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Research Article

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Contamination and Environmental Risk Assessment of Heavy Metals on macroorganism in Bonny Estuary, Niger Delta.

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Abstract

A study of heavy metal contamination and environmental risk assessment on some macroorganisms (fauna) in the Upper Bonny Estuary was investigated. Samples of surface water, sediments, and *Tympanotonus fuscatus* were collected at 5 selected stations namely: Okochiri River (S1), Ekerekana Creek (POD, S2), Okari-Ama River (S3), Ogoloma Creek (S4) and Bonny Estuary (Control, S5). Physico-chemical parameters (pH, temperature, DO, conductivity, salinity, TDS, TOC, and THC) were analyzed according to standard procedures for surface water (APHA), while heavy metal parameters (As, Cd., Cr, Pb, Hg, V and Zn) were analyzed using Atomic Absorption Spectrophotometer.The concentration of metals in the tissues of *T. fuscatus* did not vary significantly ($P<0.05$). Cr and Pb in the tissue of *T. fuscatus* were above the permissible limit of 0.5 mg / kg in most stations. Ni was above permissible limit of 0.6mg/kg in all sampled stations while V and Zn were all below permissible limits. BSAF of *T. fuscatus* was ≥ 1 for Cd in all stations, for Ni in all stations except S2 and S5, for Zn was ≥1 in S4 and S5 , and V in S3 and S4.The Risk Associated with consumption of *T. fuscatus* revealed that the Target Hazard Quotient (THQ) for Pb was≥1 in all stations sampled. Further calculations on the Hazard Index (HI) revealed values≥1 in all the stations. Histological examination on the tissues of the *T. fuscatus* showed alterations in their tissues. It can therefore be deduced that the consumption of biota from the stretch of Upper Bonny Estuary may have a significant chronic health effects on the entire populace, hence it is recommended that the consumption of *T. fuscatus* should be reduced and proper monitoring of anthropogenic activities around the creeks should be encouraged by appropriate regulatory agencies.

Keywords: Heavy metal; Contamination level; Macroorganism; Environmental risk assessment; Niger.

1. Introduction

Heavy metals contamination in environmental components (soil, air and water) has increased dramatically in urban industrial areas as a results of rapid human activities such as agricultural, urbanization and industrialization activities during the last two decades (Wei et al., 2010; Al-Khashman, 2013; Jiang et al., 2017; Hou et al., 2019; Anaero-Nweke et al., 2021).

Dust and aerosols of the atmospheric have the potential to play an important factor in modifying and or altering climate, water cycles and the characteristics of physical, chemical and biological parameters of the atmosphere (Koçak et al, 2009). Many studies were published on the health effects of metals pollution has focused on atmospheric particulate matter, soil, water plants and sediments have been conducted in several parts of the world (Abdul-Wahab and Yaghi, 2004; Al-Khashman, 2004; Arditsoglou and Samara, 2005; Al-Khashman and Shawabkeh, 2006; Pereira et al, 2007). Contamination of heavy metal of river water and surface sediments becomes the major problems in fast urbanized cities since water and sediment quality maintenance and hygiene structure do not grow along with population and urbanization (Ahmad et al. 2010). Many studies prove that the both activities (natural and anthropogenic) are largely liable for the metal abundance in the environment (Wilson and Pyatt 2007; Khan et al. 2008).

The aim of this study to determine the levels of metals and then to evaluate the metals contamination and risk assessment in macroorganism in Bonny Estuary, Niger delta

2. Study area

The sampling stations were established along Okrika Creek in Okrika Local Government Area and stretched up to the Upper Bonny Estuaryof Rivers State, Niger Delta. The river is a brackish mangrove swamp with intertidal mud flats, and influenced by semi-diurnal tidal regime. The vegetation consists of *Rhizophora racemosa, Laguncularia racemosa, R. mangle, Nypa frutican,* and *Avicennia nitida* which line the shores of the creek. The creek is tidal in both wet and dry seasons. Anthropogenic activities along the stretch of Upper Bonny Estuary include discharge of industrial effluents, sand mining, dredging, fishing, navigation, washing, bathing and recreational activities. A major industrial outfit which is situated in station 2 (Ekerekana) is the Port Harcourt Refinery Company (PHRC) [a subsidiary of the Nigerian National Petroleum Corporation (NNPC)], which generates several volumes of effluents that are channelled into the creek via a drainage system (Anaero-Nweke *et al.*, 2016). These activities may influence the natural balance of the aquatic ecosystem and consequently its biota, such as plankton, benthos and fish. Okrika River is a highly urbanized brackish ecosystem impacted mainly by anthropogenic municipal and industrial activities that have significantly increased in the past decades.

The study area has been subjected to domestic, industrial and illegal bunkering activities over the past decades and waste-water from residential houses and communities. A long the shores of the creek are located several communities.

The communities are but not limited to Okochiri, Ekerekana, Okari-Ama, Oba-ama, Ogoloma, and Kalio-Ama. Along the stretch of the river, artisanal fishers mainly exploit the fisheries. The fisher folks use wooden and dug-out canoes ranging in size from 3m to 8m long. The canoes are either paddled or powered by small outboard engines, and manned by an average of two men. From these boats, the fisher folks operate their cast nets, hook and lines, gill net and crab pots.

However, over the past decades, several studies have revealed that the sampling stations serve as the ultimate sink for a number of pollutants and increasing array of waste types, including sewage, municipal, and industrial effluents among others from the effluents and runoff from the surrounding metropolis. Bonny Estuary is an important habitat for a wide array of fish and

marine organisms, that serve as the major source of seafood to the people of Okrika and its environment, the contamination of this ecosystem is not only a major concern for the fish and wildlife resources but also for the human population.

2.1: Sample Stations

Five (5) main sample collection stations were selected in the study area as shown in Fig 1 and described in Table 1. These include;

1. Okochiri River as station 1 (S. 1): This represents the station 500 metres to the right of the point source of industrial effluent discharge.
2. Ekerekana Creek which serves as the Point Of Discharge into the river and is Station 2 (S.2)
3. Okari-Ama River as station 3 (S.3): Representing the Station 500 metres to the left of the Point source.
4. Ogoloma Creek as station 4 (S.4): Representing the entrance to a creeklet from the Bonny Estuary but a distance opposite the point source
5. Bonny Estuary (Control station) is about 700m away from Ogoloma Creek entrance

2.1.1: Description of Sampling Stations

Table 1. shows the description of sampling stations.

Sampling Station	Anthropogenic activities	Coordinates
Okochiri River	Boat related activities, receives municipal and domestic effluents from nearby residences, water surface covered by oil sleeks and dirt; Area is saturated with foul smell, little or no fishing activities, mangrove roots and stems covered with oil sheen, river filled with dead organic material.	N 04°44'36.4' E 007°06'31.7''
Ekerekana Creek	Boat related activities, point source of industrial effluent discharge, very busy in terms of human illegal bunkery activities, area is saturated with foul smell, point source of domestic effluents, public toilets with direct defeacation into the creek, little or no fishing activities, residential buildings on the shoreline	N04°44'46.9' E007°06'06.0''
Okari-Ama River	Residential building and public toilets at the shoreline of the river, fishing, fish marketing activities, illegal bunkering, boat related activities, recreational, anddredging activities and deposition of large dredge spoil wastes, direct defeacation into the river, residential buildings on the shoreline, swimming, bathing, washing, boat transportation.	N04°44'23.2' E007°05'51.8''
Ogoloma Creek	Very busy in terms of human activities, high boat transport activities, ship navigation, rich in both industrial and domestic waste, Residential buildingson the shoreline, illegal transportation of bunkering products, fishing, bathing, fish marketing, close to Port-Harcourt refinery jetty	N04°43'59.0' E007°05'05.7''
Bonny Estuary	No industrial activitis, no pipelines, high boat transportation and rate of fishing activities, ship navigation, mainly impacted by fishing activities.	N04°43'16.0' E007°04'40.8''

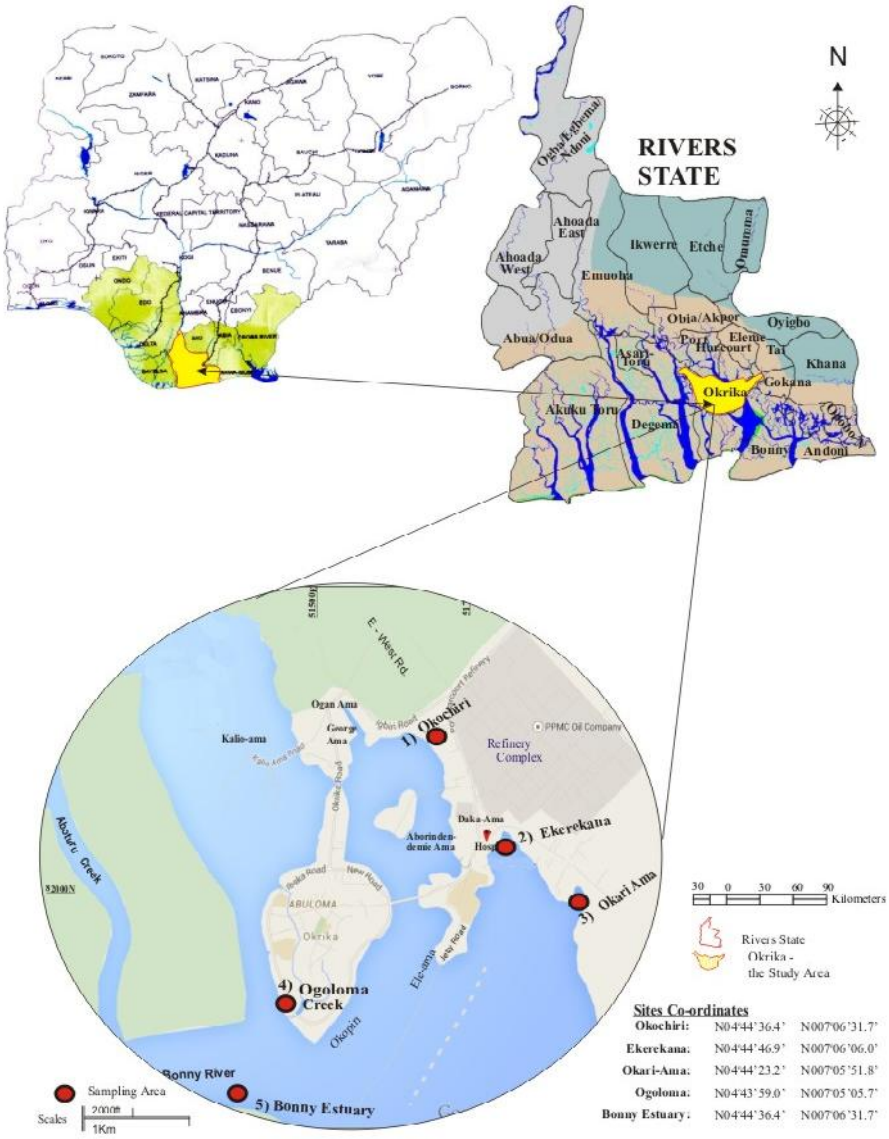


Figure1 Map of study area showing Sampling Stations

2.2: Field Sampling Operations

Surface Water, sediments and fauna were collected from the designated sampling stations. The positions of the stations were accurately located by Global Positioning System (GPS). Accurate positioning was further facilitated by careful attention to permanent and semi-permanent structures at the stations. An open motorized fibre boat was used as a means of transportation with which sampling was carried out at each of the designated sampling stations. The sampling regime was carried out monthly for 12 months and the period was also dictated by the two hydrological seasons prevalent in the tropics which brought about significant differences in the physico-chemical conditions in the bodies of water (Oyewo, 1998).

Physico-chemical parameters (pH, Temperature, DO, Conductivity, Total Dissolved Solids, Turbidity and Salinity) which could influence bioavailability and the response of biota to heavy metal toxicants were measured at each sampling station.

Surface water samples for heavy metals (50 mls) were acidified with 2 drops of concentrated HNO_3 (APHA, 1998). All samples were transported cool (4 ^oC) inan ice chest to the laboratory where the samples were transferred to a refrigerator until further processing before analysis.

2.3: *T. fuscatus* Collection

T. fuscatus 'Periwinkle'was collected by hand picking at the edge of the river at the sampling stations. Samples were collected in triplicates from each station. The collected samples were taken to the laboratory and preserved in the freezer prior to processing and analysis

2.3.1: Laboratory Analysis of Samples

The processing of all samples and physico-chemical analysis of water, sediment and fauna samples were carried out at Anal Concept Nigeria Limited. Histological analysis of selected organs was carried out in the Medical Laboratory Science Department, Rivers State University and Niger Delta University Histological Department, Nigeria. Risk assessment was calculated following standard procedures as used by Wang *et al.,* (2005) ; Ankora *et al.*,(2007).All analysis of water samples followed standard methods for the examination of water and waste water, 20th edition (APHA-AWWA-WEF, 2005).

2.3.2: *T. fuscatus* Analysis

Whole animal sample was properly cleaned by copiously rinsing all exposed and partially enclosed parts with distilled water to remove debris and all external adherents before processing for analysis.

2.3.3: *T. fuscatus* Sample Preparation

Soft tissues of collected *T. fuscatus* were extracted from the shells and dried in an oven at ± 60 ^oC for several hours until all the moisture was removed and the dry weight was constant indicating complete dryness. The dried tissue was crushed and homogenised using a domestic blender ready for digestion and subsequent analysis.

2.4: Heavy Metal Analysis in *T. fuscatus* (mg / kg)

From the powdered dry muscle tissues of biota, 0.5g was removed and placed in Peflon tubes, 4ml of a mixture of HNO_3 and H_2O_2 (1:3) was added and the reactor was covered and pre-digested overnight. The pre-digested samples were subjected to microwave digestion according to the procedure of USEPA, (2009). Atomic Absorption Spectrophotometer Model GBC by Avanta 2.02 was used for heavy metal determination.

Precautions were strictly taken in order to prevent contamination during investigation. Fish samples were washed by deionized distilled water after cutting to remove adsorbed metals on the skin. All reagents to be used were of analytical grade; glassware's were sterilizedby soaking them in 10% nitric acid and rinsed with distilled water prior to use. Deionized water was usedto prepare all aqueous solutions.

2.5: Statistical Analysis

Analysis and presentation of results was done using Microsoft excel, SPSS version 17. Data was subjected using JMP software to determine their Correlation Co-efficient, Principal Component Analysis (PCA) to determine the components responsible and cluster analysis for their grouping. Analysis of Variance (ANOVA) was used to determine their relationships and levels of significance. Other analysis include:

2.6.: Bio-Sediment Accumulation Factors (BSAF)

Bio-sediment Accumulation Factor was estimated as the ratio of the concentration of heavy metal in animal tissue to the concentration of heavy metals in the sediment (Deforest *et al.*, 2007).

BSAF =

$$\frac{\text{Heavy metal concentration in animal tissue}}{\text{Heavy metal concentration in sediment}}$$

(Deforest *et al.*, 2007).

2.7: Evaluation of Public Health Risk Associated with consumption of edible Biota

The public health risk associated with consumption of edible biota collected from upper reaches of the Bonny Estuary was evaluated by using the Estimated Daily Intake (EDI) according to Chien *et al.*, (2001) to determine the Target Hazard Quotient (THQ) whose bench mark is 1 (CODEX,2001). The oral RfD values were adapted from WHO (2008), FAO / WHO (2006) and the Integrated Risk Information System of the United States Environmental Protection agency (USEPA, 1985, 1998)

Target Hazard Quotient (THQ) is given by:

$$THQ = \frac{EDI}{RFDO}$$

EDI = Estimated Daily Intake

RFD = Reference Dose = Cr (0.003), Pb (0.00357), Cd (0.001) , Ni (0.02), Zn (0.214) V (0.009) mg / kg /d^{-1}(IRIS / USEPA, 1985, 1998)

2.7.1: Estimated Daily Intake (EDI)

The exposure duration of heavy metals to human through ingestion of contaminated food has been studied by many researchers (Chary *et al.*, 2008; Copat *et al.*, 2012). The Estimated Daily Intake (EDI) of each heavy metal in this exposure pathway was determined by the equation.

$$EDI = \frac{E_F \; x \; E_D \; x \; F_{IR} \; x \; C_f \; x \; C_m}{W_{AB} \; x \; T_A} \; x \; 10^{-3}$$

E_F = The Exposure Frequency = 365 days/year

E_D = The Exposure Durations, equalent to average life time = (54 years) (World Bank, 2015)

F_{IR} = Fresh Food Ingestion Rate (g/person/day) which is considered to be 40g/p/day (fish consumption rate was estimated to be 0.04 mg / kg^{-1} for normal adults in the Niger Delta region of Nigeria (Maximilian *et al.*, 2015)

C_m = The concentration of heavy metal in food stuffs (mg/d-w)

W_{AB} = Average Body Weight = 70kg

T_A = Is the Average Exposure of Time for non-carcinogens= EF x ED as used in previous studies (Wang *et al.*, 2005).

2.7.2: Hazardous Index (HI)

To estimate the risk to human through more than one heavy metal. The hazard index is the sum of the hazard quotients for all HMs, Which was calculated by the Eqn. (Guerra *et al.*, 2010).

$HI = \Sigma THQ = THQ_V + THQ_{Cr} + THQ_{Ni} + THQ_{cd} + THQ_{zn} + THQ_{As} + THQ_{Hg} + THQ_{Pb}$

HI value <1.0, indicates that adverse health effects are nunlikely to occur, while an HI ≥ 1 indicates probable risk of adverse health effects upon prolonged exposure.

2.8: Histopathological Analysis

Fish samples were dissected using a dissecting set under sterile condition. The gill, muscle and liver were removed from fish and washed. The extracted tissues were preserved in alcoholic Bouin's fixative. Samples of gill, muscle and liver from all stations were labeled properly and fixed in 10% neutral-buffered formalin at room temperature for 24h. After serial dehydration steps in alcohol, samples were embedded in paraffin. The blocks of embedded tissue were sectioned at 5 µm, and routinely stained with haematoxyline and eosin (HeE) and mounted on Digital Picture Exchange (DPX). Images were acquired with a Leica DFC280 digital camera attached to a light microscope (Leica 6000B).

4: Heavy Metals Contamination in *T. fuscatus*

The mean concentration of heavy metals in the soft tissues of macrobenthic invertebrates *Typanotonus fuscatus* showed variations between the different species of biota among the individual metals (P<0.05). All concentrations are recorded on a dry weight basis (mg / kg).

THC and heavy metal contamination in *T. fuscatus*

THC

The mean THC in the soft tissue of *T. fuscatus* ranged from 0.53 ± 0.37 mg / kg to 0.83 ± 0.58 mg / kg. The highest concentration was recorded in Okochiri River (0.83 ± 0.58 mg / kg) followed by Bonny Estuary, Ogoloma Creek, Ekerekana Creek and Okari-Ama with mean concentration of 0.79 ± 0.43, 0.66 ± 0.49, 0.58 ± 0.40 and 0.53 ± 0.37 mg / kg respectively. Turkey's multiple comparison at P<0.05 showed that the values were not significantly different.

The heavy metals found in the organs were in measurable but varied in concentrations from the sampled stations in the study area. Heavy metals (V, Cd, Cr, Pb, Ni, Zn) were found in the soft tissues of *T. fuscatus* collected while As and Hg were not detected.

Vanadium (V)

The mean levels of V ranged from 0.03 ± 0.03 mg / kg to 0.13± 0.11 mg / kg. The highest concentration was recorded in Okari-Ama River 0.13± 0.11 mg / kg, followed by Okochiri River, Ogoloma Creek, Ekerikana Creek with mean concentration of 0.12± 0.10 mg / kg, 0.09± 0.08 mg / kg, 0.07± 0.06 mg / kg and 0.03 ± 0.03 mg / kg respectively (Figure 4.39). Turkey's multiple comparison at P<0.05 showed that the mean concentrations were not significant.

Cadmium (Cd)

The mean concentration of Cadmium in the soft tissue of *T. fuscatus* ranged from 0.06 ± 0.1 mg / kg to 0.16 ± 0.11 mg / kg. The highest concentration was recorded in Okochiri River (0.16 ±0.11 mg / kg) followed by Ogoloma Creek, Bonny Estuary, Ekerekana Creek and Okari-Ama River with mean concentration of 0.10±0.07 mg / kg, 0.09 ±0.06 mg / kg, 0.08 ±0.13 mg / kg, and 0.06 ± 0.11 mg / kg respectively. Turkey's multiple comparison at P<0.05 showed that the mean concentration were not significantly different.

Chromium (Cr)

The mean concentration of Chromium in the soft tissue of *T. fuscatus* ranged from 0.08 ± 0.16 mg / kg to 0.13 ± 0.27 mg / kg.The highest concentration was recorded in Ogoloma Creek (0.13 ±0.27 mg / kg) followed by Okari-Ama River, Okochiri River, Ekerekana Creek and Bonny Estuary with mean concentration of 0.12 ± 0.24 mg / kg, 0.11 ± 0.22 mg / kg, 0.10 ± 0.15 mg / kg and 0.08 ± 0.16 mg / kg respectively. Turkey's multiple comparison, at P<0.05 showed that the mean concentrations were not significantly different.

Lead (Pb)

The mean concentration of Pb in the soft tissue of *T. fuscatus* ranged from 7.30 ±10.78 mg / kg to 9.85 ± 14.15 mg / kg. The highest concentration was recorded in Okochiri River (9.80 ± 14.15 mg / kg) followed by Bonny Estuary, Okari-Ama River, Ogoloma Creek and Ekerekana Creek with mean concentrations of 8.01 ± 12.98 mg / kg, 7.89 ± 10.27 mg / kg, 7.85 ± 11.93 mg / kg, and 7.30 ± 10.78 mg / kg respectively. Turkey's multiple comparison at P<0.05 showed that the mean values were not significantly different.

Nickel (Ni)

The mean concentration of Ni in the soft tissue of *T. fuscatus* ranged from 0.59 ± 0.49 mg / kg to 3.94 ± 2.86 mg / kg. The highest concentration was recorded in Ogoloma Creek (3.94 ±2.86 mg / kg) followed by Okari-Ama River, Okochiri River, Ekerekana Creek and Bonny Estuary with mean concentrations of 3.64 ± 2.43 mg / kg, 2.84 ± 2.20 mg / kg, 2.17 ± 1.49 mg / kg, and 0.59 ± 0.49 mg / kg respectively (Figure 4.43). Turkey's multiple comparison at P<0.05, showed that the values were not significantly different.

Zinc (Zn)

The mean Zn concentration in the soft tissue of *T. fuscatus* ranged from 9.44 ± 7.52 mg/kg to 19.39 ±19.50 mg/kg . The highest concentration was recorded in Bonny Estuary (19.39 ± 19.50 mg/kg) followed by Ogoloma Creek, Okochiri River, Okari-Ama River, and Ekerekana Creek with mean concentration of 13.13 ± 11.61 mg/kg, 12.49 ± 9.64 mg/kg, 10.44 ± 7.08 mg/kg, and 9.44 ± 7.52 mg/kg respectively. Turkey's multiple comparison at P>0.05 showed that the values were not significantly different

Bio-Sediment Accumulation Factor (BSAF) of *T. fuscatus*

In periwinkle the heavy metal accumulated from Pb in Okochiri River (1.30), Ni in Okochiri River (1.00), Okari-Ama River (1.00) and Ogoloma Creek (2.12) and, Cd in Okochiri River, Ekerekana Creek, Ogoloma Creek and Bonny Estuary with accumulation factor of 1.77, 1.60, 1.43 and 3.0 respectively(Table 2), Zn in Ogoloma River, and Bonny Estuary with BSAF of 1.48 and 1.49 respectively, and V in Okari-Ama River and Ogoloma Creek with accumulation factor of 1.00 and 2.38 respectively as presented in Table 2.

Table 2: Heavy Metal Bioaccumulation Factor in *T. fuscatus* in the Study Area.

Heavy metal		Okochiri (S1)	Ekerkana (POD, S2)	Okari-Ama (S3)	Ogoloma (S4)	Bonny Estuary (Control, S5)
Cd (mg/kg)	Mean concentration in Biota (mg/kg)	0.16 ± 0.11	0.08 ± 0.13	0.06± 0.11	0.10± 0.07	0.09 ± 0.06
	Mean concentration in Sediment (mg/kg)	0.09 ± 0.09	0.05 ± 0.11	0.08± 0.14	0.07 ± 0.07	0.03 ± 0.03
	BSAF of Cd	1.77	1.60	0.75	1.43	3.0
Cr (mg/kg)	Mean concentration in Biota	0.11 ± 0.22	0.10 ± 0.15	0.12± 0.24	0.13 ± 0.27	0.08 ± 0.16
	Mean concentration in Sediment	6.43 ± 3.46	5.50 ± 2.73	6.89± 0.68	3.86 ± 2.43	3.58 ± 2.89
	BSAF of Cr	0.02	0.02	0.02	0.03	0.02
Pb (mg/kg)	Mean concentration in Biota	9.85± 14.15	7.30± 10.78	7.89± 10.27	7.85 ± 11.93	8.01 ± 12.98
	Mean concentration in Sediment	7.86 ± 7.30	9.26 ± 8.59	13.84±13.00	14.53 ± 13.00	14.84± 14.72
	BSAF of Pb	1.30	0.78	0.57	0.54	0.53
Ni (mg/kg)	Mean concentration in Biota	2.84 ± 2.20	2.17 ± 1.49	3.64± 2.43	3.94 ± 2.86	0.59 ± 0.49
	Mean concentration in Sediment	2.96 ± 2.37	3.04 ± 1.81	3.69± 2.71	1.86 ± 1.28	1.69 ± 2.01
	BSAF of Ni	1.00	0.71	1.00	2.12	0.35
Zn (mg/kg)	Mean concentration in Biota	12.49 ± 9.64	9.44 ± 7.52	10.44 ± 7.08	13.13 ± 11.61	19.39 ± 19.50
	Mean concentration in Sediment	33.17 ±26.01	32.19 ± 18.76	34.18 ± 17.84	8.87 ± 6.19	12.99 ± 10.31
	BSAF of Zn	0.38	0.29	0.31	1.48	1.49
V (mg/kg)	Mean concentration in Biota	0.12 ± 0.09	0.10 ± 0.07	0.16 ± 0.11	0.19 ± 0.13	0.03 ± 0.03
	Mean concentration in Sediment	0.19 ± 0.12	0.17 ± 0.09	0.20 ± 0.13	0.08 ± 0.06	0.08 ± 0.10
	BSAF of V	0.63	0.58	1.00	2.38	0.37

Estimated Daily Intake (EDI), Target Hazard Quotient (THQ) andHazard Index (HI) from consumption of *T. fuscatus* from the study area.

The Estimated Daily Intake, THQ (Target Hazard Quotient), Hazard Index (HI) were calculated to determine the tendency of the exposed population to suffer health consequences from consumption of ***T. fuscatus*** caught from the sampled stations. The values below 1 indicates that the exposed population is unlikely to experience adverse health effects and a value greater than 1 suggest the potential for adverse health effects with increasing probability as the value increases. The THQ in this study for Pb is 1 in all stations while the Hazard Index were greater than or equal to 1(≥) in all sampled stations.

Table 3: Results of Computed Estimated Daily Intake (EDI), Target Hazard Quotient (THQ) and Hazardous Index (HI) of Heavy Metals in *T. fuscatus* from the study area

Parameters	RFD		Okochiri River (S1)	Ekerekana Creek (POD, S2)	Okari-Ama River (S3)	Ogoloma Creek (S4)	Bonny Estuary (S5)
Cd	0.001	EDI	9.14×10^{-05}	4.57×10^{-05}	3.42×10^{-04}	5.71×10^{-05}	5.14×10^{-05}
		THQ	0.09	0.04	0. 03	0.05	0.05
Pb	0.00357	EDI	5.62×10^{-03}	4.17×10^{-03}	4.50×10^{-03}	4.48×10^{-03}	4.57×10^{-03}
		THQ	1.57	1. 16	1.26	1.25	1.28
Ni	0.02	EDI	1.62×10^{-03}	1.24×10^{-03}	2.08×10^{-03}	2.25×10^{-03}	3.73×10^{-04}
		THQ	0.08	0.06	0. 10	0. 11	0.01
V	0.009	EDI	6.85×10^{-05}	4×10^{-05}	7.42×10^{-05}	5.14×10^{-05}	1.71×10^{-05}
		THQ	7.61×10^{-03}	4.44×10^{-03}	8.24×10^{-03}	5.71×10^{-03}	1.9×10^{-03}
Zn	0.214	EDI	7.13×10^{-03}	5.39×10^{-03}	5.96×10^{-03}	7.50×10^{-03}	0.01
		THQ	0.03	0.02	0.02	0.03	0.04
Cr	0.003	EDI	6.28×10^{-05}	5.71×10^{-05}	6.85×10^{-05}	7.42×10^{-05}	4.57×10^{-05}
		THQ	0.02	0.01	0.02	0.02	0.01
HI			1.79	1.29	1.43	1.46	1.39

The Histological Examination of the mantle fold, muscles and hepatopancreatic tissuesof *T. fuscatus* collected from the sampled stations

The histological examination of different sampled organs of collected *T. fuscatus* revealed the presence of histopathological alterations among examined mantle fold, muscle, and liver tissues (Plates 1 to 3). *T. fuscatus* caught from Okochiri River, Ekerekana Creek and Bonny Estuary showed normal mantle folds (MTF) with squamous cell epithelium and under laying dense contective tissue (DCT). Okari-Ama Riveralso showed a normal mantle folds (MTF) with the presence of adipocytes (AD). Ogoloma Creek showed a normal mantle folds (MTF).

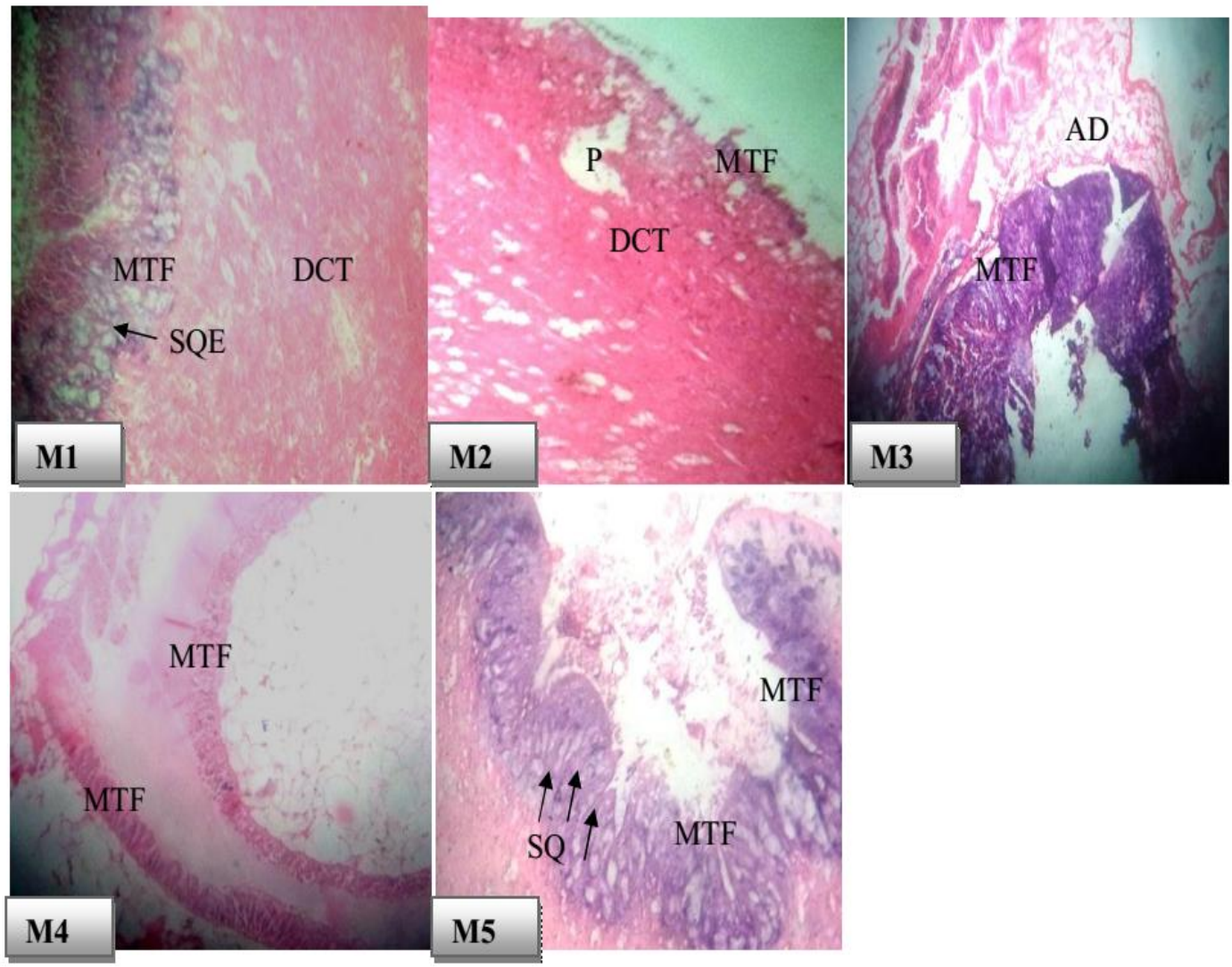


Plate 1: Photograph of Mantle fold of *T. fuscatus* caught from the 5 sampled stations.

The muscle tissue of *T. fuscatus* caught from Okochiri River and Okari-Ama River showed a normal bundle of muscle fibres (BMF) while Ekerekana Creek, Ogoloma Creek and Bonny Estuary also showed a normal bundle of muscle fibres (BMF) with the presence of adipocytes (AD).

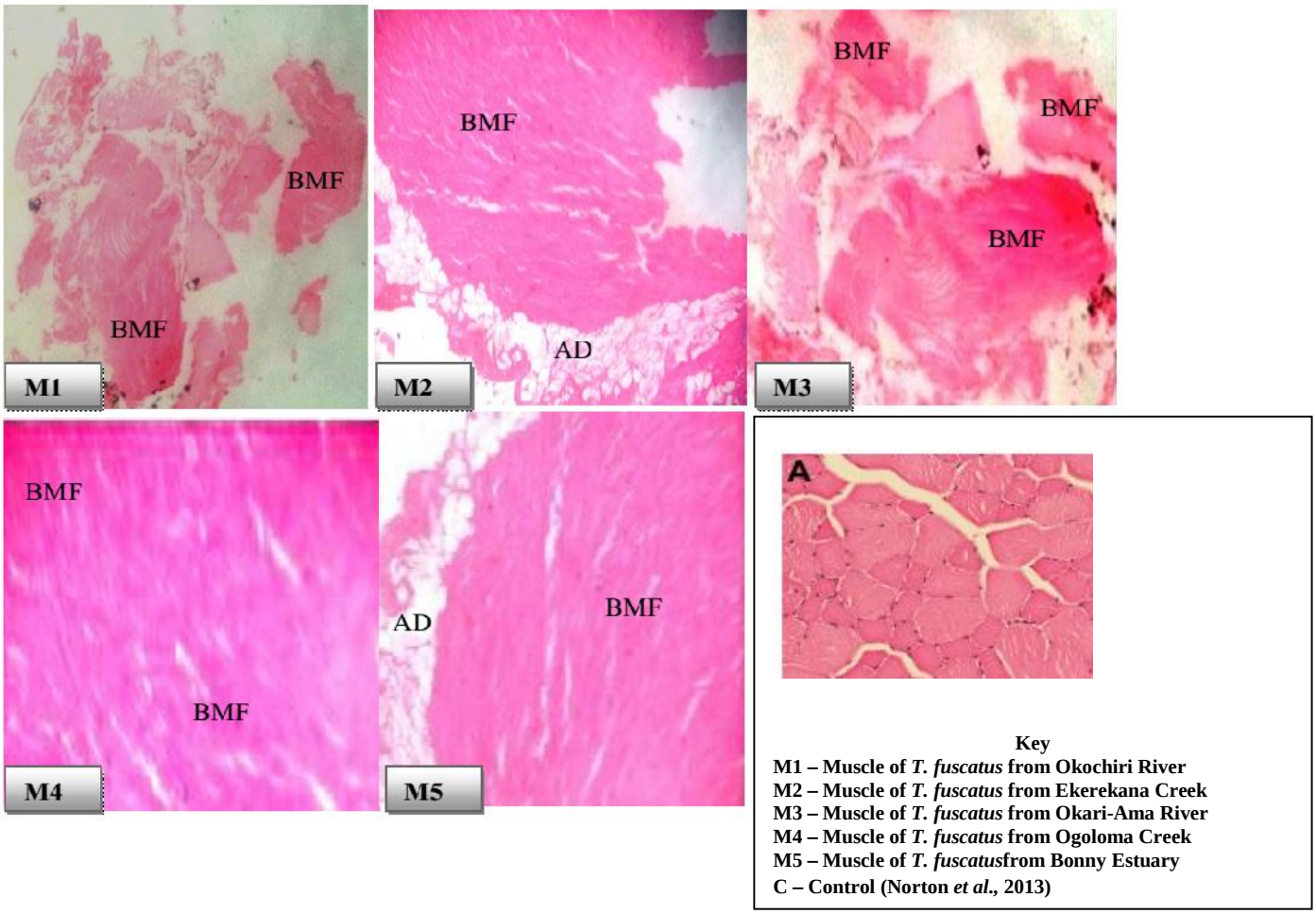
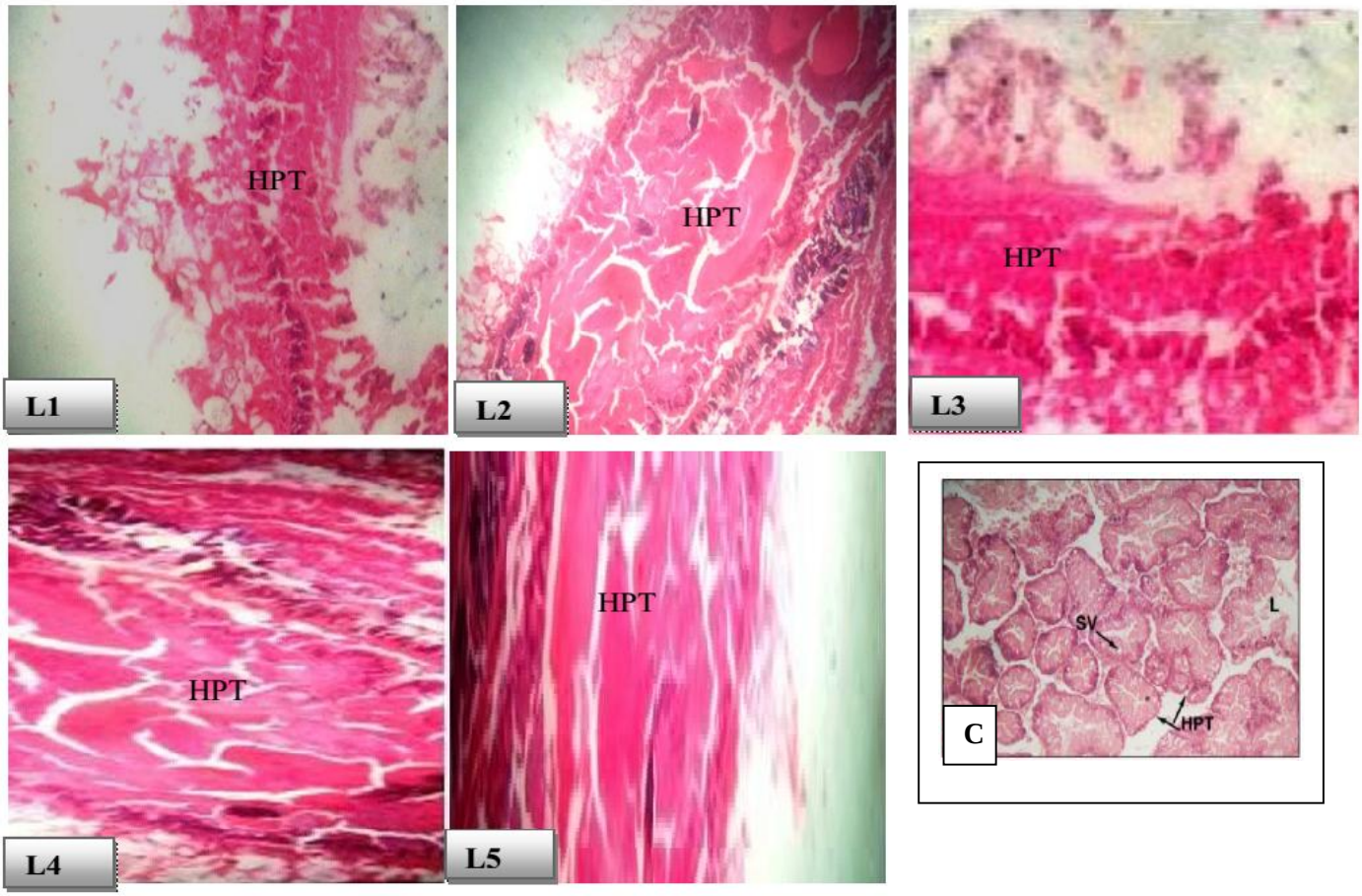


Plate 2: Photomicrograph of muscle tissue of *T. fuscatus* caught from the 5 sampled stations

The hepatopancreatic tissue of *T. fuscatus* caught from the five sampled stations showed a distorted hepatopancreatic tissue (HPT) in all the sampled stations (Plate 4.9).



Key

L1 – hepatopancreatic tissues of*T. Fuscatus* from Okochiri River
L2 – hepatopancreatic tissues of *T. fuscatus* from Ekerekana Creek
L3 – hepatopancreatic tissues of *T. fuscatus* from Okari-Ama River
L4 – hepatopancreatic tissuesof*T. Fuscatus* from Ogoloma Creek
L5 – hepatopancreatic tissuesof*T. Fuscatus* from Bonny Estuary
C –Control (Ünlu *et al.*, 2005)

Plate 3: Photographs of hepatopancreatic tissues of *T. fuscatus* caught from the 5 sampled stations

Discussion

Environmental parameters in this study showed that the Upper reaches along the stretch of Bonny Estuary is a recipient of diverse forms of wastes ranging domestic, runoff from illegal bunkering activities, jetties, municipal sewage to industrial effluent discharges. These multiple sources of organic and inorganic contaminants have negative impacts on the physico-chemical characteristics of the water body.

5.3 Heavy Metal Concentration in *T. fuscatus*

The bioaccumulation of toxic levels of heavy metals is detrimental to organisms generally including plants and animals as they biomagnified them through the food chain as well as subsequent transfer along the trophic level to humans.

Studies (Otitoloju and Don-Pedro, 2004) have pointed out that *T. fuscatus* has the ability to accumulate high levels of metals in their tissues. This study revealed that the concentration of heavy metals in the soft tissues of *T. fuscatus* were all below permissible limit except in Pb and Ni which were above permissible limits of 0.5 mg / kg and 0.6 mg / kg respectively, FAO / WHO (2012) in all the sampled stations. The computed bio-sediment accumulation factor (BSAF) indicated high level of Pb, Cd, Zn, Ni with Pb in Okochiri River, Cd in Okochiri River, Ekerekana Creek, Ogoloma Creek and Bonny Estuary. Zn in Ogoloma Creek and Bonny Estuary, Ni in Okochiri River, Okari-Ama River and Ogoloma Creek and V in Okari-Ama River and Ogoloma Creek. The bio-accumulation pattern of heavy metals in *T. fuscatu* wereslightly higher which might be due to feeding (sediment ingesting) behaviour, physiology or environment specific phenomenon (Otitoloju and Don-Pedro, 2004).

5.5: Histological Examination of the , muscles, liver and hepatopancreatic Tissues of the Studied Fauna

Histological examination of liver *T. fuscatus* of showed increased necrosis of hepatocytes which may be traced to the cumulative effect of heavy metals and their increase in concentrations in the hepatic tissue. These results agreed with several previous studies (El-Gawad, 1999). In addition, the pathological liver steatosis was reported by Kranz and Peters (1985) accompanied by additional features such as necrosis, lymphocyte infiltration, deposition of ceroids and aggregations of macrophages.

5.6: Human Health Risk Assessment

Most studies usually measure metal concentrations in environmental media and evaluate the accumulation ratio, but the true indices of potential health hazards of contaminates lies in cancer and non-cancer estimates such as EDI (Estimated Daily Intake), THQ (Target Hazard Quotient) and Hazard Index (HI) which points to the tendency of the exposed population to suffer health consequences. The THQ based assessment method shows risk level due to exposure to pollutants (Chary *et al.*, 2008). The values below 1 indicate that the exposed population is unlikely to experience adverse health effects and a value greater than 1 suggests the potential for adverse health effects with an increasing probability as the value increases. The THQ in this study for Pb in *T. fuscatus* was 1 and the HI was ≥ 1 in all the sampled stations which means the exposed population might likely suffer adverse effect upon prolonged exposure.

These findings indicate that there should be a reduced consumption of *T. fuscatus* and also the need to continuously monitor heavy metal concentration in the ecosystems predisposed to pollution and where necessary re-evaluate existing safety limits.

References

Adakole, J. A. & Anunne, P. A. (2003). Benthic macro invertebrates as indicators of environmental quality of an urban stream, zaria, Northern Nigeria. *Journal of Aquatic Science*, 18(2), 85-92.

Akan, J. C., Abbagambo, M. T., Chellube, Z. M. & Abdulrahman, F. I. (2012).Assessment of Pollutants in Water & Sediment

Samples in Lake Chad, Baga, North Eastern Nigeria. *Journal of Environmental Protection*, 3, 1428-1441.

Al-Khashman, O. 2004. Heavy metal distribution in dust, street dust and soils from the work place in Karak Industrial Estate, Jordan. Atmospheric Environment 38, 6803-6812.

Al-Khashman, O., and Shawabkeh, R. (2006). Metal distribution in soils around the cement factory in southern Jordan, Environmental Pollution 140, 387-394.

Al-Khashman, O.A., 2013. Assessment of heavy metals contamination in deposited street dusts in different urbanized areas in the city of Ma'an, Jordan. Environmental Earth Science. 70(6): 2603-2612.

American Public Health Administration (APHA) (1998). Standard Methods for the Examination of Water & Waste Water, 20th Edition, APHA, New York. 1270pp.

Anaero-Nweke, G. N. (2013). *Impact of Oil Refinery Effluent on the Water Quality: Case Study of Ekerikana Creek in Nigeria* (MSc dissertation) Kwame Nkrumah University Ghana.

Anaero-Nweke, G.N., Fei-baffoe, B., & Ekweozor, I.K.E. (2016).Tidal Influence in the Distribution of Discharged Effluents from Port Harcourt Refinery Company in Okrika Creek, Rivers State, Nigeria. *International Journal Of Scientific & Engineering Research,* 7(10), 1715-1729.

Anaero-Nweke, G.N., Ekweozor, I.K.E. Al-Khashman, O.A., 2021. Monitoring and assessment of heavy metals contamination in surface water and sediments in Bonny Estuary, Niger. Delta. International Journal of Science and Research. Vol. 10, Issue 1, 579-587.

Anyakora, C., Arbabi, M., & Coker, H. (2008). A screen for benzo (a) Pyrene in fish samples from crude oil polluted environments. *American Journal of Environmental Sciences*, *4*(2), 145-150.

APHA-AWWA-WEF (2005).Standard Methods for the examination of water & waste water, 21st edition, 900pp.

ATSDR (Agency for toxic substances & Diseases Registry) (2005).Toxicological profile for nickel, US Department of Health & Human Services, Altanta, GA, USA.

Chakravarty , M., & Patgiri, A. (2009). Metal Pollution Assessment in Sediments of the Dikrong River, N. E. India.*Journal of Human Ecology*. 27 (1), 63 – 67.

Charlatchka, R., & Cambier, P. (2000). Influence of reducing condition on solubility of trace metals in contaminated soils. *Water, Air, Soil and Pollution,* 118, 143-167.

Chen, J. C., & Lin, C. Y. (1995). Responses of oxygen consumption, Ammonia-N excretion & Urea-n excretion of Penaeus Chinensis exposed to ambient ammonia at different salinity & pH levels. *Aquaculture,* 136(3-4), 243 – 255.

Chary, N. S., Kamala, C. T., & Ras, D. S. S. (2008). Assessing risk of heavy metals farm & consuming food grown on sewage irrigated soil & food chain transfer. *Ecotoxicology &Environmental Safety,* 69(3), 513 – 524.

Chien, L. C., Hung, L., Choang, K. Y., Yeh, C. Y., Meng, P. J., Shieh, M. J., & Han, B. C. (2002). Daily intake of TBT, Cu, Zn, Cd & As for fisherman in Taiwan.*The Science of the Total Environment*, 285, 177-185.

Chien, L. C., Hung, T. C., Choang, K. Y., Yeh, C. Y., Meng, P. J., & Shieh, M. J. (2002) Daily intake of TBT, Cu, Zn, Cd & As for fishermen in Taiwan. *Science of the Total Environment*, 285(1-3), 177-85.

Chindah, A. C. (2004). Response of periphyton community to salinity gradient in tropical estuary, Niger Delta.*Polish Journal of Ecology*, 52(1), 83-89.

Chindahm A. C., & Braide, S. A. (2003).Cadmium & lead concentrations in fish species of a brackish wetland/upper Bonny Estuary, Niger Delta.*Journal of Nigerian Environment &Sociology,* 1(3), 399 – 405.

Christy, J. H., & Salmon, M. (1984).Ecology and evolution of mating systems of fiddler crabs (genus Uca).*Biological Reviews*, 59(4), 483 – 509.

Codex, Alimentarius Commission (CODEX) (2001). Codes guidelines (ALINORM 01/22). Rome, Italy: FAO/WHO.

Available on the World Wide Web: http://www.codexalimentarius.net/Assessed 24th October 2017.

Copat, C., Bella, F., Castaing, M., Fallico, R., Sciacca, S. & Ferrante, M. (2012). Heavy Metals Concentrations in fish from Sicily (Mediterranean Sea) & Evaluation of Possible Health Risks to Consumers.*Bulletin of Environmental Contamination Toxicology,* 88, 78-83.

DeForest D. K., Brix, K. V., & Adams W. J. (2007). Assessing metal accumulation in aquatic environments: the inverse relationship between bioaccumulation factors, trophic transfer factors & exposure concentration. *Aquatic Toxicology,* 84, 236–246.

Emere, M. C., & Nasiru, E. C. (2007). Macroinvertebrates as indicators of the water quality of an urbanized steam Kaduna Mogeroa. *Nature and Science*, 6(4), 1-7.

FAO/WHO (2012).Evaluation of certain food additives & the contaminants mercury, lead & cadmium; WHO Technical Report Series No. 505.

FAO/WHO/UNO (1985).Expert Consultation on energy & protein requirement Technical report Series 724, World Health organization (WHO) Geneva.

Federal Ministry of Environmental Protection (FMENV) (1999).Guidelines to Standards for Environmental Pollution in Nigeria.

FAO/WHO (Food & Agriculture Organization/World HealthOrganization).(2006). A model for establishing upper levelsof intake for nutrients & related substances. FAO/WHO

FAO / WHO (1983).Manual of Methods in Aquatic Environmental Research.Past 9.Analyses of metal & organochlorines in fish.FAO fisheries Technical paper, 212.

Nutrient Risk Assessment Workshop, May 2–6, 2005, WHOHeadquarters, Geneva, Switzerl&. Available at http://www.who.int/ipcs/highlights/full_report.pdf[accessed 27 October 2017].

Food Standards Agency (2004). Total Diet Study: Total & Inorganic arsenic in food, food surveillance information Sheet 51/04.

Hart, A. I., & Zabbey, N. (2005).Physico-Chemistry & Benthic fauna of Woji Creek in the Lower Nigeria Delta.*Nigeria Environmental Ecology*, 23(2), 361-368.

IOSHIC (1999). International Occupational Safety and Health Information centre.

Iwuoha, G. N., Osuji, L. C., & Horsfall, M. Jnr. (2012). Index Model Analysis Approach to Heavy Metal pollution Assessment in Sediments of Nworie & Otamiri Rivers in Imo State of Nigeria. *Research Journal of Chemical Sciences*, 2(8), 1 – 8.

Jiang, Y., Shi, L., Guang, A.I., Mu, Z., Zhang, H., Wu, Y. 2017. Contamination levels and human health risk assessment of toxic heavy metals in street dust in an industrial city in northwest China. Envi.Geoch.Health. 40, 2007-2020.

Jonnalagadda, S. B., & Mhere, G. (2001). Water quality of the Odzi river in the Eastern highl& of Zimbabwe. *Water Research*35, 2371 - 2376

Maximilian, O. O., Josiah, C. O., & Chigozie, D. E., (2015). Trace metal contamination in tropical endemic fish: Factorial effect interactions & in situ quantitative risk assessment. *Journal of Environmental & Occupational Science*, 4(1), 10-21.

McLusky D. S. (1989).*The estuarine ecosystem* (2nd edn). New York:Chapman& Hall.

Meyers, R. A. (2000). Encyclopedia of Analytical Chemistry, Volume 23: Inductively Coupled Plama Mass Spectrometry in Environmental Analysis (ed. Yamasaki, S. I.) John Willey & Sons Ltd., 2672 – 2692 pp.

Morgan, D. O., & McMahon, B. R. (1982). Acid tolerance and effects of sublethal acid exposure on iono-regulation and acid-base status in two crayfish Procambarus clarki and Orconectes rusticus. *Journal of Experimental Biology*, *97*(1), 241-252.

Obire, O., Tamuno, D. C., & Wemedo, S. A. (2003).Physico-chemical quality of Elechi creek in Port Harcourt, Nigeria. *Journal of*

Applied Sciences and Environmental Management, *7*(1), 43-49.

Odiete, W. O. (1999). *Environmental Physiology of Animals & Pollution.* Diversified Resources Lagos, Nigeria.

Ogbeibu, A. E., Omoigberale, M. O., Ezenwa, I. M., Eziza, J. O., & Igwe, J. O. (2014).Using Pollution Load Index & Geoaccumulation Index for the Assessment of Heavy Metal Pollution & Sediment Quality of the Benin River, Nigeria. *Natural Environment,* 2(1), 1- 9.

Ojewole, G. S., & Udom, S. F. (2005).Chemical evaluation of the nutrient composition of some unconventional animal protein sources. *International Journal of Poultry Science*, *4*(10), 745-747.

Okoye, B. C. O. (1991). "Heavy metal & organisms in the Lagos Lagoon, *International Studies*, 37, 285 – 295.

Otitoloju,A.A., & Don-Pedro, K.N. (2006). Influence of joint application of heavy metals on level of each metal accumulated in periwinkle *Tympanotonus fuscatus* (Gastropoda Potmididae). *Revista de Biologia Tropical*, 54(3), 803-814.

Otitoloju, A. A., & Don-Pedro K. N. (2002). Bioaccumulation of Heavy metal (Zn, Pb, Cu& Cd) by *Tympanotonusfuscatusvar radula* (1) exposed to sublethal concentrations of the test metal comounds in laboratory bioassays. *West African Journal of Applied Ecolology*, 3, 17 – 29.

Oyewo, E. O. (1998). Industrial sources & distribution of heavy metals in Lagos lagoon & their biological effects on estuarine animals.(Ph.D Thesis).University of Lagos, 247pp.

Pereira, de, Lopes, W., Carvalho, L., Gisele, O., Rocha, da., Bahia, N., Loyola, J., Quiterio, S., Escaleira, Arbilla, G., Andrade, J., (2007). Atmospheric concentrations and dry deposition fluxes of particulate trace metals in Salvador, Bahia, Brazil. Atmospheric Environment 41. 7837-7850.

Rahman, M. M., Asaduzzaman, M., & Naidu, R. (2013).Consumption of arsenic & other elements from vegetables & drinking water from an arsenic-contaminated area of Bangladesh. *Journal of Hazardous Materials*, 262, 1056-1063.

Sarva, M. P., Miroslav, R., MohdHarun, A., & Ahmed, Z. A. (2005).Application of sediment quality guideline in the assessment of mangrove surface sediment in Mengkabong, Lagoon Sabah.*Global Journal of Environmental Research*, 1(3), 1-9.

Sharon, B. (1997). Testing the Waters: Chemical & Physical Vital Signs of a River.River Watch Network.ISBN-0-782-34923.*http://www.fosc.org/WQData/WQParameters.htm*

Shengnan Houb, , Na Zhenga, , Lin Tanga, , Xiaofeng Jib, , Yunyang Lia, , Xiuyi Hua. 2019. Pollution characteristics, sources, and health risk assessment of human exposure to Cu, Zn, Cd and Pb pollution in urban street dust across China between 2009 and 2018. Environmental International. 128; 430-437.

Tomlinson, D. L., Wilson, J. G., Harils, C. K. & Jeffrey, D. W. (1980). Problems in the assessment of heavy metal levels in estuaries & the formulation of a pollution index.*Helgoländer Meeresuntersuchungen* , 33, 566 – 575.

Turekian, K. K., & Wedepohl, K. H. (1961).Distribution of the elements in some major units of the earth crust, *Bulletins of Geological Society of America*, 72(2), 175-192.

USEPA (1999). "US Environmental Protection Agency: Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities". Appendix E: Toxicity Reference Values. Vol. 3.

USEPA (United States Environmental Protection Agency). 1985. Drinking water criteria document on cadmium (final draft). Office of drinking water, USEPA, Washington, DC. Available at *http://www.epa.gov/iris/subst/0141.htm#reforal* [accessed 24 October 2017].

USEPA (United States Environmental Protection Agency). (1998). Chromium (VI) (CASRN 18540-29-9). Integrated risk information system. USEPA. Available at

http://www.epa.gov/iris/subst/0144.html [accessed 24 October 2017].

World Bank (2015). Life expectancy ratio 2015.

WHO, (2004).“Guidelines for Drinking Water Quality”, 3rd Edition, World Health Organization. 515pp.

WHO (1989).Heavy metals environmental aspects; Environment health criteria.No. 85. Geneva, Switzerland.

WHO (2005).“Guidelines for Drinking Water Quality”, 3rd Edition, World Health Organization. 515pp.

WHO (World Health Organization), (2008).*WHO Guidelines for drinking water quality. Third edition.Vol. 1*.Geneva, Switzerland.

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