Water quality and heavy metals monitoring in water and tissues of Nile tilapia fish from different governorates "Egyptian Aquaculture farms"

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ABSTRACT

All aquatic organisms are directly or indirectly affected by the physico-chemical characteristics of their environment, especially the chemical composition of the water, where it is the main factor affecting the cultured fish. So, the present study investigated the quality of water ponds and their impacts on fish reared in three different farms at Sahl El-Hussaynia, Sharkia governorate, Kafr El-Sheikh, governorate and at Sahl El-Tinna, Port-Saeed governorate, Egypt. Water and fish samples were taken during summer to evaluate the physico-chemical characteristics and heavy metals distribution in water and fish tissues (muscles, gill and liver). Moreover, the effect of accumulated heavy metals on glucose, total proteins and the activities of transaminases (AST and ALT) in the fish muscles was studied. Also, Physical and chemical characteristics of water (water temperature, pH, DO, NH3, NO3, total alkalinity, total hardness and phosphate) were measured.

Heavy metals varied depending upon the organs and location. Also, the order of occurrence of heavy metals in water ranked at the following order; Zn> Fe> Cu> Cd at Sahl El-Hussaynia and Sahl El-Tinna farm but at Kafr El-Shiekh farm the order was Fe> Zn> Cu> Cd. Pb metal was not detected in the three farms. In the same time, the heavy metals were found in muscles, gills, and liver in the order Fe> Zn> Cu in the three fish farms, but Pb and Cd were not detected. In the liver, levels of the heavy metals exceeded the permissible limits according to WHO (1989). Moreover, in gills the levels of Zn exceeded the permissible limits at El–Hussaynia and Kafr El-Shiekh farms, but in muscles didn't exceed the permissible limits, except the Fe. The results of glucose, total protein, and activities of AST and ALT had some fluctuations in the serum among the studied fish.

Keywords: Aquaculture, heavy metals, physico-chemical characters.

INTRODUCTION

Aquaculture is considered as one of the most important sources of animal protein production in Egypt for meeting the increasing demand for protein (Konswa, 2007). Egypt's fish farms act as temporary reservoirs for drainage water (Osman et al., 2010), where the aquatic environment with its water quality is considered the main factor controlling the state of health or disease in both cultured and wild fishes. Pollution of the aquatic environment by inorganic and organic chemicals is one of the major factors that threat the aquatic organisms (Saeed & Shaker, 2008). Water quality is a critical limiting factor for fish life and fish flesh quality, so water physico-chemical parameters should be closely monitored and the optimal limits should at all time be provided to the cultured organisms for optimum performance as well as profitability of fish production venture (Onada et al., 2015).
Water pollution is a series environmental problem in the world. It is the degradation of the quality of water that renders water unsuitable for its intended purpose. Anything which degrades the quality of water is termed as a pollutant. Water pollutant can be broadly classified as major categories namely organic, inorganic, suspended solids and sediments, heavy metals, radioactive materials and heat (Botikin and Keller, 2008).

In fishes, it is observed that the external organs are affected due to the toxic chemicals including the heavy metals, causing loss of equilibrium, increased opercular movement, irregular vertical movements, finally leading to death. Cadmium, lead, mercury and arsenic cause severe damage to the renal and nervous systems of fish as well as gill damage; severe destructive pathological changes i.e. structural lesions; (Larse, 2003; Velcheya et al., 2010; Deore and Wagh, 2012; Mahino and Nazura, 2013).

There was a strong evidence of a correlation between heavy metals concentrations in different fish tissue and those of the surface water of the polluted areas. The accumulation of metals in fish tissues depends on numerous factors, such as environmental concentrations, environmental conditions (pH, water temperature, hardness….etc), exposure duration and feeding habits. In recent years, the anthropogenic pollution of aquatic ecosystem increased the need for studies to identify the impact of heavy metals on the species living there. Monitoring programs for bioaccumulation measurements serve as a biomarker for fish from contaminated places and provide information about the environmental conditions (Zeitoun and Mehana, 2014).

Fish are often at the top of aquatic food chain and metals are accumulated in them to concentration much time higher than that present in water and sediment. Fish can absorb heavy metals through epithelial or mucosal surface of the skin, gills and gastrointestinal (Jovanovic et al., 2011).

Biochemical studies proved that, fish which were subjected to the heavy metals, showed severe reduction in the proteins, lipids levels and transaminases activities in the muscles (Almeida et al., 2001; Atli and Canli, 2007; Mohamed and Gad 2008).

Accordingly, the present study aimed to investigate the physical, chemical characteristics of water and accumulation of heavy metals in fish and water of three different fish farms and its effect on some biochemical parameter.

**MATERIALS AND METHODS**

Samples of water and Oreochromis niloticus fish were collected during summer (June to September) of 2014 from three different fish farms:-
1- A private fish farm at El-Hussaynia, Sharkia governorate (three earthen ponds supplied with water driven from Bahr El- Bakar canal (sewage water).
2- A private fish farm at Kafr El-Shiekh governorate, (three earthen ponds supplied with a mix of water driven from El-Ghabria drain (three earthen ponds supplied with agriculture drainage, industrial and sewage water).
3- A private fish farm at Sahl El-Teinna, Port Saeed governorate and had its water supply from Bahr El-Bakar which includes domestic, agricultural and industrial waste water.

**Water quality parameters**

Water samples were collected from each pond to be analyzed for different water physico-chemical parameters; temperature, dissolved oxygen, pH, alkalinity, total
hardness, unionized ammonia (NH₃), nitrate (NO₃) and phosphate (PO₄). Water samples were analyzed according to methods described by Boyd and Tucker (1992).

**Fish samples collection**

Random samples of *Oreochromis niloticus* were collected from 3 earthen fish ponds for analysis. The samples collected were labeled with an identification number, the date and place of collection, before transporting in ice packed plastic coolers to the laboratory for analysis.

**Heavy metal analysis**

For the determination of heavy metals, fish samples were carefully dissected to remove the liver and parts of the muscles. Livers and pieces of edible muscle tissues were oven dried at 85°C until constant weight (about 18 hours). A 1.0 g dry weight of tissue was ashed in muffle furnace (Thermolyne Corporation, Dubuque, Iowa, USA) for 6 hours. Ash was digested with conc. nitric acids, and diluted with 2N HCL to a constant volume. The samples were filtered into acid-washed volumetric flasks and diluted to 50 ml for elemental analysis. Concentrations of cadmium, copper, iron, lead, and zinc were then determined according to APHA (1998) using atomic absorption spectrophotometer (Thermo 6600 Thermo Electron Corporation, Cambridge, UK).

**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 according to Authman and Abbas (2007) using the following equation:

\[
BAF = \text{pollutant concentration in fish tissue (mg/kg)/pollutant (mg/l) in water or sediment.}
\]

**Biochemical Analyses**

Serum samples were used to estimate the biochemical parameters. The glucose was estimated according to the method of Trinder (1969), while total protein was determined according to Young (2001). Aspartate amino transferase (AST) and Alanine amino transferase (ALT) were determined according to the method of Reitman and Frankel (1957).

**Statistical analysis**

One way ANOVA and Duncan multiple range test were applied to test whether differences among sites and time were significant at P ≤ 0.05. Correlation coefficients; Pearson correlation (r), between the different parameters were computed. Correlation and all statistical analyses were done using SPSS for windows version 10 (SPSS, Richmond) as described by Dytham (1999).

**RESULTS AND DISCUSSION**

**Water temperature**

The highest water temperature was recorded at ponds of El-Hussaynia farm (Table 1) and the lowest was at ponds of Kafr El-Shiekh. These variations were mainly due to the differences of location; this attributed to the shallowness of most tropical fish ponds. These results were in accordance with Ali (2007).

**Hydrogen ion concentration (pH)**

The value of pH lies on the alkaline side at all sites, with total mean of 7.50±0.02, 7.65±0.01 and 7.07±0.07 in Sahl El-Hussaynia, Kafr El-Shiekh and Sahl El-Tinna farms, respectively. On the other hand, the increase of pH value in Kafr El-Shiekh may be due to increase of photosynthesis activity by phytoplankton. This may be attributed to the wide variation of phytoplankton between feeder/drains and
fishponds, where pH changes in surface water result from the interaction of various biotic and abiotic processes (Konsowa, 2007).

Table 1: Mean concentration of physico-chemical characters in water of Sahl El-Hussaynia, Kafr El-Shiekh and Sahl El-Tinna private fish farms during June to September 2014

<table>
<thead>
<tr>
<th>Locations Items</th>
<th>Sahl El-Hussaynia</th>
<th>Kafr El-Shiekh</th>
<th>Sahl El-Tinna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>31.33 + 0.77 A</td>
<td>26.68 + 2.53 A</td>
<td>29.43 + 0.20 A</td>
</tr>
<tr>
<td>pH</td>
<td>7.65 + 0.01 A</td>
<td>7.50 + 0.02 A</td>
<td>7.07 + 0.07 A</td>
</tr>
<tr>
<td>DO (mg/l)</td>
<td>6.43 ± 1.52 B</td>
<td>7.50 + 0.02 A</td>
<td>4.28 ± 0.42 C</td>
</tr>
<tr>
<td>T. alkalinity (mg/l)</td>
<td>246.67 ± 8.80 B</td>
<td>240.01 ± 2.02 B</td>
<td>366.67 ± 16.69 A</td>
</tr>
<tr>
<td>T. hardness (mg/l)</td>
<td>263.30 ± 16.45 C</td>
<td>683.30 ± 43.38 B</td>
<td>1513.30 ± 13.35 A</td>
</tr>
<tr>
<td>NO₃ (mg/l)</td>
<td>0.12 ± 0.01 C</td>
<td>0.26 ± 0.01 B</td>
<td>1.08 ± 0.05 A</td>
</tr>
<tr>
<td>NO₂ (mg/l)</td>
<td>0.32 ± 0.02 A</td>
<td>0.26 ± 0.02 A</td>
<td>0.06 ± 0.01 B</td>
</tr>
<tr>
<td>NH₄ (mg/l)</td>
<td>0.07 ± 0.02 B</td>
<td>0.49 ± 0.04 A</td>
<td>0.05 ± 0.01 B</td>
</tr>
<tr>
<td>PO₄ (mg/l)</td>
<td>0.03 ± 0.01 C</td>
<td>0.24 ± 0.04 B</td>
<td>0.64 ± 0.06 A</td>
</tr>
</tbody>
</table>

*Means with the same letter within the same row are not significantly different.

**Dissolved Oxygen**

Values of DO during the study period were 6.43±1.52, 7.50±0.02 and 4.28±0.42 mg/l at Sahl El-Hussaynia, Kafr El-Shiekh, and Sahl El-Tinna fish farms, respectively (Table 1). The low value of DO was at Sahl El-Tinna; this may be due to the presence of organic matter loaded by the higher amounts of drainage water discharged in these areas but the high value was recorded at ponds of Kafr El-Shiekh, attributed to the high level of agriculture drainage water in these ponds caused abundance of phytoplankton communities.

**Total alkalinity**

The highest value (366.67±16.69 mg/l) was observed in ponds of Sahl El-Tinna, while the the lowest value was found at Kafr El-Shiekh ponds with mean values of 240.01±2.02 and 246.67±8.80 mg/l, in Sahl El-Hussaynia fish farms, respectively (Table 1). The highest value in ponds of Sahl El-Tinna may be attributed to feeding and organic fertilization in them. This is because bacteria generated CO₂ from feed metabolism and manure decomposition dissolved calcium and magnesium carbonate present in the pond sediments (Boyd, 1990). The results were in accordance with the study of Ezzat et al. (2012), who reported that the range of total alkalinity values was 282.5 to 426.5 mg/l in drains water.

**Total Hardness**

The maximum value was recorded at Sahl El-Tinna (1513.30±13.35 mg/l) and the minimum was at ponds of Sahl El-Hussaynia with mean of 263.30±16.45 and 683.30±43.38 mg/l at Kafr El Shiekh farms, respectively (Table 1). The increasing total hardness values at Sahl El-Tinna may be due to the increasing of salinity that led to increase of hardness. These results were in agreement with that observed by Adham (2001).

**Nitrate (NO₃)**

Its concentrations decreased in ponds of Sahl El-Hussaynia and increased in ponds of Sahl El-Tinna with mean values of 0.12±0.01 and 1.08±0.05 mg/l (Table 1). This may be related to different sewage effluents that contain nitrate which originated from domestic and agricultural wastes, especially from N-containing fertilizers. Similar observations were recorded in fish ponds and El-Berka drain in Fayoum by Konsowa (2007).

**Nitrite (NO₂)**

High nitrite concentrations deactivate hemoglobin in the blood of fish, thus causing hypoxia (Mansour, 2009). Nitrite toxicity is affected by many chemical factors as calcium, bicarbonate...ect. It is rarely a problem in salt water and brackish
Water quality and heavy metals in water and tissues of Nile tilapia

The levels of nitrite in this study were 0.32±0.02, 0.26±0.02, 0.06±0.01 mg/l in Sahl El-Hussaynia, Kafr El-Shiekh and Sahl EL-Tinna fish farms, respectively. The nitrite was relatively low in Sahl El-Tinna fish ponds as a result of high value of nitrate-reducing bacteria (Koussa, 2000). Moreover, the highest concentration was recorded at Sahl El-Hussaynia which may be attributed to the direct impact of domestic and agricultural sewage discharged in these areas.

**Ammonia (NH\(_3\))**

Unionized ammonia (NH\(_3\)) is extremely toxic substance to aquatic animals that retards fish growth and may increase their susceptibility to other unfavorable conditions in fish culture system (Boyd, 1990). The European Inland Fisheries Advisory Commission (EIFAC, 1973) stated that the toxic concentration of unionized ammonia to freshwater fish for short term exposure is ranged from 0.7 to 2.7mg/l. The highest value was observed in ponds of Kafr El-Shiekh (0.49±0.04 mg/l), due to higher pH. At high pH, more and toxic ammonia is released to critical levels (Boyd, 1990). The present results agreed with those of Meade (1985) and Konsowa (2007).

**Orthophosphate (PO\(_4\))**

The lowest value of phosphate concentration was recorded in ponds of Sahl El-Hussaynia and the highest was in Sahl El-Tinna, with mean values of 0.03±0.01 and 0.64±0.06 mg/l, respectively. This may be due to agricultural run-off containing phosphate fertilizers as well as wastewater (domestic) containing detergents. The values of phosphate were similar with the study of Ali (2007) in fish ponds.

Heavy metals are the most dangerous contaminants, since they are persistent and accumulate in water, sediments and tissues of the living organisms, through bio-concentration (uptake from the ambient environment) and bio-magnification (uptake through the food chain) (Chaphekar, 1991). As a part of the aquatic environment, fish could accumulate heavy metals and acted as indicator of pollution (Mersch et al., 1993).

In Table (2), results of heavy metals in water samples showed some variations in their concentrations among the three fish farms. It is clear that iron, copper and cadmium showed the highest values at Kafr El-Shiekh farm (1.49±0.16, 0.06±0.01 and 0.003±0.001 mg/l, respectively), while Zinc showed its highest level in Sahl El-Hussaynia farm (1.12±0.16 mg/l). In addition, the water of Sahl El-Tinna maintained generally lower metal contents than Sahl El-Hussaynia and Kafr El-Shiekh farm water except for zinc concentration. This may be attributed to the higher hardness and alkalinity (Malcolm, 1995) who revealed that at higher values of these variables the metals bind to form hydroxide and carbonate complexes which are considered less toxic to fish rather than the metal ions.

Table 2: Mean concentrations of heavy metals (mg/l) in water of Sahl El-Hussaynia, Kafr El-Shiekh and Sahl El-Tinna private fish farms during June to September 2014

<table>
<thead>
<tr>
<th>Locations Items</th>
<th>Sahl El-Hussaynia</th>
<th>Kafr El-Shiekh</th>
<th>Sahl El-Tinna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>0.95±0.29 A</td>
<td>1.49±0.16 A</td>
<td>0.73±0.02 B</td>
</tr>
<tr>
<td>Zn</td>
<td>1.12±0.16 B</td>
<td>0.73±0.02 C</td>
<td>1.61±0.18 A</td>
</tr>
<tr>
<td>Cu</td>
<td>0.05±0.01 A</td>
<td>0.06±0.01 A</td>
<td>0.02±0.01 B</td>
</tr>
<tr>
<td>Pb</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Mn</td>
<td>0.03±0.01 B</td>
<td>0.16±0.03 A</td>
<td>0.001±0.00 C</td>
</tr>
<tr>
<td>Cd</td>
<td>0.002±0.001 A</td>
<td>0.003±0.001 A</td>
<td>0.001±0.00 B</td>
</tr>
</tbody>
</table>

*Means with the same letter within the same row are not significantly different
*ND = not detected limits

Thus, there are reductions in levels of the metallic ions (which are more toxic) at high alkalinity and hardness values. However concentrations of heavy metals (Zn,
Cu, Pb & Cd) in this study are below the permissible limits according to WHO (2011) and there no health based guideline–value for both Fe and Zn.

There was a positive correlation between total hardness, NO$_3$ and PO$_4$ with total alkalinity $r = 0.875$, 0.893 and 0.890, respectively, while a negative correlation was found between total alkalinity and total hardness with Fe $r = -0.843$ and -0.915, respectively. On the other hand, a negative correlation was recorded between total hardness and Cd, $r = -0.865$ but the correlation between pH and NH$_3$ with Cu was positive, $r = 0.937$ and 0.905, respectively, where a negative correlation was found between Fe and Cd with NO$_3$, $r = -0.849$ and -0.820. Moreover, the correlation between Fe and Cd with PO$_4$ was negative, $r = -0.891$ and -0.842, respectively.

The correlation coefficient matrix of water physico–chemical parameters indicated that, pH had positive correlation with ammonia and Cu, where the toxicity of water depends on the amount of unionized ammonia present, which increases when pH increases. These results agreed with that observed by Mohamed (2005). Also, Pyle et al. (2005) reported that water hardness is an important factor, that decreasing heavy metals accumulation. Where the present results revealed that there was a negative correlation between hardness and Cd concentration.

**Correlation between heavy metals and water quality parameters**

<table>
<thead>
<tr>
<th></th>
<th>T. alk</th>
<th>T. hard</th>
<th>DO</th>
<th>pH</th>
<th>NH$_3$</th>
<th>Temp</th>
<th>NO$_3$</th>
<th>NO$_2$</th>
<th>PO$_4$</th>
<th>Fe</th>
<th>Zn</th>
<th>Cu</th>
<th>Cd</th>
</tr>
</thead>
<tbody>
<tr>
<td>T. alk</td>
<td>1.00***</td>
<td>0.875**</td>
<td>-0.567</td>
<td>-0.714*</td>
<td>-0.560</td>
<td>0.224</td>
<td>0.893**</td>
<td>-0.640</td>
<td>0.890**</td>
<td>-0.843**</td>
<td>0.400</td>
<td>-0.774*</td>
<td>-0.660</td>
</tr>
<tr>
<td>T. hard</td>
<td>1.00***</td>
<td>-0.549</td>
<td>-0.454</td>
<td>-0.225</td>
<td>-0.132</td>
<td>0.975**</td>
<td>-0.616</td>
<td>0.971**</td>
<td>-0.915**</td>
<td>0.100</td>
<td>-0.525</td>
<td>-0.865**</td>
<td></td>
</tr>
<tr>
<td>DO</td>
<td>1.00***</td>
<td>0.726*</td>
<td>-0.603</td>
<td>-0.069</td>
<td>-0.644</td>
<td>0.282</td>
<td>-0.527</td>
<td>0.240</td>
<td>-0.451</td>
<td>0.589</td>
<td>0.341</td>
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</tr>
<tr>
<td>PH</td>
<td>1.00***</td>
<td>-0.714*</td>
<td>-0.472</td>
<td>-0.608</td>
<td>0.227</td>
<td>-0.425</td>
<td>0.318</td>
<td>-0.596</td>
<td>0.937**</td>
<td>0.156</td>
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</tr>
<tr>
<td>NH$_3$</td>
<td>1.00***</td>
<td>-0.649</td>
<td>-0.403</td>
<td>0.180</td>
<td>-0.199</td>
<td>0.103</td>
<td>-0.558</td>
<td>0.905**</td>
<td>-0.037</td>
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<tr>
<td>Temp</td>
<td>1.00***</td>
<td>-0.463</td>
<td>-0.098</td>
<td>0.100</td>
<td>0.256</td>
<td>-0.432</td>
<td>0.374</td>
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<tr>
<td>NO$_3$</td>
<td>1.00***</td>
<td>-0.565</td>
<td>0.923**</td>
<td>-0.849**</td>
<td>0.143</td>
<td>-0.673*</td>
<td>-0.820**</td>
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<tr>
<td>NO$_2$</td>
<td>1.00***</td>
<td>-0.674*</td>
<td>0.582</td>
<td>-0.065</td>
<td>0.252</td>
<td>0.443</td>
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<tr>
<td>PO$_4$</td>
<td>1.00***</td>
<td>-0.891**</td>
<td>0.237</td>
<td>-0.472</td>
<td>-0.842**</td>
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<tr>
<td>Fe</td>
<td>1.00***</td>
<td>-0.020</td>
<td>0.437</td>
<td>0.766*</td>
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<tr>
<td>Zn</td>
<td>1.00***</td>
<td>-0.399</td>
<td>0.161</td>
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<tr>
<td>Cu</td>
<td>1.00***</td>
<td>0.340</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Cd</td>
<td>1.00***</td>
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</tr>
</tbody>
</table>

Fish are notorious for their ability to concentrate heavy metals in their tissues. The metals exist most probably as cationic complexes and accumulate in the internal organs of fish. Table (3) shows the mean concentrations of the analyzed metals in the tissue (muscles, gills & livers) and bioaccumulation factor of *O. niloticus* of El-Hussaynia, Kafr El-Sheikh and Sahl El-Tinna private fish farms during summer season (June to Sept., 2014). Iron was the most abundant metal in the studied tissues of the fish samples. Fe accumulation was the maximum in all the organs but its highest value was observed in the muscles of fish from Sahl El-Tinna and liver and gills of those from Kafr El-Sheikh farm. Ferric and ferrous compounds can affect gills and pond productivity by taking up phosphate and restricting plankton growth (WHO, 1984). However accumulation levels reported in the present study for liver and gills of Kafr El-Sheikh farm were 155±4.00±21.90 and 385.27±38.11 mg kg$^{-1}$, respectively. Fe concentration in all organs of the three locations was higher than the permissible limits (30 mg/kg) that recorded by WHO (1989).
Table 3: Mean concentrations of heavy metals (mg/kg) in muscles, gills and livers of *O. niloticus* collected from Sahl El-Hussaynia, Kafr El-Sheikh and Sahl El-Tinna private fish farms during June to September 2014

<table>
<thead>
<tr>
<th>Metal</th>
<th>Organ</th>
<th>Sahl El-Hussaynia</th>
<th>BAF</th>
<th>Kafr El-Sheikh</th>
<th>BAF</th>
<th>Sahl El-Tinna</th>
<th>BAF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>M</td>
<td>134.07 ±10.48 B</td>
<td>141.13</td>
<td>110.56 ±22.95CB</td>
<td>74.20</td>
<td>163.01 ±22.82 A</td>
<td>233.30</td>
</tr>
<tr>
<td></td>
<td>G</td>
<td>350.50 ±10.81A</td>
<td>368.94</td>
<td>385.27 ±38.11A</td>
<td>258.57</td>
<td>369.3 ±72.53 A</td>
<td>505.80</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>1447.00 ±82.34 A</td>
<td>1523.00</td>
<td>1554.00 ±21.90 A</td>
<td>1042.95</td>
<td>1388.00 ±180.10 A</td>
<td>1901.00</td>
</tr>
<tr>
<td>Cu</td>
<td>M</td>
<td>6.25 ±0.17 A</td>
<td>125.00</td>
<td>2.88 ±0.26 B</td>
<td>48.00</td>
<td>2.20 ±0.73 B</td>
<td>110.00</td>
</tr>
<tr>
<td></td>
<td>G</td>
<td>10.10 ±0.67 A</td>
<td>202.00</td>
<td>11.04 ±2.84 A</td>
<td>184.00</td>
<td>4.49 ±0.38 B</td>
<td>224.50</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>45.17 ±0.73 B</td>
<td>903.40</td>
<td>42.97 ±12.43 B</td>
<td>716.16</td>
<td>177.11 ±30.00 A</td>
<td>8855.50</td>
</tr>
<tr>
<td>Zn</td>
<td>M</td>
<td>88.30 ±4.43 A</td>
<td>78.83</td>
<td>28.22 ±2.84 B</td>
<td>38.66</td>
<td>29.10 ±2.88 B</td>
<td>18.07</td>
</tr>
<tr>
<td></td>
<td>G</td>
<td>180.29 ±23.20 A</td>
<td>160.97</td>
<td>102.9 ±27.84 B</td>
<td>140.96</td>
<td>39.03 ±4.60 B</td>
<td>24.24</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>272.60 ±2.60 A</td>
<td>243.39</td>
<td>258.6 ±35.04 AB</td>
<td>354.25</td>
<td>230.10 ±38.9 B</td>
<td>142.92</td>
</tr>
</tbody>
</table>

Cd and Pb were not detected

*Means with the same letter within the same row are not significantly different

*BAF = Bioaccumulation Factor

The highest mean Bio-Accumulation Factor (BAF) of Fe in the muscle (233.3) was observed in fish of Sahl El-Tinna farm, while the lowest (74.2) was observed in Kafr El-Sheikh farm. In gills, the highest BAF (505.8) was observed in Sahl El-Tinna while the lowest (258.57) in Kafr El-Shiekh. In liver, the highest one (1901) was in Sahl El-Tinna, while the lowest one (1042) was in Kafr El-Shiekh. Low accumulation of metals in muscles may be due to lack of binding affinity of these metals with the proteins of muscles. This is particularly important because muscles contribute the greatest mass of the flesh that is consumed as food.

Copper is commonly a natural element in water and sediment. The metal is insoluble in water, but many of its salts are highly soluble. Copper is a fundamental micronutrient to all forms of life, in enzyme activity and random rearrangement of natural proteins (Bower, 1979). At slightly higher but sublethal concentrations, it causes chronic toxicity to aquatic life. Gainey and Kenyon (1990) mentioned that exposure of fishes to sublethal concentrations of copper leads to cardiac activity and reduction in heart rate. Dietary Cu level of 20 mg/kg significantly reduced the weight gain of growing tilapia (Shiau and Nig, 2003). Chronic toxic effects may induce poor growth, decreased immune response, shortened life span, reproductive problems, low fertility and changes in appearance and behavior (Choongo *et al*., 2005).

The mean values of copper in the fish organs followed the order: liver > gills > muscles. The concentrations of Cu in the muscles and gills of *O. niloticus* in the three different locations were lower than the permissible limits (20 mg/kg) reported by WHO (1989), while its concentrations in the liver were higher than the permissible limits. Gills accumulated lesser copper than liver. In the present study, the lowest concentrations of Cu were observed in the muscles of studied fish, similar to results recorded by Khaled (2004) and Abdo & Yacoub (2005). The highest BAF of Cu in muscle of fish were (220) recorded in Sahl El-Tinna farm and the lowest one (48) was observed in Kafr El-Sheikh, while the maximum value in gills (449) recorded in Sahl El-Tinna and the minimum value was (20) recorded in Sahl El-Hussaynia but in the liver the highest BAF was (716) recorded in Kafr El-Sheikh and the lowest one was (21) in Sahl El-Tinna.
Zinc is an essential element for normal growth, reproduction and longevity of animals (Sultana and Roa, 1998). Mining, smelting and sewage disposal are the major sources of zinc pollution (Skidmore, 1964). The mean values of zinc in fish liver were higher than those in gills and muscles. The maximum permissible level (MPL) of zinc is 50 µg/g dry wt according to Australian NHMRC (Bebbington et al., 1977) and 40 µg/g dry wt according to Food and Agriculture Organization (FAO, 1983). The mean values of zinc in the gills, liver and muscles of *O. niloticus* in Sahl El-Hussaynia were significantly higher than (MPL), while in fish muscles of Kafr El-Sheikh and muscles, gills tissue of Sahl El-Tinna fish farm was lower than (MPL). The concentrations of heavy metals (Fe, Cu, Zn, Pb, and Cd) vary according to locality (Yacoub, 2007). Metal accumulation in tissues of fish is depend upon environmental factors such as temperature, total hardness, size and age of fish and processes of biotransformation and excretion (Zhou et al., 2001).

### Table 4: Changes in serum glucose, total protein, AST and ALT of the *O. niloticus* collected from Sahl El-Hussaynia, Kafr El-Sheikh and Sahl El-Tinna private fish farms during June to September 2014

<table>
<thead>
<tr>
<th>Locations</th>
<th>Parameters</th>
<th>Sahl El-Hussaynia</th>
<th>Kafr El-Sheikh</th>
<th>Sahl El-Tinna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>25.86±5.48 AB</td>
<td>13.50±1.00 B</td>
<td>32.14±2.89 A</td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>1.93±0.15 AB</td>
<td>1.48±0.13 B</td>
<td>2.81±0.47 A</td>
<td></td>
</tr>
<tr>
<td>AST</td>
<td>53.92±11.99 A</td>
<td>36.12±5.90 A</td>
<td>35.24±1.70 A</td>
<td></td>
</tr>
<tr>
<td>ALT</td>
<td>16.83±0.71 A</td>
<td>17.43±1.54 A</td>
<td>6.92±0.62 B</td>
<td></td>
</tr>
</tbody>
</table>

*Means with the same letter within the same row are not significantly different*

Data in Table 4 shows fluctuations in glucose, total protein, AST and ALT in serum of *O. niloticus* through the different locations. However, these changes didn't take a certain or definite trend pattern. Edsall (1999) stated that biochemical characteristics of blood are important indices of the status of internal environment of the fish. Biochemical profile in fish has proved to be a sensitive index for evaluation of the fish metabolism under metallic stress. Almeida *et al.* (2001) proved that, fish subjected to metals showed reduced levels of proteins, ALT and AST activities in the fish muscles. Also, Loskova *et al.* (2002) mentioned that changes in the biochemical blood profile are mirror changes in metabolism and biochemical processes of the organism, resulting from the effect of pollutants such as the heavy metals.

**Correlation between heavy metals in liver and blood parameters**

<table>
<thead>
<tr>
<th>Fe</th>
<th>Cu</th>
<th>Zn</th>
<th>Cd</th>
<th>Glucose</th>
<th>T. pro</th>
<th>AST</th>
<th>ALT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000</td>
<td>-0.369</td>
<td>0.196</td>
<td>0.210</td>
<td>-0.241</td>
<td>-0.102</td>
<td>0.326</td>
<td>0.218</td>
</tr>
<tr>
<td>Cu</td>
<td>1.000</td>
<td>-0.363</td>
<td>-0.968&quot;</td>
<td>0.678&quot;</td>
<td>0.802&quot;</td>
<td>-0.280</td>
<td>-0.810&quot;</td>
</tr>
<tr>
<td>Zn</td>
<td>1.000</td>
<td>-0.194</td>
<td>-0.012</td>
<td>0.196</td>
<td>0.210</td>
<td>0.091</td>
<td></td>
</tr>
<tr>
<td>Cd</td>
<td>1.000</td>
<td>-0.787</td>
<td>0.870&quot;</td>
<td>0.337</td>
<td>-0.809&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucose</td>
<td>1.000</td>
<td>0.637</td>
<td></td>
<td>0.018</td>
<td>-0.573</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T. pro</td>
<td>1.000</td>
<td>-0.055</td>
<td>-0.735*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AST</td>
<td>1.000</td>
<td>0.294</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALT</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

In conclusion, levels of heavy metals found in the edible tissues (muscle) of the examined fish samples of the three locations were within the safe limits for human health according to WHO (1989) except iron, zinc, while WHO (2011) reported that no health based guide line-value for both iron and zinc. In addition, it is necessary to exercise more cautions towards water resources in these areas to keep water suitability
for aquaculture, or at least the production of good fish, which negatively affects the health of human being and general economy.

REFERENCES

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ARABIC SUMMARY

تقييم ووية المياي وتركيز المؼادن الثقيلة في مياي وأوسجة البلطي الىيلي في بعض المحافظات المصرية

نعمه عبد الفتاح علي٣ - عمالى عبد الرحمن مى٣ - إيمان عملى عبد السميع عبد الحميد٢

1- قسم بيئه وبيولوجيا الأسماك المعمل المركزى لبيكوت الثروة السمكية بالعباسة - أبوحماد - شرقيه - جمهورية مصر العربية

2- قسم الجيولوجى المعمل المركزى لبيكوت الثروة السمكية بالعباسة - أبوحماد - شرقيه - جمهورية مصر العربية

تأثر جميع الكائنات المائية بشكل مباشر أو غير مباشر من خلال خصائص بيئتها الطبيعية والكيميائية، ولا سيما التركيب الكيميائي للمياه حيث تعتبر العامل الرئيسي الذي يؤثر على الأسماك المستقرزة. لذلك كانت هذه الدراسة للتعرف على خصائص المياه وتاثيراتها على الأسماك المرباة في ثلاث مزارع مختلفة في سهل الحسينى بمحافظة الشرقية، وخاصة كفر الشيخ وذوق سهل الطينية بمحافظة بورسعيد، جمهورية مصر العربية.

أظهرت الدراسة تبايناً واضحاً في الخصائص الفيزيائية والكيميائية (درجة حرارة الماء، ودرجة الحموضة، NO₃،NH₃،DO، القربية الكلية، العصر الكلى، الفوسفات) في عينات المياه خلال موسم الصيف سنة 2014 كذلك تباينت المعادن الثقيلة في المياه ونسبة الأسماك (العضلات والبخاخين والكبد). كما تأثرت القياسات البيولوجية (الجلوكوز والبروتينات الكلى وأشباه النيتروجين) في الدم الأسماك سبباً في حالة الأسماك المرضية فما في كفر الشيخ كان أحدى النقص، في بعض الدراسات، والبخاخين والكبد كان نقص في الأحماض الثلاثة، ولم يتم رصد الرصاص أو الكادميوم.

وفي الكبد تجاوزت مستويات المعادن الثقيلة الحديد السبعة بمعدل borderColor= "#f00"" class="highlight" data-line-number="15" >أربعة (1989).

وفي البحوث تجاوزت مستويات النيك الحديد الما في سهل الحسينى وفكر الشيخ أما في الخصائص، فلم تتجاوز الحدود السبعة بشكل ما. وبناء عليه يمكن أن نخلص إلى أن مستويات المعادن الثقيلة محذرة الدراسة في الأجزاء المصابة للأكر (العضلات) في جميع المواقع كانت أقل من الحدود السبعة، وتعتبر أمانة للإفلاك البشري. بالإضافة إلى أنه من الضروسية ممارسة المزيد من الاحتباسات تجاه المواد الثقيلة في هذه المناطق لحلفاء على صلحيتها لتربية الأحياء المائية، أو على الأقل إنتاج أسماك جيدة حفاظاً على صحة الإنسان والاقتصاد العام.