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HEALTH RISK ASSESSMENT OF HEAVY METALS CONCENTRATION IN CATFISH (*Clarias gariepinus*) AND TILAPIA FISH (*Tilapia guineensis*) SAMPLES FROM SOME RIVERS IN NASARAWA WEST, NIGERIA

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ABSTRACT
In this study, heavy metals concentration in fish samples (Catfish: *Clarias gariepinus* and Tilapia: *Tilapia guineensis*) were determined for Cadmiun, Lead, Chromium, Zinc, Manganese, Iron, Copper, and Nickel from some rivers in Nasarawa (Keffi, Toto, Kokona, Karu, and Nasarawa) West, Nigeria at two different sites each. Twenty fish samples (ten cat fish and ten tilapia fish) were collected directly from the rivers in raining season between August and September 2019 and were prepared. The x-ray fluorescence spectrometry analysis result revealed the mean concentration of Cr ($1.51x10^{-3}$ mg/kg), Cd ($5.32x10^{-4}$ mg/kg), Cu ($2.52x10^{-2}$ mg/kg), Pb ($1.66x10^{-3}$ mg/kg), As ($1.89x10^{-4}$ mg/kg), Fe ($5.11x10^{-1}$ mg/kg), and Zn ($2.09x10^{-1}$ mg/kg) in cat fish, and Cr (2.33x10-3 mg/kg), Cd (1.96x10-3 mg/kg), Cu (2.70x10-2 mg/kg), Pd (2.71x10-3 mg/kg), As (2.65x10-4 mg/kg), Fe (4.98x10-1 mg/kg), and Zn (2.06x10-1 mg/kg) in Tilapia fish. The values of heavy metal concentration in catfish and tilapia fish are found to be below the world average. The estimated daily intake values for all the heavy metal investigated in catfish and tilapia fish are well within the recommended standards (RfD_0 values). The total hazard quotient values for all heavy metals under study are $5.95x10^{-3}$which is less than 1, and implies that exposure level is less than the RfD, This indicates that the daily exposure at this level is unlikely to cause adverse effects during a person's lifetime. The public are free from significant health risk due to consumption of heavy metals in fish from Nasarawa West, Nigeria.

Keywords: Heavy metals, Health risk, Fish and Nasarawa West River.

INTRODUCTION
The qualities of water have become a major challenge in the world today as it is being polluted by industrial and urban wastes generated mostly by human activities (Ojutiku and Okojevoh, 2013). High levels of heavy metals in aquatic ecosystems have raised serious public concerns around the world, due to their persistence in the environment; their potential toxic effects and ability to bio accumulate in aquatic organism. (Ghosh and Singh, 2005). Heavy metals can enter into aquatic ecosystem through natural and anthropogenic sources, such as atmospheric deposition, geological weathering, agricultural and industrial activities, domestic waste, mining activities and agricultural water runoff from farms (Webber *et al*., 2013).
Heavy metals are categorized as potentially toxic (e.g. Cd, Pb, Ni) but some of them are essential elements for normal metabolism (e.g. Cu and Zn). Even at low concentrations, toxic metals can become harmful for human health when ingested over long period of time. Essential metals can also produce toxic effects with excessive intake. In recent times, the contamination of aquatic environment with heavy metals has affected the earth waters and this is mainly because they have toxic effect on aquatic organisms (Alvarado et al., 2006; Macfarlane *et al.*, 2000). As heavy metals are not biodegradable, they can be deposited, assimilated or incorporated in water, sediment and aquatic animals (Linnik and Zubenko, 2000), thus causing heavy metal pollution in water bodies.
Heavy metal concentrations in aquatic ecosystems are usually monitored by measuring their concentrations in water, sediments and biota, such as fish (Camusso *et al.*, 1995), which generally exist in low levels in water and attain considerable concentration in sediments and biota (King and Jonathan, 2003). Heavy metal pollution may increase the susceptibility of aquatic animals to various diseases by interfering with the functioning of their immune, reproductive, and developmental process (Enviromental Protection Agency, 2001).
Rivers received sediment from various point and diffused sources which deposited at the bottom of the river and acts as both carriers and potential sources of metal accumulation in aquatic food chain by the process of biomagnifications (Webber *et al*, 2013). The human health is adversely affected by uptake of these by the fishes and water bodies. The concern about high level of trace metals in fishes (different fish species) has promoted several statutory bodies such as the WHO to establish maximum allowable concentration for some of the heavy metals in food. (WHO, 2008).
Fish have the ability to uptake and concentrate heavy metals directly from the surrounding water or indirectly from other organisms such as small fish, invertebrates, and aquatic vegetation (Mansour and Sidky,2002). In addition, fish are located at the top of the aquatic food chain and may accumulate metals and pass them to human beings through food causing chronic or acute diseases (Kalyoncu *et al*., 2012). Fish accumulate pollutants preferentially in their like liver, kidney, gills, and the effects become apparent when concentrations in such organs to attain a threshold level (Canli *et al.*, 1998; Yilmaz, 2003). However, this accumulation depends upon their intake, storage and elimination from the body (Mansour and Sidkey, 2002). This means that metals which have high uptake and low elimination rates in tissues of fish are expected to be accumulated to higher levels (Rashed, 2001). The aim of this study is to assess the health risk associated with some fish samples from some selected rivers in Nasarawa West (Keffi, Toto, Kokona, Karu, and Nasarawa), Nigeria.

MATERIALS AND METHOD

Study Area

This study was carried out between August and September2019 rainy season. Cat fish and Tilapia fish samples for elemental analysis were collected from some river in Nasarawa West (Keffi, Toto, Kokona, Karu, and Nasarawa), Nasarawa State, Nigeria

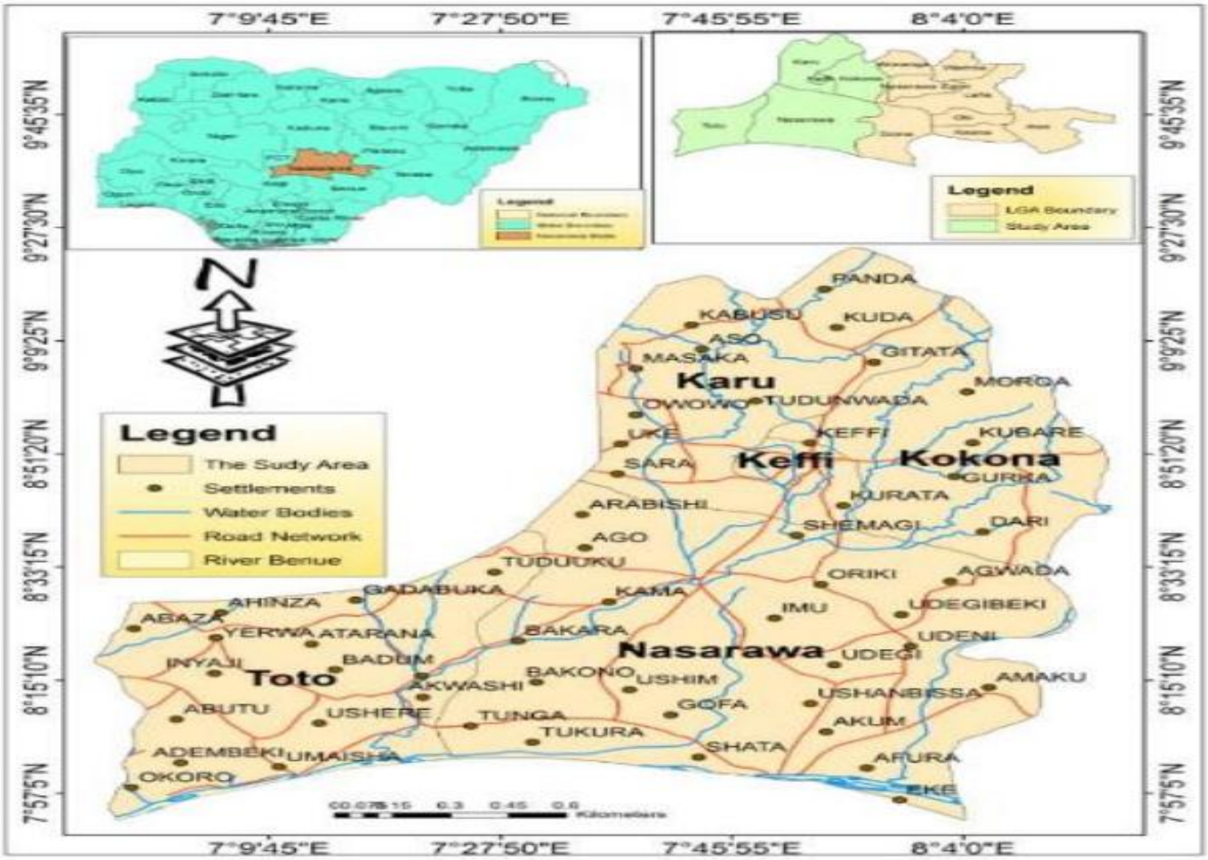

Plate 3.1: Map of Study Area (Umar *et al.*, 2018)

Sample Collection and Preparation

Samples of commonly consumed adults fishes were collected from some rivers in Nasarawa Westand were subjected to elemental analysis. X-ray fluorescence spectrometry analysis was used to determine the concentration of these heavy metals at the Centre for Solid Minerals Research and Development (CSMRD), Kaduna Polytechnic, Kaduna, Nigeria. Fish samples (Catfish; *Clarias gariepinus* and Tilapia; *Tilapia guineensis*) were collected from the rivers with the assistance of local fishermen using hook and net from the sampling sites in the selected rivers in Nasarawa West. Two fish of each species (Tilapia and Cat Fish) were collected randomly from each sampling site in Keffi, Nasarawa, Toto, Karu and Kokona. The sample were labeled with code and numbers and were placed on ice container and taken to the laboratory were drying and pulverizing of sample took place. The fish samples were ovum dried at 100^0C, grinded and were sieved through 2 mm mesh. The fish samples were then packaged in clean well labelled plastic containers and sent to Centre for Solid Minerals Research and Development (CSMRD), Kaduna Polytechnic, Kaduna, Nigeria were they are subjected to XRF spectrometry analysis.

Estimated Daily Intake

The estimated daily intake (EDI) depends on the metal concentration, food consumption, and body weight of heavy metals for adults was calculated as follows:

$$EDI = \frac{CxC_{cons}}{B_w} \qquad (1)$$

where C is the concentration of heavy metals in fish (mg/kg wet weight), C_{cons} is the average daily consumption of fish in the local area (105 g/day bw), and B_w represents the body weight (70 kg).

Target Hazard Quotient (THQ)

The THQ which is the ratio of the exposure dose to the reference dose (RfD), represents the risk of non-carcinogenic effects. The dose calculations were performed using standard assumptions from the integrated US EPA risk analysis (USEPA, 2000). The model for estimating THQ was determined following the work of Chien *et al.* (2002) as follows;

$$THQ = \frac{EFr\ x\ ED_{tot} x\ FIR\ x\ C}{RfD_0\ x\ B_w x\ ATn} x10^{-3} \qquad (2)$$

where; EFr is the exposure frequency, ED_{tot} is the exposure duration, FIR is the food ingestion rate, 10^{-3} is the unit conversion factor, C is the heavy metal concentration in fish and RfDo is the oral RfD, B_w is the average adult body weight, ATn is the average exposure time for non-carcinogens.

In this study, the total THQ was expressed as the arithmetic sum of the individual metal THQ values according to the method of Chien *et al.* (2002):

$$Total\ THQ(TTHQ) = THQ(toxicant\ 1) + THQ(toxicant\ 2) + \cdots + THQ(toxicant\ n) \qquad (3)$$

Statistical analysis

Concentrations of elements as analyzed by the X-Ray Florescence Spectrometric Analysis which has its unit in weight percent (w.t.%) were coded in an excel software package in other to generate the result in mg.kg^{-1}. The unit of the raw data in weight percent (wt%) were converted into milligram per kilogram (mg.kg^{-1}) by multiplying the values in wt% by 10,000 (1ppm or 1mg.kg^{-1} = 10,000 wt%) as the world standard acceptable unit for soil analysis (WHO, 2000). All graphs and table where derived using Microsoft Excel statistical package.

RESULTS AND DISCUSSION

The results shown the present of heavy metal concentration of Cadmiun, Lead, Chromium, Zinc, Manganese, Iron, Copper, and Nickel in Cat fish and Tilapia fish from some rivers in Nasarawa West Senatorial District of Nasarawa State (Figure 1 and 2 respectively). Although, Copper, nickel and zinc are essential elements, required by a wide variety of enzymes and other cell components and having vital functions in all living organisms, but very high intakes can have adverse health consequences (Demirezen and Uruc, 2006). On the other hand, Cd and Pb, have no biological role and hence they are harmful to living organisms even at considerably low concentrations (Elnabris *et al*., 2013). In this study, the relative dominance of heavy metals concentrations in cat fish was observed in the following sequence Fe > Zn > Cu > Pb > Cr > Cd > As, while for tilapia fish was observed in the following sequence Fe > Zn > Cu > Pb > Cr > Cd > As, with concentrations of essential elements higher than non-essential elements.

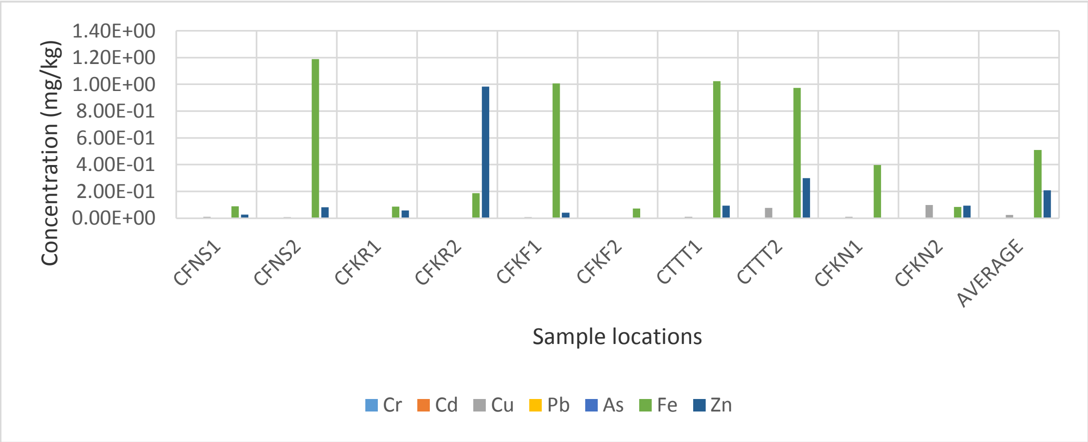

Figure 1: Heavy metal concentration in cat fish samples from some selected rivers in Nasarawa West.

The concentration of heavy metals in cat fish samples in this study, Iron (Fe) was found to have the highest mean concentration of 5.11x10^{-1} mg/kg followed by Zinc (Zn) with concentration of 2.09x10^{-1} mg/kg. The mean concentration of Lead (Pb), Chromium (Cr), Copper (Cu), Cadmiun (Cd), and Asenic (As) are 1.66x10^{-3} mg/kg, 1.51x10^{-3} mg/kg, 2.52x10^{-2} mg/kg, 5.32x10^{-4} mg/kg, and 1.89x10^{-4} mg/kg respectively. Asenic (As) was found to have the least concentration of 1.89x10^{-4} mg/kg.

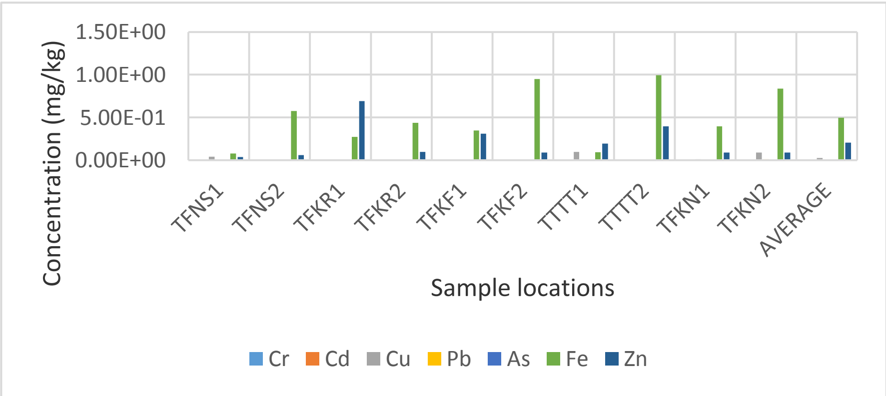

Figure 2: Heavy metal concentration in tilapia fish samples from some selected rivers in Nasarawa West.

The concentration of heavy metal in tilapia fish samples in this study, Iron (Fe) was found to have the highest mean concentration of 4.98x10^{-1} mg/kg followed by Zinc (Zn) with concentration of 2.06x10^{-1} mg/kg. The mean concentration of Lead (Pb), Chromium (Cr), Copper (Cu), Cadmiun (Cd), and Asenic (As) are 2.71x10^{-3} mg/kg, 2.33x10^{-3} mg/kg, 2.70x10^{-2} mg/kg, 1.96x10^{-4} mg/kg, and 2.65x10^{-4} mg/kg respectively. Asenic (As) was found to have the least concentration of 2.65x10^{-4} mg/kg.

Table 1: Estimated target hazard quotients (THQ) for individual cat metals fish consumption.

Heavy metals	Cr	Cd	Cu	Pb	As	Fe	Zn
RfD_O (mg/kg-day)	$3.0x10^{-3}$	$1.0x10^{-3}$	$4.0x10^{-2}$	$4.0x10^{-3}$	$3.0x10^{-4}$	$7.0x10^{-1}$	$3.0x10^{-1}$
Average (mg/kg)	$1.51x10^{-3}$	$5.32x10^{-4}$	$2.52x10^{-2}$	$1.66x10^{-3}$	$1.89x10^{-4}$	$5.11x10^{-1}$	$2.09x10^{-1}$
EDI (mg/kg-day)	$2.27x10^{-3}$	$7.98x10^{-4}$	$3.78x10^{-2}$	$2.48x10^{-3}$	$2.84x10^{-4}$	$7.66x10^{-1}$	$3.14x10^{-1}$
THQ	$7.25x10^{-4}$	$7.65x10^{-4}$	$9.05x10^{-4}$	$5.95x10^{-4}$	$9.07x10^{-4}$	$1.05x10^{-3}$	$1.00x10^{-3}$
Total THQ	$5.95x10^{-3}$						

The cat fish Estimated Daily Intake value for Chromium, Cadmium, Copper, Lead, Arsenic, Iron, and Zinc are $2.27x10^{-3}$mg/kg-day, $7.98x10^{-4}$mg/kg-day, $3.78x10^{-2}$mg/kg-day, $2.48x10^{-3}$mg/kg-day, $2.84x10^{-4}$mg/kg-day, $7.66x10^{-1}$mg/kg-day and $3.14x10^{-1}$mg/kg-day respectively. The EDI values for all the heavy metal investigated for cat fish are well within the recommended standards (RfD_0 values).

The estimated THQ values for the heavy metals investigated are Cr ($7.25x10^{-4}$), Cd ($7.65x10^{-4}$), Cu ($9.05x10^{-4}$), Pb ($5.95x10^{-4}$), As ($9.07x10^{-4}$), Fe ($1.05x10^{-3}$), and Zn ($1.00x10^{-3}$). If it is less than 1, exposure level is less than the RfD. This indicates the daily exposure at this level is unlikely to cause adverse effects during a person's lifetime, and vice versa. The THQ values for all heavy element under study are less than 1, which implies that exposure level is less than the RfD. This indicates the daily exposure at this level is unlikely to cause adverse effects during a person's lifetime, and vice versa. The total THQ ($5.95x10^{-3}$) is less than 1. However, according to the series of assumptions for health risk assessment, the THQ value was highly conservative and was a relative index. This result implies that there is no potential non-carcinogenic risk of metals for consumers through cat fish consumption from Nasarawa West, Nigeria

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Table 2: Estimated target hazard quotients (THQ) for individual metals tilapia fish consumption.

Heavy metal	Cr	Cd	Cu	Pb	As	Fe	Zn
RfD_O (mg/kg-day)	$3.0x10^{-3}$	$1.0x10^{-3}$	$4.0x10^{-2}$	$4.0x10^{-3}$	$3.0x10^{-4}$	$7.0x10^{-1}$	$3.0x10^{-1}$
Average (mg/kg)	2.3310^{-3}	$1.96x10^{-3}$	$2.70x10^{-2}$	$2.71x10^{-3}$	$2.65x10^{-4}$	$4.98x10^{-1}$	$2.06x10^{-1}$
EDI (mg/kg-day)	$3.49x10^{-3}$	$2.93x10^{-3}$	$4.04x10^{-2}$	$4.06x10^{-3}$	$3.98x10^{-4}$	$7.47x10^{-1}$	$3.09x10^{-1}$
THQ	$1.11x10^{-3}$	$2.81x10^{-3}$	$9.69x10^{-4}$	$9.73x10^{-4}$	$1.27x10^{-3}$	$1.02x10^{-3}$	$9.87x10^{-4}$
Total THQ	$9.16x10^{-3}$						

The estimated daily intake (EDI) value in tilapia fish sample for Chromium, Cadmium, Copper, Lead, Arsenic, Iron, and Zinc are $3.49x10^{-3}$mg/kg-day, $2.93x10^{-3}$mg/kg-day, $4.04x10^{-2}$mg/kg-day, $4.05x10^{-3}$mg/kg-day, $3.98x10^{-4}$mg/kg-day, $7.47x10^{-1}$mg/kg-day and $3.09x10^{-1}$mg/kg-day respectively. The EDI values for all the heavy metal investigated are well within the recommended standards (RfD_0 values). The estimated THQ values for the heavy metals investigated are Cr ($1.11x10^{-3}$), Cd ($2.81x10^{-3}$), Cu ($9.69x10^{-4}$), Pb ($9.73x10^{-4}$), As ($1.27x10^{-3}$), Fe ($1.02x10^{-3}$), and Zn ($9.87x10^{-3}$). The THQ values for all heavy element under study are less than 1, which implies that exposure level is less than the RfD. This indicates the daily exposure at this level is unlikely to cause adverse effects during a person's lifetime. The total THQ ($9.16x10^{-3}$) is less than 1. However, according to the series of assumptions for health risk assessment, the THQ value was highly conservative and was a relative index. This result implies that there is no potential non-carcinogenic risk of metals for consumers through tilapia fish consumption from Nasarawa West, Nigeria.

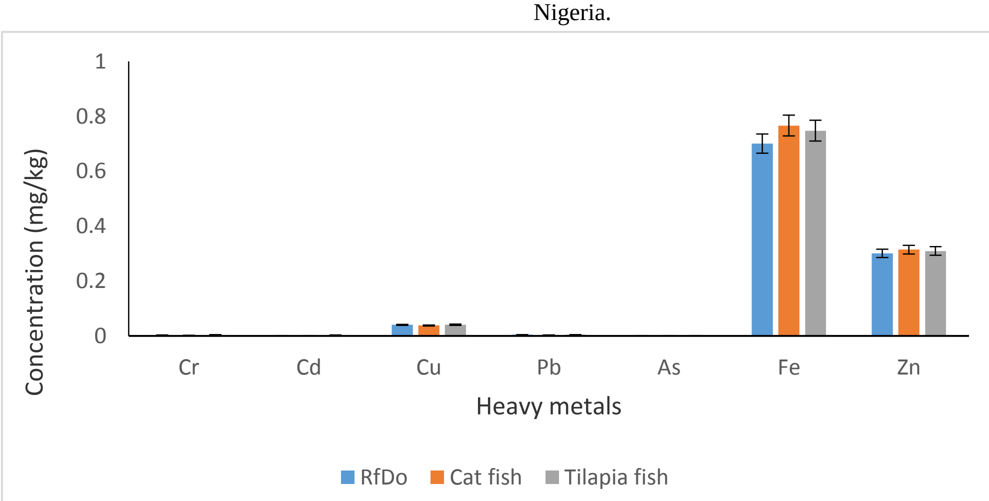

Figure 3: Comparison between EDI values for all heavy metals investigated for cat fish and tilapia fish and RfD_0.

Accumulations of metals were generally found to be relative between the two species. Their feeding habit and the bio-concentration capacity of each species has no significant effect on the species of fish under study. Heavy metals concentrations in fish may depend upon factors like duration of exposure to contaminants, feeding habits, concentrations of contaminants in their habitat, water chemistry, any contamination of fish during handling and processing, sex (Kagi and Schaffer, 1998; Boudou and Ribeyre, 1989). Although fish muscle is not an active tissue in accumulating heavy metals (Bahnasawy *et al*., 2009), the present study was concerned with the heavy metals concentrations in the fish muscles because it is the most consumed portion (Elnabris *et al*., 2013). Also some fish in polluted waters may accumulate substantial amounts of metals in their tissues which sometimes exceed the maximum acceptable levels (Kalyoncu, 2012).

CONCLUSION

It can be concluded from the findings of this study that there is no significant pollution of the rivers investigated in terms of heavy metals pollutants in the fish samples (Cat fish and Tilapia fish). The daily intake values for all the heavy metal investigated in cat fish and tilapia fish are well within the recommended standards (RfD_0 values). The THQ values for all heavy metals under study are less than 1, which implies that exposure level is less than the RfD. This indicates the daily exposure at this level is unlikely to cause adverse effects during a person's lifetime. The people of this area may not be exposed to significant health risk if they continue to consume the fish from this area.

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