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The influence of size and seasons on the bio-accumulation of heavy metals in tissues of *Clarias gariepinus* from QUA IBOE River, Southeastern Nigeria

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Abstract

The influence of size and seasons on the bio-accumulation of some heavy metals in tissues of *Clarias gariepinus* from Qua Iboe River was studied for 6 months. A total of 64 samples of *C. gariepinus* were purchased alive from fishermen across 3 sampling stations, 32 apiece for dry and wet season. Samples were analyzed spectrophotometrically for heavy metals. *Clarias gariepinus* samples had a mean length of 38.911 ± 5.260 cm and a mean weight of 1454 ± 235.419 g. Mean metals concentrations in fish tissues were higher during dry season, except for cadmium (fish muscle). Lead was not detected in the tissues of *Clarias gariepinus* during both seasons. The muscles during both seasons were slightly polluted with Cu, Cr, Fe, Mn and Ni. Size affected all metal accumulation in *Clarias gariepinus* muscles except manganese, based on their relationship strength (r-values). Size of *Clarias gariepinus* influenced heavy metals pollution.

Keywords: bio-acccumulation, heavy metals, seasons, *clarias gariepinus*, fish size, qua iboe river

1. Introduction

Environmental contamination with metals, have become a major cause for concern, mainly because of their toxic, mutagenic and carcinogenic nature even at low concentration. This makes them to be more than able to cause damages to various body organs. Heavy metal contamination destabilizes the ecological balance of any environment. Several domestic, industrial, mining, agricultural, oil exploitation and processing activities, solid waste, garbage disposal, municipal sewage, atmospheric fallout and so on introduces metals into the environment, thereby causing pollution [1, 2, 3, 4]. Heavy metals can be introduced from various harbour activities like docking, vessel paints, vessel repair facilities, antifouling, petroleum exploitation [5, 6]. When any water course is polluted with heavy metals, the tissues of the fishes that inhabit the water could accumulate these metals above levels that are unsafe, and from the fish, this metals get to humans causing various carcinogenic diseases [7]. The non-biodegradable nature of heavy metals make them to be highly persistent in the environment and may bio-magnify as you move up in the food chain [8], and this could cause an increase in the metals levels in fish tissues. The exposure of aquatic organisms to heavy metals affects fishes the most, because they accumulate these metals within their tissues [9]. Both essential and non-essential metals are capable of posing various threats to fish by affecting their biochemical, physiological, growth, reproduction activities and then mortality [10]. These metals are incorporated through the gills, skin or food [11]. Fish importance for a healthy diet cannot be over emphasized, this is because of the fact that fish has low fat, high protein and is rich in essential nutrients like; omega-3 fatty acids [12]. According to statistics, 60% of the overall protein taken by adults in rural areas of Nigeria are from the consumption of fish and other fish products, and are used as medicines (fish oil), livestock feeds, and even recreations [13]. Around the world, 25 percent of the total animal protein taken by people is from fish and shellfish [14]. *Clarias gariepinus* (African sharp tooth catfish) belongs to the Clariidae family. They could also be described as air-breathing catfishes. It is a large eel-like fish with a white belly and dark gray or black colour at the back. It can grow and attain a maximum weight of 60kg (130Ib) and total length of 1.7m (5ft 7In) [15]. Their bodies are slender, flat bony headed, posses a broad and terminal mouth with four pairs of barbells. Their pectoral fins have spines and also posses' gill arches with its breathing organs [15]. *Clarias gariepinus* feeds on dead and living animal matter. Their wide mouth makes them to swallow large prey whole [16]. They are carnivorous predators, which feed on *Tilapia zillii*, molluscs and other small fishes. Heavy metals accumulation in tissues of fish relies on factors like: size, age, feeding habit, capture season [17]. Levels of metals contamination in fish could also depend on the numbers of trophic levels, fish species, sampling location, type of pollutant and so on [18]. The length of time in water and bio-activity of a metal could also affect fish tendency to accumulate metals [19, 20, 21] reported higher values of copper, iron and zinc during the dry season for *Chrysichthys nigrodigitatus*. [22, 23] reported that some metals could either increase or decrease with length of fish. It is important to study how size and seasons affects heavy metal accumulation in fishes, because few studies have been carried out on the subject matter. The study was aimed at assessing how seasons and size affects the heavy metals accumulation in tissues of *Clarias gariepinus*.

2. Materials and Methods

2.1 Description of Study Area

Geographically, the river lies between latitude $4^o40'$ N and longitude $7^o55'$ E [24] (Fig. 1). It is about 150 to 180km in distance covered. The River runs along the Eket, Ibeno, Una and Mbo Local Government Areas axis of Akwa Ibom State, and then empties into the Atlantic Ocean. Its estuary is very close to the terminal point of Exxon-Mobil. Qua Iboe River has its origin from Umuahia, Abia State, and flows across different communities of Abia State and through its estuary in Ibeno, and then empties into the Atlantic Ocean. Qua Iboe River Estuary has a tidal height of one meters and three meters during the neap and spring tides [25]. The River is well known to have a long period of rainy season, which usually starts April and ends around November, as well as a brief dry season period, usually between December and March [25]. Various human induced waste like; municipal waste, urban run-off, industrial discharges from food processing industries, garbage's, metal scraps and so on are emptied into the river, mainly at the Atabong Marina and Iwuochang stations of the River [24]. Residents of this River are known to be fully engaged in fishing, construction of boat, Ferryboat transportation, dredging, logging of woods and farming. Also, the river serves as the main source of water to the rural communities of the river [24].

2.2 Collection of Fish Samples

Fish were sampled on a monthly basis over a six months period; between January and June, 2015. Thirty-two (32) Samples of *Clarias gariepinus* were purchased alive from fishermen across the three sampling stations (UAC, Iwuochang and Mkpanak beach) of Qua Iboe River during the dry season and thirty-two (32) samples of *Clarias gariepinus* were also purchased during wet season, and a total of sixty-four (64) samples of *Clarias gariepinus* were used in all. The months of January, February and March were considered as dry season, while April, May and June were considered dry season. The fish samples were caught alive at the time of each sampling across each station by the fisherman. The samples were put into an ice chest immediately after samples collection, in order to keep the specimens as fresh as possible to prevent tissue decay. The fish samples were transported immediately to the Ministry of Science and Technology Laboratory, Uyo, Akwa Ibom State, where the samples were preserved in the freezer while awaiting dissection and preparation of tissues for Spectrophotometric metal analysis. The metals analyzed were copper, chromium, zinc, iron, manganese, cadmium, lead and nickel.

2.3 Measurement of Basic Biological Parameters

After collection of the fish samples, during each sampling occasion, their weight and length were taken. Length was measured using a measuring board to the nearest centimeters (cm), while the weight was measured using a sensitive electronic weighing balance to the nearest grams (g).

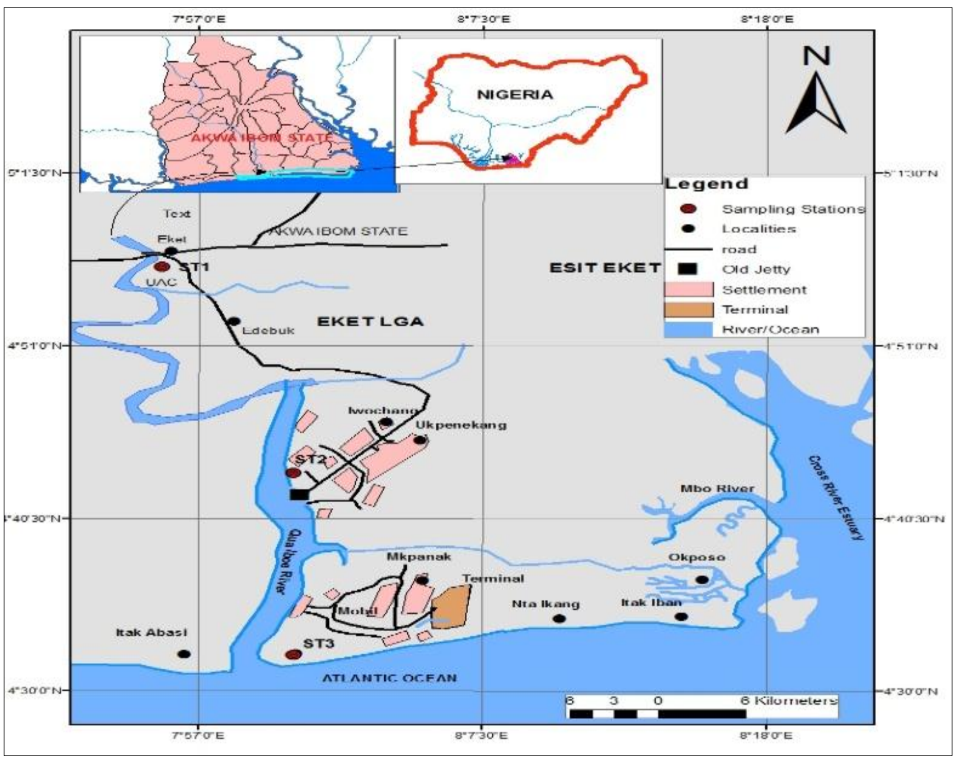

Fig 1: Map showing the Study Area, Qua Iboe River.

2.4 Fish Processing and Heavy Metals Analysis

In the Science and Technology Laboratory, the fish samples preserved in ice were allowed to thaw first and assume a normal temperature of the laboratory (20ºC - 27ºC). The gills, liver and muscles were oven-dried and grinded into powder separately. Two grammes of grinded samples were put into Teflon, and then digested with four milliliters of concentrated nitric acid (HNO_3). The Teflon tubes was closed and placed in stainless steel bomb, which was then heated to a temperature of 110ºC for one hour and then to 150ºC for three hours. The samples were cooled by adding distilled water, and were then opened to allow for proper cooling. The samples were then analysed in mg/kg for cadmium, copper, zinc, chromium, iron, manganese, nickel and lead concentrations spectrophotometrically [26].

2.5 Statistical Analysis and Data Grouping

The heavy metals concentration in *Clarias gariepinus* collected across the three (3) sampling stations of the study area for each season were grouped by finding their mean and standard deviation, in order to have a single value of each metal for the dry and rainy season. Mean and standard deviation was also carried on the length and weight of all *Clarias gariepinus* collected throughout the study. Student t-test was used to test for significant difference in concentration of metals in the tissues of *Clarias gariepinus* between the rainy season and dry season. Co-relation was carried out between metal concentration in fish tissues and sizes of fish, to access size influence in metal accumulation. All the statistical analysis was carried out using Predictive Analytical Software (PASW, version 20).

3. Results

Seasonal variations in the mean concentration of heavy metals in gills of *Clarias gariepinus* from Qua Iboe River is shown in Table 1. Throughout dry season, concentrations of copper in *Clarias gariepinus* gills ranged from 2.12-8.34 mg/kg, having a mean and standard deviation of 5.536 ± 1.131 mg/kg. The chromium concentrations ranged from 0.038-1.810 mg/kg, having a mean and standard deviation of 0.615 ± 0.392 mg/kg. Zinc concentrations ranged from 12.21-34.80 mg/kg, having a mean of 22.348 ± 8.416 mg/kg. Iron had a concentration range of 0.24-41.51 mg/kg, having a mean of 25.996 ± 6.563 mg/kg. Manganese had a concentration range of 0.46-41.51 mg/kg, having a mean of 13.543 ± 2.836 mg/kg. Cadmium had a concentration range of 1.14-3.11 mg/kg, having a mean of 2.167 ± 0.879 mg/kg. Lead was not detected at all in the gills of *Clarias gariepinus*. The nickel concentrations ranged from 0.45-31.20 mg/kg, having a mean of 19.551 ± 5.061 mg/kg. During the rainy season, copper concentrations in the gills of *Clarias gariepinus* ranged from 2.80-5.21 mg/kg, having a mean of 4.156 ± 0.265 mg/kg. The chromium concentrations had a range of 0.021-0.820 mg/kg, having a mean and standard deviation of 0.514 ± 0.319 mg/kg. Zinc had a concentration range of 9.01-26.81 mg/kg, having a mean of 16.989 ± 6.122 mg/kg. Iron had a concentration range of 0.22-30.62 mg/kg, having a mean and standard deviation of 18.994 ± 0.251 mg/kg. Manganese had a concentration range of 0.41-6.42 mg/kg, having a mean of 4.331 ± 0.298 mg/kg. Cadmium concentration had a range of 0.40-0.62 mg/kg, having a mean and standard deviation of 0.513 ± 0.085 mg/kg. Lead was not detected at all in the gills of *Clarias gariepinus* during rainy season. The nickel concentrations ranged from 0.38-24.4 mg/kg, with a mean and standard deviation of 15.913 ± 1.932 mg/kg. The mean concentration of copper, chromium, zinc, iron, manganese, cadmium and nickel in *Clarias gariepinus* gills during dry season were all higher than that of rainy season (Fig 2). However, t-test showed no significant difference in chromium, zinc, iron and nickel concentrations in gills of *Clarias gariepinus* between rainy and dry season at P>0.05. But copper, manganese and cadmium showed significant difference in its concentration in gills of *Clarias gariepinus* between rainy and dry season at P<0.05 (Table 1). The copper, chromium, iron, manganese and nickel concentrations in gills were above the WHO permissible limit during both seasons, while zinc and cadmium concentrations were below the WHO permissible limit (Table 1).

Table 1: Seasonal variation in heavy metals concentration (mg/kg) in gills of *Clarias gariepinus* from Qua Iboe River

Metals	Dry season	Rainy season	WHO Limit
Cu	5.536 ± 1.131[a] (2.12 – 8.34)	4.156 ± 0.265[b] (2.80 – 5.21)	3.0
Cr	0.615 ± 0.392[a] (0.038 – 1.810)	0.514 ± 0.319[a] (0.021 – 0.820)	0.05
Zn	22.348 ± 8.416[a] (12.21 – 34.80)	16.989 ± 6.122[a] (9.01 – 26.81)	10 -75
Fe	25.996 ± 6.563[a] (0.24 – 41.51)	18.994 ± 0.251[a] (0.22 – 30.62)	0.3
Mn	13.543 ± 2.836[a] (0.46 – 41.51)	4.331 ± 0.298[b] (0.41 – 6.42)	0.5
Cd	2.167 ± 0.879[a] (1.14 – 3.11)	0.513 ± 0.085[b] (0.40 – 0.62)	3.0
Pb	BDL	BDL	-
Ni	19.551 ± 5.061[a] (0.45 – 31.20)	15.913 ± 1.932[a] (0.38 – 24.40)	0.6

Values are in Mean ± standard deviation (Ranges in Parenthesis)
BDL – Below detectable limit
*Means with the same superscript are not significantly different (P>0.05)

Seasonal variations in the mean concentration of heavy metals in liver of *Clarias gariepinus* from Qua Iboe River is shown in Table 2. Throughout the dry season, concentrations of copper in *Clarias gariepinus* liver ranged from 2.31-10.60 mg/kg, having a mean of 7.659 ± 3.542 mg/kg. Chromium had a concentration range of 0.039-1.91 mg/kg, having a mean and standard deviation of 0.993 ± 0.602 mg/kg. Zinc concentrations ranged from 11.01-29.32 mg/kg, having a mean of 17.857 ± 5.004 mg/kg. Iron had a concentration range of 0.25-58.21 mg/kg, having a mean of 36.018 ± 7.008 mg/kg. The manganese concentrations ranged from 0.48-24.31 mg/kg, having a mean and standard deviation of 14.851 ± 3.178 mg/kg. The cadmium concentrations ranged from 0.48-4.24 mg/kg, having a mean of 2.563 ± 1.580 mg/kg. Lead was not detected at all in the liver of *Clarias gariepinus*. The nickel concentrations ranged from 0.48-30.56 mg/kg, with a mean and standard deviation of 18.963 ± 2.382 mg/kg. During the rainy season, copper concentrations in the liver of *Clarias gariepinus* ranged from 2.00-3.611 mg/kg, having a mean of 2.882 ± 0.242 mg/kg. Chromium had a concentration range of 0.02-1.56 mg/kg, having a mean and standard deviation of 0.928 ± 0.637 mg/kg. Zinc concentrations ranged from 8.20-25.11 mg/kg, having a mean of 12.643 ± 6.451 mg/kg. Iron had a concentration range of 0.18-48.22 mg/kg, having a mean of 30.990 ± 2.891 mg/kg. Manganese had a concentration range of 0.37-15.53 mg/kg, having a mean of 9.410 ± 2.712 mg/kg. The cadmium concentrations ranged from 1.86-3.12 mg/kg, having a mean of 2.340 ± 0.643 mg/kg.

Table 2: Seasonal variation in heavy metals concentration (mg/kg) in Liver of *Clarias gariepinus* from Qua Iboe River

Metals	Dry season	Rainy season	WHO Limit
Cu	7.695 ± 3.542[a] (2.31 – 10.60)	2.882 ± 0.242[a] (2.00 – 3.61)	3.0
Cr	0.993 ± 0.602[a] (0.03 – 1.91)	0.928 ± 0.637[a] (0.029 – 1.56)	0.05
Zn	17.875 ± 2.002[a] (11.01 – 29.32)	12.643 ± 6.451[a] (8.20 – 25.11)	10 -75
Fe	36.018 ± 7.008[a] (0.25 – 58.21)	30.990 ± 2.891[a] (0.18 – 48.22)	0.3
Mn	14.851 ± 3.178[a] (0.48 – 24.31)	9.410 ± 2.712[b] (0.37 – 15.53)	0.5
Cd	2.563 ± 1.580[a] (0.48 – 4.24)	2.340 ± 0.643[a] (1.86 – 3.12)	3.0
Pb	BDL	BDL	-
Ni	18.963 ± 2.382[a] (0.48 – 30.56)	17.287 ± 1.380[a] (0.35 – 26.22)	0.6

Values are in Mean ± standard deviation (Ranges in Parenthesis)
BDL – Below detectable limit
*Means with the same superscript are not significantly different (P>0.05)

Lead was not detected at all in the liver of *Clarias gariepinus* during rainy season. The nickel concentrations ranged from 0.35-26.22 mg/kg, with a mean and standard deviation of 17.287 ± 1.380 mg/kg. During dry season, the mean copper, chromium, zinc, nickel, manganese, cadmium and Iron concentrations in liver of *Clarias gariepinus* were all higher than that of rainy season (Fig 3). However, t-test showed no significant difference between chromium, nickel, zinc, iron, cadmium and copper concentrations in liver of *Clarias gariepinus* between rainy and dry season at P>0.05. But manganese showed difference in significance in its concentrations in liver of *Clarias gariepinus* between dry and rainy season (P<0.05) (Table 2). The chromium, iron, manganese and nickel concentrations in liver were above the WHO limit during both seasons, while zinc and cadmium concentrations were below the WHO limit during both seasons and copper was above WHO limit during dry season (Table 2).

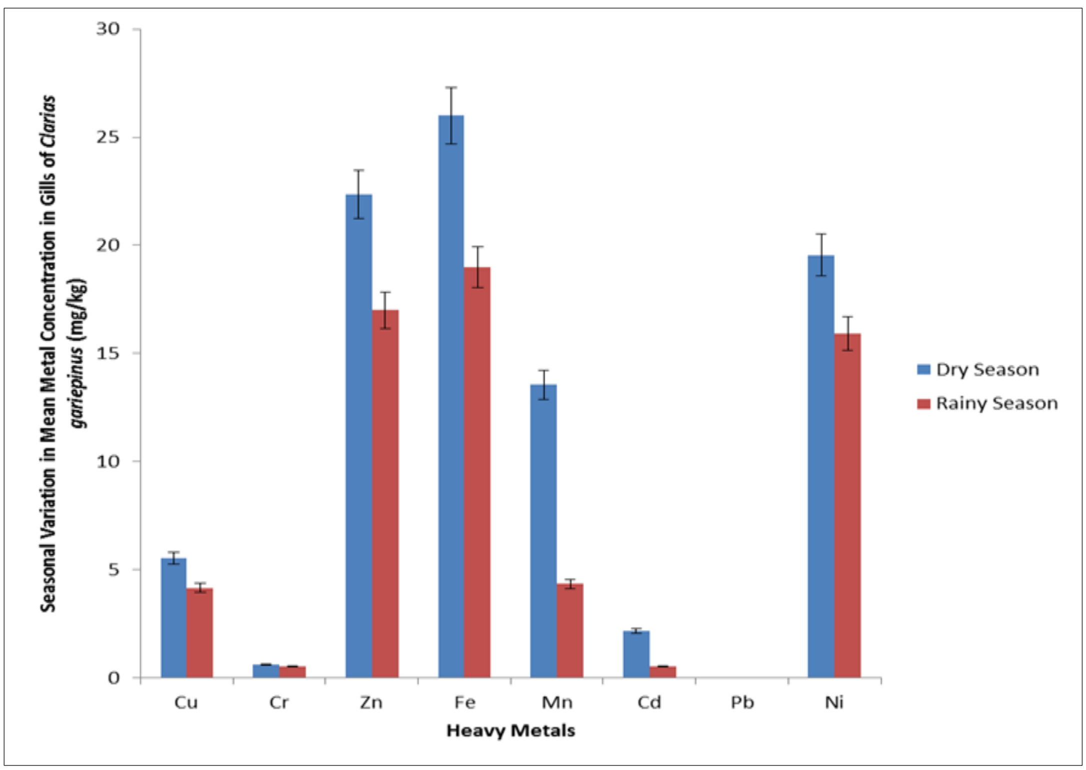

Fig 2: Mean seasonal variation in metal concentration in gills of *Clarias gariepinus* from the study area

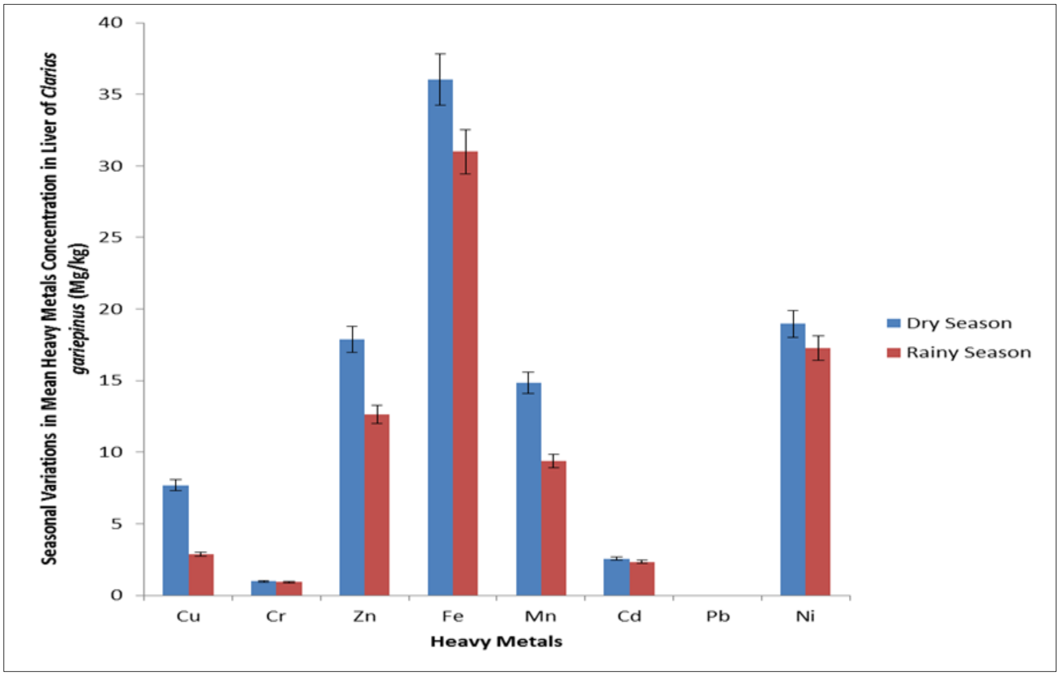

Fig 3: Seasonal variation in mean concentrations of metals in liver of *Clarias gariepinus* from the study area

Seasonal variation in the mean concentrations of heavy metals in muscles of *Clarias gariepinus* from Qua Iboe River is shown in Table 3. Throughout the dry season, concentrations of copper in *Clarias gariepinus* muscles ranged from 1.30-5.30 mg/kg, having a mean of 3.694 ± 1.118 mg/kg. The chromium concentrations had a range of 0.02-0.85 mg/kg, having a mean and standard deviation of 0.376 ± 0.208 mg/kg. Zinc had a concentration range of 9.21-18.62 mg/kg, having a mean of 12.017 ± 2.002 mg/kg. Iron had a concentration range of 0.12-29.32 mg/kg, having a mean of 17.896 ± 2.484 mg/kg. Manganese had a concentration range of 0.31-13.62 mg/kg, having a mean of 7.867 ± 2.020 mg/kg. Cadmium had a concentration range of 0.24-1.01 mg/kg, having a mean of 0.613 ± 0.356 mg/kg. Lead was not detected at all in the muscle of *Clarias gariepinus* through-out the study during dry season. The nickel concentrations ranged from 0.35-24.10 mg/kg, having a mean and standard deviation of 14.408 ± 1.842 mg/kg. During rainy season, copper concentrations in the muscle of *Clarias gariepinus* ranged from 1.10-2.81 mg/kg, having a mean of 2.108 ± 0.195 mg/kg. The chromium concentrations had a range of 0.01-0.33 mg/kg, having a mean and standard deviation of 0.186 ± 0.117 mg/kg. Zinc had a concentration range of 8.90-11.17 mg/kg, having a mean of 10.270 ± 1.076 mg/kg**.** The iron concentrations had a range of 0.01-24.32 mg/kg, having a mean and standard deviation of 15.485 ± 2.376 mg/kg. Manganese had a concentration range of 0.22-12.47 mg/kg, having a mean of 7.580 ± 1.137 mg/kg. Cadmium had a concentration range of 3.71-4.18 mg/kg, having a mean of 4.003 ± 0.152 mg/kg. Lead was not detected at all in the muscle of *Clarias gariepinus* during rainy season. The nickel concentrations ranged from 0.28-18.35 mg/kg, with a mean and standard deviation of 11.624 ± 2.569 mg/kg.

Table 3: Seasonal variation in heavy metals concentration (mg/kg) in Muscles of *Clarias gariepinus* from Qua Iboe River

Metals	Dry season	Rainy season	WHO Limit
Cu	3.694 ± 1.118[a] (1.30 – 5.30)	2.103 ± 0.195[a] (1.10 – 2.81)	3.0
Cr	0.376 ± 0.208[a] (0.02 – 0.85)	0.186 ± 0.117[b] (0.014 – 0.330)	0.05
Zn	12.017 ± 2.002[a] (9.21 – 18.62)	10.270 ± 1.076[a] (8.90 – 11.17)	10 -75
Fe	17.896 ± 2.484[a] (0.12 – 29.32)	15.485 ± 2.376[a] (0.100 – 24.32)	0.3
Mn	7.867 ± 2.020[a] (0.31 – 13.62)	7.580 ± 1.137[a] (0.22 – 12.47)	0.5
Cd	0.613 ± 0.356[a] (0.24 – 1.01)	4.003 ± 0.152[b] (3.71 – 4.18)	3.0
Pb	BDL	BDL	-
Ni	14.408 ± 1.842[a] (0.35 – 24.10)	11.624 ± 2.569[a] (0.28 – 18.35)	0.6

Values are in Mean ± standard deviation (Ranges in Parenthesis)
BDL – Below detectable limit
*Means with the same superscript are not significantly different (P>0.05)

During dry season, the mean concentrations of copper, nickel, iron, chromium, manganese and zinc in *Clarias gariepinus* muscle were all higher than that of rainy season, but the reverse was the case for cadmium (Fig 4). However, t-test showed no significant difference between the concentration of nickel, iron, manganese, zinc, cadmium and copper in *Clarias gariepinus* muscle between rainy and dry season at P>0.05. But chromium and cadmium showed significant difference in its concentrations in muscle of *Clarias gariepinus* between dry and rainy season (P<0.05) (Table 3). The chromium, iron, manganese and nickel concentrations in muscles were above the WHO limit during both seasons, while zinc concentrations was below the WHO limit during both seasons and copper was above WHO limit during dry season, while cadmium was above the WHO limit during the rainy season (Table 3).

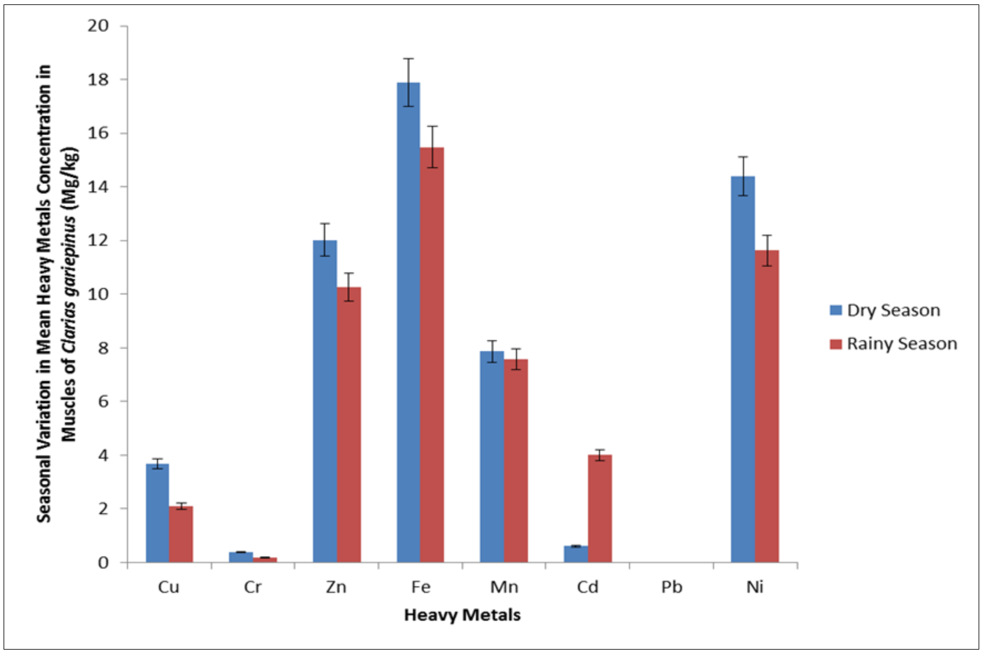

Fig 4: Seasonal variation in mean concentrations of metals in muscle of *Clarias gariepinus* from the study area.

Overall summary of the mean concentrations of metals in *Clarias gariepinus* tissues from Qua Iboe River during dry and rainy season is shown in Table 4. Throughout dry season, mean concentrations of metals in *Clarias gariepinus* tissues from Qua Iboe River were; 5.642 ± 2.059, 0.661 ± 0.257, 17.410 ± 5.179, 26.637 ± 12.317, 12.087 ± 5.237, 1.780 ± 1.032 and 17.641 ± 3.499 mg/kg for copper, chromium, zinc, iron, manganese, cadmium and nickel respectively. During the rainy season, the mean metal concentrations in tissues of *Clarias gariepinus* from Qua Iboe River were; 3.047 ± 1.269, 0.543 ± 0.406, 13.300 ± 3.408, 21.823 ± 11.749, 7.107 ± 3.428, 2.283 ± 1.746 and 14.941 ± 4.711 mg/kg for copper, chromium, zinc, iron, manganese, cadmium and nickel respectively. Mean concentration of manganese, copper, chromium, nickel, iron and zinc in tissues of *Clarias gariepinus* were higher for dry season, but a reverse was the case for cadmium (Fig 5). However, t-test showed no significant difference between concentrations of iron, copper, chromium, nickel, manganese, cadmium and zinc in *Clarias gariepinus* tissues between rainy and dry season at P>0.05 (Table 4). The copper, chromium, iron, manganese and nickel concentrations in tissues were above the WHO limit during both seasons, while zinc and cadmium concentrations were below the WHO limit during both seasons (Table 4).

Table 4: Seasonal variation in heavy metals concentration (mg/kg) in Tissues of *Clarias gariepinus* from Qua Iboe River

2	Dry season	Rainy season	WHO Limit
Cu	5.642 ± 2.059^{a}	3.047 ± 1.269^{a}	3.0
Cr	0.661 ± 0.257^{a}	0.543 ± 0.406^{a}	0.05
Zn	17.410 ± 5.179^{a}	13.300 ± 3.408^{a}	10 -75
Fe	26.637 ± 12.317^{a}	21.823 ± 11.749^{a}	0.3
Mn	12.087 ± 5.237^{a}	7.107 ± 3.428^{a}	0.5
Cd	1.780 ± 1.032^{a}	2.283 ± 1.746^{a}	3.0
Pb	BDL	BDL	-
Ni	17.641 ± 3.499^{a}	14.941 ± 4.711^{a}	0.6

Values are in Mean ± standard deviation (Ranges in Parenthesis)
BDL – Below detectable limit
*Means with the same superscript are not significantly different (P>0.05)

The summary of the mean length (cm) and mean weight (g) of *Clarias gariepinus* sampled from Qua Iboe River through-out the study is shown in Table 5. The mean length of *Clarias gariepinus* in the month of January, February, March, April, May and June were 42.5, 37.1, 40.9, 37.6, 37.1 and 38.1 cm respectively, having a total mean and standard deviation of

38.911 ± 5.260 cm. The mean weight of *Clarias gariepinus* in the month of January, February, March, April, May and June were 1555.5, 1374.0, 1566.6, 1298.3, 1588.1 and 1346.6 g respectively, having a total mean and standard deviation of 1454.861 ± 235.419 g.

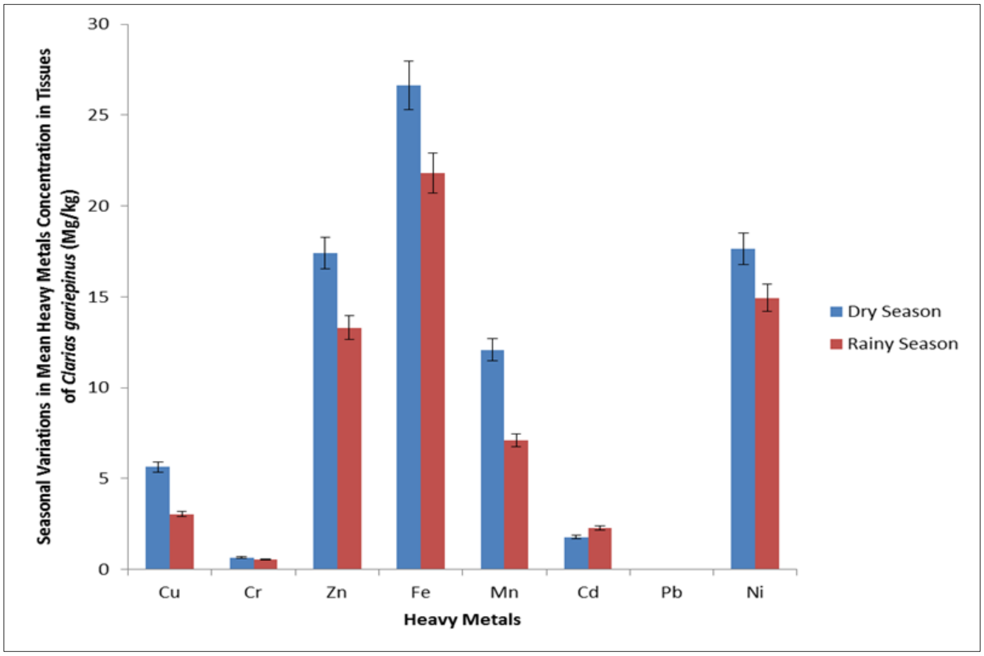

Fig 5: Mean seasonal variation in mean concentrations of metals in *Clarias gariepinus* tissues from the study area

Table 5: Mean length and weight of *Clarias gariepinus* sampled from the study area across the three stations, throughout the study.

Sampling occasion	Month	Mean length (cm)	Mean weight (cm)
1	January	42.5	1555.5
2	February	37.1	1374.0
3	March	40.9	1566.6
4	April	37.6	1298.3
5	May	37.1	1588.1
6	June	38.1	1346.6

Mean length = 38.911±5.260
Mean weight = 1454.861±235.419

The summary of relationship (correlation values and correlation equation) between concentration of metals in muscle of in Fish and Size is shown in Table 6a, 6b and 6c. The concentrations of Copper and Iron in Fish muscle positively related significantly (Strong relationship) with the length of Fish (r = 0.79 and 0.75 respectively) at P<0.05, while concentrations of Chromium, Nickel and Zinc in muscle of the fish positively and slightly related significantly (Positive Slightly Strong relationship) with the length of Fish (r = 0.74, 0.71 and 0.60 respectively) at P<0.05. Cadmium in Fish Muscle negatively and slightly related significantly (Negative slightly strong relationship) with the length of Fish (r = -0.61) at P<0.05 (Table 6a). Chromium concentrations in Fish muscle positively and slightly related significantly (Slightly Strong relationship) with the Weight of Fish (r = 0.51) at P<0.05, all the other metals either had positive or negative weak relationship with weight (Table 6b). The length significantly affected the Copper and Iron concentrations in Fish muscle. The Cadmium, Nickel and Zinc concentrations in Fish Muscle was affected slightly by Length. Chromium concentration in Fish Muscle was affected slightly by Length and Weight of Fish (Table 6a).

Table 6: Relationship between concentrations of metals in muscle of fish and length, weight of fish
a) Fish muscle and length

Muscle concentration Against length(cm)	r- value	R^2- value	Equation	Relationship Inference
Cd	-0.61	0.37	Y= -0.5017X + 21.819	Negatively slightly strong
Cr	0.74	0.54	Y= 0.0906X - 3.0833	Positively slightly strong
Cu	0.79	0.63	Y= 0.3667X – 11.025	Positively Strong
Fe	0.75	0.56	Y = 0.7652X – 5.7521	Positively Strong
Mn	-0.45	0.20	Y = -0.0507X + 12.892	Negatively Weak
Ni	0.60	0.36	Y = 0.669X - 7.8210	Positively slightly strong
Zn	0.71	0.51	Y = 0.5607X – 10.657	Positively slightly strong

b) Fish muscle and weight

Muscle concentration Against Weight(g)	r- value	R^2- value	Equation	Relationship Inference
Cd	-0.37	0.13	Y= -0.0053X + 10.092	Negatively Weak
Cr	0.51	0.26	Y= 0.0011X - 1.1762	Positively slightly strong
Cu	0.42	0.18	Y= 0.0035X – 1.8058	Positively Weak
Fe	0.35	0.12	Y = 0.0062X + 14.577	Positively Weak
Mn	-0.46	0.21	Y = -0.0009X + 12.241	Negatively Weak
Ni	0.33	0.10	Y = 0.0065X + 8.7675	Positively Weak
Zn	0.29	0.08	Y = 0.0041X + 5.1775	Positively Weak

c) Relationship comparison of metals in fish muscle against length and weight

Metal Relationship Comparison	Muscle against length (cm) r – value	Muscle against Weight (g) r-value	Size Effect
Cd	-0.61	-0.37	Length(slight relationship)
Cr	0.74	0.51	Both length and Weight (slightrelationship)
Cu	0.79	0.42	Length
Fe	0.75	0.35	Length
Mn	-0.45	-0.46	-
Ni	0.60	0.33	Length (slight relationship)
Zn	0.71	0.29	Length (slight relationship)

Correlation Rating: 0.75 – 0.99 (Strong), 0.50 – 0.74 (Slightly Strong), 0.15 – 0.49 (Weak), 0 – 0.14 (No Relationship)

4. Discussion

The metal accumulation in gills, liver and muscles of *Clarias gariepinus* obtained during dry season were all higher than that obtained during the rainy season, except for cadmium in the case of muscles. This corroborated with [21] report, who also stated higher values for copper, iron and zinc during dry season in fish. The higher accumulation of metals in *Clarias gariepinus* tissues during dry season and lower metal accumulation during rainy season is due to increase in temperature and evaporation; during dry season and due to low bio-availability, arising from the dilution by heavy rains [27]. The higher cadmium concentrations in muscles during rainy season could be due to introduction of increased petrol spill, vessel paint pigment and pesticides from farmlands along with water run-off into the river. The mean metal concentrations in *Clarias gariepinus* tissues sampled during dry season and rainy season were all higher than the report of [27] for rainy season and dry season, except for copper of the study which was lower than that of [27]. These variations could be due to difference in amount of rainfall, temperature (evaporation rate), study area, and study period, human activities between the study areas. The copper, chromium, iron, manganese and nickel concentrations in tissues were above the WHO limit during both seasons, while zinc and cadmium concentrations were below the WHO limit during both seasons, this indicates that the muscles during both seasons were slightly polluted with copper, chromium, iron, manganese and nickel. Size, which has to do with fish length and weight (age), has the capacity to influence heavy metals accumulation in fish. [22, 23] have reported that some metals could either increase or decrease with length of fish. Copper and iron accumulation in fish muscle related strongly and positively with fish length, and this indicates that the copper and iron concentrations in fish increases with increase in length. Copper and iron accumulation in fish muscle had a weak positive relationship with fish weight. This indicates that length had influence on copper and iron accumulation in fish muscle. Chromium, nickel and zinc accumulation in fish muscle had a positive slight strong relationship with length of fish, and this indicates that the Chromium, nickel and zinc concentrations in fish increases slightly with increase in length. Chromium accumulation in fish muscle had a slight positive strong relationship with fish weight, and this indicates that the chromium concentrations in fish increases slightly with increase in length. Nickel and zinc accumulation in fish muscle had a weak positive relationship with fish weight. This indicates that length had influence on copper and iron accumulation in fish muscle. This indicates that both length and weight affected chromium concentrations in fish muscle slightly, and length slightly affected the nickel and zinc accumulation in fish muscle. Cadmium accumulation in fish muscle had a negative slight strong relationship with fish length, indicating that the cadmium accumulation in fish muscle increases with decrease in length. The negative co-relation between cadmium concentrations in fish muscle and length could be due to the difference in metabolic activity between younger and older fish [28]. The cadmium concentrations in fish muscle had a negative weak relationship with weight, indicating that cadmium concentrations in fish muscle came slightly from length. Manganese accumulation in *Clarias gariepinus* muscle was affected slightly by both length and weight negatively by both length and weight, and as such manganese accumulation could be influenced by other factors like; age, sex, fish health, season, sampling stations, bio-activity of metals and so on. This size influence on metal accumulation observed in this study corroborated with that reported by [23], who reported that size affects metal accumulation.

5. Conclusion

The study revealed that the mean metals concentrations in fish tissues were higher during dry season, except for cadmium (fish muscle). Lead was not detected in the tissues of *Clarias gariepinus* during both seasons. The muscles during both seasons were slightly polluted with copper, chromium, iron, manganese and nickel. Size affected all metal accumulation in *Clarias gariepinus* muscles except manganese, based on their relationship strength (r-values). In conclusion, size of *Clarias gariepinus* influenced heavy metals pollution.

6. References

1. Rim-Rukeh A, Ikhifi GO, Okokoyo PA. Effects of agricultural activities on the water quality of Orogodo

River, Agbor Nigeria. Journal of Applied Science and Research. 2006; 2(5):256-259.
2. Abu GO, Egenonu, C. The current pollution status of the new Calabar River in Nigeria Delta Region of Southern Nigeria: A survey of antibiogram profiles of its bacterial isolates. African Journal of Environmental Science and Technology. 2008; 2(6):134-141.
3. Nduka JK, Orisakwe OE, Ezenweke LO. Some physiological parameters of potable water supply in Warri, Niger Delta Area of Nigeria. Scientific Research Essay. 2008; 3(11):547-551.
4. Umoren IU, Udousoro II. Fractionation of Cd, Cr, Pb and Ni in roadside soils of Uyo, Niger Delta region: Nigeria using the optimized BCR sequential extraction technique. The Environmentalist. 2009; 29(3):280-286.
5. Tim F, Jonathan S, Ravi I, Jim S. Interactions between metals and microbial communities in New Beford harbours, Massachusetts. Environment and Health Perspective. 1998; 106:1033-1039.
6. Chaerun SK, Tazak K, Asada R, Kogure K. Alkane degrading bacteria and heavy metals from Nakohodka oil spill polluted seashore in the sea of Japan after five years of remediation. The Science reports of Kanazawa University. 2004; 49:1-2.
7. Ulozlu OD, Tuzen M, Mendil D, Soylak M. Trace metal content in nine species of fish from the black and Aegean seas, Turkey Food Chemistry. 2007; 104:835-840.
8. Eja ME, Ogori OR, Arikpo GE. Bioconcentration of heavy metals in surface sediments from the Great Kwa River Estuary, Calabar South-Eastern Nigeria. Journal of Nigerian Environment and Society. 2003; 1:247-256.
9. Henry F, Amara R, Courcot L, Lacouture D, Bertho ML. Heavy metals in four fish species from the French coast of the Eastern English channel and southern bight of the North Sea. Environment International. 2004; 30:675-683.
10. Yilmaz AB. Comparison of heavy metals levels of grey mullet (*Mugil cephalus L.*) and sea bream (*Sparus aurata L.*) caught in Iskenderun bay (Turkey). Turkish Journal of Veterinary and Animal Sciences. 2005; 29:257-262.
11. Bardajandi LR, Gomez G, Fernandez MA, Abad E, Rivera J, Gonzalez MJ. Study on PCBS, PCDD/FS, organochlorine pesticides, heavy metals and arsenic content in freshwater fish spices from the River Turia (Spain).Chemosphere. 2003; 53:162-171.
12. Damodhar U, Reddy MV. Assessment of heavy metals concentrations in water and four fish species from the Uppanar River at Cuddalore (Tamil Nadu, India). Continental Journal of Environmental Sciences. 2012; 6(3):32-41.
13. Igwegbe AO. Effects of location, season and processing on heavy metal contents in selected locally harvested fresh fish species for Borno State of Nigeria. A. Ph.D Thesis, department of food sciences and technology, faculty of Engineering, University of Maiduguri, Nigeria. 2013, 160.
14. Bahnasawy M, Khidr A, Dheina N. Seasonal variations of heavy metals concentrations in mullet, *Mugil cephalus* and *Liza ramada* (Mugilidae) from lake Manzala, Egypt. Journal of Applied Sciences Research. 2009; 5(7):845-852.
15. Froese R, Pauly D. Biology of *Clarias gariepinus*. New York Printing Press, USA. 2014, 62.
16. Anoop KR, Sundar KSG, Khan BA, Lal S. Common morrhen Gallinula Chloropus in the diet of the African catfish *Clarias gariepinus* in Keoladeo, Ghana national park, India. India Birds. 2009; 5(2):22-23.
17. Farkas A, Salanki J, Specziar A. Age and size specific of heavy metals in the organs of freshwater fish, *Abramis brama*. Populating a low contaminated site. Water Research. 2003; 37:959-964.
18. Asuquo FE, Ewa-Oboho I, Asuquo EF, Udo PJ. Fish species used as biomarker for heavy metal and hydrocarbon contamination for Cross River, Nigeria. The Environmentalist. 2004; 2:29-37.
19. Ekpo KE, Asia IO, Amayo KO, Jegede DA. Determination of lead, cadmium and mercury in surrounding water and organs of some species of fish from Ikpoba River in Benin City, Nigeria, International Journal of Physical Science. 2008; 3(11):289-292.
20. Akan JC, Abdul-Rahaman FI, Sodipo OA, Akandu PI. Bio-accumulation of some heavy metals of six freshwater fish caught from lake Chad in Doron Buhari, Maiduguri, Borno State, Nigeria. Journal of Applied Science Environment and Sanitation. 2009; 4(2):103-114.
21. Ndimele PE, Kumolu-Johnson CA, Anetekhai MA. Spatial and temporal Variations of some heavy metals in water, sediment and *Chrysichthys nigrodigitatus* (Lacepede, 1803) from Ologe lagoon, Lagos, Nigeria. International Journal of Biological Chemistry. 2011; 5(4):248-253.
22. Evans DW, Dodoo DK, Hanson PJ. Trace elements concentrations in fish livers. Implications of variations with fish size in pollution monitoring. Marine pollution Bulletin. 2013; 26(6):329-334.
23. Ololade IA, Lajide L, Amoo IA. Accumulation of heavy metals by fish (*Tilapia zilli*), crabs (*Callinectes sapidus*) and periwinkles (*Littorina littorea*): A case study of Ilaje Rivers in Ondo, Nigeria. Science Research Analysis. 2007; 3(1):16-23.
24. Umoren IU, Onianwa PC. Impact of refinery effluent on the physico-chemical properties of a water body in the Niger Delta. Journal of Applied Ecology and Environmental Research. 2012, 61-72.
25. Dan SF, Umoh UU, Osabor VN. Seasonal variation of enrichment and contamination of heavy metals in the surface water of Qua Iboe River Estuary and adjoining creeks, South-south, Nigeria. Journal of Oceanography and Marine Sciences. 2014; 5(6):45-54.
26. Whiteside PJ, Milner BA. Pyeunicam Atomic Absorption Data Book, 6th Edition, Pyeunicam Ltd, Cambridge. 1984, 125.
27. Obasohan EE, Eguavoen OJ. Seasonal variations of bioaccumulation of heavy metals in a fresh water fish (*Erpetoichthys calabaricus*) from Ogba River, Benin City, Nigeria. African Journal of General Agriculture. 2008; 4(3):153-163.
28. Canli M, Atli G. The relationship between heavy metals (Cd, Cr, Cu, Fe, Pb, Zn) levels and the size of six mediterranean fish species. Environmental pollution. 2003; 121:129-136.