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# Effect of Some Water Drains on Heavy Metals Accumulation in Nile Tilapia as Compared to River Nile

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## ABSTRACT

In the current study, a comparison was conducted between different water drains (Bahr El-Baqar, El-Rahawy and Um El-Resh) and the River Nile water at El-Kanater sector in terms of muscle pollution. In addition, the effect of pollution on heavy metals concentrations in the liver and gills of fish samples from different locations was studied. All heavy metal concentrations examined for the Nile tilapia harvested from El-Rahawy and Um El-Resh were lower than the permissible limits, except for lead which showed slightly higher values. The levels of all studied metals such as Fe, Zn, Cu and Pb were above the permitted levels for human consumption in Bahr El-Baqar drain. Consequently, fish consumption from Bahr El-Baqar drain should not be permitted. While, the Nile tilapia sampled from the River Nile is safe for human consumption. Higher pollution levels were recorded for Bahr El-Baqar drain, with regard to four heavy metals including Fe, Zn, Cu and Pb. Consequently, a strict monitoring program should be applied in order to sustain the safety of the Nile tilapia for consumers.

## INTRODUCTION

The eutrophication of drain water resulting from municipal sewage and agricultural drain water loaded with fertilizers leads to higher photosynthetic activity. Algae, which are lately eaten by fish, absorb huge amounts of heavy metals during photosynthesis. **El- Wasify *et al.*( 2019)** explained that polluted water transfer heavy metals through the food chain; with natural food uptake by fish, metals increase in fish tissue, and subsequently become a threat to human beings. **El-Sheekh (2009)** postulated that, the bioaccumulation of heavy metals in fish can reach up to 106 times their concentration in water through natural food uptake.

At current times, pollution of aquatic environment is considered a growing and important problem worldwide since heavy metals accumulate in fish through food chain at toxic concentrations **(Al- Kenawy & Aly, 2015)**. Therefore, fish are considered as bio-indicators of aquatic system health **(Wildianarko *et al.*, 2000)**. Fish are used in evaluating aquatic health, especially the Nile tilapia that has ecological value, being economically important as food for low income families **(Alaa, 2012)**.

Fish muscles constitute the edible part of fishes that are used in evaluating health risk and permissible limits since humans obtain approximately 25% of animal protein from its consumption **(Bahnasawy *et al.*, 2009; El Batrawy *et al*., 2018)**.

The current study investigated the concentrations of nine heavy metals (Fe, Zn, Cr, Mn, Ni, Cu, Co, Pb and Cd) in muscles, gills and livers of the Nile tilapia, compared to the national and international permissible limits. The main objectives of the Egyptian government are to improve the quality of harvested fish. Several authors assessed that the Egyptian drains include 90 drains covering agricultural drains, industrial drains as well as untreated sewage drains **(Abd El Satar *et al*., 2017; Gohr *et al*., 2019)**.

Contamination of fish organs is an early warning of water quality problems, and it is used to safeguard public health **(Mansour & Sidky, 2002; Darweesh *et al*., 2019)**. **El Sayed *et al*. (2011)** elucidated that, the concentrations of heavy metals in edible parts of fish can be used to compare and bio monitor safety of fish consumption among different locations.

Fish uptake of heavy metals can be performed through two mechanisms: polluted water (adsorption) and from feeding on polluted algae and plankton present in the food chain, consequently fish are considered as an indicator of pollution **(Ali *et al.*,2016)**.

Tilapia is known as one of the cultivated species used in fish culture in Egypt and is reared in drain water according to the Egyptian Law. Therefore, the study of pollution of the Nile tilapia reared in drain water is important to protect human health.

The objectives of the current study included the comparison between different water drains (Bahr EL-Baqar, EL-Rahawy and UM El-Resh) and the water of the River Nile at El-Kanater sector in terms of muscles pollution. The effect of pollution on heavy metals concentrations in the liver and gills of fish sampled from different locations was also studied.

## MATERIALS AND METHODS

The present study was carried out at the Central Laboratory of Environmental Quality Monitoring, Ministry of Water Resources and Irrigation, Egypt. The objectives of study was to compare heavy metals accumulation in medium-sized Nile tilapia harvested from three major drains (Bahr El-Baqar, El-Rahawy and Um El-Resh) compared to those harvested from the River Nile at El Kanater El Khyria. Nine heavy metals were tested for their accumulation in different organs of the Nile tilapia (liver, gills and muscles) harvested from these different sites. The tested fish tissues were examined for levels of heavy metals (cadmium, chromium, cobalt, copper, lead, iron, zinc, nickel and manganese) on dry matter basis. Random samples of medium-sized Nile tilapia (300-350 grams each) were harvested from each drain as well as the site chosen along the River Nile to examine the variation of the levels of heavy metal accumulations among different sites as well as among different organs.

### 1. Heavy metals analysis in fish

To determine heavy metals accumulation in different organs of the Nile tilapia, harvested fish were dissected to separate liver, gills and muscles of each fish. These organs were oven dried at 105ºC for 12 hours until constant weight was obtained. One gram dry weight of each organ was transformed to ash using muffle furnace (550ºC). Digestion of ash was performed using concentrated nitric acid, which was diluted with 2N HCl to a constant volume.The digested solution was cooled to room temperature, filtered and diluted to reach a final volume of 25ml using deionized water. Heavy metals concentrations in selected organs were determined according to **APHA (1998)** guidelines using Inductivity Coupled plasma device (ICP OES 5300 DV,U.S.A). All metals concentrations in the Nile tilapia tissues were reported in mg/kg dry weight since dry weight comparison yields stable figures for comparison.

### 2. Study area

The study sites are located in northern Egypt. Three drains were selected during the current study. Bahr El-Baqar drain is located in the eastern Delta passing through Qalubyia, Sharqia, Ismailia and Port Said Governorates, and most drains are located in the Sharqia Governorate, with coordinates of 31˚ 7’0" N and 32˚ 6’0" E. It runs from Cairo to Lake Manzala for about 170 km, with a depth range of 1 – 3m and width range of 30–70m **(Taha *et al*., 2004; Fouad *et al*., 2020)**, whereas El-Rahawy drain lies between latitudes 30˚10 N to 30˚12 N and longitudes 31˚2 E to 31˚3 E. It is about 12.41km and passes through El-Rahway village, receiving from many villages that are established along its sides agricultural and domestic wastes that are left without purification in addition to the sewage of El-Giza Governorate while discharging these wastes directly without treatment into the Roetta branch of the River Nile **(El-Sheekh *et al*., 2010)**. On the other hand, Um El-Resh drain is in Port Said Governorate and is disbursed into Bahr Al-Baqar drain at El Kanater El-Khyria 30° 11' 53" N 31° 07' 28" E. Compared to the River Nile, Bahr El-Baqar and El-Rahawy drains are characterized by heavy pollution of sewage and industrial wastes.

### 3. Sampling

Within each site, all nine metals were analyzed in triplicate samples, and sampling was repeated three times during the summer season. All fish samples analyzed during the experiment totaled 108 specimens (27 specimens from each site). Each analyzed sample was a composite sample from three fishes (pooled samples). Each sample included one gram dry weight tissue taken from each dissected organ, with triplicate samsples from each site replicated three times during the summer season.

### 4. Statistical analysis

The descriptive analyses of data (means and standard deviations) were obtained using the computer program (SPSS In., version 8.0 for windows). The experiment was designed and statistically analyzed as a completely randomized design. Data were subjected to one-way analysis of variance, and Duncan multiple range test was used to determine differences among treatment means (**Duncan.1955**). Probability level (0.05) was set for significance. Duncan multiple range test was employed to detect significant difference among means in different locations and different tissues.

## RESULTS AND DISSCUSION

### 1. Cadmium pollution

The observed levels of cadmium in muscle tissues of the Nile tilapia ranged from 0.165- 0.602mg/ kg ( Table 1) among different sites during the current study and were lower than the upper guideline limits of 2.0mg/ kg, as recommended by **(WHO, 1995; FEPA, 2003)**. For all sampled fish from all sites, Cd values were lower than the acceptable permissible limits approved by **USEPA (2000)** and **FDA (2001)**. Moreover, values were lower than the Egyptian law (**E.O.S.Q.C, 1993**), which indicated permissible limits of 2.0mg/ kg on dry weight basis. Higher cadmium concentration in the Nile tilapia may originate from pesticides and superphosphate. The main sources of Cd contamination include agricultural activities and industrial activities (electrical appliances and ceramics) as reported by **Ahmed *et al*. (2018**). **Cicik and Engin (2005)** explained that cadmium is absorbed from water by gills and from food (i.e. algae and plankton) via digestion, and thereafter is transported by blood to the liver, where accumulation takes place. **Khaled (2004)** postulated that cadmium could be adsorbed through gills and absorbed through food chain, with a distribution pattern in a decreasing order (liver> gills> muscls).

### 2. Lead pollution

The highest Pb concentration (5.94 mg/kg) in muscles was recorded in Bahr El Baqar drain, while intermediate values were recorded in El-Rahawy and Um El Resh locations (2.46 & 2.89mg/ kg, respectively). It was noticed that the lowest muscles' pollution was recorded in the River Nile site (0.028mg/ kg). Consequently, fish obtained from Bahr El Baqar exceeded the permissible limits representing a high risk to the health of consumers.

Accumulation of lead in tilapia muscles may be due to the use of fertilizers, gasoline, paints and cosmetics **(Ahmed *et al*., 2018)**. Excessive lead levels among drains have primarily induced by house hold plumping. In this respect, **Sharmeen *et al*., (2014**) reported that domestic sewage is a major source of lead. The levels of Pb observed in fish muscles sampled from the River Nile were lower than the upper permissible limits of 2.0mg/ kg (**WHO, 1985; FEPA, 2003**).The highest Pb concentration was observed in the muscles of tilapia from sewage drains (Bahr El Baqar and El Rahawy):(2.89-5.94 mg/kg),while Pb in the River Nile recorded lower values. Lead concentrations in sampled tilapia fluctuated between 2.46 & 5.94mg/ kg on dry weights basis in all studied drains, recording values higher than the permissible limits reported by **WHO (1989)**, **Egyptian laws (1993)** and **E.C. reports (2006)** which indicate a maximum permissible limit of 2.0mg/ kg on dry weight basis.

**Callender (2014)** illustrated that atmospheric deposition, phosphate mineral sources and rock weathering are main inputs for heavy metals pollution in aquatic environment. **Helmy *et al*. (2020)** claimed that lead accumulation in water could be ascribed to industrial and agricultural discharges, dust polluted by lead in air and lead contained in pesticides and dissolution of lead plumping **(Sepe *et al*, 2003)**.

The concentration of lead during the current study showed the lowest values in the muscles of the Nile tilapia (0.028 mg/kg dry weight) gathered from the site chosen in the River Nile, while intermediate values were recorded in the Nile tilapia muscles (2.46-2.89 mg/kg dry weight) in El-Rahawy and Um El-Resh drains. Fish samples collected from

Bahr El-Baqar drain had the highest lead concentrations compared to those of other locations. **Ibrahim and Omar (2013)** postulated that cadmium and lead are considered the most toxic heavy metals in terms of carcinogenic hazard. The sewage drains examined during the current study (Bahr El Baqar and El Rahwy drains) had higher muscles' pollution than those of Um El-Resh drain.

When sampling locations were compared, the River Nile site had muscle concentration of cadmium (0.139mg/ kg), while the respective concentration of lead recorded a value of 0.028mg/ kg, which are considered well below the permissible guideline limits, being safe for human consumption. Whereas, Bahr El Baqar and El Rahawy sewage drains were above the permissible limits in terms of muscle concentrations regarding the health hazards of cadmium and lead. The potential human health risk under the exposure to lead above the permissible limits through adult ingestion includes both carcinogenic and non-carcinogenic hazards. Edible fish tissue for cadmium were within the **Egyptian organization laws (1993)**, while those for lead in all drains were above the permissible limits of the **Egyptian organization guidelines (1993)**.

**3. Zinc and iron pollution**

Bahr El Baqar site showed the highest concentration of Zn in the muscles of the Nile tilapia (126.7mg/ kg dry weight). Lower values of Zn concentrations were detected in the muscles of the Nile tilapia (0.635- 16.1mg/ kg) in the River Nile,Um El Resh and E Rahawy drains. These values are considered within the safe limits for human consumption and do not represent hazard for human health. On the other hand, fish collected from Bahr El Baqar drain represent a greater risk hazard to human health since muscles' value for Zn (126.7 mg/kg) exceeded the permissible limits of 40.0mg/ kg.

Zinc and iron were registered at the highest concentrations in all organs, with the highest levels in liver and gills tissues, followed by muscles. Fish accumulated zinc and iron from both diet (food chain) and surrounding water, with significant differences among different sites. Since liver accumulated higher levels of heavy metals than muscles, it is supposed that polluted food (i.e. algae and plankton) was the primary source for uptake of heavy metals.

In addition, the Fe residues in the muscles of the Nile tilapia ranged from 6.72-12.72mg/ kg dry weight in all drains and the River Nile alike, except for those of Bahr El-Baqar which averaged 154.97mg/ kg dry weight. Similarly, zinc concentration in fish muscles of Bahr El-Baqar drain (126.77mg/ kg dry weight) was extremely high compared to other sites, which recorded values fluctuating from 6.0- 16.1mg/ kg dry weight.

**4. Muscles pollution among sites**

Iron, zinc and copper were the most abundant elements in the Nile tilapia muscles, followed by lead and cadmium, as shown in the following sequential order: Fe>Zn>Cu>Pb>Cd. The least abundant elements followed a sequence where chromium>Manganese >cobalt>nickel. The result of the current study (Table1) indicate that fish muscles had lower concentrations of all elements than gills and liver. In general, heavy metals concentrations in tilapia muscles from the River Nile were within the international permissible limits; whereas, fish samples collected from Bahr El-Baqar drain showed the highest concentrations of Fe, Zn, Cu and Pb which are above the permissible limits. Consequently, edible parts (muscles) of the Nile tilapia from River Nile are safe for consumption. Higher concentrations of lead were observed in fish harvested from El-Rahway and Um El-Resh drains; however, all other metals were within the permissible limits set by **FAO (1983)**, **USEPA (2000)** and **WHO (2017)**.

The accumulation trends of heavy metals in muscles during the current study included major elements such as Zn, Fe and Cu, while other elements such as Mn, Ni, Cr and Co were minor elements. The Nile tilapia harvested from El-Rahawy and Um El-Resh had all heavy metal concentrations lower than the permissible limits, except for lead which had slightly higher values than the permissible limits according to **FAO (1983)**, **USEPA (2000)** and **WHO (2017)**. Generally, the levels of essential metals (Fe, Zn and Cu) were higher than those of non-essential metals (Pb and Cd).This finding coincides in with those of **Aly (2016)** and **Yacoub *et al.* (2021)**.

**Table 1.** Heavy metals accumulation (mg/kg dry weight) in muscle of medium-sized Nile tilapia harvested from different drains

| Element | Bahr El-Baqar | El-Rahawy | Um El-Resh | River Nile |
|---|---|---|---|---|
| **Cd** | 0.165 $\pm 0.055^{a}$ | 0.582 $\pm 0.400^{b}$ | 0.602 $\pm 0.181^{b}$ | 0.139 $\pm 0.010^{a}$ |
| **Pb** | 5.94 $\pm 1.50^{c}$ | 2.89 $\pm 0.943^{b}$ | 2.46 $\pm 0.105^{b}$ | 0.028 $\pm 0.009^{a}$ |
| **Cr** | 0.378 $\pm 0.060^{ab}$ | 5.03 $\pm 1.59^{c}$ | 0.261 $\pm 0.141^{a}$ | 1.88 $\pm 0.282^{b}$ |
| **Co** | 0.280 $\pm 0.261^{a}$ | 0.483 $\pm 0.200^{a}$ | 0.269 $\pm 0.026^{a}$ | 0.518 $\pm 0.165^{a}$ |
| **Mn** | 0.667 $\pm 0.273^{a}$ | 0.400 $\pm 0.302^{a}$ | 0.501 $\pm 0.405^{a}$ | 2.23 $\pm 0.363^{b}$ |
| **Ni** | 0.028 $\pm 0.010^{a}$ | 0.050 $\pm 0.019^{b}$ | 0.017 $\pm 0.002^{a}$ | 0.017 $\pm 0.002^{a}$ |
| **Cu** | 45.31 $\pm 25.66^{b}$ | 4.62 $\pm 0.848^{a}$ | 0.002 $\pm 0.001^{a}$ | 3.34 $\pm 1.27^{a}$ |
| **Zn** | 126.77 $\pm 15.33^{c}$ | 0.635 $\pm 0.361^{a}$ | 16.10 $\pm 2.22^{b}$ | 6.06 $\pm 2.37^{ab}$ |
| **Fe** | 154.97 $\pm 6.99^{b}$ | 6.72 $\pm 1.21^{a}$ | 12.72 $\pm 1.19^{a}$ | 8.54 $\pm 1.78^{a}$ |

**a,b… means in the same row with different superscripts are significantly different (*P*<0.05).**

### 5. Gills pollution among sites

For heavy metals accumulation in the gills of Nile tilapia (Table 2) considering the studied sites, Bahr El-Baqar drain had the highest levels of accumulation with respect Zinc (178.3 mg/kg), iron(174.5 mg/kg), copper (78.0 mg/kg) and lead (9.44 mg/kg). However, El-Rahawy drain had higher levels of copper (47.9 mg/kg) in the Nile tilapia gills. **Donia *et al*. (2017)** showed higher concentrations of heavy metals in gill samples compared to muscle samples. Gill tissues are in direct exposure to contaminated water which adsorbs to the external surface of gill apparatus **(Bahnasawy *et al*., 2009)**. The high levels in gills of fish may be explained by adsorption and absorption of heavy metals complexing with the mucus covering the external surface of gills. While, the thick layer of mucus covering gills allow the absorption of metals (**Salaah *et al*., 2022**). **Al Naggar *et al*. (2018)** showed that the gills and liver of the Nile tilapia had the highest levels of heavy metals compared to edible muscles. Remarkably, the type of organ in fish determines the concentration of heavy metals, being higher in gills and lower in muscles (**Houri *et al*., 2018**). Gills are continually exposed to water, consequently concentrations of heavy metals in gills reveal their concentration in drain water (**Romeo *et al*., 1999; Ahmed *et al*., 2014**).

**Omar *et al*. (2015)** elucidated that fish muscles' pollution could be used to evaluate the potential risk of fish consumption. Consequently, fish muscles contamination should be used to monitor pollution problems in aquatic environment which protect public health. Fish can absorb heavy metals directly via gills, and indirectly through polluted natural food (i.e. plankton through food chain). Phytoplankton and zooplankton accumulate large amounts of different heavy metals present in the environment, while fish feed on polluted food and concentrate it in different organs with higher concentrations.

### 6. Liver pollution among sites

When heavy metals levels in liver were compared among different sites (Table 3), it was observed that liver in Bahr El-Baqar site had higher levels of iron (365.2mg/ kg), zinc (246.9mg/ kg), copper (63.2mg/ kg) and lead (30.7mg/ kg).This indicates that liver in Bahr El-Baqar site had higher levels of heavy metals accumulations compared to those of other sites. Several studies reported that the highest heavy metals concentrations accumulated in the liver of fish and the lowest heavy metals concentrations accumulated in muscles and gills (**Mohamadi *et al*., 2011**). **Al-Kenawy and Aly (2015)** investigated heavy metals accumulation in different organs of fish and found that most metals' accumulation takes place in liver and gills, while fish muscles had the least metals levels. Moreover, **Ghannam *et al*. (2015)** explained that liver and gills have greater physiological role than muscles, leading to varying accumulation levels among different organs. In addition, liver is regarded as the primary organ of detoxification in fish and vertebrates. The distribution of heavy metal concentrations among organs followed the order of: liver>gills>muscles according to **Alaa (2012)**. **Yacoub (2007)** noticed that the liver of fish has high metallothionein, which performs the detoxification mechanism. While, liver is metabolically active organ, accumulating heavy metals in higher concentrations, in contrast to muscles which are considered non-active tissue **(Bahnasawy *et al*., 2009)**.

**Table 2.** Heavy metals accumulation (mg/kg dry weight) in gill of medium-sized Nile tilapia harvested from different drains

| Element | Bahr El-Baqar | El-Rahawy | Um El-Resh | River Nile |
|---|---|---|---|---|
| **Cd** | 0.358 ±0.106[a] | 0.376 ±0.125[a] | 3.31 ±1.51[b] | 0.135 ±0.039[a] |
| **Pb** | 9.44 ±1.50[c] | 3.06 ±0.320[b] | 9.96 ±0.941[c] | 0.487 ±0.174[a] |
| **Cr** | 0.393 ±0.01[a] | 6.06 ±2.94[b] | 0.681 ±0.254[a] | 0.260 ±0.072[a] |
| **Co** | 1.359 ±0.700[b] | 1.61 ±0.197[b] | 0.213 ±0.070[a] | 0.436 ±0.069[a] |
| **Mn** | 5.79 ±1.35[c] | 11.71 ±0.696[d] | 0.340 ±0.113[a] | 1.89 ±0.174[b] |
| **Ni** | 0.04 ±0.02[ab] | 0.06 ±0.028[b] | 0.020 ±0.004[a] | 0.027 ±0.003[ab] |
| **Cu** | 78.04 ±12.97[c] | 47.92 ±15.17[b] | 15.36 ±1.34[a] | 3.86 ±0.671[a] |
| **Zn** | 178.33 ±53.66[b] | 24.76 ±2.094[a] | 21.85 ±1.76[a] | 12.86 ±0.216[a] |
| **Fe** | 174.53 ±23.55[b] | 18.93 ±0.615[a] | 18.72 ±0.068[a] | 11.25 ±0.433[a] |

**a,b… means in the same row with different superscripts are significantly different (*P*< 0.05).**

The higher heavy metals concentrations in liver of fish can be ascribed to the presence of a binding protein (metallothionein), which works in metal homeostasis, lowering metal toxicity **(Abd El-Khalek *et al*., 2012)**. While, muscles have lower level of this binding protein **(Papagiannis *et al*., 2004)**. Liver is the organ with the highest heavy metals concentrations followed by gills, while muscle tissue has the lowest concentrations ( **El-Sayed *et al*., 2011**). Liver accumulates the highest level of all heavy metals, while muscles accumulate the lowest concentration according to **khaled (2004)**. Gills accumulated intermediate levels of all heavy metals, which showed that polluted natural food (algae and plankton) is the primary source for heavy metals uptake. The above results agree with the findings of numerous authors **(Saeed & Shaker, 2008; Farouk, 2009; Yosef & Goma, 2011; Abd-El-Khalek *et al*., 2012; El-Shaer & Al Abssawy, 2019; Aly *et al*., 2020; Farouk *et al*., 2020)**.

**Table 3.** Heavy metals accumulation (mg/kg dry weight) in liver of medium-sized Nile tilapia harvested from different drains

| Element | Bahr El-Baqar | El-Rahawy | Um El-Resh | River Nile |
|---|---|---|---|---|
| **Cd** | 0.287 ±0.110[a] | 2.35 ±1.303[b] | 2.33 ±0.953[b] | 0.991 ±0.721[ab] |
| **Pb** | 30.76 ±11.105[c] | 8.30 ±2.630[ab] | 18.08 ±1.172[b] | 2.86 ±0.733[a] |
| **Cr** | 0.690 ±0.201[a] | 5.90 ±1.499[b] | 0.591 ±0.276[a] | 4.57 ±0.846[b] |
| **Co** | 0.582 ±0.140[a] | 2.85 ±0.848[b] | 0.771 ±0.237[a] | 0.035 ±0.030[a] |
| **Mn** | 4.76 ±0.461[b] | 8.63 ±2.993[c] | 0.674 ±0.193[a] | 2.13 ±0.424[ab] |
| **Ni** | 0.065 ±0.014[a] | 0.070 ±0.012[a] | 0.066 ±0.046[a] | 0.042 ±0.039[a] |
| **Cu** | 63.23 ±22.81[b] | 58.51 ±25.43[b] | 13.24 ±0.868[a] | 3.67 ±0.431[a] |
| **Zn** | 246.96 ±37.16[b] | 47.87 ±13.71[a] | 18.41 ±1.45[a] | 16.64 ±1.96[a] |
| **Fe** | 365.23 ±141.81[b] | 165.55 ±32.34[a] | 24.13 ±5.30[a] | 17.38 ±2.72[a] |

**a,b… means in the same row with different superscripts are significantly different (*P*<0.05).**

## 7. Standard permissible limits

The levels of all studied metals (Fe, Zn, Cu and Pb) were above the permitted levels for human consumption with respect to Bahr El-Baqar drain. Consequently, fish consumption from Bahr El-Baqar drain should not be permitted. El-Rahawy and Um El-Resh drains had acceptable values of all heavy metals, except for lead where it ranged from 2.46- 2.89mg/ kg, which are not acceptable according to WHO, FAO and the Egyptian standards. The lowest heavy metal pollution in sampled fish was observed in the River Nile fish and were within the acceptable values for fish consumption according to the European Commission **(EC, 2006)** and **World Health Organization (2017)**.

According to world-wide standards, the results of the current study had acceptable permissible levels for fish consumption in the River Nile station at El-Kanater, while Um El-Resh and El-Rahawy drains had slightly higher levels of lead in fish but acceptable levels for all other heavy metals under study.

According to the **European commission (2006**), acceptable permissible limits for heavy metals in fish muscles must be below 40.0mg/ kg for zinc; 50.0mg/ kg for iron; 10mg/ kg for chromium and 30mg/ kg for copper in edible fish flesh. The WHO acceptable limits for the consumption of fish are 2.0mg/ kg for lead and 1.0mg/ kg for cadmium **(WHO**, **1995)**. Essential heavy metals that include manganese, iron, cobalt, and copper are necessary in fish metabolism but are toxic when their concentrations are high **(Gulec & Aksu, 2012)**. However, non-essential metals such as cadmium, chromium, lead and nickel are toxic to fish and human, even in trace concentrations. The Western Australian Food and Drug Regulations had set the permissible level of nickel at 5.5mg/ kg wet weight according **to Plaskett and Potter (1979)**. In Egypt, the maximum levels of pollution with heavy metals in fish muscles were set according to, **FAO (1983)** and **WHO (1989)** and **EOSQS (1993)**.

The concentrations of cobalt and manganese in the muscle of fish from the River Nile were slitghtly higher than those of drains due to the phytoremediation and biosorbtion of heavy metals by aquatic plants,alage and bacteria in drains compared to the River Nile. However, the concentration of cobalt and manganese in muscle of fish from the River Nile were within the permissible limits (0.5 mg/kg and 30 mg/kg respectevily) according to **FAO (1983)** and **FAO (1992).**

Concentrations of the studied metals in edible parts of tilapia samples were found within the safe limits in the River Nile station. In fish sampled from El-Rahawy and Um El-Resh drains, heavy metals concentrations in the edible part (muscles) were within the recommended levels for the human consumption, except for lead which had slightly higher values, while all other metals were within the recommended values for human consumption.

Lead concentrations in the muscles of the Nile tilapia were higher than the standard permissible concentration of lead in Bahr El-Baqar drain (5.9 mg/kg), El-Rahawy drain (2.89 mg/kg) and Um El-Resh drain (2.46 mg/kg). While, lead concentration in fish muscles samples collected from the River Nile (0.028 mg/kg) were within permissible concentrations as recommended by **WHO (1989)**.The increase in lead levels in fish muscles sampled from Um El-Resh drain is due to the discharge of large amount of agricultural drainage water entering into its channel.

In spite of heavy metals contamination in the edible fish muscles in El-Rahawy and Um El-Resh drains, all studied heavy metals did not exceed the recommended permissible limits, except for lead levels. However, some heavy metals in fish sampled from Bahr El-Baqar drain exceeded the standard permissible limits and are considered unsafe for human consumption.

Copper, iron and zinc have higher permissible concentrations in fish muscles are considered biologically essential, and become only toxic at very high concentrations (**Bahnasawy *et al*., 2009**). However, all other heavy metals have toxicity and lower limits according to the Egyptian General Authority for Standards and Quality Control (**Anwar *et al*., 2011; Al-Naggar *et al*., 2018**).

## CONCLUSION

The concentrations of most heavy metals in muscle tissues of fish harvested from Bahr El-Baqar drain exceeded the acceptable limits indicated by FAO and WHO organizations since Bahr El-Baqar drain is considered as the most polluted drain in Egypt especially with Pb, Cu, Zn and Fe heavy metals. Body concentrations of heavy metals of the Nile tilapia harvested from the River Nile were the lowest compared to fish exposed to drain waters during the current study. The present study showed that heavy metals concentrations had the least values in muscles and the highest levels were recorded in gills and liver organs, reflecting high metabolic activities in gills and liver compared to muscles. The results of the current study indicate that the Nile tilapia fish sampled from the River Nile are safe for human consumption, while fish sampled from Bahr El Baqar sewage drain represent greater risk hazard when consumed by humans due to pollution above the safe limits caused by anthropogenic activities. Consequently, strict control by the Egyptian Laws should be enforced over drain waters of Bahr El-Baqar drain. Bahr El-Baqar drain had higher pollution of four heavy metals that include Fe, Zn, Cu and Pb. Consequently, strict monitoring programs should be applied in order to yield Nile tilapia which is safe for consumers.

## REFERENCES

**Abd-El-Khalek, D.E.; El-Gohary, S.E. and El-Zokm, G.M. (2012).** Assessment of heavy metals pollution in Oreochromis niloticus in EL-Max Fish Farm, Egypt. *The Egyptian Journal of Experimental Biology (Zoology)*., *8*(2 )**:** 215-222.

**Abdel-Satar, A.M.; Ali, M.H. and Goher, M.E. (2017).** Indices of water quality and metal pollution of Nile River, Egypt. The Egyptian Journal of Aquatic Research., 43(1):21-29.

**Ahmed, Q.; Khan, D. and Elahi, N. (2014).** Concentrations of heavy metals (Fe, Mn, Zn, Cd, Pb, and Cu) in muscles, liver and gills of adult Sardinella Albella (Valenciennes, 1847) from Gwadar water of Balochistan, Pakistan. FUUAST Journal of Biology., 4(2):195-204.

**Ahmad, M.K.; Nafiu, S.A.; Baba, H.A.; Rashida, I.U.; Zakariyya, M. and Abubakar, S. (2018).** Heavy metals bioaccumulation in tissues of Tilapia zilli as indicators of water pollution in kafinchiri reservoir, Kano-Nigeria. Bayero Journal of Pure and Applied Sciences., 11(1):443-450.

**Alaa, G. M. (2012).** Biomarkers in Nile tilapia Oreochromis niloticus niloticus (Linnaeus, 1758) to assess the impacts of river Nile pollution: bioaccumulation, biochemical and tissues biomarkers. Journal of Environmental Protection., 2012.

**Ali, N.A.; Mohamed, M.A.; El-Hameed, A. and Eman, A.A. (2016).** Water quality and heavy metals monitoring in water and tissues of Nile tilapia fish from different governorates. Egyptian Journal of Aquatic Biology and Fisheries., 20(3):103-113.

**Al-Kenawy, D.A. and Aly, N.A. (2015).** Levels of some heavy metals in muscles and liver of freshwater farmed fish at abbassa. Abbassa Int. J. Aqua., 8(1):20-35.

**Al Naggar, Y.; Khalil, M. S. and Ghorab, M. A. (2018).** Environmental pollution by heavy metals in the aquatic ecosystems of Egypt. Open Acc. J. Toxicol, 3, 555603.

**Aly, M. Y. (2016).** Comparison of heavy metals levels in muscles, liver and gills of three fish species collected from agricultural drainage water AT El-Abbassa fish farm, Sharkia, Egypt. Egyptian Journal of Aquatic Biology and Fisheries., 20(3):103-112.

**Aly, M. Y. M.; El-Gaar, D. M. K.; Salaah, S. M. and Abdo, M. H. (2020).** Evaluation of Heavy Metals and Oxidative Stress with Biochemical Parameters as Bioindicators of Water Pollution and Fish in Lake Burullus, Egypt. Mari. Scie. Res. Ocean. J., 1(3): 30-34.

**American Public Health Association. (1998).** Standard methods for the examination of water and wastewater. Washington, DC: American Public Health Association. Inc.(APHA).

**Anwar, J.; Shafique, U. and Anzano, J. M. (2011).** Treatment of chromium polluted water through biosorption-an environment friendly approach. Materials Science Research Journal., 5(4): 317.

**Bahnasawy, M., Khidr, A.A. and Dheina, N., (2009).** Seasonal variations of heavy metals concentrations in mullet, Mugil cephalus and Liza ramada (Mugilidae) from Lake Manzala, Egypt .journal of applied sciences research., 5(7):845-852.

**Callender, E. (2014).** Heavy metals in the environment - historical trends. Reference Module in Earth Systems and Environmental Sciences., from Treatise on Geochemistry (Second Edition) 11: 59-89.

**Cicik, B. and Engin, K. (2005).** The effects of cadmium on levels of glucose in serum and glycogen reserves in the liver and muscle tissues of Cyprinus carpio (L. 1758). Turk. J. Vet. Anim. Sci., 29: 113-117.

**Darweesh, M.; Gamal El-Dein, M.; Abou-Shleel, H.; and A El-Shirbeny, M.;(2019).** Seasonal variation of heavy metals in water and organs of Oreochromis niloticus at Rosetta Branch, River Nile, Egypt. Egyptian Journal of Aquatic Biology and Fisheries., 23(3):513-526.

**Donia, G.; Hafez, A.; & Wassif, I. (2017).** Studies on Some Heavy Metals and Bacterial Pollutants in Tilapia Fish of El Salam Canal, Northern Sinai, Egypt. Egyptian Journal of Aquatic Biology and Fisheries, 21(4): 67-84.

**Duncan, D. B. (1955).** Multiple range and multiple F tests. biometrics, 11(1): 1-42.

**EC (European Communities Commission Regulation) No 1881/2006 of 19 December, (2006).** Setting Maximum Levels for Certain Contaminants in Foodstuffs, 364. Official J. of the European Union:5–24.

**El-Batrawy, O.A.; El-Gammal, M.I.; Mohamadein, L.I.; Darwish, D.H. and El-Moselhy, K.M. (2018).** Impact assessment of some heavy metals on tilapia fish, Oreochromis niloticus, in Burullus Lake, Egypt. The Journal of Basic and Applied Zoology., 79(1):1-12.

**El-Sayed, E.S.; Khater, Z.; El-Ayyat, M. and Nasr, E.S. (2011).** Assessment of heavy metals in water, sediment and fish tissues, from, Sharkia province, Egypt. Egyptian Journal of Aquatic Biology and Fisheries., 15(2):125-144.

**El-shaer, F.M. and Al Abssawy, a.n. (2019).** Assessment of heavy metals concentration in water and edible tissues of Nile tilapia (Oreochromis niloticus) and (Clarias gariepinus) from Burullus Lake, Egypt with liver histopathological as pollution indicator. Journal of the Egyptian Society of Parasitology., 49(1):183-194.

**El-Sheekh M. (2009).** River Nile Pollutants and Their Effect on Life Forms and Water Quality, in: Dumont, H.J. (Ed.), The Nile: Origin, Environments, Limnology, and Human Use. Springer Netherlands, Dordrecht. 395-405.

**El-Sheekh, M. M.; Deyab, M. A.; Desouki, S. S. and Eladl, M. A. G. D. A. (2010).** Phytoplankton compositions as a response of water quality in El Salam canal, Hadous drain and Damietta branch of River Nile, Egypt. *Pak. J. Bot*., *42*(4): 2621-2633.

**Elwasify, A.Y.; Ghanem, M.H.; El-Bamby, M.M. and Ali, F.A. (2019).** Seasonal and regional variations of five heavy metals in water, sediments and fishes inhabiting Lake Qarun, Egypt. Al-Azhar Journal of Agricultural Research., 44(1):128-135.

**EOSQC (Egyptian Organization for Standaridization Quality and Control) (1993).** "Maximum level for heavy metal contaminants in Food." Es. no. 2366.

**FAO (1983).** Food and Agricultural Organization. Compilation of legal limits for hazardous substances in fish and fishery products. FAO Fisheries Circular (FAO), Rome: 764.

**FAO (1992).** Committee for inland fisheries of Africa; Report of the third session of the Working party on pollution and fisheries. Accra, Ghana. 25 - 29 November 1991. FAO fisheries. Rep., No. 471. Rome, FAO. 1992. 43p.

**Farouk, A. A. (2009).** Some studies on water pollution of Manzala Lake by heavy metals and others and effect of these on stock assessment of fish. M.SC. Thesis. Fac. of sci. Al Azhar Univ. Chemistry Dep.

**Farouk, A. E.; MG Mansour, E. and MT, M. (2020).** Assessment of some heavy metals contamination and thier pollution indices in water and fish organs of (Oreochromis niloticus and Clarias gariepinus) in Burullus and Edku lakes,(A comparative study). Egyptian Journal of Aquatic Biology and Fisheries., 24(5): 609-637.

**FDA (Food and Drug Agency) (2001).** Fish and fisheries products hazards and controls guidance. 3. Silver Spring: Center for Food Safety and Applied Nutrition, US Food and Drug Administration.

**FEPA (Federal Environmental Protection Agency) (2003).** Guide lines and standards for Environmental Pollution control in Nigeria., 238p.

**Fouad, H.A.; Hefny, R.M., Kamel, A.M.B.M.M.;, El-Liethy, M.A. and Hemdan, B.A. (2020).** Assessment of biological augmentation technology of hazardous pollutants existing in drainage water in Bahr El-Baqar drain, Egypt. Egypt. J. Chem.

**Ghannam, H.E.; El Haddad, E.S.E. and Talab, A.S. (2015).** Bioaccumulation of heavy metals in tilapia fish organs. Journal of Biodiversity & Environmental Science., 7(2):88-99.

**Goher, M.E.; Ali, M.H. and El-Sayed, S.M. (2019).** Heavy metals contents in Nasser Lake and the Nile River, Egypt: an overview. The Egyptian Journal of Aquatic Research., 45(4):301-312.

**Gulec, A. K., and Aksu, O. (2012).** Effects of handling on physiological profiles in turkish crayfish, Astacus Leptodactylus. World Journal of Fish and Marine Sciences., 4(6):684-688.

**Helmy, N. M.; Srour, T. M.; and Abdalla, A. E. (2020).** Heavy Metals in Grey Mullet (Mugil cephalus) Fish Collected From Barseque Fish Farm, El-Behera Governorate-Egypt. Journal of the Advances in Agricultural Researches., 25(2):144-163.

**Houri, K.; Fegrouche, R.; Mansouri, D.; Allami, H. and Fadli, M. (2018).** Distribution of degree of contamination by heavy metals of the gills muscle, liver and gonads of Lepomis gibbosus Linnaeus, 1758 (Centrachide Fish. Percifome, Actinopterygiis). International Journal of Fauna and Biological Studies., 5(2):163-169.

**Ibrahim, A.A. and Omar, H.M. (2013).** Seasonal variation of heavy metals accumulation in muscles of the African Catfish Clarias gariepinus and in River Nile water and sediments at Assiut Governorate, Egypt. J Biol Earth Sci., 3(2) :236-248.

**Khaled, A. (2004).** Heavy metals concentrations in certain tissues of five commercially important fishes from El-Mex Bay, Alexandria, Egypt. Egypt. J. Aquat. Biol. Fish., 8: 51–64.

**Mansour, S. and Sidky, M. (2002).** Eco-toxicological studies. Heavy metals contaminating water and fish from Fayoum Governorate, Egypt, Food Chemistry., 78 (1): 15-22.

**Mohammadi, M.; Sary, A.A.; Khodadadi, M.(2011).** Determination of heavy metals in two barbs, Barbus grypus, and Barbus xanthopterus in Karoon and Dez Rivers, Khoozestan, Iran. B. Environ. Contam. Tox., 87, 158.

**Omar, W.A.; Mikhail, W.Z.; Abdo, H.M.; Abou El Defan, T.A. and Poraas, M.M. (2015).** Ecological risk assessment of metal pollution along greater Cairo sector of the river Nile, Egypt, using nile tilapia, Oreochromis niloticus, as Bioindicator. Journal of toxicology.

**Plaskett, D. and Potter, I. C. (1979).** Heavy metal concentrations in the muscle tissue of 12 species of teleost from Cockburn Sound, Western Australia. Marine and Freshwater Research., 30(5):607-616.

**Papagiannis, I.; Kagalou, I.; Leonardos, J.; Petridis, D.; Kalfakakou, V. (2004).** Copper and zinc in four freshwater fsh species from lake Pamvotis (Greece ). Environm Int., 30(3):357–362.

**Romeo, M.; Siau, Y.; Sidoumou, Z. and Gnassia-Barelli, M. (1999).** Haevy metal distribution in different fish species from Mauritania Coast. Sci Total Environ., 232:169-175.

**Saeed, S. M. and Shaker, I. M. (2008).** As sessm ent of heav y m etals pollution in water and s edim ents a nd thei r effec t on Or eoc hr omi s niloticus in the north ern Delta L ak es , Egy pt. Eighth I nt. Sym p. Tilapia in Aquaculture., 475 -490.

**Salaah, S. M.; Zanaty, N. and El-Naggar, M. M. (2022).** Evaluation of heavy metals contents and the possible risk in the surface water and fish of Lake Qarun, Egypt. Egyptian Journal of Aquatic Biology and Fisheries., 26(4): 1067-1091.

**Sepe, A.; Ciaralli, L.; Ciprotti, M.; Giordano, R.; Fumari, E. and Costantini, S. (2003).** Determination of cadmium, chromium, lead and vanadium in six fish species from the Adriatic Sea. Food Addit. Contam., 20: 543-552.

**Sharmeen, R.; Khan, M.Z.; Yasmeen, G. and Ghalib, S.A. (2014).** Levels of heavy metals (cadmium, chromium, copper and lead) on water and selected tissues of Oreochromis mossambicus from different locations of Malir River, Karachi. Canadian Journal of Pure and Applied Sciences, 8(3):3011-3018.

**Taha, A.A.; El-Mahmoudi, A.S. and El-Haddad, I.M. (2004)**. Pollution sources and related environmental impacts in the new communities southeast Nile Delta, Egypt. Emir J Eng Res., 9(1):35–49.

**USEPA (2000).** United States Environmental Protection Agency. Guidance for assessing chemical contaminant data for use in fish advisories volume 2 risk assessment and fish consumption limits, 3rd ed.

**WHO (World Health Organization) (1985).** Guidelines for drinking water quality Vol. (1):30. Recommendation. Geneva.

**World Health Organization (WHO), (1989).** National Research Council Recommended Dietary Allowances (10th ed), National Academy Press. Washington, DC, USA.

**WHO (1995).** World Health Organization, Inorganic Lead. Environmental Health Criteria Number 165, Geneva.

**World Health Organization, (2017).** Global status report on water safety plans: a review of proactive risk assessment and risk management practices to ensure the safety of drinking-water.

**Widianarko, B.; Van Gestel, C.A.M.; Verweij, R.A. and Van Straalen, N.M. (2000).** Associations between trace metals in sediment, water and guppy, Poecilia reticulata (Peters), from urban streams of Semarang, Indonesia. Ecotoxicol. Environ. Safety., 46: 101-107.

**Yacoub, A.M. (2007).** Study on some heavy metals accumulated in some organs of three River Nile fishes from Cairo and Kalubia governorates. African J. Biol. Sci., 3: 9-21.

**Yacoub, A.M.; Mahmoud, S.A. and Abdel-Satar, A.M. (2021).** Accumulation of heavy metals in tilapia fish species and related histopathological changes in muscles, gills and liver of Oreochromis niloticus occurring in the area of Qahr El-Bahr, Lake Al-Manzalah, Egypt. Oceanological and Hydrobiological Studies, 50(1):1-15.

**Yosef, T. A. and Gomaa, G. M. (2011).** Assessment of Some Heavy Metal Contents in Fresh and Salted (Feseakh) Mullet Fish Collected from El-Burullus Lake, Egypt. J. American Science., 7(10): 137-144.