Assessment of Heavy Metal Pollution in Water, Shrimps and Sediments of Some Selected Water Bodies in Ondo State.

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Abstract

The introduction of heavy metals into the aquatic ecosystems through the extensive exploitation and exploration of crude oil in Nigeria has become the subject of environmental risks. This study was carried out to assess the physico-chemical parameters, and concentrations of heavy metals (Mn, Cu, Pb, Fe, Zn, and Cd) in water, shrimps and sediments from the coastal waters in Ondo State, Nigeria. The result of the water samples show that electrical conductivity and dissolved oxygen varied from (2.68±0.89 µS/cm and 7.79±0.49mg/l) in Idiogba to (4.52±4.16 µS/cm and 8.2±1.16mg/l) in Bijimi respectively. The values were not significantly different across the stations. The heavy metals with the highest concentrations in water, *Nematopalaemon hastatus, Farfantepenaeus notialis* and sediments were Mn (2.82±1.46), Zn (7.511±0.190), Zn (7.011±0.165) and Mn (18.48±0.90) respectively. Metals in water samples, Zn, Cd, Pb, and Cu in shrimps were within the WHO and FEPA limits, while that of Mn and Fe in shrimps, and metals in sediments were above. The concentration of heavy metals in the sediments was higher than in water and shrimps. Therefore, close monitoring of the environment is recommended with a view to sustain the biodiversity of the ecosystem.

Keywords: *Nematopalaemon hastatus, Farfantepenaeus notialis*, exploitation, exploration, ecosystem

Introduction

The high influx of toxic chemical substances into the aquatic ecosystems has made heavy metals priority pollutants. These metals evolve from extensive industrial activities and agricultural practices, exploration and exploitation of crude oil, formation of ores, weathering of rocks and leaching or as a result of increased population (Biney 1994). They become bio-concentrated and bio-amplified along the food chain as they persist in the aquatic environment. They inhibit primary production, carbon, nitrogen and phosphorus mineralization, and the synthesis and activities of enzymes in sediments and surface waters (McDonald 2000).

Fishes ingest heavy metals from the surrounding waters, planktons, other feeding diets and sediments resulting to their accumulation in reasonable amounts (Olawusi-Peters and Akinola 2017). Metals such as Copper and Zinc are essential for metabolism in fish at low concentrations while some others such as Lead and Cadmium are toxic to living organisms (Virha *et al.,* 2011). When present at high concentrations, these metals impose serious damage to metabolic, physiological and structural systems of organisms in the aquatic environment. Sediments are an important sink and long-term store of a variety of pollutants, particularly heavy metals, and may serve as an enriched source of food for benthic organisms in estuarine ecosystems (Wang *et al.,* 2002; Spencer and MacLeod, 2002) because they are in constant flux with the overlying water column (Bai *et al.,* 2010; Deng *et al.,* 2010; Ayejuyo *et al.,* 2010). The occurrence of increased concentrations of heavy metals in sediments can be a good indicator of man-induced pollution rather than natural enrichment of the sediment by geological weathering (Adebowale *et al.,* 2008; Wang *et al.,* 2010). However, metals cannot always be fixed by sediments permanently. Some of the sediment-bound metals may be remobilized and released into water as a result of changes in environmental conditions that leads to acidification and reduction/oxidation and impose adverse effects on living organisms (Liu 2009).

The coastal waters of Nigeria is under increasing pressure from industrial pollution, oil spills, anthropogenic activities and agricultural wastes. These pressures pose potential threat to the entire ecosystems and human well-being. Therefore, there is the need for this study with a view to help the problems of environmental pollution to provide salient data which will assist in the coastal waters quality evaluation. This study reports the levels of heavy metals; cadmium (Cd), lead (Pb), zinc (Zn), copper (Cu), Manganese (Mn) and Iron (Fe) in water, shrimps and sediments collected from some coastal waters in Ondo State and the influence of the physicochemical parameters of water on these heavy metals.

Materials and Methods

Study area:

The study was carried out in Ayetoro (4°46'20. 388" E 6°6'54.77" N), Bijimi (4°51'51.231" E 6°1'28.304" N), Idiogba (4°48'31.374" E 6°4'49.729" N), and Asumogha (4°50'7. 862" E 6°3'12.49" N). They share boundaries with Okitipupa Local Government Area in the North; the Atlantic Ocean in the South; Ijebu Waterside Local Government Area (Ogun State) in the West and Delta State in the East and consists of over five hundred settlements spreading over 3,000km^2 and has over 180km long shoreline thereby making it the longest coastline in Nigeria. It is shown in Fig 1.

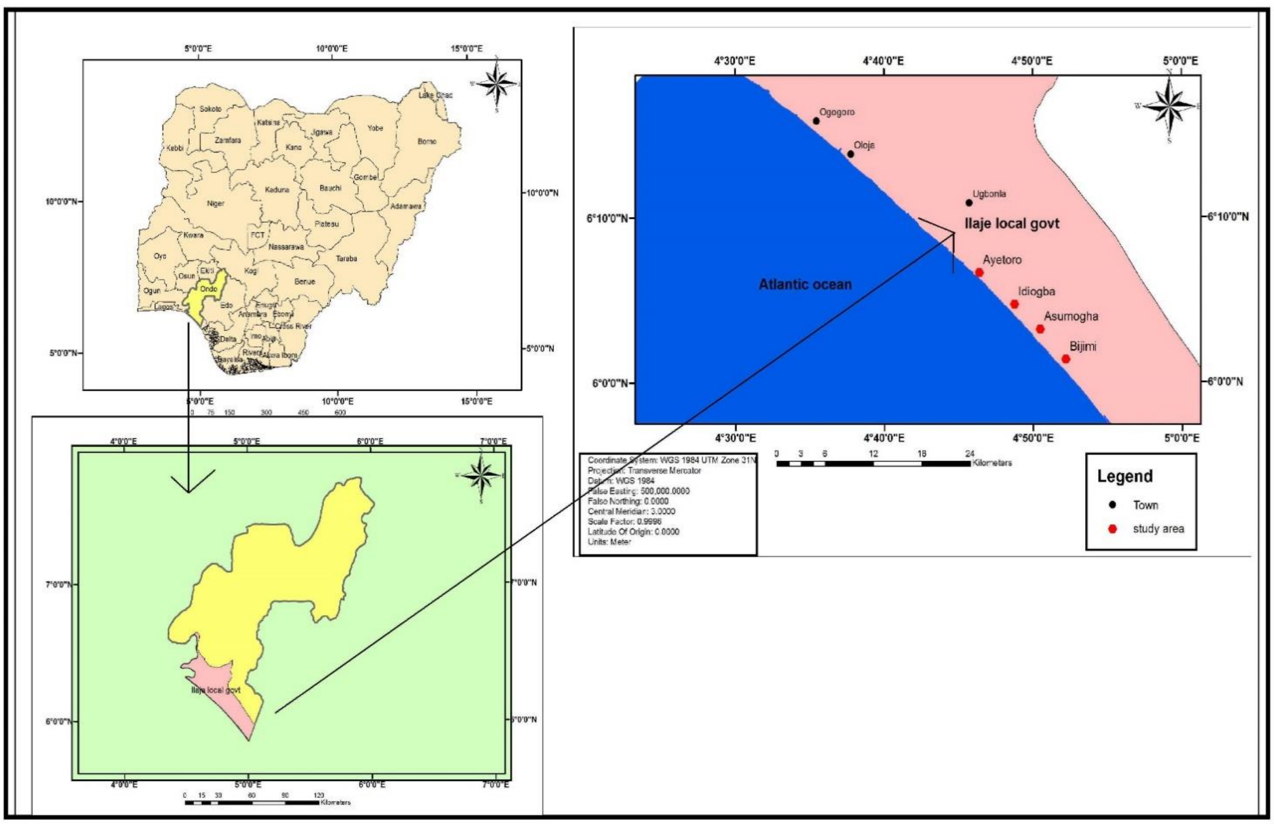

Fig 1: Map showing the study area. Red circle indicates the sampling sites

Samples Collection:
The study was carried out in Ayetoro, Bijimi, Idiogba, and Asumogha, within the coastal area of Ondo State from May to July 2014. Samples (water, shrimps and sediments) were collected between 10:00am to 11:00am. Water samples were collected in triplicate from each location at sub-surface level 25-30cm, using 250 ml sampling bottles. Shrimps were collected from the artisanal fishermen who employed Mallian traps for shrimp capture while the sediments samples were collected manually in polyethylene bag from three different points 50 m apart with depth of 0.2 m by using bottom grab. The samples were transported in ice chest to the laboratory for analysis. The shrimps were sorted into different groups and identified to species level using FAO Identification Guide (FAO, 1981).

Determination of physico-chemical parameters of water:
Temperature of the water was measured in degree Celsius (°C) in-situ using mercury in glass thermometer while turbidity, electrical conductivity, pH, dissolved oxygen, biological oxygen demand, salinity and chemical oxygen demand were measured in the laboratory using Hanna Multi parameter Meter model HI 9828.

Determination of Heavy Metals (Water, Shrimps and sediments):
Water sample of 25ml was measured into a digestion tube and 20ml of nitric acid was added. It was digested at 160 °C for 2 hrs until there was a clear or colorless solution according to APHA (1998). Shrimps samples were oven dried to a constant weight at 60 °C for 2 days and 0.2 g of pulverized weight was put in a 50 ml digestion tube, 2.5 ml of H_2SO_4/selenium mixture were added and heated at 200 °C until the solution fumed. In each test tube, 3 ml of H_2O_2 were added and heated to 330 °C until clear (for 2 hrs) (APHA, 1998). Sediments samples were air-dried and sieved with 2 mm mesh screen and about 1 gm of the finest dried grains were prepared and analyzed using a mixture of concentrated H_2O_2, HCl and HNO_3 in accordance with standard procedures (APHA, 1998). The heavy metals in the digest were determined using Techcomp AA 6000 Atomic Absorption Spectrophotometer.

Statistical analysis:
The data obtained were subjected to one-way analysis of variance (ANOVA) and correlation analysis to compare the variations in parameters among stations over the sampling period and to know the relationship amongst the parameters respectively using statistical package for social science (SPSS) 16.0.

Bio-concentration factor (BCF):
The BCF for each heavy metal was calculated according to Authman and Abbas (2007) using the following equation: BCF = $\frac{Cs}{Cw}$
where; Cs = Level of heavy metal level in shrimps and Cw = Level of heavy metal level in water

Bioaccumulation factor (BAF): The BAF was calculated according to Authman and Abbas (2007) using the following equation :

$$BAF== \frac{Ca}{Cs}$$

where; Ca = Concentration of metal in shrimps and Cs= Concentration of metal in sediment

Results

Physico-chemical parameters of water:
The physicochemical parameters of water vary slightly in the four stations as shown in Table 1. The temperature of water ranged from 28.89±1.58 °C to 29.45±1.35 °C with the mean values at 29.39±1.29; 29.45±1.35; 28.89±1.58; and 29.11±1.65 °C in Idiogba, Bijimi, Ayetoro, and Asumogha respectively. Turbidity was constant with 0.02±0.02 NTU in all the stations. Electrical conductivity ranged from 2.68±0.89 μhom's/cm to 4.52±4.16 μhom's/cm with mean values of 2.68±0.89; 4.52±4.16; 2.83±1.02; and 4.42±4.06 μhom's/cm in Idiogba, Bijimi, Ayetoro, and Asumogha respectively.

Table 1: Physicochemical parameters of water

Parameters	Idiogba	Bijimi	Ayetoro	Asumogha
Temperature ^oC	29.39±1.29^a	29.45±1.35^a	28.89±1.58^a	29.11±1.65^a
Turbidity (NTU)	0.02±0.01^a	0.02±0.02^a	0.02±0.02^a	0.02±0.02^a
Conductivity (µhom's/cm)	2.68±0.89^a	4.52±4.16^b	2.83±1.02^a	4.42±4.06^b
pH	5.13±0.29^a	5.44±0.61^a	5.27±0.47^a	5.47±0.61^a
DO (mg/l)	7.79±0.49^a	8.20±1.16^a	7.83±0.55^a	8.16±1.18^a
BOD (mg/l)	2.97±0.42^a	3.21±0.90^a	2.95±0.48^a	3.19±0.89^a
Salinity (ppt)	9.39±0.55^a	10.06±0.34^a	9.54±0.37^a	10.17±0.43^a
COD (mg/l)	13.62±0.35^a	13.46±0.46^a	13.57±0.08^a	13.59±0.20^a

Means for groups in homogeneous superscripts are not significantly different at P<0.05

The water was slightly acidic with pH range from 5.47±0.61 to 5.13±0.29. Dissolved oxygen (DO) ranged from 7.79±0.49mg/l to 8.20±1.16mg/l with mean values of 7.79±0.49; 8.20±1.16; 7.83±0.55; and 8.16±1.18 mg/l in Idiogba, Bijimi, Ayetoro, and Asumogha respectively. The value of Biological oxygen demand (BOD) and Chemical oxygen demand (COD) ranged from 2.97±0.42 mg/l to 3.21±0.90 mg/l and 13.46±0.46 mg/l to 13.62±0.35 mg/l respectively, while salinity ranged from 9.39±0.55 ppt to 10.17±0.43 ppt.

Heavy metal concentration in water:

The concentrations of heavy metal in the water samples are presented in Table 2.

Table 2: Concentration of heavy metal in water

Metals	Idiogba	Bijimi	Ayetoro	Asumogha	WHO (1997)	FEPA (1991)
Zinc	0.01±0.01^b	0.01±0.01^b	0.01±0.01^b	0.00±0.00^a	5.00	20.00
Lead	0.00±0.00^a	0.01±0.02^b	0.00±0.00^a	0.01±0.02^b	0.05	<1.00
Iron	0.07±0.03^a	0.43±0.42^b	0.06±0.06^a	0.31±0.33^b	0.30	0.30
Manganese	2.82±1.46^b	2.02±0.08^a	1.79±0.15^a	2.09±0.03^a	0. 01	0.05
Copper	0.00±0.00^a	0.00±0.00^a	0.00±0.00^a	0.00±0.00^a	1.00	<1.00
Cadmium	0.00±0.00^a	0.01±0.00^b	0.00±0.00^a	0.00±0.00^a	0.05	<1.00

Means for groups in homogeneous superscripts are not significantly different at P<0.05

The concentrations of Zn (0.01±0.01) mg/l in Idiogba, Bijimi, and Ayetoro, Pb (0.01±0.02) mg/l in Bijimi and Asumogha, Cd (0.01±0.00) mg/l, and Fe (0.07±0.03) mg/l, (0.06±0.06) mg/l in Bijimi, Idiogba and Ayetoro respectively were generally low when compared to the WHO, and FEPA recommended standard. On the other hand, Mn with mean values of (2.82±1.46) mg/l, (2.02±0.08) mg/l, (1.79±0.15) mg/l, (2.09±0.03) mg/l in Idiogba, Bijimi, Ayetoro, and Asumogha respectively, and Fe with mean values of (0.43±0.42) mg/l in Bijimi and (0.31±0.33) mg/l in Asumogha were generally high when compared with the WHO and FEPA recommended standard. Cu was not detected in any of the stations.

Heavy metal concentration in shrimps:

The heavy metal concentration in the tissue of *Nematopalaemon hastatus* and *Farfantepeneaus notialis* are presented in Fig 2. The concentration of lead ranged between 0.015±0.002 mg/l in Idiogba to 0.027±0.001mg/l in Ayetoro while copper ranged between 1.867±0.291 mg/l in Idiogba to 3.055±0.168 mg/l in Bijimi, and zinc between 5.345±0.367 mg/l in Bijimi to 7.511±0.192 mg/l in Ayetoro. Cadmium was constant at 0.01±0.000 mg/l in all the stations. These metals were generally low when compared to the WHO recommended standard. Manganese ranged between 2.556±0.369 mg/l in Asumogha to 4.655±0.291 mg/l in Ayetoro and iron ranged between 4.211±0.019 mg/l in Idiogba to 5.900±0.033 mg/l in Bijimi and were above the WHO permissible limit.

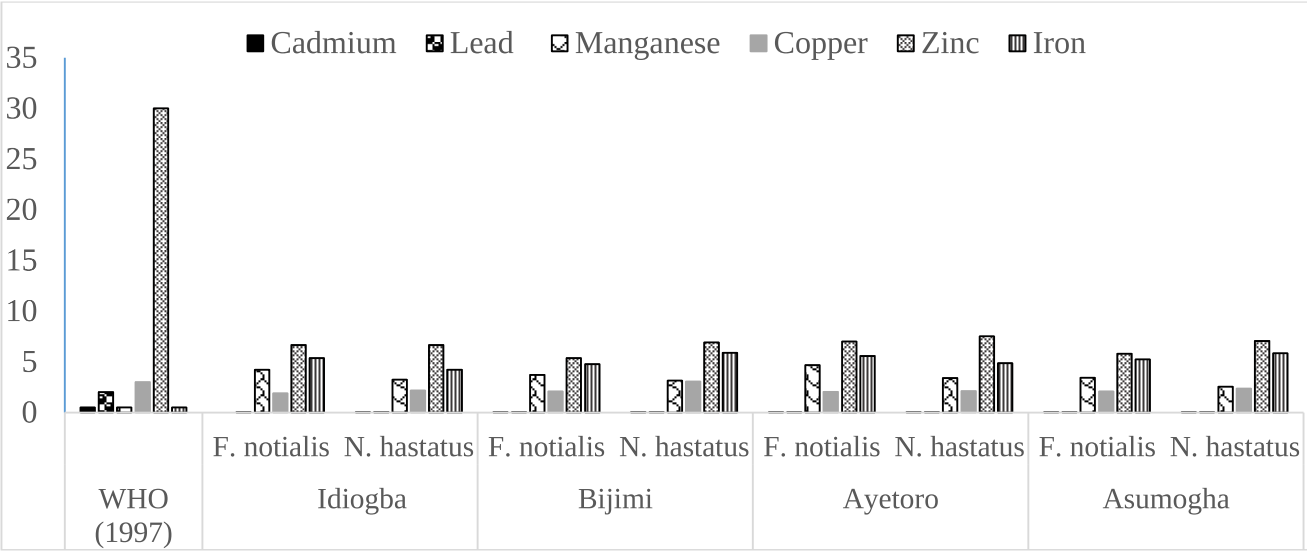

Fig 2: Concentration of heavy metal in *N. hastatus* and *F. notialis*

Heavy metal concentration in sediment:

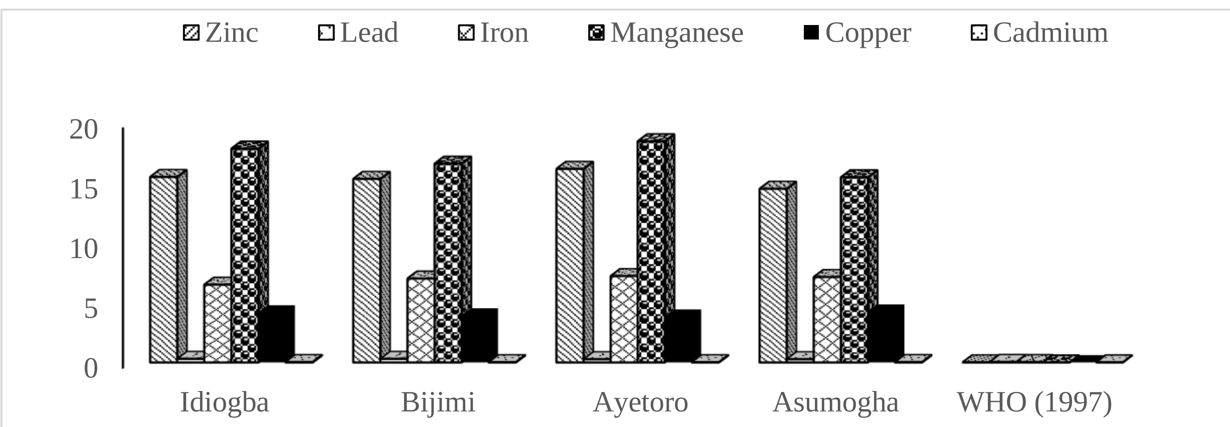

Fig 3: Concentration of heavy metal in sediment

The concentrations of heavy metal in sediment is presented in Fig 3. The mean levels of heavy metals in the sediments showed significant difference ($p<0.05$) among the stations, and the concentrations of the metals were generally high and fell above the acceptable limits described by WHO (1997). Zn ranged from 14.53±0.23 mg/l in Idiogba to 16.19±0.38 mg/l in Ayetoro, while the concentration of Pb ranged from 0.27±0.01 mg/l in Ayetoro to 0.30±0.03 mg/l in Bijimi. The mean values were (0.30±0.03; 0.30±0.01; 0.27±0.01; and 0.27±0.04 mg/l) in Idiogba, Bijimi, Ayetoro, and Asumogha respectively. Higher mean values of Fe were observed in Bijimi (7.03±0.49 mg/l), Ayetoro (7.24±0.54 mg/l), and Asumogha

(7.16±0.08 mg/l), while the lowest mean value (6.52±0.21 mg/l) was observed in Idiogba. For Mn concentration, the values ranged from 15.49±0.35 mg/l in Asumogha to 18.48±0.90 mg/l in Ayetoro. The concentration of Cu ranged from 3.86±0.15 mg/l in Ayetoro to 4.28±0.23 mg/l in Asumogha while Cd ranged from 0.02±0.02 mg/l in Idiogba to 0.03±0.03 mg/l in Ayetoro.

Bio-concentration factor (BCF):
The BCF of the detected metal from the stations is presented in Table 3. The BCF values were in the order: Ayetoro>Idiogba>Bijimi>Asumogha for the stations and the order Zinc > Iron > Lead > Manganese > Copper > Cadmium for the metals.

Table 3: BCF of shrimps-water across the stations in the coastal waters of Ondo state.

	Idiogba		Bijimi		Ayetoro		Asumogha	
	N.hastatus	*F.notialis*	*N.hastatus*	*F.notialis*	*N.hastatus*	*F.notialis*	*N.hastatus*	*F.notialis*
Zinc	664.40	666.70	692.20	534.50	751.10	701.10	0.01	0.01
Iron	60.16	76.67	13.72	11.03	80.73	92.78	18.85	16.92
Lead	0.01	0.01	2.00	2.30	0.01	0.01	1.60	2.00
Manganese	1.15	1.49	1.55	1.84	1.89	2.60	1.22	1.64
Copper	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cadmium	0.01	0.01	0.10	0.10	0.01	0.01	0.01	0.01

Bioaccumulation Factor (BAF):
The heavy metal mobility in shrimps from the sediments was characterized by the BAF for all the stations and shown in Table 4.

Table 4: BAF of shrimps-sediment across the stations in the coastal waters of Ondo state.

	Idiogba		Bijimi		Ayetoro		Asumogha	
	N.hastatus	*F.notialis*	*N.hastatus*	*F.notialis*	*N.hastatus*	*F.notialis*	*N.hastatus*	*F.notialis*
Zinc	0.428	0.430	0.450	0.348	0.464	0.433	0.487	0.400
Lead	0.073	0.050	0.067	0.077	0.100	0.067	0.059	0.074
Iron	0.649	0.823	0.839	0.675	0.669	0.769	0.816	0.733
Manganese	0.181	0.236	0.187	0.223	0.183	0.252	0.165	0.220
Copper	0.515	0.443	0.771	0.525	0.541	0.53	0.548	0.486
Cadmium	0.033	0.033	0.050	0.050	0.050	0.050	0.033	0.100

The results show that the BAF follows the order: Ayetoro>Bijimi> Idiogba>Asumogha in the stations. The BAF values showed slight variations and ranges between Zn (0.348-0.487) in Bijimi and Asumogha, Pb (0.05-0.1) in Idiogba and Ayetoro, Fe (0.646-1.0) in Idiogba and Asumogha, Mn (0.165-0.252) in Asumogha and Ayetoro, Cu (0.443-0.771) in Idiogba and Bijimi and Cd (0.033-0.1).

Correlation analysis of water physicochemical parameters and heavy metals in water:
The Pearson correlation analysis between water physico-chemical parameters and heavy metals in the water is shown in Table 5. The correlation value showed that Fe was positively correlated to turbidity, conductivity, dissolved oxygen, BOD and salinity. In addition, and Pb was positively correlated to salinity and dissolved oxygen, Cd to DO, and Zn to COD.

Correlation analysis of heavy metals in sediments:
The Pearson correlation analysis between heavy metals in water and sediments is shown in Table 6.

The result shows a correlation coefficient between Zn*s*-Zn*w* with the value r=0.747. In contrast, Zn*s*-Pb*w* with the value r= -0.604, and Mn*s*-Pb*w* with the value r= -0.859 were negatively correlated.

Table 5: Correlation coefficients between heavy metals and physicochemical parameters in water collected in Ondo State Coastal water

	Zn*w*	Pb*w*	Fe*w*	Mn*w*	Cd*w*	Tempe °C	Turb (NTU)	Cond (µs/cm)	pH	DO (mg/l)	BOD (mg/l)	Salinity (ppt)	COD (mg/l)
Zn*w*													
Pb*w*	-0.346												
Fe*w*	0.273	0.580*											
Mn*w*	0.127	-0.319	-0.128										
Cd*w*	0.200	0.577*	0.466	-0.236									
Tempe °C	-0.062	0.183	0.432	0.240	0.108								
Turbidity (NTU)	0.566	0	0.621*	0.104	0	0.664*							
Conductivity (µs/cm)	-0.038	0.440	0.669*	-0.160	0.269	0.715**	0.626*						
pH	-0.209	0.541	0.379	-0.237	0.275	0.679*	0.407	0.417					
DO (mg/l)	-0.307	0.994**	0.587*	-0.392	0.636*	0.166	0	0.441	0.550				
BOD (mg/l)	0.451	0.203	0.846**	0.030	0.127	0.638*	0.929**	.738**	0.376	0.202			
Salinity (ppt)	-0.136	0.834**	0.733**	-0.296	0.400	0.421	0.372	0.452	0.799**	0.831**	0.516		
COD (mg/l)	0.682*	-0.135	0.546	0.188	-0.223	0.262	0.859**	0.334	0.023	-0.153	0.818**	0.203	

Significant levels are indicated by * at $p < 0.05$, ** at p<0.01.

Table 6: Correlation coefficients between heavy metal of water and sediments collected in Ondo State Coastal waters

	Zn*s*	Pb*s*	Fe*s*	Mn*s*	Cu*s*	Cd*s*	Zn*w*	Pb*w*	Fe*w*	Mn*w*	Cu*w*	Cd*w*
Zn*s*												
Pb*s*	0.429											
Fe*s*	0.234	-0.088										
Mn*s*	0.702*	0.071	0.058									
Cu*s*	0.033	0.216	0.432	-0.126								
Cd*s*	-0.106	-0.084	-0.079	-0.287	0.731**							
Zn*w*	0.747**	0.556	0.243	0.479	0.343	0.076						
Pb*w*	-0.604*	0.000	0.257	-0.859**	0.125	0.000	-0.346					
Fe*w*	-0.280	-0.073	0.528	-0.320	0.524	0.197	0.273	0.580*				
Mn*w*	-0.087	0.411	-0.520	0.150	0.419	0.442	0.127	-0.319	-0.128			
Cu*w*	.^{c}	.^{c}	.^{c}	.^{c}	.^{c}	.^{c}	.^{c}	.^{c}	.^{c}	.^{c}		
Cd*w*	-0.034	0.333	0.059	-0.232	-0.199	-0.378	0.200	0.577*	0.466	-0.236	.^{c}	

Significant levels are indicated by * at $p < 0.05$, ** at $p<0.01$

Discussion

The physico-chemical parameters of water obtained in this study were within the tolerable range in all the stations. The temperature value (28.89 C – 29.45 C) of the coastal waters of Ondo State falls within the optimal water temperatures of 28 C – 30 C, within which maximal growth rate is strengthened, conversion of food is efficient, and the capacity and ability to resist diseases and toxins are enhanced (Ajibare, 2014). There were variations in water temperatures across the stations, however, these variations were not significantly different as earlier reported for the coastal waters in Ondo State by Ajibare (2014), Bolarinwa *et al.,* (2016) and Olawusi-peters and Akinola (2017). Turbidity which is an index of water clarity and the extent in which the material suspended in water decreases the passage of light through water was low and constant in all the stations. Although, this could be affected by salinity as salt settles sediments, the presence of salts in estuaries has the effect of reducing turbidity (Ajibare, 2014). The result obtained was similar to the report of Anitha and Surgitha (2013).

The electrical conductivity shows variation with respect to the different stations as it ranged between 2.68 µhom's/cm and 4.52 µhom's/cm. this shows that the sample stations contains appreciable amount of dissolved ions thus forming a saline barrier for the survival of sensitive organisms. This report agreed with Sikoki and Veen (2004) and Olawusi-Peters and Akinola (2017) who both obtained a conductivity range of 2.68 -10 µhom's/cm and described it as totally poor in chemicals. The authors opined that the ability of fish to maintain osmotic pressure differs, as a result optimum conductivity for fish production and survival will differ amongst species. The salinity recorded indicates a brackish environment and agrees with Karleskint *et al.,* (2009) that the range of salinity in brackish water is from 0.5 to 30 ppt. The changes in salinity are due to the influx of freshwater from land run off caused by tidal variations, human mediated activities in the area and proximity to the marine water. The water samples were acidic and the pH values falls below the WHO permissible limit (pH 6.5-8.5). Though low pH values or acidic waters allows toxic elements and compounds such as heavy metals to become mobile thus producing conditions that are inimical to aquatic life (APHA, 1995). The result agrees with Umavathi *et al.,* (2007) who observed a pH range of 5 to 8.5 and stated it to be conducive for plankton growth. Dissolved oxygen is an important aquatic parameter, whose presence is vital to aquatic fauna. It plays crucial role in the growth, distribution and behavior of aquatic organism. The dissolved oxygen obtained was above the recommended limit (4-6 mg/l) for better aquatic life. This could be attributed to the intensed human-mediated activities resulting into continual aeration of the water thereby leading to dispersal, destruction and death of aquatic fauna. Although, the result was similar to the report of Olawusi-Peters and Ayo-Olalusi (2009), Abdus-Salam *et al.,* (2010) and Bolarinwa *et al.,* (2016).

The results of heavy metals in water and organisms showed no significant differences among the stations. The level of concentrations in the coastal waters, organisms and sediments of Ondo State amongst the four stations follows the order Mn>Fe>Zn>Pb>Cd>Cu while the sequence of the concentration of heavy metal in the stations was Ayetoro>Idiogba> Bijimi>Asumogha.

The present investigation shows that the concentrations of certain metals such as Cadmium, Copper, Zinc and Lead were generally low in water and organisms when compared to recommended values for coastal waters (WHO, 1997) and FEPA (1991). The highest metal concentrations recorded in sediments may be due to the fact that when metal pollutants are released into aquatic environment, they do not remain in aqueous phase but, are adsorbed on to the sediments. Thus, the sediment acts as a sink for pollutants, hence the reason for its higher concentrations of these metals. Koffi *et al.,* (2014) noted that aquatic sediments absorb persistent and toxic chemicals to levels of many times higher than the water column concentration. Thus, varied metals in sediments influence the concentration of some heavy metals in the water. The concentration of Manganese and Iron in the environment could be as a result of the interrelationship between the two minerals as they are bio-chemically active transition metals. Wang *et al.,* 2011 revealed that enhanced concentrations and pollution of the coastal sediments by manganese is common due to its ubiquitous natural occurrence, ease of mobilization and extensive association with industry. This also contributes widely to its high concentration and pollution of the overlying water bodies and bioaccumulation in organisms as they are sessile and benthic feeders. Anthropogenic activities from municipal wastes, agrochemical production and distribution located within the coast exert the metals toxicity to the fish and aquatic life (Olawusi-Peters and Akinola, 2017). This is alarming for authorities and hazardous to the human health who feed on the organisms, since Fe and Mn in the human body tends to cause deadly diseases. Constant and consistent exposure to these metals will thereby decrease the fitness of the organism in the ecosystem. The result observed in this study is similar to the reports of Asaolu and Olaofe (2004), Aderinola *et al.,* (2009), and Adedeji and Okocha (2011).

Furthermore, the low concentrations of heavy metals such as zinc and copper can cause stress in fish which can lead to smaller body weight thereby reducing their ability to compete for food and habitat. This phenomenon suggests that metal levels in the surrounding biota are very low and are not interfering with the normal metabolic processes of the shellfishes. The correlation analysis applied to assess the relationship between physico-chemical parameters and heavy metal concentrations in water shows that concentrations of Iron, and Lead are significant and positive correlated with dissolved oxygen and salinity, as Cadmium was positively correlated to DO. This shows that the variables of mineralization influence the concentrations of some heavy metals in water. The correlation between heavy metal concentration in the water and the sediments also showed a strong relationship of metal contents.

The sequence of the BCF water-organisms of all metals was Zn>Fe>Pb>Mn>Cd>Cu, and Ayetoro>Idiogba>Bijimi>Asumogha for the stations. The values are very high showing greater mobility of metals in water towards the shrimps. This indicates that the organisms had great potential to accumulate the chemicals. The BAF was generally high, indicating that the bioaccumulation of heavy metals occurred in organisms. Bioaccumulation is often related to the fact that metals of different kind tends to accumulate differently in fish tissue, considering the feeding, swimming, and metabolic activity of the species. The occurrence of high BCF and BAF values in Ayetoro are an indication of the huge anthropogenic, industrial, and agricultural activities going on in and around the area and the dense human population around the place.

Conclusion

The physicochemical characteristics of the coastal water samples revealed a brackish environment with low chemical pollutants burden. The present study reveals the concentration of metals (Iron, Zinc, Manganese, Copper, Cadmium and Lead) in sediment which were generally high when compared with recommended values, indicating pollution. It also shows that the accumulation of heavy metals is predominant in sediments rather than of water and organisms, which can be linked to the fact that sediments act as an important host for all toxic metals, contaminants and dead organic matter descending from the ecosystem above. This therefore shows the impact of anthropogenic and industrial activities to the concentration of heavy metal. Thus, great attention should be given along the coastal region in order to control the anthropogenic inputs. Also, proper monitoring and continuous environmental assessment is highly essential along the coastal zone as indiscriminate effluents from various sources must be stopped or treated appropriately before being discharged into the coast.

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