Monitoring Toxins and Human Health Risk Assessment of Clarias Gariepinus from Nwangele River in Imo State, Nigeria

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ABSTRACT

Polycyclic aromatic hydrocarbons (PAHs) and heavy metals are ubiquitous environmental contaminants which have caused worldwide concerns as toxic pollutant. This study reports the concentrations of 8 PAHs and 4 heavy metals (Al, As, Pb, and Hg) in clarias gariepinus collected from Nwangele River in Imo State Nigeria. The mean concentration of heavy metals was between 0.06-2.67 mg/kg, with Arsenic having the highest concentration. Daily intake of heavy metals was estimated using daily fish consumption of 0.03643kg/person/day from literature. Referenced oral dose RfD for the four metals were: 0.043, 0.003, 0.004, 0.0001 respectively. Health Risk index (HRI) of heavy metals were < 1 for Al and Pb, but were very high for As and Hg. For PAHs, concentrations showed 13, 4.5, 36.6, 19.6, 80.9, 50.2, 5.1, and 22.4 mg/kg for fluorine, phenanthrene, anthracene, benzo(k) flouranthene, benzo(a) pyrene, benzo (b) flouranthene, pyrene, and dibenzyl (a-h) anthracene respectively. The study indicated that with reference to Al and Pb, fish from the river were safe for consumption. Conversely, the fish were unsafe with reference to concentrations of PAHs, As, and Hg. The study recommended prevention measures towards water pollution and consumer awareness of health hazard in consuming contaminated fish.

Keywords: PAHs, Heavy metals, Human Health risk assessment

INTRODUCTION

Aquatic ecosystems are susceptible to receiving and accumulating toxins or contaminants. In particular, polycyclic aromatic hydrocarbons (PAHs) and heavy metals have been identified as general causes of the deterioration of aquatic ecosystems in recent decades [1]. Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous and persistent environmental contaminants found in sediments and associated waters of urbanized estuaries and coastal areas [2,3,]. Polycyclic aromatic hydrocarbons (also called PAH, PAHs, PAH'S, polyaromates, polyaromatic hydrocarbons) are a group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat [4]. They are a class of compounds found in crude oil and are everywhere in the aquatic ecosystem. PAHs are the most toxic pollutants of crude oil and are remembered by the United States Environmental Protection Agency (EPA) as priority toxic components because of its persistence in the environment and are toxic to fishes; thus, PAHs are of special interest following oil spills and in environmental control. They come from natural and anthropogenic sources. Wastewater, atmospheric deposition, and petroleum spillage are some of the most important PAH sources. PAHs and their intermediate degradation products have the potential to generate toxic or mutagenic effects in fish and humans [5].

Heavy metals are natural trace components of the aquatic environment, whose level have been reported to be on the increase in recent times due to pollution from industrial wastes, changes in geochemical structure, agricultural and mining activities [6,7]. Heavy metals unlike organic contaminants are not degraded with time, but concentration can only increase through bio-accumulation [8]. Fish are often at the top of aquatic food chain and studies have shown that they assimilate these heavy metals through ingestion of suspended particulates, food materials and/or by constant ion exchange process of dissolved metals across lipophilic membranes like the gills or adsorption of dissolve metals on tissues and membrane surfaces [9]. On adsorption, the pollutant is carried in the blood stream to either a storage point (bone) or to the liver for transformation or storage [10]. With fish constituting an important link in the food chain, its contamination by toxic metals causes a direct threat, not only to the entire aquatic environment, but also to humans that utilize it as food. From a human health perspective, mercury, arsenic, cadmium and lead have been identified as primary contaminants of concern [11]. These metals have no bio-importance in human biochemistry and physiology, but its consumption, even at very low concentration can be toxic [12]. This study therefore aims at examining toxins in fish collected from Nwangele River in Imo State Nigeria.

MATERIALS AND METHODS

Area of Study

Nwangele River is located in Nwangele Local Government Area of Imo State, Nigeria. The river which is believed to have originated from Isiekenesi town passes through several villages in Amaigbo and empties into Oramiriukwa a tributary of Imo River [13]. Nwangele Local Government Area has an area of 63 km^2 (24 sq mi) and a population of 127,691 as of the 2006 census. Geographical coordinates are 5°42’37.0”N 7°07’33.1"E. The name of the Local Government Area was derived from the popular *Nwangele* River.

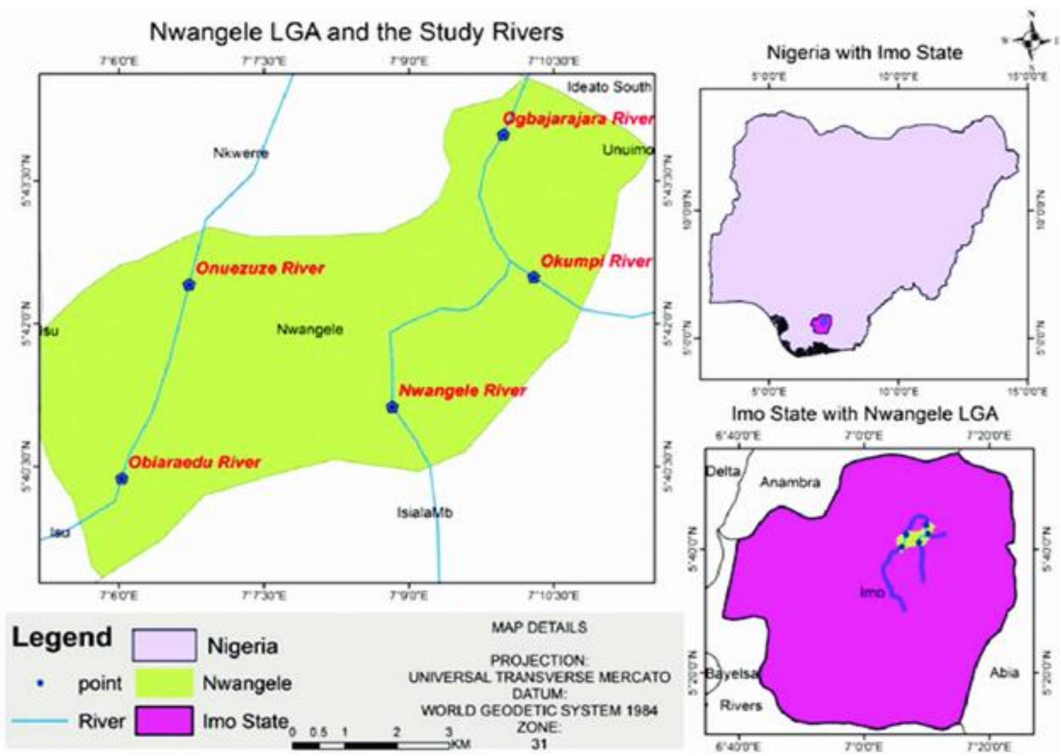

Fig 1: Map of Study Area, showing the River (Nwangele) Source: Ihenetu et al., [14]

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SAMPLE COLLECTION

Sample of Clarias gariepinus were collected from the river with the help of fisher men in the community. On collection, fish sample were stored in pollution-free sealed polythene covers and transported to springboard laboratory Awka, Amambra State, Nigeria and stored at−20◦C in the deep freezer until analysis.

Digestion of Sample for heavy metals

2g of the c. gariepinus sample was weighed with the aid of digital weighing balance into crucible, covered and inserted into the muffle furnace at the temperature of 550 0 C for 2hours, allowed to cool and then 20ml of 20% sulphuric acid was measured into 250ml beaker containing the sample, stirred and digested on hot plate at the temperature of 60 0 C for 30minutes, allow to cool and filtered with whatman no.4 filter paper and the volume make up to 50ml and stored in a reagent bottle for heavy analysis.

METHODS FOR HEAVY METALS

Heavy metal analysis was conducted using Varian AA 240FS Atomic Absorption Spectrophotometer (AAS) according to the method of APHA [15] (American Public Health Association).

Estimation of PAHs.

Samples were analyzed in springboard laboratory Awka, Amambra State, Nigeria. All the samples were quantified for 8 components of PAHs (fiuorene, phenanthrene, anthracene, pyrene, benzo[b]fiuoranthene, benzo[k]fiuoranthene, benzo[a]pyrene, and Dibenzyl (a-h) anthracene) using HPLC with programmable fiuorescence detection at excited and emission wavelengths of 260 and 500nm, respectively. About 20μL of sample was injected through an autosampler into C18 column (Zorbax 4.6 × 250mm) of 5μm particle size. The temperature of the column was maintained at 20◦C. Water/acetonitrile (ACN) was used as mobile phase with a fiow of 1mL/min. The initial content of ACN was 50% and then increased into 60% (0–3min) and95% (3–14min). These levels were held constant for 24 minutes until the end of the analysis. Recoveries of the compounds from fortified samples (50ppb) ranged from 78% to 94%, and the concentrations were not corrected for percent recovery. Concentrations of PAHs are reported on mg/kg.

Health Risk Assessment of Heavy

The potential health risks of heavy metal consumption through fish were assessed based on the daily intake of metal (DIM), health risk index (HRI), and the target hazard quotient (THQ) [16, 17]. The daily intake of metals (DIM) was calculated to averagely estimate the daily metal loading into the body system of a specified body weight of a consumer.

Daily intake of metals (DIM)

DIM = DFC x FMC

DFC = Daily fish consumption

FMC = Fish metal concentration

Health Risk Index (HRI)

HRI = DIM/RfD

DIM = Daily intake of metal

RfD = Reference oral dose for each metals

HRI < 1 means the exposed population is safe.

Hazard Index (HI)

$HI = \sum HRI_a + HRI_b + HRI_c \ldots$

Summation of HRI of individual heavy metals under study [18]

Statistical Analysis

Data on heavy metals concentration were subjected to one-way analysis of variance (ANOVA) using SPSS version 22. All statistical test was regarded significant when $P < .05$.

RESULTS

Heavy Metals Concentration in Fish Tissue from Nwangele River

The concentration of the aluminum, Arsenic, Lead and mercury in the body of fish in Nwangele Rive where analyzed. Three (3) specimen (clarias gariepinus) from different point of the river were collected and analyzed for the heavy metals. The mean concentrations for each of the heavy metals were as follows: aluminum 0.463ppm, arsenic 2.66ppm, lead 0.06ppm and mercury 0.587ppm. Table 1 shows the heavy metal concentration from samples, their mean concentration and the test of significance with WHO/FAO standard.

Table 1: Heavy metals concentration in fish Tissue

Heavy metal	Individual Sample Concentration(ppm)			Mean Concentration(ppm)	WHO/FAO 2011 LimitStandard (ppm)
	A	B	C		
Aluminum	0.475	0.463	0.451	0.463^b	0.5
Arsenic	2.666	2.565	2.767	2.666^c	0.1
Lead	0.09	0.06	0.03	0.06^a	0.3
Mercury	0.587	0.484	0.688	0.587^b	0.5

^{abc} Means with same superscript are not significantly different (0.05)

From the table above, the concentration of aluminum in fish body was lower than WHO/FAO [19] standard. The test of significance also shows that the permissible limit was significantly higher than the concentration in fish body. Arsenic concentration in fish body was significantly higher than the permissible limit. Lead concentration in fish body was significantly lower than the permissible limit. Mercury concentration in fish body was slightly higher than the permissible limit in terms of value but was not significantly higher than the FAO/WHO [19] permissible limit/standard.

Polycyclic aromatic hydrocarbon concentration (PAH_s) in fish body from Nwangele River.

Table 2: Showed the concentration of polycyclic aromatic hydrocarbon in fish from Nwangele River. The concentration of eight (8) compounds in the family of polycyclic aromatic hydrocarbon (PAH_s) were analyzed and used to determine the total (PAH_s) concentration.

Table 2: PAH_s concentration in fish Tissue from Nwangele River.

Compounds	Mean Concentration (mg/kg)
Fluorine	13
Phenanthrene	4.5
Anthracene	36.6
Benzo (k) flouranthene	19.6
Benzo (a) pyrene	80.9
Benzo (b) flouranthene	50.2
Pyrene	5.1
Dibenzyl (a-h) anthracene	22.4
PAH_s total	232.3mg/kg

The table above indicates that total PAH concentration in fish body is 232.2 mg/kg wet wt.

Health Risk Assessment of Heavy Metals

The daily intake of metals, Health risk index, and Hazard index for heavy metals were estimated. Table 3 below showed the health risk assessment of heavy metals.

Table 3: Health Risk Assessment of Heavy Metals

Heavy metal	DIM	RfD	HRI	HI
Aluminum	0.0169	0.043	0.393	
Arsenic	0.0971	0.003	323.667	
Lead	0.0022	0.004	0.55	
Mercury	0.0214	0.0001	214	538.61

DISCUSSION

The result of the study indicated higher concentrations of Arsenic and Mercury above WHO permissible limit. Aluminum and Lead were lower than WHO standard. The level of As was relatively high. Health risk assessment of heavy metals indicated that exposed populations are at high risk with respect to Arsenic and Mercury. Amqam et al, [20] reported HRI > 1. Arsenic affects the body, especially the blood which can affect the bone marrow and change the composition of blood cells, on the liver causing central necrosis and cirrhosis of the liver. The effect of arsenic on the kidneys is vessel damage, tubules and glomerular kidneys. The kidneys first affected by arsenic are glomerular so proteinuria occurs. The effect of arsenic on the cell system can cause damage to cell mitochondria which causes a decrease in cell energy causing cell death [20]. Mercury is a systemic poison and is accumulated in the liver, kidneys, spleen, and bones. In the body, mercury is excreted through urine, faeces, sweat, saliva, and milk. Mercury poisoning will cause symptoms in the central nervous system such as personality abnormalities and tremors, convulsions, senility, insomnia, loss of self-confidence, irritation, depression, and a sense of fear. Mercury poisoning can also cause gastrointestinal symptoms such as stomatitis, hypersalivation, colitis, chewing pain, gingivitis, black lines on the gums (leadline), and loose and skin problem such as dermatitis and ulcers/wounds [20].

The level of risk is greatly influenced by the amount of Hg and As intake. Several factors influence the intake, such as the concentration of chemicals in fish, body weight, duration of exposure, intake rate, and frequency of exposure [21]. Risk is a probability. It does not mean that individual with HRI>1 will definitely experience adverse health effects. The value shows that individuals with HRI>1 have a higher probability of experiencing adverse impacts than individual with HRI=1. Thus, risk management is necessary to control and minimize the estimated risk within the community. The research conducted at the Kenjeran Beach in Surabaya showed that respondents who consumed contaminated fish with an average mercury concentration of 99.11 g/day had a mercury concentration in their hair of 0.5 ppb [20]. Mercury in fish may be in the form of methylation because of the bioaccumulation and biomagnification process in the food chain. Fish also not only accumulates mercury metal in water but can convert organic mercury to metal mercury in their bodies through biomethylation [20].

The total PAH's concentration of 232.3mg/kg was higher than the concentration reported by Olayinka et al, [22]. Dhananjayan and Muralidharan [23] reported levels of PAH's in fish from Mumbai Harbour, India below the levels reported in the present study. The study showed that tissue concentrations of PAHs in fish far exceeded the FAO/WHO guidelines for concentrations of PAHs in food (0.001 mg kg^{-1}fw) considered safe for human consumption [24].

CONCLUSION AND RECOMMENDATION

Present study shows that the concentration of heavy metals and PAHs were high in the fish analyzed. After reviewing the above mentioned studies it may be recommended that: awareness should be raised about water pollution and the dangers of heavy metals and PAHs contamination in fish; Exposure of fish consumers to contaminated fish should be discouraged; Waste disposal into water bodies should be stopped by relevant agencies; Nigerian food and health agencies should be more proactive in making available, limits (minimum and maximum permissible) for contaminants in food to the public; there is need for contaminants evaluation for fish sold in various markets.

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