Direct Research Journals

Direct Research Journal of Agriculture and Food Science

Vol. 9, Pp. 29-35, 2021
ISSN 2354-4147
DOI: https://doi.org/10.26765/DRJAFS15297456
Article Number: DRJAFS15297456

https://directresearchpublisher.org/drjafs/

Full Length Research Paper

Assessment of some toxic elements in aquatic bio-indicator (*Clarias gariepinus*) sold in Katcha and Minna, Niger State Nigeria: Major threats to food safety

Oguh, C.E.[1*], Obiwulu, E.N.O.[2], Uzoefuna, C. C.[3], Adinnu, C.M.[4], Mohammed Y.M.[5], and Augustine, O.[6]

[1]Department of Surveillance and Epidemiology, Nigeria Centre for Disease Control, Abuja, Nigeria.
[2]Department of Integrated Science, Delta State College of Education Agbor, Delta State Nigeria.
[3]Department of Biochemistry, University of Nigeria, Nsukka, Enugu State, Nigeria.
[4]Department of Food science and technology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.
[5]Department of Animal Biology, Federal University of Technology Minna Niger State, Nigeria.
[6]Department of Pharmaceutical chemistry, University of Benin, Benin City, Nigeria.
*Corresponding Author E-mail: collinsoguh@gmail.com

Received 17 January 2021; Accepted 22 February, 2021

ABSTRACT: The major problems in human diets are the presence of toxic materials in consumable foods. Fishes have been used for many years as indicators of environmental pollution status, and, thus, they are regarded as good indicators of metal pollution in marine environments. This study aimed to assess some toxic elements in *Clarias gariepinus* (Cat fish) sold in Minna, Niger State Nigeria and the health risk associated with their consumption. The fishes used for the study were purchased from Katcha market and Minna fish market from different sellers and these were done in triplicates. The level of some trace metals such as Arsenic (As), Cadmium (Cd), Chromium (Cr), Lead (Pb), and Mercury (Hg), were investigated using Atomic Absorption Spectroscopy (AAS). The Bioaccumulation factor and health risk (daily intake, health risk index and hazard index) from the consumption of these fishes was assessed using standard methods and formula. Fish samples were digested using a modified procedure from the Association of Official Analytical Chemists (AOAC) and were subsequently analyzed using AAS. The results showed that trace metals in fishes sold in Minna town were higher than the WHO/FAO permissible limit of metal in fishes. There is significant different (*P<0.05*) between the fishes sold in Minna and that of Katcha. Total hazard index of all metals in *C.gariepinus* from Katcha market and Minna fish market were 0.37 and 1.25 respectively. This concludes that fish in Minna market are contaminated with heavy metals (HMs) with deleterious effect on consumption and also bioaccumulate in the fish. The risk assessment shows that fish in Minna are contaminated with potentially toxic elements and could pose health risk from heavy metal contamination when consume via food chain.

Keywords: *Clarias gariepinus*, hazard assessment, heavy metals, Niger state, safety

INTRODUCTION

The consumption of fish is seen among high proportion of the population as a cheap way of increasing the protein, minerals and vitamin content in the body. Fish have been used as indicators of environmental pollution status, and, thus, they are regarded as good indicators of metal pollution in aquatic environments (Mohammed *et al.*, 2016). Fishes are mostly vulnerable and heavily exposed to pollution because they cannot escape from the detrimental effects of pollutants in their environment i.e.

they are cold blooded animals and survive only in water bodies (Oguh *et al*., 2019a; Mahboob *et al*., 2014). Toxic elements i.e. HMs are the most important pollutants in aquatic life because of their toxicity, accumulation and bio-magnification by marine organism. In aquatic environments, heavy metals (HMs) pollution is cause by direct atmospheric deposition, geologic weathering or through the discharge of agricultural chemicals, municipal waste, residential or industrial waste products, and water treatment plants waste. Fish can be contaminated with trace metal when different parts of the fish are exposed to the air or from polluted or contaminated rivers which cause serious health risk of consumers.

Environmental pollutants such as HMs bioaccumulate in food chain when the fish are consume by human which can cause an antagonistic effects (chronic or acute diseases) and even death of consumers, so fish among other animals are used to determine the health condition of aquatic ecosystem. Bioaccumulation of heavy metals means an increase in the degree of toxic metals in a living organism over a period of time, compared with chemical's level in the environment. Several studies have showed that accumulation of HMs in fish tissue is mainly dependent on the HMs concentration in the water and exposure period; though some other environmental factors such as pH, water temperature, hardness, oxygen concentration, salinity, alkalinity and dissolved organic carbon may affect and play significant roles in metal's accumulation and toxicity to aquatic life especially fish (Jitar *et al.,* 2014; Authman *et al.,* 2015; Oguh *et al*., 2019b).

More times very young stages of fish (larvae and juveniles) grow up in the near shore zone of the river, where the water quality is heavily contaminated (Zaqoot *et al.,* 2017). Accumulation of HMs varies from fish species to the other; some fish accumulate more heavy metal than others. The toxicity effects of toxic elements can affect individual growth rates, physiological functions, reproduction, and even mortality in fish. Toxic metals accumulate in fish bodies by three possible ways: gills, digestive track and body surface. The gills are considered as the significant site for direct uptake of metals from the water (Beijer and Jernelov, 1986), HMs in fish come mainly from their diet, though the body surface is normally estimated to take minor part in uptake of heavy metals in fish (Selda and Nurşah, 2012). Fish are used in bioaccumulation tests for aquatic organism because it is a higher tropic level organism and are usually eaten by human (Olaifa *et al*., 2004).

Trace metal refers to any metallic chemical element that has a relatively high density greater than 5 g/cm^3 and is toxic or poisonous even at low concentrations. Examples of some toxic heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Ti) and lead (Pb). The densities of Pb, Hg and Cd are 11.4 gcm^{-3}, 13.6 gms/cubic cms and 8.65 gms/cubic cms respectively (Oguh *et al*., 2020). It has been shown that even low concentration of Hg, Cd, Pb, Al and As can cause a wide variety of health problems (Hassaan *et al*., 2016). Toxicity of heavy metal can result in damaged or reduced mental and central nervous function, lower energy levels and damage to blood composition, lungs, kidneys, liver and other vital organs. Long-term exposure of HMs may result in slowly progressing physical, muscular and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy and multiple sclerosis. Allergies are not common and repeated long-term contact with some toxic metals may cause cancer. Metals elements such as Cd, Hg, As and Pb are non-essential and therefore have toxic effects on living organisms such as damage to the renal and nervous systems of fish as well as gill damage (severe destructive pathological changes, i.e. structural lesions) (Barka *et al*., 2001; Lars, 2003; Velcheva *et al*., 2010; Deore and Wagh, 2012).

Lead has been shown to damage the liver, kidneys, heart, brain, nerves and other organs. Exposure to Pb causes increase in heart disease, anemia, high blood pressure, and reproductive disorders osteoporosis (brittle bone disease) especially in men. Cadmium is highly toxic metal because it's cause serious illness, rheumatoid arthritis (RA), full skeletal deformities, cancer, depressed growth, hypertension, diarrhea, vomiting, stomach problems, fractures in bone, damage to DNA, failure in reproduction and fertility, cause damage to nervous system, damage to immune system, cancer, fetal deformity and death (Mansour and Sidky, 2002). Effect of chromium on humans by fish intake are faded immune system, Skin diseases, Cause ulcer and upset stomach, Respiratory track problem, Alteration in genetic material, Lung cancer, liver and kidney damage and Death. Mercury toxicity include visual field construction, behavioral changes, memory loss, headaches, tremors, loss of fine motor control, spasticity, hair loss, mental retardation to fetus and fetal deformity, cerebral polsy, blindness, deafness and muscular rigidity (Clarkson *et al.,* 2003). Arsenic is acutely toxic element and large intakes can result in adverse symptoms to gastrointestinal tract, severe disturbances of the cardiovascular and central nervous systems and eventually death. The latest WHO evaluation concludes that, exposure to arsenic via drinking water is causally related to cancer in the lungs, kidneys, urinary bladder and skin (WHO, 2001).

Fish are considered as an excellent source of polyunsaturated fatty acids (predominantly omega-3 fatty acids), protein, Zn, iron and calcium (Toth and Brown, 1997). Fish is a valuable and cheap food item, and also major part of the human diet. The accumulation of several chemicals in fish is as a result of pesticides runoff from nearby farms, detergent as a result of washing in the reservoir and dump materials in the sites. This increases high concentrations of heavy metals in the water body, which cause the disruption of the ecological balance of river water. Fish in such areas can be contaminated with HMs, consumption of this fishes by humans can cause accumulation of these toxic metals in the food chain which could cause an adverse health effect from consuming fishes in the river. Hence, the study aim to determine the assessment of some toxic elements in aquatic bio-indicator (*Clarias gariepinus*) sold in Katcha and Minna, Niger State Nigeria-Major threats to food safety and the health risk associated with their consumption.

MATERIALS AND METHODS

African Catfish (*Clarias gariepinus)*, were selected for the study because it is the major consumed fish in Niger State. The rusted dry fishes used for the study were bought from Katcha Market and Minna fish market, Niger State Nigeria.

Sample collection

Sample collections were carried out according to the methods described by Oguh et al., 2020. The fishes used for the study were purchased from two different locations (Katcha Market and Minna fish market). In each location the fishes were purchased from six different sellers and joined together to have a represent sample. The fishs samples were purchased between the months of January, 2021.

Fish tissue preparation

Dry Fish samples were rinsed with distilled water to get rid of any remnants of trace metals on the outer surface of the fish. Muscle tissues of fish (dorsal muscle) was used in this study because it is the major target tissue for metal storage and is the most edible part of the fish. Fish tissues were cut and oven dried for 1 hour at 90ºC to a constant weight. After ensuring of samples complete dryness they were removed and then grounded into powder using ceramic mortar and sieved through 20µm mesh and then stored in polyethylene bottles at 30ºC until analysis.

Digestion of Fish Samples

Exactly 5 g of the dry powdered sample was put into a 50 ml beaker with 5 ml of HNO_3 and 5 ml of H_2SO_4. When the fish tissue stopped reacting with HNO_3 and H_2SO_4, the beaker was then placed on a hot plate and heated at 60°C for 30 min. After allowing the beaker to cool, 10 ml of HNO_3 was added and returned to the hot plate to be heated slowly to 120°C. The temperature was increased to 150°C, and the beaker was removed from the hot plate when the samples turned black. The sample was then allowed to cool before adding H_2O_2 until the sample was clear. The content of the beaker was transferred into a 50 ml volumetric flask and diluted to the mark with ultra-pure water. All the steps were performed in the fume hood. Digested samples were analyzed for levels of As, Cd, Cr, Hg and Pb using Atomic Absorption Spectroscopy. The above procedures in this section followed the guidelines from the Analytical Methods for Atomic Absorption Spectroscopy.

Health risk assessment of HMs via the consumption of fishes

Risk assessment was evaluated by considering only the edible part (muscles tissues) of the fish and to determine daily intake of metal (DIM), health risk index (HRI) and hazard index (HI).

Daily intake of metals (DIM)

The DIM was calculated to estimate the daily loading of metals into the body system (via the consumption of fish) of a specified body weight of a consumer according to (USEPA, 2011). The DIM was determined using:

$$ADDM = DI\ (kg/day) \times M_{fish}\ (mg/kg)/BW\ (kg)$$

Where;

ADDM = Average daily dose (mg,kg/d) of the metal into the body via the consumption of fish.
DI = the daily intake of fish for adult is 0.227 kg/day^{-1} for food describe by Shakeri *et al.* (2015)
M_{fish} = the concentration of HMs in the fish tissues (mg/kg)
BW = Represent the estimated average body weight of investigated in adult (55 kg for adults).

Health risk index (HRI)

The health risk index (HRI) for the populations through the consumption of contaminated fish was assessed based on the DIM relative to reference oral dose (RfD) for each metal. This is an index justifying individual's risk of HMs. The HRI value of less than one implies safe tread and is considered acceptable; otherwise, the fish may pose heavy metals risk. The HRI of the fish was calculated using a formula describe by USEPA, 2017.

$$HRI = ADDM/\ RfDM$$

Where;

ADDM = represents the average daily dose (mg,kg/d) of the metal
RfDM = is the reference dose of the metal (mg,kg/d)
RFDM is defined as the maximum tolerable daily intake of metal with no adverse effect.
HRI is the ratio between exposure and the reference oral dose (RfD). If the values are lower than one (1), there will be no obvious risk.

Estimation of hazard index (HI)

The hazard index (HI) was calculated to determine the overall risk of exposure to all the heavy metals via the ingestion of a contaminated fish using a formula describe by USEPA, (2002). The hazard index (HI) is the summation of the HRI arising from all the metals examined. The value of the hazard index is proportional to the magnitude of the toxicity of the fish consumed. HI > 1 indicates that the predicted exposure is likely to pose potential health risks. However, a hazard index >1 does not necessarily indicate that a potential adverse health effects will result, but only indicates a high probability of posing health risks.

$$HI = \Sigma HQAs + HQCd + HQCr + HQHg + HQPb$$

Statistical analysis

The data obtained were analyzed using IBM Statistical Product and Service Solution (SPSS) version 25 and Microsoft excel 2013. The results were expressed as mean ± standard deviation (SD). One way analysis of variance (ANOVA) was carried out as $P < 0.05$ considered statistically significant.

RESULTS

Concentration of heavy metals in fishes

The HMs mean concentrations of As, Cd, Cr, Hg and Pb analyzed in *Clarias gariepinus* from Katcha market (KM) and Minna market (MM) are shown in (Table 1). The concentration of HMs (As, Cd, Cr, Hg, and Pb) in KM and MM were 0.52, 0.83, 0.67, 0.31, 0.98 and 1.54, 1.91, 1.12, 1.32, 1.04 mg/kg respectively. The result shows that fishes from MM were more contaminated with HMs than KM. The concentration of HMs on fish from KM and MM were all greater than the maximum permissible limit of HMs in fish as recommended by FAO/WHO (2016); FAO, (1993) and Saha *et al*. (2016).

Estimation of average daily dose of metal (ADDM)

The average daily dose of metals for adult (via the consumption of fish from KM and MM) was estimated according to the average fish consume through the food chain. The ADDM values for HMs as (0.002, 0.006), Cd (0.003, 0.007), Cr (0.002, 0.004), Hg (0.001, 0.005), and Pb(0.004, 0.004) in fish from KM and MM respectively for HMs. The result shows that fishes in MM and KM have less ADDM but continuous consumption may cause health risk (Figure1).

Estimation of Health Risk Index HRI

The HRI of HMs As, Cd, Cr, Cu, Hg, and Pb in *C.gariepinus* from KM and MM were 0.2, 0.06, 0.001, 0.1, 0.01 and 0.6, 0.14, 0.002, 0.5, 0.01 respectively. The HRI for fishes were all less than one which do not indicate toxicity of metals (Figure 2).

Estimation of Hazard index (HI)

The HI of the overall health risk exposure of all analyzed heavy metals via the ingestion of a contaminated fish *C.gariepinus* is shown in (Figure3). Total Index of all metals in KM, and MM were 0.37 and 1.25 respectively. The result shows that Fishes Minna markets were highly contaminated with heavy metals. HI > 1 indicates that the predicted exposure is likely to pose potential health risks.

DISCUSSION

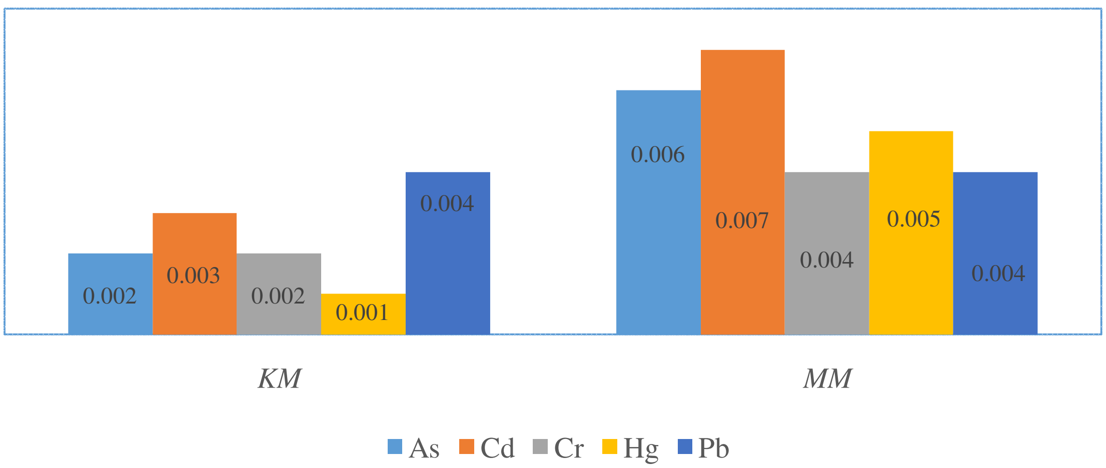
The result shows that fish purchased from Minna fish market were contaminated with heavy metal compared to the fish purchased in Katcha Market. This may be due to the different locations and sources of fish, Katcha is one of the LGA in Niger state and they cultivate a lot of fish due to rivers surrounding them and Minna is the state capital, fish sellers bring fishes from different part of the state to sale. This fishes are expose during transport and might accumulate a lot of Metals in the process also due to high vehicular movement in the urban areas (Minna Market) may also be a cause of accumulation of metal. Fish habitat have been contaminated with many anthropogenic activities such as washing of clothes, nitrate from soap are discharge in the water and combustion. Aquatic life abound in the waters can bioaccumulate these toxic metals and subsequently transfer it to consumers via food chain. Fish accumulate large quantities of toxic metals and the accumulation depends upon the intake and elimination from the body. There was significant difference in the concentrations of HMs in fish's locations (Katcha market and Minna fish market).There was a significant increase of metal in *C.gariepinus* purchase from MM than in KM. The variation in the level of HMs accumulation in different location may support the view that there is a variation in

Table 1: Concentration of heavy metals in fish samples,

Heavy Metals	Fish samples		PL(mg/kg) by FAO/WHO
	KM(mg/kg)	MM(mg/kg)	2016*, Saha et al., 2016**
As	0.52 ± 0.25^b	1.54 ± 0.03^a	0.01*
Cd	0.83 ± 0.08^b	1.91 ± 0.11^a	0.05*
Cr	0.67 ± 0.09^b	1.12 ± 0.05^a	1.5**
Hg	0.31 ± 0.12^b	1.32 ± 0.10^a	0.01*
Pb	0.98 ± 0.11^b	1.04 ± 0.04^a	0.3*

Results Expressed as Mean ± SD. Mean values with different superscript letters on the rows are considered significant (P<0.05). PL=Permissible limit, n=3

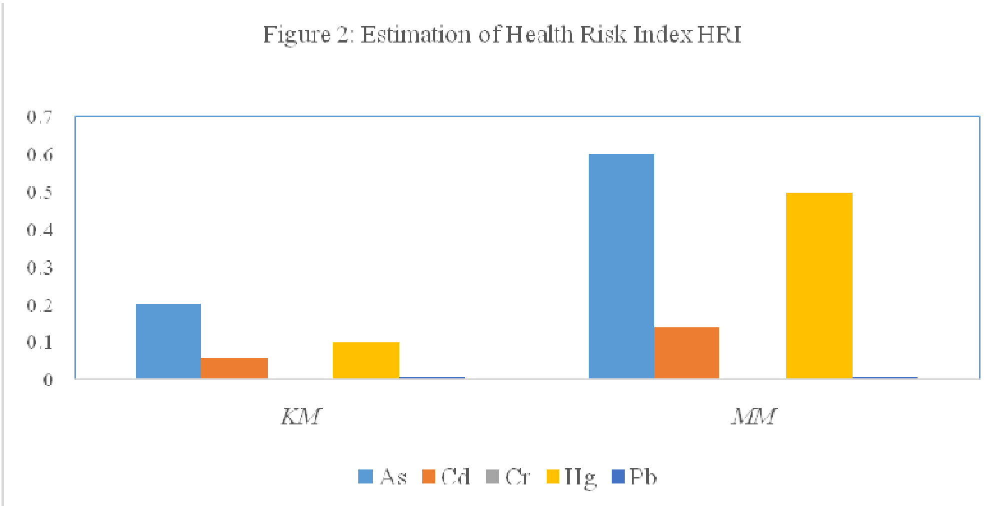
Figure 1: Estimation of average daily dose of metal (ADDM)

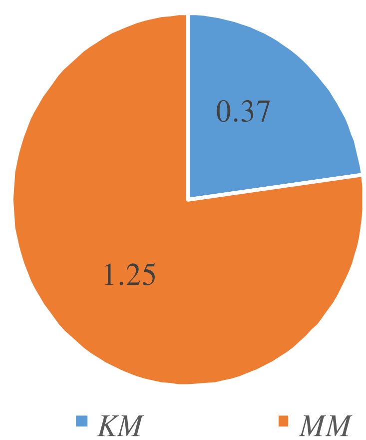


ability of fish to accumulate HMs depending on their sources or habitat. The HMs (As, Cd, Cr, Hg, and Pb) dictated in fishes from MM were all above the FAO/WHO, 2016 permissible limit of 0.01, 0.05, 1.5, 0.01, and 0.3 mg/kg respectively (Table 1). The mean concentrations of HMs in MM decrease in the following order Cd>As>Hg>Cr>Pb. The levels of Cr were comparatively lower in the fish samples which are in accordance with the findings of Oguh *et al*. (2019a) who also recorded low Cr in fish sample from contaminated water. Heavy metals and nutrients absorbed by fish are usually translocated to different parts of the fish which could reduce the concentrations in the water. However, availability of HMs in the water and continuous stay in the polluted water could lead to higher concentration in the fish.

Arsenic affects almost all organs during its acute or chronic exposure. Toxicity is due to arsenic's effect on many cell enzymes, which affect metabolism, DNA repair and brain problem. The most prominent chronic manifestations of As involve the skin, lungs, liver and blood systems. The levels of Cd recorded in this study was however much higher than the values of 0.27 mg/kg reported for fish by Hossam *et al*. (2017). Cadmium is a dangerous element because it can be absorbed via the alimentary track; penetrate through placenta during pregnancy and damage membrane and DNA. High dose of chromium is observed to cause Bronchopneumonia, chronic bronchitis, diarrhea, emphysema, and headache, irritation of the skin, itching of respiratory tract, liver diseases, lung cancer, nausea, renal failure, reproductive toxicity, and vomiting. Mercury poisoning symptoms include blindness, deafness, brain damage, digestive problems, kidney damage, lack of coordination and mental retardation. Lead can cause serious injury to the brain, nervous system, red blood cells, low IQ, impaired development, shortened attention span, hyperactivity, mental deterioration, decreased reaction time, loss of memory, reduced fertility, renal system damage, nausea, insomnia, anorexia, and weakness of the joints when exposed to high lead. The bio-accumulated metals on the fish may interact directly with biomolecules such as nucleic acid, protein, carbohydrate and disrupting critical biological processes which results to toxicity (Huang *et al.,* 2017; Oguh *et al.,* 2019b).

The daily intake indicates the amount of HMs that will be taken in the body when such fish is consumed.





The study shows a significant amount of HMs from the consumption of fish in a day. The HRI values were less than one indicating that consumers of fishes from KM and MM may not be exposed to health risk but continuous consumption may lead to accumulation. Hazard index (HI) which shows the overall risk of exposure to all analyzed metal indicate that the consumption of fish can pose health risk to consumer through the intake of metal since the values of the HI obtain were all greater than 1.

Conclusion

The study concludes that trace metals concentrations exceed the permissible recommended values, which suggest that fish from these areas are not fully safe for human health.

REFERENCES

Authman MMN, Zaki MS, Khallaf EA Abbas HH (2015). Use of Fish as Bio-indicator of the Effects of Heavy Metals Pollution. *J. Aquac. Res. Development* 6: 328. doi:10.4172/2155-9546.1000328.

Barka S, Pavillon JF, Amiard JC (2001). Influence of different essential and non-essential metals on MTLP levels in the Copepod Tigriopus brevicornis Comparative Biochemistry and Physiology Part C: *Toxicol. Pharmacol*. 128:479-493.

Beijer K, Jernelov A (1986). Sources, transport and transformation of metals in the environment. *Handbook on the toxicology of metals. Elsevier, Amsterdam*. Pp. 68-84.

Clarkson TW, Magos L, MyersGJJ (2003). The toxicology of mercury: Current exposures and clinical manifestations. *New England Journal of Medicine*, 349: 1731-1737.Deore SV, Wagh SB(2012). Heavy metal induced histopathological alterations in liver of *Channa gachua* (Ham). *Journal of Experimental Science*, 3(3): 35-38.

Food and agriculture organization of the united nation FAO (1993).Water quality and fish health, by Z. Svobodová, R. Lloyd, J. Máchová and B. Vykusová. EIFAC Technical paper 54. M.45 ISBN 92.5-103437.0

Hassaan MA, El Nemr A, Madkour FF (2016). Application of Ozonation and UV assisted Ozonation on Decolorization of Direct Yellow 50 in Sea water, *The Pharmaceutical and Chemical Journal,* 3(2): 131-138.

Hossam AZ, Adnan MA, Hisham NW (2017). Baseline Concentration of Heavy Metals in Fish Collected from Gaza Fishing Harbor in the Mediterranean Sea along Gaza Coast, Palestine. *Turkish Journal of Fisheries and Aquatic Sciences 17:* 101-109. DOI: 10.4194/1303-2712-v17_1_12.

Huang Z, Lu Q, Wang J, Chen X, Mao X (2017). Inhibition of the bioavailability of heavy metals in sewage sludge biochar by adding two stabilizers, 12.

Jitar O, Teodosiu C, Oros A, Plavan G Nicoara M (2014). Bioaccumulation of heavy metals in marine organisms from the Romanian sector of the Black Sea. *N. Biotechnol*. doi: 10.1016/j.nbt.2014.11.004.

Lars J (2003). Hazards of heavy metal contamination. British Medical Bulletin, 68(1): 167-182.

Mahboob S, Al-Balawi HFA, Al-Misned F, Al-Quraishy S, Ahmad Z (2014). Tissue metal distribution and risk assessment for important fish species from Saudi Arabia. *Bull Environ Contam Toxicol* 92: 61-66.

Mansour SA, Sidky MM (2002). Ecotoxicological Studies, 3 Heavy metals contaminating water and fish from Fayoum Governorate. Egypt *J. Food Chem. 78(1)*, 15-22.

Oguh CE, Joseph PS, Osuji CA, Ubani CS, Okunowo WO (2019a). Risk Effect of Water Treatment Sludge on Bioaccumulation of Heavy Metals in Water, Fish (*Oreochromis niloticus*, and *Clarias gariepinus*) from River Chanchaga Minna Niger State, Nigeria. *International Journal of Agriculture, Environment and Bioresearch,* **4**(5):67-86. http://dx.doi.org/10.35410/IJAEB.2019.4431.

Oguh CE, Osuji CA, Obasi GO, Amadi EU, Okpaka CO, Nwizia BP (2019b). Seasonal Investigation of Heavy Metal Risk Assessment in Tilapia(*Oreochromis niloticus*) from Contaminated River Chanchaga Niger State, Nigeria. *Archives of Environmental Science and Environmental Toxicology,***2**(2):1-11. http://dx.doi.org/10.29011/2688-948X.100019.

Oguh CE, Osuji CA, Benjamin EC, Ugwu CV, Musa AD.(2020). Health Risk Assessment of Some Toxic Elements in Aquatic Bioindicator (*Clarias gariepinus* and *Oreochromis niloticus*) from Tagwai Reservoir Dam Minna, Niger State Nigeria Scholars International Journal of Biochemistry,3(2): 12-2110.36348/sijb.2020.v03i02.001Olaifa FE, Olaifa AK, Adelaja AA, Owolabi AG (2004). Heavy Metal Contamination of *Clarias gariepinus* From A Lake And Fish Farm In Ibadan, Nigeria.*African Journal of Biomedical Research, Vol. 7: 145 – 148.*

Saha N, Mollah M, Alam M, Rahman MS (2016). Seasonal investigation of heavy metals in marine fishes captured from the bay of Bengal and the implications for human health risk assessment. *Food Control*, 70, 110–118.

Selda OT, Nurşah A (2012). Relationship of Heavy Metals in Water, Sediment and Tissue with Total Length, Weight and Seasons of Cyprinus carpio L., 1758 From Isikli Lake (Turkey), *Pakistan J. Zool,* 44(5), 1405-1416.

Shakeri A, Shakeri R, Mehrabi B (2015). Potentially toxic elements and persistent organic pollutants in water and fish at Shahid Rajaei dam, north of Iran. *International journal of Environmental Science and Technology*, 12(7), 2201–2212. https://doi.org/10.1007/s13762-015-0754-9.

Toth JF, Brown RB (1997). Racial and gender meanings of why people participate in recreational fishing. *Leisure Sci.* 19:129-146.

United States Environmental Protection Agency (USEPA) (2017). Human health risk assessment model ecological risk assessment; 2017. Available:https://www.epa.gov/risk/humanhealth- risk-assessment#self.

USEPA (2011). Exposure Factors Handbook: 2011 Edition, EPA/600/R-090/052F, Office of Research and Development, Washington, DC, USA,.

USEPA (2002). Multimedia, multi-pathway and multi-receptor risk assessment (3MRA) modellling system. U.S Environmental Protection Agency, Office of Research and Development, Washington DC. 2002;1-9.

Velcheva E, Tomova D, Arnaudova D, Arnaudov A (2010). Morphological investigation on gills and liver of fresh water fish from Dam Lake "Studen Kladenets". *Bulgarian Journal of Agriculture Sciences*, 16(3): 364-368.

WHO (2001). Arsenic and Arsenic compounds: Environmental Health Criteria.Vol.224.Geneva: World Health Organization. International Program on Chemical Safety (IPCS), Geneva, Switzerland.

WHO/FAO (2016). *Joint FAO/WHO Food Standard Programme Codex Alimentarius Commission 10th Session.* Working document for information and use in discussions related to contaminants and toxins in the gsctff (Prepared by Japan and the Netherlands) 4 - 8 April 2016.

Zaqoot HA, Adnan MA, Hisham NW (2017). Baseline Concentration of Heavy Metals in Fish Collected from Gaza Fishing Harbor in the Mediterranean Sea along Gaza Coast, Palestine. *Turkish Journal of Fisheries and Aquatic Sciences 17: 101-109*. 10.4194/1303-2712-v17_1_12.