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Heavy Metals Level and Physicochemical Properties of Surface Water from Mbaa River in Inyishi Town, Ikeduru Local Government Area, Imo State, Nigeria

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ABSTRACT: The objective of this paper is to investigate the levels of heavy metals and physicochemical properties of surface water from the Mbaa River in Inyishi Town, Ikeduru Local Government Area of Imo State, Nigeria using appropriate standard methods. Data obtained show that concentrations of most of these heavy metals were much higher than the maximum permissible limits. Pb and Al were found to be at highly elevated levels as they ranged from 0.37 mg/l to 0.69 mg/l and 3.86 mg/l to 10.36 mg/l respectively. Cr and zinc were below their respective WHO and SON standard guidelines. Probable sources of these metals could be the aluminium processing industry domiciled within the vicinity of the study area. It could be recommended that appropriate water treatment facility be provided in the study for sustainable agricultural and environmental practices.

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The water we drink is an essential ingredient for our wellbeing and a healthy life; unfortunately, polluted water and air are common throughout the world (Europian Public Health Alliance, 2009). Everybody irrespective of their stages of development, social and economic condition, have the right to access good drinking-water for their basic needs (WHO, 2004). In Nigeria most of the industries are situated along the river banks for easy availability of water and also for wastes disposal. These wastes often contain a wide range of contaminants and chemicals which greatly change the pH of water. It is found that one-third of the total water pollution in Nigeria comes in the form of industrial effluent discharge, solid wastes and other hazardous wastes (Mosley et al., 2004). Most of these defaulting industries are petrochemical industries, sugar mills, distilleries, leather processing industries, paper mill, agrochemicals and pesticides manufacturing industries, aluminum extrusion industries, pharmaceutical industries and many more. For industries like this, the surface water is their main source for waste disposal. Most industries have treatment facilities for industrial effluents. But this is not the case for small scale industries because they cannot afford enormous investments in waste treatment and pollution control. Consequently, at the end of each period the problem of pollution takes menacing concern. The problem of water pollution has become worse due to toxic heavy metals. The rising trend in concentration of heavy metals in water bodies has attracted considerable interest amongst ecologists globally during the last ten years and has also begun to cause issues in most of the industrialized towns. Untreated or allegedly treated industrial effluents

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often contains variable amounts of heavy metals such as arsenic, lead, nickel, cadmium, copper, mercury, zinc and chromium (Singare and Sharma, 2010), which have the potential to contaminate crops growing under such irrigation. These heavy metals have a significant effect on the aquatic plants and animals which through bio-magnification enter the food chain and eventually affect the human beings as well. Heavy metal pollution is an ever increasing problem of aquatic bodies. In India, cases of toxic heavy metal accumulation in aquatic ecosystems has been reported regularly (Patil, 2009). These toxic heavy metals entering in aquatic environment are adsorbed and forms free metal ions and soluble complexes that are available for uptake by biological organism (Salomons, 1984). The metals associated with particulate material are also available for biological uptake (Lee, 2000), and are deposited in estuarine sediments (Weston, 2002). Once deposited, binding by sulfides and/or iron hydroxides immobilizes trace metals until a change in redox or pH occurs (Adams and Maher, 1999). Thus, surficial sediments, particularly the fine fraction, accumulate trace metals and provide a means for evaluating the long term accumulation of contaminants (Kennicutt, 1994; Singare, 2010). Hence there is a need for extensive monitoring of river water pollution along the industrial zones over long periods of time in order to describe average metal precipitation (Johansson, 1977) Therefore the objective of this paper is to investigate the levels of heavy metals and physicochemical properties of surface water from the Mbaa River in Inyishi Town, Ikeduru Local Government Area of Imo State, Nigeria.

MATERIALS AND METHODS

Area of Study: Ikeduru L.G.A. is one of the 27 L.G.As of Imo State, Nigeria with a population of 199,316 according to the 2006 National Population Census; with an annual growth rate of 9%. It is located on longitude 7°04'E and 7°14'E and latitude 5°29'N and 5°39'N. It is drained by series of rivers and streams namely Mbaa, Oramiriukwa and Okatankwo. The rivers are characterized by dry valleys which are usually covered by flood waters in periods of high rainfall. The aquifers are recharged by means of flood water infiltration during the rainy season. The major economic activities here are farming, small scale fishing, trading, banking and civil services located at the headquarters Iho. In this study, the Mbaa river transverses Inyishi, Amaimo, and Eziama communities in Ikeduru LGA of Imo State; with Inyishi hosting an aluminium extrusion plant (ALEX Ltd). There is no reported incidence or evidence of improper waste disposal practices such as waste discharge into the surrounding water bodies; however there is a high probability of some environmental impact resulting from industrial production activities within the community. Other sources of potential water contamination may result from erosion water run-off, fishing activities, farming activities such as washing of some farm produce in the rivers (example bread-fruit, cassava) and washing of motor vehicles along the river banks etc.

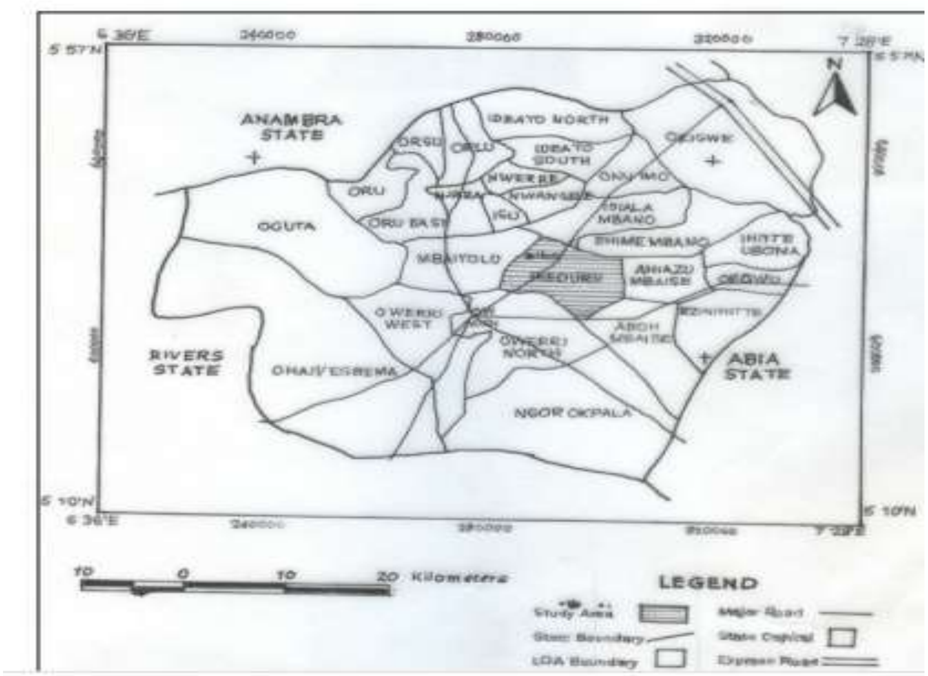

Fig 1. Map of Imo State showing the study area

Climatic Conditions: The study area is in the humid tropics with over 2,000mm of rainfall per annum and a mean annual temperature of about 27^{0}C. The rainy season commences in March/April and ends in October/November.

Study design: Effluents were collected from the nearby aluminum extrusion industry (ALEX) and water samples were collected at 5 selected points along the receiving river.

Sampling: Samples of the effluent were collected directly from the industry each month for a period of six months (Febuary- July, 2016) as well as the water samples which were collected at five distinct points in the river during the morning, afternoon and evening period using 50cl bottles. (number of samples collected each month, n =16). The bottles were thoroughly washed with distilled water twice, at the point of collection; the bottles were rinsed with the water samples before sample collection, corked tightly and labeled. All the samples were taken to the Soil science laboratory of National Root Crops Research Institute, Umudike where the test was carried out.

*Determination of heavy metals***:** by the Atomic Absorption Spectrophotometer (American Chemistry Society. Washington DC 1968). 100ml of the sample was measured into a beaker and placed on a hot plate to evaporate to dampness, 10ml of conc. HNO_3 added and further heated to reduce the volume, 5ml of per chloric acid was added to the sample and heated to complete the digestion, until a profuse per chloric fumes emerged. The sample was transferred into a 50ml volumetric flask and made up to the mark using distilled water. The digest was used for the determinations of the heavy metals using the atomic absorption spectrophotometer. PG 500 Instruments. Water analysis by atomic absorption and flame emission spectroscopy. Trace inorganic elements in water (Udochukwu et al., 2017).

Statistical analysis: Values of the various parameters were subjected to statistical analysis using statistics package for social science (SPSS). Completely randomize Design (CRD) with three replicates for each site in each parameter analyzed was used for the Analysis of variance (ANOVA) thereafter Dorcan Multiple Range Test (DTMRT) was used for mean differentiation. Data were then represented with mean ± standard error.

RESULTS AND DISCUSSIONS

The results from the first month shows that the effluent's pH (9.27), TDS (5649) and the temperature recorded in site 3 (41.27±67^{o}C were higher than WHO and SON limits (Table1).

Table 2, shows that Ni, Cu, Pb were also higher than the permissible limits. It was observed in the second month that temperature for site 1 to 5 which ranged from 28.00±0.29 to 29.27±2.08^{o}C and that of the effluent (34^{o}C) were above the permissible limits (Table 3). Also (Table 4) shows that Al and Pb for site 1 to 5 were above the permissible limits. Finally in the third month, it was observed that temperature, NO_3^- and NH_4^+ for site 1 to 5 were above the WHO and SON permissible limits.

Table 1: Mean ± SE for parameters measured at selected sampling sites for physicochemical parameters of the 1st month.

Parameters	Site 1	Site 2	Site 3	Site 4	Site 5	Effluent	WHO	SON
pH	4.51±0.06^{a}	5.17±0.48^{a}	4.53±0.03^{ab}	4.42±0.00^{b}	4.46±0.003^{ab}	9.27	8.50	6.50 – 8.50
Temp (^{0}C)	34.56±0.02^{ab}	29.89±2.48^{b}	41.27±6.71^{a}	34.57±0.01^{ab}	34.9±0.003^{ab}	34.60	23.50	
Colour (EBC)	0.01± 0.01^{b}	0.04 ±**0.02**^{a}	0.01±.0003^{b}	0.001 ± 0.00^{b}	0.008 ± 0.00^{b}	0.03		
Turbidity (NTU)	0.03±0.01^{c}	0.08±0.02^{b}	0.02 ± .001^{c}	0.21 ± 0.02^{a}	0.01 ±.0003^{c}	0.05	5.00	-
EC (µS/cm)	7.37±2.11^{b}	5.30 ±0.85^{ab}	2.63 ± 0.03^{a}	4.23 ±0.03^{ab}	3.80±0.003^{a}	133.60	400.00	1000.00
DO (Mg/l)	4.20 ± 0.01^{a}	3.80 ± 0.01^{b}	4.00 ± 0.04^{ab}	4.33±0.01^{a}	4.37±0.27^{a}	174.00	5.00	
BOD (Mg/l)	1.20 ± 0.01^{b}	1.6 ± 0.01^{a}	1.11±0.01^{a}	1.2±0.01^{b}	0.9±0.01^{c}	11.30	3.00	-
COD (Mg/l)	14.41 ±0.43^{a}	14.18 ±2.52^{a}	7.00 ± 1.24^{a}	6.08 ± 0.40^{a}	5.02 ± 0.31^{a}	179.42		200.00
TDS(Mg/l)	31.33 ± 8.95^{ab}	35.30 ± 4.65^{a}	11.33 ± 0.03^{c}	18.03±0.03^{bc}	16.53±0.03^{bc}	5649.00	500.00	500.00
TSS (Mg/l)	14.22 ± 2.87^{a}	16.24 ± 1.33^{a}	4.58 ± 0.003^{b}	2.85 ± 0.00^{b}	3.09 ± 0.003^{b}	1981.00		1500.00
Salinity (Mg/l)	0.03 ±0.01^{a}	0.03 ±0.01^{a}	0.01±.003^{b}	0.02 ± .003^{ab}	0.03 ± .003^{ab}	6.33	200.00	
NH_4^+ (Mg/l)	7.47 ± 3.45^{b}	15.53 ± 5.43^{a}	2.77 ± 0.03^{b}	5.63 ± 0.03^{b}	5.63 ± 0.03^{b}	30.80		4.00
NO_3^- (Mg/l)	10. 83 ±1.42^{a}	7.33 ± 0.83^{ab}	6.13 ± 1.27^{b}	3.70 ± 0.30^{b}	5.20 ± 1.90^{b}	30.34	50.00	50.00
Cl^- (Mg/l)	38.99 ± 2.05^{b}	81.71±25.75^{a}	35.45 ±0.03^{b}	49.63±0.03^{ab}	39.33 ±0.33^{b}	365.88	250.00	250.00
Ca^{2+} (Mg/l)	93.70 ±17.48^{a}	73.28±12.36^{ab}	60.11 ± 0.01^{c}	60.03 ±0.03^{c}	40.33 ± 0.33^{c}	160.3	150.00	150.00
Mg^{2+} (Mg/l)	24.32 ±7.03^{ab}	30.63 ± 5.58^{a}	36.47±0.003^{a}	12.16±0.003^{b}	24.30±0.003^{ab}	36.47	150.00	
PO_4^{3-} (Mg/l)	36.55 ± 4.73^{c}	21.75 ± 5.46^{d}	46.63 ± 0.03^{a}	26.46±0.003^{d}	40.24 ±0.007^{a}	184.00		5.00
K^+ (Mg/l)	0.38±0.11^{a}	0.46±0.07^{a}	0.63 ±0.08^{a}	0.57±0.07^{a}	0.59 ±0.02^{a}	3.45	200.00	
Na^+ (Mg/l)	1.12 ±0.12^{a}	0.99±0.05^{ab}	0.97 ± 0.03^{ab}	0.95 ± 0.03^{ab}	0.85 ± 0.03^{b}	20.10	200.00	

In (Table 6), aluminium both for the effluent and site 1 to 5 were all above the WHO and SON permissible limits. The study revealed that the pH values of the river appeared to be slightly acidic in most of the tables as it had values at 4.42 to 6.40 and outside the permissible limit by WHO and SON standard. It was also observed that the pH of all the effluents was pH>8.5 which indicates that the water is hard WHICH corroborated with (Mosley et al, 2004; Udochukwu et al., 2014). The EC values confirmed the low level of TDS in the river water.

Table 2: Mean $\pm$ SE for parameters measured at selected sampling sites for heavy metals of the 1st month.

(Mg/l)	Site 1	Site 2	Site 3	Site 4	Site 5	Effluent	WHO	SON
Ni	0.27 ± 0.05^{ab}	0.14 ± 0.09^{b}	0.31 ± 0.0003^{a}	0.28 ± 0.0003^{ab}	$.29 \pm 0.004^{ab}$	0.19	< 0.10	0.20
Cu	0.18 ± 0.08^{c}	0.26 ± 0.16^{c}	0.45 ± 0.0003^{b}	0.71 ± 0.0003^{a}	0.85 ± 0.0003^{c}	1.36	< 0.05	1.00
Pb	0.60 ± 0.002^{b}	$0.78 \pm .10^{a}$	0.62 ± 0.01^{b}	$0.61 \pm .0003^{b}$	$0.60 \pm .0003^{b}$	0.60	0.05	0.01
Fe	12.11 ± 0.32^{a}	7.50 ± 2.70^{b}	12.59 ± 0.001^{a}	12.50 ± 0.0003^{a}	12.58 ± 0.003^{a}	9.98	_	_
Zn	2.17 ± 0.06^{a}	2.14 ± 0.17^{a}	01.75 ± 0.0^{b}	$2.05 \pm .0003^{a}$	1.72 ± 0.0003^{c}	4.62	5.00	3.00
Cd	0.05 ± 0.03^{b}	0.24 ± 0.08^{a}	$0.06 \pm .0003^{b}$	0.05 ± 0.00^{b}	$0.059 \pm .003^{b}$	0.35	< 0.01	0.03
Al	10.12 ± 0.25^{a}	6.68 ± 1.72^{b}	10.36 ± 0.03^{a}	10.33 ± 0.33^{a}	10.03 ± 0.03^{a}	10.12	0.20	0.20
Cr	0.01 ± 0.001^{b}	0.06 ± 0.02^{a}	0.01 ± 0.00^{b}	$0.01 \pm .0003^{b}$	0.01 ± 0.0003^{b}	0.02	< 0.05	0.05

Means with the same alphabet are not significantly different
SE means Standard Error, < 0.01 Implies that the values were below the minimum detectable limit of 0.01

Table 3: Mean $\pm$ SE for parameters measured at selected sampling sites for physicochemical parameters of the 2nd month

Parameters	Site 1	Site 2	Site 3	Site 4	Site 5	Effluent	WHO	SON
pH	4.7 ± 0.12^{a}	4.9 ± 0.17^{a}	5.13 ± 0.38^{a}	5.53 ± 0.38^{a}	5.3 ± 0.27^{a}	9.10	8.50	6.50 – 8.50
TEMP(^{0}C)	28.00 ± 1.29^{a}	28.67 ± 0.84^{a}	29.27 ± 1.58^{a}	27.80 ± 0.95^{a}	29.27 ± 2.08^{a}	34	23.50	
Colour(EBC)	0.30 ± 0.01^{a}	$0.03 \pm .02^{a}$	$0.03 \pm .05^{a}$	$0.03 \pm .01^{a}$	$0.02 \pm .003^{a}$	0.154		
Turbidity(NTU)	0.10 ± 0.01^{b}	0.03 ± 0.01^{a}	0.02 ± 0.003^{a}	0.03 ± 0.005^{a}	0.03 ± 0.01^{a}	0.245	5.00	-
EC(μScm^{-1})	3.10 ± 0.32^{a}	2.89 ± 0.43^{a}	3.24 ± 1.12^{a}	3.26 ± 0.66^{a}	4.62 ± 0.79^{a}	138.40	400.00	1000.00
DO(mg/l)	4.29 ± 0.28^{b}	4.69 ± 0.42^{b}	4.69 ± 0.42^{b}	3.20 ± 0.01^{a}	3.47 ± 0.05^{a}		5.00	
BOD(mg/l)	1.16 ± 0.12^{a}	1.47 ± 0.36^{a}	0.96 ± 0.89^{a}	1.82 ± 0.58^{a}	1.60 ± 0.21^{a}	208.40	3.00	-
COD(mg/l)	12.18 ± 0.09^{c}	11.33 ± 0.26^{b}	11.61 ± 0.21^{b}	11.11 ± 0.34^{b}	8.10 ± 0.10^{b}	184.50		200.00
TDS(mg/l)	35.87 ± 7.53^{ab}	17.37 ± 3.06^{a}	38.07 ± 11.15^{ab}	75.07 ± 22.04^{ab}	88.7 ± 34.9^{b}	1066.00	500.00	500.00
TSS(mg/l)	93.23 ± 45.80^{a}	93.47 ± 47.12^{a}	122.73 ± 57.60^{a}	86.83 ± 41.3^{a}	86.3 ± 41.7^{a}	955.0		1500.00
Salinity(mg/l)	0.11 ± 0.04^{b}	0.02 ± 0.08^{a}	0.02 ± 0.01^{a}	0.01 ± 0.001^{a}	$.01 \pm 0.001^{a}$	4.22	200.00	
NH_4^+(mg/l)	7.467 ± 2.47^{a}	6.73 ± 0.85^{a}	5.60 ± 1.61^{a}	8.40 ± 2.80^{a}	6.27 ± 1.21^{a}	43.50		4.00
NO_3^-(mg/l)	6.07 ± 2.84^{a}	4.40 ± 0.83^{a}	3.27 ± 1.24^{a}	5.60 ± 2.14^{a}	4.67 ± 0.93^{a}	28.00	50.00	50.00
Cl^-(mg/l)	43.70 ± 3.12^{a}	62.60 ± 3.12^{b}	72.75 ± 6.02^{b}	41.35 ± 4.26^{a}	60.5 ± 3.93^{b}	2410.00	250.00	250.00
Ca^{2+}(mg/l)	20.69 ± 2.40^{a}	38.74 ± 11.66^{a}	26.07 ± 3.08^{a}	18.72 ± 10.7^{a}	30.8 ± 4.81^{a}	400.80	150.00	150.00
Mg^{2+}(mg/l)	18.63 ± 1.63^{a}	22.71 ± 7.21^{a}	17.83 ± 3.53^{a}	12.97 ± 8.11^{a}	17.01 ± 4.2^{a}	73.00	150.00	
PO_4^{3}(mg/l)	9.67 ± 2.40^{a}	12.52 ± 4.36^{a}	16.13 ± 1.70^{a}	13.93 ± 0.71^{a}	14.20 ± 2.3^{a}	112.00		5.00
K^+(mg/l)	0.397 ± 0.03^{a}	0.51 ± 0.13^{a}	0.45 ± 0.04^{a}	0.63 ± 0.05^{a}	0.72 ± 0.17^{a}	2.80	200.00	
Na^+(mg/l)	0.89 ± 0.09^{a}	0.78 ± 0.22^{a}	0.81 ± 0.17^{a}	0.77 ± 0.10^{a}	0.80 ± 0.06^{a}	27.40	200.00	

Table 4: Mean $\pm$ SE for parameters measured at selected sampling sites for heavy metal of the 2nd month (mg/l)

	Site 1	Site 2	Site 3	Site 4	Site 5	Effluent	WHO	SON
Ni	0.05 ± 0.02^{a}	0.05 ± 0.01^{a}	0.06 ± 0.02^{a}	0.41 ± 0.32^{a}	0.06 ± 0.01^{a}	1.90	< 0.10	0.20
Cu	0.12 ± 0.05^{a}	0.10 ± 0.02^{a}	0.18 ± 0.04^{b}	0.17 ± 0.03^{b}	0.45 ± 0.12^{b}	12.40	< 0.05	1.00
Pb	0.43 ± 0.19^{a}	0.64 ± 0.22^{a}	0.37 ± 0.14^{a}	0.50 ± 0.23^{a}	0.61 ± 0.25^{a}	1.19	0.05	0.01
Fe	4.58 ± 0.57^{a}	4.60 ± 0.53^{a}	7.63 ± 1.41^{a}	6.79 ± 1.19^{a}	5.54 ± 2.46^{a}	20.66	-	-
Zn	3.93 ± 0.94^{a}	2.05 ± 0.08^{a}	2.47 ± 0.31^{a}	3.30 ± 0.35^{a}	3.41 ± 1.03^{a}	7.00	5.00	3.00
Cd	0.17 ± 0.07^{a}	0.41 ± 0.02^{a}	0.41 ± 0.08^{a}	0.24 ± 0.03^{a}	0.76 ± 0.67^{a}	1.04	< 0.01	0.03
Al	4.96 ± 0.13^{a}	4.71 ± 0.78^{a}	5.33 ± 0.54^{a}	5.75 ± 1.91^{a}	5.76 ± 1.21^{a}	40.20	0.20	0.20
Cr	0.10 ± 0.01^{a}	0.08 ± 0.01^{a}	0.42 ± 0.34^{a}	0.37 ± 0.32^{a}	0.06 ± 0.01^{a}	0.60	< 0.05	0.05

Means with the same alphabet are not significantly different
SE means Standard Error, < 0.01 Implies that the values were below the minimum detectable limit of 0.01

The result also implies that the water is palatable for domestic and agricultural use (Schwab et al, 1993). A low turbidity was recorded across in the effluent and across the five (5) sites which is in line with WHO recommendations (Smith and Davis-Colley, 2001; Atuanya et al., 2016). The BOD values also complied with WHO permissible limits. It was reported that natural water with the BOD values of 4mg/l is considered to be slightly polluted with organic matter, but safe for drinking (Alpha, AWWA and WEF, 1998). Stream keepers field guide (1991) reported that unpolluted natural waters should have a BOD of 5mg/l or less. The high COD value in the sample effluent recorded indicates that the effluent had high organic load. (Basawaray et al, 2014). Low level of COD recorded across tables (1,3,5,) could therefore suggest that there may not be direct influence of effluent discharge into the river and also that such a river is good for irrigation, domestic and aquatic life.

Table 5: Mean ± SE for parameters measured at selected sampling sites for physicochemical parameters for the 3rd month.

	Site 1	Site 2	Site 3	Site 4	Site 5	Effluent	WHO	SON
pH	5.13±0.18^{a}	5.03±0.28^{a}	5.70±0.25^{b}	5.87±0.41^{b}	6.23±0.19^{b}	8.60	8.50	6.50 –8.50
Temp(^{0}C)	27.17±0.58^{a}	27.43±0.79^{a}	26.80±1.15^{a}	26.57±0.27^{a}	26.57±0.27^{a}	28	23.50	
Colour(EBC)	0.08±0.03^{a}	0.05±0.01^{a}	0.06±0.03^{a}	0.13±0.09^{a}	0.11±0.05^{a}	0.205		
Turbidity(NTU)	0.08±0.03^{a}	0.08±0.02^{a}	0.07±0.02^{a}	0.08±0.03^{a}	0.08±0.03^{a}	0.118	5.00	-
EC((µS/cm))	3.60±0.55^{a}	3.48±1.37^{a}	2.84±0.91^{a}	2.62±0.82^{a}	4.50±0.65^{a}	228.00	400.00	1000.00
DO(mg/l)	3.42 ± 0.11^{a}	3.74 ± 0.10^{a}	4.34 ± 0.23^{a}	4.64 ± 0.25^{a}	6.59 ± 3.30^{a}		5.00	
BOD(mg/l)	1.29 ± 0.04^{a}	1.35 ± 0.78^{a}	1.72 ± 0.21^{a}	1.53 ± 0.03^{a}	1.31 ± 0.27^{a}	5.40	3.00	-
COD(mg/l)	14.14±0.43^{a}	14.21±2.67^{a}	7.00 ± 1.24^{a}	6.16 ± 0.58^{a}	5.10 ± 0.61^{a}	245.60		
TDS(mg/l)	19.00±2.80^{a}	12.57±0.35^{a}	12.43±2.48^{a}	13.47±2.33^{a}	14.67±0.66^{a}	4090.0	500.00	500.00
TSS(mg/l)	8.77±0.43^{b}	7.52±0.37^{a}	8.87±1.34^{b}	8.97±1.70^{b}	12.00±1.21^{b}	266.50		1500.00
Salinity(mg/l)	12.00±1.21^{b}	0.09±0.03^{a}	0.05±0.005^{a}	0.05±0.03^{a}	0.10±0.05^{a}	5.20	200.00	
NO_3^- (mg/l)	15.40±2.91^{a}	8.40±1.61^{a}	11.90±3.86^{a}	15.40±2.42^{a}	10.66±3.20^{a}	36.40	5.00	5.00
Cl^- (mg/l)	37.24±2.70^{a}	53.17±7.38^{a}	44.04±3.95^{a}	47.93±5.37^{a}	42.47±5.74^{a}	219.80	250.00	250.00
Ca^{2+} (mg/l)	72.44±4.37^{b}	62.06±4.12^{b}	48.09±6.12^{a}	42.76±11.88^{a}	48.10±4.68^{a}	192.41	150.00	150.00
Mg^{2+} (mg/l)	33.23±3.53^{a}	26.74±2.44^{a}	8.64±1.62^{a}	21.48±4.23^{a}	31.76±8.19^{a}	85.11	150.00	
PO_4^{3-} (mg/l)	11.45±1.93^{a}	13.27±1.42^{a}	12.95±2.10^{a}	12.50±2.89^{a}	11.69±2.39^{a}	195.00		5.0
K^+ (mg/l)	0.32±0.05^{a}	0.52±0.10^{b}	0.37±0.07^{a}	0.50±0.01^{b}	0.71±0.16^{b}	4.33	200.00	
Na^+ (mg/l)	0.69±0.04^{a}	0.64±0.04^{a}	0.44±0.09^{a}	0.63±0.23^{a}	0.69±0.21^{a}	23.60	200.00	
NH_4^+ (mg/l)	19.27±4.25^{a}	14.47±3.27^{a}	18.67±6.12^{a}	21.47±4.60^{a}	22.40±3.23^{a}	100.80		4.00

Means with the same alphabet are not significantly different; SE means Standard Error,

Table 6: Mean ± SE for parameters measured at selected sampling sites for heavy metals ofthe 3rd month. (Mg/l)

	Site 1	Site 2	Site 3	Site 4	Site 5	Effluent	WHO	SON
Ni	0.10±0.13^{a}	0.07±0.01^{a}	0.08±0.03^{a}	0.40±0.0.32^{a}	0.06±0.0.12^{a}	2.60	< 0.10	0.20
Cu	0.12± 0.01^{a}	0.13±0.12^{a}	0.16±0.03^{a}	0.14±0.05^{a}	0.27±0.08^{a}	13.00	< 0.05	1.00
Pb	0.38±0.18^{a}	0.75±0.28^{a}	0.25±0.27^{a}	0.47±0.28^{a}	0.60±0.27^{a}	2.20	0.05	0.01
Fe	4.39±1.37^{a}	6.42±2.67^{a}	6.83±1.36^{a}	6.25±2.84^{a}	5.44±2.17^{a}	14.50	-	-
Zn	2.77±0.27^{b}	1.32±0.26^{a}	2.25±0.60^{ab}	2.90±0.08^{b}	2.30±0.35^{ab}	6.80	5.00	3.00
Cd	0.17±0.02^{a}	0.14±0.004^{a}	0.17±0.03^{a}	0.49±0.34^{a}	0.89±0.42^{a}	0.34	< 0.01	0.03
Al	3.86±0.0.44^{a}	4.52±0.27^{a}	4.27±0.0.23^{a}	4.25±0.80^{a}	4.87±0.67^{a}	33.50	0.20	0.20
Cr	0.27±0.22^{a}	0.07±0.01^{a}	0.05±0.02^{a}	0.15±0.08^{a}	0.05±0.01^{a}	0.47	< 0.05	0.05

Means with the same alphabet are not significantly different
SE means Standard Error, < 0.01 Implies that the values were below the minimum detectable limit of 0.01

Ammonia values recorded were high and contrary to the permissible limit of SON at 4.0mg/l. Such high level of Ammonia in the water could be due to industrial activities, domestic and fecal matter in and around the river bank. Also the very high ammonia content of the effluent may not pose a strong issue to the water body because according to USAS, (2014), NH_3 (un-ionized ammonia) is particularly toxic to aquatic animals than NH_4^+. Also Brian (2016) reported that NH_4^+ is readily used by algae and other aquatic plants. The presence of Cl^- in Mbaa, river agrees with the report of Nwoko and Ezeibe (2015) who reported that chloride is commonly found in streams and freshwater. Some of the heavy metals like Pb and Al were found to be at highly elevated levels while Cr and zinc were below the WHO and SON permissible limits (Udochukwu et al., 2020). These trace metals (lead and cadmium) have been implicated to be responsible for certain health disorders. Cd is a known human carcinogen and has been reported to originate from impurities in phosphate fertilizers (Onyenechere et al, 2011). Other possible source which includes, metal smelting and refining, leachates from nickel-cadmium batteries discarded carelessly. The first explanation seems more plausible as there is extensive agricultural activity within the study area, with potential high use of NPK fertilizers. Elevated levels of these heavy metals beyond WHO level may suggest that there may be a possible link with activities of industries in terms of waste and effluent discharge and the metal content of the river. Also metals may enter the river through geological weathering and human activities such as passing product and waste pipes through the river water to the points of discharge causing the leaching of the pipe metallic components into the river.

Conclusion: The impact of domestic, agricultural and industrial waste channeled into the water body cannot be over emphasized. The quality of this water body cannot be guaranteed due to constant disposal of industrial effluents, agricultural activities, high vehicular traffic, and beach side laundry by locals, and fishing. An aggregation of these activities obviously has a significant impact on the hydrological balance of Mbaa River. A detailed campaign should be put in place, elucidating the mechanism of water pollution especially with regard to these toxic industrial effluents.

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