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Distribution of Some Airborne Rare Earth Metals, Vanadium and Niobium in the Aswan Arid Area, Egypt

FATMA S. M. HASSAN

Chemistry Department, Faculty of Science, Aswan, Egypt

Two metals of the lanthanides (lanthanum and cerium) together with four transition metals (scandium, yttrium, vanadium and niobium) have been determined in Aswan dustfall in twelve experimental sites. To reveal the relative metals distribution throughout the town, contour maps and isometric maps have been drawn for each trace metal using an advanced mainframe computer programme. With the exception of vanadium in all sites and cerium in a few sites, the level of trace metals (TM) cotamination of the Aswan topsoils is limited. This will probably be the case until the end of the 21st century, providing there is no major change of anthropogenic sources.

INTRODUCTION

The construction of the High Dam in Aswan in 1960 and the creation of Lake Nasser south of it, have affected the local weather regime (information from the Egyptian meteorological Authority). This has consequences on the quantity and type of dust fallout. A net work monitoring programme was established[1], with intention of studying the natural dustfall particles in Aswan town during the year 1982. A very simple method[2] of dry collection bucket was adapted for seasonal sampling of dustfall, houshold dust, and street dust from around the town (Fig. 1, Appendix I).

It has previously been suggested a model of the seasonal yield of dustfal minerals in Aswan area in relation to the weather changes during the year 1982[2]. It has been established that there are three provenances of dustfall, including natural and anthropogenic sources. The present work has been planned to detect the annual distribution and accumulation of the airborne trace metals on Aswan topsoils comparable data will be sought from other localities.

EXPERIMENTAL

In each of the twelve experimental sites of the dustfall (Fig. 1) sampling has been carried out regularly every three months by the use of six collecting buckets, each of five liters size and with basal area of 139.56 cm^2. X-ray fluoresence has been used for the analyses of the annual bulk samples. A representative dustfall sample from Aswan area for the year 1982 was prepared. Part of each sample was analysed for the TM composition by means of atomic absorption and the remainder of the sample has been used as a standered for XRF analyses.

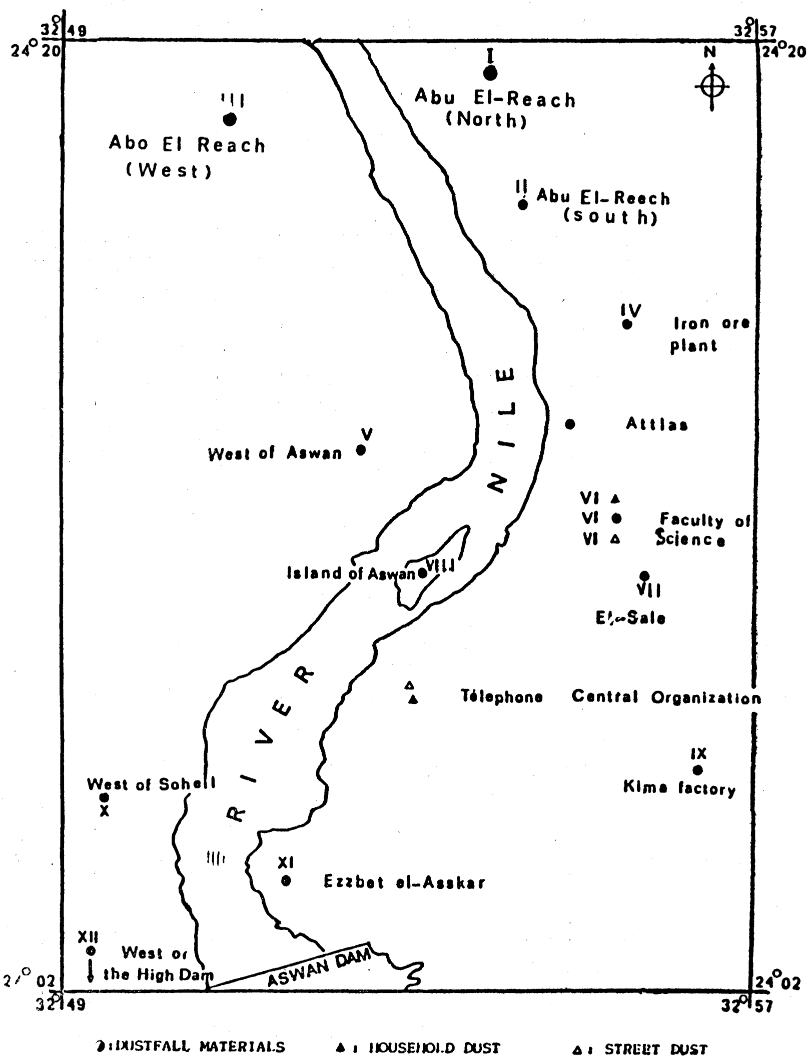

Fig. 1 Location of the experimental sites of the monitoring network dust materials in Aswan, Egypt.

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 map and an isometric map (Fig. 2 to 5). In order to calculate the annual accumulation of the TM in the topsoil (Table 2) the basal areas of the sampling buckets were taken into consideration. Rowland *et al.*[3] found out that the particles of the less than 4 μm size is capable of penetrating lung tissues.

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	Faculty 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	
Sc	18	22	20	13	19	23	22	17	24	18	21	21	19.8
Y	5	2	6	0	2	14	3	1	2	3	2	2	3.5
La	24	25	26	13	18	15	1	12	16	15	15	20	16.66
V	104	133	119	156	127	118	77	133	108	89	149	115	119
Nb	3	1	4	1	1	7	ULD	ULD	1	2	ULD	ULD	1.5
Ce	62	69	73	7	28	46	33	32	45	38	36	42	42.58

ULD = Under the limit of detection

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	VIII	IX	X	XI	XII
Sc	15.28	18.68	16.18	1.91	4.7	4.57	16.96	4.69	10.06	7.74	6.25	4.39
Y	4.24	1.7	5.09	—	0.49	2.78	2.31	0.28	0.84	1.29	0.59	0.42
La	20.37	21.22	22.07	1.91	4.46	2.98	0.77	3.31	6.61	6.45	4.46	4.18
V	88.28	112.9	101.0	22.88	31.4	23.4	59.37	36.7	45.27	38.3	44.32	24.04
Nb	2.55	0.85	3.39	—	0.25	1.39	—	—	0.42	0.86	—	—
Ce	52.63	58.57	61.97	1.03	6.93	9.14	25.4	8.83	18.86	16.34	10.7	8.78

RESULTS AND DISCUSSION

Throughout the following part, the analytical results of the annual bulk samples will be discussed. In this part it is emphasis on the local TM distribution in Aswan and has been extended to estimate the annual values of TM input to the topsoils.

XRF ANALYSES OF BULK SAMPLES

Values of the TM detected do not vary substantially in the different sites (Table 1), except for V in almost all sites and Ce in sites I, II, III. Comparison of the contour map and the isometric map for each trace metal throughout Aswan town with the location map has led to the following conclusion:

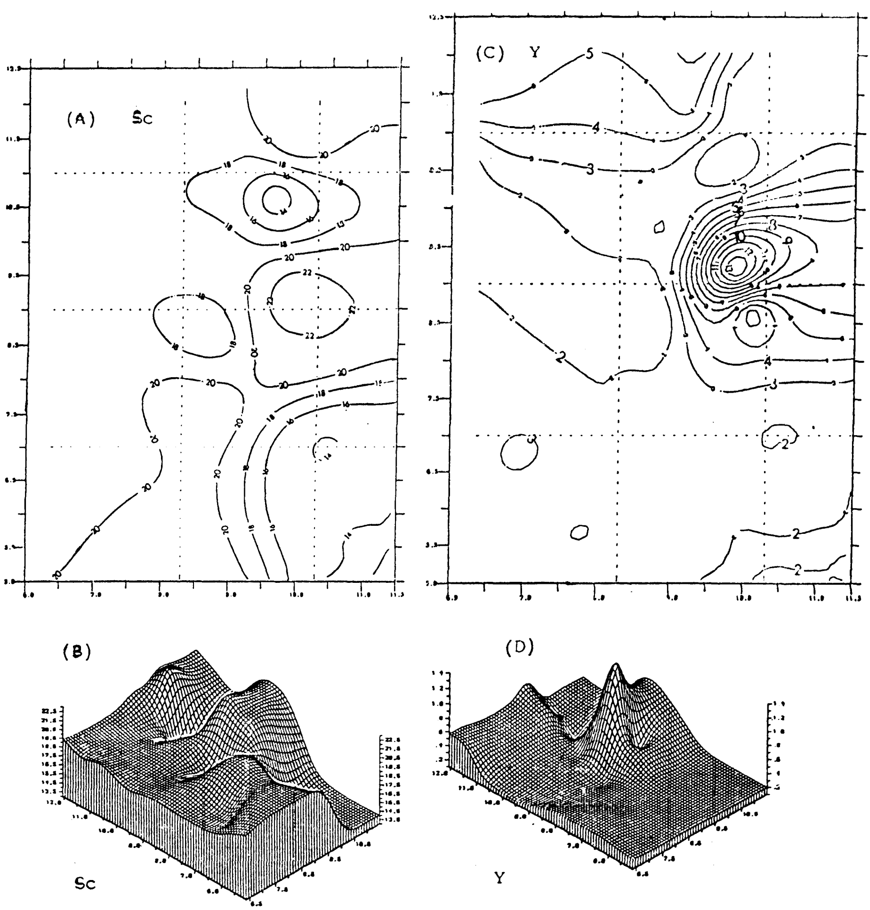

Fig. 2 Contour map and isometric projection showing the distribution of scandium (A&B) and yttrium (C&D) in Aswan.

Scandium and Yttrium

The highest value of Sc and Y (24 and 14 ppm) were detected at Kima, site IX and Faculty of science, site VI, respectively. Another two peaks for Sc (23 ppm) present at Faculty of science site VI east of the Nile and (22 ppm) at Abu El Reech and El-sale site II and VII. The general contouring pattern of the Sc trace metal shows a southeast distribution crossing the Nile bank. The isometric map (Fig. 2) exhibits a gradual increase from Kima site towards the south direction. The isometric map (Fig. 2) exhibits a gradual decrease from the scandium peaked zone in Kima site towards the north and south. The contouring pattern of Y (Fig. 2) is compatible with that of Sc, implying shared provenance. The isomeric map of Yttrium distribution shows a general taper off towards the south and the north/west.

Comparing the elemental composition of dustfall in Aswan with dust

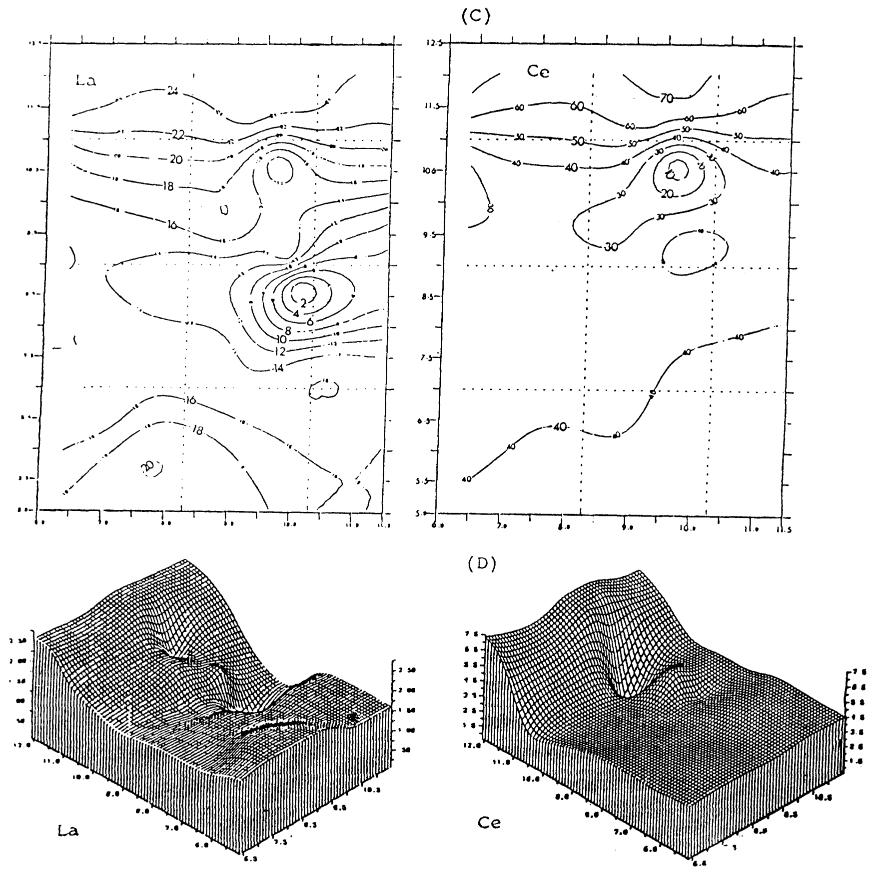

Fig. 3 Contour map and isometric projection showing the distribution of lanthanum (A&B) and cerium (C&D) in Aswan.

from air samples from north Norway (5), North America (6), and South Africa (7) the Sc and Y values of TM in the Aswan fallout are rather high. However, the Sc values of Aswan fallout are dramatically increased in the northeast sector of the town with gradual decrease westwards accross the River Nile.

Lanthanum and Cerium

The detected values of La and Ce rare earth metals (Table 1) are generally higher than those of Sc and Y (vide supra) and range between 24 and 26 and 46 and 73 ppm respectively. The highest values of La & Ce rare earth metals (26 & 73 ppm) were detected in a sample from Abu El-Reesh site No. III. Visual technique used for trend surface analysis of La and Ce maps indicate a northward and southward increase with gradual decrease eastward and towards the central part of the town (Fig. 3).

In comparison with other cities, the maximum quantities of La and Ce in Aswan dust are much less than those reported in North Norway[5], North America[6] and Europe[7].

Vanadium and Niobium

Concentrations of vanadium and niobium between 77 and 156, and 1 and 7 ppm respectively. These trace metals are relatively rich in the annual composite sample which was collected from the iron ore plant, site No. IV. The site with the next highest abundance of these TM is No. XI (Ezzbet El Asker). However, the Nb is the least abundant TM in all the analysed samples (Table 1). From (Fig. 4) it can be noticed that the distribution of V is condensed at the northern east part of the town with gradual decrease towards the centre and the southwest sectors. While one can observe from Fig. 4 that the high concentration of Nb is located at the eastern part of the city. It also exhibits a gradual decrease towards the north and the southeast parts of the town. In general, maximum concentrations of V and Nb trace metals in Aswan dustfall are lower than those are reported in North Norway[5], North America[6], and Europe[7].

Accumulation of the trace metals in topsoils

The construction of the High Dam in Aswan has substantially reduced the seasonal transportation and the deposition of fertile clay and silt over cultivated land. Consequently, 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 in the plants and in the animals and human beings which consume them. Anthony *et. al.*[5] have reported that, with the levels of metals contamination now characteristic of urban areas of the world, there is definitely enhanced entry of potentially toxic

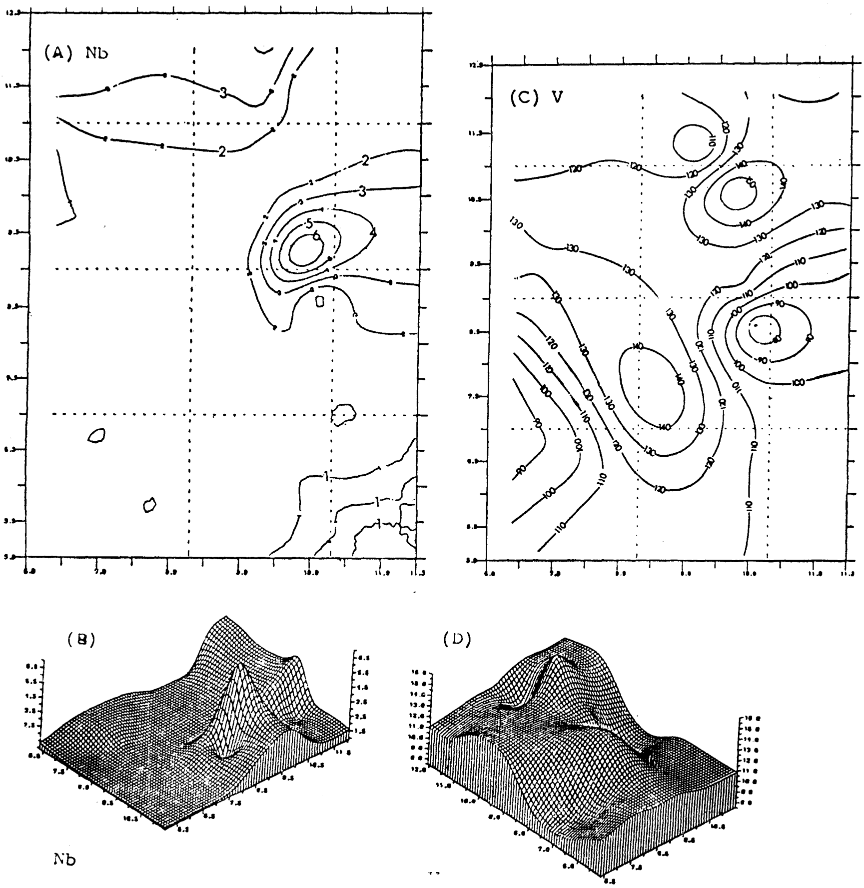

Fig. 4 Contour map and isometric projection showing the distribution of niobium (A&B) and vanadium (C&D) in Aswan.

elements into food chains. An example of TM effects is a high incidence of dental carries in areas in the west of England contaminated by heavy metals[6].

Because few people now subsist on food grown locally, the possible consequences of contamination of the soil are extremely to assess. The calculations in Table 2 mainly indicate the existance of a particular hazard which requires attention.

Effects of the trace-metals upon the agricultural land

Together with the hazards to human beings and farm animals, natural dustfall materials and wind-blown dust are major factors while considering the agricultural land of the dry regions. The mean annual addition of trace-metal to the topsoil of cultivated land is given in Table 2. If this level of contamination were sustained over 100 years, then the given data of Table 2 should be multiplied by 100. Consequently, according to current estimates of the median soil content[7], the level of TM contamination to the Aswan topsoils is quite fair and will be so until the end of the forthcoming century.

TABLE 3

MEAN ANNUAL ADDITION OF TRACE-METALS (ppm) TO THE UPPER 20 cm OF SOIL (topsoil)

Element	Sc	Y	La	V	Nb	Ce
I	1.5×10^{-2}	4.3×10^{-3}	2.6×10^{-2}	8.9×10^{-2}	2.6×10^{-3}	5.3×10^{-2}
II	2.2×10^{-3}	1.7×10^{-3}	2.5×10^{-3}	1.3×10^{-2}	8.6×10^{-4}	6.8×10^{-2}
III	1.7×10^{-2}	5.1×10^{-3}	2.2×10^{-2}	0.1022	3.4×10^{-3}	6.3×10^{-2}
IV	1.9×10^{-3}	—	1.9×10^{-3}	2.3×10^{-2}	—	0.001
V	4.7×10^{-3}	4.9×10^{-3}	4.5×10^{-3}	3.2×10^{-2}	2.5×10^{-4}	7×10^{-3}
VI	4.6×10^{-3}	2.8×10^{-3}	3×10^{-3}	2.4×10^{-2}	1.4×10^{-3}	2.9×10^{-3}
VII	1.7×10^{-2}	2.3×10^{-3}	7.9×10^{-4}	6×10^{-2}	—	2.6×10^{-2}
VIII	4.7×10^{-3}	8.2×10^{-4}	3.4×10^{-3}	3.7×10^{-2}	—	8.9×10^{-3}
IX	0.010	8.5×10^{-4}	6.7×10^{-3}	4.6×10^{-2}	4.5×10^{-4}	1.9×10^{-3}
X	8.9×10^{-3}	1.3×10^{-2}	7.5×10^{-4}	4.4×10^{-3}	8.7×10^{-4}	1.9×10^{-2}
XI	0.063	0.6×10^{-3}	5.2×10^{-4}	5.1×10^{-3}	—	1.2×10^{-3}
XII	4.4×10^{-3}	4.2×10^{-4}	4.8×10^{-4}	2.8×10^{-3}	—	1.01×10^{-3}
Medium soil concentration	7(0.5–55)	40(10–250)	40(2–180)	90(3–500)	10(6–300)	50(3–170)

TABLE 4

CORRELATION COEFFICIENT VALUES OF TRACE METALS IN THE ASWAN DUSTFALL

Element	Ce	Nb	V	La	Y
Sc	0.818	−0.23	0.83	0.73	0.02
Y	0.238	0.91	−0.2	0.036	
La	0.205	−0.051	0.797		
V	0.639	−0.362			
Nb	0.031				

Statistical Analyses

Correlation coefficient of the different TM has been computed from data of 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 (Sc and Ce, Sc and La; Y and Ce, and Y and Nb; La and V, and V and Ce). This indicates that each pair of TM might come out from the same source. On the other hand pairs of TM showing inverse relation are (Sc and Nb and Y and V). In order to assess the source of the dustfall of Aswan area in terms of interrelationship of the elemental constituent of trace elements, comparison between the present calculation (Table 4) and those representing the widely distributed soil, beds, and ores in Aswan area has been carried out. Kaoline soils[8,9], Nubian sandstone beds including ooletic iron ore and phosphate[10,11] deposited of Aswan area are considered. From the comparison it can be noticed that trace elements Sc, Y and Nb are directly related to each other. Moreover, the trace elements La, V, and Ce are directly related to each other. Previous investigation of the weathering products of the Aswan granitic rocks indicated that titanium and aluminium are directly related to trace elements Sc, Y and Nb. On the other hand Fe and phosphorus of both Aswan iron ore and the phosphorites are directly related to La, V and Ce. Consequently the author believes that the weathered granitic rocks as well as the Aswan iron-phosphate formations are main sources of these trace metals.

CONCLUSION

Distribution of dustfall out in Aswan area indicated that:

The trace metal V (77–156 ppm) gradually increases from the east to both northword and southward directions.

The trace metals Y and Nb show increase of values in the north and east of the city with gradual decrease southwestward. Also values of cerium show a general increase from the east to both the west and north directions crossing the River Nile (Fig. 5).

The scandium, yttrium, lanthanum, and niobium trace metals show much lower values in Aswan fallout than the vanadium and cerium.

The mean annual addition of the trace metal to the topsoil of cultivated land is given in Table 3. If this level of addition have sustained over ten decades, then the level of TM contamination would be in general quite limited and will be so until the end of the forthcoming century. Exception, however is vanadium at site III (Abu-El Reesh).

Whatever the source of these trace elements, the wind regime[1] could be one of the most important factors influencing their areal distribution in Aswan city.

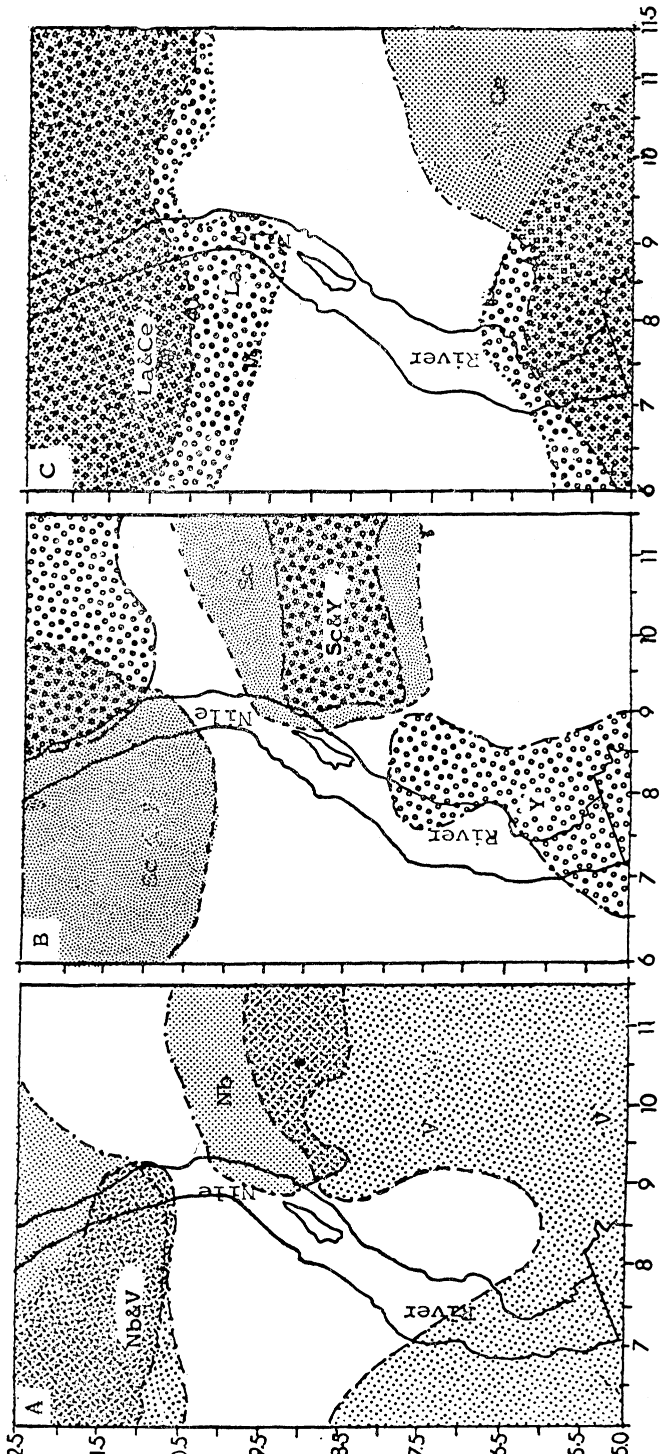

Fig. 5 Composite maps showing distribution-boundaries of the trace-metals detected in dustfall in Aswan during the year 1982: (A) boundaries of V and Nb, (B) boundaries of Sc and Y, and (C) boundaries of La and Ce.

APPENDIX—I

WEIGHT OF DUSTFALL (Ton/sq km) ON ASWAN CITY DURING THE FOUR SEASONS OF THE YEAR 1982 AND MEAN VALUES 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	104.1	48.8	74.36
XII	High Dam, west(desert)	7.56	89.61	82.44	29.39	52.25
Mean values		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	32	33	22	26

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

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