The Economical Value of Nile Tilapia Fish "*Oreochromis niloticus*" in Relation to Water Quality of Lake Nasser, Egypt

Safaa M. Ezzat, Reham M. ElKorashey and Mohammed M. Sherif

Central Laboratory for Environmental Quality Monitoring (CLEQM), National Water Research Center (NWRC), Cairo, Egypt
Reham_Korashey@yahoo.com

Abstract: The present study was carried out to evaluate the quality of Nile Tilapia fish "*Oreochromis niloticus*" collected from three main localities (Adendan, Abou Simbel and Toushka) in Lake Nasser, Egypt. Throughout four season's survey (2010 – 2011), 36 water samples and 60 fish samples were assayed. The Physicochemical and bacteriological parameters in the lake water were found within permissible limits. The macroscopical examination of collected fish samples confirmed their freshness, with no detected signs of clinical abnormalities. However, 23 fishes (38.3%) out of 60 were found positive for helminth parasites. The positive hosts were infected with nematodes (71.2%) and trematodes (28.8%) in the larval stage, whose incidence was restricted to the gills only and didn't exceed 1 – 6 larvae/fish. The infection was always single and not mixed and included the genera *Amplicaecum*, *Contracaecum* and *Clinostomum*. The total number of parasite individuals exhibited clear seasonal variation, being significantly higher in winter (53.3%), followed by spring (40%), summer (33.3%) and least in autumn (26.6%). The muscles - main edible parts – were completely free from any larvae or adult worms and testified their safety for human consumption. The concentrations of four trace metals (Cu, Fe, Pb and Zn) and their bioaccumulation factors (BAF) in both fish gills and muscles were found satisfactory compared to FAO and EOSQC permissible limits and the WMPT scoring system and didn't constitute threat to public health. The study concluded that trace metals bioaccumulation and parasites burden in *Oreochromis niloticus* are considered a proxy of both water quality and ecology of Lake Nasser which is by far suitable for fishing activities and safe consumption of this fish species. The study recommended proper cooking, salting or freezing of fish as a precautionary measure and prohibited disposal of infected fish parts in water ways. Regular monitoring of water and fish quality is a must.
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1. Introduction

Fish is an important source of protein to humans and other animals. Fish industry also offers employment opportunities to many people as well as income at household and national levels (FAO, 1996).

The tilapias are freshwater fish that belong to the family Cichlidae, and they are exclusively associated with Africa and Middle East. According to FAO (2004), tilapias (*Oreochromis* sp.) are among the most cultured fish worldwide. China alone produce 706,585 MT (representing 50% of the total world population), followed by Egypt (167.7 MT) (El-Sayed, 2006).

Initially, tilapias were considered to be more resistant to bacterial, parasitic, fungal, and viral diseases compared to other species of cultured fish. In more recent years, however, tilapias have been found to be susceptible to both bacterial and parasitic diseases. The presence of the pathogen in the environment of the fish is inadequate to cause a disease outbreak. Other factors usually come in to play. This phenomenon is often precipitated by "stress" (Yanong & Francis-Floyd, 2002).

Stress in fish may be induced by various abiotic environmental factors such as changes in water temperature, pH, oxygen concentration and water pollutants including pesticides, insecticides, petroleum products and heavy metals. Biotic interactions such as predator pressure, parasitic and bacterial invasions, strong competition with other organisms or among the fish in overcrowded areas as well as human activities related to fish rearing and harvesting can also be a source of stress (Witeska, 2005).

Among environmental pollutants, metals are of particular concern, due to their potential toxic effect and ability to bioaccumulate in aquatic ecosystems (Censi *et al.*, 2006). When fish are exposed to elevated levels of metals in a polluted aquatic ecosystem, they tend to take these metals up from their direct environment (Framobi *et al.*, 2007). Transport of metals in fish occurs through blood and the metals are brought into contact with the organs and the tissues of the fish and consequently accumulated to different extents (Kalay & Canli, 2000). Prolonged exposure to heavy metals even in very low concentrations has been reported to induce morphological, histological and biochemical alterations in the tissues which may critically influence fish quality (Kaoud & El-Dahshan, 2010).

Unfavorable environmental conditions are the main contributors to stress phenomenon that weakens immunity and opens the pathway to pathogens and parasites (Eissa, 2002). Under favorable conditions, internal parasites are frequent and scarcely increase so as to lead to clinical signs. Most fish parasites are believed to cause little or no harm to their host fish in case of light infections. Fish frequently serve as intermediate or transport host for larval parasites of many animals, including humans. However, there mere presence often renders fish undesirable by consumers causing economic losses to fish producers (Ryan & Joseph, 2000).

Severe parasitic infestations are becoming threats for fish health management and production throughout the world. It cause decrease in growth rate, weight loss, affect yield of fish products, spread human and animal diseases, postpone sexual maturity of fish and increase fish mortalities (Chandra, 2006).

Parasitic infection in fish is thus detrimental to the fish industry because it lowers the quality and quantity and hence the economical value of fish (Kaddumukasa *et al.,* 2006).

Considerable attention has been given to fish parasites in Lake Nasser by various investigators, dating back to the seventies. During the last years, some tilapia fish procured from the Lake and sold in various fish markets were found to be harboring some parasitic infections in the head and viscera. This caused panic among consumers and raised a lot of inquires about their nature and how they affect public health (Bishai *et al.,* 2000).

The study we present was conducted to evaluate the quality of Nile Tilpia fish *Oreochromis niloticus* from Lake Nasser in Egypt with respect to helminth parasite community and bioaccumulation of some important trace metals in both gills and muscles in different seasons. The association between parasites prevalence, metals bioaccumulation and water quality of Lake Nasser was also assessed.

2. Materials and Methods

Study area

High Dam Lake is one of the largest man-made Lakes in Africa. It is bounded by latitudes 24°N in Egypt and 21°S in Sudan. It includes Lake Nasser which extends for about 330 Km in Egypt and Lake Nubia 160 Km in Sudan. The volume of stored water ranges from 160 b.c.m at the highest level (182 m) to 90 b.c.m at the lowest level (150 m). Lake Nasser water is a major source used for drinking, irrigation, fisheries and other domestic purposes (Toufeek & Korium, 2009a).

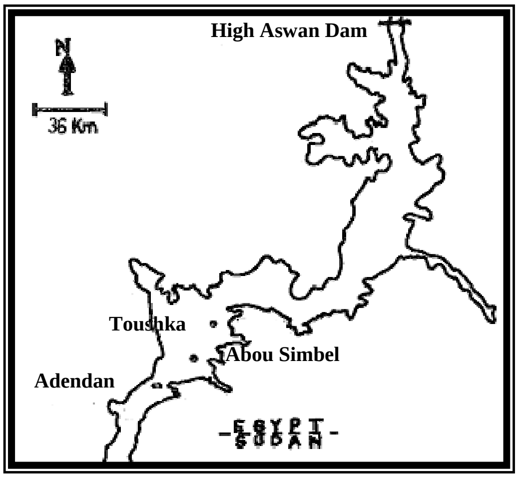

Figure (1): Lake Nasser map showing stations of study

Lake Nasser has a long and narrow shape with dendritic side areas called khors, the shallow water of which provides a good habitat for aquatic plants and planktons which are suitable source of food for natural fish culture. *Tilapia nilotica* form a common population of fish species in the lake with an average of 90 – 95% of total production (Rashed, 2001).

Samples collection

The present study started by collecting water and fish samples seasonally from three sites in Lake Nasser (Adendan, Abou Simbel and Toushka) through 2010-2011 (Figure 1).

Water samples were collected in triplicates from each site in various containers specialized to suit the nature of tested parameter according to Standard Methods for Examination of Water and Wastewater (APHA, 2005), and delivered in iced cooler box to the Central Laboratory for Environmental Quality Monitoring, National Water Research Center "CLEQM" where it has been analyzed.

A total number of sixty specimens of *Oreochromis niloticus* fish were collected from the above mentioned sites (5 fish were taken randomly from each site) with average body weight of 250 – 500 g and average body length 20 – 50 cm. Fish samples were transported to Fish Diseases Department, Animal Health Research Institute in double walled polyethylene bags in an iced cooler box with minimum delay under good conditions, where clinical and parasitological examinations were carried out.

Water analysis

Analytical methods for chemical and bacteriological determinations were carried out according to Standard Methods for Examination of Water and Wastewater (APHA, 2005). For chemical analysis, field parameters including temperature, pH, dissolved oxygen (DO) and electrical conductivity (EC) were measured in situ using the multi-probe system, model Hydralab-Surveyor. In lab, total dissolved solids (TDS) were determined by the gravimetric method, turbidity using Nephelometric method, ammonia by Kjeldahl method using the Gerhardt Vapodest 20S programmable distillation system, while total alkalinity was detected by titration method using 0.02 N H_2SO_4. Major anions were determined using Ion Chromatography (IC) model DX-500 while Major cations and trace metals were measured using the Inductively Coupled Plasma–Mass Spectrometry (ICP - MS), Perkin Elmer Sciex, ELAN 9000.

For bacteriological analysis, the membrane filter technique was applied. Total coliforms, fecal coliforms and fecal streptococci were determined according to standard methods No. 9222B, 9222 D and 9230 C on M- Endo Agar LES, M-FC agar, and M-Enterococcus agar medium, respectively. All media used were obtained in a dehydrated form, Difco USA. Results were recorded as Colony Forming Unit (CFU/100 ml) using the following equation:

$$\text{Colonies } / 100 \text{ ml} = \frac{\text{counted colonies}}{\text{ml of sample filtered}} \times 100$$

Fish analysis

Clinical examination:

Fish were examined macroscopically for freshness and clinically for any abnormal clinical signs according to (Noga, 2010).

Parasitological examination:

All fish specimens were dissected in the laboratory by ordinary method, carefully examined for localization of helminth parasites and their favorite site. Detected parasites in each fish were collected by Pasteur pipette and dissecting needle and counted, then transferred into petridishes containing warm saline solution to obtain a fully relaxed and extended parasites.

The maximum length of each specimen was measured using a pair of vernier callipers. Morphological and parasitological identification was carried out under binocular microscope according to Moravec (1994); Woo (1995) & Paperna (1996).

Trace metals determination:

Representative samples (about 1 g) from gills and muscles of each fish specimen were removed and oven dried for 24 h at 70^0C till constant weight. The dried samples were digested in microwave digestion system (model Milestone, MLS-1200 mega, Germany) using concentrated nitric and hydrochloric acids. The obtained solutions were cooled to room temperature, filtered and diluted to a final volume of 100 ml using de-ionized distilled water. The concentrations of copper, iron, lead, and zinc were determined using Inductively Coupled Plasma–Mass Spectrometry (ICP - MS), Perkin Elmer Sciex, ELAN 9000. Results were expressed in mg/kg dry weight.

Bioaccumulation Factor (BAF)

The bioaccumulation factor (BAF) is the ratio between the accumulated concentration of a given pollutant in any organ and its dissolved concentration in water and it was calculated according to Neuhauser *et al.* (1995); AbdAllah & Moustafa (2002) using the following formula:

$$\text{BAF} = \frac{\text{Pollutant concentration in fish organ (mg/kg)}}{\text{Pollutant concentration in water (mg/l)}}$$

The Waste Minimization Prioritization Tool (WMPT) is a scoring system that was developed by EPA to rank chemicals based on their presistence (P), bioaccumulation potential (B), and human (HT) and ecological toxicity (ET). Chemicals are given a score of 1 (low concern), 2 (medium concern), or 3 (high concern) for P, B, and HT or ET. A score of 1 is assigned to BAF values less than 250; a score of 2 is assigned for BAF values from 250 to 1000; and a score of 3 is assigned for BAF values exceeding 1000 (Drexler *et al.*, 2003). BAF values for heavy metals in fish gills and muscles were calculated using the above equation then compared to WMPT scoring system.

Statistical analysis:

Data were presented as mean ± standard error using MINTAB statistical software.

3. Results and Discussions

Water analysis

The results of physicochemical analysis, trace metals, major anions and cations were compared to the permissible limits of the Egyptian law 48/1982 regarding the protection of River Nile and water ways from pollution.

Physicochemical parameters

Temperature plays a significant role in the outbreak of parasitic infections in fish populations, which are often associated with high and low temperature extremes. The variation in water temperature depends mainly on the climatic conditions, sampling times, the number of sunshine hours and also affected by specific characteristics of water environment such as turbidity, wind force, plant cover and humidity (Shahat *et al.*, 2011).

Results illustrated in Figure (2a) showed that the temperature for all sampling locations in Lake Nasser ranged between 18.5 – 29.2^0C with mean value 23.6±1.107 ^{0}C. Such temperature range favours tilapia survival and reproduction which often doesn't occur below 20 ^{0}C (Popma & Masser, 1999).

pH values illustrated in Figure (2b) for all sampling locations ranged between 7.74 – 8.22 with mean value 8.07±0.047, where in all cases it falls within the permissible limits (7.0 – 8.5). In general, tilapias can survive at pH ranging between 5 and 10, while they do best in a pH range of 6 to 9 (Popma & Masser, 1999).

The increase in the Electrical Conductivity (EC) values is related to the increase in total dissolved solids and water temperature (Abdo *et al.*, 2010). Figure (2c) showed that EC values ranged between 215 – 240 µmhos/cm with an average of 230±2.55 µmhos/cm, while TDS values ranged between 137 – 162 mg/l with an average of 149±2.33 mg/l indicating that all the values were less than the permissible limits (500 mg/l) Figure (2d).

Water turbidity measured in Lake Nasser varied between 3.52 – 25.8 NTU with an average of 10.71±1.72 NTU (Figure 2e). The increase in turbidity could be mainly related to flood water originating from Ethiopian highland during summer season which is known by its high turbidity (Toufeek & Korium, 2009a), yet all recorded values during the four seasons fall within limits (50 NTU).

Oxygen is the first limiting factor for growth and well-being of fish. Although tilapia can survive acute low dissolved oxygen concentrations of < 0.3 mg/l for several hours, yet metabolism, growth, and disease resistance are depressed when DO falls below 1 mg/l (Popma & Masser, 1999). Moreover, increasing water temperature reduces the rate of DO in water. - Respiration and oxygen consumption by tilapias will also increase, leading to further demand for oxygen by tissues. Therefore, DO > 5 ppm is required for good growth of tilapias (El-Sayed, 2006). Results illustrated in Figure (2f) demonstrate DO values ranging between a minimum of 5.98 mg/l in summer and a maximum of 7.58 mg/l in winter with an average of 6.79±0.15 mg/l. These values (>5 mg/l) favor fish survival, reproduction and health (Toufeek & Korium, 2009a).

Total alkalinity refers mostly to carbonate (CO_3^{2-}), bicarbonate (HCO_3^-) and hydroxide (OH^-) ions. Results obtained in this study showed that HCO_3^- was the main contributor to total alkalinity in Lake Nasser water. The values given in Figure (2g) ranged between 102 – 141 mg/l with a mean value of 116±3.93 mg/l with no violation to recommended limits (150 mg/l). Total alkalinity may be attributed to bicarbonate, the final product produced from decomposition of organic matter by bacteria (Shahat *et al.*, 2011).

The prolonged exposure to ammonia concentrations > 0.2 mg/l were found to be detrimental to fish, predisposing tilapias to diseases and massive mortalities (Amal & Zamri-saad, 2011). Ammonia values recorded in Lake Nasser during this investigation were found to be < 0.01 mg/l for all sampling sites in all seasons. Such phenomenon favors fish culture purposes.

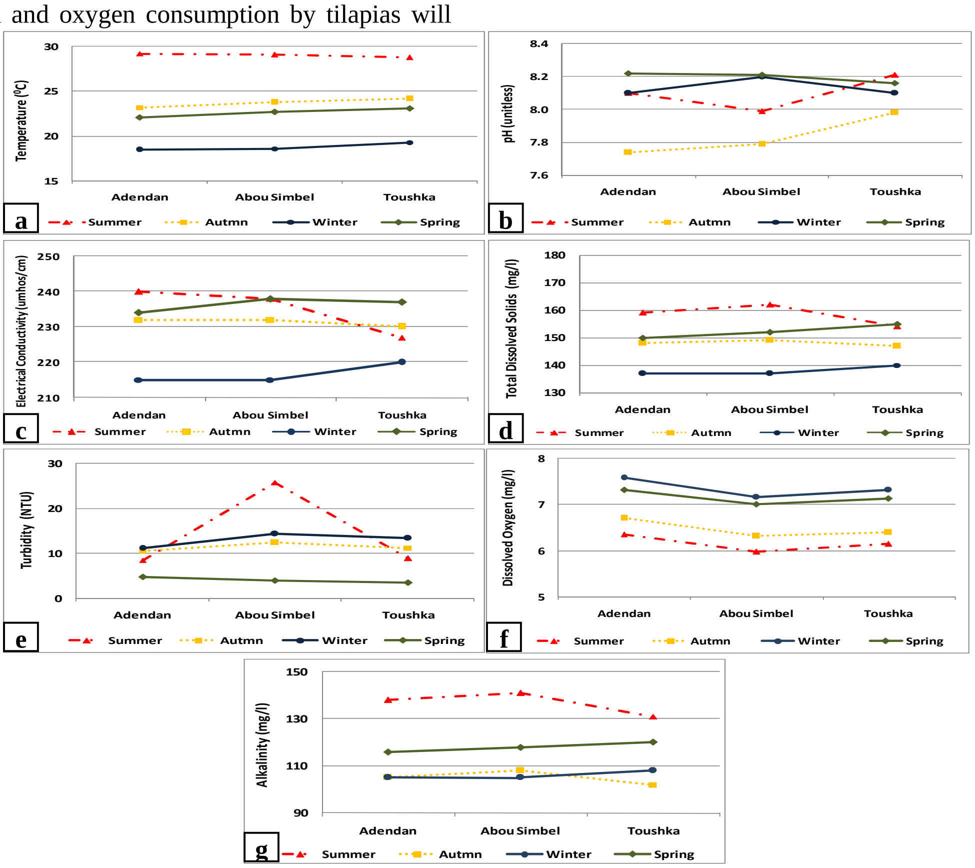

Figure (2): Seasonal variation of physicochemical parameters in water of Lake Nasser

Major anions

The given data in Figure (3) showed that nitrate (NO_3^-), sulphate (SO_4^{2-}) and chloride (Cl^-) concentrations ranged between 0.24 – 1.5 (mean 0.71±0.116) mg/l, 13.1 – 20.9 (mean 17.13±0.63) mg/l and 2.6 – 11.1 (mean 5.41±0.901) mg/l, respectively. All recorded values were within permissible limits. NO_3^- and SO_4^{2-} concentrations indicate that the lake is not highly influenced by human activities or point sources of pollution, while low levels of Cl^- positively correlate with EC values and support the soft nature of Lake Nasser water (Toufeek & Korium, 2009a).

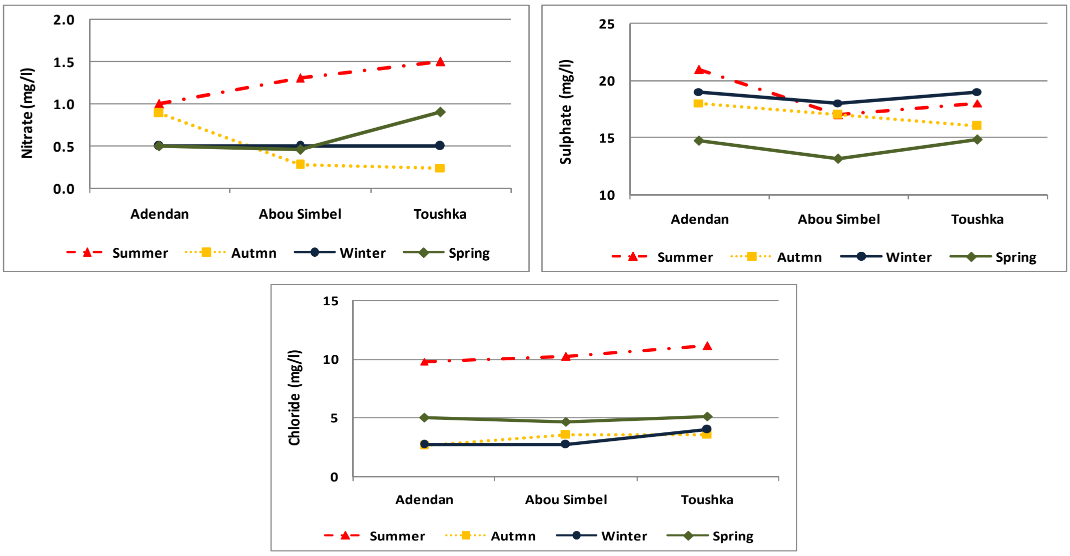

Figure (3): Seasonal variation of major anions in water of Lake Nasser

Major cations

Available data illustrated by Figure (4) showed that the concentrations of sodium (Na^+), potassium (K^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}) were naturally variable from season to another according to changes in physicochemical parameters as temperature, pH, DO and suspended solids coming with water flood. Na^+, K^+, Ca^{2+} and Mg^{2+} values ranged between 21 – 36 (mean 28±1.49) mg/l, 1 – 6 (mean 3.4±0.48) mg/l, 20.8 – 30.6 (mean 23.8±0.95) mg/l and 6.76 – 9.84 (mean 8.47±0.33) mg/l, respectively. These concentrations in different seasons and regions lie within permissible range (Toufeek & Korium, 2009b).

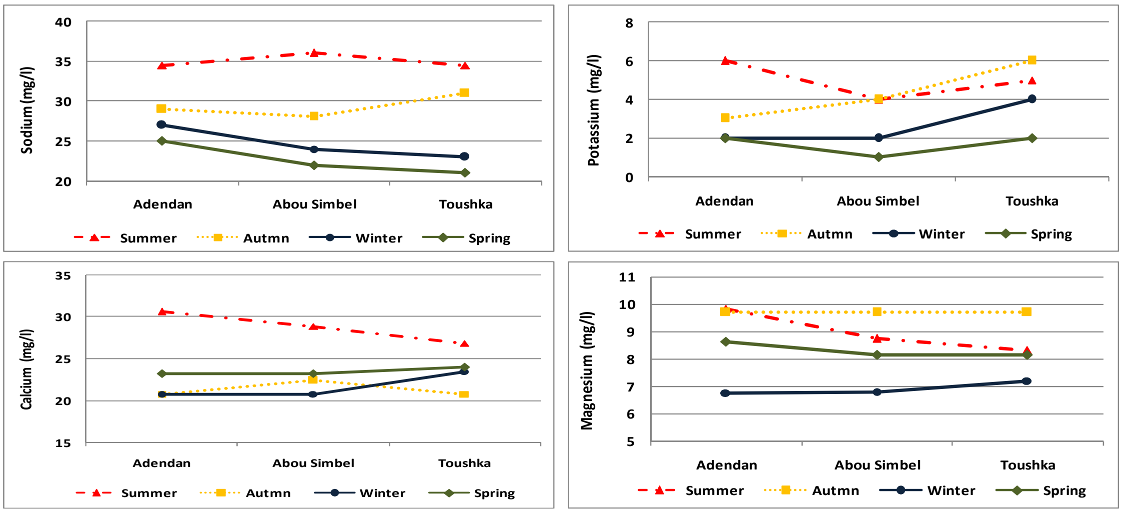

Figure (4): Seasonal variation of major cations in water of Lake Nasser

Trace metals

Trace amounts of metals are naturally present in freshwater from weathering of rocks, soils and atmospheric depositions. However, higher concentrations can cause severe toxicological effects on human and aquatic ecosystem.

In this study, a total number of fifteen trace metals (aluminium, arsenic, barium, cadmium, cobalt, copper, nickel, lead, iron, zinc, manganese, chromium, vanadium, selenium and tin) were analyzed, out of which the results of only four detected metals where listed in Table (1). Concentrations of other metals were below instrument detection limit (0.001 mg/l for arsenic, barium, cadmium, nickel, chromium and selenium; 0.005 mg/l for aluminium, cobalt, vanadium and tin; 0.006 mg/l for manganese).

Table (1): Concentration values of detected trace metals in water of Lake Nasser

Metals	Concentrations (mg/l)		
	Min	Max	Mean±SE
Copper	0.006	0.014	0.01±0.0007
Iron	0.091	0.175	0.14±0.0068
Lead	0.001	0.002	0.0015±0.000093
Zinc	0.134	0.214	0.162±0.0072

As shown in Table (1), Cu, Fe, Pb and Zn were found in low concentrations indicating that the lake is not subjected to metal pollution (Heikal, 2000). Figure (5) clearly demonstrates that concentrations of these metals were within standard limits (1 mg/l for Cu, Fe and Zn and 0.05 mg/l for Pb) and that they follow the order zinc > iron > copper > lead.

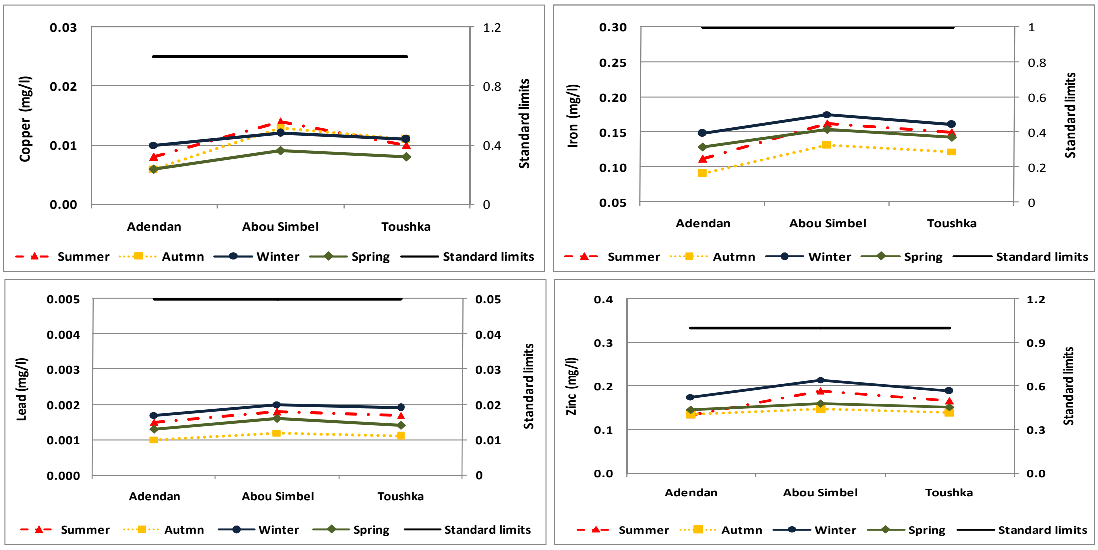

Figure (5): Seasonal variation of trace metals in water of Lake Nasser

Maximum levels were detected in winter, probably due to decrease in both temperature and pH which favours the increased mobilization of metals from sediment to water (Abdel-Satar, 1998).

Metals level in sampling locations followed the order Abou Simbel > Toushka > Adendan. This could be attributed to increased human activities, fishery boats and tourships in Abou Simbel (Rashed, 2001).

Bacteriological parameters

Bacteriological assessment is still the primary water quality issue in judging the microbiological status of water resources, especially those used for drinking, irrigation and fish culture.

In this study, the bacteriological assessment of water in Lake Nasser was carried out through monitoring of conventional bacterial indicators; Total Coilforms (TC), Fecal Coliforms (FC) and Fecal Streptococci (FS). The data obtained were presented in Tables (2 & 3) and illustrated by Figure (6).

Table (2): Densities of bacterial indicators in water of Lake Nasser

Parameters	Count (CFU/100ml)		
	Min	Max	Mean±SE
Total coliforms	1000	4800	1239±358
Fecal coliforms	1	55	22.3±5.82
Fecal streptococci	10	150	50.1±14.45

The given data in Table (2) showed that all bacterial indicators were recorded in low densities, following the order total coliforms > fecal streptococci > fecal coliforms. Total coliforms may naturally originate from sediment and soil or as a result of some agricultural activities along the lake banks, while the low counts of both fecal coliforms and fecal streptococci indicate limited fecal pollution mainly originating from animal source rather than human source or direct sewage (Mara & Horan, 2003).

Figure (6) clearly demonstrates that densities of indicator bacteria were within international standard limits (5000, 2000 & 1000 CFU/100 ml) for total coliforms, fecal coliforms and fecal streptococci, respectively. Consequently, the lake is considered to be safe from bacteriological point of view (Tebbutt, 1998 & Heikal, 2000). Bacterial counts in sampling locations followed the order Abou Simbel > Toushka > Adendan, with the highest peak in winter followed by spring, summer and autumn.

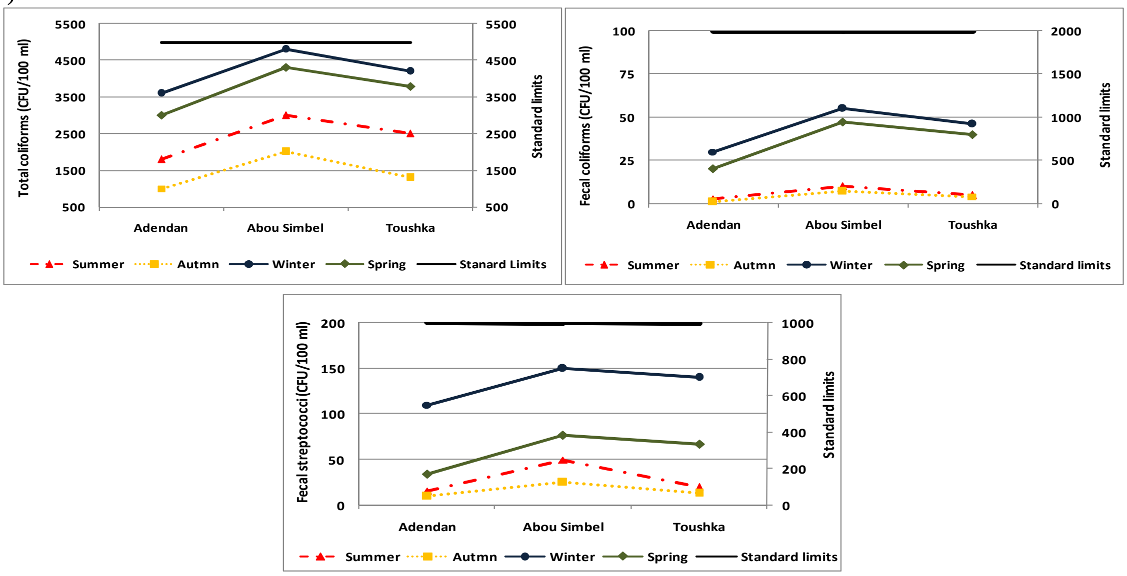

Figure (6): Seasonal variation of bacteriological parameters in water of Lake Nasser

The fecal streptococci have been used together with fecal coliforms to differentiate human fecal contamination from that of other warm blooded animals. FC/FS ratio of 4 or more indicates a contamination of human origin, whereas a ratio below 0.7 is indicative of animal pollution (Pourcher *et al.*, 1991; Bitton, 1994 & APHA, 2005).

Table (3): FC/FS ratio in water of Lake Nasser

Seasons	Localities		
	Adendan	Abou Simbel	Toushka
Summer	0.18	0.2	0.25
Autumn	0.10	0.28	0.30
Winter	0.27	0.36	0.32
Spring	0.58	0.61	0.59

Throughout four season's survey, counts of FS were found to be higher than that of FC in all studied sites and recorded values more than 100 CFU/100ml in winter. Table (3) showed that FC/FS ratio was always < 0.7 in all seasons for all sites, thus indicating that the source of fecal pollution in the lake is most probably of animal origin.

The previous findings might be interpreted in terms of the lake ecology which supports the presence of animal excreta from different reptiles hosting the lake as well as droppings of migratory birds in winter season whose numbers have increased tremendously after construction of the high dam and the lake formation.

Fish analysis

Clinical examination

The macroscopical examination of all collected samples confirmed fish freshness, with no detected signs of clinical abnormalities concerning both external and internal body organs.

Parasitological examination

In the recent years, there has been increasing interest in the interrelationship between parasitism and pollution, especially in aquatic habitat. This relationship is not simple and in essence involves a double edged phenomenon, in which parasitization may increase host susceptibility to toxic pollutants or in which pollutants may result in increase in the prevalence of certain parasites (Vidal Martinez, 2007). Nematodes and trematodes are usually considered the most economically important helminth parasites of fish in the world, as their presence can reduce the economic value of marketed fish.

The present study involved investigating the helminthic parasites of *Oreochromis niloticus* collected from Lake Nasser in four different seasons. Data obtained were presented in Table (4) and illustrated by Figures (7 & 8) and plate (1).

Table (4): Helminthes fauna of *Oreochromis niloticus* collected from Lake Nasser in different seasons

Localities	Season	No. of infested fishes	Incidence rate	Intensity of infestation per fish	Infested site	Larval identification	
						Class of parasites	Genus of parasites
Adendan	Summer	1	20%	2 Larvae	Gills	Nematodes	*Amplicaecum* sp.
	Autumn	1	20%	1 Larva	Gills	Nematodes	*Amplicaecum* sp.
	Winter	3	60%	1 - 6 Larvae	Gills	Nematodes	*Contracaecum* sp.
	Spring	1	20%	2 Larvae	Gills	Nematodes	*Contracaecum* sp.
Abou simbel	Summer	2	40%	1 - 3 Larvae	Gills	Nematodes	*Amplicaecum* sp.
	Autumn	2	40%	1 - 4 Larvae	Gills	Nematodes	*Amplicaecum* sp. *Contracaecum* sp.
	Winter	3	60%	2 - 6 Larvae	Gills	Nematodes	*Contracaecum* sp.
	Spring	3	60%	3 -4 Larvae	Gills	Trematodes	*Clinostomum* sp.
Toushka	Summer	2	40%	1 - 3 Larvae	Gills	Nematodes Trematodes	*Amplicaecum* sp. *Clinostomum* sp.
	Autumn	1	20%	1 Larva	Gills	Trematodes	*Clinostomum* sp.
	Winter	2	40%	1 - 3 Larvae	Gills	Nematodes	*Contracaecum* sp.
	Spring	2	40%	4 Larvae	Gills	Trematodes	*Clinostomum* sp.

In summer season, 5 out of 15 fish samples were found to be infested with parasites, whose incidence rate reached about 33.3% with an intensity of infestation 1-3 larvae/fish. The site of infestation was restricted to the gills rather than the muscles, abdominal cavity or the general body viscera which were free from any adult worms or larvae.

The total number of isolated larvae was 10, belonging to two main classes of parasites; nematodes and trematodes. Nematodes larvae were identified as *Amplicaecum* sp., whose length ranged between 3.4 – 4 cm, with an incidence rate of 90% and intensity of infestation 1 – 3 larvae/fish. On the other hand, trematode larvae were identified as *Clinostomum* sp. with an incidence rate of 10% and intensity of infestation 1 larva/fish with average length 1.8 cm. *Amplicaecum* sp. were prevalent in fish samples collected from the three sites, while *Clinostomum* sp. was detected only in samples from Toushka. It is to be mentioned that, the most infested localities in summer season were Abou simbel and Toushka (40%) and the least was Adendan (20%) (Table 4, Figure 7 & plate 1).

Table (4) showed the helminthes fauna detected in autumn season in which 4 out of 15 examined samples were infected with nematodes and trematodes. The incidence rate was about 26.6% and the intensity of infestation was 1 – 4 larvae/fish being observed only in the gills. No adult worms were detected and the total number of isolated larvae was 7. Nematode larvae were classified into two genera, *Amplicaecum* and *Contracaecum*. The incidence rate of *Amplicaecum* was 28.6%, and the number of larvae didn't exceed 1 larva / fish whose length was about 4 cm. The infected samples were collected from both Adendan and Abou Simbel. Meanwhile, the incidence rate of *Contracaecum* larvae was 57.1% and intensity of infestation 4 larvae/fish with an average length ranging between 3-3.5 cm being mostly dominant from Abou Simbel. Trematode larvae were classified as *Clinostomum* sp. whose incidence rate was 14.3% and intensity of infestation 1 larva/fish whose length was about 1.6 cm. *Clinostomum* was detected only in Toushka. In autumn season, the location mostly affected was Abou Simbel (40 %), followed by Adendan and Toushka (20 %) (Table 4, Figure 7 & plate 1).

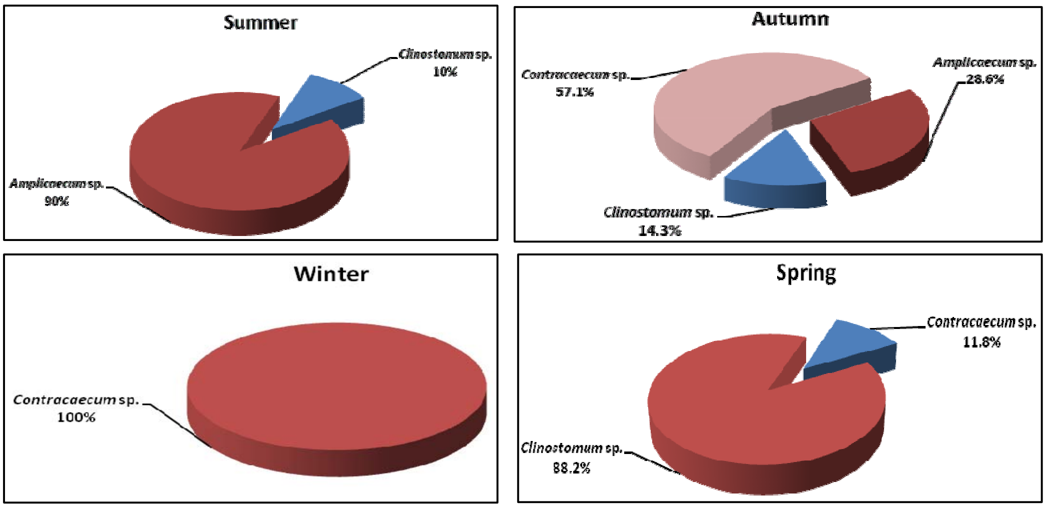

Figure (7): Percentages of identified parasites in different seasons

Table (4) demonstrated the identified parasites in winter season. Out of 15 examined fish samples, 8 were infested with the larval stage of the genus *Contracaecum* which belongs to the class nematodes. 53.3% represented the incidence rate of infection in winter whose intensity reached 1 – 6 larvae/fish. The total number of isolated larvae was 25 mainly localized in the gills.The incidence rate of *Contracaecum* sp. was 100% with intensity 1 – 6 larvae/fish, being dominant in Abou Simbel and Adendan (60%) and least in Toushka (40%) (Table 4, Figure 7 & plate 1).

In spring season, the prevalence of both nematodes and trematodes in fish samples was observed. 6 out of 15 fishes (40%) were infested, in which 2 – 4 larvae/fish were detected in gills and the total number of isolated larvae were 17. The nematode larvae were identified as *Contracaecum* sp., whose length reached about 3 cm, with an incidence rate of 11.8% and intensity of infestation 2 larvae/fish and were detected only in fish samples collected from Adendan. *Clinostomum* was the genus identified in class trematodes during this season, with incidence rate 88.2%, intensity 3 – 4 larvae/fish, average length 1.1 – 1.6 cm and was detected in fish samples from Abou Simbel (60%), followed by Toushka (40%) and Adendan (20%) (Table 4, Figure 7 & plate 1).

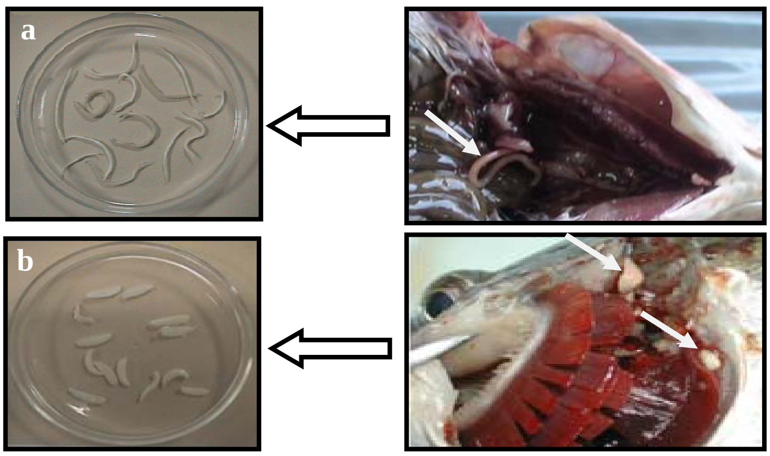

Plate (1): *Oreochromis niloticus* infected with a) nematodes & b) trematodes with closer views

The present demonstrated results were supported by those of earlier investigators who reported isolation of nematodes and trematodes from *Oreochromis niloticus* in several aquatic environments (Bishai *et al.,* 2000; Thabit, 2004; Kaddumukasa *et al.,* 2006; Taher, 2009 & Eissa *et al.*, 2011). The total number of parasite individuals exhibited clear seasonal variation, being significantly higher in winter (53.3%), followed by spring (40%), summer (33.3%) and least in autumn (26.6%) (Figure 8). This phenomenon could be interpreted in terms of the life cycle nature of these parasites, which involves the presence of snails as first intermediate host, followed by fish as second intermediate host and finally aquatic birds and reptiles as definitive final host (Syobodova & Kolarova, 2004).

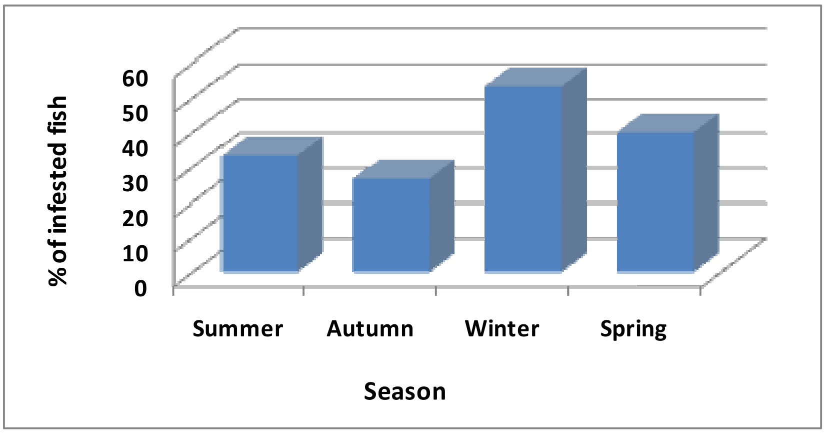

Figure (8): Percentages of infested fish in different seasons

The ecological changes developed after construction of the high dam and formation of Lake Nasser caused an increase in the number of migratory birds around the lake particularly in winter season. This was reflected during the study through the positive significant correlation between the increase in number of parasites with the increase in fecal streptococci count in winter season whose principle source are migratory birds (Tables 2, 3 and Figure 6). Moreover, the feeding habits of *Oreochromis niloticus* include the fecal droppings of aquatic birds and reptiles containing helminth parasites (Oso *et al.*, 2006). The above interpretations could be supported by the fact that parasites identified in this study have been previously reported as allogenic parasites which develop and mature in aquatic birds and mammals whose natural migrations favor dispersion, giving them a wide geographic distribution (Bush *et al.*, 2003). Thus, it is strongly possible to find these types of parasites in fish hosting the Upper Nile regions where their final hosts (crocodiles, frogs, snakes and aquatic birds) predominate.

The appearance of these parasites in spring and summer may be linked to the high temperatures in hot and warm seasons which favor development of snails, the primary intermediate host for them (Zandar *et al.,* 1999).

The detected parasites throughout the study were identified exclusively in larval stages. No adult worms were reported, indicating that *Oreochromis niloticus* mainly acts as intermediate host (Taher, 2009). The gills were the target habitat possibly due to the fact that gills are considered the most important part rich in blood, persuading the helminth for parasitism (Arafa *et al.*, 2005). The parasite community had low numbers (1 – 6) larvae/fish and didn't exceed the hazard limits for human consumption (15 worms). Up till now, no human infections with those parasites from infected fish have been reported in Egypt, probably due to Egyptian's feeding habits which don't prefer eating improperly cooked, smoked or raw fish (Bishai *et al.*, 2000). The phenomenon reported in this study highlights the motive role played by the environmental and ecological nature in Lake Nasser rather than a pollution problem.

Trace metals determination

The presence of trace metals in aquatic ecosystem is an alarming problem worldwide. Fish have been introduced as excellent biological markers of metals in water, since they occupy high trophic levels and are important food source (Agah *et al.*, 2009).

In the present study, the concentrations of four trace metals (Cu, Fe, Pb and Zn) detected in water analysis were determined in both gills and muscles of fish specimens and compared to permissible limits as recommended by Food and Agriculture Organization (FAO, 1983) and the Egyptian Organization for Standardization and Quality Control (EOSQC,1993).

Table (5): Concentration values of trace metals in gills and muscles of *Oreochromis niloticus* collected from Lake Nasser

Metals	Gills			Muscles		
	Concentrations (mg/kg dry weight)					
	Min	**Max**	**Mean±SE**	**Min**	**Max**	**Mean±SE**
Copper	4.4	11.8	8.06±0.659	0.4	2.3	1.23±0.175
	(546)	(983)	(829)	(54.5)	(209)	(128)
Iron	12	30	22.3±1.53	0.4	2.1	1.19±0.147
	(132)	(173)	(158)	(4.4)	(12.0)	(8.3)
Lead	0.08	0.25	0.173±0.0165	0.001	0.006	0.004±0.00048
	(80)	(138)	(112)	(0.9)	(3.0)	(2.3)
Zinc	15.6	30.8	22.69±1.346	9.8	20.3	14.5±0.84
	(115)	(154)	(139)	(72)	(98)	(89)

* Values between brackets are bioaccumulation factors (BAF)

Results demonstrated in Table (5) showed that the mean concentrations of Cu, Fe, Pb and Zn in gills of *Oreochromis niloticus* were 8.06 ± 0.659, 22.3 ± 1.53, 0.173 ± 0.0165 and 22.69 ± 1.346, respectively, while in muscles they were 1.23 ± 0.175, 1.19 ± 0.147, 0.004 ± 0.00048 and14.5 ± 0.84 for these metals in the same order. Metals detected in gills follow the descending order Zn>Fe>Cu>Pb, while in muscles they were ranked as Zn>Cu>Fe>Pb.

The presence of trace metals inside the fish tissues is often affected by many external and internal factors. Metals concentration is correlated with ambient metals level in the surrounding environment, the available metal form in water, the structure of the target organ as well as the interaction between the metal and this organ (EL-Naggar *et al.*, 2009). In view of the previous findings, the presence of Zn in both gills and muscles could be anticipated to the increase in total dissolved Zn in the lake water and consequently increase in metal availability and uptake by different fish organs (Yacoub, 2007). Comparative data for both metal content of water and fish tissues (Tables 1 & 5) suggest a strong link between water characteristics and fish quality.

Bioaccumulation Factor (BAF) gives an indication about the accumulation efficiency for any particular pollutant in any fish organ. The BAF values recorded in Table (5) showed that for gills and muscles BAF values were 829&128, 158&8.3, 112&2.3 and 139&89 for copper, iron, lead and zinc, respectively. By comparing those values with the WMPT, it was shown that iron, lead and zinc were given score of 1 (low concern) since their BAF values were less than 250, while copper given score of 2 (medium concern) were its BAF values fall between 250 and 1000.

These results showed that Nile Tilapia fish from studied area in Lake Nasser can undergo bioaccumulation of copper metal in their gills from the Lake water (Kalfakakour and Akrida – Demertzi, 2000; Rashed, 2001 & Abdel-Baki *et al.*, 2011).

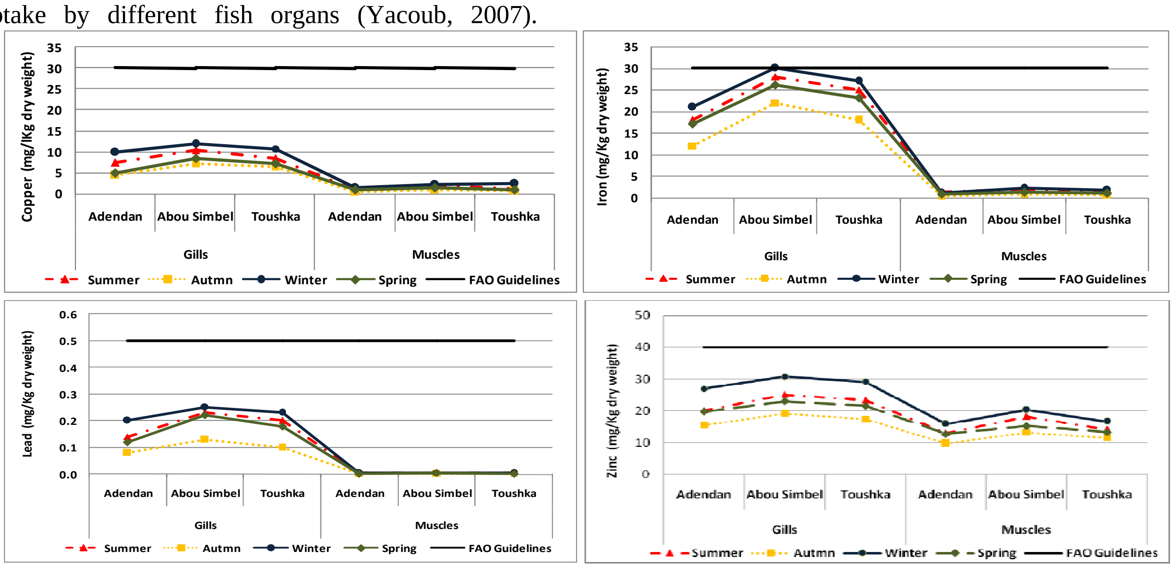

Figure (9): Seasonal variation of trace metals concentration in gills and muscles of *Oreochromis niloticus* collected from Lake Nasser

Clearly Figure (9) showed that metals concentration in gills and muscles of fish samples follow the order Abou Simbel > Toushka> Adendan. The same observation was recorded in water analysis, thus indicating that metals in fish are mostly derived from water. Similar results were concluded by (Rashed, 2001 & Abdel-Baki *et al.*, 2011).

In the present study, the seasonal variation played a major role in metal ion speciation and the comparative concentrations of each metal and thereby availability for uptake by fish organs. As shown in Figure (9), winter represented the master season, owing to the decrease in temperature and pH of water which favors metals mobilization. These results are in harmony with those previously reported by Abdel-Satar & Shehata (2000) and Fayed (2004).

Among all parts of fish under study, the gills accumulated the highest concentrations of Zn, Fe, Cu and Pb metals compared to those detected in muscles (Figure 9). This phenomenon is supported by the fact that gills are the first target organ for water borne pollutants, since they participate in many important functions in fish, such as respiration, osmoregulation and excretion, which makes them in close contact with the external environment and sensitive to changes in water quality (Au, 2004 & Fernandes *et al.,* 2008). In this respect, several studies confirmed our findings (Kaoud & El-Dahshan, 2010; Abdel Baki *et al.,* 2011 & El-Bakary, 2011)

The obtained results represented in Table (5) and illustrated by Figure (9) showed that trace metals under study in both gills and muscles of Tilapia from Lake Nasser were within the safety permissible levels as recommended by FAO and EOSQC. The low concentrations of metals in fish suggest that they are mainly derived from agricultural wastes reaching the lake body containing chemical fertilizers and biocides as a result of constructing agricultural farms on the lake shores since 1987, rather than heavy loads from industrial wastes. Again, increased human activities, fishery boats and tour ships may also contribute to such phenomenon. Metals level in muscles-the main edible part in fish-are so far satisfactory and doesn't constitute any threat to public health and human use. These results agree with those reported by Awadallah *et al.,* (1985) & Rashed (2001).

Conclusion

The present study concluded that the various water quality parameters under investigation in different seasons and regions in Lake Nasser lie within permissible ranges. Trace metals bioaccumulation and parasites burden in Nile Tilapia fish "*Oreochromis niloticus*" didn't provoke the national and international safety limits and are considered a proxy of both water quality and ecology of Lake Nasser, which in more specific words contributed strongly to fish quality and its economical value. Lake Nasser is by far suitable for fishing activities and safe consumption of this fish species.

Recommendations

Fish must be gutted soon after capture, well cooked or properly salted. Freezing at -20^{0}C for 72 hrs or heating above 55^{0}C for 10 seconds kill the parasites.

Disposal of viscera or infected fish parts in water should be totally prohibited.

Regular monitoring of trace metals level in fish is necessary.

Extended investigations along the River Nile and its two branches to study this phenonomenon is important to ensure successful fishery management plans.

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Corresponding author
Reham M. ElKorashey
Central Laboratory for Environmental Quality Monitoring (CLEQM), National Water Research Center (NWRC), Cairo, Egypt
Reham_Korashey@yahoo.com

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