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ASSESSMENT OF METALS POLLUTION IN THE SEDIMENTS OF LAKE BURULLUS, S.E. MEDITERRANEAN, EGYPT

BY

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تقييم التلوث بالعناصر في رواسب بحيرة البرلس جنوب شرق البحر المتوسط - مصر

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تهدف الدراسة الحالية إلى تقدير نسبة العناصر الثقلية الموجودة في رواسب بحيرة البرلس . وقد تم تحليل عناصر النحاس والرصاص والزنك والكاديوم باستخدام جهاز البلازما . وتم حساب معامل حمل التلوث على النحو التالي الكاديوم > الرصاص > النحاس > الزنك . وجد ارتباط بين مستوى التلوث بالعناصر الثقلية في رواسب البحيرة وكل من كميه المياه المنصبة في البحيرة عن طريق المصارف - حركة التيارات وعملية التمعدن البيولوجي .

ABSTRACT

The present study aims to quantify the heavy metals contents in the sediments of Lake Burullus. Cu, Pb, Zn, and Cd were analyzed using ICP spectrometer. The contamination factors (CF) were calculated for each element. The CFs were found to fall in the following sequence : Cd > Pb > Cu > Zn. The pollution load index (PLI) was also estimated. Chernoff face analysis was used to represent the pollution extent at different stations. The level of pollution by heavy metals is mainly induced by the input from the drains, the biomineralization and the current circulations.

INTRODUCTION

Establishment of metal levels in sediments can play an important key role in detecting sources of pollution in aquatic systems. Lake Burullus has an area of 370 km^2. It occupies a central position along the Mediterranean coast of Egypt. It is connected to the Mediterranean through Boughaz El-Burg. Water depth ranges from 50 to 160 cm. The lake receives 3.6 x 10^6 m^3 of water annually, almost from domestic and agricultural sewage. Lake Burullus is a mesotrophic lake i.e. average chlorophylla 6.6 mg/m^3. The present study intends to scrutinize the pollution status in the lake sediments.

Materials and Methods

During 1990, a single sampling for a total of 16 surface sediments were collected, from different parts of the lake using grab sampler (Fig. 1). Sediment samples were prepared for analysis by washing with distilled water, drying and crushing to pass 300 mesh sieve. The digestion of sediment was done using a mixture of HF/HCLO4/HNO3. Analysis for Cd, Cu, Pb and Zn contents were preformed using ICP Spectrometer. Reproducibilty was checked by duplicate analyses of the samples. A Standard Reference Material (SRM 1646) was used to check the deviation from certified values being ± 7.4%

for Cu, ± 1.81% Cd, ± 8.13% for Pb and ± 7.45% for Zn. NCSS statistical package was used for data processing.

Results and Discussion

The results of the chemical analysis and the average concentrations (± standard deviation) for the different elements are shown in Table 1. In general maximum values for metals concentrations are always found in station 10. Pb ranged from 390 µg/g to 176 µg/g with an average of 259 ± 62.5 µg/g. Cu fluctuated from 151 µg/g to 17 µg/g (average 72.34 ± 42.29). Cd minimum value was 2.8 µg/g and the maximum value was 13.6 µg/g (average 5.79 ± 2.94). Zn, on the other hand, had an average contents of 81.9 ± 56.59 and ranged between 186.4 µg/g and 10 µg/g. In order to compare relatively between the different stations, a multivariate representation in the form of star plot was used (Fig. 2). A star plot is formed for each observation (station) in which the number of rays is equal to the number of variables (elements). The length of each ray is proportional to the relative value of that variable. The rays are connected forming the star. From Fig. 2, it is clear that station 10, which is located in the southern part of the lake, exhibits the highest concentrations. Station 3, follows station 10 in magnitudes of elemental concentrations. Stations, 1,5 and 14 show contamination of Cu, Zn and Pb relative to Cd. On the other hand, stations 11, 12, 15, 9 and 16 have very low contents of different elements.

To quantify the magnitude of pollution by different elements as well as the mutual effect of the studied elements, the contamination factors [1] were employed (CF = metal concentration in sediment/base value for lake sediments [2]). The base value corresponds to baseline or background concentrations reported from locations unaffected by man's activities [3]. The calculated CFs were found to fall in the following sequence : Cd > Pb > Cu > Zn (Table 1). In accordance with a suggestion by Tomlinson et al. [1] for classification of heavy metal levels in estuaries, the Pollution Load Index (PLI) were calculated for different stations sampled according to the following formula :

$$PLI = \sqrt[4]{CF_{Cd} \times CF_{Pb} \times CF_{Cu} \times CF_{Zn}}$$

The highest PLI i.e. 6.755 was observed in the southern part of the lake where the sewage enters the lake through different drains, while the lowest PLI i.e. 1.186 was found in the northern part away from the drainage system. The high CF values for Cd and Pb indicate that both metals are the major pollutants to cause the relatively Pollution Load Inex. The Chernoff face analysis [4] was used to interpret visually the extent of pollution at different stations (Fig. 3). Chernoff diagram is designed using caricatures of the human face to represent multivariate data. It associates variables in a data set with various features of the face. These stylized faces can in fact be used to represent the interplay for up to 16 variables [5]. Their principal advantages are that the human brain is especially equipped to analyze and interpret facial expressions and because facial features are linked (e.g. tightly knit eyebrows usually go with pursed lips), inter-relationships between different variables can also be readily depicted [5]. Chernoff face analysis for the present study, was designed to reflect the connotation of pollution. The most obvious, indicative facial features e.g. the mouth smile was chosen to represent the PLI for different samples. Eye spacing was selected to present the CF for Pb, while CF for Cd was illustrated by the brow length. The nose length discriminated the CF of Cu. The CF of Zn was distinguished by ear width. The happy face of stations 11, 12, 16, 9, 2, 4 and 7 are those samples of low pollution effects. On the other hand, the sad faces (i.e. stations 10, 3 and 1) graphically demonstrated the stations most affected by pollution.

The distribution of different elements may be controlled by the mineralogy of the sediments. The shells of organisms in Lake Burullus may concentrate Cd and thus act as a source to the sediments [6]. However, the increase of Cd in the shells, also may reflect the increase of environmental availability of this element. This has been shown for Cd, where the increase of Cd in mollusks' shell reflects the increase of Cd in the ambient water [7 and 8]. The positive correlations between Cd with different studied elements (r = 0.57, P = 0.022 for Cu; 0.529, P = 0.035 for Zn and 0.6006, P = 0.014 for Pb) possibly indicate the effect of biomineralization in concentrating these elements. However, these correlation levels may indicate possible other sources (e.g. associated with organic matter, controlled by the host mineralogy) for each element rather than skeletal contaminations. Lake Burullus sediments are largely contributed by

Table 1.
Results of the different elements studied, the calculated contamination Factors (CF) and the calculted Pollution Load Index (PLI) For different Stations.

Sample #	Cu*	Pb*	Cd*	Zn*	CF_{Cu}	CF_{Pb}	CF_{Cd}	CF_{Zn}	PLI
1	150.8	346	4.6	173.8	3.351	10.177	11.5	1.47	4.9
2	65.4	256	4	66.8	1.453	7.529	10	0.566	2.805
3	117	342	11.2	150	2.6	10.06	28	1.271	5.523
4	59.4	228	3	75	1.32	6.706	7.5	0.636	2.549
5	79	290	2.8	91.2	1.756	8.529	7	0.773	3
6	70.6	242	6.8	77	1.569	7.118	17	0.653	3.337
7	46.6	276	4	62.4	1.036	8.118	10	0.53	2.584
8	67.2	256	4.4	90	1.493	7.529	11	0.763	3.117
9	43.4	206	3.6	31.6	0.964	6.059	9	0.268	1.937
10	152	390	13.6	186.4	3.378	11.471	34	1.58	6.755
11	17	182	4.6	10	0.378	5.347	11.5	0.085	1.186
12	41.2	226	5.6	31	0.916	6.647	14	0.263	2.176
13	121	306	7	100.4	2.689	9	17.5	0.851	4.357
14	72.8	216	5.4	138	1.618	6.353	13.5	1.169	3.569
15	30.4	206	6.6	11.4	0.676	6.059	16.5	0.097	1.8
16	23.6	176	5.2	15.2	0.524	5.177	13	0.129	1.46
Average	72.34	259	5.79	81.89	1.61	7.53	14.44	0.694	3.18
± St. Dev	42.29	62.5	2.94	56.59	0.91	1.77	7.03	0.46	1.49

* Concentrations are in µg/g

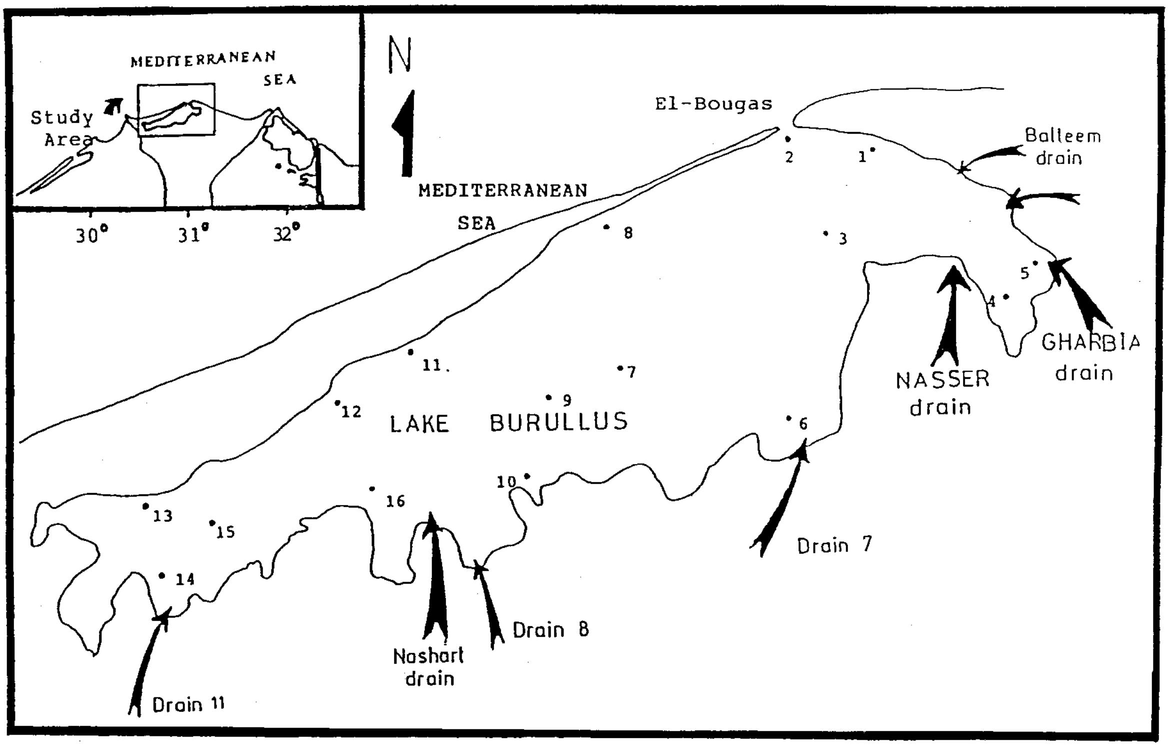

Figure 1. Map of Lake Burullus showing the location of the collected samples

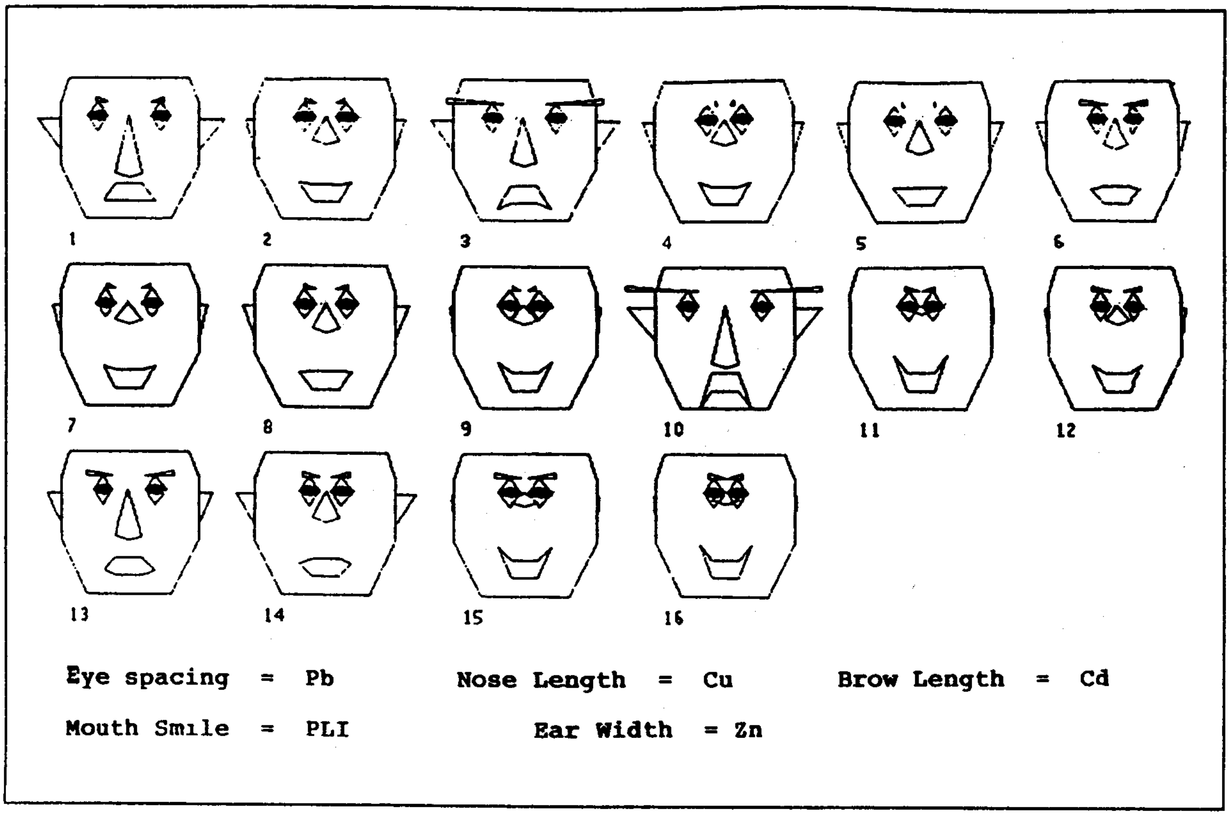

Figure 2. Multivariate star plot of the results for different stations.

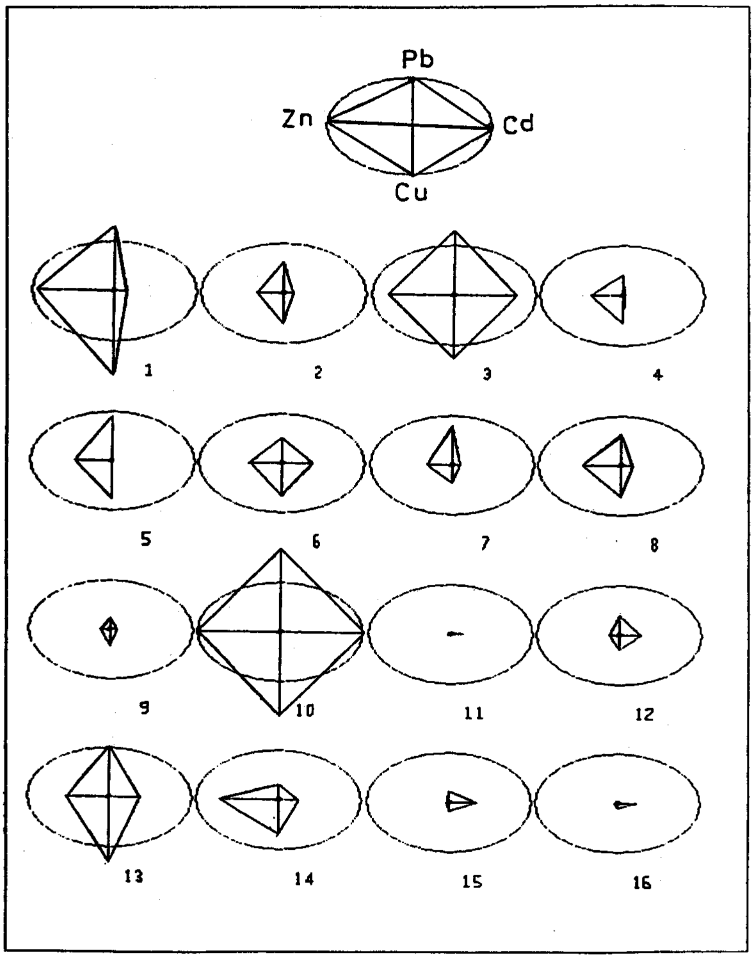

Figure 3. Chernoff face diagrams represent the calculated contamination factors and the Pollution Load Indices (PLI) for the different stations.

river Nile, where no regional distribution pattern within the sediments of the lake could be observed [9]. This may reflect the difference in elemental contents at different stations.

The high metal concentrations found in the stations near Boughaz El-Burg, and some drains, are possibly due to flocculation processes. A decrease in the dissolved fraction of Cu and Pb with increase in salinity was observed [10]. This was attributed to colloidal fraction present in the dissolved phase which flocculate out upon meeting salt water [10]. The net salt gain by Lake Burullus during 1987/1988 was 10 x 10^3 ton [11]. Salinity in Lake Burullus is not constant [12]. This may explain the sporadic distribution of the studied elements.

Conclusion

Metal pollution in lake Burullus is mainly associated with the input from different drains, the mineralogical contents and biomineralization. The current circulation in the lake and the mixing processes also caused flocculation and precipitation of colloidal forms.

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