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Profile of Some Trace Elements in the Water - Surficial Sediment of Wadi El-Natrun Depresion Lakes, Egypt

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Abstract: Profiles of some trace elements (Fe Mn, Zn, Cu, pb and Cd) were detected in saline water and surficial sediment of Wadi El-Natrun depression lakes. The trace elements concentrations largely indicate the influence of weathering of terrigenous sources on land. The order of the studied trace elements in brine lakes of Wadi El-Natrun from high to low concentrations are Mn > Pb > Fe > Zn > Cu > Cd and Pb > Fe > Cu > Zn > Mn > Cd in ground water well, in addition to in the sediment Fe > Pb > Mn > Zn > Cu > Cd respectively. Also, the present results revealed that Zn, Cd and Pb in saline water of Wadi El-Natrun Lakes are within guidelines except for Cu. In sediment Cd and Pb are higher than guidelines except for Zn.

Key words: Trace elements · Water · Surficial sediment · Wadi El-Natrun depression lakes · Egypt

INTRODUCTION

Wadi El-Natrun, with its alkaline lakes, is an elongated depression about 90 Km North West of Cairo between latitudes 30º 15` north and longitude 30º 30` east (Fig. 1). Its average length is 60 Km and average width about is 10 Km. The bottom of the Wadi is 23 m below sea-level and 38 m below the water level of the Rosetta branch of the Nile [1]. The lowest part of the depression, encircled by contour zero, covers an area about is 272 Km^2. Inland lakes and crusts occupy the area surrounded by contour zero[2].

Drainage is mainly contained to small rills and stream lets. It is hard to recognize the pattern of drainage, probably due to the scarcity of rain and the deflation of sand which covers most of the Wadi features. A number of small shallow lakes extended along the deepest parts of the Wadi in an axial position near the eastern edge of the depression. These

lakes receive a limited supply of ground water which seeps into the depression. Since the evaporation rate is high and the lakes lie in closed basins without outlet, the water in the lakes has a high salt concentration and are susceptible to the shallow alluvial and Eocene limestone aquifers in the study area [2].

Adeel and Attia [3] recorded that the Wadi lies 23 m below sea level and is characterized by a series of 20 small disconnected lakes in the bottom of the Wadi. Ten of these lakes are relatively larger in size and have permanent water reservoirs in all or some of their parts. The largest lakes are lake Al-Gaar in the north west side of the depression and lake Umm Risha in the south east direction. On other side, the smaller permanent lakes are Al-Hammra, Al-Fasda, Al-Bida, Al-Khadra, Al-Zugm (Zaagig) and Abu-Gubara.

The lakes in two ways, as springs in some of the lakes as very small streams or trickles found on the seoping edgs of these lakes which find their way directly to the lakes. The origin of the water entering the wadi has been discussed by many authors Adeel and Attia [3] and Pavlov [4] attributed the source of the water to the radial inflow of underground water towards the lakes. Shata and El-Fayoumi [5] recorded that the main source of the water to this depression comes from underground water flow the Rosetta branch and its branches. Atia *et al.*[6] believed that the origin of the water is the Nile water infiltrating through sands and grovels constituting the strata separating the Wadi from the river. Recently, Sturchio *et al.* [7] addressed the origin of the water in the western Nile Delta by consideration of chemical and isotopic data for water samples collected from the area. They concluded that these waters are generally less enriched in D and O^{18} than Nile River water.

Taher [8] represented that the metal concentrations in a decrease in the order were: Pb > Cu > Cd > Ni > Zn > Fe > Mn in water and Pb > Zn > Cu in lakes II and III, while in the first lake decreasing order is Cu > Zn > Pb in sediment. Also, sediments with microbial mats were found to concentrate heavy metals above background sediment values.

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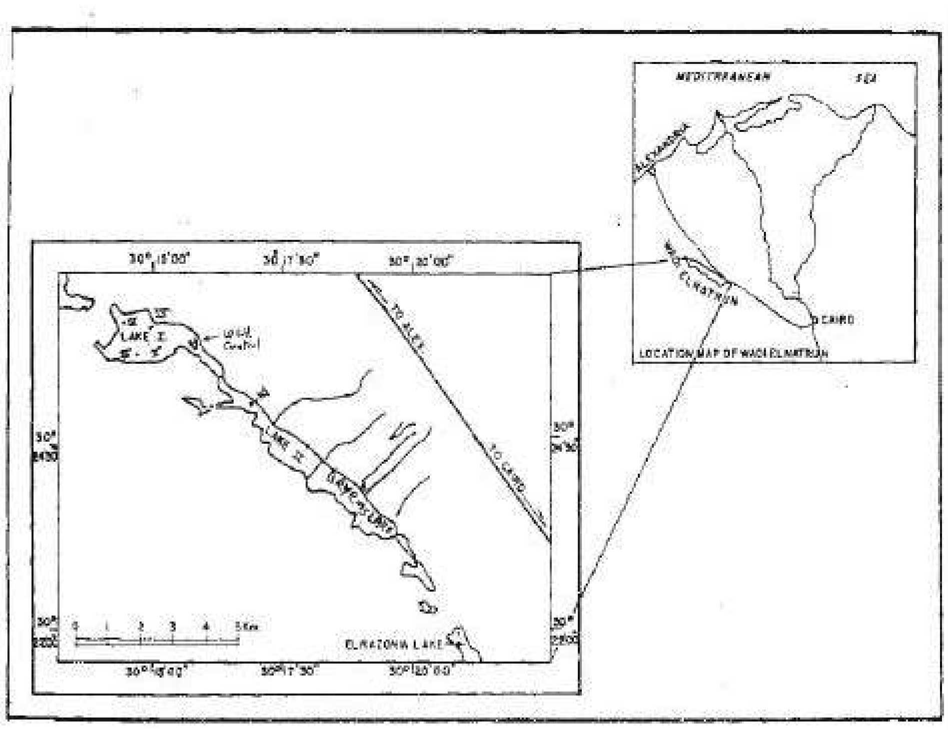

Fig. 1: Wadi El-Natrun, with its alkaline lakes

The present study aimed to give complete information on the profile of some trace elements (Fe, Mn, Zn, Cu, Pb and Cd) in the water and surficial sediment of Wadi El-Natrun depression lakes.

MATERIALS AND METHODS

The present study was extended from autumn 2003 to summer 2004 during four successive seasons. From the first big area lake (I) name (El-Bida) four brine water samples on the shore sides around the lake were collected. From the second small area lake name El-Hammra, one brine water sample was collected from the shore side of the lake. As well as ground water sample was collected from a well originated on the first lake, this sample is considered as control. The positions of stations I, II, III and IV in the first lake, station V in second lake and well ground water are represented (Fig. 1).

Brine water samples were manually collected using polyethylene gloves and stored in 500 ml polyethylene bottles. The samples were preserved in an ice-box and returned immediately to the laboratory. A part of brine water samples were preserved immediately after collection by acidifying with concentrated HNO_3 to pH < 2; by using 5 ml for 1 liter of water sample. Heavy metals extracted from water samples using nitric acid digestion method according to APHP [9].

Sediment shore samples were collected by hand using polyethylene gloves stored in polyethylene bags. The sediment samples were dried in Oven at 60 °C and finally grinds in an agate mortar, the digested according to Kouadiol and Trefry [10].

The total concentrations of trace elements (Fe, Mn, Cu, Zn, Cd and Pb) in water and sediment of Wadi El-Natrun depression lakes were measured using Inductive Coupled Plasma (ICP-400 Spectro Perkin Elmer, USA)

Statistical Analysis: The relationships between the different studied trace elements in the water and sediment were assigned by computing the correlation coefficients (r) using Microsoft Office Excel (2003).

RESULTS

Seasonal variations of Fe, Mn, Zn, Cu, Pb and Cd (µg/l) in the brines lakes of Wadi El-Natrun as well as in the ground water were recorded in Table 1. In addition to, the concentrations of this element in surficial sediment of Wadi El-Natrun lakes were recorded in Table 2. The results of the studied trace elements revealed that, the high concentrations of Fe, Pb, Mn, Zn, Cu and Cd in hyper saline and ground waters were recorded during spring and slightly increase during autumn -winter and

Table 1: Seasonal variations of trace elements studies in the Wadi El-Natrun depression lakes water (μg/l) during 2003-2004

	First Lake				Second Lake	
Stations Elements	I	II	III	IV	V	Well Control
(a) autumn						
Fe	136	116	90	155	15	342
Pb	20	44	36	90	362	277
Mn	290	306	332	283	638	32
Zn	43	46	46	28	12	40
Cu	9	12	4	7	9	33
Cd	3	4	7	8	13	4
(b) winter						
Fe	133	112	49	109	5	444
Pb	10	39	27	103	683	438
Mn	285	300	352	265	1130	38
Zn	54	45	47	27	11	42
Cu	11	10	3	8	16	11
Cd	3	3	9	7	13	2
(c) spring						
Fe	270	220	216	320	26	158
Pb	139	52	231	180	192	84
Mn	337	326	275	389	444	43
Zn	39	44	45	47	3	39
Cu	14	54	6	11	3	97
Cd	4	5	4	1	11	8
(d) summer						
Fe	5	16	5	37	25	126
Pb	181	113	131	95	211	308
Mn	279	292	370	309	338	14
Zn	8	10	8	10	22	37
Cu	2	3	2	2	6	115
Cd	6	3	8	1	14	7

Table 2: Seasonal variations of trace elements studies in the Wadi El-Natrun depression lakes sediment (μg/g) during 2003-2004

	First Lake				Second Lake
Stations Elements	I	II	III	IV	V
(a) autumn					
Fe	1089	4724	3240	1784	9345
Pb	272	1267	1710	500	1913
Mn	15	160	153	41	328
Zn	14	19	22	11	38
Cu	3	7	8	5	12
Cd	1.2	0.6	1.4	0.8	1.0
(b) winter					
Fe	4550	3393	2380	2842	12569
Pb	492	676	1324	834	699
Mn	217	106	73	58	226
Zn	21	29	13	13	26
Cu	7	11	4	6	14
Cd	0.3	0.9	0.4	0.7	5.5
(c) spring					
Fe	6422	1066	1009	621	3582
Pb	574	528	532	357	1488
Mn	242	180	61	25	97
Zn	24	18	14	8	28
Cu	12	4	4	2	9
Cd	0.3	1.5	0.6	0.9	0.3
(d) summer					
Fe	4629	529	6330	1889	130
Pb	1776	156	3274	610	30
Mn	407	23	324	40	10
Zn	15	4	41	11	4
Cu	8	1	18	6	1
Cd	1.5	0.4	3.2	0.7	0.7

the lower values were found during summer. On the other side, the obtained results of this elements in Wadi El-Natrun sediment lakes were increase during autumn / winter and were decreased during spring / summer periods respectively.

DISCUSSION

The distribution of metals in water, biota and sediments of the aquatic system is a function of the metals concerned and reveals the contamination states of the system [11].

Although inland saline lakes have been extensively studied for the last twenty years [12-14], little information is available on the behaviour of trace metals in such environments. This is particularly true for modern brines where reduced sulphur is also, present.

In view of the obtained results the concentrations of studied trace elements in saline lakes of Wadi El-Natrun are very low when compared with ground water. This is mainly attributed to the hypersaline water and increasing in pH values of this lakes which may facilitate in the sedimentation of these elements from water to sediment lakes. In addition to, the high concentration values of Cl^{-}. This agrees with that reported by Taher [8]. He showed that, in Wadi El-Natrun brines, the increased in Cl-concentrations can increase in metal solubility due to the formation of soluble chloro-complex of some trace metals. The order of the studied trace metals in brines lakes of Wadi El-Natrun from high to low concentrations are Mn > Pb > Fe > Zn > Cu > Cd and for ground water were collected in the same seasons are; Pb > Fe > Cu > Zn > Mn > Cd.

Generally, hypersaline ecosystem sediments are considered as a sink and source for trace metals. A number of authors has shown that sediments rich in organic materials operate as a biochemical sink for heavy metals, mainly due to the high concentrations of organic matter and sulphides under permanently reducing conditions [15,16].

The obtained trace metals concentration in the sediment are very high during different seasons inversely the obtained in saline water lakes. This may be attributed to, the unique ecosystem of lakes, high pH values, CO_3^{--}, $SO_4^{--}$and organic matter concentrations which facilitate the precipitations of studied trace elements from water to sediment of lakes. This interpretation was supported by the Jacobs and Emerson [17] who reported that, the high concentrations of trace elements as well as enrichment ratios could be due to the precipitation of these metals along with Fe as poly sulphide minerals by hydrogen sulphide which is thought to be evolved from sulphate-reducing bacteria. Colvert *et al* [18] and Pruysers *et al* [19] revealed that Cu and Zn are known for their high affinity for humic substances. These can represent a major part of the organic matter in recent sediments. Cu is also associated with the diagenesis of organic matter in sediments during its burial [20]. The association of Cu, Zn and Pb or their sulphides with organic matter can be either direct within the organic matrix or indirect, that is, adsorbed on fine grained sediments associated with higher organic carbon contents [20]. Mn oxide or hydroxide export from the suspended matter plays an important role in the distribution dynamic of total trace elements in the lake water [21].

The correlation coefficient "r" tested for the studied heavy metals in water and sediment of the Wadi El-Natrun depression lakes revealed that a positive and negative correlations between different studied elements in water and sediment. The average values of "r" at $P < 0.05$ for Fe, Pb, Mn, Zn, Cu and Cd in water with those in sediment were found to be (r = -0.62, 0.13, 0.33, -0.51, -0.05 and 0.17). The negative correlation of Fe and Zn showed that the increase or decrease in concentrations of two elements in water and sediment are dependent. Fe in water was negative correlation with Mn (r = -0.94, -0.85, -0.5), but in sediment was highly positively correlation (r = 0.93, 0.76, 0.72 and 0.91) during different seasons. Pb and Cd are highly significant positive correlation in water (r = 0.91, 0.81 and 0.87) and was not correlated in sediment except for summer (r = 0.98). Zn and Cu are strong positive correlation in sediment (r = 0.94, 0.87, 0.86 and 0.99) at $P < 0.01$) during different seasons and in water (r = 0.38 and 0.98) during spring and summer seasons. The obtained results of "r" among studied heavy metals in water and sediment during different seasons are declare that, the strong inter-relationships between those metals and the distribution of them are dependent. Also, the positive correlations between Fe / Mn, Zn / Cu and Pb / Cd indicated that each two elements are closely associated with each other in lake water and sediment. This was coincident with that reported by Abdel-Satar [21] on the Manzalah Lake. Moreover Taher [8] showed that the organic materials constitute a major part of the sediments and sulphat reducing bacteria probably provide the main chemical process operating in Wadi El-Natrun Lakes sediment. The order concentrations of the studied trace metals in Wadi El-Natrun Lakes

Table 3: Water quality guidelines of metals (µg/l) for fresh and salt water according to USEPA [22] at total hardens 350 mg/l

	Fresh water		Salt water		
Elements	Chronic	Acute	Chronic	Acute	Present results
Zn	340.0	340	86.0	86.0	11.6-35.00
Cu	26.0	44	3.7	5.8	3.0-17.60
Cd	5.6	17	8.8	40.0	5.0-7.000
Pb	9.5	240	8.5	220.0	94.2-172.0

Table 4: Sediment quality guidelines of elements (µg/g)

	USEPA [22]			
Elements	PEL	PEL	Salmons and Forstne, [23]	Present results
Zn	124	271	< 100	4-41
Cd	0.68	4.21	1	0.3-5.5
Pb	30.2	112	20-30	30-1710

sediment from high to low concentrations; Fe > Pb > Mn > Zn > Cu > Cd. As whole, the comparison between the present concentrations of some trace elements Zn, Cu, Cd and Pb in the water and sediment of Wadi El-Natrun Lakes with guidelines cited by USEPA [22] as recorded in the following Table 3.

From Tables 3 and 4 it is clear that, the studied trace elements (Zn, Cd and Pb) in saline water of Wadi El-Natrun lakes are within guidelines except for Cu. In sediment Cd, Pb are higher than guidelines except for Zn.

In conclusion Wadi El-Natrun appears to be a unique aquatic ecosystem among saline lakes. The high concentration of Cl-and pH values were increase in the elements solubility due to formation of soluble chloro-complex of some trace elements. The mechanism of accumulation of trace metals in the sediment is controlled by the degree of variation in texture and lithogenic component in sediment, as well as the physico-chemical environment. It is recommended to increase the numbers of under ground water wells influx in the lakes to improve the water quality and dilution of salinity lakes.

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