	33.00	22.00	26.00

* Collection of dustfall was carried out in six buckets having a total basal area of 837 cm and a volume of 30 litres.