Research Journal of Animal, Veterinary and Fishery Sciences _____ISSN 2320 – 6535
Vol. **6(3),** 1-6, April **(2018)** *Res. J. Animal, Veterinary and Fishery Sci.*

Assessment of some heavy metals in the liver of freshwater Catfish (*Clarias gariepinus*) in Northeastern Nigeria

M.M. Gashua[1*], J. Kabir[2], M.M. Suleiman[3], H.I. Abdulrahman[4], A.M. Talba[5], N.O. Ahmed[6] and S.M. Jajere[1]
[1]Department of Veterinary Public Health and Preventive Medicine, University of Maiduguri, Borno State, Nigeria
[2]Department of Veterinary Public Health and Preventive Medicine, Ahmadu Bello University Zaria, Kaduna State Nigeria
[3]Department of Veterinary Pharmacology and Toxicology, Ahmadu Bello University Zaria, Kaduna State, Nigeria
[4]Department of Veterinary Medicine, University of Maiduguri, Borno State, Nigeria
[5]Veterinary Teaching Hospital, Ahmadu Bello University Zaria, Kaduna State, Nigeria
[6]Ministry of Animal Resources and Nomadic Resettlement Bauchi, Bauchi State, Nigeria
mgmuhammad@unimaid.edu.ng

Available online at: www.isca.in, www.isca.me
Received 21st January 2018, revised 10th April 2018, accepted 22nd April 2018

Abstract

This study was aimed at assessing the levels of Cadmium (Cd) and Lead (Pb) in the liver of freshwater catfish Clarias gariepinus (C. gariepinus) from three fishing sites in Bade Local Government Area along the coast of River Yobe, Northeastern Nigeria. The concentrations of Cd and Pb in the liver of (C. gariepinus) were determined using atomic absorption spectrophotometer. A total of 41 samples were collected from Gada (n=12), Egjin Kavuru (14) and Zarara (15). The results obtained showed that 95.1% and 65.9% of the studied fish contained Cd and Pb respectively at concentrations above the maximum acceptable concentrations recommended by the WHO/FAO Joint Committee on Food and Additives (JECFA). Concentrations of Cd by location showed no significant difference (P<0.05) among the different fishing sites but there was statistically significant difference (p<0.05) in Pb concentrations between fish samples from Gada and EgjinKavuru on one hand and Zarara on the other hand. People who habitually consume catfish from this river stand the risk of exposure to low doses of Cd and Pb. Further studies are therefore recommended to evaluate the heavy metal pollution status of River Yobe and also to ascertain the levels of other nephrotoxic metals in different species of fish, meant for human consumption, from the river.

Keywords: Freshwater catfish, cadmium, lead, atomic absorption spectrophotometer, Yobe State, Nigeria.

Introduction

Fresh water bodies can become contaminated by a wide range of pollutants including heavy metals released from industrial, domestic, and other anthropogenic activities[1-4]. Once released into water bodies, heavy metals can marinate and gain access into plants, fish and other living organisms inhabiting the polluted waters. People and animals get exposed to these metals by consuming the contaminated forages, water and fish[5-14]. Although some heavy metals such as Magnesium (Mg), Calcium (Ca), Zinc (Zn) and Iron (Fe) have been reported to be of bio-importance to man, consumption of Pb, Cd, Arsenic (As) and Mercury (Hg) even at trace amounts can have ruinous health effects[15-23]. Due to the nature of their habitation, aquatic organisms seldom do away with the detrimental effects of pollutants in their environment[24-26]. Fish have been made the most popular choice in the assessment of pollution status of natural water bodies possibly because, they are the most understood aquatic organisms[27,28] which also have the ability to accumulate toxic chemicals present in their diet and environment[29-34,]. Several studies have reported varying concentrations of heavy metals in fish raised in some Nigerian rivers[35-41].

Northern Yobe abound with water bodies providing stable fish supply and employment to the local populace, has been faced with serious health problems such as chronic kidney disease (CKD) in the last decade particularly among those communities inhabiting the coast of River Yobe. Although the actual cause has not been identified, there were concerns by the local people as to whether consumption of fish raised in River Yobe could be responsible. In a report, Komadugu Yobe Basin Water Audit report[42], written by a committee set by the Federal Ministry of Water Resources, Nigeria in collaboration with the International Union for Conservation of Nature, it was highlighted that there were growing evidence of pollution status of the Komadugu-Yobe river basin and that the pollution could have some negative impacts on the basin's communities[42]. Similarly, in a preliminary study, Waziri and Ogugbuaja[43] have reported presence of some pollution indicators in water samples drawn from different locations along River Yobe. Although, the research did not pinpoint any specific pollutant in the river, it has however strengthened further the findings of the Komadugu Yobe Basin Water Audit report. This study was therefore aimed at assessing the extent of bioaccumulation of some heavy metals in fish collected from River Yobe intended for human consumption.

Materials and methods

The study area: This study was carried out in Bade local government area, Yobe state. It is located between longitude 12º52´N and latitude 10º58´E, with an area of about 772 KM^2 and a population of 139,804[44], predominantly peasant farmers, fishermen and small-scale traders[45]. It is situated in semi-arid zone and River Yobe is the main water body that passes through the LGA, which also serves as the main source of fish and water to most of the communities. Hadejia and Jama' are rivers that meet in the Hadejia Nguru Wetlands (Figure-1) form the River Yobe, which drains into Lake Chad[42].

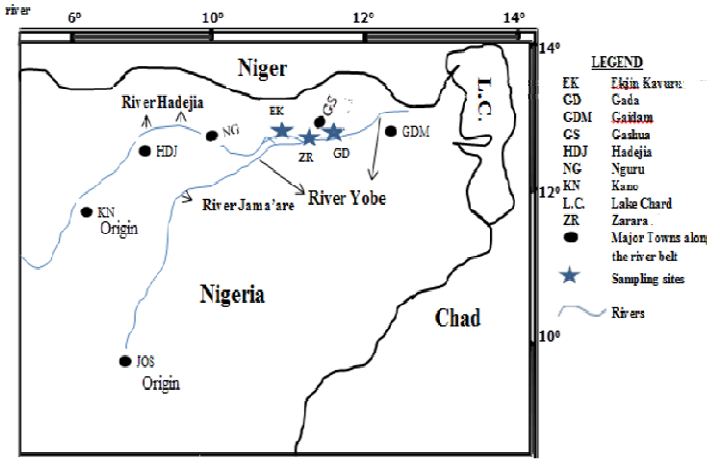

Figure-1: Map showing origins of river Yobe and the sampled sites[46].

Sample collection: Freshwater catfish were purchased from three different locations where anglers converge to sell their daily catches along the coast of River Yobe within the boundaries of Bade LGA, Yobe state. The locations which were identified by their local names include 'Gada', 'Zarara' and 'Egjin-Kavuru'. A total of 45 catfish samples were obtained. The samples were immediately placed in an ice-packed container, labeled and transported to the laboratory. Each sample was carefully dissected using stainless steel knife and the liver removed, oven dried at 105^0C to a weight ranging between 0.10g and 0.50g. Samples were later placed in colorless polythene bags, labeled and transported to Industrial and Environmental Technology laboratory, Department of Industrial and Environmental Technology, National Research Institute for Chemical Technology Zaria, Nigeria, for further processing and analysis. By the end of the drying, 12 (29.2%) liver samples from Gada, 14 (34.2%) samples from Egjin Kavuru and 15 (36.6%) samples from Zarara were obtained. Four samples were discarded due to human error.

Sample processing and analysis: Whole quantity of the dried sample was homogenized using pestle and mortar and transferred into a 250ml glass beaker placed on a hot plate at 60^oC, 10ml of freshly prepared 1:1 HNO_3:H_2O_2 solution was then added and allowed to stay until the homogenate dissolves completely to produce a clear solution. The solution was cooled at room temperature and the content was filtered using Whatmann Filter paper size 125mm[39,47]. The final volume was made up to 20ml with deionized water. Ten per cent HNO_3 solution was used to wash the entire laboratory glass wares used and were rinsed in deionized water.

The Cd and Pb contents were analyzed by flame atomic absorption spectrophotometry (FAAS) using Varian AA240FS apparatus (Varian Manufacturing Company, Australia) with Zeaman's background correction. The spectrophotometer was controlled by Spectra AA version 5.1 software program. Calibration curves were based on three standards (2, 4 and 8 ppm) for both metals. Instrument blanks (0.5% HNO_3) and check standards were processed with all samples. All catfish liver samples containing Cd and Pb concentrations above 0.2 mg/kg and 1.0 mg/kg respectively were considered above the maximum acceptable concentration (MAC)[48].

Statistical analysis: The data obtained were analyzed using the JMP statistical software version 11. The figures were expressed with mean (±SEM) values. Differences in concentrations between fish from different locations were computed using One Way Analysis of Variance at $p<0.05$ and Fisher's Exact test was used to compare the categorized (High and Low) concentrations of metals in the catfish by location with MAC set by JECFA.

Results and discussion

Data for concentrations of Cd and Pb in parts of River Yobe are presented in Table-1. The mean ± SEM concentration of Cd in the liver of catfish from the selected locations indicate that catfish from Gada had mean Cd concentrations of 1.01±0.19 mg/kg, Egjin Kavuru 0.84±0.17mg/kg and Zarara 0.62±0.17 mg/kg (Table-1). Thirty-nine (95.1%) fish samples had Cd concentration above the maximum acceptable concentration (MAC). No statistical difference in concentration of Cd between fish from different sampling sites was observed (Table-1).

Table-1: Mean Cd concentrations in the liver of catfish from three parts of River Yobe in relation to maximum acceptable concentrations[48].

Sampling site	n	Mean±SEM (mg/kg)	*High (%)	Low (%)
Gada	12	1.006^a ±0.19	12^a (100)	0 (0)
Egjin Kavuru	14	0.844^a ±0.17	12^a (85.7)	02 (14.3)
Zarara	15	0.642^a ±0.17	15^a (100)	0 (0)
Total	41		39 (95.1)	2 (4.9)

Variables in the same column with same superscript are not significantly different at $p<0.05$. *Concentrations above 0.2 mg/kg considered high.

On the other hand, the mean ± SEM Pb concentration in Catfish from Gada was 12.98±2.81mg/kg, Egjin Kavuru 4.05±2.60 mg/kg and Zarara 7.34±2.51mg/kg (Table-2). Twenty-seven (65.9%) fish sample had Pb concentration above the MAC and there was statistical significant difference ($p<0.05$) between fish samples from Gada and Zarara ($p=0.0002$) and between Egjin Kavuru and Zarara ($p=0.02$) (Table-2).

Table-2: Mean Pb concentrations in the Liver of Catfish from some Parts of River Yobe in Relation to Maximum Permissible Limits[48].

Sampling site	n	Mean±SEM (mg/kg)	*High (%)	Low (%)
Gada	12	12.98^{a}±2.81	12^{a} (100)	0 (0)
Egjin Kavuru	14	4.046^{a}±2.60	04^{a} (28.6)	10 (71.4)
Zarara	15	7.34^{a}±2.51	11^{b} (73.3)	04 (26.7)
Total	41		27 (65.9%)	14 (34.1%)

Variables in the same column with same superscript are not significantly different at $p<0.05$. *Concentrations above 1.0 mg/kg is considered high.

The higher concentrations of Cd and Pb recorded in catfish samples from this study could be indicative of possible pollution of the water body presumably from the soil since the region has been reported to have considerable amount of Cd and Pb in dust storm[49], and in some sources of water meant for human consumption[50]. Previously, fish has been used as indicators of pollution status of the water they lived in[29-31,33]. In some studies on freshwater fish between polluted and unpolluted rivers, Ghazaly[51] and Swales *et al.*[52] have reported fish from polluted water bodies having higher Cd and Pb levels than those from unpolluted waters. The findings of this study could suggest how widely distributed Cd and Pb are in the study area. The high levels of Cd and Pb, respectively found in Gada could possibly be attributed to its location. Gada is located in the local Government Headquarters, which is an urban settlement and also the commercial center of the entire communities. The population is denser, hence high levels of domestic sewage disposal, waste from automobile workshops, leaked fuel from water pumps used in irrigation etc., which are usually evident by the river shores. More so, use of phosphate fertilizers and agricultural chemicals on irrigated lands could play significant role in increasing the heavy metal burden in and around the water body[53-55,25]. Once deposited near a river, heavy metals and other pollutant can easily be washed into and pollute the water bodies and also the terrestrial life inhabiting it[5,7,8,25,33]. Since the concentrations of Cd and Pb in catfish samples obtained from all the three locations of River Yobe are higher than the MAC, it suggests that communities who habitually consume catfish from this river could be at risk of exposure to Cd and Pb.

Conclusion

Detecting substantial amount of these heavy metals in these areas suggest the need for public health awareness to the surrounding communities on the effect of their daily activities in relation to their health. Similarly, government can formulate policies that would curtail the indiscriminate disposal of substances that could put the whole community at risk.

Acknowledgement

The authors wish to thank Yobe State Government for financially supporting this research, Bade Emirate Council, Provosts and staff of Umar Suleiman College of Education Gashua (Science Department in particular) where sample was processed prior to transportation for analysis, Yobe State College of Agriculture Gujba, the Principal and staff of GSTC Gashua, all the staff of the Departments of Veterinary Public Health and Preventive Medicine ABU Zaria and University of Maiduguri for their cooperation during this study.

References

1. Babatunde A.M., Waidi O.A. and Adeolu A.A. (2012). Bioaccumulation of Heavy Metals in Fish (*Hydrocynus forskahlii, Hyperopisus bebe Occidentalis* and *Clarias gariepinus*) Organs in Downstream Ogun Coastal Water, Nigeria. *Transnational Journal of Science and Technology*, 2(5), 119-133.

2. Zaharia C. (2015). Evaluation of water pollution status in Bahlui River (Iasi town area) due to domestic and urban wastewater treatment activities. *Journal of Engineering Studies and Research*, Bacau, 21(4), 79-88.

3. Seidel M., Jurzik L., Brettar I., Höfle M.G. and Griebler C. (2016). Microbial and viral pathogens in freshwater: current research aspects studied in Germany. *Environmental Earth Sciences*, 75, 1384. https://doi.org/10.1007/s12665-016-6189-x.

4. Zaharia C. (2017). Decentralized wastewater treatment systems: Efficiency and its estimated impact against onsite natural water pollution status. A Romanian case study. *Process Safety and Environmental Protection*, 108, 74-88. https://doi.org/10.1016/j.psep.2017.02.004

5. Antoniou V., Tsoukali-Papadopoulou H., Epivatianos P. and Nathanael B. (1989). Cadmium concentrations in beef consumable tissues in relation to age of animals and area of their breeding. *Bulletin of Environmental Contamination and Toxicology,* 43(6), 915-919.

6. Burger J., Gaines K.F., Boring C.S., Stephens W.L., Snodgrass J., Dixon C., Mc Mahon M., Shukla S., Shukla T. and Gochfeld M. (2002). Metal Levels in Fish from the Savannah River: Potential Hazards to Fish and Other Receptors. *Environmental Research*, 89(1), 85-97. https://doi.org/10.1006/enrs.2002.4330

7. Frodello J.P., Viale D. and Marchand B. (2002). Metal concentrations in the milk and tissues of a nursing *Tursiops truncates* female. *Marine Pollution Bulletin*, 44(6), 551-554.

8. Phillips C.J.C. and Prankel S.H. (2011). Cadmium and the Welfare of Animals. *Elsevier,* 451-455.

9. Roggeman S., van den Brink N., Praet N.V., Blust R. and Bervoets L. (2013). Metal exposure and accumulation patterns in free-range cows (Bostaurus) in a contaminated natural area: Influence of spatial and social behaviour. *Environmental Pollution*, 172, 186-199. DOI: 10.1016/j.envpol.2012.09.006

10. Taweel A., Shuhaimi-Othman M. and Ahmad A.K. (2013). Assessment of heavy metals in tilapia fish (*Oreochromisniloticus*) from the Langat River and Engineering Lake in Bangi, Malaysia, and evaluation of the health risk from tilapia consumption. *Ecotoxicology and Environmental Safety*, 93, 45-51. https://doi.org/10.1016/j.ecoenv.2013.03.031

11. Leung H.M., Leung A.O.W., Wang H.S., Ma K.K., Liang Y., Ho K.C., Cheung K.C., Tohidi F. and Yung K.K.L. (2014). Assessment of heavy metals/metalloid (As, Pb, Cd, Ni, Zn, Cr, Cu, Mn) concentrations in edible fish species tissue in the Pearl River Delta (PRD), China. *Marine Pollution Bulletin*, 78(1-2), 235-245. https://doi.org/10.1016/ j.marpolbul.2013.10.028

12. Gann G.L., Powell C.H., Chumchal M.M. and Drenner R. W. (2015). Hg-contaminated terrestrial spiders pose a potential risk to songbirds at Caddo Lake (Texas/Louisiana, USA). *Environmental Toxicology and Chemistry*, 34(2), 303-306. doi:10.1002/etc.2796

13. Gu Y.G., Lin Q., Wang X.H., Du F.Y., Yu Z.L. and Huang H.H. (2015). Heavy metal concentrations in wild fishes captured from the South China Sea and associated health risks. *Marine Pollution Bulletin*, 96(1-2), 508-512. https://doi.org/10.1016/j.marpolbul.2015.04.022

14. Sibanda T., Selvarajan R. and Tekere M. (2015). Urban effluent discharges as causes of public and environmental health concerns in South Africa's aquatic milieu. *Environmental Science and Pollution Research*, 22(23), 18301-18317. https://doi.org/10.1007/s11356-015-5416-4

15. Ferner D.J. (2001). Toxicity Heavy Metals. *eMed. J.*, 2(5), 1.

16. Nolan K. (1983). Copper Toxicity Syndrome. *J. Orthomol. Psychiatry*, 12(4), 270-282. Oboh I.P. and Edema C.U. (2007). Levels of heavy metals in water and fishes from the River Niger, *Journal of Chemical Society of Nigeria*, 32(2), 29-34.

17. Duruibe J.O., Ogwuegbu M.O.C. and Egwurugwu J.N. (2007). Heavy metal pollution and human biotoxic effects. *International Journal of Physical Sciences*, 2(5), 112-118.

18. Jumba I.O., Kisia S.M. and Kock R. (2007). Animal Health Problems Attributed to Environmental Contamination in Lake Nakuru National Park, Kenya: A Case Study on Heavy Metal Poisoning in the Waterbuck Kobus Ellipsiprymnus defassa (Ruppel 1835). *Archives of Environmental Contamination and Toxicology*, 52(2), 270-281.

19. Dahunsi S.O., Oranusi S.U. and Ishola R.O. (2012). Differential bioaccumulation of heavy metals in selected biomarkers of *Clariasgariepinus*(Burchell, 1822) exposed to chemical additives effluent. *Journal of Research in Environmental Science and Toxicology*, 1(5), 100-106.

20. Galadima A. and Garba Z.N. (2012). Heavy metals pollution in Nigeria: causes and consequences. *Elixir Pollution*, 45, 7917-7922

21. Hoffmann S.R., Blunck S.A., Petersen K.N., Jones E.M., Koval J.C., Misek R., Frick J.A., Cluff H.D., Sime, C.A., McNay M., Beckman K.B., Atkinson M.W., Drew M., Collinge M.D., Bangs E.E. and Harper R.G. (2010). Cadmium, Copper, Iron, and Zinc Concentrations in Kidneys of Grey Wolves, Canis lupus, from Alaska, Idaho, Montana (USA) and the Northwest Territories (Canada). *Bulletin of Environmental Contamination and Toxicology,* 85(5), 481-485. DOI: 10.1007/s00128-010-0126-6

22. Mungai T.M., Owino A.A., Makokha V.A., Gao Y., Yan X. and Wang J. (2006). Occurrences and toxicological risk assessment of eight heavy metals in agricultural soils from Kenya, Eastern Africa. *Environmental Science and Pollution Research*, 23(18), 18533-18541. DOI: 10.1007/s11356-016-7042-1

23. Nakayama S.M.M., Ikenaka Y., Hamada K., Muzandu K., Choongo K., Yabe J., Umemura T. and Ishizuka M. (2013). Accumulation and biological effects of metals in wild rats in mining areas of Zambia. *Environmental Monitoring and Assessment*, 185(6), 4907-4918. DOI: 10.1007/s10661-012-2912-6

24. Dickman M.D. and Leung K.M. (1998). Mercury and organochlorine exposure from fish consumption in Hong Kong. *Chemosphere*, 37(5), 991-1015.

25. Olaifa F.E. and Ayodele I.A. (2004). Presence of hydrocarbon and heavy metals in some fish species in the Cross River, Nigeria. *African Journal Livestock Extension*, 3, 90-95.

26. Bastami K.D., Afkhami M., Mohammadizadeh M., Ehsanpour M., Chambari S., Aghaei S., Esmaeilzadeh M., Neyestani M.R., Lagzaee F. and Baniamam M. (2015). Bioaccumulation and ecological risk assessment of heavy metals in the sediments and mullet *Liza klunzingeri* in the northern part of the Persian Gulf. *Marine Pollution*

Bulletin, 94(1-2), 329-334. https://doi.org/10.1016/j.marpolbul.2015.01.019

27. Buikema A.L., Niederlehner B.R. and Cairns J. (1982). Biological Monitoring: Part IV – Toxicity Testing. *Water Res*., 16(3), 239-262.

28. Squadrone S., Benedetto A., Brizio P., Prearo M. and Abete C. (2015). Mercury and selenium in European catfish (*Silurusglanis*) from Northern Italian Rivers: Can molar ratio be a predictive factor for mercury toxicity in a top predator?. *Chemosphere*, 119, 24-30. https://doi.org/10.1016/j.chemosphere.2014.05.052

29. Labonne M., Basin S., Othman D. and Luck J. (2001). Lead Isotopes in Muscels as Tracers of Metal Sources and Water Movements in a Lagoon (Thau Basin, S. France). *Chemical Geology*, 181(1-4), 181-191.

30. Goodwin T.H., Young A., Holmes M., Old G., Hewitt N., Leeks G., Packman J. and Smith B. (2003). The Temporal and Spatial Variability of Sediment Transport and Yields within the Bradford Beck Catchment, West Yorkshire. *Science of the Total Environment*, 314, 475-494

31. Osman A., Wuertz S., Mekkawy I., Exner H. and Kirschbaum F. (2007). Lead Induced Malformations in Embryos of the African Catfish Clarias Gariepinus (Burchell, 1822). *Environmental Toxicology*, 22(4), 375-389.

32. Uzairu A., Harrison G.F.S., Balarabe M.L. and Nnaji J.C. (2009). Concentration Levels of Trace Metals in Fish and Sediment from Kubanni River, Northern Nigeria. *Bull. Chem. Soc. Ethiop*, 23(1), 9-17.

33. Authman M.M.N., Zaki M.S., Khallaf E.A. and Abbas H.H. (2015). Use of Fish as Bio-indicator of the Effects of Heavy Metals Pollution. *Journal of Aquatic Research and Development*, 6(4), 1-13. doi:10.4172/2155-9546.1000328

34. Arulkumar A., Paramasivam S. and Rajaram R. (2017). Toxic heavy metals in commercially important food fishes collected from Palk Bay, Southeastern India. *Marine Pollution Bulletin*, 119(1), 454-459. https://doi.org/10.1016/j.marpolbul.2017.03.045

35. Kakulu S.E., Osibanjo O. and Ajayi S.O. (1987). Trace metal content of fish and shellfishes of the Niger delta area of Nigeria. *Environment International*, 13(3), 247-251.

36. Oboh I.P. and Edema C.U. (2007). Levels of heavy metals in water and fishes from the River Niger. *Journal of Chemical Society of Nigeria*, 32(2), 29-34.

37. Ogamba E.N., Inyang I.R. and Seiyaboh E.I. (2010). Levels of Cadmium and Lead in the Tissue and Liver of Fish (*Clariasgariepinus*) around some Oil-Flow Stations in Bayelsa State, Niger Delta. *African Journal of Applied Zoology & Environmental Biology,* 12(1), 1-6.

38. Eneji I.S., ShaíAto R. and Annune P.A. (2011). Bioaccumulation of Heavy Metals in Fish (*Tilapia zilli* and *Clariasgariepinus*) Organs from River Benue, North ñ Central Nigeria. *Pakistan Journal of Analytical and Environmental Chemistry*, 12(1-2), 25-31.

39. George F., Raymond O., Dominic O. and Toyin A. (2013). Seasonal Variation in Heavy Metal Content of Tongue Sole, *Cynoglossus brownii* and Croaker, *Pseudotolithus typus* from Lagos and Delta States, Nigeria. *British Journal of Applied Science & Technology*, 3(4), 1548-1557.

40. Udiba U.U., GaujeBalli Odey M.O., Umar S.M., Ashade N. O., Odeke E.H., Mukhtar Bala and Dawaki S.I. (2014). Contaminants Levels of African Cat Fish (*Clariasgariepinus*) Tissues: A Comparative Study of River Galma, River Kubanni and Fish Farms in Zaria, Nigeria. *Merit Research Journal of Environmental Science and Toxicology*, 2(8), 156-166.

41. Adeosun F.I., Akinyemi A.A., Idowu A.A., Taiwo I.O., Omoike A. and Ayorinde B.J.O. (2015). The effects of heavy metals concentration on some commercial fish in Ogun River, Opeji, Ogun State, Nigeria. *African Journal of Environmental Science and Technology*, 9(4), 365-370. Doi:10.5897/AJEST2014.1659

42. KYBP (2006). Komadugu Yobe Basin Water Audit Report by Afremedev Consultancy Services Limited for FMWR-IUCN-NCF Komadugu Yobe Basin Project, Kano, Nigeria.

43. Waziri M. and Ogugbuaja V.O. (2010). Interrelationships between physicochemical water pollution indicators: a case study of River Yobe-Nigeria. *American Journal of Scientific and Industrial Research,* 1(1), 76-80.

44. National Population Commission (NPC) (2006), http://www.population.gov.ng/

45. Oruonye E.D. (2009). Geographical Aspects of Yobe State. Fab Educational Books, Jos. ISBN 978-978-900-433-1,121.

46. Barchiesi S., Cartin M., Welling R. and Yawson D. (2013). Water and Nature Initiative (Wani): Case Study-Komadugu Yobe Basin. Upstream of Lake Chad, Nigeria. GPS Printing, France *https://portals.iucn.org/library/node/10105*

47. Asegbeloyin J.N., Onyimonyi A.E., Ujam O.T., Ukwueze N.N. and Ukoha P.O. (2010). Assessment of toxic trace metals in Selected Fish Species and Parts of Domestic Animals. *Pakistan Journal of Nutrition,* 9(3), 213-215.

48. JECFA (2011). Joint FAO/WHO food standards programme codex committee on contaminants in foods. 5th session, 64-89.

49. Uduak O. and Hassan U.M. (2007). Analysis of dust storm for some metals. *Journal of Allied Science and Technology,* 2(1), 76-82.

50. National Agency for Food Drug Administration and Control (NAFDAC) (2006), RE: *Kidney Disease in Bade Local Government Area*. Report of water analysis, Ref: NAFDAC/70/COM/0047.

51. Ghazaly K.S. (1992). A comparative study of trace element accumulation in tissues of the teleost Tilapia zilii from contaminated and clean areas. *Bulletin of the Nat. Inst. Ocean Fish*, *ARE,* 18, 37-41.

52. Swales S., Storey A.W., Roderick I.D., Figa B.S., Bakowa K.A. and Tenakanai C.D. (1998). Biological monitoring of the impacts of the Ok Tedi copper mine on fish populations in the Fly River system, Papua New Guinea. *Science of the Total Environment*, 214, 99-111.

53. Page A.L., El Amamy M.M. and Chang A.C. (1986). Cadmium in the environment and its entry into terrestrial food chain crops. *In*: Foulkes, E.C. eds., *Handbook of experimental pharmacology,* 80, 33-74.

54. ATSDR (1999). Agency for Toxic Substances and Disease Registry. Toxicological profile for cadmium http:// www.atsdr.cdc.gov/toxprofiles/tp5.html.

55. Zasadowski A., Barski D., Markiewicz K., Zasadowski Z., Spodniewska A. and Terlecka A. (1999). Levels of cadmium contamination of domestic animals (cattle) in the region of Warmia and Masuria. *Polish Journal of Environmental Studies*, 8(6), 443-446.