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Accumulation and Distribution of Copper and Zinc in Both Water and Some Vital Tissues of Two Fish Species (*Tilapia zillii* and *Mugil cephalus*) of Lake Qarun, Fayoum Province, Egypt

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Abstract: This study was carried out on Lake Qarun, Fayoum Province, Egypt throughout four seasons, spring 2004 to winter 2005. The concentration of Zn in water as well as in fish organs was always higher than Cu. Correlations between concentration of heavy metals in water and fish organs were elucidated. The concentrations of heavy metals in fish samples indicated that *Tilapia zillii* were higher than those of *Mugil cephalus*, which is attributed to their feeding behavior. It was found that these metals have been accumulated in fish organs in different concentrations, which were much higher, several times in some cases, than those found in the surrounding water. The analysis of variance (ANOVA, 1-way analysis) for heavy metals in water and fish organs indicated significant difference. Bioaccumulation factor values showed that the trend of accumulation of metals in fish organs was apparent in liver, gills and muscle, respectively. Lesions deformations were detected and analyzed to clarify the possible role of water pollution on the efficiency of fish and hence the declining fish production of Lake Qarun. The results suggest that the Lake Qarun system is contaminated with heavy metals and the consumption of fishes of the Lake could pose health damage to the local population whose diet consists mainly of fish. A recommendation is given to rescue Lake Qarun from these serious ecological problems.

Key words: Water pollution, physico-chemical parameters, heavy metals, Tilapia, Mugil, bioaccumulation, histopathology, Lake Qarun, Egypt

INTRODUCTION

In natural aquatic ecosystems, metals occur in low concentrations. In recent times, however, the occurrence of metal contaminants especially the heavy metals in excess of natural loads has become a problem of increasing concern. This situation has arisen as a result of the rapid growth of population, increased urbanization and expansion of industrial activities, exploration and exploitation of natural resources, extension of irrigation and other modern agricultural practices as well as the lack of environmental regulations (FAO, 1992).

Lakes are more sensitive to pollution inputs because lakes flush out their contents relatively slowly. Even under natural conditions, lakes undergo eutrophication, an aging process that slowly fills in the lake with sediment and organic matter. The eutrophication process alters basic lake characteristics such as depth, biological productivity, oxygen levels and water clarity (USEPA, 1994).

Lake Qarun, the field of the present investigation, one of the five large lakes in Egypt, is a remnant of a much bigger one and was originally a fresh water lake. It is an inland closed basin with no apparent natural outlets, of about 40 km length, 5.7 km mean width and has an average depth of 4.2 m. It lies in an arid region, occupying the deepest part of Fayoum Province in the Western Desert of Egypt and lies about 85 km to the Southwest of Cairo (Mansour *et al*., 2001a). Many fish farms were established around this lake (Mansour and Sidky, 2002, 2003). The lake suffered drastic chemical changes during the last years where it is used as a general reservoir for agricultural wastewaters drainage of Fayoum Province, as well as for the drainage of the fish farms. Therefore, its salinity increases progressively from 14 to 38% (Bishai and Kirollus, 1980) which affects greatly the lake biota. In addition, the exacerbation of eutrophication of the lake's water that caused by the nutrient load from the agricultural drainage water (Sabae and Ali, 2004). These conditions led to change in the biodiversity of the

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different biota. Accordingly, fresh water fishes have almost disappeared with the exception of salinity-tolerant species like *Tilapia zillii*, *T. aurea* and *T. nilotica*.

The lake receives the agricultural and sewage drainage water from Fayoum Province and the neighboring cultivated lands through a system of twelve drains. Most of the drainage water reaches the lake through two main drains, El-Batts (at the northeastern corner) and El-Wadi (near mid point of the southern shore), whereas there are minor drains poured its drainage water into the lake by means of hydraulic pumps but in small amounts and add comparatively little water to the lake. The minor drains are recently connected with a larger drain, namely Dayer El-Birka, which transfers a part of wastewater to the lake by pumping stations (Mansour *et al.*, 2000; Abdel-Mageed, 2005a, b; Ali and Fishar, 2005).

The Egyptian Company for Salts and Mineral (EMISAL) located on the southern coast of the lake, where a part, known as Batnat Abo Ksah, was cutoff from the lake and divided into number of concentrating ponds, to concentrate the lake water as much as 10 times the original salinity. The effluents of EMISAL brine water discharged also into the lake and caused increasing in the most parameters.

Lake Qarun received annually about 450 million cubic meters of agricultural wastewater drainage, which approximately balances the amount of lake water lost annually by evaporation; leading to progressive increase of salinity and detrimental effects to the lake environment; e.g., its fauna and flora (Ahmed, 1994; El-Shabrawy and Taha, 1999). It received about 226.3 and 100.84 million cubic meter of wastewater from El-Wadi and El-Batts drains, respectively (Goher, 2002; Abdel-Satar *et al.*, 2003).

Copper is essential as micronutrient for fish and aquatic life, widely used as a very effective algaecide and molluscicide (Saeed, 1999; Shaker *et al.*, 2000). The permissible levels of copper in water are 1.0 ppm, while, in fish tissues, they are 20 ppm according to WHO (1984). Since copper from anthropogenic sources eventually contaminates water bodies, toxicity of this metal to aquatic organisms has been intensely studied over the past two decades (Getachew, 1988; Authman, 1998; Khallaf *et al.*, 1998; Shakweer, 1998; WHO, 1998; Adham *et al.*, 1999; Khallaf *et al.*, 2003; Oliveira-Filho *et al.*, 2004; Shaw and Handy, 2006).

Zinc is an essential trace element in living organisms, being involved in nucleic acid synthesis and occurs in many enzymes. Background values of zinc in natural inland surface waters may vary from 0.001 to 0.2 mg L^{-1} or even higher. Zinc and its compounds are extensively used in commerce and in medicine. The common sources of it are galvanized ironwork, zinc chloride used in plumbing and paints containing zinc. It is soluble in water and illness may be caused by drinking water containing zinc (Clarke *et al.*, 1981). Zinc wastes can have a direct toxicity to aquatic life and fisheries can be affected by either zinc alone or more often together with copper and other metals (Alabaster and Lloyd, 1982).

Taking into consideration that the lake is a closed ecosystem and as a result of extensive evaporation of water , the accumulation of chemical pollutants (salts, heavy metals, pesticides and other pollutants) is expected to increase annually in all its components (e.g., water, sediment and fish) and to change their quality and affect their aquatic life (Mansour and Sidky, 2002).

This study focuses on the studying of the physico-chemical characteristics of Lake's water and the distribution of copper and zinc in both water and some common fish species (*Tilapia* and *Mugil* sp.) organs throughout four seasons from spring 2004 to winter 2005.

MATERIALS AND METHODS

Study area: Lake Qarun is a closed saline basin located between longitudes of 30° 24\ and 30° 49\ E and latitude of 29° 24\ and 29° 33\ N in the lowest part of Fayoum depression at the western desert, about 80 km south west of Cairo. It has an irregular shape of about 40 km length and about 6 km mean width. The area of the lake is about 240 km^2 (about 20235 hectares or 53000 acres). The lake is shallow, with mean depth of 4.2 m and the depth changes from region to another according to the quantity of drainage water received from the cultivated lands at the different times of the year. Nearly, most of the lake's area has a depth ranging between 5 to 8 m. The water level of the lake fluctuated between 43 to 45 m below mean sea level (Sabae, 1993). The area is hot and dry, rainfall is rare, the annual rainfall has been recorded as 10 mm, but this value may change from one year to other (Samy, 2000; Ali *et al.*, 2005).

Sampling and procedure: The present study was carried out from March 2004 to February 2005 during four subsequent seasons. Samples of water were seasonally taken from different localities covering the whole lake area. At the same time, fish species were collected from the same location in the lake where the water samples were taken.

On site sampling, the temperature (°C) of the surface water, salinity (g L^{-1}), conductivity (mmhos/cm), dissolved oxygen (mg L^{-1}) and pH were measured using electronic portable m (Yellow Springs Instrument Co., Ohio, Model 33) and digital pH meter (Model 206, Lutron, Taiwan).

A water sampler (polyvinyl chloride Van Dorn bottle) of 2L capacity was used to collect surface water (e.g., 15 cm depth) from different localities. The chemical parameters were measured using methods adopted by standard methods described in APHA (1992).

Two fish species (Bolti: *Tilapia zillii* and Bouri: *Mugil cephalus*), the most common type of fish in Lake Qarun and widely consumed by the local population in Egypt, were collected from the commercial catch of Lake Qarun.

Two hundred fish specimens [100 *T. zillii* (15.7 cm; 66.3 g) and 100 *M. Cephalus* (22.4 cm; 180.3 g)] were collected. After the dissection of fish samples, parts of gills, liver and muscles (epaxial muscle from below the dorsal fin of each fish) were removed and kept for later analysis. The samples were preserved in an icebox and returned immediately to the laboratory where they were kept frozen at -20°C until analyzed within a few days of sampling.

Analysis of heavy metals: Concentrations of some heavy metals were determined in water and fish samples. The samples analyzed were prepared by the methods of APHA (1992). Samples were analyzed by flame atomic absorption spectrophotometer to detect the concentrations of the heavy metals: Cu and Zn (expressed in mg L^{-1} and mg kg^{-1} dry wt for water and fish samples, respectively).

The accumulation factor (AF): The Accumulation Factor (AF) is the ratio between the accumulated concentration of a given pollutant in any organ and its dissolved concentration in water. It gives an indication about the accumulation efficiency for any particular pollutant in any fish organ. Accumulation Factor (AF) was calculated according to Aboul Ezz and Abdel-Razek (1991) using the following equation:

$$\text{Accumulation Factor (AF)} = \frac{\text{Pollutant concentration in fish organ (mg kg}^{-1}\text{)}}{\text{Pollutant in water (mg L}^{-1}\text{)}}$$

Histopathological studies: For histopathological examinations, tissue specimens from liver and gills were fixed in neutralized formalin, dehydrated, embedded in paraffin wax and sectioned at 5 μm then stained with Hematoxylin and eosin (H and E) and examined microscopically for histopathological changes (Bernet *et al*., 1999).

Statistics: The comparison between means and standard errors was tested for significance using ANOVA analysis and Duncan's multiple range tests. In addition, the correlation of physico-chemical parameters and the levels of heavy metals in fish organs were assessed using Pearson's correlation analysis. All statistical analyses were calculated, using the computer program of SPSS Inc. (2001, version 11.0 for Windows) at the 0.05 level of significance.

RESULTS

Physicochemical parameters: The minimum water temperature was recorded during winter (19.8°C), while the maximum one was observed during summer and autumn (31.2 and 30.2°C, respectively) (Table 1). The higher values of Electrical Conductivity (EC) were recorded during summer and spring, 42.38-45.30 mmhos/cm, while the lower (32.72-40.57 mmhos/cm) were recorded during winter and autumn, respectively. The higher value of Total Dissolved Solids (TDS) was recorded during summer 27.4 g L^{-1}) and the lower value was recorded during winter (9.3 g L^{-1}). The minimum value of salinity was recorded during spring (39.0%) and the maximum value was recorded during summer (39.5%). The pH values of the lake water were slightly alkaline, with the lowest reading was recorded during winter (7.5), while the maximum record was recorded during summer (8.1). For dissolved oxygen, the maximum value was measured during winter (10.3 mg L^{-1}), while the lowest reading was recorded in summer (8.43 mg L^{-1}). For total alkalinity, the lower values recorded during spring and autumn (248.0 and 249.3 mg L^{-1}, respectively) while the higher values were recorded during winter and summer (252.3 and 257.3 mg L^{-1}, respectively). The chloride values were fluctuated in the ranges from 1.76-3.08 g L^{-1} during winter and spring and 4.85-6.67 g L^{-1} during autumn and summer. For total hardness, the lower value recorded during spring (644.3 mg L^{-1}) while the higher value was recorded during winter (664.3 mg L^{-1}). The seasonal variations of nitrite shows that the lower values recorded during spring and winter (0.25 mg L^{-1}) while the higher values were recorded during summer and autumn (0.27 mg L^{-1}). The results of the nitrate revealed that the higher values recorded during summer and autumn (0.32 mg L^{-1}) while the lower values were recorded in spring and winter (0.30 mg L^{-1}).

Copper and zinc: The concentrations of copper in water showed a regular distribution pattern, where there were an obvious gradual decrease from summer (2.93 mg L^{-1}) to winter (1.25 mg L^{-1}) and return to increase during spring (2.59 mg L^{-1}). Zinc concentrations in water were higher in

Table 1: Seasonal variations of some physicochemical characteristics of Lake Qarun water during the period of study

	Parameters						
Seasons	Temperature (°C)	Electrical conductivity (mmhos/cm)	Total dissolved solids (g L^{-1})	Salinity (‰)	pH	Dissolved oxygen (mg L^{-1})	Total alkalinity (mg L^{-1})
Spring	22.8±2.46^{b}	42.38±0.92^{b}	19.2±1.33^{b}	39.0±0.00^{a}	7.8±0.17^{ab}	9.23±0.2^{b}	248±2.65^{b}
Summer	31.2±1.69^{a}	45.30±1.14^{c}	27.4±2.12^{a}	39.5±0.29^{a}	8.1±0.12^{a}	8.43±0.12^{c}	257.3±2.91^{a}
Autumn	30.2±2.02^{a}	40.57±0.96^{b}	18.7±0.84^{b}	39.2±0.17^{a}	7.8±0.12^{ab}	8.5±0.09^{c}	249.3±1.76^{b}
Winter	19.8±0.72^{b}	32.72±0.61^{a}	9.3±0.5^{c}	39.2±0.17^{a}	7.5±0.03^{b}	10.3±0.32^{a}	252.3±1.2^{ab}
F-value	9.08**	33.67**	30.34**	1.27	3.22	17.77**	3.43

Table 1: Continued

	Parameters					
Seasons	Chloride (g L^{-1})	Total hardness (mg L^{-1})	nitrite (mg L^{-1})	Nitrate (mg L^{-1})	Copper (mg L^{-1})	Zinc (mg L^{-1})
Spring	3.08±0.45^{c}	644.3±4.37^{b}	0.25±0.00^{a}	0.30±0.01^{a}	2.59±0.14^{a}	0.14±0.006^{a}
Summer	6.67±0.8^{a}	655.3±4.63^{ab}	0.27±0.02^{a}	0.32±0.01^{a}	2.93±0.09^{b}	0.18±0.009^{b}
Autumn	4.86±0.18^{b}	656.7±5.92^{ab}	0.27±0.02^{a}	0.32±0.01^{a}	1.8±0.12^{c}	0.12±0.01^{c}
Winter	1.76±0.21^{c}	664.3±4.81^{a}	0.25±0.00^{a}	0.30±0.01^{a}	1.25±0.11^{d}	0.096±0.006^{d}
F-value	19.78**	2.75	0.67	0.97	12.34**	9.22**

Data are represented as means±Standard Error (SE). Means with the same letter in the same column are not significantly different ($p \leq 0.05$). ** Highly significant ($p \leq 0.01$)

summer (0.18 mg L^{-1}) and lower in winter (0.096 mg L^{-1}). The values of all the studied parameters in spring, summer and autumn with the exception of salinity, the dissolved oxygen, total alkalinity and total hardness were significantly increased when compared with the values of winter. A highly significant increase ($p<0.01$) started in summer and continued till winter for the parameters of total dissolved solids and chloride, while for the values of the copper and zinc concentrations, a highly significant increase ($p<0.01$) started in spring and continued till winter. The values of the electrical conductivity showed a highly significant decrease ($p<0.01$) from summer until winter. On the other hand, the salinity, nitrite and nitrate values showed insignificant distribution during different seasons, while the dissolved oxygen values showed a highly significant increase ($p<0.01$) during winter, spring and autumn compared with the values of summer. Temperature, pH, dissolved oxygen, total alkalinity and total hardness showed irregular distribution during different seasons.

Concentration of copper and zinc in the organs of various fish species

Copper concentrations: Table 2 shows the concentrations of Cu in the muscle, liver and gills of the *Tilapia* and *Mugil* species caught from the various areas of Lake Qarun.

***Tilapia zillii*:** These concentrations ranged from 12.74 to 36.27 mg kg^{-1}, from 10.85 to 26.95 mg kg^{-1} and from 5.93 to 17.85 mg kg^{-1} in the liver, gills and muscle, respectively, with the lower values recorded in winter and the higher values recorded in summer.

***Mugil cephalus*:** These concentrations ranged from 6.44 to 18.46 mg kg^{-1}, from 4.20 to 10.80 mg kg^{-1} and from 1.31 to 5.01 mg kg^{-1} in the liver, gills and muscle, respectively, with the lower values recorded in winter and the higher values recorded in summer.

Zinc concentrations: Table 3 shows the concentrations of Zn in the muscle, liver and gills of the *Tilapia* and *Mugil* species caught from the various areas of Lake Qarun.

***Tilapia zillii*:** These concentrations ranged from 10.48 to 27.91 mg kg^{-1}, from 6.91 to 19.91 mg kg^{-1} and from 3.00 to 13.56 mg kg^{-1} in the liver, gills and muscle, respectively, with the lower values recorded in winter and the higher values recorded in summer.

***Mugil cephalus*:** These concentrations ranged from 4.58 to 13.97 mg kg^{-1}, from 2.15 to 8.79 mg kg^{-1} and from 0.79 to 3.85 mg kg^{-1} in the liver, gills and muscle, respectively, with the lower values recorded in winter and the higher values recorded in summer.

As seen in Table 2 the copper and zinc concentrations in different organs of *Tilapia* and *Mugil* sp. showed a highly significant decrease ($p<0.01$) in the fish collected during spring, autumn and winter when compared with the corresponding values of those collected during summer. The most pronounced decrease was noticed in the fish collected during winter followed by those collected during autumn and finally during spring.

Table 2: Concentrations of Copper (Cu) (mg kg^{-1}) and the accumulation factor (AF) in different organs of *Tilapia* and *Mugil* sp. from Lake Qarun during the period of study

	Copper (Cu^{++})								
	Liver			Gills			Muscle		
Seasons	Tilapia	Mugil	t-test	Tilapia	Mugil	t-test	Tilapia	Mugil	t-test
Spring	24.25±1.11^{b}	14.4±0.64^{b}	7.710**	15.13±0.76^{b}	10.30±0.48^{a}	5.36**	12.75±0.79^{b}	3.55±0.23^{b}	11.23**
Summer	36.27±2.57^{a}	18.46±1.18^{a}	6.29**	26.95±2.13^{a}	10.80±0.82^{a}	7.08**	17.85±0.89^{a}	5.01±0.36^{a}	13.36**
Autumn	17.71±0.50^{C}	8.02±0.38^{C}	15.46**	13.34±0.35^{bC}	6.08±0.35^{b}	14.74**	9.94±0.38^{C}	2.00±0.11^{C}	19.93**
Winter	12.74±0.81^{d}	6.44±0.43^{C}	6.86**	10.85±0.51^{C}	4.20±0.31^{C}	11.09**	5.93±0.35^{d}	1.31±0.14^{d}	12.27**
F-value	47.40**	58.48**		37.02**	37.02**		59.72**	51.52**	
Accumulation Factor (AF)									
Spring	9.36	5.56		5.84	3.98		4.92	1.37	
Summer	12.38	6.30		9.20	3.69		6.09	1.71	
Autumn	9.84	4.46		7.41	3.38		5.52	1.11	
Winter	9.98	5.15		8.68	3.36		4.74	1.05	
t-test	15.36†	13.91†		10.41†	24.63†		17.36†	8.70†	

-Data are represented as mean±SEM. -Means with the same letters in the same column are not significantly different ($p<0.05$). † Significant at the 0.05 level (2-tailed, ** highly significant

Table 3: Concentrations of Zinc (Zn) (mg kg^{-1}) and the Accumulation Factor (AF) in different organs of *Tilapia* and *Mugil* sp. from Lake Qarun during the period of study

	Zinc (Zn^{++})								
	Liver			Gills			Muscle		
Seasons	Tilapia	Mugil	t-test	Tilapia	Mugil	t-test	Tilapia	Mugil	t-test
Spring	22.2±1.22^{b}	12.92±0.52^{a}	6.997**	13.30±0.51^{b}	6.98±0.40^{b}	9.77**	11.0±0.62^{b}	3.08±0.07^{b}	12.77**
Summer	27.91±0.76^{a}	13.97±0.97^{a}	11.30**	19.91±0.48^{a}	8.79±0.57^{a}	14.83**	13.56±0.51^{a}	3.85±0.30^{a}	16.43**
Autumn	15.08±0.56^{C}	6.82±0.25^{b}	13.41**	11.15±0.29^{C}	5.00±0.32^{C}	14.29**	7.64±0.31^{C}	1.76±0.10^{C}	17.94**
Winter	10.48±0.63^{d}	4.58±0.25^{C}	8.70**	6.91±0.42^{d}	2.15±0.16^{d}	10.62**	3.00±0.20^{d}	0.79±0.04^{d}s	10.89**
F-value	85.24**	62.79**		156.52**	52.48**		107.21**	70.77**	
Accumulation Factor (AF)									
Spring	158.57	92.29		95.00	49.86		78.57	22.00	
Summer	155.06	77.61		110.61	48.83		75.33	21.39	
Autumn	125.67	56.83		92.92	41.67		63.67	14.67	
Winter	109.17	47.71		71.98	22.40		31.25	8.23	
t-test	11.54†	6.81†		11.67†	6.39†		5.76†	5.12†	

Data are represented as mean±SEM. Means with the same letters in the same column are not significantly different ($p<0.05$). †Significant at the 0.05 level (2-tailed), ** highly significant

Accumulation Factor (AF): For Cu and Zn, it was found that their concentrations in different organs of the studied fish species were several times higher than their concentrations in water. It is obvious from the data given in Table 2 and 3 that these factors were mostly higher in the liver in comparison with the gills and muscle of studied fish species.

However, the accumulation factors of the two elements under investigation in the present study ranged from one to one hundred. In some cases, this factor exceeded one hundred, as it was the case of zinc accumulation in the liver and gills of *Tilapia zillii*. Values of the accumulation factor for Cu from water to fish organs were lower than those of Zn.

Histopathological lesions of liver and gills:

***Tilapia zillii* Liver:** Hepatic tissue showed degenerative changes of various types. Some cells stained homogeneously eosinophilic with indistinct cytoplasmic membrane indicating cloudy swelling. The majority of parenchymal cells showed vacuolar degeneration. The central vein was some times congested with blood cells including chronic inflammatory infiltrate cells. These are mainly plasma cells with their extensive basophilic cytoplasm and small dark rounded nuclei. However in some scattered areas sinusoids contained few inflammatory cells (Fig. 1-3).

***Gills*:** All the examined specimens were in bad condition and revealed the same symptoms with different degrees of severity. The most common features were proliferation of the interlamellar epithelial cells and the secondary gill lamellae became irregular in shape. Gill arches showed edema with prominent E.G. cells infiltration (Fig. 4-7).

Blocking of interlamellar spaces by the proliferated epithelial cells was the most common symptom, frequently accompanied with dislocation and degeneration of chloride cells and hemorrhage. The fusion of secondary lamellae as a result of proliferation of inter lamellar epithelium was clear and degeneration of gills tissue was observed. The epithelial layer became lifted because of sub epithelial edema. The secondary lamellae in turn became shorter. Proliferation of the cells in the basal area

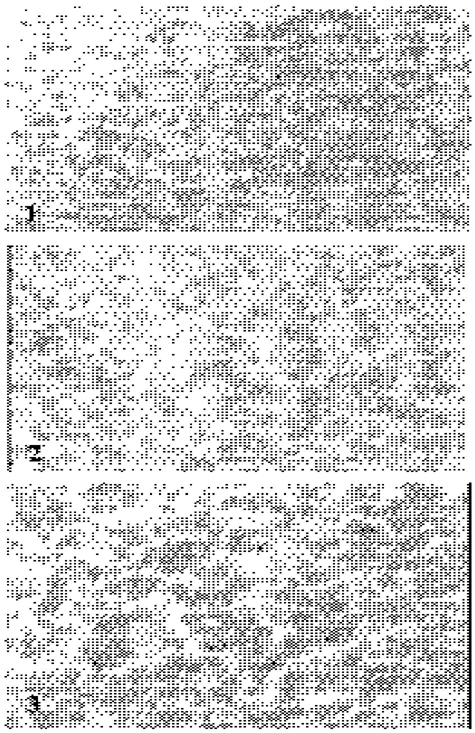


Fig. 1-3: Hepatopancreas of *Tilapia zillii* showing vacuolar degeneration. H and E X400

and degeneration of chloride cells were clear in some areas. On the other hand, some other areas showed complete deformation of the primary and secondary lamellae including proliferation of epithelial cells, edema and hemorrhage. Hyperplasias of secondary lamellar cells with telangiectasis accompanied with deformation or even destruction of pillar system have been noticed. Gills sloughing, necroses of lining epithelium of secondary lamellar cells with telangiectasis and congestion of branchial blood vessels have been noticed.

Mugil cephalus **Liver:** The parenchymal cells were highly vacuolated. The cytoplasm became faintly stained with eosin. Inflammatory reaction surrounded portal tracts that were occluded with blood cells. In some specimens, the nuclei appeared shrunk and irregular in shape, the vacuolated cytoplasm indicates vacuolar degeneration. Also round vacuolation indicates fatty degeneration. Melanomacrophages were observed singly or in groups lying adjacent to blood vessels, bile ducts and hepatopantcreatic lobules. Blood congestion occurred in the sinusoids or small veins in the liver. Atrophy of the hepatic cells was noticed in the adjacent area of blood congestion. Congestion and dilation of sinusoids were noticed (Fig. 8-12).

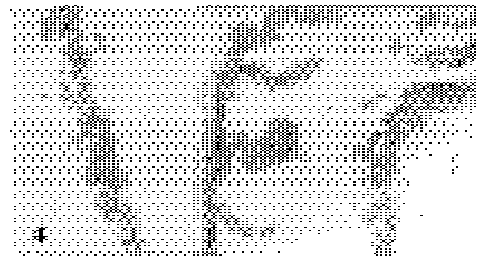


Fig. 4: Gills of *Tilapia zillii* showing hyperplasia of secondary lamellar cells with telangiectasis. H and E X400

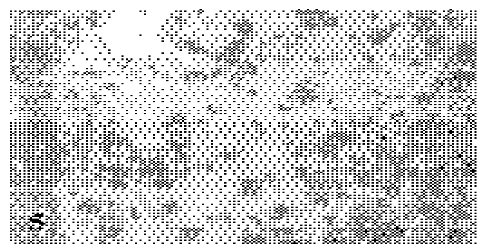


Fig. 5: Gill arch of *Tilapia zillii* showing edema with prominent E.G. cells infiltration. H and E X400

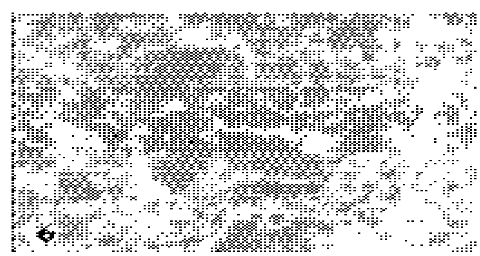


Fig. 6: Gill arch of *Tilapia zillii* showing edema with prominent E.G. cells infiltration. H and E X400

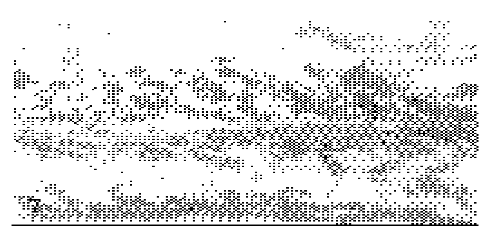


Fig. 7: Gills of *Tilapia zillii* showing necrosis of lining epithelium of secondary lamellar cells with telangiectasis. H and E X400

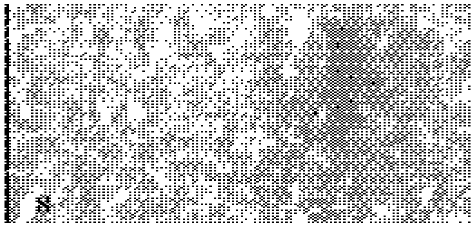


Fig. 8: Hepatopancreas of *Mugil cephalus* showing vacuolar degeneration with congestion and dilation of sinusoids and some what activation of melanomacrophage centers. H and E X400

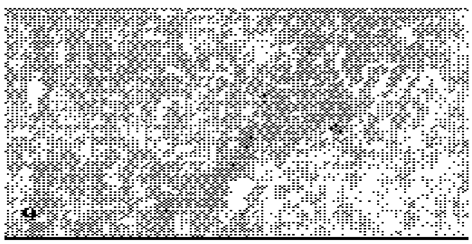
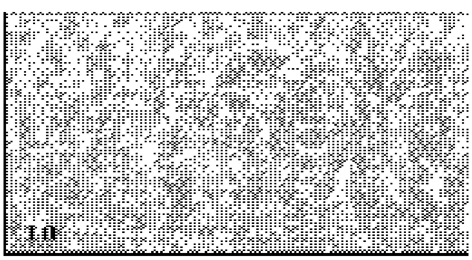


Fig. 9: Hepatopancreas of *Mugil cephalus* showing vacuolar degeneration with activation of melanomacrophage centers. H and E X400



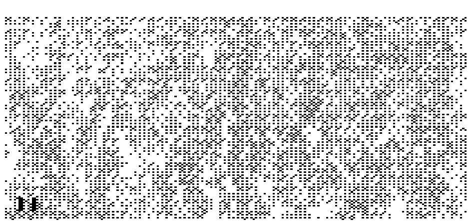


Fig. 10-11: Hepatopancreas of *Mugil cephalus* showing vacuolar degeneration. H and E X400

Fig. 12: Hepatopancreas of *Mugil cephalus* showing focal activation of melanomacrophage centers. H and E X400

DISCUSSION

Assessment and control of aquatic pollution depended upon physico-chemical monitoring to identify and quantify toxicants and to provide data that, for regulatory purposes, could be compared to allowable concentrations for particular recipient water (Pascoe, 1987; Mansour *et al*., 2001b). The concept that water quality criteria are the basis for any kind of water pollution control policy is certainly valid (FAO, 1987).

Physico-chemical characteristics

Temperature: The water temperature increased in the summer season due to the increasing in air temperature. There is no clear thermal stratified recorded in the lake due to shallowness of the lake (4 m depth in average) and it is considered being homoeothermic in nature (Soliman, 1989; Anon, 1997; Ali, 2002).

Electrical conductivity: The increasing of the values during summer may be attributed to the decreasing on the water level as a result of high rate of evaporation and lowering the amount of drainage water pour in the lake during this season (Abdel-Moniem, 1991). During winter, the lower values were due to direct effect of dilution by drainage water especially areas facing the drains. This is in agreement with the conclusion of Anon (1997) which mainly attributed to pouring of the brine water wastes of salt marches belonging to EMISAL Company directly into the drain. It was found that, the values of EC are tremendous than and more thousands folds of, the 200 μmhos/cm value marking eutrophication in aquatic habitats as specified by Talling and Talling (1965). Consequently, Lake Qarun is considered highly eutrophied.

Total dissolved solids (TDS): The total dissolved solids increased during summer (27.4 g L^{-1}), that mainly attributed to high rate of evaporation and lowering the water level in the Lake due to the flow of the drainage water from the main drains was lowered. While the TDS decreased during winter (9.3 g L^{-1}) which may be attributed to the raising of the water level in the lake because of increasing of the amount of drainage water during winter (Ali, 2002). It was noticed that the TDS values in Lake Qarun far exceeding the permissive limit of 500 mg L^{-1} (USEPA, 2000). TDS reflect the increasing extent of industrial and domestic discharge in aquatic habitats (Welcomme, 1985). High values of TDS were found to affect survival and growth of fish (Dicketson and Vingard, 1999).

Salinity: As a whole, the salinity considered being the main factor responsible for the deterioration of the environmental conditions of the Lake Qarun and the drop in its fish production (Anon, 1997).

The highest value of 39.5 ‰ recorded during summer may be attributed to the high rate of evaporation during summer reaching to maximum value of 25.67 cm/month during August (Ali, 2002) which, lead to elevated the value of salinity (Garcia and Niell, 1993; Herbst, 2002). While the lowest value of 39.0 ‰ recorded during spring, may be due to the effect of dilution arises from drainage water from El-Bats drain, as recorded by Vidondo *et al.* (1993) and Mainping (2002).

pH: The pH values are low during winter than other seasons, which may be attributed to the decomposition of organic matter. Furthermore, the pH values increased relatively during summer, autumn and spring. This relative increase mainly attributed to the increasing of photosynthetic activity, which reduces the CO_2 amount in water. In addition, this may be attributed to the low levels of dissolved oxygen where there is a negative correlation (r =-0.879) (Table 4) between pH and dissolved oxygen. This finding agreed with those of Abdel-Moniem (1991), who mentioned that the pH of Lake Qarun is related with oxygen content. As a whole, the pH spectrum of Lake Qarun water revealed the predominance towards alkaliphilous side. Its values showed narrow variations and were always around eight. These results were agreed with that reported by Abdel-Moniem (1991), Anon (1997), Ali (2002) and Goher (2002).

Dissolved oxygen: The highest value of DO of 10.3 mg L^{-1} recorded during winter, which mainly attributed to decreasing of temperature, prevailing winds action that permits to increase the solubility of atmospheric oxygen gas (Saad, 1980). The DO values showed relative decrease during summer (8.43 mg L^{-1}) which is mainly attributed to elevation of water temperature that leading to decrease the solubility of oxygen gas (Rai, 2000; Ueda *et al.*, 2000), in addition to the oxidation of organic matter by the microbial activity of microorganisms, which consumes a part of dissolved oxygen. This is agreement with the results obtained by Cole (1979), Abdel-Moniem (1991), Sabae (1996) and Anon (1997). Besides increasing of salinity during summer, affect the solubility of oxygen gas adversely. These findings is confirmed by a significant negative (r =-0.953) correlation between DO and water temperature; which is in agreement with the results obtained by Saad (1987), El-Ghobashy (1991) and Abdel-Satar and Elewa (2001) and a negative correlation (r =-0.425) between DO and salinity.

Alkalinity: For total alkalinity, the obtained results increased during summer and winter whereas decreased during autumn and spring. The increasing of bicarbonate during winter attributed to decrease in water and air temperatures led to the precipitation of calcium bicarbonate. In addition, the values showed increasing during summer with maximum value of 257.3 mg L^{-1} which attributed to increasing the decomposition rate of

Table 4: Pearson's correlation coefficient matrix for some physico-chemical parameters of water of Lake Qarun and the concentrations of Copper (Cu) and zinc (Zn) in different organs of *Tilapia* and *Mugil* sp.

	Cu	CuTl	CuTg	CuTm	CuMl	CuMg	CuMm	Zn	ZnTl	ZnTg	ZnTm	ZnMl	ZnMg	ZnMm
Cu	1.000													
CuTl	0.949	1.000												
CuTg	0.844	0.970*	1.000											
CuTm	0.968*	0.991**	0.941	1.000										
CuMl	0.977*	0.975*	0.902	0.965*	1.000									
CuMg	0.991**	0.907	0.778	0.927	0.965*	1.000								
CuMm	0.976*	0.990**	0.931	0.984*	0.996**	0.952*	1.000							
Zn	0.957*	0.998**	0.960*	0.998**	0.968*	0.913	0.987*	1.000						
ZnTl	0.991**	0.982*	0.906	0.988*	0.991**	0.970*	0.996**	0.984*	1.000					
ZnTg	0.941	0.993**	0.965*	0.996**	0.949	0.889	0.973*	0.998**	0.972*	1.000				
ZnTm	0.990**	0.947	0.851	0.978*	0.950*	0.967*	0.961*	0.963*	0.982*	0.957*	1.000			
ZnMl	0.991**	0.919	0.797	0.932	0.976*	0.999**	0.962*	0.922	0.976*	0.897	0.963*	1.000		
ZnMg	0.989*	0.956*	0.866	0.984*	0.953*	0.962*	0.966*	0.971*	0.984*	0.965*	0.999**	0.959*	1.000	
ZnMm	0.999**	0.963*	0.869	0.979*	0.982*	0.984*	0.984*	0.970*	0.996**	0.957*	0.991**	0.985*	0.991**	1.000

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed), Cu = Copper (mg L^{-1}). Zn = Zinc (mg L^{-1}). T = *Tilapia* sp., M = *Mugil* sp. l = Liver. g = Gills. m = Muscle organic matter and/or enhancing the anaerobic processes which increases carbon dioxide in the water column (Elewa, 1993).

The decreasing of alkalinity during spring with lowest value of 248.0 mg L^{-1} is mainly attributed to decrease in water level because of low discharged amount of drainage water and slightly high rate of evaporation.

Chlorisity: The highest value of Cl^- of 6.67 g L^{-1} was recorded during summer that attributed to the impacts of salt marches adjacent to the Lake, the seepage of salts from the adjacent cultivated lands and underground water (Bishai and Kirollus, 1980; Siliem, 1993a). Besides the effluents of EMISAL company brine water discharged into the Lake as reported by Anon (1997), who decide, without any doubt, that the effluents of EMISAL brine water discharged into the lake, which caused increasing in the most parameters. Furthermore, the high rate of evaporation during summer season and low water level of the lake; as well as, the decrease in the discharged runoff during summer; regard the main reason for increase the chloride content. This is confirmed by the Significant positive correlation (r = 0.959 and r = 0.739) between Cl^- and temperature and salinity, respectively.

The lowest values of 1.76 and 3.08 g L^{-1} recorded during winter and spring attributed mainly to the dilution effect of the introduced agricultural runoff from El-Bats drain, especially, during spring where the amount of discharged runoff increased. These results are agreed with that reported by many authors (El-Wakeel and Wahby, 1970; Soliman, 1989; Abdel-Moniem, 1991; Siliem, I993a-d; Mansour *et al.*, 2000). The limit of Cl^- for domestic purposes is fixed at 250 mg L^{-1} (USEPA, 1986).

Total hardness: In the present study, the general seasonally average trend was characterized by a progressive increase during winter (664.3 mg L^{-1}) and autumn (656.7 mg L^{-1}) seasons and decrease during summer (655.3 mg L^{-1}) and spring (644.3 mg L^{-1}). Cole (1979) reported that the increase in hardness concentration in winter may be due to the increase in dissolved oxygen with temperature decrease, but the decrease in levels in summer were due to the carbonic acid decrease leading to the precipitation of $CaCO_3$.

Nitrite: It is quite clear from the above mentioned results that, nitrite contents in Lake Qarun showed relative narrow seasonal fluctuations. The results declared that the nitrite concentration increases during summer and spring, which mainly attributed to oxidation of exist ammonia-yielding nitrite as reaction intermediate (Wetzel, 1983).

European Economic Community standards (Ali, 2002) has set 100 μg L^{-1} as a maximum admissible limit for nitrite in natural water and here in all cases, Lake Qarun exceed the admissible levels by several times and this may due to increase of organic pollutants or domestic wastes. Nitrite poisoning causes fish mortality resulting in converting hemoglobin to form methemoglobin as indicated by Boyd (1979 and 1990).

Nitrate: Nitrate is a prime plant nutrient and rising in its concentrations might be expected to increase the eutrophication of waters (Goher, 2002).

In Lake Qarun, the nitrate values in water varied, in the same trend of nitrite, in the range from 0.30 mg L^{-1} (winter and spring) to 0.32 mg L^{-1} (summer and autumn). From the mentioned results, it is obviously that, nitrate contents in Lake Qarun showed also a relative narrow seasonal fluctuation. Nitrate concentrations are dependent on the type of agricultural runoff. In the areas where nitrate is derived from organic pollution, the high nitrate may be accompanied by high chloride concentration and this is confirmed here by the positive correlation (r = 0.903) between nitrate and chloride.

When the above mentioned physical and chemical parameters compared with the standard values set by the local Egyptian laws (48, 60, 61 and 62 and 4/1994) and the USEPA (1986), it is found that most of these parameters were higher than the recommended standards and this affect the biota in the studied area and form a public health problem.

Concentrations of copper and zinc in the water of Lake Qarun: It appears that seasonal variations in the concentrations of trace elements in the lake are strongly dependent on both the drainage water discharged from the various drains in the lake as well as the velocity and direction of winds. The presence of trace metals in Lake Qarun is mainly of allochthonous origin due to either agricultural influx, wastes of fish farms or sewage via surrounding cultivated lands.

The distribution patterns of Cu and Zn in the Lake water increased in hot seasons (spring and summer) which may be attributed to the release of heavy metals from sediments to the overlying water under the effect of both high temperature (r = 0.531 and 0.667, for Cu and Zn, respectively) and fermentation process resulted from decomposition of organic matter (Elewa *et al.*, 2001). In addition, the values of Cu and Zn showed an obvious decrease in the water during cold period (winter and autumn) due to precipitation of heavy metals from water column to the sediments under slightly high pH values (r = 0.902 and 0.965, for Cu and Zn, respectively) and the adsorption of heavy metals onto organic matter and their settlement downward (Goher, 2002).

Table 5: Comparison of heavy metals concentrations in Lake Qarun water with other Egyptian areas

Location		Cu	Zn	Reference
Lake Qarun	(2004-2005)	1.25-2.59 mg L^{-1}	0.096-0.18 mg L^{-1}	Present study
		0.08 mg L^{-1}	0.047 mg L^{-1}	Ibrahim (1996)
	(1997-1999)	0.085-0.208 mg L^{-1}	0.021-0.034 mg L^{-1}	Mansour and Messeha (2001)
	(Summer 2000)	0.23 mg L^{-1}	1.16 mg L^{-1}	Elghobashy *et al.* (2001)
	(1997-1999)	0.152 mg L^{-1}	0.027 mg L^{-1}	Mansour and Sidky (2002)
	(1999-2000)	0.032-0.045 mg L^{-1}	0.023-0.038 mg L^{-1}	Goher (2002)
	(Summer 2003)	0.036-0.057 mg L^{-1}	0.029-0.050 mg L^{-1}	Ali and Fishar (2005)
Fish Farms around Lake Qarun (2003)		0.028-0.034 mg L^{-1}	0.061-0.069 mg L^{-1}	Ali and Abdel-Satar (2005)
Wadi El-Raiyan Lakes and		0.001-0.195 mg L^{-1}	0.003-0.035 mg L^{-1}	Saleh *et al.* (1988)
Water Springs (1984-1985)		0.017-0.034 mg L^{-1}	0.054-0.073 mg L^{-1}	Aboul Ezz and Abdel-Razek (1991)
Lake Manzala	(Summer 2000)	0.19 mg L^{-1}	1.37 mg L^{-1}	Elghobashy *et al.* (2001)
	(Summer 2000)	0.11 mg L^{-1}	0.04 mg L^{-1}	Elghobashy *et al.* (2001)
Lake Borollus	(2000-2002)	0.003-0.015 mg L^{-1}	0.004-0.020 mg L^{-1}	Radwan and Shakweer (2004)
	(Summer 2000)	0.17 mg L^{-1}	0.08 mg L^{-1}	Elghobashy *et al.* (2001)
Lake Edku	(2001-2002)	0.014-0.049 mg L^{-1}	0.011-0.126 mg L^{-1}	Masoud *et al.* (2004)
	(1999-2001)	0.013-0.017 mg L^{-1}	0.006-0.022 mg L^{-1}	Shakweer and Abbas (2005)
Lake Mariut	(Summer 2000)	0.24 mg L^{-1}	0.33 mg L^{-1}	Elghobashy *et al.* (2001)
Ismalia Canal	(Summer 2000)	0.13 mg L^{-1}	0.33 mg L^{-1}	Elghobashy *et al.* (2001)
	(Summer 2000)	0.26 mg L^{-1}	0.65 mg L^{-1}	Elghobashy *et al.* (2001)
River Nile	(2002)	ND	0.001-1.02 mg L^{-1}	Abbas and Mahmoud (2003)

ND = Not Detected

The values of the studied heavy metals (especially of Cu) were higher than that permitted by USEPA (1986), the Egyptian local laws (48, 60, 61 and 62 and 4/1994) and the Ministry of Health Standards where the permissible levels for water usage were (1 mg L^{-1}) for Cu and Zn.

The present results of Cu and Zn concentrations in water are higher than those recorded by many authors (Table 5) in different areas of Egypt.

Concentrations of copper and zinc in fish organs: The concentrations of Cu and Zn in fish samples indicate that *Tilapia zillii* seemed to be more contaminated than *Mugil cephalus*. These observations are mainly due to different fish habitat and the influence of the surrounding ecosystem status. These results are in disagreement with the findings of Ali (2002), Mansour and Sidky (2002), Ali and Fishar (2005), Ali and Abdel-Satar (2005) and Obasohan *et al.* (2006) who reported that *Mugil* sp. seemed to be more contaminated than *Tilapia* sp.

Copper (Cu^{2+}): Average copper concentrations in organs of the two fish species were detected in the following manner: muscle <gills <liver. On seasonal basis, summer and spring recorded the highest values of Cu in different organs. The copper concentrations in water peaked in summer and spring and this may be the reason of increase of copper in fish organs during these seasons, while lower values of Cu in water during autumn and winter showed the high tendency of organs to accumulate Cu. The present results indicate that liver accumulated higher amounts of copper and this may be due to its ability to retain Cu (Abbas *et al.*, 2002). The present results agree with those obtained by Wiener and Giesy (1979), Eisenberg and Topping (1986), Abou-Zaid *et al.* (1988a, b), Benedetti *et al.* (1989), Ghazaly (1992), Ghazaly *et al.* (1992), Gomaa *et al.* (1995) and Zyadah (1995) who found that copper showed higher concentrations in liver than flesh of different fish species from Egypt and different places of the world. It has also been mentioned by Salanki *et al.* (1982) that in fishes, the liver is the selective organ for storage of copper. Accumulation in the liver can be the result of detoxicating mechanisms and may originate from metal in the food.

Zinc (Zn^{2+}): The total concentration values of zinc in organs of the two fish species were detected in the following manner: muscle < gills < liver. The higher values of Zn recorded in different organs during summer and spring may be attributed to the increase of Zn concentrations in water during these seasons. The present results are in accordance with those obtained by Gomaa *et al.* (1995) and Zyadah (1995) who mentioned that the higher values of Zn were found in liver and the lower values were detected in muscles of different fish species from waters of Egypt and other countries. However, zinc is absorbed and transported through blood to various body tissues for either storage in liver, spleen and gonads or excreted out by the kidney as explained by Abdel-Moneim *et al.* (1991). Thus, the different organs take their needs from zinc and the excessive tend to accumulate as storage. These results agreed with those reported for Lake Manzalah for *T. zillii* and *C. lazera* by Zyadah (1997) and Abdel-Baky *et al.* (1998). Ahdy (1982) in her study on the accumulation of Zinc in the liver, gut and muscle of some fish species from Lake Mariut, found that higher accumulation of zinc in *Tilapia nilolica* occurred in the fish liver while minimum values were found in the muscles. This agrees with the present results.

It is clear from present that, Cu and zinc accumulation pattern have the similar behavior in both two fish species with noticeable increase in liver than gills and edible muscle. The higher concentrations of heavy metals in fish liver has been attributed according to Saleh (1982) and Asitis *et al.* (1983) to the fatness of liver and also to the fact that the fish liver extracts the poisons from the blood through its circulation inside the body of the living organism. On the other hand, the muscles showed considerable amounts of metals. This may be correlated with fat-content in muscle tissues and its great affinity to combine with heavy metals (Shenouda *et al.*, 1992).

The concentrations of Cu and Zn in the various organs of fish caught from the lake were greatly dependant on the concentrations of these elements in the ambient water. The relationships between heavy metal concentration in fish organs and in external water environment were significant and in some cases were highly significant (Table 4).

On comparing, the present results of Cu and Zn with those reported by FAO (1983) for the allowable concentration (Cu = 20 mg kg^{-1}; Zn = 40 mg kg^{-1}) for human consumption, it is clear that, the results indicate safety in the edible muscles for two fish species but in liver and gills, the toxicity is slightly increased in both studied species. The data also revealed that, the bioaccumulation of the recorded metals in fish were higher than the permissible levels (Cu = 20 mg kg^{-1}; Zn = 50 mg kg^{-1}) recommended by WHO (1984). Adding to that, the present values of heavy metals estimated in the different organs of the two fish species are in some cases, relatively higher than those recorded for same species in different environments (Table 6 and 7).

The accumulation factor or the relative index of the concentration of the heavy metal in the fish organ to that in water showed dreadful results (Table 3 and 4), when compared to the real concentration of those pollutants in water (Table 1).

Histopathological lesions of liver and gills: Anoxia is one of the main reasons for cloudy swelling or fatty degeneration of the liver. Oxygen deficiency as a result of gill degeneration being the most common cause of cell damage and distruction (Abbas *et al.*, 2002). Degeneration and necrosis of hepatocytes may be attributed to the cumulative effect of heavy metals and the increase of their concentrations in the hepatic tissue. These results agreed with Förlin *et al.* (1986), who stated that the liver has an important detoxical role of endogenous waste products as well as externally derived toxins such as heavy metals.

Abbas *et al.* (2002) mentioned that the liver of *O. aureus* toxicated with copper showed numerous bile ductules besides few lymphocytes in the portal areas and

Table 6: Comparison of copper (Cu) concentrations (mg kg^{-1} dry wt.) in different fish organs from Lake Qarun with other Egyptian and African areas

	Cu								
	Tilapia sp.				*Mugil* sp.				
Location	Liver	Gills	Muscle	Whole body	Liver	Gills	Muscle	Whole body	Reference
Lake Qarun	12.74-36.27	10.85-26.95	5.93-17.85	-	6.44-18.46	4.20-10.80	1.31-5.01	-	Present study
	2.96	0.48	0.22	-	-	-	-	-	Elghobashy *et al.* (2001)
	-	-	-	1.7				5.7	Mansour and Sidky (2002)
	-	-	-	6.43-10.54	-	-	-	8.91-9.00	Ali and Fishar (2005)
Fish Farms around	-	-	-	3.0	-	-	-	4.9	Mansour and Sidky (2002)
Lake Qarun	-	-	-	8.2-10.3	-	-	-	10.5-12.3	Ali and Abdel-Satar (2005)
Wadi El-Raiyan Lakes and Water Springs	-	-	1.3-5.3	-	-	-	-	-	Saleh *et al.* (1988)
Lake Manzala	-	-	0.361-0.421	-	-	-	-	-	Aboul Ezz and Abdel-Razek (1991)
	38.1	1.9	1.42	-	-	-	-	-	Elghobashy *et al.* (2001)
Lake Borollus	44.8	2.13	2.18	-	-	-	-	-	Elghobashy *et al.* (2001)
	35.18-62.14	-	2.88-9.81	-	-	-	-	-	Shakweer and Radwan (2004)
Lake Edku	41.9	1.83	1.7	-	-	-	-	-	Elghobashy *et al.* (2001)
	25.10-88.69*	-	4.47-19.33*	-	-	-	-	-	Shakweer and Abbas (2005)
Lake Mariut	3.49	-	0.09	-	-	-	-	-	Ghazaly (1992)
	8.6	0.95	0.63	-	-	-	-	-	Elghobashy *et al.* (2001)
Ismalia Canal	2.87	0.39	0.17	-	-	-	-	-	Elghobashy *et al.* (2001)
River Nile	13.5	1.38	1.1	-	-	-	-	-	Elghobashy *et al.* (2001)
Alexandria	4.8-6.2*	5.5-6.7*	0.3-1.6*	-	-	-	-	-	Ghazaly *et al.* (1992)**
Lakes Awassa and	-	-	1.03-2.78	-	-	-	-	-	Ataro *et al.* (2003)
Ziway, Ethiopia	602-797	7.08-8.58	1.68-4.95	-	-	-	-	-	Kebede and Wondimu (2004)

* Wet weight. ** Based on fishes collected from 3 different areas

Table 7: Comparison of zinc (Zn) concentrations (mg kg^{-1} dry wt.) in different fish organs from Lake Qarun with other Egyptian and African areas

	Zn								
	Tilapia sp.				*Mugil* sp.				
Location	Liver	Gills	Muscle	Whole body	Liver	Gills	Muscle	Whole body	Reference
Lake Qarun	10.48-27.91	6.91-19.91	3.00-13.56	-	4.58-13.97	2.15-8.79	0.79-3.85	-	Present study
	124.3	100	20.7	-	-	-	-	-	Elghobashy *et al.* (2001)
	-	-	-	8.6				16.0	Mansour and Sidky (2002)
	36.9-61.5		19.9-36.1						Ali (2002)
	-	-	-	22.83-26.29	-	-	-	27.52-30.84	Ali and Fishar (2005)
Fish Farms around	-	-	-	17.0	-	-	-	18.8	Mansour and Sidky (2002)
Lake Qarun	-	-	-	49.2-66.3	-	-	-	78.7-83.2	Ali and Abdel-Satar (2005)
Wadi El-Raiyan Lakes and Water Springs	-	-	1.8-14.1	-	-	-	-	-	Saleh *et al.* (1988)
Lake Manzala	-	-	3.26-3.34	-	-	-	-	-	Aboul Ezz and Abdel-Razek (1991)
	214	182	43.7	-	-	-	-	-	Elghobashy *et al.* (2001)
Lake Borollus	162	9.5	41.3	-	-	-	-	-	Elghobashy *et al.* (2001)
	21.15-53.18	-	13.84-36.89	-	-	-	-	-	Shakweer and Radwan (2004)
Lake Edku	133	93.3	27.7	-	-	-	-	-	Elghobashy *et al.* (2001)
	25.51-89.08*	-	6.11-27.93*	-	-	-	-	-	Shakweer and Abbas (2005)
Lake Mariut	2.12	-	0.28	-	-	-	-	-	Ghazaly (1992)
	130.7	106	34	-	-	-	-	-	Elghobashy *et al.* (2001)
Ismalia Canal	56.3	51.7	11.5	-	-	-	-	-	Elghobashy *et al.* (2001)
River Nile	107	87	34	-	-	-	-	-	Elghobashy *et al.* (2001)
	11.85-23.21*	11.29-112.40*	4.98-22.64*	-	-	-	-	-	Abbas and Mahmoud (2003)
Lakes Awassa and	-	-	23.04-30.92	-	-	-	-	-	Ataro *et al.* (2003)
Ziway, Ethiopia	85.6-115.9	82.3-97.1	34.6-38.6	-	-	-	-	-	Kebede and Windimu (2004)

* Wet weight

degenerative changes of the hepatocytes. The same results were previously recorded by EI-Bagori (2001) who attributed these lesions to the severe toxic effect. Among the observed histopathological lesions of liver, the macrophage aggregates have been shown to be involved in a number of fish diseases and as phagocytic cells (Agius, 1979). Mousa (1999) previously detected the presence of melanomacrophages and they were attributed to the impairment of the electrolyte exchanges between the intracelluar and the extra-celluar fluids (Marie *et al.* 1998). In addition, the presence of melanomacrophages may be due to the increase of the body catabolism, or may be due to the anorexia (Mousa, 1999). In accordance, the pathological liver steatosis was reported by Kranz and Peters (1985) as a case accompanied by additional features such as necrosis, lymphocyte infiltration, deposition of ceroids and aggregations of macrophages. Abd El-Gawad (1999) mentioned that, *Oreochromis niloticus* fish exposed to zinc Sulphate, showed the following symptoms: the liver showed vacuolated hepatocytes with frequent necrosis, evidenced by pyknosis. The bile canaliculi were dilated.

It is possible that the damage of the gills could be a direct result of the salts, heavy metals, pesticides, sewage and fertilizers, which are conveyed to the lake with the drainage, water (Temmink *et al.*, 1983; Shoman and Gaber, 2003). Hyperplasia shortening and fusion of the secondary gill lamellae that may lead lo a great disturbance of gas exchange and ionic regulation were noticed (Balah *et al.*, 1993). Lamellar telangictasis resulted from rupture of pillar cells and capillaries under effect of heavy metals pollution and leads to an accumulation of erythrocytes in the distal portion of the secondary lamellae (Randi *et al.*, 1996). The subepithelial space of the secondary gill lamellae was infiltrated with inflammatory cells. This finding is in agreement with that previously mentioned by Pascoe *et al.* (1986) and Randi *et al.* (1996). *Mucinous metaplasia* of lamellar epithelial lining is considered as adaptive mechanism against heavy metal toxicity.

Gills of tilapia exposed to the copper showed hyperplastic changes in the epithelial cells of secondary lamellae (Marie *et al.*, 1998; Mousa, 1999). The hyperplasia induced by any pollutant may be duo to the simple response to cellular necrosis as previously mentioned by Marie *et al.* (1998). Moreover, Shaker *et al.* (2000) reported that, the epithelial hyperplasia is known as a protective and defense mechanism of fish gills. The congestion in branchial blood vessels may be due to the counter irritation and paralysis of vasoconstrictors of stimulating vasodilators (Marie *et al.*, 1998).

Abd El-Gawad (1999) mentioned that, *Oreochromis niloticus* fish exposed to zinc Sulphate, showed the following symptoms: the gills were pale and congested. The epithelial covering of the gill filaments was hyperplastic and edematous with vacuolated epithelial covering of the gill rakers. The lamellar blood spaces showed telangiectasis.

Mallat (1985) reported that the pathological changes of fish gills are induced by elevated heavy metals and low oxygen content in water.

As reported by Mallatt (1985) the heavy metals stimulate secretion of mucus by fish gills. Accordingly, the proliferation and stimulation of mucous cells and an increase in mucus production generally occur in response to zinc (Mattliiessen and Brafield, 1973) and copper (Wilson and Taylor, 1993).

CONCLUSION AND RECOMMENDATION

From the present study, it could be concluded that metal pollution problems in the studied area were serious as reflected by the relatively high metal concentrations recorded in the collected water samples. However, because of the high rate of evaporation, the concentrations of heavy metals may soon reach a dangerous level, which may effect the utilization of the lake for fish production and may also pollute the ground water of the nearby springs and be transferred through the food chain to wild life of the surrounding area. In addition, we can conclude that, the salinity is considered the main factor responsible for the deterioration of the environmental condition of the Lake Qarun and drop in its fish production. So that, the lake may be converted into a dead water body due to the progressive increase in its salinity for the next decades unless a certain treatment is done by removing a certain quantities of its high-salinity for adjusting the salinity of the lake at desired level which is suitable for fish to survive.

Generally, all elements were more concentrated in the non-edible parts of the fish, livers and gills where metal concentrations were several-fold higher than the edible muscles. On the other hand, the modes of living and feeding habits as well as the physiology of various organs of fishes are believed to play an important role in the rates of trace elements accumulation. However, these fish may represent a serious effect on the health of the local inhabitants around the Lake area who depend primarily in their diets on Lake fishes where high concentrations of heavy metals implicate fish tissues affecting its quality and hence become a threat to man.

Finally, from the previous mentioned discussion and conclusion we can say that, Lake Qarun needs to coordinate different efforts to rescue it from these serious ecological problems. Nowadays, the overcoming of these problems can be possible by using proper management, scientific specialized researches and conclusive implementation of recommended solves.

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