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TRACE METAL POLLUTION OF RECENT MOLLUSCAN SHELLS FROM LAKE QARUN SEDIMENTS, EGYPT

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Key words: environmental factors, trace metals, mollusc shells, Lake Qarun.

ABSTRACT

This paper aims to present a complete picture on the trace metals distribution in the recent mollusk an shells from Lake Qarun sediments. The mollusk an shells were collected during August 2003 and analyzed for the trace metals viz: As, Ba, Cd, Cr, Co, Cu, Fe, Mn. Mo, Ni, Pb, Se, Sr, V and Zn. Their relative order abundance in bivalve shells was: Fe> Cu> Sr> Zn> Mn> Pb> Ni> Se> As> Ba> Cr> Mo> Co>V >Cd, while in gastropod shells was: : Fe> Zn> Mn> Sr> Cu > As > Pb> Se> Ba> Ni>Cr> Mo> Co> V> Cd. The elements were more abundant in gastropod shells. Most elements were associated with aragonite(i.e. nepionic stage) in eastern and middle zone close to the source of the elements and with increasing age(i.e. in adult stage) associated with calcite in western sector. This is due to the mineralogy of shells, secondary alteration, location, environmental parameters, activity of organisms and source of sediments.

INTRODUCTION

Lake Qarun (Fig. 1) is located in an arid region occupying the deepest part of Fayoum depression in the western desert of Egypt. The lake is a closed, complex ecosystem has dynamic sediments. Closed, because it is an inland saline basin of about 4 km length, 5.7 km width, and has an average depth 4.2 m. Complex, because several state variables are needed to describe it, because the lake is not a homogeneous system but its various parts have different characteristics, and dynamic sedimen... because the physical, chemical and biological characteristics vary continuously over time. The lake may be regarded as a reactor limited sideward, upwards and downwards by three interfaces(human activity, agriculture drains/ water, water/ air and water/sediments) at which the exchanges of material are particularly active.

Due to the low average depth of the lake, the productive layer is in direct contact with activities of the decomposers and are most active. This accelerates the biogeochemical cycle between the macro- and micro fauna, sediments and the water. Pollution of lake systems is in an inevitable consequence of urban, rural and industrial development. Pollutants types and sources are diverse and include phosphorus and nitrogen from rural and agricultural practices, trace metals derived from industrial sources including base metal refining and metallurgical processing (Wittman, 1981; Roy and Crawford, 1984; Batley, 1987; Chenhall *et. al.*, 1993) and sediment influx in excess of natural levels (Kilby and Balty, 1993).

Throughout of world, one key adverse environmental impact of trace metal contamination of the sediment and water column, not only in lake, but also in terrestrial, riverine and marine settings. This is the potential for transference of toxic metals (e.g. Pb, As, Cd, Hg) into the food chain (Wittman, 1981; Keller, 1992; Lalibert *et. Al.*, 1992). Geochemical study of recent mollusk shells was recently dealt in details by several authors as Lowenstam (1954), Turikian and Armstrong,1960, Pilky and Goodel (1962), Dodd (1963), Chave(1964), Aliev (1971), Clark and Lutz (1980), Ismail and Abdel Aal (1986) and lotfy (1997, 2000, 2001, 2002 and 2003).

In such dynamic ecosystem and in view of the increased role of agriculture drain water reaching the lake, important changes have taken place which need to be evaluated and documented.

For this reason, the present study is deemed to be necessary. It includes detailed study on the status of fifteen elements in surficial molluscan shells in sediments to illustrate the relation between chemical composition, mineralogy, metabolism, secondary alteration and ecologic interpretation.

MATERIAL AND METHODS

Lake bottom samples (25 stations) were collected once during August 2003, using Peterson grab sampler (Fig. 1).

Lake water samples were collected at each station (Fig. 1) for determination of dissolved oxygen and salinity that analyzed according to the methods described by Strickland and Parsons (1972) and Packman induction salinometer. The pH values of water were measured by a pocket pH meter directly in the field. The total alkalinity was determined by titration versus standard HCl, using methyl orange indicator.

The shells of the bivalve *Haminoeo orbgnyana* (nepionic and adult) and the gastropod *Melanoides tuberculata* (nepionic and adult) were separated from the samples and identified.

The concentrations of As, Ba, Cr, Co, Cu, Fe, Mn. Mo, Ni, Pb, Se, Sr, V, Zn in the studied species were determined using the Inductivity Coupled Plasms (ICP) in the Central Laboratory for Environmental Quality Monitoring (CLEQM), National Water Research Center, Kanater, Egypt.

The pH values of sediments were determined by a pocket pH meter in the laboratory. The chloride content of sediments was measured gravimetrically according to the method mentioned by Hillebrand *et al.* (1953). Carbonate was determined by the method described by Alexeyev (1971) and organic matter was determined according to the method of El Wakeel and Riley (1957).

RESULTS AND DISCUSSION

General Characteristics of Lake Water and Sediments

According to the data recorded in Table (1) and Fig. (2), the dissolved oxygen in the west zone was 8.72 mg/l, then it decreased towards the middle zone (7.46 mg/l) and attained lowest eastwards (6.2 mg/l). Changes in total alkalinity content in water attained a highest value westwards (94.3 mg/l), then decreased towards the middle and eastwards reached to 78.32 mg/l and 62 .32 mg/l, respectively.

Values of salinity in bottom water at the study site was 33.21‰ in average, ranging from 38.68‰ at highest in west zone to and 27.64‰ at lowest in east zone and 33.16‰ at middle zone. The pH value of water was 8.9 in average, ranging from 8.6 at lowest in east zone to 9.2 at highest in west zone and 8.9 in middle zone.

Lake Qarun sediments showed a wide variation in carbonate content from one place to another. The calculated average of carbonate content was varied from 29.77% at east zone to 37.42% at west zone and attained 36.63% at the middle zone. The average of total salt content ranged between 0.25% at the middle, 0.3% and 0.36% at highest in east and west zone, respectively. The distribution of organic matter in the bottom sediments of the lake follows the salt content distribution. The highest was observed at west zone and attained 18.6%, while in the middle and east zones reached to 12.6% and 16.4%, respectively. The pH values of sediment were 9.2 in average, ranging between 9.11 at lowest in east sector and 9.31 at highest in middle zone, and it reaçhed to 9.25 at west zone.

Lotfy (1997) proved that the carbonate phases of mollusk shells (i.e. *Haminoeo orbgnyana*) consist mainly of aragonite and calcite (Table 1 and Fig. 2). The maximum value of aragonite was occurred in the eastern area (97.88%), and decreased westwards 992.5%), while calcite content reached to The maximum value (7.5%) at west area, and 2.12% at lowest in east zone. He also proved that the carbonate phases of gastropod shells (i.e. *Melanoides tuberculata*) consist mainly of aragonite and calcite. Aragonite content was varied between 28.5% at west area and 93.5% at east zone, while calcite content ranged from 6.5% at east zone to 71.5% at west zone.

Trace Elements Abundance in Bivalve Shells

Trace metals abundances in bivalve shells from Lake Qarun sediments have been previously documented by Lotfy (1997), who concluded that the most abundant trace elements of environmental significance were Mg, Sr, Fe and Mn. The levels of Mg, Fe and Mn increased generally westwards, where the Sr level decreased in that direction.

Tables (2, 3 and 4) and Figs. (3, 4 and 5), show the levels of arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), cobalt (Co),copper (Cu), iron (Fe), manganese (Mn), molybdenium (Mo), nickel (Ni),lead (Pb), selenium (Se), strontium (Sr);vanadium (V) and zinc (Zn) in the studied bivalve shells (i.e. *Haminoeo orbgnyana* in nepionic and adult stage) and gastropod shells (i.e. *Melanoides tuberculata* in nepionic and adult) from the sediments of Lake Qarun.

From Table (2) and Fig. (3), the average level of As and Ba in bivalve shells ranged between o.12 – o.68 and o.21 – 0.63 ppm$\times10^{-3}$, respectively. The As in adult stage of *Haminoeo orbgnyana* attained a highest value in west zone with an average of 2.1 ppm$\times10^{-3}$, then it decreased abruptly in the middle zone with an average of 0.12 ppm $\times10^{-3}$, while a highest value of Ba was recorded westwards, (o.63ppm$\times10^{-3}$) and the lowest towards the middle zone (0.16 ppm$\times10^{-3}$), As level in nepionic stage ranged between 0.13-o.68 ppm$\times10^{-3}$ and the maximum value in the middle zone, while Ba level varied from 0.25 -0.33ppm$\times10^{-3}$, and attained a highest value in west zone . Generally, the highest value of As was recorded in the middle zone and nepionic stage, while Ba increased westwards and in adult stage.

The average levels of Cd, Co, Cr, Cu and Fe varied between 0.003-0.11, 0.01- 0.5, 0.012- 0.7, 0.14- 6.8, 0.8- 6.7 ppm$\times 10^{-3}$,respectively. According to the distribution of these elements in *Haminoeo orbgnyana*, the eastern zone proved to have a high Fe level, reaching 6.7ppm$\times 10^{-3}$ in adult stage, while the high value of Cu (6.8ppm$\times 10^{-3}$) was recorded in the middle zone and nepionic stage. Finally, the western zone proved to have a high levels of Cd, Co and Cr in adult stage, reaching to 0.11,0.5and o.7ppm$\times 10^{-3}$,respectively.

From Table(2) and Fig. (3), the levels of Mn, Mo, Ni, and Pb in the *Haminoeo orbgnyana* shells ranged from 0.5- 2.2, 0.01- 0.5, 0.009- 5.4 and 0.1- 5.4ppm$\times 10^{-3}$, respectively. Their maximum values were recorded westwards and in adult stage, except Mn in nepionic stage .

The mean level values of Se, Sr, V and Zn varied between 0.09- 2.5, 0.6- 5.2, 0.007- 0.14 and 0.95- 2.63ppm$\times 10^{-3}$, respectively. Their distribution attained the highest in western sector in adult stage, except Sr and Zn in nepionic stage.

The zonal distribution of trace metals in bivalve shells of Lake Qarun proved that the highest level of Ba, Cd, Co, Cr, Mn, Mo, Ni, Pb, Se, Sr, V and Zn was found in western sector, while As and Cu values increased in middle zone and Fe reached the highest in eastern zone.

According to the age of the shells , the highest levels of Ba, Cd, Co, Cr, Fe, Mo, Ni, Pb, Se, Sr and V attained in adult stage , while that of As, Cu, Mn, Sr, and Zn were recorded in nepionic stage.

Enrichment Factors(E.F.)for the shells can be derived using the following expression:

$$\text{E.F.} = \frac{\text{mean concentration of trace metals in nepionic stage}}{\text{mean concentration of trace metals in adult stage}}$$

With the exception of the eastern sector(close to the El Bats agriculture drain), the E.F. for As, Cd, Cu, and Sr were greater than 1.55,2.33, 1.29, and 1.44, respectively, while Ba, Co, Cr, Fe, Mn, Mo, Ni, Pb, Se, V and Zn levels exhibited low enrichment in nepionic stage.

In the middle sector(close to the El-Wadi agriculture drains), the E.F. for As, Ba, Cd, Co, Cr, Cu, Fe, Mo, Ni, Pb, Se, V and Zn were greater than 5.67, 1.56, 1.8, 9.2, 6, 48.58, 189, 12, 7.78, 5, 8, 8.57 and 2.66, respectively, while Mn and Sr levels exhibited low enrichment in nepionic stage.

In the west sector, the E,F, for Mn, Sr and Zn were greater than 1.57, 1.86 and 1.56, respectively, while As, Ba, Cd, Co, Cr, Cu, Fe, Mo, Ni, Pb, Se and V levels in nepionic stage exhibited low enrichment.

Trace Elements Abundance in Gastropod Shells

Lotfy (2000) concluded that Fe, Mn and Zn are more associated with bivalve shells, while Cu, Pb and Cd are more associated with gastropod shells. From Table(3)and Fig. (4), the mean concentration of As, Ba, Cd, Co and Cr in gastropod shells(i.e. *Melanoides tuberculata*) varied between 0.3- 5.3, 0.06- 2.7, 0.001- 2.7, 0.01- 1 and 0.01- 0.56ppm$\times 10^{-3}$, respectively. According to the zonal distribution of these trace metals in gastropod shells, the western sector proved to have the high values of As, Ba, Cd and Co levels, reaching 5.3, 2.7, 0.07 and 1 ppm$\times 10^{-3}$, respectively, in adult stage, while Cr level increased in middle zone and in nepionic stage.

The average levels of Cu, Fe, Mn, Mo and Ni in the *Melanoides tuberculata* shells were 0.13- 4.1, 0.9- 5.4, 0.9- 5.9, 0.02- 0.7 and 0.1- 1.04ppm$\times 10^{-3}$, respectively. The distribution of Cu and Fe in gastropod shells were reached to the maximum value in nepionic stage and western sector, while the high value of Mn, Mo and Ni were recorded in adult stage and western sector.

The mean concentrations of Pb, Se, Sr, V and Zn in gastropod shells are shown in Table (3) and Fig. (4). Their average levels were 0.09- 4.4, 0.13- 2.6, 0.12- 6.9, 0.007- 0.4and 0.54- 7.64ppm$\times 10^{-3}$ respectively. According the zonal distribution of Pb, Se, Sr, V and Zn in gastropod shells, the western zone proved to have the maximum values in adult stage. Finally, in the distribution of trace metals in gastropod shells, the highest levels of As, Ba, Cd, Co, Cu, Fe, Mn, Mo, Ni, Pb, Se, Sr, V and Zn were found in western sector, while Cr level was increased in the middle zone.

According to the age of *Melanoides tuberculata* snails, the highest levels of As, Ba, Cd, Co, Mn, Mo, Ni, Pb, Se, Sr, V and Zn attained in the adult stage, while the highest levels of Cr, Cu and Fe appeared in nepionic stage.

With the exception of the western sector, the E.F. for Cu and Fe were greater than 2.28 and 1.38 , while As, Ba, Cd, Co, Cr, Mn, Mo, Ni, Pb, Se, Sr, V and Zn levels in nepionic stage exhibited low enrichment factors (Table 4).

In the middle sector(close to the El-Wadi agriculture drains), the E.F. for As, Cd, Co, Cr, Cu, Fe and Zn were greater than 1, 1, 8, 2, 67, 5.49, 3.31 and 3.73, respectively, while Ba, Mn, Mo, Ni, Pb, Se, Sr and V in nepionic shells had the lowest enrichment factors.

In the eastern sector(close to the El Bats agriculture drain), the E.F. for Ba, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Se, Sr, V and Zn were greater than 3.33, 10, 2.5, 2, 2, 0.08, 3.11, 2.78, 3, 4, 3.33, 3.85, 1.2, 9.33. 4.29 and 6.96, respectively. While As value in nepionic stage exhibited low enrichment factors.

Trace Metals Distribution and Environmental Factors

Zonal trace metals distribution and environmental factors changes proved that the west sector of the lake is characterized by elevated average values of Ba, Cd, Co, Cr, Mo, Ni, Pb, Se, V and Zn in adult stage while Mn, Fe and Se in nepionic stage. In gastropod shells As, Ba, Cd, Co, Mn, Mo, Ni, Pb, Se, Sr, V and Zn levels are high in adult stage, while the middle zone is enriched in As and Cu in nepionic of bivalve shells, while in gastropod shells is enriched with Cr in nepionic shells. Finally in eastern zone ,the lake is enriched with Fe in adult stage in bivalve shells.

The relative order of abundance of elements in bivalve shells is:
Fe> Cu> Sr> Zn> Mn> Pb> Ni> Se> As> V> Ba> Cr> Mo> Co> Cd.
While in gastropod is:Fe> Zn>Mn> Sr> Cu> As> Pb> Se> Ba> Ni> Cr> Mo> Co> V> Cd.

Cd, Cu, Fe, Ni and V are more abundant in bivalve, while As, Ba, Co, Cr, Mn, Mo, Pb, Se, Sr, and Zn are more abundant in gastropod shells.

By using the E. F. relations, it is proved that in the eastern zone (close to El-Bats drain) Ba, Co, Cr, Fe, Mn, Mo, Ni, Pb, Se, Sr, V and Zn levels exhibited high enrichment in the bivalve nepionic shells, while As, Cd, Cu and Sr were low Ba, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Se, Sr, V and Zn were greater in nepionic stage, while As in adult stage.

In the middle zone (close to El- Wadi drain), most of elements were high abundant in nepionic bivalve shells, except Mn and Sr. While in gastropod shells As, Cd, Co, Cu, Fe and Zn were more abundant in nepionic stage.

In western sector, most of elements have maximum value in nepionic bivalve shells, except Mn, Sr and Zn were low. In gastropods, most of elements were more enrichment in adult stage, except Cu and Fe were more abundant in nepionic stage.

The relationship matrix between trace metals distribution and the environmental factors (Figs 2, 3, 4 and 5) shows the following: the combined values have strong pathetic and antipathetic relations. Chlorite, organic matter, carbonate, calcite and some chemical parameters in water (salinity, pH, alkalinity and oxygen), most of elements in bivalve (except

As, Cu and Fe) and most of elements in gastropod shells (except Cr) are positively correlated with each other and increase westwards. In middle zone, As is reached to high value in bivalve shells and Cr in gastropod shells. In eastern zone which has a high content of aragonite, there is decreasing in environmental parameters and increasing in Fe in bivalve shells.

Thus, as expected most of elements are incorporated into carbonate phases (Lotfy, 1997, 2000, 2002 and 2003; Kostka *et al.* 1999, Vital, 1999; Labonne *et al.*, 2003).

There are several factors, of which the most important are temperature, salinity, water depth and siliclastic, that control carbonate minerals deposition as $BaCO_3$ (witherite), $FeCO_3$ (siderite), $PbCO_3$ (cerussite),$MnCO_3$ (rhodochrosite), $SrCO_3$ (stronianite), $ZnCO_3$ (smithsonite) and others Keller, 1992).

The organic matter in sediments is known to be slightly enriched in many of the rarer elements, particularly V, Mo, Ni, Co, As and Cu, and locally many others (Henderson, 1984).

Matching the average levels of elements in mollusk shells of Lake Qarun (Tables 2 and 3) with those in carbonate sediments (Turikian *et al.* 1961), results indicated that Cr and Pb are slightly enriched in the mollusk shells. With comparison with standard shale (Krauskopf and Bird, 1995), results showed that most elements are low except Cd, Cu and Se in mollusk shells.

The remobilization of elements from sources is mainly controlled by the absorbed processes and is mostly caused by four types of chemical changes in water: 1)elevated salt, 2) changes in the redox, 3)lowering of pH and 4) increasing alkalinity, in addition to biochemical processes and activity of organisms.

However, in the mollusc shells of Lake Qarun which consist mainly of aragonite mineral, by variation of environmental factors in sediments (increasing of chloride, organic matter and carbonate and decreasing of pH values) and in water (increasing of salinity, pH, alkalinity and oxygen content) and by variation of aragonite to calcite, there in ten dency to high accumulation of Ba,Cd, Co, Cr, Mn, Mo, Ni, Pb, Se, Sr, V and Zn in bivalve shells and most of elements in gastropod shells by depending on the activity of organisms.

The results proved that the main sources of trace metals in the mollusc shells in lake Qarun is the agricultural drains as El-Bats and El-Wadi, due to the high association of trace metals in the nepionic stage of mollusc shells at the region close to the drains (i.e. eastern and middle zones), and with increasing distance and time, trace metals concentrate in the adult stage (westwards).

CONCLUSIONS

The distribution of fifteen of trace metals (As, Ba, Cd, Cr, Co, Cu, Fe, Mn. Mo, Ni, Pb, Se, Sr, V and Zn) in recent mollusk an shells, that were collected from Lake Qarun sediments, proved that western zone is characterizes by elevated average values of Ba, Cd, Cr, Co, Mo, Ni, Pb, Se, V and Zn in bivalve adult stage and Mn and Sr in nepionic stage, while As and Cu were highly enrichment in middle sector in nepionic bivalve shells and Fe is highly enrichment in eastern zone in adult bivalve shells. In gastropod shells As, Ba, Cd, Co, Mn. Mo, Ni, Pb, Se, Sr, V and Zn were highly enrichment in western sector in adult stage, while Cu and Fe were highly enrichment in eastern zone in nepionic stage.

Their total average levels in mollusc shells were: 1.04, 0.58, 0.02, 0.24, 0.17, 2.4, 3.52, 2, 0.19, 0.7, 1.26, 0.9, 2.3, 0.08 and 2.49, respectively.

The relative order abundance of elements in bivalve shells is: Fe> Cu> Sr> Zn> Mn> Pb> Ni> Se> As> V> Ba> Cr> Mo> Co> Cd, in gastropod shells is: Fe> Zn > Mn> Sr > Cu> As> Pb> Se> Ba> Ni> Cr> Mo> Co> V>Cd.

The most elements are more abundant in gastropod shells. By using of E.F., the distribution of elements proved that most of elements are more associated in nepionic stage in eastern and middle sectors which are close to agriculture drains and mineral composition of shells (i.e. more aragonite), tends to increase towards the western zone in adult stage of molluscan shells.

The distribution of trace metals in the mollusk shells is mainly controlled by some factors as elevated salt, increasing organic matter, pH, alkalinity and oxygen content and decreasing of pH in sediments and transformation of aragonite to calcite, tend to increase absorbed processes of trace metals in the carbonate phases westwards.

All elements in molluscan shells were lower than that of standard shale and carbonate sediments, except Cd, Cu and Se, which are shown higher levels when compared with those recorded in the carbonate sediments.

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Table (1): The recorded average measurements of some mineralogical and chemical environmental parameters in water and sediments of Lake Qarun.(August 2003)

Zone	sediment								water			
	pH	Cl^{-1} %	O.M .%	CO_3^{-2} %	Aragonite% A	Aragonite% B	Calcite% A	Calcite% B	pH	Alkal. Mg/l	Salini. %	O_2 MG/L
East	9.1	0.3	16.4	29.8	97.9	93.5	2.1	6.5	8.6	62.3	27,6	6.2
Middle	9.31	0.25	12.6	36.6	94.5	61	5.5	39	8.9	78.3	33.2	7.5
West	9.25	.36	18.6	37.4	92.5	28.5	7.5	71.5	9.2	94.3	38.7	8.7

Table(2): Average concentration of trace metals(ppm $\times 10^{-3}$) in the bivalve shells of *Haminoea Orbgnyana*(A= adult, B= nepionic).

zone	•	As	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
East	A	.20	.32	.003	.09	.23	2.8	6.7	1.4	.19	.09	.8	.9	1.1	.09	1.8
	B	.31	.28	.007	.06	.11	3.6	4.6	.5	.11	.08	.6	.35	1.5	.03	1.2
	Ave	.26	.3	.005	.08	.17	3.2	5.6	.98	.15	.08	.7	.55	1.3	.06	1.6
Mid.	A	.12	.16	.005	.01	.01	.14	3.1	1.5	.01	.01	.1	.1	1.5	.01	.95
	B	.68	.25	.009	.09	.07	6.8	5.7	1.1	.12	.07	.5	.8	.6	.06	2.5
	Ave	.4	.21	.007	.05	.04	3.8	4.4	1.3	.07	.04	.3	.4	.9	.04	1.7
west	A	2.1	.63	.11	.7	.7	3.1	3.7	1.4	.5	5.4	5.4	2.5	2.8	.14	1.7
	B	.13	.33	.007	.1	.1	.19	.8	2.2	.01	.1	.1	.09	5.2	.01	2.6
	Ave	1.12	.48	.059	.4	.4	1.7	2.4	1.8	.26	2.7	2.7	1.3	4	.07	2.2
	Tot.	.59	.33	.02	.13	.2	2.9	3.8	1.4	.16	.96	1.3	.75	2.1	.06	1.9
••			10	-	.1	11	4	-	110	.4	20	9	.1	610	20	20
•••		130	580	.3	19	90	45	47200	850	2.6	68	20	.4	300	130	95

Table(3): Average concentration of trace metals(ppm $\times 10^{-3}$) in the gastropod shells of *Melanoides tuberculata*(C= adult, D= nepionic).

zone	*	As	Ba	Cd.	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
East	C	.6	.06	.001	.02	.01	.13	.9	.9	.02	.01	.09	.13	.12	.01	.54
	D	.3	.2	.01	.05	.02	.4	2.8	2.5	.06	.04	.3	.5	1.12	.03	3.8
	Ave	.45	.13	.005	.04	.02	.27	1.85	1.7	.04	.03	.2	.32	.62	.02	2.2
Mid.	C	.8	1.2	.01	.01	.21	.71	1.6	2.6	.33	.7	1.6	1.1	3.11	.11	.88
	D	.8	.36	.01	.08	.56	3.9	5.3	1.18	.09	.05	.5	.8	.6	.03	3.3
	Ave	.8	.78	.01	.04	.39	2.31	3.45	1.89	.21	.38	1.1	.95	1.86	.07	2.1
west	C	5.3	2.7	.07	1	.54	1.8	3.9	5.9	.7	1.04	4.4	2.6	6.9	.4	7.6
	D	1.1	.4	.02	.01	.31	4.1	5.4	3.1	.12	.9	.8	1.3	3.6	.07	2.6
	Ave	3.2	1.55	.045	.51	.43	2.95	4.65	4.5	.41	.97	2.6	1.95	3.6	.24	5.1
	Tot.	.48	.82	.02	.2	.28	1.84	3.32	2.7	.22	.46	1.28	1.07	2.58	.11	3.1
**			10	-	.1	11	4	-	110	.4	20	9	.1	610	20	20
***		130	580	.3	19	90	45	47200	850	2.6	68	20	.4	300	130	95

*= Type of shells **= Standard of carbonate (Turkian and et al.,1961) all value $\times 10^{-3}$.
***=Standard shale (Krauskopt and Bird, 1995) all value $\times 10^{-3}$

Table(4): Enrichment factors of trace metals in nepionic / adult stage of A-bivalve and B- gastropod in the studied shells.

zone	*	As	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
East	A	1.55	.88	2.33	.67	.48	1.29	.69	.36	.58	.89	.75	.39	1.44	.33	.66
	B	.5	3.33	10	2.5	2	3.08	3.11	2.78	3	4	3.33	3.85	9.33	4.29	6.96
Mid.	A	5.67	1.56	1.8	9.2	6	48.5	1.89	.69	12	7.78	5	8	.4	8.57	2.66
	B	1	.3	1	8	2.67	5.49	3.31	.45	.27	.07	.31	.73	.19	.27	3.73
west	A	.06	.51	.06	.02	.14	.06	.22	1.57	.02	.02	.02	.04	1.86	.06	1.56
	B	.21	.15	.29	.01	.57	2.28	1.38	.53	.17	.87	.18	.5	.52	.18	.34

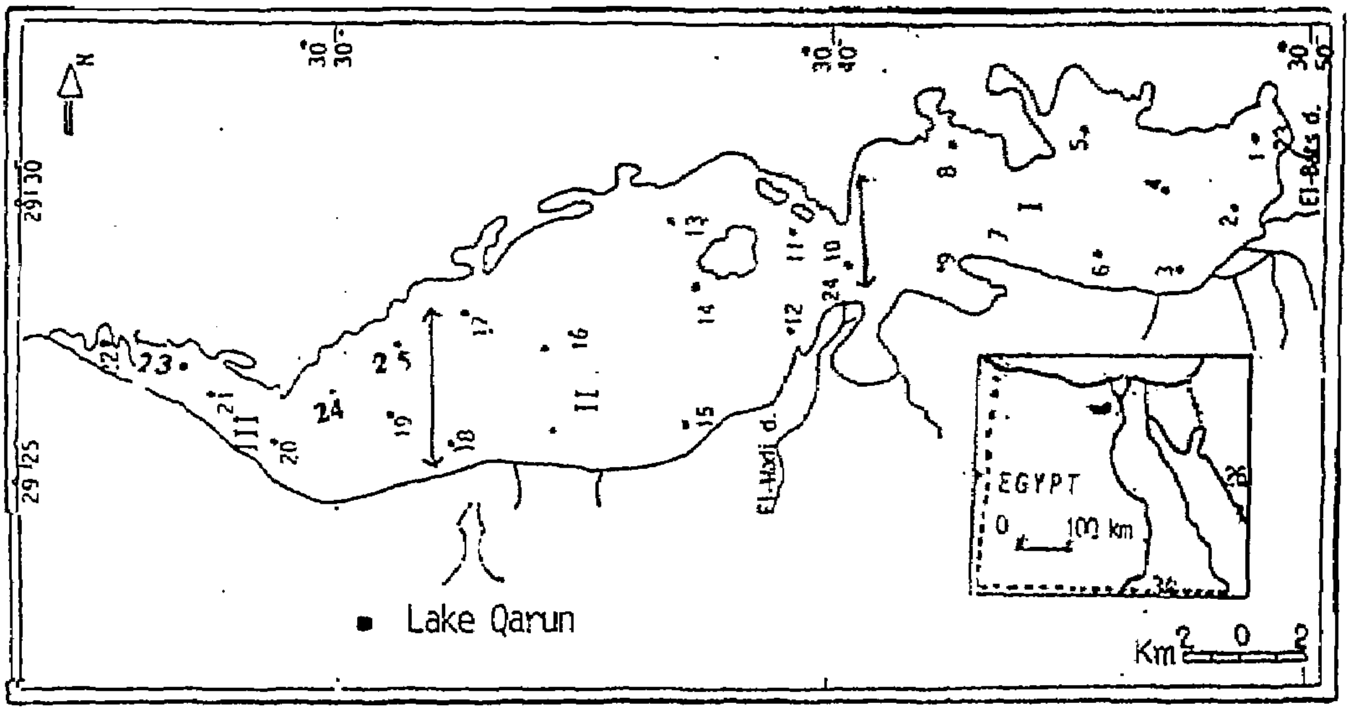
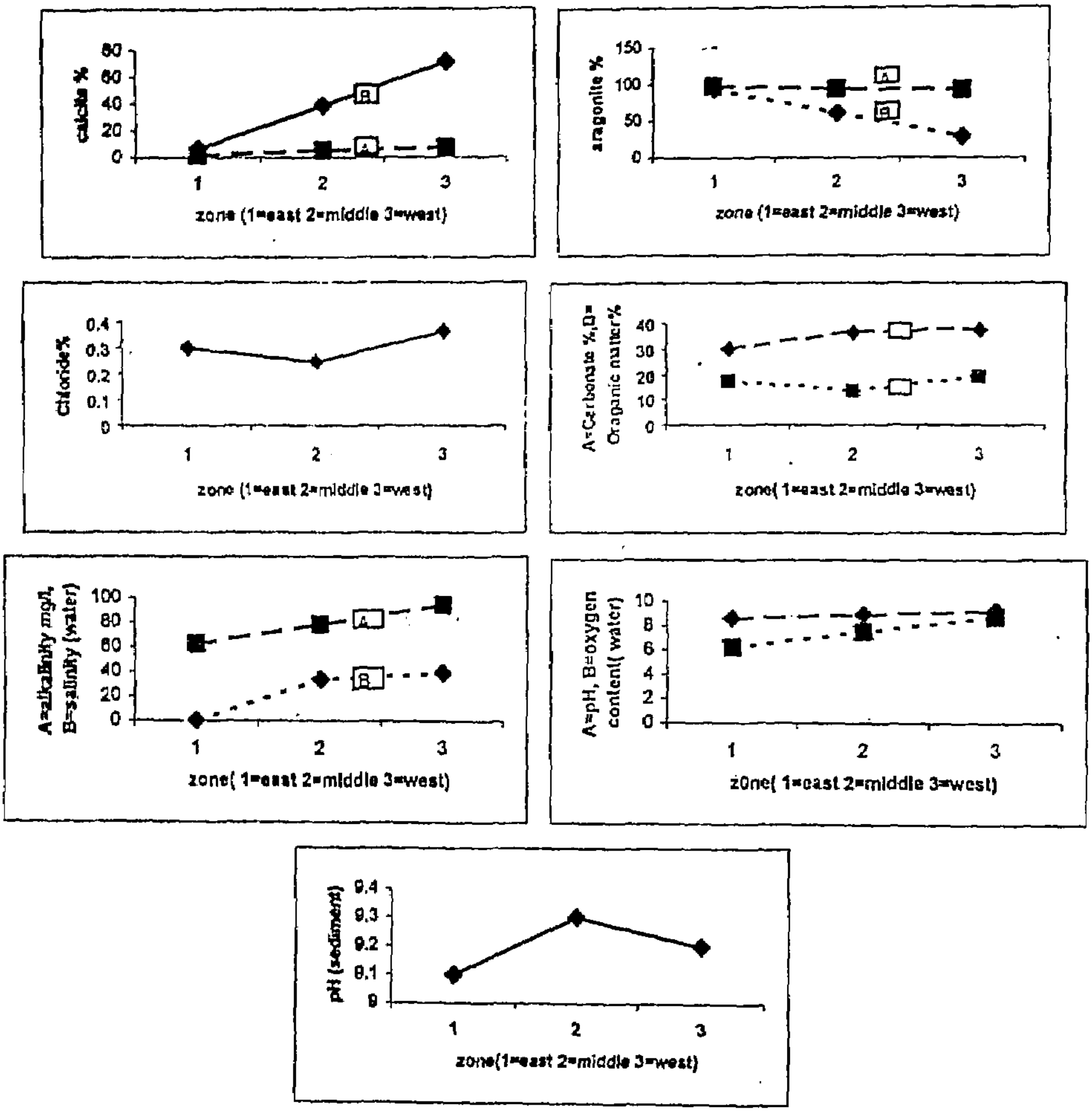
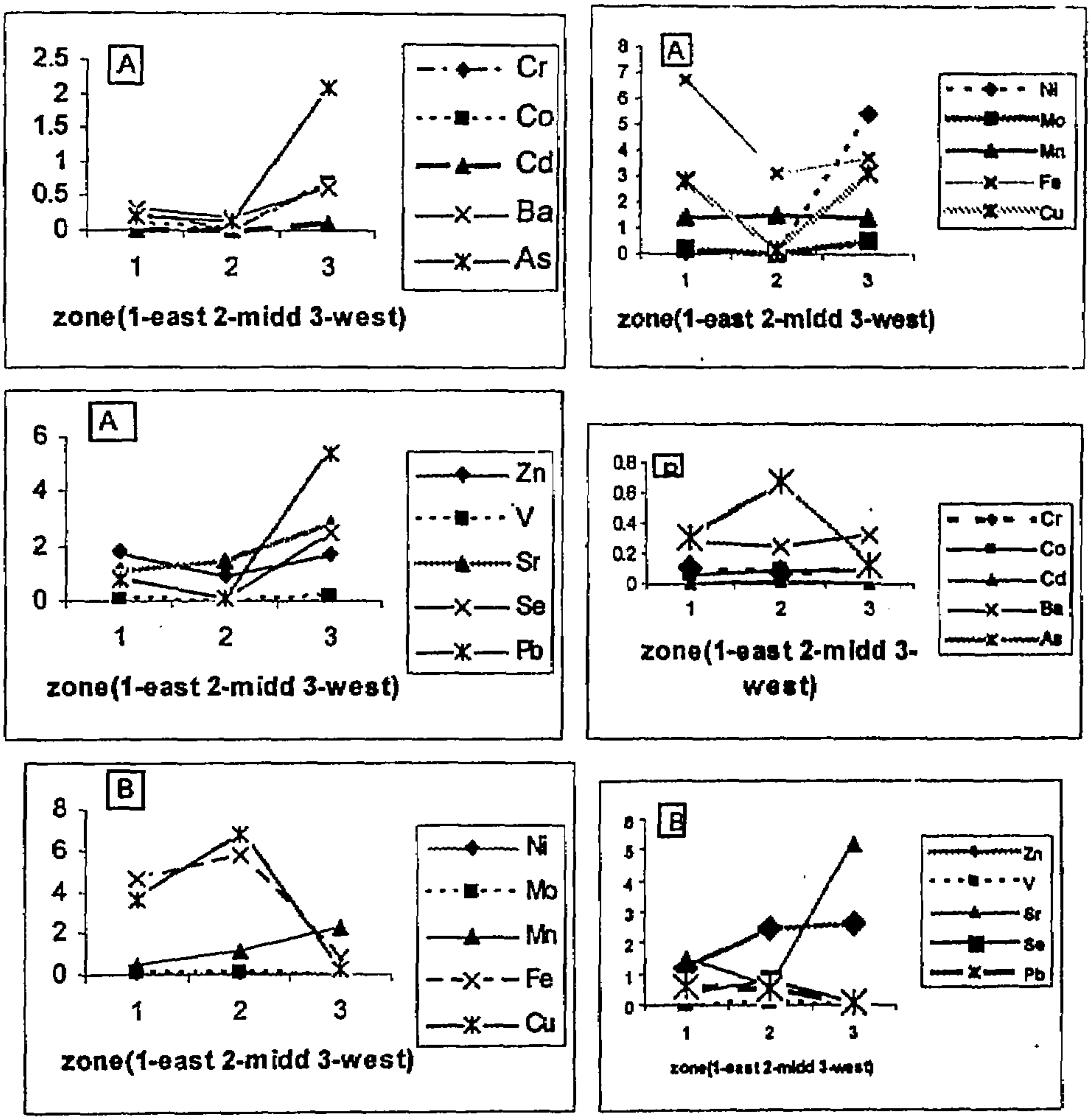


Fig (1) : Map of Lake Qarun showing the location of sampling.

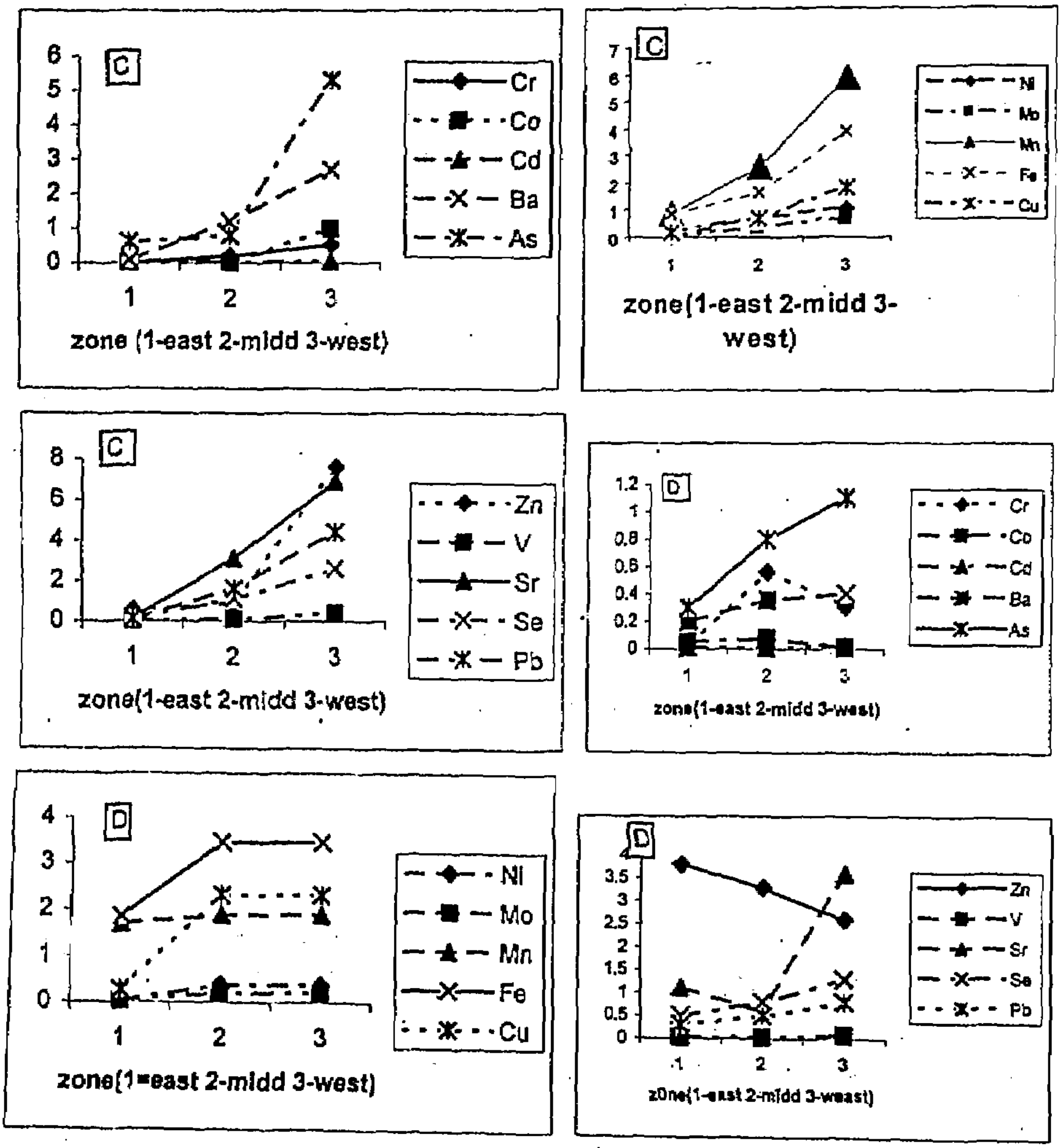
Figure(2): The zonal distribution of environmental parameters in A-*Haminoea orbgnyana*(bivalve) and B- *Melanoides tubarculata*(gastropod), sediments and water (calcite and aragonite in shells, chloride, carbonate and organic matter in sediments)



Figure(3): Zonal average distribution of trace metals(ppm $\times 10^{-3}$) in the studied shells of *Haminoea orbgnyana* in Lake Qarun (bivalve A= adult, B= nepionic).



Figure(4): Zonal average distribution of trace metals(ppm $\times 10^{-3}$) in the studied shells of *Melanoides tuberculata* in Lake Qarun (gastropod C= adult, D= nepionic).



Figure(5): Zonal average distribution of trace metals(ppm $\times 10^{-3}$) in the studied shells of bivalve and gastropod from Lake Qarun.