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Trace metal accumulation in the organs of the fish *Sarotherodon galilaeus* from Alaro stream in Ibadan, Nigeria

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Abstract

Trace metal accumulation in the organs of the fish *Sarotherodon galilaeus* from Alaro stream in Ibadan was assessed. A total of 25 fishes were caught in the sampling of Alaro stream. Dissections were carried out using dissecting set to remove the gills, fins, gut (intestine), liver, bones and muscle. Acid digestion was carried out after drying and pulverization of the fish organs. Inductively coupled plasma-mass spectrometer (ICP-MS) was used for the trace metal analyses while bovine liver standard reference material (SRM) from the National Institute of Standards (NIST) was used for quality assurance of the results. This study shows that mean concentration of the following trace metals As, Cd, Cu and Pb in *S.galilaeus* from the Alaro stream in Ibadan exceeded the World Health Organization (WHO) guideline limits set for most of the organs. This means that Alaro stream is polluted and fish (*S.galilaeus*) caught from the stream is unfit for human consumption due to the public health consequences posed in consuming such food.

1. Introduction

Industrial effluents discharged into water bodies contain trace metals that are toxic to the biota [1]. They also contain hazardous compounds such as phenols, aldehydes, ketones, amines, cyanide, metallic wastes, plasticizer, toxic acids, corrosive alkalis, oils, grease, dyes, biocides, suspended solids, non-degradable matter, radioactive wastes and thermal pollutants from numerous industries [2]. Trace metals are of public health concern due to their toxicity, ability to bioaccumulate in aquatic ecosystems and their persistence in the natural environment [3]. Fish have great potential to bioaccumulate and biomagnify trace metals in their organs [4]. Thus, fish contamination in fresh water ecosystem by trace metals is a potential threat to human health. This is because fish are an affordable source of protein in the human diets and they have the ability to feed on various planktonic materials that are contaminated by trace metals. The biomagnification of trace metals by different fish species is variable which depends on species physiology and metabolism. Species possess different potential in their tendency to accumulate trace metals in different organs of their bodies at different levels [5]. The exposure of fish and other aquatic organisms to trace metals in aquatic ecosystem is a function of the level of concentration of dissolved metals in the water body, hence their use for biomonitoring pollution

[6]. This study is necessary because there is paucity of literature on trace metal accumulation in different fish species in Nigeria. In this study, an assessment of the profiles of As, Cd, Cu and Pb in the organs of *Sarotherodon galilaeus galilaeus* caught from Alaro stream in Ibadan is undertaken to evaluate organ differentials in the accumulation of the trace metals in the fish.

2. Materials and Methods

2.1. Sampling Area

Alaro Stream which is located within the hydro-ecological system of the Oluyole Industrial Estate in Ibadan,

Nigeria receives effluents from diverse sources of trace metal pollution. The Alaro stream flows into Oluyole Estate in a west-south east direction from its source at Agaloke near Apata in Ibadan. It joins River Ona at the south end of a meat processing factory as its main tributary. The stream receives effluents from diverse industries. Effluents from both natural and anthropogenic sources are discharged into Alaro stream directly or indirectly through run-off, leaching or seepage especially during the rainy season or as windblown materials during the dry season. The Oluyole industrial estate is located between latitude 7° 21'N -7 ° 22'N and longitude 3 ° 50'-3 ° 52'E. Table 1 shows the types of industries that discharge effluents into Alaro Stream and their potential pollutants.

Table 1. Industrial activities and their potential pollutants in Alaro Stream

Industry	Number of industries	Potential pollutants
Food processing		
i.carbonated beverages	2	Alkalis, phenols, suspended solids, detergents, fermented starches, pathogens, nitrates, trace metals from oiling machine parts and organic wastes
ii.confectionery and biscuit	2	Organic wastes(solids and suspended), macro metals, pathogens, total suspended solids(TSS), biochemical oxygen demand (BOD), PH
iii.animal husbandry and meat processing	1	Organic wastes, macro and trace metals
Iron and fabrication		
i.steel	2	Trace metals, cyanide, fluorides, chromates, thiocyanates, naphthalenes
ii.metal foundry	2	Diverse trace metals
iii.crown corks	1	Metal filings, macro and trace metals
Wood processing	1	Waste lignin, organic sulphur, mercury, magnesium, sulphide, terpenes, arsenates mercaptans, macro and trace metals

2.2. Fish Collection and Identification

Fish were collected from the entire Alaro stream downstream of the effluent outfall. Fish were collected using the following techniques: Cast nets with mesh sizes ranging between 30-50mm with varying dimensional sizes were used. These nets were left for about three minutes before retrieving with a drawing string to check for any entangled fish. In addition, gill nets with mesh sizes of 30-50mm and varying dimensions were tied to stakes with a lead weight on the stream bed and maintained vertically in water with the aid of floats overnight. 25 fishes were caught in the sampling of Alaro stream.

Fish collected were identified using the textbook by Moses [7]. Fish were sacrificed by stunning with table salt. The dissections were carried out using dissecting set to remove the gills, fins, gut (intestine), liver, bones and muscle. These tissues were oven dried at 105°C for 6hours. Each organ was pulverized separately by means of a porcelain mortar and pestle. The pulverized samples were kept in sample sachets and sealed prior to analyses.

2.3. Fish Organ Digestion for Trace Metal Analyses

Fish organ digestion was carried out by adding 2ml trace metal grade HNO₃ to 0.5g of each powdered sample in Teflon digestion tubes which were heated at 105 °C for 1

hour in a heat block. The clear solution was then allowed to cool down, followed by addition of 1ml H₂O₂, after the simmering, boiled and left overnight. The digested sample was diluted to the 10ml mark using MilliQ water. These were then transferred into deionized water-rinsed test tubes for the inductively coupled plasma mass spectrometer (ICP-MS) analyses. Standard Reference Materials (SRM) comprising of bovine liver from the National Institute of Standards and Technology (NIST-1577) were used to obtain accurate values for fish organs. The Agilent 7700 ICP-MS was used for the analyses of the samples because it combines a high-temperature ICP (inductively coupled plasma) source with a mass spectrometer, which converts the atoms of the metals in the sample to ions that are separated according to their mass/charge ratios by a quadrupole mass analyzer (MS). The inductively coupled plasma-mass spectrometry (ICP-MS) was preferred to other facilities because it is rapid, precise, accurate, and extremely sensitive multimetal analytical technique for the determination of heavy metals in solid sample materials.

3. Results and Discussion

3.1. Standard Reference Materials and Quality Assurance

Percentage recoveries from the reference material were

all above 70% with values of 85.9% (As), 88.3% (Cd), 91.7 % (Cu) and 75.3% (Pb). The results were also corrected for errors using MilliQ water as the blank using the inductively coupled plasma-mass spectrometer (ICP-MS).

3.2. Trace Metal Concentration in the Fish Organs

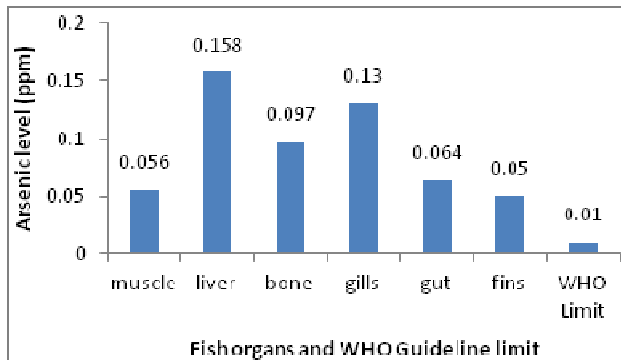


Figure 1. Mean As in the organs of *S. galilaeus* and WHO Guideline limit.

The range of the As in the organs was 0.000-0.176ppm, while the highest mean concentration was in the liver (0.158ppm) and the lowest was in the fins (0.05ppm). World Health Organization (WHO) guideline limit of 0.01ppm (10ug/l) was exceeded in all the organs. The ability of different organs to store, deplete and excrete trace metals (As) is responsible for the differences in the levels of the mean concentration of As [1,8]. Bioavailability of As in Alaro stream and the fish organs is due to the preservatives used in wood processing that are eventually discharged as effluents into the water shown in table 1 as well as geogenic sources. Results of mean concentration of Cu in the organs of *S. galilaeus* is shown in figure 2.

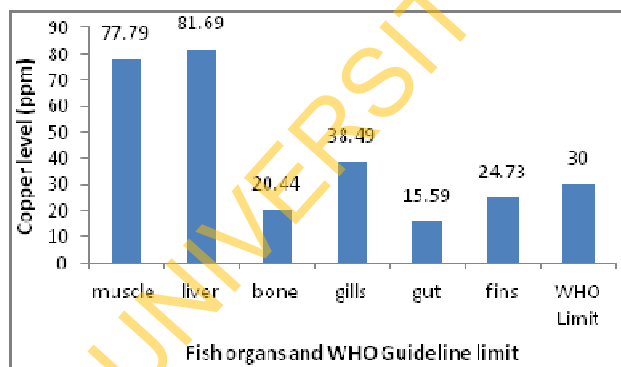


Figure 2. Mean Cu in the organs of *S. galilaeus* and WHO Guideline limit

The highest mean concentration of Cu in the organs of *S. galilaeus* was in the liver (81.69ppm), while the lowest was in the gut (15.59ppm). The increasing order of the mean concentration in the fish organs was: gut<bone<fins<gills<muscle<liver. With the exception of bone, gut and fins, the muscle, liver and gills exceeded the WHO guideline limit of 30ppm in food [9]. Results of mean concentration of Cd in the organs of *S. galilaeus* is

shown in figure 3.

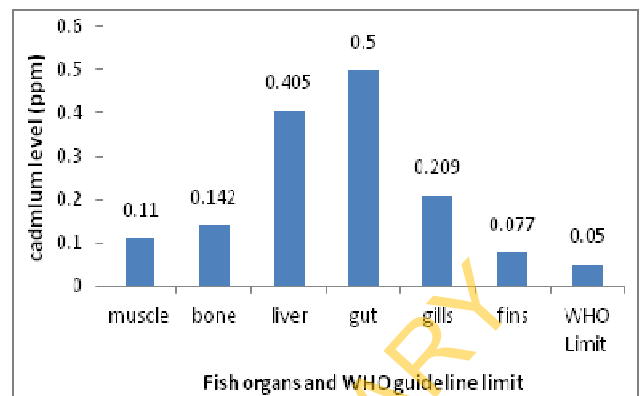


Figure 3. Mean Cd in the organs of *S. galilaeus* and WHO Guideline limit

The range of Cd in the organs of *S. galilaeus* was 0.000-0.686ppm with the highest mean concentration in the gut (0.5000ppm) while the lowest was in the fins (0.077ppm). Mean Cd in the fish organs of *S. galilaeus* was in the order: fins<muscle<bone<gills<liver<gut. All the mean concentration of Cd in the organs exceeded the World Health Organization (WHO) guideline limit of 0.05ppm. The high mean Cd concentration in the gut is due to its role as in digestion [7]. Results of the mean concentration of Pb in the organs of *S. galilaeus* are shown in figure 4.

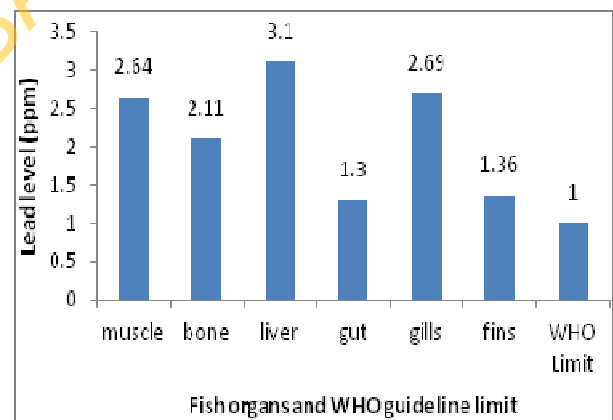


Figure 4. Mean Pb in the organs of *S. galilaeus* and WHO Guideline limit

The range of the Pb in the organs of *S. galilaeus* was 0.00-3.85ppm while the highest mean concentration was in the liver (3.10ppm) and the lowest was in the gut (1.30ppm). Mean Pb concentration in the organs was in the order: gut<fins<bone<muscle<gills<liver. All the mean concentration of Pb in the organs exceeded the WHO recommended limit standard of 1.00ppm. This high Pb level in the organs of *S. galilaeus* is due to bioavailability of the trace metal in the aquatic ecosystem from leaded gasoline, industrial effluents and geogenic sources as described by Odieta [1], Akaahan and colleagues [10] and Akan and colleagues[11].

4. Conclusion

This study shows that mean concentration of the following trace metals As, Cd, Cu and Pb in *S.galilaeus* from the Alaro stream in Ibadan exceeded the World Health Organization (WHO) guideline limits set for most of the organs. The high trace metal level can be attributed to the discharge of untreated industrial effluents laden with trace metals into Alaro stream as shown in Table 1. This means that Alaro stream is polluted and fish such as *S.galilaeus* caught from the stream is unfit for human consumption due to the public health consequences posed in consuming such food.

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