IMPACT OF CAGE-FISH CULTURE IN THE RIVER NILE ON PHYSICO-CHEMICAL CHARACTERISTICS OF WATER, METALS ACCUMULATION, HISTOLOGICAL AND SOME BIOCHEMICAL PARAMETERS IN FISH

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Abstract

The present study was conducted to assess the effect of cages aquaculture on the physico-chemical properties of water and chlorophyll "a" of the River Nile and the possible metals (Fe, Zn, Cu, Mn, Cd and Pb) bioaccumulation in different organs of Oreochromis niloticus reared in cages and fish living free in the Nile and their associated biochemical and histopathological alterations. Water and fish samples were collected from Nile water (near El-Serw village) and five cages (at sites namely; Kafr El-Arab; Al-Bostan; Al-Sawahel; Al-Adlya and El-Saad) at Damietta Branch during autumn season of the year 2006. Physical and chemical properties of water were higher in cages than that of the River Nile. In water, Cd & Pb values in the cages area increase that of the Nile; however their concentrations were lower than the permissible limits. The higher values of metals were accumulated in fish collected from the Nile than those reared in cages except Cd and Pb. No significant differences were detected in different biochemical parameters except ALAT as well as no considerable histopathological changes were detected in both compared fish. A positive correlation existed between heavy metals concentrations in fish organs and serum constituents between (Fe in muscles and Alb.; Fe in gills and liver and ALAT); (Zn in gills and Creatinine & ALAT); (Mn in muscles and urea and Mn in gills and ALAT); (Cd in muscles and Creatinine and Cd in liver and ALAT) and (Pb in muscles and glucose). All studied metals concentrations in muscle tissues have an average below the maximum tolerance levels and safe for human consumption. The increase in cages numbers, effluents from the electric power station and human activities at the area of cages may be the reason for changing of some physical and chemical

properties of water. Cages has no effect on metals accumulation, blood and histopathological changes in fish.

Key words: Physico-chemical, water, heavy metals, histological and biochemical, fish, cages, River Nile.

INTRODUCTION

Fisheries and aquaculture in Egypt is a significant source of animal protein. Fish are raised commercially in one of four culture settings: open ponds, raceways, tanks, or cages. Cage culture of fish utilizes existing water resources but encloses the fish in a cage or basket which allows water to pass freely between the fish and the pond. Factors such as increasing consumption of fish, some declining wild fish stocks, and a poor farm economy have produced a strong interest in fish production in cages. So, cage ongrowing has to become the primary basis for the rapid growth of the fish farming sector. Recent developments include expansion of cage culture in the Nile. The commercial culture of freshwater fish in cages was initiated by modest capital investment requirements, simple technology, the limited availability of land and water for pond fish culture.

Cage culture also offers the farmer a chance to utilize existing water resources which in most cases have only limited use for other purposes; many types of water resources can be used, including lakes, reservoirs, ponds, streams and rivers which could otherwise not be harvested. It is highlighted that cage farms in the world are nowadays pursuing an increase of production capacities by installing more cages, increasing the cage size as well as by increasing automation (Masser, 1997).

Cage-culture fish production in Egypt has increased from 12,885 tones in 1998 to 32,059 tones in 2003 then decreased to 19,839 tones in 2005 (GAFRD, 2006). Nile tilapia *Oreochromis niloticus*; silver carp, *Hypophthalmichthys molitrix* and mullet, *Mugil cephalus* or *Liza ramada* are the main species produced.

In Egypt a successful cage culture present in the River Nile at silver carp cages area in Rashid and tilapia cages area in Damietta region. However, environmental concerns and policies restricted the distribution of cage culture.

Because the potential for horizontal expansion of freshwater pond aquaculture appears to be poor, development efforts should be focused on cage culture in the River Nile, irrigation canals (about 4,700 km) and inland lakes; such as Wadi Al-Raiyan Lakes, the High Dam Lake and offshore and on-shore mariculture.

The aquatic environment with its water quality is considered the main factor controlling the state of health and disease in both cultured and wild fishes. Pollution of the aquatic environment by inorganic and organic chemicals has been recognized as one of the major factors posing serious threat to the survival of aquatic organisms including fish; Mason (1996). Heavy metals have drastic environmental impact on all organisms. Metal ions can be incorporated into food chains and concentrated in aquatic organisms to a level that affects their physiological state.

Cage researches are limited because large scale open pond culture is more economically viable and, therefore, received more attention. Today cage culture is receiving more consideration by both researchers and commercial producers. Essa *et al.* (2006) studied the environmental evaluations of fish cages in Rashid and Damietta Branch, whereas Ibrahim and El-Naggar (2006) estimated the accumulation of heavy metals in the whole fish reared in cages in the River Nile of Egypt at Damietta Branch.

The present study was conducted to assess the effect of cages aquaculture on the physico-chemical properties of water and chlorophyll "a" of the River Nile and the possible metals bioaccumulation in different organs (muscle, gills and liver) of *Oreochromis niloticus* reared in cages and those living free in the Nile and their associated biochemical and histopathological alterations. The study of fish muscle tissues is one of the means for investigating the amount of heavy metals reaching man by food chain, whereas gills and liver tissues could be analyzed to determine the potential effects of a contaminant on fish health.

MATERIALS AND METHODS

1- Sampling and sites

Water and fish samples were collected at Damietta Branch from the open water of the River Nile near El-Serw village site (I) and from five cages at sites namely; Kafr El-Arab (II) before the electric power station and Al-Bostan (III); Al-Sawahel (IV); Al-Adlya (V) and El-Saad (VI) after the electric power station (Fig. 1) during the autumn season of the year 2006.

a) Water samples were taken at different places at each site by a PVC tube column sampler at depth of half meter from the water surface. The samples at each site (c.f. 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.

b) Fish samples (*Oreochromis niloticus*) were collected from different sites by fishermen. The total lengths of the fish ranged between 16.0 cm and 28.0 cm for *Oreochromis niloticus* in cages and 10.0 cm and 18.5 cm in the open water of the Nile, while the mass of the fish was in the range of 83.0 to 386.0 g for cages and 23.3 to 93.5 g for the Nile fish. Blood samples were withdrawn from the caudal vein using potassium salt of EDTA as anticoagulant for determination of blood parameters. For heavy metals detection, fish samples kept frozen in ice box until transferred to the laboratory for sub-sampling of different tissue/organs. Tissue specimens (liver, kidney, spleen and gills) were taken from both compared fish fixed in 10% buffered formalin and processed by routine histopathological procedures.

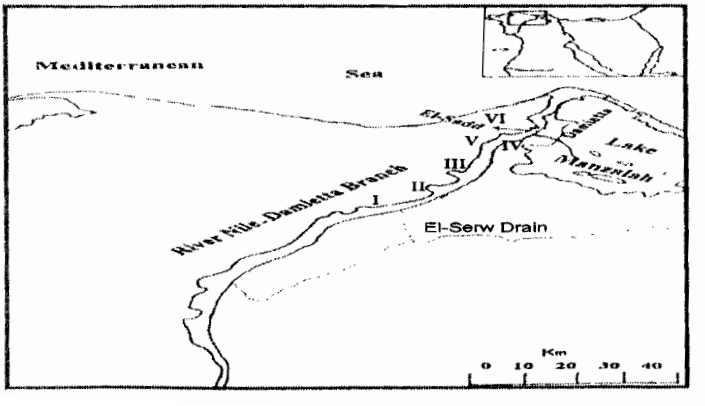

Fig. 1. Sampling sites at Damietta branch

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, µmoh) and total dissolved solids (TDS, mg/l) were determined using a salinity-conductivity meter (model, YSI EC300). Dissolved oxygen (mg/l) was measured by using a digital oxygen meter (Model YSI 55). Transparency (m) was measured by using a Secchi Disc of 20 cm diameter (Boyd and Tucker, 1992). Total hardness (mg/l), calcium hardness (mg/l), total alkalinity (mg/l), nitrogen compounds (NH_3-N, NO_2-N and NO_3-N) (mg/l) and, phosphate (mg/l) as well as chlorophyll "a" (µg/l) were determined according to American Public Health Association (APHA, 1985).

b- Heavy metals

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

c- Biochemical analysis

Blood samples were collected from the caudal veins and blood was allowed to set for 30 min. at 4 °C to clot, and then centrifuged for 5 min at 1000 rpm. The serum samples were stored at -20 °C until later used to analyze total protein, albumin, urea, creatinine, uric acid, glucose, ALAT (Alanine amino transferase) & ASAT (Aspartate amino transferase) according to the method described by Moss (1984). Blood samples were preserved in sodium fluoride for estimating blood glucose.

d- Histopathological investigation

Clinical and postmortem examinations performed by using the method described by (Robert, 1978). The tissue sections were stained with hematoxyline-eosin (H&G) and examined under the light microscope (Luna, 1967).

e- Statistical analysis

Data were statistically analyzed according to (Bailey, 1981). The level of significance for the analysis is 0.05. The relationships between concentrations of heavy metals in fish tissues and different serum constituents were also carried out.

RESULTS AND DISCUSSION

Physical and chemical characteristics of water

The physical and chemical properties of the aquatic environment forms the habitat for the host of organisms living in lakes, rivers, streams and estuaries and plays a significant role in the maintenance of a healthy environment and production of sufficient fish food organisms.

Physico-chemical characteristics are illustrated in table (1). The hydrogen ion concentration (pH value) lies in the alkaline side and show no remarkable difference at all sites with values ranged between 7.85 (site I) and 7.81 in cages area with no remarkable difference at all sites. Similar observations were recorded by Zyadah (1997) in the River Nile. Arrignon (1999) mentioned that, the safe range of environmental pH for the survival of fish is approximately 5-9.

Table 1. Physico-chemical characteristics of water collected from the River Nile (I) and cage-fish culture (II-VI) at Damietta branch.

Region	River Nile	Cages					
Item	(I)	(II)	(III)	(IV)	(V)	(VI)	Mean
pH	7.85±0.02	7.90	7.79	7.72	7.81	7.82	7.81±0.03
SD	2.45±0.02	2.40	2.25	2.30	2.35	2.30	2.32±0.03
EC	0.2249±0.001	0.4438	0.4650	0.4747	0.4722	0.4680	0.4647***±0.005
TDS	153.9±0.57	302.5	314.1	323.3	322.9	320.0	316.56***±3.88
T. alk.	157.5±0.17	153.0	153.0	145.5	153.0	169.0	154.7±3.86
T.H	137.5±1.18	133.0	143.0	135.5	133.0	139.0	136.7±1.92
Ca^{++}	56.0***±0.25	40.0	48.0	44.0	44.0	40.0	43.2±1.50
DO	5.52**±0.07	5.12	4.36	3.75	4.26	4.30	4.36±0.22
NH_3-N	ND	ND	ND	ND	ND	ND	ND
NO_2-N	0.059±0.001	0.063	0.085	0.102	0.088	0.092	0.086**±0.006
NO_3-N	0.17±0.01	0.20	0.45	0.51	0.50	0.35	0.40**±0.06
PO_4-P	0.002±0.00	0.004	0.009	0.008	0.005	0.007	0.007**±0.00
Chl. "a"	7.76±0.08	7.88	8.16	7.94	8.11	8.28	8.07*±0.07

*, **, *** Significantly difference at ($P < 0.05$) between each parameter at River Nile and cages.

No significant differences showed in the Secchi disc readings (transparency) of the River Nile water (mean 2.26 m at site I) and the cages area (mean 2.32 m) (Table, 1). (Masser (1997) mentioned that, transparency or light penetration is blocked by suspended soil, organic material (detritus), and the plankton (floating or suspended microscopic plants and animals) of water. From Secchi disc readings and chlorophyll "a", cages in this study do not show which always higher amounts of suspended clay, detritus or plankton.

Electric conductivity and total dissolved solids show highly significant difference between cages (mean EC = 0.4647 µmoh and TDS = 316.56 mg/l) and River Nile water (mean EC = 0.2249 µmoh and TDS = 153.9 mg/l at site I) as shown in table (1). This may be related to the fish wastes and uneaten food. No differences are observed in the values of total alkalinity and total hardness while calcium ions showed significant difference between water of cages and that of the Nile as shown in table (1).

In this study the concentration of dissolved oxygen in the river water (5.52 mg/l at site I) increases that of cages (mean 4.36 mg/l) as shown in table (1). No oxygen depletions were illustrated in cages; this could be explained as no large amounts of organic matter present into the cages which could be formed due to rapid bacterial decomposition of the detritus. This could be explained as the adequate depth and currents of the Nile water is important for keeping the fish wastes away from the cage, maintaining adequate circulation through the cage. In general, warmwater species such as catfish and tilapia need a dissolved oxygen concentration of 4 mg/l DO or greater to maintain good health and feed conversion (Masser, 1997).

The amount of nitrite-nitrogen content was low in cages (mean 0.086 mg/l) and 0.059 mg/l at site I (Table, 1). On the other hand, nitrate-nitrogen concentration was by far the most dominant constituent of the total inorganic nitrogen compounds. The values ranged from 0.20-0.51 mg/l (mean 0.40 mg/l) in cages to 0.17 mg/l in River (site I) (Table, 1). This reflects good conditions for aeration which maintain dissolved oxygen concentrations and support higher decomposition rates for low organic matter result from fish wastes and uneaten feed. Arrignon (1999) mentioned that in well oxygenated water, NH_3-N and NO_2-N values decrease that of NO_3-N.

Dissolved phosphate showed very small values and fluctuated between 0.004 and 0.009 mg/l (mean 0.007 mg/l) in cages and its values at River was 0.002 mg/l (Table, 1). This indicated that there is no effect for organic load and fertilizers.

The concentration of chlorophyll "a" which is an indication for the primary productivity (phytoplankton) of the aquatic environment showed slightly increase in cages (mean 8.07µg/l) compared with that of the River Nile (7.76 µg/l) (Table, 1). The density of the plankton become so small and this leads to no critical dissolved oxygen concentration was reached in the cage due to nighttime respiration demands or the plankton die-offs. The difference between cages and River Nile is significant for EC, TDS, Ca^{++}, DO, NO_2-N, NO_3-N, PO_4-P and chlorophyll "a" (Table, 1).

Heavy metals accumulation in water and fish

In water, concentration of metals followed the order of: Fe > Mn > Zn > Cu > Pb > Cd. Water samples before cages (site I) accumulated high levels of Fe, Cu and Mn (average of 223.92, 5.58 and 37.39 µg/l, respectively) than the cages area (mean 150.86, 4.35 and 31.22 µg/l) but still under the legal limits (US EPA, 1999) as shown in table (2). This may be related to the direct effect of disposal of untreated sewage wastes from El-Serw drain which collects its contents from vast areas with various human activities. However, Zn, Cd and Pb highly accumulated in water of the cages area than site (I) as shown in table (2). Zinc, Cd and Pb reached (average of 7.01, 1.00 and 0.86 µg/l) at site (I) before cages and (average of 11.96, 1.71 and 2.05µg/l) in the cages region, respectively. This could be attributed to the heavy load of wastes and effluents draining into cages area, particularly from developing industries and agriculture beside the domestic wastes. Also, effluents from the electric power station which lies close to the cages area may be the caused of the increased values of these metals. Zyadah (1997), Hamed (1998), Abdel-Baky (2001) and Ibrahim and El-Naggar (2006) recorded higher values of these metals than those in the present study in the Nile water before the cages area and after the electric power station. This means that cages not the reason for increasing levels of Cd and Pb in water.

Table 2. Average concentrations of heavy metals (µg/l) in water samples collected from the River Nile (I) and cage-fish culture (II-VI) at Damietta branch.

Region	River Nile	Cages area						*PL
Metal	(I)	(II)	(III)	(IV)	(V)	(VI)	ave.	
Fe	223.92	124.41	203.5	99.84	267.52	59.04	150.86	300.0
Zn	7.01	13.83	20.84	8.32	11.40	5.43	11.96	120.0
Cu	5.58	6.38	4.71	3.16	4.92	2.56	4.35	13.0
Mn	37.39	26.00	39.76	29.12	35.34	25.89	31.22	170.0
Cd	1.00	1.02	2.01	1.92	2.11	1.51	1.71	4.30
Pb	0.86	2.01	3.94	0.63	2.08	1.57	2.05	2.50
ave.	45.96	29.02	45.79	23.83	53.90	15.92	33.69	

*PL: permissible limits (µg/l) according to US EPA, 1999.

In fish, bioaccumulation of Fe, Zn, Cu, Mn, Cd and Pb varied considerably in muscle, gills and liver tissue of *Oreochromis niloticus* in cages and the River Nile fish before cages (site I) (Table, 3 & 4). The order ranged between the highest levels in liver and gills, followed by lower levels in the muscle tissue. Similar observations were recorded by Zyadah (1997); Shaker & Saeed (2007). The sequence of metals in cages was as follows: Fe > Cu > Zn > Mn > Pb > Cd, while in fish of the Nile, Cd concentration exceeded that of Pb (Table 4). Liver is the site of high bioaccumulation especially for Fe, Zn and Cu, while muscle tissues had the lowest concentration. The high Fe concentrations in the liver tissue may be due to iron-containing enzymes and the extensive vascular system of the liver, as the hemoglobin in the blood binds approximately three quarters of the Fe in the body (Voynar, 1960). The reason for the high accumulation of Zn and Cu in the liver could be related to the specific metabolism process and enzyme catalyzed reaction involving Zn and Cu taking place in the liver (Abdel-Baky, 2001). The high metal concentrations in liver reflect its multifunctional role in detoxification and storage.

The highest concentrations of Mn were clearly found in the gills tissue of fish in both cages and the Nile. This may be attributed to the complex formation between both metal ions and the protein structure in gills which contain nitrogen, oxygen and sulfur as previously reported by Cotton and Wilkinson (1980). Katz *et al.* (1972) mentioned that gills tissue is the main route of uptake of Mn, which shows little absorption through the gut from food.

Table 3. Average concentration of heavy metals (µg/g dry wt.) in tissue/organs of *Oreochromis niloticus* reared in cages area and the River Nile.

Metal	Fe	Zn	Cu	Mn	Cd	Pb	ave.
River Nile (I)							
Muscle	77.04	30.61	2.44	3.04	0.024	0.097	18.88
Gills	597.31	131.11	10.67	80.78	0.0٢٠	0.163	136.67
Liver	725.23	236.34	662.66	49.22	0.297	0.060	278.97
Kafr El-Arab (II)							
Muscle	51.11	26.01	2.52	1.65	0.037	0.305	13.61
Gills	181.18	52.36	3.97	20.20	0.711	0.425	43.141
Liver	341.05	38.28	151.15	8.56	0.205	0.213	89.91
Al-Bostan (III)							
Muscle	36.33	36.13	2.43	1.69	0.040	0.503	12.85
Gills	151.79	25.54	4.76	1.92	0.053	0.026	30.68
Liver	227.62	66.75	331.28	7.91	0.038	0.506	105.68
Al-Sawahel (IV)							
Muscle	95.32	42.76	5.92	1.93	0.047	0.237	24.37
Gills	185.74	35.77	6.54	29.81	0.104	0.470	43.07
Liver	220.96	41.2	491.73	24.48	0.152	0.346	129.81
Al-Adlyia (V)							
Muscle	95.32	34.90	8.40	3.99	0.053	0.020	23.79
Gills	174.24	56.70	6.46	1.94	0.391	0.091	39.97
Liver	428.83	124.61	338.61	13.07	0.052	1.715	151.15
El-Saad (VI)							
Muscle	72.40	40.39	6.15	2.34	0.054	0.084	20.24
Gills	187.02	55.91	7.14	37.59	0.046	0.333	48.01
Liver	891.92	63.94	251.67	28.31	0.071	2.186	206.35

The bioaccumulation pattern of Cd in the order of liver > gills > muscle in cages and liver > muscle > gills in the Nile. The sequence of Pb was liver > gills > muscle in cages and (gills > muscle > liver) in the Nile (Table 4). Higher values of Fe, Zn, Cu and Mn were accumulated in the Nile fish (site I) than those fish reared in cages (Table, 4 and Fig., 2).

Table 4. Comparison between heavy metals concentrations (µg/g dry wt.) in tissue/organs of *Oreochromis niloticus* reared in cages and free living in the River Nile at Damietta Branch.

Reg.	Cages				River Nile				#PL
Metal	Muscle	Gills	Liver	ave.	Muscle	Gills	Liver	ave.	(mg/d)
Fe	70.10 ± 11.79	175.99 ± 6.45	422.08 ±123.62	222.72	77.04 ± 9.31	597.31* ± 160.9	725.23* ± 61.73	466.53	43.0
Zn	36.04 ± 2.88	45.26 ± 6.22	66.96 ± 15.52	49.42	30.61 ± 2.82	131.11** ± 31.94	236.34 ± 36.32	132.69	60.0
Cu	5.08 ± 1.15	5.77 ± 0.60	312.89 ± 56.08	107.91	2.44 ± 0.65	10.67 ± 3.45	662.66* ±139.24	225.26	3.0
Mn	2.54 ± 0.44	18.29 ± 7.23	16.47 ± 4.19	12.43	3.04 ± 0.10	80.78** ± 20.06	49.22 ± 7.05	44.35	2-9
Cd	0.046* ±0.007	0.261* ±0.13	0.104 ± 0.026	0.14	0.024 ±0.005	0.020 ± 0.001	0.297** ± 0.052	0.11	0.1##
Pb	0.230 ±0.085	0.269 ±0.08	0.676 ± 0.401	0.39	0.097 ± 0.02	0.163 ± 0.003	0.0.060 ± 0.011	0.13	0.214
Ave.	19.01	40.97	136.53	65.50	18.88	136.68	334.75	163.43	

#PL: Permissible limits (wet wt.) according to FAO/WHO (1999). ##µg/g. *, **, *** Significantly difference at ($P < 0.05$) between each organ in fish of River Nile and cages.

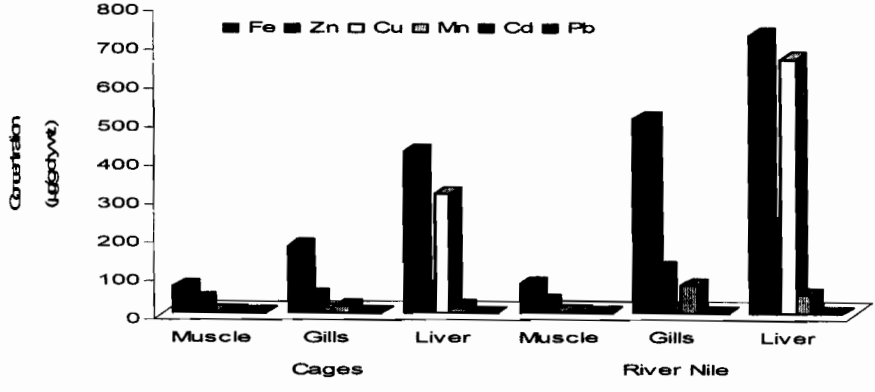

Fig. 2. Variations of metals conc. (µg/g dry wt.) in tissue/organs of *Oreochromis niloticus* reared in cages and free living in the River Nile at Damietta Branch.

This could be attributed to the relative dilution effect of the lipids content of tissues as mentioned by Farkas *et al.* (2003) and Saeed (2007). Also, fish in cages (feed on commercial pellet diets) had higher values of lipid than those in natural water which feed on natural food (phytoplankton and zooplankton) and accumulates high values of metals. However, the concentrations of Cd in organs of fishes inhabiting cages slightly increase that of the Nile fish except liver (Table, 4). Pb concentration in fish organs of cages exceeded those of the Nile. This may be due to the fact that the cage area has high concentration levels of Cd & Pb which may be attributed to the waste water of the electric power station that lies close to the cage area. However, all metals concentrations on average below the maximum tolerance levels for human consumption established by the FAO/WHO (1999). Ibrahim and El-Naggar (2006) mentioned that fish cultured in cages accumulated lower concentrations of metals than fish collected from the Nile at Kafr El-Zayat city.

Table 5. Mean metals concentrations in water (µg/l) and tissue/organs of Tilapia species (µg/g dry wt.) compared with other references in the River Nile.

Fe	Zn	Cu	Mn	Cd	Pb	Ref.
Water						
-	100.0	470.0	-	20.0	40.0	(1)
75.9	24.04	7.69	25.13	3.02	5.67	(2)
-	230.0	9.0	23.0		10.0	(3)
246.0	84.0	55.0	-	25.0	314.0	(4)
150.86	11.96	4.35	31.22	1.71	2.05	(5)
Muscle						
-	13.0	6.59	2.14	0.017	0.08	(1)
19.21	14.80	1.56	3.76	0.159	0.52	(2)*
77.03	30.61	2.44	2.14	0.024	0.097	(5)
Gills						
-	8.89	4.50	-	0.19	0.28	(1)
48.40	29.48	5.44	6.31	0.327	0.64	(2)*
508.17	118.31	7.93	73.00	0.004	0.098	(5)
Liver						
-	27.4	27.0	-	0.14	0.31	(1)
56.42	40.12	24.98	12.5	0.379	0.96	(2)*
725.23	236.34	662.66	49.23	0.297	0.060	(5)

* Wet wt., (1): Zyadah (1997), (2): Hamed (1998), (3): Abdel-Baky (2001),

(4): Ibrahim & El-Naggar (2006) and (5): Present study.

Values of metals in muscle tissue were low compared to those recorded in *O. niloticus* in the Nile by Zyadah (1997) and Hamed (1998) at Damietta branch (Table, 5). It is clear from this study that, site II, which had low numbers of cages and situated (about 5 km) before the power station, showed lower values of most parameters as shown in tables (1, 2 and 3). So, crowdness and random distribution of cages, human activities (including random projects constructed on the Nile flanks, developing industries and agriculture beside the domestic wastes) and water disposal from the electric power station play an important role in increasing values of some parameters and metals in water and fish inhabiting cages.

Biochemical analysis

Analyses of serum or plasma constituents have proved to be useful in detection and diagnosis of metabolic disturbance and disease (Aldrin *et al.*, 1982). The present study as shown in table (6) revealed no significant differences between cage-culture fish and free-living fish in the Nile in most estimated parameters except in total protein value where there was low significant value between the two comparative group of fish where the total protein is higher in cage-culture fish than free-living one and this may be attributed to adequate supplement ration which contain high protein level and also the low effort enhanced by the cage-culture fish to get their food. No strong competition between cage-culture fish to get its needing from the food and due to low energy exhausted by cage-culture fish in metabolic function inside their body. As shown in table (6), there is a highly significant difference between cage-culture fish and free-living fish in River Nile in ALAT where it is higher in free living fish than cage-culture fish and this may be returned to high accumulation of heavy metals in liver where the heavy metals detoxification takes place first by ALAT but at high heavy metals concentrations ASAT is involved in this process (Heath, 1995). He also added that chronic exposure to heavy metals caused increase in ALAT and ASAT. Copper accumulation in the liver is strong inhibitor of ASAT (Christensen, 1971). Enzymes from different tissues may be affected very differently by Cd. Hilmy *et al.*

(1985) stated that, ALAT was induced by Cd in the non-hepatic tissues (heart and kidney) of mullet but inhibited in the liver tissue. Perhaps the best plasma enzyme for assessing liver damage in fish is sorbitol dehydrogenase (SDH) (Dixon et. al., 1987).

Table 6. Concentration of serum constituents of *Oreochromis Niloticus* reared in cages area and free Living in the River Nile.

Item	Gluco.	Album.	T. p.	Uric A.	Creat.	Urea	ASAT	ALAT
Reg.	(mg/dl)	(g/dl)	(g/ dl)	(mg/ dl)	(mg/ dl)	(mg/ dl	(U/l)	(U/l)
Cages	81.0 ±3.03	36.04 ±2.88	3.25* ±0.10	3.94 ±1.23	0.6875 ±0.16	8.09 ±1.18	32.5 ±4.29	7.28 ±1.55
River Nile	75.25 ±3.25	1.35 ±0.08	2.82 ±0.14	1.25 ±0.25	0.8675 ±0.02	9.49 ±0.23	42.5 ±1.19	40.25*** ±2.43
F_{value}	1.68	1.47	6.25	4.29	1.32	1.36	5.04	130.94
P_{value}	0.2431	0.2712	0.0465	0.0838	0.2943	0.2872	0.0659	0.00

*, ***Significantly difference at ($P < 0.05$) between each parameter at River Nile and cages.

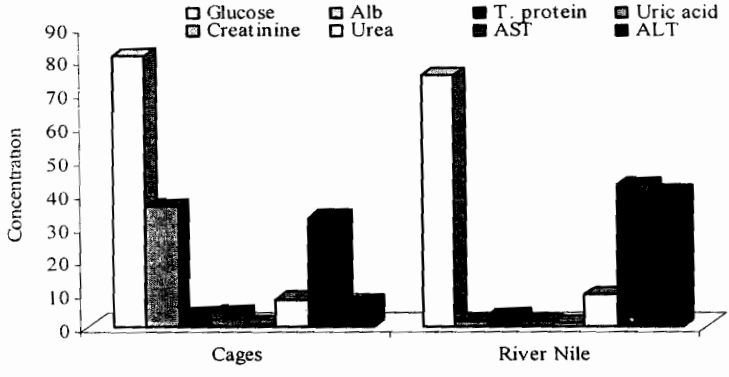

Fig. 3. Concentration of serum constituents of *Oreochromis niloticus* reared in cages and the natural water of the River Nile at Damietta Branch.

Relationships between concentration of heavy metals in fish organs and serum constituents are illustrated in table (7). It is evident that positive correlation existed between (Fe in muscles and Alb.; Fe in gills and liver and ALAT); (Zn in gills and Creatinine & ALAT); (Mn in muscles and urea and Mn in gills and ALAT); (Cd in muscles and Creatinine and Cd in liver and ALAT) and (Pb in muscles and glucose).

Table 7. Statistical correlation between concentrations of heavy metals in fish organs and serum constituents.

Metal	Org.	Serum constituents							
		Gluc.	Creat.	U.A.	Urea	AST	ALT	Alb	TP
	Musc.	-0.4831	-0.0891	-0.6561	0.0206	-0.8144*	0.0339	0.8592*	-0.0748
Fe	Gills	-0.5738	-0.8974*	-0.3868	0.3306	0.4578	0.9216**	-0.0207	-0.8381*
	Liver	-0.2321	-0.8450*	-0.6163	0.5517	0.2079	0.8311*	0.4134	-0.8989*
	Musc.	-0.4005	0.0966	0.0419	-0.3906	0.0540	-0.0123	-0.4967	0.3506
Zn	Gills	0.4401	0.9623**	-0.6381	0.4604	0.3571	0.9873***	0.1714	-0.9052*
	Liver	0.2564	-0.5648	-0.509	0.3111	0.1642	0.5241	0.2589	-0.4981
	Musc.	0.4708	0.6141	-0.2380	0.1232	-0.9124*	-0.5341	0.6402	0.3610
Cu	Gills	-0.4142	-0.4572	-0.4943	0.0824	0.3032	0.5987	-0.3662	-0.2120
	Liver	-0.1221	-0.7973	-0.5438	-0.0061	0.4289	0.8062	-0.2433	-0.4342
	Musc.	-0.6492	-0.3349	-0.8602*	0.8189*	-0.2788	0.5164	0.5671	0.5970
Mn	Gills	-0.2901	-0.9563**	-0.5112	0.0473	0.4394	0.9221**	-0.1013	-0.6518
	Liver	0.1352	-0.7058	-0.5231	-0.0010	0.2231	0.6301	0.0722	-0.4133
	Musc.	0.3541	0.8776*	0.1772	-0.1943	-0.7532	-0.8906*	0.2797	0.7301
Cd	Gills	-0.1961	0.6712	-0.2803	0.3532	-0.7961	-0.5402	0.5979	0.3302
	Liver	-0.2164	-0.9301**	-0.5511	0.0401	0.3968	0.8911*	-0.0691	0.6132
	Musc.	0.9521**	0.3572	0.7539	-0.5221	0.4223	-0.4719	-0.6338	0.5281
Pb	Gills	-0.1292	0.4762	0.1534	-0.7817	-0.6278	-0.5849	0.0911	0.7402
	Liver	-0.1253	0.7273	-0.1278	0.4102	-0.6788	-0.5837	0.5011	0.3192

*, **, ***; correlation coefficient (r) is significant at 0.05 probability level.

Iron in muscles was negatively correlated with ASAT and also Fe in gills and liver with Creatinine & TP. Zinc in gills revealed significant negative correlation with TP. Another negative correlation existed between Cu in muscles and ASAT. Manganese in muscles showed negative correlation with uric acid and with Creatinine in gills. Cadmium in muscles and liver showed significant negative correlation with ALAT and Creatinine, respectively.

Clinical symptoms and postmortem lesions

No abnormal behavior was recorded. The postmortem lesions revealed yellow or pale brown color of liver of cage-culture fish which appeared proportionally enlarged in size with slightly rounded edges which may be due to the high content of fat and glycogen. On the other hand, the free-living fish showed light brown liver, beside slight or absence of fatty materials between the

mesentry while it increased in cagé-culture fish. These findings may be returned to the differences in feeding materials constituents and abundance of ration bulk.

The histopathological investigation showed no dramatic alterations in cage-culture fish or free-living fish in the Nile except the gills in free-living fish showing slight hyperplasia of primary lamella and increase number of eosinophilic granular cells (EGC) (Fig. 4). Such mild reaction may be attributed to the continuous irritation caused by large number of phytoplankton, zooplankton. Also some pollutants may be encountered or due to increased accumulation of heavy metals as shown in table (4).

The hepatocytes of cage-culture fish appeared pale eosinophilic dye or lost their cytoplasmic staining (Fig. 5). Such changes may be returned to accumulation of fat and glycogen in liver due to over feeding. This result coincide with that of Robert (1989) who stated that the main feature in the extreme infiltration of hepatocytes by lipid which cause loss of cytoplasmic staining and distortion of hepatomuralia. The spleen of cage-culture fish showed alternative areas of activation and depletion of hemopoietic elements with high level of pale staining pigments of melanomacrophage center (Fig. 6). These lesions may be attributed to lipoid liver disease which caused by rancid fat containing ration (Robert, 1989) who said that rancid lipids are toxic per se; induce high level of free radicals, peroxides, aldehydes and ketones which react with protein to lower its biological value and have addeterious effect on those vitamins which are not themselves atioxidents. In spleen of some cases of free-living fish showed multiple melanomacrophage centers which increase in number, size and intensity of color than cage-culture fish (Fig. 7). This may be back to increase of catabolism due to poorness of natural feeding.

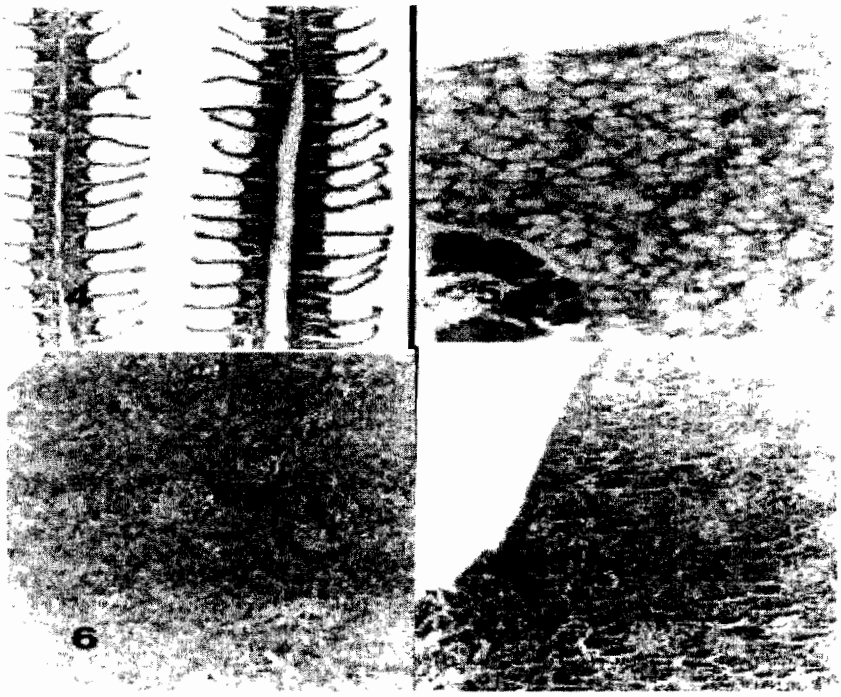

Fig. (4): Free-living tilapia in River Nile gills, showing slight hyperplasia of primary lamella and increase number of eosinophilic granular cells. H & E stain, X 300.

Fig. (5): Cage-culture fish liver, showing loss of cytoplasmic staining. H & E stain,X 600.

Fig.(6):Cage-culture fish spleen, showing alternative areas of activation and depletion of haemopoietic elements with high level of pale staining pigments of melanomacrophage center. H & E stain, X 150.

Fig.(7):Free-living tilapia in River Nile spleen, showing multiple melanomacrophage centers which increase in number, size and intensity of color than cage-culture fish. H & E stain, X 300.

CONCLUSION

The present study indicates that EC, TDS, Ca^{++}, DO, NO_2-N, NO_3-N, PO_4-P and chlorophyll "a" showed significant difference between water of the River Nile and that of cages. In water, metals concentrations were lower than the permissible limits and Cd & Pb values in the cage area increase that of the Nile. Higher values of metals were accumulated in fish of the Nile than those reared in cages except Cd and Pb. All studied metals concentrations have an average below the maximum tolerance levels for human consumption. Both physiological functions and histological investigation revealed little alterations or variations in both compared fish. Increase in cages numbers, effluents from the electric power station and human activities in the cages area may be the reason for changing of some physical and chemical properties of water. Cages has no effect on metals accumulation, blood and histopathological changes in fish.

RECOMMENDATIONS

Economically cage-fish culture has to expand in Egypt through the natural resources to increase fish production in Egypt in parallel with water quality management; water pollution control and environmental protection. Feeding rates and quality adjustments are important to avoid water quality deterioration which may be resulted from overfeeding and wastes. The cages should have a bottom to collect sinking pellets and waste products. Cages should be placed where water currents are greatest, usually to the windward side. At least 50 to 100 meter should separate each cage to optimize water quality. Adequate depth of the cage (mean 10 m) is important for keeping the fish wastes away from the cage, maintaining adequate circulation through the cage. The high cage density has to decrease to avoid potential navigation and pollution problems. It may be necessary to stock grass and silver carp in a mixed culture with Nile tilapia to clean water inside the cages. There is a need for close coordination of different government agencies involved in management of water resources to maintain a balance between cage aquaculture development and the environmental considerations.

REFERENCES

1. Abdel-Baky, T. E. 2001. Heavy metals concentrations in the catfish *Clarias gariepinus* from River Nile, El-salam canal and Lake Manzala and their impacts on cortisol and thyroid hormones. Egypt. J. Aquat. Biol. & Fish. 5 (1): 79-98.
2. Alabaster, J. S. and R. Lloyed. 1982. Water Quality Criteria of Freshwater Fish. 2nd Ed. Butterworth Scientific, London.
3. Aldrin, J. F., G. L. MCssger and L. F. Bandin. 1982. La biochemic clinique en aquaculture. Interest et perspectives. Cnexo. Actes. Celloq. 14: 291-326.
4. A. P. H. A. 1985. American Public Health Association. Standard Methods for the examination of water and wastewater. 16th ed. Washington, D.C. USA.
5. A. O. A. C. 1990. Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. "Atomic Absorption Method for Fish". Washington, D.C.
6. Arrignon, J. 1999. Management of Freshwater Fisheries. Published by Science Publishers, Inc., USA.
7. Bailey, N. T. 1981. Statistical Methods in Biology. 2nd ed. (Biological Science Texts).
8. Boyd, C. E. and C. S. Tucker 1992. Water Quality and Pond Soil Analysis for aquaculture. Alabama Agricultural Experimental Station. Auburn Univ.
9. Christensen, G. M. 1971. Effects of metal cations and other chemicals upon the in vitro activity of two enzymes in the blood plasma of the white sucker, *Castostomus commerson* (lacepede), Chem. Biol. Interact., 4, 351.
10. Cotton, F. and J. Wilkinson 1980. Advanced Inorganic Chemistry. 4TH ed., Wily Inter. Science. 724 pp.
11. Dixon, D. G., P. V. Hodson, and k. L. Kaiser 1987. Serum sorbitol dehydrogenase activity as an indicator of chemically induced liver damage in rainbow trout. Environ. Toxicol. Chem. 6 (685).
12. Essa, M. A., A. M. Nour, H. A. Mabrouk, Z. M. El-Sherif, M. A. Zaki, S. M. Aboul-Ezz and E. A. Omar (2006). Technical and environmental evaluation of

fish cage culture in the River Nile of Egypt. International Conference On Aquatic Resources: Needs and Benefits. September 18-21, Alexandria, Egypt.

13. (FAO/WHO), Expert Committee on Food Additives. 1999. Summary and conclusion, 53rd meeting, Rome, 1-10 June.
14. 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.
15. GAFRD; General Authority for Fishery Resources Development (2006). Year-Book of Fishery Statistics in Egypt, Cairo, Egypt.
16. Hamed, M. A. 1998. Distribution of heavy metals in the River Nile ecosystem, Damietta Branch between Mansoura city and Damietta Province. J. Egypt. Ger. Soc. Zool. 27 (A): 399-415.
17. Heath, A. G. 1995. Text Book of Water Pollution and Fish Physiology. 2nd ed. Lewis publishers, New York.
18. Hilmy, A. M., M. B. Shabana, and A. Y. Daabees. 1985. Effects of cadmium toxicity upon the in vivo and in vitro activity of proteins and five enzymes in blood serum and tissue homogenates of *Mugil cephalus*. Comp. Biochem. Physiol., 81 c. 145.
19. Ibrahim, N. A. and G. O. El-Naggar. 2006. Assessment of heavy metals levels in water, sediment and fish at cage fish culture at Damietta Branch of the river Nile. J. Egypt. Acad. Environ. Develop. 7 (1): 93-1114.
20. Katz, M., R. S. Legorge, D. Weitkamp, J. M. Cummins, D. Anderson and D. R. May. 1972. Effects on freshwater fish. *J. WPCF.* 44 (6): 1226-1250.
21. Luna, G. L. 1968. Manual of Histological Staining Methods of Armed Forces Institute of pathology. 3rd ed. McGraw-Hill Co. New York.
22. Mason, C. F. 1996. Biology of Freshwater Pollution. 3rd ed. Essex Uni. England.
23. Moss, D. W. 1984. Methods of Enzymatic Analysis. Ed. H.U. Bergmeyer, Verlag-Chemie, 3rd edition, V4: 92-106.

24. Masser, M. P. 1997. Cage Culture (Site Selection and Water Quality). Southern Regional Aquaculture Center (SRAC Publication No. 161), the United States Dept. of Agriculture.

25. 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.

26. Roberts, R. G. (1978). Fish Pathology. Ist ed. Bailliek Trndail, London.

27. Roberts, R. G. (1989). Fish Pathology. 2nd ed. Bailliek Trndail, London.

28. 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.

29. Shaker, I. M. & Saeed, S. M. (2007). Estimation of metal pollution status of Lake Edku through tissues analysis of three cichlid fishes. Egypt. J. Aquat. Biol. & Fish. 11 (3): 393-406.

30. (USEPA) 1999. United States Environmental Protection agency National Recommended Water Quality Criteria Correction Office of Water, EPA 822-Z-99-001, 25 pp.

31. Voynar, A. I. 1960. *Biologicheskaya Rol'mikroelementov v Organizme Zhivotnykh I Cheloveka* (*Biological Function of Trace elements inAnimals and Man*). Vyssh, shk. Press, Moscow.

32. Zyadah, M. A. 1997. A study on levels of some heavy metals in River Nile estuary, Damietta branch, Egypt. J. Egypt. Ger. Soc. Zool. 23 (A): 149-160.

تأثير الأقفاص السمكية بنهر النيل على الخواص الطبيعية والكيميائية للمياه، و تراكم العناصر الثقيلة والفحص الهستولوجى وبعض القياسات البيوكيميائية فى أسماك البلطى النيلى

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تم دراسة المواصفات الفيزيقية والكيميائية للمياه ومتبقيات بعض العناصر الثقيلة (الحديد، الزنك،النحاس، المنجنيز، الكادميوم والرصاص) وبعض القياسات البيوكيميائية والهستولوجية لأسماك البلطى فى منطقة الأقفاص السمكية بدمياط ونهر النيل فى المنطقة البعيدة عن الأقفاص بغرض معرفة مدى تأثيرها على صلاحية البيئة المائية وكذلك الصحة العامة للأسماك وقد أظهرت هذه الدراسة أن:-

- تركيزات الأملاح الكلية الذائبة، النتريت، النترات، الفوسفور، الكلوروفيل مستويات أعلى فى مياه الأقفاص بينما أظهرت مياه نهر النيل تركيزات أعلى من الأكسجين الذائب والكالسيوم. وكان تركيز العناصر الثقيلة فى المياه أقل من النسب المسموح بها عالميا. وأظهر الحديد والمنجنيز و النحاس مستوى أعلى فى مياه نهر النيل بينما سجل الزنك و الكادميوم والرصاص تركيز أعلى فى مياه الأقفاص.

-كما أظهرت الدراسة أن تراكم العناصر الثقيلة (الحديد- الزنك- النحاس- المنجنيز) فى أسماك نهر النيل أعلى من مثيلاتها فى الأقفاص بينما أظهرت تركيزات الكادميوم والرصاص مستويات أعلى فى الأقفاص عن مثيلاتها فى نهر النيل. كما أوضحت الدراسة أن أنسجة الكبد والخياشيم لها قابلية كبيرة لإختزان العناصر عن العضلات التى لاتمثل أى خطورة على المستهلك حيث أن تركيز العناصر بها مازال أقل من النسب المسموح بها عالميا. وأوضحت الدراسة أن كثافة الأقفاص السمكية وإنتشارها بطريقة عشوائية ووجودها بجوار المنطقة السكنية ومحطة توليد الكهرباء له الأثر فى زيادة عنصرى الكادميوم و الرصاص. كما أوضحت الدراسة أن الحالة الصحية للأسماك جيدة وذلك لعدم وجود أى فروق معنوية فى

القياسات البيوكيميائية والهستولوجية فى الأسماك المرباة فى الأقفاص وأسماك نهر النيل التى إستخدمت كضابط لهذه القياسات.

-وتوصى الدراسة بزيادة المساحة المتاحة للإستزراع السمكى بالأقفاص وذلك نظرا للعائد الإقتصادى الكبير ولكن بإختيار الأماكن المناسبة بالنيل والرقابة الدائمة والتنسيق بين الجهات المختصة.