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Heavy Metal Contamination of Vegetation by Sawmill Activities along Udu River

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ABSTRACT

Water bodies are acknowledged dumping ground for both industrial, manufacturing and domestic activities along coastlines. The Owhase creek, a typical example of a stream receiving wood wastes from sawmill industries is a source of water and livelihood to indigenous community and also as a routes to neighbouring communities. Hence, this study is carried out to review the "Heavy Metal Contamination of Vegetation by Sawmill Activities along Udu River". While fish sampling was carried out twice, one during the wet season (July) and another one during the dry season (December), both samples were tested for heavy metal contamination using the APHA 3111A test method exploring the single acid wet oxidation method to extract the heavy metals. Results from this study revealed that sawmill activities has significant environmental impact on the Owhase creeks and its environment. The values for heavy metals investigated in this study such as Iron (Fe) and Cadmium (Cd) values ranging from 1.921 to 12.412 mg/l and 0.044 to 0.147 mg/l respectively and they are above the national regulatory limits of <1 mg/l and 0.005 mg/l respectively (NSDWQ, 2015). Also, Iron (Fe) values across kolokolo (Synodontis rukwaensis) and bounds (Cirrhinus reba) internal organs were higher than the permissible limits. Zinc (Zn) values was higher than the permissible limits in the intestine of the Kolokolo (Synodontis rukwaensis) and the gills and intestines of the bounds (Cirrhinus reba). Cadmium (Cd) values were higher than the permissible limits in the gills, intestines, and bones of the bounds (Cirrhinus reba) fish species only. It was recommended that sawdust from sawmill should not be dumped into the waterways to avoid further pollution of the waters. The level of heavy metal contamination in the water body should be monitored regularly. Such data should be used for the assessment of health risk in the habitat.

1 INTRODUCTION

Pollution of water ways by organic discharges in Nigeria is perhaps a serious threat posed to the Nigerian inland waters. Sources of pollution of the inland waters of Nigeria are well known. The most notable point source arises from the dumping of untreated or partially treated sewage into the River [Ogbogu and Akinya, (2002); Adakole and Anunne, (2003)], brewery effluents into the river [Ogbeibu and Edutie, (2002)] discharge of bio-degradable wood wastes from sawmill located along the lagoon. Agbaire, *el. al.,* (2016) reported a reduction

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in fish diversity associated with discharge of municipal wastes and industrial pollutants into the aquatic environment. Sawdust is visibly, small particles of wood produced through a tool or device for cutting, typically a thin blade of metal with a series of sharp teeth. Sawdust refers to the tiny-sized and powdery wood waste produced by the sawing of wood. The size of sawdust particles depends on the kinds of wood from which the sawdust is obtained and also on the size of the saw teeth. About 10-13% of the total volume of the wood log is reduced to sawdust in milling operations; this sawdust generally depends largely on the average width of the saw kern and the thickness of the timber sawed [Paulrud, *et. al., (2002)*]. The Owhase creek of Owhase community in Udu local government of Delta State, Nigeria is a typical example of a stream receiving wood wastes from sawmill industries. These wastes often contain significant spectrum of organic substances capable of producing adverse effects on the physical, chemical and biotic or indirectly affect human health [FAO, (1991)]. These wastes often contain significant spectrum of organic substances capable of producing adverse effects on the environment and indirectly affect human health. Proper disposal of sawmill waste has long been an intractable problem [El Haggar, (2010); Brunner and Rechberger (2015)]. A significant amount of the sawn log remains in the yards as waste in various forms such as off-cuts, slabs, ends, and sawdust. Wastes are often mounted in heaps along the river bank when saw mills are located close by the river. Often the wastes spill over from the heaps into the water to contaminate it and hamper aquatic life. Surface waters including rivers, lakes, and seas aside functioning as a source of freshwater for domestic and industrial uses serve multiple functions most of them being critical to human settlement and survival [Ayobahan, *et. al.,* (2014*)*]. They also provide water for irrigation. Although surface waters serve various purposes, they still receive large quantities of industrial, agricultural, and domestic waste, including municipal sewage. Surface water pollution may pose a serious threat to public health and aquatic ecosystem (Longe, *et. al.,* 2010). Decomposition of wood residue is a slow process that can result when water percolates, or flows through wood residue or when wood waste is stored in pits or landfills where it may come in contact with groundwater in decades of leachate formation. Typically, leachates from pure wood residue are dark coloured, petroleum like odour, and foams in water. Substances naturally occurring in wood include; resin acids, lignins, terpenes, fatty acids and tannins. Wood residue leachate produced creates another source of leachate [FAO, (1991)]. The objective of this study is to examine and assess the impacts of sawmill wood wastes on the water quality of Owhase creek

2 MATERIALS AND METHODS

2.1 *Description of Sampling Area*

Udu is a town in the Udu Clan, under Udu Local Government Area of Delta State, Nigeria. Its population is over 32,000. Udu shares boundaries with Aladja, Ekete, Owhase, Egini, Orhuwhorun and Ujevwu communities. Ovwian is the biggest town in the Udu Local Government area. The Udu River is a major navigable channel of the Niger Delta, southern Nigeria. It takes its origin from around Utagba Uno and flows southwest through zones of freshwater swamps, mangrove swamps, and coastal sand ridges. Table 1 shows the Geographical Coordinates of the Sampling Points. It is a relatively large water body which stretches within latitudes 5°21’-6°00’ N and longitude 5°24’-6°21’E, covering a surface area of about 255 square km with a length of about 150 km. It drains various tributaries and empties into the brackish Forcados that in turn empties into the Atlantic Ocean. It possesses a dendritic drainage pattern.

2.2 *Collection of Water and Fish Samples*

The water samples were collected twice for both dry and wet seasons, covering a total period of four (4) months. The wet season sampling was carried out in May and July, while the dry season sampling was carried out in October and December. These samples were collected at the point of discharge of the sawmill wastes into the river (known as Point Source – PS), and also at 100m before the point of discharge (known as Upstream Sample – US), and 100m after the point of discharge (known as Downstream Sample – DS). The control samples were collected at about 1km away from the study area. All the samples collected were geo-referenced using Global Positioning System (GPS). The samples for physic-chemical parameters were collected into 2 litres pre-sterilized bottles. The sampler wore rubber gloves sprayed with ethanol. The sampler held the bottom of the sample container with the open end of the sample bottle directly facing the river and submerged at the water surface. Heavy metals samples were collected into 100ml pre-sterilized bottles, and acidified with 2 drops of diluted sulphuric acid, the fish sampling was carried out twice, one during the wet season (July) and another one during the dry season (December). Samples were collected through a canoe which was paddled across sample sites using frame net mesh size of 3 mm with total area of 4.6 m^2. This frame net was pulled by two persons from each side of the net end from downstream to upstream to collect fish from the pool of the river. Two (2) different species of fish were collected. To collect fish from riffle, a frame net was fixed at the downstream of the selected riffle of each site held by two persons and the third person disturb the fish from upstream of that riffle chasing the fish towards the fixed frame net while gill net, baited hooks and lines were used along the shore. Upon landing, all the fish were immediately preserved in 10% formalin solution in labelled plastic containers. In the laboratory, fish were identified

Using keys descriptions.

2.3 *Heavy Metals Analysis*

The heavy metals in the samples were analysed using APHA 3111A test method. Single acid wet oxidation method was used to extract the heavy metals from samples through digestion. 50ml of a well – mixed water sample was measured into a 150-ml beaker. 5.0ml of conc. HNO_3 was added. The solution was evaporated to near dryness on a hot plate, and allowed to cool. Another 5.0ml of conc. HNO_3 was added to the beaker, and covered immediately with a watch glass. The heating continued with the addition of HNO_3 as necessary until light-colour residue was obtained (digestion is completed). 1-2ml of conc. Table 2 shows Heavy Metal Concentrations of Surface water during Wet Season (July). HNO_3 was added to the residue, and washed with distilled water. It was then filtered into 100-ml volumetric flask to remove silicate and other insoluble materials. Then it was made up to the mark with distilled water. The solution was thereafter stored in 125-ml polypropylene bottle for Atomic Absorption Spectrophotometer (AAS) analyses, which was used to detect various heavy metals in the samples, with the use of different heavy metals cathode lamps. Table 3 shows Heavy Metal Concentrations of Surface water during Wet Season (December). Also, Table 4 shows Heavy Metal Concentrations of Surface water during Dry Season (D1). Table 5 shows Heavy Metal Concentrations of Surface water during Dry Season (D2). Table 6 indicates Average Wet Season Results of Surface Water in comparison with Regulatory Standards. Table 7 indicates. Average Dry Season Results of Surface Water in comparison with Regulatory Standards. Table 8 shows Heavy metals Concentration in Fish, Wet season. Table 9 indicates Heavy metals Concentration in Fish, Dry season, and Table 10: Mean Result of heavy metals Concentrations in fishes (Wet and Dry seasons) in Comparison with Regulatory Standards.

Exchangeable cations like Sodium, Potassium, Calcium and Magnesium were also analysed using Flame photometer.

Table 1: Geographical Coordinates of the Sampling Points

Sample Type	No of Sample	GPS Coordinates	
		Northing	**Easting**
Point Source	4	5º30'65.106	5º47'21.372
Upstream	4	5º30'16.462	5º47'31.634
Downstream	4	5º31'5.621	5º46'54.158
Control	4	5º30'4.246	5º47'9.884
1st fish specie	2	5º31'13.228	5º47'2.948
2nd fish specie	2	5º30'53.480	5º47'4.260
TOTAL	**20**		

3 RESULTS AND DISCUSSION

3.1 *Results*

Table 2: Heavy Metal Concentrations of Surface water during Wet Season (July)

Wet season – May					
Parameters	**Unit**	**PS**	**DS**	**US**	**Control**
Fe	mg/l	9.741	6.483	1.252	3.216
Zn	mg/l	1.737	0.689	<0.001	0.126
Pb	mg/l	<0.001	<0.001	<0.001	<0.001
Cd	mg/l	0.081	0.068	0.031	<0.001
Cu	mg/l	<0.001	<0.001	<0.001	<0.001
Cr	mg/l	<0.001	0.004	<0.001	<0.001
Ni	mg/l	<0.001	<0.001	<0.001	<0.001

Table 3: Heavy Metal Concentrations of Surface water during Wet Season (December)

Wet season – July					
Parameters	**Unit**	**PS**	**DS**	**US**	**Control**
Fe	mg/l	10.629	7.267	1.401	3.891
Zn	mg/l	1.843	0.732	<0.001	0.169
Pb	mg/l	<0.001	<0.001	<0.001	<0.001
Cd	mg/l	0.089	0.074	0.036	<0.001
Cu	mg/l	<0.001	<0.001	<0.001	<0.001
Cr	mg/l	0.009	0.015	<0.001	<0.001
Ni	mg/l	0.037	<0.001	<0.001	<0.001

Table 4: Heavy Metal Concentrations of Surface water during Dry Season (D1)

Dry season – October					
Parameters	**Unit**	**PS**	**DS**	**US**	**Control**
Fe	mg/l	17.203	11.724	3.045	6.861
Zn	mg/l	3.861	2.137	0.082	0.291
Pb	mg/l	<0.001	0.016	<0.001	<0.001
Cd	mg/l	0.302	0.146	0.067	0.024
Cu	mg/l	0.009	0.003	<0.001	<0.001

Cr	mg/l	0.044	0.032	<0.001	<0.001
Ni	mg/l	0.061	0.024	<0.001	<0.001

Table 5: Heavy Metal Concentrations of Surface water during Dry Season (D2)

Dry season – December					
Parameters	**Unit**	**PS**	**DS**	**US**	**Control**
Fe	mg/l	12.074	8.292	1.986	5.167
Zn	mg/l	2.147	0.967	<0.001	0.235
Pb	mg/l	<0.001	<0.001	<0.001	<0.001
Cd	mg/l	0.116	0.091	0.042	<0.001
Cu	mg/l	<0.001	<0.001	<0.001	<0.001
Cr	mg/l	0.013	0.021	<0.001	<0.001
Ni	mg/l	0.047	<0.001	<0.001	0.008

Table 6: Average Wet Season Results of Surface Water in comparison with Regulatory Standards

Average Wet Season (Heavy Metals Concentrations)							
Parameters	**Unit**	**PS**	**DS**	**US**	**Control**	**FMEnv**	**DPR**
Fe	mg/l	10.185	6.875	1.327	3.554	<1	<1
Zn	mg/l	1.790	0.711	<0.001	0.148	3	<15
Pb	mg/l	<0.001	<0.001	<0.001	<0.001	<0.05	<0.05
Cd	mg/l	0.085	0.071	0.034	<0.001	NA	0.005
Cu	mg/l	<0.001	<0.001	<0.001	<0.001	1	<1.5
Cr	mg/l	<0.001	0.010	<0.001	<0.001	0.05	NA
Ni	mg/l	<0.001	<0.001	<0.001	<0.001	<0.05	NA

Table 7: Average Dry Season Results of Surface Water in comparison with Regulatory Standards

Average Dry Season (Heavy metals Concentrations)							
Parameters	**Unit**	**PS**	**DS**	**US**	**Control**	**FMEnv**	**DPR**
Fe	mg/l	14.639	10.008	2.516	6.014	<1	<1
Zn	mg/l	3.004	1.552	0.082	0.263	3	<15
Pb	mg/l	<0.001	0.016	<0.001	<0.001	<0.05	<0.05
Cd	mg/l	0.209	0.119	0.055	0.024	NA	0.005
Cu	mg/l	0.009	0.003	<0.001	<0.001	1	<1.5
Cr	mg/l	0.029	0.027	<0.001	<0.001	0.05	NA
Ni	mg/l	0.054	0.024	<0.001	0.008	<0.05	NA

Table 8: Heavy metals Concentration in Fish, Wet season

	Kolokolo (*Synodontis rukwaensis*)				**Bounds (*Cirrhinus reba*)**			
Parameters	**Gills**	**Intestine**	**Bone**	**Flesh**	**Gills**	**Intestine**	**Bone**	**Flesh**
Fe (mg/kg)	52.347	143.193	12.762	2.238	263.561	537.803	38.657	11.638
Cd (mg/kg)	<0.001	<0.001	<0.001	<0.001	2.075	4.769	<0.001	<0.001
Cu (mg/kg)	0.529	0.937	<0.001	<0.001	0.084	0.168	<0.001	<0.001
Zn (mg/kg)	27.735	46.126	6.482	2.715	72.486	137.114	13.097	6.241
Cr (mg/kg)	<0.001	<0.001	<0.001	<0.001	0.046	0.347	<0.001	<0.001
Pb (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Ni (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hg (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 9: Heavy metals Concentration in Fish, Dry season

Parameters	Kolokolo (*Synodontis rukwaensis*)				Bounds (*Cirrhinus reba*)			
	Gills	Intestine	Bone	Flesh	Gills	Intestine	Bone	Flesh
Fe (mg/kg)	182.553	367.194	42.427	9.146	311.593	831.246	71.631	26.710
Cd (mg/kg)	<0.001	<0.001	<0.001	<0.001	2.368	7.811	0.136	<0.001
Cu (mg/kg)	1.481	2.073	0.036	<0.001	0.281	0.646	<0.001	<0.001
Zn (mg/kg)	61.944	83.357	9.712	6.636	104.546	437.175	34.428	11.057
Cr (mg/kg)	0.026	0.081	<0.001	<0.001	0.097	0.214	0.011	<0.001
Pb (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ni (mg/kg)	<0.001	<0.001	<0.001	<0.001	0.007	0.023	<0.001	<0.001
Hg (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 10: Mean Result of heavy metals Concentrations in fishes (Wet and Dry seasons) in Comparison with Regulatory Standards

Parameters	Kolokolo (*Synodontis rukwaensis*)				Bounds (*Cirrhinus reba*)				WHO/FAO
	Gills	Intestine	Bone	Flesh	Gills	Intestine	Bone	Flesh	
Fe (mg/kg)	117.45	255.194	27.5945	5.692	287.577	684.525	55.144	19.174	<0.30
Cd (mg/kg)	<0.001	<0.001	<0.001	<0.001	2.2215	6.29	0.136	<0.001	<0.005
Cu (mg/kg)	1.005	1.505	0.036	<0.001	0.1825	0.407	<0.001	<0.001	<2.25
Zn (mg/kg)	44.8395	64.7415	8.097	4.6755	88.516	287.145	23.7625	8.649	<50
Cr (mg/kg)	0.026	0.081	<0.001	<0.001	0.0715	0.2805	0.011	<0.001	<0.16
Pb (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.2
Ni (mg/kg)	<0.001	<0.001	<0.001	<0.001	0.007	0.023	<0.001	<0.001	<0.6
Hg (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.5

3.2 Discussion

Heavy metals are elements having atomic weights between 63.546 and 200.590 [Okoh, *et. al.*, (2016)], and a specific gravity greater than 4.0 [Irerhievwie and Akpoghelie, (2015)]. They exist in water in colloidal, particulate and dissolved phases with their occurrence in water bodies being either of natural or anthropogenic origin. A heavy metal is a member of a loosely-defined subset of elements that exhibit metallic properties [Duffus, (2002)]. Some heavy metals are dangerous to health and environment (e.g. mercury, cadmium, lead, Chromium). Some may cause corrosion (e.g. zinc, lead). Some of these elements are actually necessary for humans in minute amount (cobalt, copper, chromium, manganese and nickel) while others are carcinogenic or toxic, affecting, among others, the central nervous system (manganese, mercury, lead, arsenic), the kidneys or liver (mercury, lead, cadmium, copper) or skin, bones, or teeth (nickel, cadmium, copper, chromium) [Fowler, (2009)]. Unlike organic pollutants, heavy metals do not decay and thus pose a different kind of challenge for remediation (Baby *et al.,* 2010). Heavy metals are trace elements, and as such are required by animals and plants in small quantities. They are also being referred to as micronutrients. Their main role in the cell is at the active centre of enzymes or as co-factors in enzyme reactions. In short supply, they can limit the growth of micro-organisms such as algae, the primary producers. However, toxicity to plants and animals can result from high concentration of trace elements (Onosemuode and Makun, (2022). For this study, table 1 explains the geographical coordinate of the sample points. While table 2 -3 reveals the heavy metal concentration of surface water for the sampling season, table 4 and 5 reveals the heavy metal concentration of the fish samples for the sampling season. Results from table 2 and 3 revealed that the concentration of heavy metals in the water samples were higher in July when compared to those collected in May. The reverse trend occurred for water samples analysed for heavy metal in table 4 and 5. Heavy metal concentration were higher in table 4 when compared to concentrations obtained in table 5 (Irerhievwie and Akpoghelie, 2015; Okoh, et al., 2016). Data from this study further revealed that the heavy metals' concentrations had Iron mean values of 10.185mg/l, 6.875mg/l and 1.327mg/l (table 6) and 14.639mg/l, 10.008mg/l and 2.516mg/l (table 7). Data's for table 8 for PS, DS and US, reveals that the water samples have SD value of 3.15, 2.22 and 0.84. Zinc had mean values of 1.790mg/l, 0.711mg/l and <0.001 for wet season, while dry season had 3.004mg/l, 1.552mg/l and <0.001 for PS, DS and US, with the SD value of 0.86, 0.60 and 0.01. Cadmium recoded mean values of 0.085mg/l, 0.071mg/l and 0.034 (wet season), and 0.209mg/l, 0.119mg/l and 0.055mg/l (dry season) for PS, DS and US, with the SD value of 0.09, 0.03 and 0.01. Chromium had mean values of 0.009mg/l, 0.010mg/l and <0.001 (wet season), and 0.059mg/l, 0.027mg/l and <0.001 (dry season). The mean values for Nickel were observed to be 0.037mg/l, <0.001 and <0.001 (wet season), and 0.057mg/l, 0.024mg/l and <0.001 (dry season) for PS, DS and US. The control (wet and dry seasons) had mean values of 3.554mg/l and 6.014mg/l (Fe) with the SD value of 1.74, while 0.148mg/l and 0.263mg/l (Zn) with the SD value of 0.08. Meanwhile, Pb and Cu values were below the instrument's detection limits of <0.001 for PS, DS and US (wet and dry season), while the control had <0.001 for Pb, Cd, Cu, Cr and Ni both wet and dry seasons. According to the Agency for Toxic Substances and Disease Registry (2004), intentionally high uptakes of copper may cause liver and kidney damage even death. The graphical representation of heavy metal concentrations is shown in Figure 1 below.

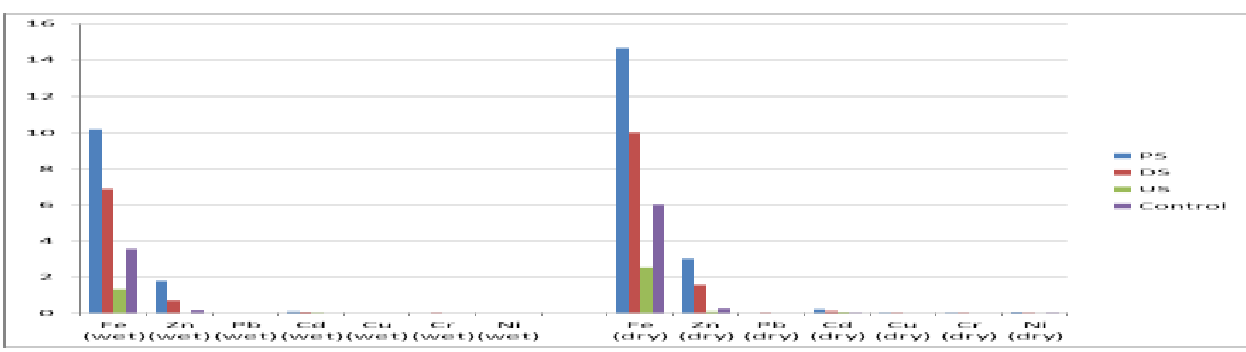

Figure 1: *Heavy metals' Concentrations of Surface water in the study area in comparison with control*

Results obtained from this study reveals the mean concentration of heavy metal concentration in the water samples for both raining and dry season as shown in table 6 and 7 were higher for Fe and Cd for both tolerance limit for the Department of Petroleum Resources and the Federal Ministry of Environment but were only higher for Pb. Data\s obtained from table 9 in the raining season for heavy metal concentration in fish samples revealed that bioaccumulation of Fe were higher in Fe, Cd, Zn and Cr and the reverse is in the case for Cu. This study further revealed that there is no significant bioaccumulation of heavy metals in Pb, Ni and Hg. Similar trend were observed from table 10 for the dry season except for the gills and intestines of ***Cirrhinus** reba* species re a significant concentration of Ni were noticed. The mean concentration of heavy metal in the two fish species in table 10 revealed tha Fe and Cd were significantly higher than the WHO/FAO permissible limit**.** Zn concentration were higher in the intestine of ***Synodontis rukwaensis*** while similar results in obtained for the gills and intestine of *Cirrhinus reba*. Cu, Cr, Pb, Ni and Hg were below the permissible limit. Bioaccumulation of toxic heavy metals in the different tissues may harm animal health and causes damage to their normal physiological processes [Malik and Maurya, (2014)]. Heavy metal toxicity drastically affects the rate of survivability and reproductive capacity of the organisms. Some of these have been reported to be highly carcinogenic, mutagenic and teratogenic depending on the species, dose and exposure time [Ngo, *et. al.*, (2011)]. Being the top consumers of the aquatic ecosystem fishes are affected most [Akpoghelie and Irerhievwie, (2015).]. Heavy metal toxicity sometimes damages the nervous system of fish that affects the interaction of fish with its environment [Akpoghelie and Irerhievwie, (2015)]. For this study, the internal organs (gills, intestines, bones, and flesh) of two species of fishes were studied, kolokolo (Synodontis rukwaensis) and bounds (Cirrhinus reba). The levels of heavy metals were compared against World Health Organization (WHO) and Food and Agriculture Organization (FAO) permissible limits. This results further reveals the level of sawmill wood waste pollution affecting the study area. The findings from this study agree with those obtained in previous [Okoh, *et. al.,* (2016); Akpoghelie and Irerhievwie, (2015); Rueda, *et al.,* (2004); Francis, *et al.,* (2006)]. [Baby, *et al.,* (2010)] Stated that the ecosystem is influenced by organic contaminants and has resulted to low diversity species. In this study, the study area has massive deposit of wood waste with poor management practice with no structure to reducing the impacts of sawmill wood wastes on aquatic bodies.

4 CONCLUSIONS

The activities of sawmill operations have been established to be antagonistic to the surface water quality in Nigeria. The surface water is observed to be contaminated due to the crude methods of waste disposal into the river without treatment. This has greatly affected the eco-system and negatively impacted on the health of consumers of such water. Therefore, the need to adopt eco-friendly approaches in waste disposal and management should be of paramount interest these days. It can be concluded from this study that sawmill wood waste contains pollutants that are beyond the Federal Ministry of Environment, Department of Petroleum Resources, and Standard Organization of Nigeria limit, hence, proper disposal technique should be developed. Iron (Fe) values across kolokolo (Synodontis rukwaensis) and bounds (Cirrhinus reba) internal organs were higher than the permissible limits. Zinc values was higher than the permissible limits in the intestine of the kolokolo (Synodontis rukwaensis) and the gills and intestines of the bounds (Cirrhinus reba). Cadmium (Cd) values were higher than the permissible

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limits in the gills, intestines, and bones of the bounds (Cirrhinus reba) fish species only. It is recommended that the level of heavy metal contamination in the water body should be monitored regularly. Such data should be used for the assessment of health risk in the habitat. Also, proper awareness should be provided to the residents and workers in the study area about the harmful effect of indiscriminate sawmill activities on the environment.

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