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Research Article

HEAVY METAL CONTAMINATION OF FISH SOLD AT NIGERIA'S RIVERINE AND COASTLINE MARKETS: AN OBSERVATIONAL VIEW STUDY

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ABSTRACT

Fish constitutes a very important source of protein in the diet of many Nigerians hence occupying an important segment of the food chain. The fish sold at Nigeria's riverine and coastal markets is usually obtained from those nearby bodies of water and the safety of these fishes for human consumption becomes mandatory to prevent various human diseases. This review perspective paper looked at the level of Heavy Metal (HM) contamination of fishes sold at Nigeria's riverine and coastal markets. Data was obtained from Calabar, Port Harcourt, Lagos, Onitsha, Asaba, Abeokuta, Warri, and Badagry and 57 scholarly articles met the inclusion criteria. Contamination of fishes with the following HMs was analysed: Lead (Pb), Cadmium (Cd), Zinc (Zn), Copper(Cu), Iron (Fe), Nickel (Ni), Chromium (Cr), Antimony (Sb), Mercury (Hg), Arsenic (As), Cobalt (Co), Aluminum (Al), Vanadium (V), Selenium (Se), and Silver (Ag). Analysis of the data showed that HMs that contaminated fishes most were Pb (70.18%, n=40), Cd (61.40%, n=35), Zn (59.65%, n=34), Cu (54.39%, n=31) and Fe (54.39%, n=31); and HMs with bioaccumulation in fishes above the FAO/WHO maximum thresholds were Pb (62.50%, n=40), Fe (54.84%, n=31), Cu (38.71%, n=31), Cd (37.14%, n=35) and Cr (36.00%, n=25) and hence toxic for human consumption. Fish contamination is bound to be on the increase and lack of appropriate knowledge by people on solid wastes disposal is generally seen as the major cause of soil, water and fish contamination with HMs. There is therefore need for more sensitization and creation of more public awareness on dangers of indiscriminate solid wastes disposal on our soils, water and fishes. Also, laws governing wastes management in cities and towns should be strengthened, and strictly implemented with stiff penalties for offenders to serve as deterrent.

Keywords: Bioaccumulation, Coastline, Contamination, Fishes, Heavy Metals, Markets, Nigeria.

INTRODUCTION

Fish is a major component of aquatic food that is rich in protein and principally omega-3 fatty acids-EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) which cannot be synthesized in the body. The omega-3 fatty acids are essential for optimum functioning of several body tissues and organs, hence preventing several diseases[1,2]. These include: lowering of and maintenance of normal blood pressure, maintaining a healthy heart, reducing incidence of heart attack, stroke and sudden death; healthy development of brain and nerves, and infant vision during pregnancy; reduce depression, attention deficit hyperactivity disorder (ADHD), dementia, Alzheimer's disease and diabetes mellitus; and they reduce the risk of arthritis and mitigate inflammation. People that eat fish more regularly appear younger due to its anti-aging properties[3-5]. Fish is a common food found in Nigeria's riverine and coastal markets and is common in the hinter lands far away from the coasts as well. These fishes are sold in fresh forms, partially or fully dried and smoked as well. There has however been a growing concern about the level of contamination of these sea foods with Heavy Metals (HMs) due to a sustained increase in human activity within and around Nigeria's coastal waters capable of generating heavy metals[6-9]. These heavy metals when ingested in high concentrations through fish consumption and hence accumulate to toxic levels in human tissues could trigger various diseases in humans from metabolic and chronic organ diseases to cancers[10, 11].In Sub-Saharan Africa, HM contamination of fish has generally become a common phenomenon. Our riverine and coastal areas become heavily contaminated with heavy metals through natural processes like air erosion of dusts as well as soil erosion and human activities such as industrialization, transportation indiscriminate waste disposal and agricultural practices. Dusts from air and soil contaminated by heavy metals many a times end up in our streams and rivers which flow into the rivers Niger and Benue which at their confluence in Lokoja flow down the Niger delta area ending up in riverine and coastal areas which area part of the sinks for the HMs they carry, and may cause their adverse effects to the inhabitants of these sinks of which fishes are a crucial component. In Sub-Saharan Africa,an estimation of concentration of HMs: Manganese (Mn), Cadmium (Cd), Lead (Pb), Mercury (Hg), Arsenic (As) and Iron (Fe) in fishes sold in greater Accra region in Ghana showed that accumulation of the HM followed the descending order of Fe>Mn> Cd, and Pb, while Hg and As were undetected. The concentration of Fe and Cd in both the Tilapia and Catfish tested were in excess of the maximum limit approved by the WHO for human consumption[12]. And in another similar study in Korle region in central Accra, the levels of contamination of Arsenic (As), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Mercury (Hg), Nickel (Ni), Lead (Pb) and Zinc (Zn) in *Trachinotusovatus*, *Mugilcurema* and *Mugilcephalus in e-wastes dump sites and was compared with Scombercolias*, Pseudotolithussenegallusfrom TemaNewTown fish market. Calculated risk indices showed comparative elevated As and Hg exposure in the former[13]. In Sierra Leone the soils near Pampana river and the fishes therein were assessed and found to contain very high concentrations of carcinogenic and non-carcinogenic HMs posing serious health risk to people living in the locality[14]. This study was therefore set up to assess the level of HM contamination of fishes sold at Nigeria's major coastal towns and cities through a systematic literature search so as to propose appropriate control measures to reduce it.

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MATERIALS AND METHODS

This study was based on a systematic literature search of electronic data bases such as Google Scholar, PubMed/Medline, web of science, EMBASE, SciElo, Cochrane library and AJOL on fish contamination. The search involved phrases such as: Heavy Metals contamination of Fish, Heavy Metals contamination of aquatic life, Environmental contamination of foods and fish, Fish pollution, air, soil and water pollution, Elemental pollution or contamination of fish, Sources of heavy metals in coastline and riverine areas, and Bioaccumulation of heavy metals in fishes or aquatic life. The search was limited to fishes sold at Nigeria's riverine and, coastline markets and cities covered a period of 36 years (1986-2021). Data was analysed using simple descriptive methods and also simple quantitative methods of sum, mean, and percentages.

RESULTS

Articles obtained from systematic review on HM contamination of fishes were obtained from findings in Calabar, Port Harcourt, Lagos, Onitsha, Asaba, Abeokuta, Warri, Asaba and Badagry. A total of 57 articles met the criteria for selection to be included in the study. Not all the HMs were uniformly assessed by authors in various studies as the number of HMs assessed varied from Two to Nine in a single study with majority between five and seven. Analysis of findings from the various studies showed that Pb (70.18%, n=40), Cd (61.40%, n=35), Zn (59.65%, n=34), Cu (54.39%, n=31) and Fe (54.39%, n=31) were the most documented HMs contaminating fishes at Nigeria's coastal markets. Other HMs implicated were: Ni (45.61%, n=26), Cr (43.86%, n=25), Sb (40.35%, n=23), Hg (35.09%, n=20), As (26.32%, n=15), Co (15.79%, n=9), Al (10.53%, n=6), V (7.02%, n=4), Se and Ag (3.51%, n=2 each) as seen in Table 1.An analysis of the toxicity levels of fishes with HMs contamination sold in the designated markets showed that Pb (62.50%, n=40), Fe (54.84%, n=31), Cu (38.71%, n=31), Cd (37.14%, n=35) and Cr (36.00%, n=25) had HM levels respectively above the maximum threshold approved by FAO/WHO. Toxicity levels of other HMs contaminating fishes were: As (33.33%, n=15), Co (33.33%, n=9), Al (33.33%, n=6), Sb (30.43%, n=23), Zn (26.47%, n=34), Ni (19.23%, n=26), Hg (15.00%, n=20), V (0.00%, n=4), Se (0.00%, n=2), and Ag (0.00%, n=2) as seen in Table 2.

Table 1. Heavy Metals contaminating fishes in markets along Nigeria's coastal lines (N= 57)

Heavy Metal	Frequency	Percentages (%)
Lead (Pb)	40	70.18
Cadmium (Cd)	35	61.40
Zinc (Zn)	34	59.65
Copper (Cu)	31	54.39
Iron (Fe)	31	54.39
Nickel (Ni)	26	45.61
Chromium (Cr)	25	43.86
Antimony (Sb)	23	40.35
Mercury (Hg)	20	35.09
Arsenic (As)	15	26.32
Cobalt (Co)	9	15.79
Aluminium (Al)	6	10.53
Vanadium (V)	4	7.02
Selenium (Se)	2	3.51
Silver (Ag)	2	3.51

Table 2. Estimation of Toxicity Levels of HMs contaminating fishes in markets along Nigeria's coastal lines.

Heavy Metal	Number of Fishes Contaminated	Number of Fishes Toxic for Human Consumption	Percentages(%)
Lead (Pb)	40	25	62.50
Iron (Fe)	31	17	54.84
Cupper (Cu)	31	12	38.71
Cadmium (Cd)	35	13	37.14
Chromium (Cr)	25	9	36.00
Arsenic (As)	15	5	33.33
Cobalt (Co)	9	3	33.33
Aluminium (Al)	6	2	33.33
Antimony (Sb)	23	7	30.43
Zinc (Zn)	34	9	26.47
Nickel (Ni)	26	5	19.23
Mercury (Hg)	20	3	15.00
Vanadium (V)	4	0	0.00
Selenium (Se)	2	0	0.00
Silver (Ag)	2	0	0.00

DISCUSSION

Analysis of the findings showed that the HMs most heavily contaminating fishes sold at the designated markets were Pb (70.18%), Cd (61.40%), Zn (59.65%), Cu (54.39%) and Fe (54.39%) and the least contaminating HMs were Al (10.53%), V (7.02%), Se (3.51%) and Ag (3.51%). Based on toxicity levels, HMs whose contamination exceeded the maximum allowable threshold levels for human consumption most were Pb (62.50%), Fe (54.84%), Cu (38.71%), Cd (37.14%), and Cr (36.00%). Furthermore, HMs that showed lowest levels of toxicity among the fishes were Ni (19.20%), Hg (15.00%), Vanadium (0.00%), Se (0.00%) and Ag (0.00%). Some *of the most common sources of HM contamination of soils, water and fishes include* wastes like refuse dumps, effluent from industries, sewage, fuel spills from dumps and mechanic workshops washing into stagnant and flowing waters, rivers and canals. It has also been established that HMs contamination can arise from: hospital and pharmaceutical wastes and effluents; agricultural materials such as herbicides, pesticides and chemical fertilizers; fossil fuel combustion from both mobile machineries as well as stationary heavy duty industrial plants; wastes and effluents from metallurgical industries; discarded and buried electronic components and semi-conductors; batteries, pigments and paints[15-18]. Studies are increasingly unveiling the heavy contamination of river Niger with HMs right from its origin in the highlands of Guinea as it traverses Mali, Niger, Benin and Nigeria carrying HMs along its course[19]. The various anthropogenic and natural activities in cities such as Tembakounda, Bamako, Timbuktu, Niamey, Lokoja, Onitsha and Asaba along the banks of river Niger as it traverses along these cities, towns and villages will carry HMs along before emptying into the Niger delta region in its branches, canals and channels[15,16,20-22]. HMs contamination of the bodies of waters at the coastal lines continues from both close and distant human activities generating them and continuously increasing their levels. The toxicity levels attained by many of the fishes being sold poses serious health risk from human consumption due to their ability to cause cancers, metabolic diseases such as diabetes mellitus, hypertension, stroke, and end organ failures such as kidney and heart. Fishes occupy a high position in the food chain, serve critical nutritional needs of humans especially communities depending largely on it as staple food, and high Cr contamination can destroy its gills. Cr specifically when eaten by

humans from heavily contaminated fishes over a prolonged period of time could lead to diseases such as: Faded immune system, Skin diseases, Peptic ulcer and stomach upset, Respiratory failure, Alteration in genetic material, and Lung and liver cancers[23-26].The Niger delta region of Nigeria where river Niger empties all its waters also serves as the final recipient(sink)of all the HMs carried along its course posing probably a higher risk of HM contamination of its soils and sea foods. Although in many of the studies, HM contamination of fishes were still found to be within the tolerable levels approved by FAO/WHO, their continuous contamination and accompanying bioaccumulation is bound to continue. Regular evaluation of the soils, water and the fishes at the markets becomes necessary to detect early HM toxicity. Metropolitan boards of Nigerian coastal cities and towns should map out safer methods of identification and eventual disposal of wastes likely to be heavily loaded with HMs so as to reduce soil and fresh water contamination[27-30]. This study also recommends that more public awareness and sensitization need to be heightened up by deploying social media in addition to organized electronic and print media against indiscriminate dumping of refuse in coastal fresh waters and burying same under the ground so as to reduce leaching and eventual circulation of HMs in the environment. Activities of artisans such as battery repairers, automobile mechanics and welders should be given proper orientation and training on how to safely dispose of wastes emanating from their daily activities. Information from the various cities studied on wastes management show that lack of general appropriate attitude and knowledge towards wastes disposal has been a major human factor responsible for HM contamination of fishes. Governments should therefore enact waste management laws that carry with it stiffer penalties on offenders, and also establish solid waste recycling plants in towns and cities so as to effectively curb HM dissemination and accumulation in those communities[31,32].

CONCLUSION

This study has shown that HMs contamination of fishes in Nigeria's coastlines is a major health issue and the situation is bound to increase due to the increasing human activities generating them. Lack of appropriate knowledge about the dangers of indiscriminate and uncontrolled wastes disposal by people has contributed significantly to the generation of HMs in the said environments leading to contamination of soil, air, water and fishes.

RECOMMENDATION

More awareness and health education should be carried out by the regional health authorities on the dangers of indiscriminate and improper wastes disposal in our communities and call for attitudinal change. More vigorous campaigns concerning Environmental Impact Assessment (EIA), Environmental Management and Monitoring on activities that lead to HM emissions to the environment should be strictly enforced all over the country. Governments should establish solid wastes recycling plants in cities and towns and ensure their sustained optimum functionality. Finally, governments should enact workable wastes management laws and ensure strict enforcement to clean the environment, its waters, air, soils, fishes and other aquatic life.

CONFLICT OF INTEREST

None.

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