LIMNOLOGICAL STUDIES ON LAKES AND FISH FARMS IN WADI EL-RAIYAN AREA, WESTERN DESERT, EGYPT

SAEED, M. S.[1] AND S. A. ABDEL-MAGEED[2]

Central Lab. for Fish Research, ARC, Giza
1- Limnology dept., 2- Aquaculture dept.

(Manuscript received 20 February 2008)

Abstract

The present study was carried out to evaluate the physical and chemical characteristics of water at three sites (the upper and lower lake as well as fish farms) in Wadi El-Raiyan area and their effect on fish production. Concentrations of metals (iron, zinc, manganese, copper, cadmium, and lead) were also determined in some organs of tilapia species to detect the degree of pollution in this area. Water and fish samples were collected monthly during the spring season of the year 2005. Electric conductivity, total dissolved solids, transparency, total hardness, calcium hardness and chloride showed marked variations at the three sites. No oxygen depletions were observed in the three sites and it lies in the safe range for aquatic organisms. In water, the levels of Fe (in fish farms), Cu (in upper lake and fish farms) and Pb (in upper and lower lake) exceeded the maximum world permissible limits. Gills and liver tissues had higher tendency to accumulate metals more than muscles. Metal concentrations in the edible part of the examined fish were in the safety permissible levels for human consumption. Primary productivity (phytoplankton) in water is limited in the habitat of the lakes and growth of fish exhibit well-being and higher condition factor and hepato-somatic index in fish farms and lake I than lake III. The difference in metal concentrations among different sites was insignificant ($p>0.05$).

Key words: Physical, chemical, water, heavy metals, fish. Wadi El-Raiyan lakes, fish farms.

INTRODUCTION

Wadi El-Raiyan is a great depression in the Western Desert of Egypt (south of Fayoum), located about 150 km southwest of Cairo and lies 30° 23' E and 20° 68' N (Fig. 1). It is considered as one of the most arid areas in the world. The extremely high rate of evaporation coupled with very low precipitation could lead to increased concentration of pollutants and a rapid increase in salinity of the man-made lakes in this area.

El-Raiyan lakes were created as a reservoir for agricultural drainage wastewater. Since 1973 excess drainage water was transferred to this depression, resulting in two lakes (Raiyan I and Raiyan III), connected by a small connection waterway. The connection has waterfalls on both sides; the area between the falls is called Raiyan II. The total area of the lakes are 18,000 ha (43,000 feddan) and provide fish production of 1992 tones in 2005 (40 % tilapia, 30 % mullet and a mixture of other species) (GAFRD, 2006). The lakes receives the agricultural drainage water from a branch of El-Wadi drain which inflows in the upper lake of Wadi El-Raiyan (with an area of 6,374 ha). The water then moved through a series of tunnels and open canals about 5 km long and over a 25 m high falls to the great (lower) lake. With almost no precipitation and a very high evaporation rate, an increase in salinity takes place. In 1990 the salinity ranged between 1 and 2 ppt; presently it is in the order of 4-5 ppt (NWRP, 2000).

Increase in salinity will cause a change in fish composition. For the dominant fish species a further rise in salinity is no problem; the production will slowly move towards euryhaline tilapias and a larger share of mullets (NWRP) 2000. Production might provide marine species introduced timely and the value of fish will rise. The Lake is a suitable habitat for a variety of fish species, especially that of commercial importance.

Heavy metals from natural and anthropogenic sources are continually released into aquatic ecosystems, and they are a serious threat because of their toxicity, long persistence, bioaccumulation, and biomagnifications in the food chain. Pollutants from agricultural waste including pesticides and fertilizers as well as other effluents of industrial activities and runoffs will certainly pass into the biotic elements (especially fish) of the ecosystem. Concerning the interaction of fishes and their environment, it could be stated that fishes are more liable to be affected with environmental pollutants than the land animals and can accumulate trace metals from their environment and act as indicators for these elements in the environment. Therefore, they can be considered as excellent organisms for the study of some long-term changes in heavy metals concentrations in their ecosystem (Mason, 2002).

Limited efforts to monitor contaminant burdens in fish fauna have been undertaken (Saleh *et. al.*, 1988) in Wadi El-Raiyan area. Agricultural drainage water that contains fertilizers and pesticides besides effluents from fish farms enhance the lake's metal burden.

The present study was carried out to evaluate the physical and chemical characteristics of water in the lakes and fish farms in Wadi El-Raiyan area and their effect on fish production. Also, levels of Fe, Zn, Cu, Mn, Cd and Pb in water and some tissue/organs (muscle, gills and liver) of four tilapia species (*Oreochromis aureus, Tilapia zillii, Oreochromis niloticus* and *Sarotherodon galilaeus*) inhibited the lakes and *Oreochromis niloticus* reared in fish farms were determined to provide information contributing to the effective monitoring of both the environmental quality and health of organisms inhabiting the lake ecosystem.

MATERIALS AND METHODS

1- Sampling:

Water and fish samples were collected monthly during the spring season of the year 2005 from lakes (upper lake I & lower lake III) and fish farms in Wadi El-Raiyan area. Water samples were taken from the four margins and middle of each lake and from three ponds in fish farms using PVC tube column sampler at a depth of half meter from the water surface. The samples at each site (Fig. 1) were mixed in a plastic bucket and a sample of 1 liter was placed in a polyethylene bottle, kept refrigerated and transferred cold to the laboratory for analysis. Fish samples were collected from different sites by fishermen. Fish samples were sorted and kept frozen in ice box and transferred to the laboratory for sub-sampling of different tissue/organs.

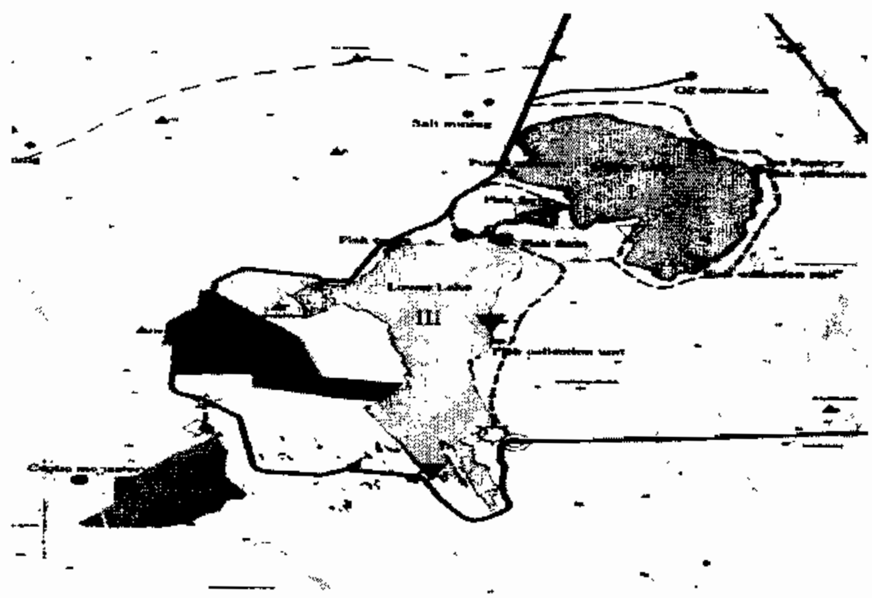

Fig. 1. Map of Wadi El-Raiyan area.

2- Laboratory analyses:

a- Physical and chemical parameters of water

Hydrogen ion concentration (pH) was measured with an Accumet pH meter (Model 25, Fisher Scientific). Electric conductivity (EC) and total dissolved solids (TDS) were determined using a salinity-conductivity meter (model YSI EC 300). Dissolved oxygen was measured using a digital oxygen meter (Model YSI 55). The concentration of total hardness, calcium hardness, carbonate and bicarbonate alkalinity (as $CaCO_3$), total phosphorus and chloride were estimated according to American Public Health

Association (APHA, 1985). Total nitrogen was measured according to Grasshoff *et al.* (1983). Concentration of all parameters were expressed as mg/l, except chloride as g/l and chlorophyll "a" content as µg/l. Transparency (m) was measured using a Secchi Disc of 20 cm diameter (Boyd and Tucker, 1992).

b- Heavy metals

In water samples, heavy metals were extracted with conc. HCl for Fe, Zn, Mn, Cu, Cd and Pb analysis (Parker, 1972), whereas in fish samples metals were extracted by the method described in Association of Official Analytical Chemists (AOAC, 1990). Atomic Absorption Spectrophotometer instrument (Model Thermo Electron Corporation, S. Series AA Spectrometer with Gravities furnace, UK) was used to detect the heavy metals. The concentrations of heavy metals were expressed as µg/l for water and µg/g dry weight for tissues (muscle, gills and liver).

c- Growth parameters

Fish condition which an indication for the fatness of fish was assessed using two different metrics: CF (K) and HSI. CF is a measure of somatic energy reserves associated with recent feeding activity and calculated as: K = gutted fish weight (W) /L^3) X 100, while Hepato-somatic index (HSI) is associated with liver energetic reserves and metabolic activity and calculated from the equation: HSI = (liver weight/ gutted fish weight (W) X 100 according to Schreck and Moyle (1990).

3- Statistical analysis:

One-way ANOVA and Duncan multiple range test were used to evaluate the significant difference in the concentration of different items studied with respect to lakes and fish farms. A probability at level of 0.05 or less was considered significant (Bailey, 1981). Standard errors were also estimated. Correlation coefficients among the different parameters were computed.

RESULTS AND DISCUSSION

Physical and chemical factors of water:

Hydrogen ion concentrations were on the alkaline side and varied slightly among sites where it was 8.47 at the upper lake I, 8.69 in the lower lake III and reached 8.92 in fish farms as shown in table (1). Increasing the pH value in fish farm water is related to the increase of primary production which causes an increase in photosynthesis involving the uptake free carbon dioxide from carbonate and bicarbonate and precipitation of calcium carbonate (Abel, 1998).

Table 1. Mean of physical and chemical factors in water of upper lake (I) and lower lake (III) and fish farms in Wadi El-Raiyan area.

Region / Item	(I)	(III)	Fish farm
pH	$8.47^{c} \pm 0.01$	$8.69^{b}\pm0.03$	$8.92^{a}\pm0.06$
SD	$1.43^{b}\pm0.12$	$3.75^{a}\pm0.43$	$0.32^{c}\pm0.01$
EC	$2.63^{b}\pm0.27$	$13.83^{a}\pm0.44$	$3.57^{b}\pm0.10$
TDS	$1.81^{c}\pm0.07$	$10.88^{a}\pm0.13$	$2.43^{b}\pm0.08$
Salinity	$1.83^{b}\pm0.03$	$7.77^{a}\pm0.30$	$1.98^{b}\pm0.09$
Cl^{-}	$0.55^{c}\pm0.02$	$3.80^{a}\pm0.14$	$1.35^{b}\pm0.02$
CO_3^{--}	$14.00^{b}\pm1.15$	$18.33^{b}\pm1.67$	$28.33^{a}\pm0.88$
HCO_3^{-}	$255.33^{a}\pm4.91$	$207.67^{c}\pm6.17$	$238.33^{b}\pm1.67$
T.H	670.0b±44.10	$2566.7^{a}\pm66.67$	$600.0^{b}\pm23.09$
Ca-hard.	$250.0^{c}\pm5.77$	$1500.0^{a}\pm10.00$	$200.0^{b}\pm16.62$
DO	$7.64^{a}\pm0.23$	$6.97^{a}\pm0.41$	$5.55^{b}\pm0.41$
TN	$2.05^{b}\pm0.13$	$1.68^{b}\pm0.08$	$9.58^{a}\pm0.44$
TP	$0.015^{b}\pm0.00$	$ND^{c}\pm0.00$	$0.15^{a}\pm0.001$
Chl. "a"	$9.22^{b}\pm0.05$	$7.74^{c}\pm0.05$	$44.03^{a}\pm0.64$

Letters a, b and c show differences among sites. Data shown with different letters are statistically different at $P < 0.05$ level.

Transparency values were 1.43 m in the upper lake I and 3.75 m in the lower lake III, whereas in fish farm was 0.32 m. This may attribute to the higher depth and lower primary productivity (phytoplankton growth) in the two lakes. Water losses its suspended material contents (phytoplankton blooming and suspended particles) as water moves from lake I to lake III to increase transparency coupled with the large depth of the lake.

Electrical conductivity, total dissolved solids, chloride, total hardness and calcium hardness were higher in lake (III) as shown in table (1). Water salinity was 1.83 g/l in lake I, 7.77 g/l in lake III and 1.98 g/l in fish farms. This may mainly due to the fact that lake III is an enclosed basin with almost no precipitation and a very high evaporation rate which lead to a rapid increase in salinity and other components.

Carbonate content averages were higher in fish farms (28.33 mg/l) compared to 14.00 mg/l in lake I or 18.33 mg/l in lake III as shown in table (1). This may be due to increase in primary productivity and photosynthesis activity which result in absorbance of free carbon dioxide from carbonate and bicarbonate in water and precipitation of calcium carbonate. Carbonates in lake III was higher than that in lake

I, this may be due to the fact that calcium and magnesium (which are basis) neutralize carbon dioxide in water and a part of bicarbonate transferred to carbonate which results in a progressive increase in pH and carbonate (Arrignon, 1999). Bicarbonate content in Lake I was higher than that in lake III and fish farms because the continuous input of agricultural drainage water.

Dissolved oxygen distribution shows a slight difference between lake I (7.64 mg/l) and lake III (6.96 mg/l). Arrignon (1999) mentioned that oxygen solubility in water decrease as salinity increase. Fish farms had dissolved oxygen value of 5.64 mg/l. The higher values of DO in lakes may be related to the high water volume and consequently rate of aeration, while the lower values in fish farms may be attributed to the high rate of activity. No oxygen depletions were noticed in the studied area.

The higher total nitrogen value was recorded in fish farms (9.58 mg/l) and the lower one was observed in lake III with no significant difference as shown in table (1). Total nitrogen content was directly proportional to chlorophyll "a" concentration (as indication of phytoplankton biomass) and total phosphorus. Abel (1998) mentioned that, the limiting factor for primary productivity is the availability of inorganic nutrients, particularly phosphate. Total phosphorus in lake III was lower than in lake I as a result of phosphorus precipitation. Total nitrogen, total phosphorus and chlorophyll "a" in fish farm (9.58, 0.15 and 44.03, mg/l, respectively) recorded higher values than those in the two lakes, this because of heavy presented artificial feed and high rate of fish/area. Primary productivity (phytoplankton) in water is limited in the habitat of the lakes.

Average of metal concentrations in water at the two lakes and fish farms are presented in table (2) and were found in the following order: Fe > Zn > Cu > Mn > Pb > Cd. The metal averages attained their maximum values at fish farms (68.59 µg/l) followed by upper lake (52.36 µg/l) then the lower lake (46.97 µg/l) as shown in table (2). The level of Fe (346.0 µg/l) in fish farms, Cu (25.67 and 17.52 µg/l) in lake I and fish farms, respectively and Pb in lake I and lake III (2.98 and 9.02 µg/l, respectively) were higher than the allowable limits (Fe: 300.0, Cu: 13.0 and Pb: 2.5 µg/l) which estimated by USEPA (1999). This may be related to the soil content of iron and use of copper components as algaecides. Also, increased Pb values in the two lakes may result from spill of leaded petrol from fishing and tourism boats and dust which holds a huge amount of lead from the combustion of petrol in automobile cars. Saleh *et al.* (1988) reported that, Pb concentration in Wadi El-Raiyan lakes was higher than the world's stream levels. Cu and Cd in lake I increase those in fish farms, this may related to renewed and continuous additional of drainage water. Zn, Mn and Cd levels are still lower than that of the world legal limits (Zn:120.0, Mn:170.0 and Cd:4.3 µg/l).

Table 2. Average concentration of heavy metals (μg/l) in water samples of the three sampling sites at Wadi El-Raiyan area.

Region	U. lake	*PL	L. lake	*PL	Fish	*PL	*PL
Metal	(I)	%	(III)	%	farms	%	(μg/l)
Fe	269.72	89.91	232.93	77.64	346	115.33	300.0
Zn	12.19	10.16	32.85	27.38	17.52	14.60	120.0
Mn	2.79	1.64	2.15	1.26	29.82	17.54	170.0
Cu	25.67	197.46	4.87	37.46	17.52	134.77	13.0
Cd	0.83	19.30	ND	0.00	ND	0.00	4.3
Pb	2.98	119.20	9.02	360.80	0.67	26.80	2.5
average	52.36		46.97		68.59		

*PL: permissible limits (US EPA, 1999). ND: Not detectable.

Heavy metals accumulation in fish organs:

Tables (3, 4 & 5) showed the results of heavy metals accumulated in organs of different fishes collected from the three studied sites at Wadi El-Raiyan area. The bioaccumulation patterns were found to vary according to the fish species, mainly according to their different feeding habits and the routes of metal uptake with higher values accumulated in tissues of *Oreochromis aureus* and *Oreochromis niloticus* and the minimum ones were observed in *Tilapia zillii* as shown in fig. (2). This can be explained by the fact that these species are voracious fish and can tolerate marginal environmental conditions as mentioned by Soliman *et al.* (1998).

Mason (2002) mentioned that, fish with higher metabolic rates accumulate contaminants faster, where feeding results in a higher metabolism and greater uptake of pollutants across the gills. Also, uptake of food from surrounding water together with the mobile behavior of fish, cause the variation in metal levels both between different fish species and fish from different localities.

The present data showed that, gills and liver had a high tendency to accumulate high concentrations of heavy metals, while muscle tissue tends to retain lower concentrations of such metals. The recommended daily intake for an adult is 48, 60, 2.0-9.0, 3.0 and 0.214 mg/day wet weight for Fe, Zn, Mn, Cu and Pb respectively according to FAO/WHO (1999). Also, the permissible daily intake of Cd and Pb is 0.1 and 214.0 μg wet weight as recorded by FAO/WHO (1999). So, a normal daily diet including this fish species poses no health risk to consumer. For comparison between values in this study and legal limits; (μg/g wet wt.=μg/g dry wt./5 when the moisture be assumed 80%).

Table 3. Average concentration of heavy metals (μg/g dry wt.) in muscle tissue of each fish species collected from upper lake (I), lower lake (III) and fish farms.

Metal Sp.	Fe	Zn	Mn	Cu	Cd	Pb	Av
				Upper lake			
O. aur.	105.56	53.01	0.79	3.59	ND	0.60	27.38
T. zillii	55.01	35.81	0.75	2.46	ND	0.38	15.74
S. gal.	62.57	35.74	0.62	2.36	ND	ND	16.88
O. nil.	36.34	28.97	0.31	1.71	ND	0.10	11.24
Ave.	64.87	38.38	0.62	2.53	ND	0.36	17.81
				Lower lake			
O. aur.	61.65	45.06	0.64	13.19	0.004	ND	20.09
T. zillii	58.63	55.45	0.69	2.99	ND	ND	19.63
S. gal.	46.68	35.7	1.03	3.24	ND	0.21	14.48
O. nil.	88.55	45.67	1.04	2.76	0.007	0.43	23.08
Ave.	63.88	45.47	0.85	5.55	0.003	0.16	19.32
				Fish farms			
O. nil.	62.12	32.31	0.72	2.39	0	0.11	16.28
PL* (mg/d)	43.0	60.0	2.0 – 9.0	3.0	0.1**	0.214	

ND: Not detectable. *PL: Permissible limits (wet wt.) according to FAO/WHO (1999). **μg/g.

Table 4. Average concentration of heavy metals (μg/g dry wt.) in gills of fish species collected from upper lake (I), lower lake (III) and fish farms.

Metal Sp.	Fe	Zn	Mn	Cu	Cd	Pb	ave.
				Upper lake			
O. aur.	715.25	144.4	6.69	5.95	0.202	9.45	146.99
T. zillii	527.34	104.41	4.79	2.73	0.031	1.73	106.84
S. gal.	701.04	85.62	5.91	3.01	ND	2.97	133.09
O. nil.	363.15	77.53	5.99	4.48	ND	ND	75.192
ave.	576.70	102.99	5.85	4 04	0.058	3.54	115.53
				Lower lake			
O. aur.	1012	139.53	4.14	4.71	0.863	ND	193.54
T. zillii	490.63	102.84	2.78	4.48	0.008	0.06	100.13
S. gal.	612.04	102.72	6.54	4.13	ND	ND	120.91
O. nil.	575.43	111.31	10.05	3.39	ND	2.33	117.09
ave.	672.53	114.10	5.88	4.18	0.436	0.60	132.92
				Fish farms			
O. nil.	785.67	66.79	8.29	3.53	0.06	ND	144.06

ND: Not detectable.

Table 5. Average concentration of heavy metals (µg/g dry wt.) in liver of fish species collected from upper lake (I), lower lake (III) and fish farms.

Metal Sp.	Fe	Zn	Mn	Cu	Cd	Pb	ave.
Upper lake							
O. aur.	NM	NM	NM	NM	NM	NM	NM
T. zillii	872.13	76.98	3.39	106.48	0.51	0.8	176.72
S. gal.	1058.0	149.29	8.37	91.38	0.44	ND	217.91
O. nil.	1961.2	210.05	12.35	133.29	6.58	4.63	388.02
ave.	1297.10	145.44	8.04	110.38	2.51	1.81	260.88
Lower lake							
O. aur.	1688.8	301.64	9.62	307.73	0.101	2.59	385.08
T. zillii	360.83	91.67	3.83	242.38	ND	ND	116.45
S. gal.	NM	NM	NM	NM	NM	NM	NM
O. nil.	508.66	83.02	5.8	280.96	0.514	2.27	146.87
ave.	852.77	158.78	6.42	277.02	0.21	1.62	216.13
Fish farms							
O. nil.	294.28	57.99	2.86	148.07	0.147	0.018	83.89

ND: Not detectable; NM: not measured.

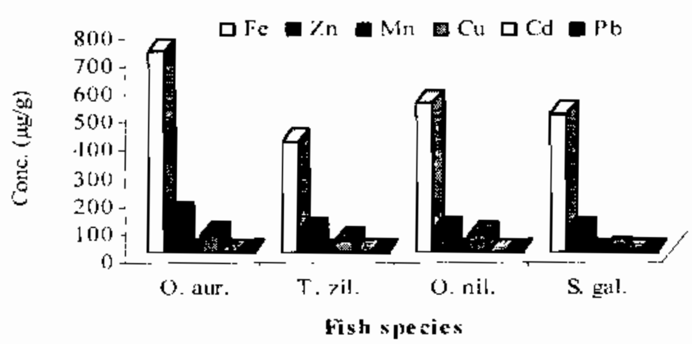

Fig. 2. Variation of total average concentration of heavy metals in different fish species collected from the studied sites.

Fishes collected from the upper lake exhibit the highest values of metals, while the lowest one were detected in fish farms as shown in table (6) and fig. (3). The order of abundance of metals in muscle tissue was as follow: Fe > Zn > Cu > Mn > Pb > Cd, while in gills tissues was Fe > Zn > Mn > Cu > Pb > Cd and in liver was Fe > Cu > Zn > Mn > Pb > Cd.

Regarding variation among different sites at Wadi El-Raiyan area, fish species from both the upper and lower lake accumulate higher level of metals compared with those reared in fish farms as shown in table (6) and fig. (3), this may be attributed to the relative dilution effect of the lipids content of tissues (Farkas et al. 2003). Also, fish in fish farms feed mainly on commercial pelleted diets, while those in natural water feed mainly on natural food (phytoplankton and zooplankton) which accumulates high values of metals. Saleh et al. (1988) concluded that the concentration of heavy metals in plankton were 4000 to 10000 times higher than those in water. So, the bioaccumulation of these metals in plankton affects its levels in fish.

Table 6. Total mean of heavy metals conc. (µg/g dry wt.) in different organs of fish species collected from different sites at Wadi Al-Rayan area.

Metal	Upper Lake			Lower Lake			Fish farms		
	M	G	L	M	G	L	M	G	L
Fe	64.87 ±15.4	576.70 ± 83.02	1297.1 ± 291.29	63.88 ± 6.63	672.53 ±115.99	852.77 ±363.9	62.12 ± 5.22	785.67 ± 83.44	294.28 ± 82.01
Zn	38.38 ± 5.13	102.99* ± 14.91	145.44 ± 33.31	45.47 ± 2.20	114.10* ± 8.71	158.78 ± 61.90	32.31 ± 2.12	66.79 ± 2.77	57.99 ± 10.35
Mn	0.62 ± 0.15	5.85 ± 0.39	8.04 ± 2.24	0.85 ± 0.09	5.88 ± 1.59	6.42 ± 1.47	0.72 ± 0.03	8.29 ± 0.45	2.86 ± 0.91
Cu	2.53 ± 0.42	4.04 ± 0.74	110.38 ± 31.79	5.55 ± 2.43	4.18 ± 0.29	277.02 ±302.13	2.39 ± 0.22	3.53 ± 0.19	148.07± 18.54
Cd	ND	0.058 ± 0.04	2.51 ± 1.76	0.003 ±0.002	0.436 ± 0.02	0.205 ± 0.14	ND	0.064 ± 0.00	0.147 ± 0.01
Pb	0.36 ± 0.11	3.54 ± 2.07	1.81* ± 1.05	0.16 ± 0.48	0.60 ± 0.65	1.62* ± 0.71	0.11 ± 0.01	0.33 ± 0.03	0.018 ± 0.00
Av.	17.81	115.53	260.88	19.32	132.95	216.13	16.28	144.06	83.89
T. av.	131.41			122.80			81.41		

*P < 0.05 between the same organs in the same raw.

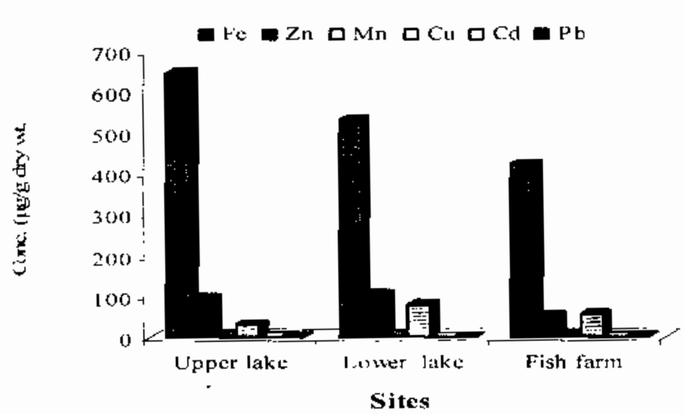

Fig. 3. Total average concentration of heavy metals in fish at different studied sites at Wadi Al-Rayan area

From the results, it is conspicuous that, Fe was the highest accumulated metal in fish tissues while Cd was the lowest one. The high accumulation of heavy metals in metabolic organs as gills and liver to the metallothioneins proteins which are synthesized in gills and liver tissues when fishes are exposed to heavy metals and detoxify them. Similar findings were reported by Ibrahim et al. (2000) and Saeed (2007).

Fish condition which an indication for the fatness of fish was assessed using two different metrics: CF (K) and HSI. CF is a measure of somatic energy reserves associated with recent feeding activity, while Hepato-somatic index (HSI) is associated with liver energetic reserves and metabolic activity. By comparing the condition factor of fish species in the three sites studied, it could be observed that the condition factor and hepato-somatic index were higher in fishes of fish farms and upper lake (I) than that in the lower lake (III) as shown in fig. (4). This could be explained by the higher productivity and good nutritive conditions in these sites. This also explains the well-being of these fishes in fish farms and upper lake (I) compared with lake (III). These results are in accordance with that of Soliman et al. (1998) in Lake Manzala and Koussa (2000) in Lake Mariut who attributed the increase in fish growth to the high productivity of water.

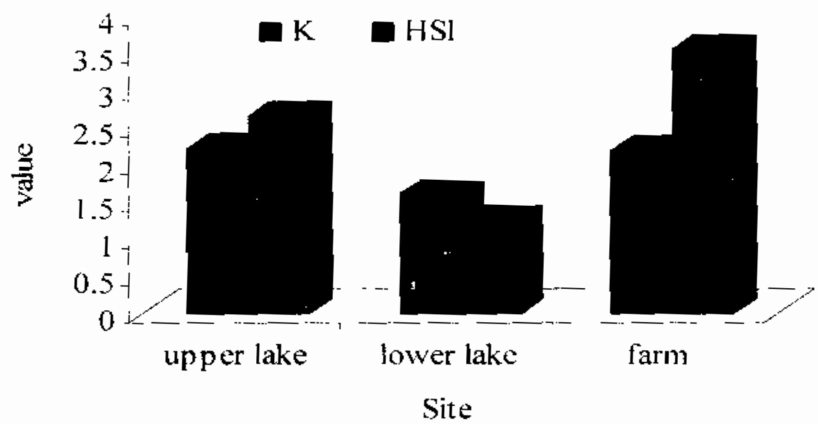

Fig 4. Comparison of hepato-somatic index (HSI) of tilapia species collected from the three sites at Wadi El-Raiyan area.

Statistical analysis of data revealed the occurrence of significant correlation among different parameters as shown in table (7). The relation between heavy metals in water and muscle tissues is insignificant. This may as a result of the amounts of metals accumulated or bioconcentrated in various tissues by fish is mostly independent of the concentrations in the ambient water where very high levels being accumulated in organisms from very low levels in water Mason (2002). He also mentioned that, metal concentrations in algae and bryophytes are significantly correlated with concentrations in water and there are no consistent correlations, however, between environmental levels of metals and concentrations in invertebrates and fish.

Table 7. Significant correlation between different parameters.

Item	r	P	Item	r	P
pH & CO_3	0.8991	0.000	TP & chl a	0.9981	0.000
pH & TN	0.8315	0.005	Sal. & HCO_3	-0.928	0.000
pH & TP	0.7992	0.010	TN & DO	-0.8412	0.005
pH & chl a	0.8258	0.006	K & chl a	0.6776	0.045
CO_3 & chl a	0.9072	0.000	HIS & chl a	0.7697	0.015
SD & chl a	-0.7480	0.020	K & TP	0.6901	0.040
DO & chl a	-0.8170	0.007	HIS & TN	0.7473	0.021
TN & chl a	0.9974	0.000			

r: correlation coefficient; P: probability level (r is significant at P = or < 0.05).

CONCLUSION

Primary productivity (phytoplankton) in water is limited in the habitat of the lakes. The availability of inorganic nutrients, particularly phosphate enhance the fish conditions (condition factor and hepato-somatic index) in fish farms and lake I which is directly proportional to higher productivity and good nutritive conditions in water. On the other hand, fish in lake III showed lower growth parameters. The present results indicate that although metal concentrations in the edible part of the examined fish were in the safety permissible levels for human consumption, the water burden of Cu (lake I and fish farms) and Pb (lake I and lake III) have increased and could affect the utilization of this important source for fish production.

RECOMMENDATION

Increased input of nutrients can cause increase in productivity of the lakes. So, if shore of Wadi El-Raiyan lakes (especially lower lake) fertilized with low quantities of inorganic nitrogen and phosphorus, the primary productivity will increase which in turn can provide increased productivity of herbivorous and detritivorous fish, leading to increased overall production.

Acknowledgments: the authors thank Mr. Hossam K. Abdel-Raoof, head of Shakshouk branch, Environmental Affairs Authority, Al-Fayoum governorate for his useful help during the field work.

REFERENCES

1. Abel, P. D. 1998. Water pollution biology, 2nd ed. Printed in Great Britain by T.J. international Ltd. London. 286 pp.
2. American Public Health Association (APHA) 1985. Standard methods for the examination of water and wastewater.16th ed. Washington, D.C. 1268 pp.
3. Association of Official Analytical Chemists (AOAC) 1990. Official methods of analysis, 15th ed. "Atomic absorption method for fish". Washington, D.C.
4. Arrignon, J. 1999. Management of freshwater fisheries. Published by Science Publishers, Inc., USA. 582 pp.

5. Bailey, N. T. 1981. Statistical methods in biology, 2nd ed. Biological Science Texts, 216 pp.
6. Boyd, C. E. and C. S. Tucker. 1992. Water quality and pond soil analysis for aquaculture. Alabama agricultural experimental station. Auburn. Uni. 183 pp.
7. FAO/WHO. 1999. Expert Committee on Food Additives. Summary and conclusion, 53rd meeting, Rome, 1-10 June.
8. Farkas, A., J. Salanki and A. Specziar. 2003. Age- and size- specific patterns of heavy metals in the organs of freshwater fish *Abramis brama* L. populating a low-contaminated site. Water research, 37: 959-964.
9. General Authority for Fishery Resources Development (GAFRD). 2006. Year-Book of fishery statistics in Egypt (1990-2006), Cairo.
10. Grasshoff, K., M. Ehrhardt and K. Kremling. 1983. Methods of seawater analysis. 2nd ed. Deerfield Beach. Florida Basel, Weinhein, Germany. 267 pp.
11. Ibrahim, A. M., M. H. Bahnasawy, S. E. Mansy and R. I. El-Fayomy. 2000. On some heavy metal levels in water, sediment and marine organisms from the Mediterranean coast of Lake Manzalah. Egypt. J. Aquat. Biol. & Fish. 4 (4): 61-81.
12. Koussa, A. A. 2000. Effect of industrial and organic pollution on potential productivity and fish stock of Lake Mariut, Northern Egypt with a predictive study of that effect on the Lake. Ph. D. Thesis. Fac. Sci. Ain Shams Univ.
13. Mason, C. F. 2002. Biology of freshwater pollution. 4rd ed. Essex Uni. England. 387 pp.
14. National Water Resources Plan for Egypt (NWRP) 2000. Fisheries and Water Resources. NWRP Technical Report No. 6. Ministry of water Resources and Irrigation, Egypt. Planning Sector.
15. Parker, R. C. 1972. Water analysis by atomic absorption spectroscopy. Varian techtron, Switzerland. In: E.I. Adeyeye (Editor), Determination of trace heavy metals in *Illisha Africana* fish and in associated water and sediment from some fish ponds. Int. J. Environ. Stud. 45: 231-238.
16. Saeed, S. M. 2007. Accumulation of heavy metals in different tissue/organs of the Nile catfish, *Clarias gariepinus*, at Lake Edku, as a biomarker of environmental pollution. Egypt. J. Aquat. Biol. & Fish. 11 (3): 417-434.
17. Saleh, M. A., M. H. Saleh, M. M. Fouda, M. S. Abdel-Latif and B. L. Wilson. 1988. Inorganic pollution of the man-made lakes of Wadi El-Raiyan and its impact on aquaculture and wildlife of the surrounding Egyptian desert. Arch. Environ. Contam. Toxicol., 17: 391-403.
18. Schreck, C. B. and P. B. Moyle. 1990. Methods for fish biology. Amer. Fisher. Soci., Bethesda, Maryland, USA. 684 pp.
19. Soliman, I. A., K. A. Shawky and A. E. El-Agamy. 1998. Some biological aspects of four cichlid species in Lake Manzala. Bull. Inst. Oceanogr. & Fish. 24: 313-323.
20. United States Environmental Protection agency (USEPA). 1999. National Recommended Water Quality Criteria Correction Office of Water, EPA 822-Z-99-001, 25 pp.

دراسات ليمنولوجية على البحيرات والمزارع السمكية

بمنطقة وادى الريان، الصحراء الغربية، مصر

سمير محمد سعيد موسى[1]، صفوت عبد الغنى عبد الحميد[2]

المعمل المركزى لبحوث الثروة السمكية بالعباسة، مركز البحوث الزراعية.

١- قسم الليمنولوجى ٢- قسم الإستزراع

أجريت هذه الدراسة على البحيرات(بحيرة ١ و بحيرة ٣) والمزارع السمكية بمنطقة وادى الريان وذلك لتقدير الخواص الفيزيقية والكيميائية والأملاح المغذية وكثافة العوالق الحية النباتية (والتى تعتبر الغذاء الرئيسى للأسماك) وتركيز بعض العناصر الثقيلة (الحديد-الزنك-المنجنيز- النحاس- الكادميوم-الرصاص) فى المياه وبعض الأنسجة (عضلات-خياشيم-كبد) للأسماك الأكثر شيوعا فى البحيرات (البلطى الأزرق والنيلى والأخضر والجاليلى) وفى المزارع السمكية (البلطى النيلى) وبعض العوامل البيولوجية الخاصة بنمو الأسماك (معامل الحالة والمعامل الكبدى). وأوضحت النتائج مايلى: تراوحت درجة تركيز الأيون الهيدروجينى (من ٨,٤٧ فى بحيرة ١ إلى ٨,٩٢ فى بحيرة٣)، شفافية المياه (من ٠,٣٢ سم فى المزارع إلى ٣,٧٥ متر فى بحيرة ٣)، ملوحة المياه (من ١,٨٣ جم/لتر فى المزارع إلى ٧,٧٧جم/لترفى بحيرة ٣)، الأكسجين الذائب (من ٥,٥٥ ملجرام/لتر فى المزارع إلى ٧,٦٤ ملجرام/لتر فى بحيرة ١) والكالسيوم (من ٢٠٠ ملجرام/لتر فى المزارع إلى ١٥٠٠ملجرام/لتر فى بحيرة ٣). كانت تركيزات الأملاح المغذية قليلة وتراوحت قيمة النتروجين الكلى بين ١,٦٨ ملجرام/لتر فى بحيرة ٣ و٩,٥٨ ملجرام/لتر فى المزارع والفوسفور الكلى تراوح بين صفر فى بحيرة ٣ إلى ٠,١٥ ملجرام/لتر فى المزارع وذلك بسبب فقد هذه الأملاح خلال المسافة الطويلة التى تقطعها مياه الصرف الزراعى فى الصحراء للوصول إلى بحيرات الريان. تعتبر البحيرات فقيرة فى محتواها من الكائنات الأولية الهائمات النباتية (الفيتوبلانكتون) حيث تباينت الكتلة الحية للعوالق النباتية ممثلة بكلوروفيل-أ من ٧,٧٤ ميكروجرام/لتر فى بحيرة ٣ إلى ٤٤,٠٣ ميكروجرام/لتر فى المزارع السمكية. تركيز العناصر فى الأسماك أعلى بكثير منه فى المياه وكان ترتيب تركيزات هذه العناصر فى المياه والأسماك كالآتى: الحديد> الزنك> النحاس> المنجنيز> الرصاص> الكادميوم. ولقد فاقت تركيزات الحديد (فى مياه المزارع السمكية) والنحاس (فى مياه بحيرة ١والمزارع) والرصاص (فى مياه بحيرة ١، بحيرة ٣)

الحد الأقصى المسموح به دوليا. كان تراكم العناصر الثقيلة فى أسماك البلطى الأزرق والبلطى النيلى أعلى من مثيلاتها فى البلطى الأخضر والبلطى الجاليلى. كما أن تراكم العناصر الثقيلة فى أسماك المزارع أقل من مثيلاتها فى أسماك بحيرة ١، بحيرة ٣. كما ظهر أن أنسجة الكبد والخياشيم لها قابلية كبيرة لإختزان العناصر بينما أظهرت العضلات ميلا أقل. وتركيزات العناصر فى عضلات الأسماك مازالت أقل من النسب المسموح بها عالميا. سجل معامل الحالة والمعامل الكبدى أعلى قيمة له فى المزارع السمكية وأقلها فى بحيرة ٣ وإرتبط هذا بنمو العوالق النباتية ممثلة بكلوروفيل-أ وأيضا تركيزات الأملاح المغذية. يمكن زيادة الإنتاج السمكى من بحيرات الريان بزيادة الكتلة الحية للعوالق النباتية ممثلة بكلوروفيل-أ (والتى تعتبر الغذاء الرئيسى للأسماك) عن طريق زيادة تركيزات الأملاح المغذية (النتروجين والفوسفور) وذلك بتسميد الشواطئ الضحلة للبحيرات وخاصة بحيرة ٣ بالمصادر المناسبة لهذين

العنصرين. ولحساب كميات النتروجين والفوسفور التى يجب إضافتها لهذه البحيرات يجب إستقطاع أجزاء

منها وإضافة نسب مختلفة من النتروجين (نسبة متغيرة) والفوسفور (نسبة ثابتة) مثال: (١:٥) أو (١:١٤) بالجرام (٢,٤ جم النتروجين/م^{٢} + ٠,٤٨ جم فوسفور/م^{٢}) أو (٦,٧٢ جم النتروجين/م^{٢} + ٠,٤٨ جم فوسفور/م^{٢}) للوصول لأفضل إنتاجية للمياه من الكائنات الأولية.