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Environmental geochemistry, chemical speciation, and bioavailability of lead metal pollution in water and surficial bottom sediments of Burullus Lagoon, Egypt

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Abstract : Burullus Lagoon is a part from of a river Nile valley system. It is located on thenorthwestern side of Nile Delta. The lagoon has a shallow depth and brackish water and receives drainage water through several drains at its southern and north-eastern sides. Boughaz El-Burullus connects the lagoon with the Mediterranean Sea, which.
Understanding the mobility and bioavailability of lead metal in the bottom sediments of the Burullus Lagoon is substantial for the design of remediation processes and the institution of environmental recommendation for lead metal pollution. Single extractions using fractionation of Pb metal from twenty-one samples into five operationally defined groups: exchangeable *(EXC),* carbonate *(CA),*Fe-Mnoxy-hydroxides (FM), *organic(OM)and residual (*RES) *fractions.* The chemical analyses preceded using atomic absorption spectrometry after using the digestion technique. Lead distribution patterns in lagoon's water increase toward northeastern directions, possibly due to flocculation processes close to her lagoon inlet while the average content of lead in the studied sediments *(*156ppm*)* is about eight-fold the average earth's crust. *Pb was mostly bound to the residual fraction (186 ppm). The next most important fraction for Pb was the exchangeable fraction (100 ppm) followed by the carbonate and organicfractions (45 ppm) then the* Fe-Mn hydroxide *fraction (13 ppm).*The fractions in terms of lead levels was in the order RES> EXC >> OM > CA>FM.
Ecological pollution index for lead and its fractions shows that the metal speciation pattern is above the critical level that indicates that all metal species posed high-riskassessment to surrounding ecosystem in short or medium-term, except for the Fe-Mn hydroxide *fraction.* Anthropogenic activities count as the main reason for pollution in the lagoon. Bureaucracy program for monitoring the concentrations and apportionment of lead in the water lagoon, sediments, fish and other aqueous organisms related to food chain is recommended to decree.
Keywords : Burullus Lagoon, bottom sediments, pollution, Pb, Egypt.

Introduction

TheBurullus Lagoonforms a part of the River Nile system and it is one of northern out of four coastal shallower lakes at the Nile Delta of Egypt, namely; Maryout, Edku, Burullus and Manzala. It is located between the two Nile Delta branches. The present area of lake Burullus is about 420 km^2 (100000 feddan) of which 370 km^2 is open water Younis andNafea[1].The length of the lagoon is about 53 km; its width is about 13 km Frihy and Dewidar[2].Boughaz El-Burullus connects the lagoon, at its northeast side, to the sea. However, sand sheets and sand dunes separate the lagoon from the sea. The Burullus Lagoon receives drainage water at its southern boundary through seven drains, where four of these drains occur on the southern side. Terra drain and El-

Gharbia drain at the northeastern side of the lagoon. It also receives fresh water from Brimbal Canal situated at extremity western portion of the lagoon. Agricultural lands encompass the southern and eastern fringes of the lagoon.

Heavy metals naturally accumulate in bottom sediments, water, and air. However, Burullus Lagoon, in particular, contains high concentrations of lead contaminants. The available literatures confirm that the lagoon receives extremely large inputs of toxic metals from different anthropogenic sources and especially from agricultural, industrial drain and fishery boat emissions. The environmental problems of the lagoon originate mainly from the human influences; also, the lagoon seems to be distinct in terms of waste material receives. As far as the authors are aware, numerous studies focused on the degradation and ecology of the Burullus Lagoon, e.g., Ahmed etal. [3], Ramadaniet[4] al., Radwan[5-6],Dewidar and Khedr[7], Al-Sayeset al.[8], Chen, et al.[9], Mohamed**,** et al.[10], Mamdouh**,** et al.[11], El-Asmar, et al.[12], Khalil and El-Gharabawy[13],among others. Many authors study metal speciation in aquatic ecosystems (Li et al.[14], Svete, et al.[15],Fan et al.[16], Sharmin Shaila et al.[17], Shanthi et al.[18], Prusty et al.[19],Weng, et al.20).

Lead metal occurs in different speciation, therefore, sequential extraction adopted to assess themobility and bioavailability of lead in the contaminated lagoon bottom sediments. Tessier*et al*.[21], proposed the sequential separation scheme of heavy metals in soils into exchangeable, carbonate-bound, Fe-Mn oxides bound, organic bound and residual fractions. Potentially lead can be releasedbyhuman activity into environment ecosystem from industrial and agricultural operations. Many and varied anthropogenic uses of lead metal through which it enters into the aquatic environment (Siegel[22]).In spite of the crucial issue of the Burullus lagoon pollution by heavy metals, the published data are rather insufficient and fragmented. The main thematic of the present study is to map water and bottom sediment pollution in the lagoon using genuine chemical analysis data.

Material And Methods

Fourteen sites covering the Burullus Lagoon body specified during summer 2014.Each site represented by a surface water sample and a bottom sediment sample. In addition, seven bottom sediment samples also collected from sites near to theoutlet of the agricultural drains (Fig. 1). Water samples were collected manually by a plastic bottle sink 20 cm below the water surface, while sediments collected by Ekman grab sampler. The preparation of water and sediment for trace metal determination done according to the procedure described in FAO technical paper No.158.

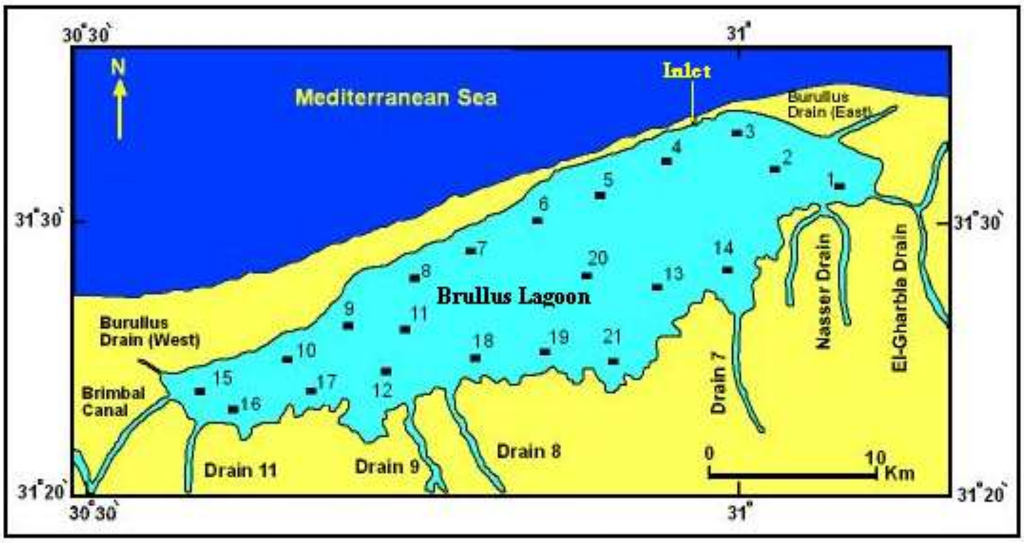

Figure (1): Key map of Burullus Lagoon showing the location of the sampling sites.

Sediment samples were air-dried, disintegrated and representative quotient was pulverized to size -100 mesh for chemical analysis. The chemical analysis preceded on whole sediment samples for the lead metal using atomic absorption spectrometry (Perkin-Elmer 3110, USA) with graphite atomizer HGA-600, after using the digestion technique according to the standard APHA[23]

Sequential Extraction Procedure:

The sequential extraction of the lead metal conducted on representative samples in order to assess the potential mobility and bioavailability of this metal in the studied sediments. According to Tessier, *et al.*[21],the sequential extraction divides the sample into 5 fractions according to the followingprocedure:

Fraction 1: The exchangeable fraction (EXC) is an extract of 8 ml of 1M 2MgCl at neutral pH for 1 h.
Fraction 2: The carbonate-bound fraction (CA) is an extract of 8 ml of 1M Sodium acetate adjusted to pH 5.0 with Acetic acid (for 5 h).
Fraction 3: The Fe-Mn oxy-hydroxides bound fraction (FM) is an extract of 0.04 M Hydroxylamine hydrochloride in 25% Acetic acid (v/v) at 96°C with occasional stirring for 6 h.
Fraction 4: The organic-bound fraction(OM)is an extract of 3 ml of 30% hydrogen peroxide in 0.02 M nitric acid (adjusted to pH 2 with HNO_3), then heated to 85°C for 2 h with occasional stirring.
Fraction 5: The Residual/lithogenic fraction (RES) is obtained by complete digestion of the residue with a mixture of 3 HF-HCI/HNO_3 in a digestion bomb. The overall recovery rates of the analyzed heavy metals range from 90 to 110 %.

Results and Discussions

Lead Metal in Lagoon Water

The total lead content of the investigated water is fluctuates between 5.9 and26.1 µg/l, averaging12 µg/l (Table 1).The spatial distribution ofleadindicatesan increase toward northeastern directions, possibly due to flocculation processes close to lagoon inlet, besides possible contribution from fossil fuel combustions resulting froma fishing boat and navigation process (Figure 2)**.** The data listed in table 1 indicate that the concentrations of Pbin the lagoon water have concentrations higher than that in Mediterranean Sea water (0.00003µg/l). Evaporation under the prevailing arid condition can also enhance the lead content in the lagoon water.

Table 1: Concentrations of lead in water and bottom-sediment samples of Burullus Lagoon and data of five steps of lead fractionation

	Total lead content		**Lead fractionations in sediments ppm**				
Stations	**In water µ g/l**	**In sediments ppm**	**(EXC)** Exchangeable	**(CA)** Carbonate bond	**(FM)** Fe-Mn hydroxide bond	**(OM)** Organic bond	**(RES)** Insoluble
1	9.5	165	38.6	15.3	3.1	16	92
2	22.9	203	38.6	19.9	11.8	24.9	108
3	26.1	186	37.9	23.1	2.8	14	108
4	17.4	210	42	34	4.5	22.1	107
5	13.7	164	37.9	28.1	5.7	20	72
6	9.2	227	39.9	26.8	2.4	18.1	140
7	8.7	110	37.7	30.6	5.6	19.8	16
8	7.4	140	39.3	15	3.6	20.1	62
9	7	121	41.6	7.1	2.9	16.6	53
10	5.9	131	41.7	23.5	1.6	15.4	49
11	6.7	179	42.1	10	5.7	15.4	106
12	6.1	121	40.3	15.6	10.5	23.1	32
13	8.9	144	44.4	22.6	4	21.7	51
14	18.7	140	41.3	21.9	4.1	15.3	57
15	N.m	113	40.7	4.6	9	14.4	44
16	N.m	152	39.8	6.5	3.3	15.3	87
17	N.m	143	40.3	7.1	6.5	12.8	76
18	N.m	163	39.9	19	3	14.9	86
19	N.m	145	37.9	33.4	5.5	14	54

20	N.m	145	39.9	16.1	5.9	10.6	73
21	N.m	166	41.6	6.2	6.2	34	78
Averag	12	156	40.2	18.4	5.1	18.0	74.4
Max	26.1	227	44.4	34.0	11.8	34.0	139.8
Min	5.9	110	37.7	4.6	1.6	10.6	16.3

N.m: Not collected so, not measured

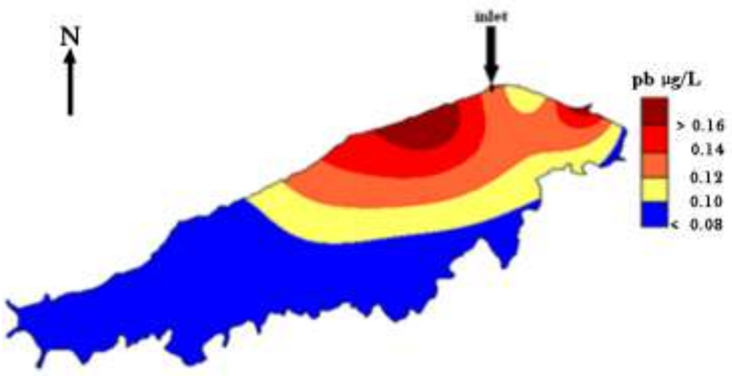

Figure 2:Spatial distribution map of lead metal in µg/l, in the studied lagoon water.

Table 2: Lead metal average (ppm)of the present work compared with the averages of shale published by Mason and Moor[25], Solomns and Forest[26] ,Freshwater sediments USPH[27] ,average earth crust McLennan and Taylor[24],average data on Burullus Lagoon by, Radwan and Shakweer[6],Mamdouh[28]and Masoud, *et al*.[29]

Reference	Pb	Reference	Pb
Average shale of Mason and Moor[25]	20	Radwan and Shakweer [6]	7
Solomns& Forest [26]	19	Mamdouh [28]	4
Fresh water sediments (USPH)[27]	20	Masoud,*et al.*,[29]	14
Average Earth's crust McLennan and Taylor[24]	20	Present study	156

Geochemical backgrounds

The comparison between the average of the present data and average earth's crust, as quoted by McLennan and Taylor[24], illustrates thatthe studied sediments are about eight-fold(156 ppm) the earth's crust average (Table 2).

Lead metal content in the lagoon sediments

As the main pollutant, WHO[30] reported lead as a strongly absorbed into sediment and soil particles reducing its availability to organisms. The following is a short discussion on the environmental condition of leadmetal, which may cause several hazardous or vulnerable effects on the human environment. The geochemical distribution map of lead outlines the potential sites of the study area (Figure 3).Table 1quotes the lead concentration in the investigated sediments where it ranges from 110 ppm to 227 ppm, averaging149 ppm. This average value is more than eight-fold the maximum permissible limit (MPL)as quoted by Kabata-Pendias [31] for the worldwide soil (20ppm).

The frequency distribution of the Pb is unimodal with a maximum at about 130-160 ppm (Figure 4 and Table 3).The distribution of lead in sediment increases to the north where agricultural activity and the human activities at El-Maksaba and Mastarouh villages, and northeastern portion of the lake near Boughaz El-burg where fishing activity using boat engine motor giving two high concentration spots. The western side of the lake shows declining in pollution level.

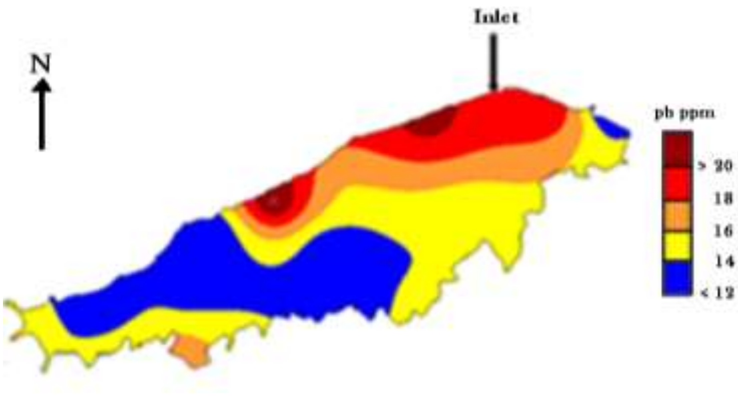

Figure 3: Geochemical maps of Lead metal in ppm in the studied bottom lagoon sediment.

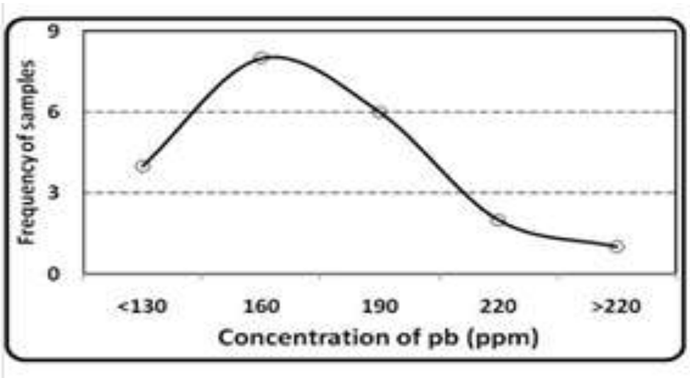

Figure 4: Frequency distribution of lead in the studied lagoon sediments.

Table 3: Frequency & distribution data for Pb ppm for 21 bottom lagoon sediments.

Bin	Lower	Upper	Count	Percent	total	Percent
1	110	130	4	19.0	4	19
2	130	160	8	38.1	12	57.1
3	160	190	6	28.6	18	85.7
4	190	220	2	9.5	20	95.2
5	220	227	1	4.8	21	100

Fractionation of lead metal in the studied lagoon:

The geochemical phases at each extraction step are largely operationally defined and indicate relative rather than absolute chemical speciation. The main interpretations are based on the solubility of metals. According to Rieuwerts, *et al.*[32], the bioavailability of metal in sediments depends on their distribution between the solid and solution phases. This distribution is due to the soil processes of cation exchange, specific adsorption, precipitation and complexation and pH value

The geochemical maps, based on sequential extraction data, show that anthropogenic activity and geochemical behavior of lead control the metal speciation pattern (Figure 5). The exchangeable fraction (Figure 5) controlled by southern drain especially drain 7, while this fraction decreases towardEl-Maksaba and Mastarouhv illages at the northern side of the lagoon. The distribution of carbonate fraction in sediment increases towards the middle and eastern sides of the lagoon where agricultural and human activities at El-Maksaba and Mastarouh villages. Although the Fe-Mn oxy-hydroxides bound fraction represents less contribution, it disperses over most of the lagoon area. The organic fraction increases toward the middle side of the lagoon. This suggests that the main part of the lead is possible of anthropogenic origin. The concentration and distribution of the residual fraction increase toward the southwestern and northeastern sides of the lagoon, reflecting the possible lithogenicorigin of lead, in association with crystallinesilicate minerals (Figure 5).

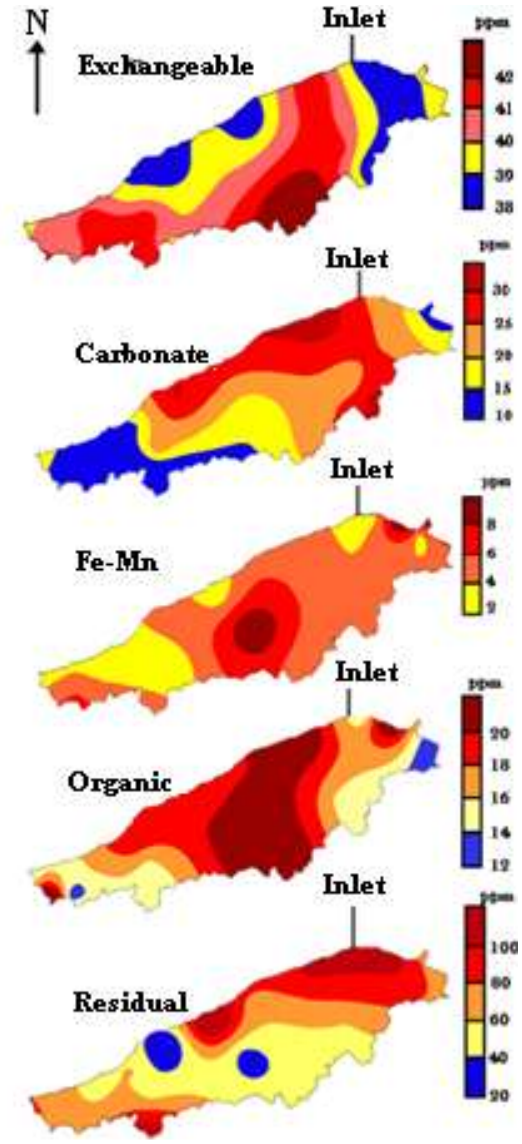

Figure 5:Geochemical maps of lead fractionations in the studied bottom lagoon sediment.

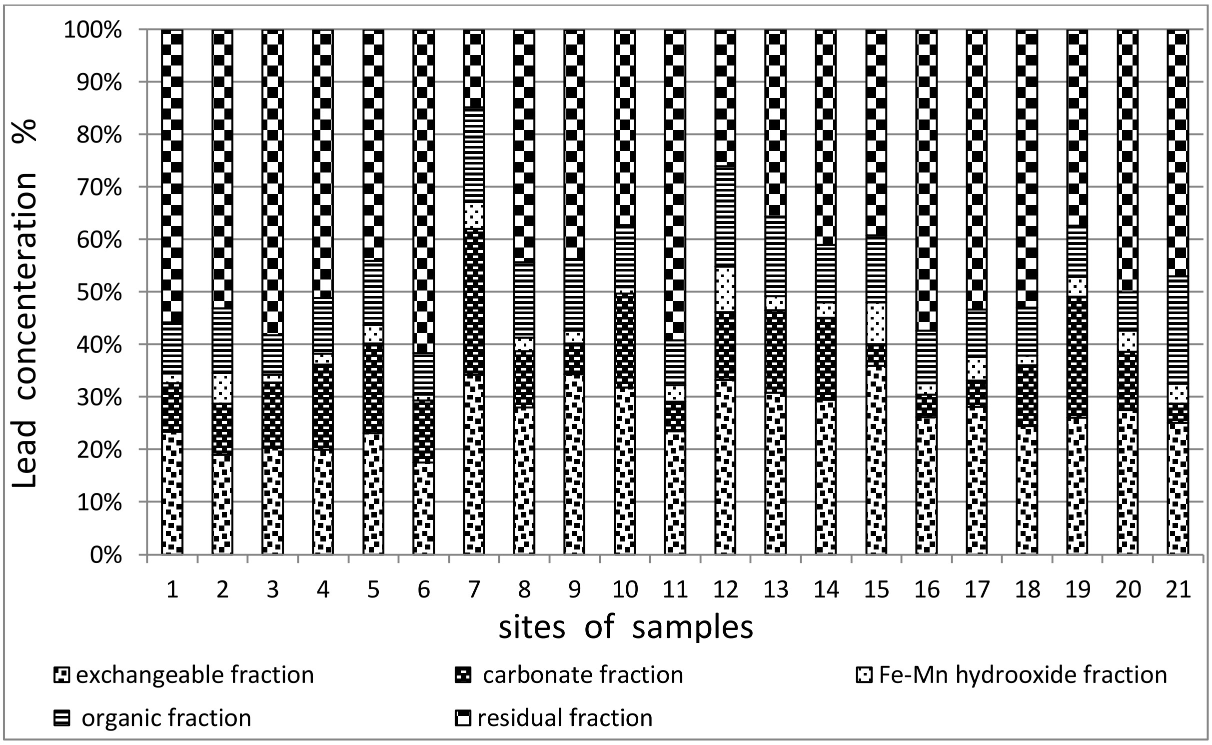

Figure 6:Lead fractionation in Burullus Lagoon bottom sediments.

The amount of lead present in the residual fraction ranges from 89.7% to 10.3 % with an average of 47.8 %, of the total content. The non-residual fractions represent 52.5% of the total Pb, in average. Among the non-residual fractions, lead mostly concentrates in the exchangeable and carbonates fractions **(Figure 6).**These two fractions represent26.9 to 50.3%, averaging 37.6% of the total lead. The organic fraction accumulates important quotient of lead in lagoon sediments, which accounts for 6.8% to 21.8%, averaging 11.5%, of the total lead content. The Fe-Mn oxy-hydroxides fraction represents the least contribution of about 3.3% of the total lead content, in average. The average data of lead speciation in Burullus Lagoon sediments suggest the following order of abundance; residual fraction > exchangeable fraction >carbonate fraction > organic fraction> Fe-Mn oxy-hydroxides fraction.

The regional pollution index (RPI):

The determination of the pollution degree of the bottom sediments of the Burullus Lagoon attained by normalizing the metals concentration to its Maximum Permissible Limits (MPL) defined for the worldwide soil. The MPL of an element refers to the “pollution standard level or goal” in the following equation of the regional pollution index (RPI):

RPI =Pollution concentration × 50 / Pollutant standard level or goal

For each region, the highest calculated index expresses the RPI for that region. An RPI of 50 corresponds to the relevant standard/goal. The following summarizes RPI classes: (a) Low pollution index from 0 to 24, (b) Medium pollution index from 25 to 49, and (c) High pollution index 50 or higher. The calculated the RPI of the studied Burullus Lagoon bottom sediments experienced high pollution levels by the exchangeable and residual fractions, as well as medium pollution level by carbonate and organic bond fractions but low pollution by the Fe-Mn oxy-hydroxides bound fraction(Table 4).

Table 4:Calculated regional pollution index (RPI) for the bottom sediment of the lagoon.

Stations	Total content	(EXC) Exchangeable	(CA) Carbonate bond	(FM) Fe-Mn hydroxide bond	(OM) Organic bond	(RES) Insoluble
1	413	97	38	8	40	230
2	508	97	50	30	62	270
3	465	95	58	7	35	271
4	525	105	85	11	55	269
5	410	95	70	14	50	181
6	568	100	67	6	45	350
7	275	94	77	14	50	41
8	350	98	38	9	50	155
9	303	104	18	7	42	132
10	328	104	59	4	39	122
11	448	105	25	14	39	265
12	303	101	39	26	58	79
13	360	111	57	10	54	128
14	350	103	55	10	38	144
15	283	102	12	23	36	111
16	380	100	16	8	38	218
17	358	101	18	16	32	191
18	408	100	48	8	37	216
19	363	95	84	14	35	136
20	363	100	40	15	27	181
21	415	104	16	16	85	195
Avera	390	100	45	13	45	186
Max	568	111	85	30	85	350
Min	275	94	12	4	27	41

Enrichment Factor (EF)

Enrichment Factor is an effective tool to evaluate the magnitude of contaminants in the environment. The controlling element for the enrichment factor calculation is iron (Fe) according to the formula proposed by Rubio, *et al.*[33]:

Enrichment Factor (EF) = $(M/Fe)_{sample}/ (M/ Fe)_{background}$

Where M is the concentration of a metal. The background value is that of average shale, obtained by McLennan and Taylor [24].The EF values:

- < 2 indicate that the metal is entirely from crustal materials or natural processes.
- > 2 suggest that the sources are more likely to be anthropogenic
- 2 - 5 moderate enrichment,
- 5 – 20 significant enrichment,
- 20 - 40 very high enrichment
- >40 extremely high enrichment

The enrichment factor (Ef) of lead metal in the studied lagoon sediments recommends that Fe-Mn oxy-hydroxides bound fraction is entirely related to crustal materials or natural processes. The carbonate bond and organic bond fractions show moderate enrichment level, whereas the residual fraction and the total lead content bear a significant degree of enrichment (Table 5). Finally, the spatial distribution of lead enrichment has a moderate level of most parts of the lagoon which seems likely to be anthropogenic.

Table 5: Calculated enrichment factor for sediment samples of the lagoon.

Stations	Total content	(EXC) Exchangeable	(CA) Carbonate bond	(FM) Fe-Mn hydroxide bond	(OM) Organic bond	(RES) Insoluble
1	34.08	7.97	3.16	0.64	3.30	19.00
2	41.75	7.94	4.09	2.43	5.12	22.17
3	39.68	8.09	4.93	0.60	2.99	23.08
4	44.48	8.90	7.20	0.95	4.68	22.75
5	38.36	8.87	6.57	1.33	4.68	16.91
6	47.75	8.39	5.64	0.50	3.81	29.41
7	23.10	7.92	6.43	1.18	4.16	3.42
8	30.00	8.42	3.21	0.77	4.31	13.29
9	25.88	8.90	1.52	0.62	3.55	11.29
10	27.36	8.71	4.91	0.33	3.22	10.19
11	37.03	8.71	0.64	1.18	3.19	23.96
12	25.41	8.46	3.28	2.20	4.85	6.61
13	31.28	9.64	4.91	0.87	4.71	11.14
14	29.97	8.84	4.69	0.88	3.28	12.29
15	27.62	9.95	1.12	2.20	3.52	10.83
16	31.34	8.21	1.34	0.68	3.15	17.96
17	32.72	9.22	1.62	1.49	2.93	17.46
18	33.58	8.22	3.91	0.62	3.07	17.76
19	30.71	8.03	7.08	1.17	2.97	11.48
20	30.93	8.51	3.43	1.26	2.26	15.47
21	34.20	8.57	1.28	1.28	7.00	16.07
Average	33.31	8.58	3.83	1.10	3.85	15.88
Max	46.68	9.13	6.99	2.43	6.99	28.75
Min	26.88	9.21	0.64	0.39	2.59	3.98

Table 6: Four groups comprising the contamination factors

Group	Cf Value	Contamination factor of lagoon sediment
i	< 1	Low contamination.
ii	1 - 3	Moderate contamination.
iii	3- 6	Considerable contamination.
iv	≤ 6	Very high contamination.

Table 7: Calculated contamination factor for the bottom sediment samples of the lagoon.

Stations	Total content	(EXC) Exchangeable	(CA) Carbonate bond	(FM) Fe-Mn hydroxide bond	(OM) Organic bond	(RES) Insoluble
1	8.3	1.9	0.8	0.2	0.8	4.6
2	10.2	1.9	1.0	0.6	1.2	5.4
3	9.3	1.9	1.2	0.1	0.7	5.4
4	10.5	2.1	1.7	0.2	1.1	5.4
5	8.2	1.9	1.4	0.3	1.0	3.6
6	11.4	2.0	1.3	0.1	0.9	7.0
7	5.5	1.9	1.5	0.3	1.0	0.8
8	7.0	2.0	0.8	0.2	1.0	3.1
9	6.1	2.1	0.4	0.1	0.8	2.6

10	6.6	2.1	1.2	0.1	0.8	2.4
11	9.0	2.1	0.5	0.3	0.8	5.8
12	6.1	2.0	0.8	0.5	1.2	1.6
13	7.2	2.2	1.1	0.2	1.1	2.6
14	7.0	2.1	1.1	0.2	0.8	2.9
15	5.7	2.0	0.2	0.5	0.7	2.2
16	7.6	2.0	0.3	0.2	0.8	4.4
17	7.2	2.0	0.4	0.3	0.6	3.8
18	8.2	2.0	1.0	0.2	0.7	4.3
19	7.3	1.9	1.7	0.3	0.7	2.7
20	7.3	2.0	0.8	0.3	0.5	3.6
21	8.3	2.1	0.3	0.3	1.7	3.9
Avera	7.8	2.0	0.9	0.3	0.9	3.7
Max	11.4	2.2	1.7	0.6	1.7	7.0
Min	5.5	1.9	0.2	0.1	0.5	0.8

Contamination factors (CF)

The contamination factor (CF) expresses the level of contamination of sediments. The following equation by Hökanson[34], classifies the contamination levels into four groups (Table 6).

CF= (Metal content in the sediment) / (Metal content in natural reference sediment)

Where the reference value is the background obtained by McLennan and Taylor[24].

The obtained data suggest moderate contamination forthe exchangeable and residualfractions, but low contamination for the other fractions (Table 7).

Geo-accumulation index (I_{geo})

Müller[35] defined the geo-accumulation index (I_{geo}) to enable an assessment of the enrichment degree by considering the anthropogenic pollution, the geochemical background values, and the effect of natural digenesis. The I_{geo} was calculated according to the following equation:$I_{geo} = \log2 (C_n / 1.5 \times B_n)$, *where*Cn is the measured concentration of the element n in sediment sample, and Bn is the geochemical background value of the element n according to McLennan and Taylor[24].A constant of 1.5 is used due to a given metal fluctuations in the soils as well as some very small anthropogenic influences (Loska,*et al.*[36],).The geo-accumulation index consists of seven classes or grades (Table 8), and the highest class (six) reflects a 100- fold enrichment above the background values (Förstner, *et al.*[37],).

The geo-accumulation index (I_{geo}) values for lead in the studied bottom sediment of the lagoon indicate uncontaminated to moderate contaminated for total lead content, exchangeable and residual fractions, but uncontaminated for other fractions(Table 9).

Table 8: Seven classes encompassing the geo-accumulation index

Class	**(I_{geo}) Value**	**quality of Lake sediment samples**
A.	≤0	uncontaminated
B.	0-1	Uncontaminated to moderate contaminated
C.	1 -2	Moderate contaminated
D.	2-3	Moderate to heavily contaminated
E.	3-4	Heavily contaminated
F.	4-5	Heavily to extremely contaminated
G.	>5	Extremely contaminated

Table 9: Calculated geo-accumulation index (I_{geo}) for bottom sediments of the lagoon.

Stations	Total content	(EXC) Exchangeable	(CA) Carbonate bond	(FM) Fe-Mn hydroxide bond	(OM) Organic bond	(RES) Insoluble
1	0.7	0.1	-0.3	-1.0	-0.3	0.5
2	0.8	0.1	-0.2	-0.4	-0.1	0.6
3	0.8	0.1	-0.1	-1.0	-0.3	0.6
4	0.8	0.1	0.1	-0.8	-0.1	0.6
5	0.7	0.1	0.0	-0.7	-0.2	0.4
6	0.9	0.1	0.0	-1.1	-0.2	0.7
7	0.6	0.1	0.0	-0.7	-0.2	-0.3
8	0.7	0.1	-0.3	-0.9	-0.2	0.3
9	0.6	0.1	-0.6	-1.0	-0.3	0.2
10	0.6	0.1	-0.1	-1.3	-0.3	0.2
11	0.8	0.1	-0.5	-0.7	-0.3	0.6
12	0.6	0.1	-0.3	-0.5	-0.1	0.0
13	0.7	0.2	-0.1	-0.9	-0.1	0.2
14	0.7	0.1	-0.1	-0.9	-0.3	0.3
15	0.6	0.1	-0.8	-0.5	-0.3	0.2
16	0.7	0.1	-0.7	-1.0	-0.3	0.5
17	0.7	0.1	-0.6	-0.7	-0.4	0.4
18	0.7	0.1	-0.2	-1.0	-0.3	0.5
19	0.7	0.1	0.0	-0.7	-0.3	0.3
20	0.7	0.1	-0.3	-0.7	-0.5	0.4
21	0.7	0.1	-0.7	-0.7	0.1	0.4
Average	0.7	0.1	-0.2	-0.8	-0.2	0.4
Max	0.9	0.2	0.1	-0.4	0.1	0.7
Min	0.6	0.1	-0.8	-1.3	-0.5	-0.3

Conclusions

Burullus Lagoon is one of four shallow coastal lakes in northern Egypt. It receives huge quantity of agricultural, industrial, municipal and domestic wastewater, in addition to navigation and fishing activities. The studiedelementhasa distribution that increases toward northeastern direction due to flocculation processes close to the lake inlet. The present work is based on chemical analysis data on the bottom sediments of the Burullus Lagoon. According to contamination factors, enrichment factors and the regional pollution index relative to average earth's crust the lagoon sediments hold markedly very high contamination by lead at all stations. The distribution of heavy metal in Burullus Lagoonconfirms that El-Maksaba and Mastarouh villages at northern area derive agricultural pollution, whereas El-Gharbia drain derives the industrial wastes of the textile factories of El-Mahalla El-Kobrato the lagoon. More industrial wastes as electroplating and synthetic fiber production, also the fishing boats contribute as possible sources of pollution.

Among all the fractions, residual fraction seems to the main carrier of lead (52 % of total content).In turn, a significant percentage of the metal occurs in the non-residual or mobile fractions. The speciation and bioavailability of lead follow the order; Res > EXC > OM > CA > Fe-Mnat concentrations; *186, 100, 45.3, 45, and 13 ppm,* respectively.

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