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IMPACT OF BREWERY EFFLUENT ON SEDIMENT QUALITY OF THE OMI-ASORO STREAM, ILESA, OSUN STATE, NIGERIA.

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ABSTRACT

In view of assessing the effect of industrial effluent discharges on the water quality of the Omi-Asoro stream at Ilesa, by the International Breweries Plc, sediments samples were analysed for physicochemical parameters. Physicochemical parameters of the sediment samples were determined using standard analytical procedure. Heavy metal concentrations in sediments were analysed using Atomic Absorption Spectrophotometric technique. The results revealed that Omi-Asoro stream sediment has the following mean characteristics: pH 6.8±1.8, Organic Carbon 3.4±1.2 %, Organic Matter 6.0±2.0 %, Sand 78.6±1.0 %, Clay 9.8±6.7 % and Silt 11.6±5.4%.
The Pearson correlation and ANOVA were performed on the results obtained.
The average levels of the heavy metals in the sediments revealed that only zinc with 158 ± 102 mg/kg exceeded the limit set by USEPA of 124 mg/kg and < 100 mg/kg limit set by USPHS. All other metals were below the limits (Table 2.). There is a strong positive correlation between the heavy metals in the water to that in the sediment, except for cobalt that is significantly different in its distribution in sediment (Table 4.)

Key Words: Brewery Effluent, Physico-chemical parameters, Heavy Metals, Correlation, Omi-Asoro Stream Sediment.

INTRODUCTION

Environment is being polluted by human activities naturally and artificially. This is called anthropogenic activities of man (Hassan, 2004). In newly reclaimed lands, agricultural and industrial activities may create different sources of pollution (Taha *et al.,* 2004). The dynamic balance in the aquatic ecosystem is upset by human activities, resulting in pollution which is manifested dramatically as fish kill, offensive taste, odour, colour, and unchecked aquatic weeds. Chemicals and their products are very important to mankind due to its benefits they accrue. However, exposure to them during production, usage and their uncontrolled discharge into the environment has caused a lot of hazards to man, other organisms and the environment itself. Thousands of chemicals have been reported to exhibit toxic effects in lives (Nowierski *et al.*, 2006; Herrera-Silveira *et al.*, 2004).

Surface sediments are specific elements of the natural environment. They are a "natural sponge" that absorbs all kinds of pollutants occurring in water. The structure of sediments together with their developed surface makes them a natural sorbent in which the accumulation of all sorts of harmful substances takes place. Substances and elements including trace metals, polycyclic aromatic hydrocarbons (PAHs), phenols, pesticides, and other compounds have been determined in sediments (Solecki and Chibowski, 2000). The transportation of organic contaminants in a water environment depends on their solubility in water. Most contaminants e.g. (PAHs, PCB) are characterized by low solubilities, and their transportation over considerable distances can be significantly limited if they are absorbed in the sediments. Once deposited in sediments, these compounds are less subject to photochemical and biological oxidation and thus tend to persist for longer periods and to accumulate in high concentrations.

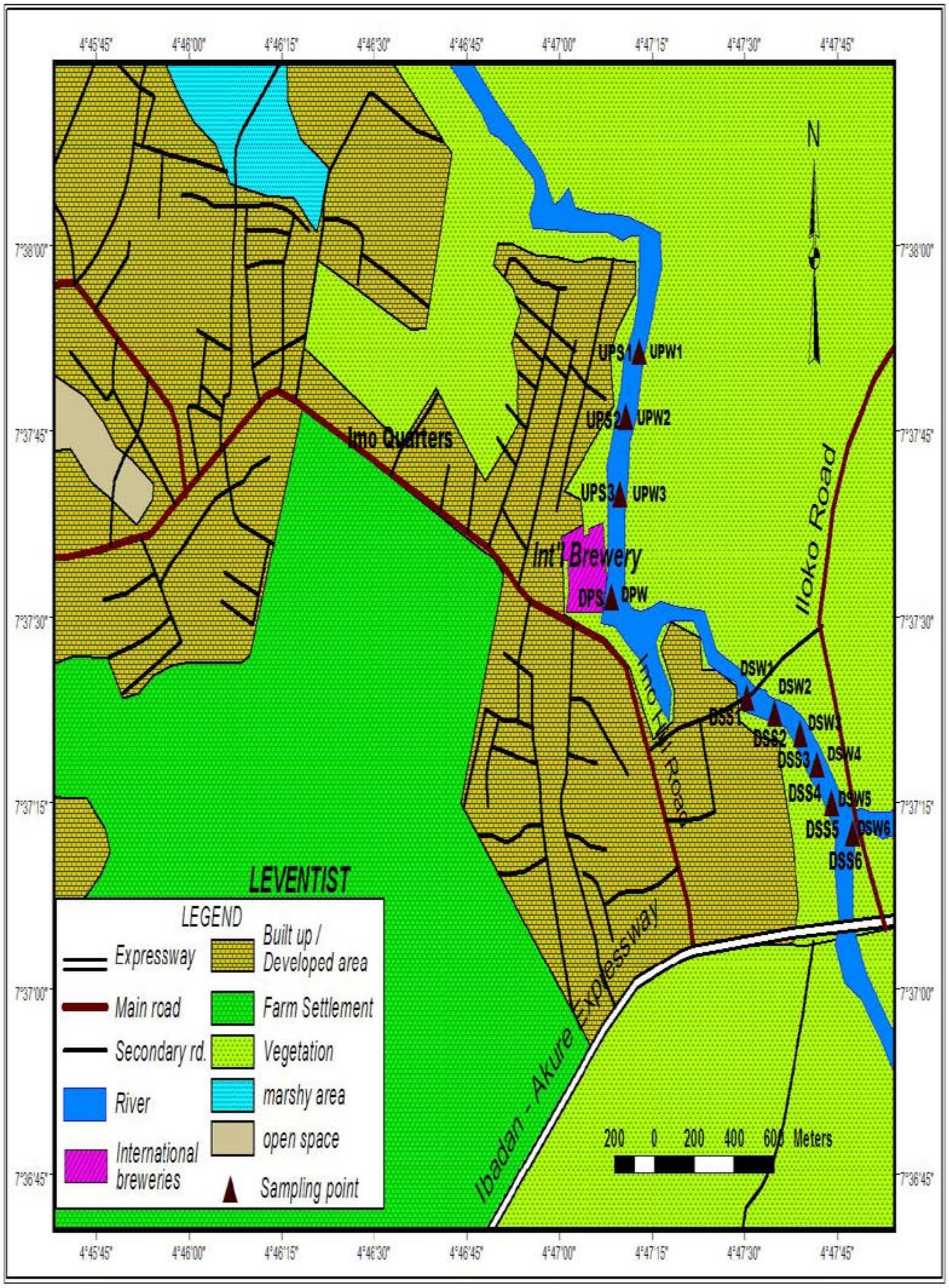
In some cases, the adsorbed contaminants can be remobilized and secondary water pollution may occur. This takes place when the solubility of contaminants is increased (e.g. by the presence of surfactants), or when the particles of the contaminants undergo desorption from an immovable matrix and undergo a secondary sorption on particles with a sorption ability higher than that of the sediments, and which are carried by water currents (in general only the finer fractions (<63 µm) are transported by river currents (Baran *et al*., 2002).

Heavy metal pollution of aquatic ecosystem is often most obvious in sediments, macrophytes and aquatic animals, than in elevated concentrations in water (Linnik and Zubenko, 2000). Biomonitors are organisms or systems of the area that can be used to establish variation in the bioavailability of any parameter including heavy metals in the marine environment (Karen, 2005). Sediments have frequently been analysed to identify sources of trace metals in the aquatic environment because of the high accumulation rate exhibited. Sediment analysis allows contaminants that are absorbed by particulate matter, which escape determination by water analysis to be identified (Karen, 2005). The non residual fraction of the sediment is considered to be mobile and therefore is likely to become available to aquatic organisms.

Ipeaiyeda and Onianwa (2009) Impact of brewery effluent on water quality of the Olosun River in Ibadan, Nigeria reported that the river Olosun is faced with increasing problems of being a receptacle for untreated brewery effluent. Beer production in the brewery industry involves three main steps: malting, brewing and fermentation. The byproducts (e.g. mash, yeast surplus) generated from those steps are responsible for pollution when mixed with effluents. In addition, cleaning of tanks, bottles, machines and floors produces high quantities of polluted water. Brewery effluents, having chemical (with very high organic contents) and microbial contaminants, results in a rather chaotic layout of utilities such as water supply, irrigation and laundry of the receiving river (Doubla *et al.*, 2007, Belgiomo *et al.*, 2007). When all these processes were over, the soil and the sediments are the recipients of the discharge of these toxic, untreated and polluted wastes.

DESCRIPTION OF SAMPLING SITE AND STUDY DESIGN

Ilesha (Ilesa) is the largest town and the capital of Ijesha (Ijesa) kingdom in Osun State, Nigeria. It Latitude lies on 8.92°N and Longitude 3.42°E. There were about 600,000 inhabitants which were recorded in 2004 population census. The town has a brewery and other local industries that manufacture nails, carpet, vegetable oil and pure water factory. There are also publishing and recording firms. There are prominent quartzite ridges which lie east of Ilesa where gold mining activities takes place, this place is known as the Iperindo goldfield. Omi-Asoro stream is located within Ilesa-East Local Government of Osun State, South Western Nigeria. The town is a fast growing agricultural community apart from having the tendency of becoming a better business environment. Water from this stream is used for drinking, agricultural, domestic and industrial purposes especially the brewery in the area. This present study will provide useful reports on the level of heavy metals on the sediment quality of Omi-Asoro stream that receives effluent from the International Breweries Plc. located in Ilesa. This will be able to serve as a set of data for future research.



MATERIALS AND METHODS

Sampling Design

For the purpose of this study, the section of the stream was segmented into three namely upstream, discharge point and downstream.

Upstream – Three sampling points were denoted UPS 1, UPS 2 and UPS 3 the sediments were labeled UPS 1, UPS 2 and UPS3 respectively. Sediment for heavy metals was also collected at each point.

Discharge point – The point at which the waste water is being discharged to the river through concrete cement pipe is regarded as the discharge point. It is laid underground from premises of breweries into the stream that is receiving the wastewater just at the back of the brewery fence. This point was designated as DPS for the sediment.

Downstream – Six sampling points were located along the stream. They are denoted as sediment DSS 1, DSS 2, DSS 3, DSS 4, DSS 5 and DSS 6 respectively.

Ten sediment samples were collected for physicochemical and heavy metals analysis. The sediments were collected into polyethylene bags by means of a grab. Sediment samples for the determination of organic carbons, heavy metals, pH, and soil particle size were collected in polythene bags which were air-dried for several days in the laboratory.

Determination of Heavy Metals in Sediments

The analysis of heavy metals in the sediment samples involves the digestion of the sediment samples with mixture of two acids in ratio 3:1 (HCl : HNO_3). The determination of heavy metal concentration in the digest was done using an Atomic Absorption Spectrophotometer (AAS). The principle involves the atomization of samples by thermal sources and the absorption of a specific wavelength by the atomic source as it is excited. The radiation used is a hollow cathode lamp containing as its cathode, the same element under analysis. The quantity of the same element absorbed by the atomic vapour is proportional to the concentration of the atoms in the ground state.

Spectrophotometric measurement of heavy metal

Flame Atomic Absorption Spectrophotometer (AAS) was employed for the measurement of the absorbance of the heavy metals. The lamps of the heavy metals were operated at wavelength specified by the manufacturer. The sediment samples were air dried, sieved through a 2mm sieve. 2g of the sample was then weighed into a centrifuge tube and 20mL of Aqua regia was then added. The mixture was heated over a water bath for 2 hours and the solution was then filtered into a 25mL volumetric flask and made up to mark with distilled water. The concentration of the heavy metals in the sediments was then determined by an atomic absorption spectrophotometer (AAS). (Model: VGP210). Blanks were also prepared for the (AAS).

Statistical Analysis

All data generated were analyzed statistically by calculating mean, standard deviation, Anova and correlation.

RESULTS AND DISCUSSION

TABLE 1: Physicochemical parameters in sediment samples along Omi-Asoro stream, Ilesa.

	pH	0rganic carbon %	0rganic Matter %	%SAND	%CLAY	%SILT
UPS1	8.0	3.0	5.1	69.2	9.4	21.4
UPS2	8.1	3.0	5.4	91.2	1.4	7.4
UPS3	8.0	3.0	5.4	77.2	5.4	17.4
DPS	8.2	3.3	5.6	69.2	17.4	13.4
DSS1	7.8	4.8	8.3	79.2	13.4	7.4
DSS2	8.1	4.0	7.5	71.2	15.4	13.4
DSS3	6.6	4.9	8.0	63.2	21.4	15.4
DSS4	4.2	3.0	5.0	87.2	5.4	7.4
DSS5	3.8	4.0	7.0	91.2	3.4	5.4
DSS6	5.0	0.9	1.5	87.2	5.4	7.4
Mean±S.D	6.8±1.8	3.4±1.2	6.0±2.0	78.6±1.0	9.8±6.7	11.6±5.4

Table 2: Heavy metals concentrations (mg/Kg) in sediment at upstream, discharge point and downstream along Omi Asoro stream, Ilesha.

Sampling points	Cd	Co	Ni	Zn	Pb	Cr	Mn
UPS1	1.01	4.28	10.6	396	3.98	< 0.98	1550
UPS2	< 0.1	0.83	1.48	95	0.6	< 0.98	420
UPS3	0.2	2.53	2.61	212	0.38	< 0.98	610
DPS	0.1	2.60	3.49	198	1.31	< 0.98	290
DSS1	0.46	5.93	29.5	231	16.8	20.2	2190
DSS2	0.20	3.76	5.23	212	5.05	1.93	750
DSS3	0.60	4.06	2.61	58	3.31	< 0.98	1050
DSS4	< 0.1	2.3	1.8	71	1.46	< 0.98	270
DSS5	< 0.1	0.14	4.94	12	4.38	Nil	Nil
DSS6	0.08	3.06	2.78	93	10.2	15.3	450
Mean±SD	0.4±0.34	3.0±1.7	6.5±8.5	158±102	4.8±5.1	12.5±9.5	840±650

Table 3: Comparison of average level of heavy metals in sediments from Omi Asoro stream with some sediment quality guidelines

Parameters	Overall average	Range	USEPA(1997) TEL	PEL	Salomons & Forstner (1984) USPHS (1997)
Cd	0.38±0.34	< 0.1-1.01	0.68	4.21	1
Co	3.00±1.70	0.14 -1.01	-	-	-
Ni	6.50±8.50	1.48-29.5	15.9	42.8	45 -65
Zn	158±102	12 -396	124	271	< 100
Pb	4.75±5.13	0.38- 16.8	30.2	112	20 -30
Cr	12.5±9.50	<0.98- 20.2	52.3	160	-
Mn	840±651	270 -2190	-	-	-

Table 4.Correlation levels of heavy metals in sediments along Omi-Asoro stream, Ilesa

	Cd	*Co*	*Ni*	*Zn*	*Pb*	*Cr*	*Mn*
Cd	1						
Co	0.729887	1					
Ni	0.431273	0.688995	1				
Zn	0.717558	0.591908	0.441145	1			
Pb	0.238787	0.630473	0.823566	0.139089	1		
Cr	0.071421	0.542335	0.702937	0.063631	0.953062	1	
Mn	0.77988	0.884883	0.847421	0.62956	0.650683	0.520722	1

Physicochemical Parameter of Omi-Asoro Sediments.

pH

The pH of the stream sediments ranged from 3.8 to 8.2, with a mean level of 6.8 ± 1.8. The result indicated that the sediments of this stream are slightly acidic. This is supported by the pH of the water, with the mean level of 6.6 ± 0.2. The pH level has important effects on the heavy metals present in the sediment. Cu and Pb form stable complexes with dissolved organic matter, and few of these exist as free hydrated metal ions when pH is not strongly acidic. (Table 1)

Total Organic Carbon

The total organic carbon of sediment samples showed a regular pattern and trend. The total organic carbon of the sediments ranged from 0.9 % to 4.8 %. The mean level of the total organic carbon obtained was 3.4 ± 1.2 %. Highest and lowest levels of total organic carbon were recorded at sites DSS1 (4.8 %) and DSS6 (0.9%) respectively. Organic carbon ultimately leads to the formation of humus which plays a very important role in both aquatic and terrestrial ecosystems because it increases the cation exchange capacity of sediments and serves as an important reservoir for nutrients such as nitrogen, phosphorus and sulphur. (Table 1)

Total Organic Matter

The total organic matter of the sediment samples ranged from 1.5 % to 8.3%. The mean level of the total organic matter obtained was 6.0 ± 2.0 %. The high organic matter in the sample made it easier for aquatic plants to grow well in this stream. The normal range of organic matter obtained signified that metal in the sediments are bio available since trace metals are known to form complexes with organic matter which influences their availability. (Table 1).

Sediment Mechanical Properties

Sediments mechanical properties are of great importance because it determines the level of biological activity that can be supported by the sediments. The high percentage of silt in UPS1 could be as result of dead leaves and aquatic organisms' present in the stream. This can affect the amount of sand present in the sediment which is moderately high. The high content of clay in DSS3 could be the nature of the muddy environment in the sampling point (Table 1).

Soil Texture

Natural soils are comprised of soil particles of varying sizes. The soil-size groups, called soil separates, are sands (the coarsest), silts, and clays (the smallest). The relative proportion of soil separates in a particular soil determines its soil texture. Texture is an important soil characteristics because it will, in part, determine water intake rates (infiltration), water storage in the soil, the ease of tilling the soil, the amount of aeration (vital to root growth), and will influence soil fertility. For instance, a coarse sandy soil is easy to till, has rapidly and easily loses plant nutrients which are drained away in the rapidly lost water. High-clay soils (over 30%) have very small particles that fit tight together, leaving little open space, which means there is little room for water to flow into the soil. This makes high-clay soils difficult to wet, difficult to drain, and difficult to till.

% Clay

The range level of the clay in Omi-Asoro sediment is 1.4 % to 21.4%, the mean value is 9.8 ± 6.7%. DSS3 has the highest value of clay and this helps in water retaining capacity. Just a little water can percolate, while that of UPS2 has the lowest % clay; hence it has the lowest water retaining capacity. (Table 1).

Variation in the Heavy Metal levels of Omi Asoro Stream Sediments.

Cadmium levels in sediment 0.08 mg/kg to 1.01 mg/kg. The cadmium mean level of 0.4 ± 0.3 mg/kg was found to be accumulated in the sediment of Omi Asoro stream, and this was compared with the Tolerable Effect level (TEL) and Probable Effects Level (PEL) as guidelines for sediment quality established by USEPA of (0.68 mg/kg and 4.21 mg/kg). The level was also compared with sediment quality guidelines cited by Salomons and Forstner and USPHS of 1 mg/kg (Table 3). The overall cadmium level was found to be lower than these limits (Table 2). A linear positive correlation exists between cadmium and other heavy metals in the Omi Asoro stream sediments and cadmium exhibits a strong positive correlation with cobalt, zinc and manganese (r = 0.729, 0.718 and 0.779 respectively) at $p<0.01$ (Table 4). ANOVA showed that F statistical (0.275) is less than F critical (4.737) for the concentration of cadmium at the upstream, discharge point and downstream sediment. Hence there is no significant difference in the distribution of the metal.

The cobalt levels ranged from 0.14 mg/kg to 5.93 mg/kg and the average level of 3.00 ± 1.70 mg/kg for sediment of the Omi Asoro stream respectively. (Table 2)

However, highest level of Co was obtained in the sediment at the downstream. A linear correlation exists between cobalt and other heavy metals in the Omi Asoro stream sediment. This indicates that cobalt exhibits a strong positive correlation with manganese (r = 0.885) and moderate correlation with chromium (r = 0.542) at $p<0.01$(Table 4). ANOVA showed that F statistical of (6.480) is higher than F critical of (4.737) for the concentration of cobalt at the upstream, discharge point and downstream sediment. Hence there is a significant difference in the distribution of the metal.

The level of nickel in the sediments obtained ranged from 1.48 mg/kg to 29.5mg/kg and the average level is 6.5 ± 8.5 mg/kg. Comparison with TEL and PEL sediment quality standards set by USEPA of (15.9 mg/kg and 52.8 mg/kg) and the sediment quality guidelines cited by Salomons and Forstner and USPHS of (45 mg/kg to 65 mg/kg) revealed that the Ni level in the present study is low (Table 3). The highest level is found downstream of 29.5 mg/kg (Table 2.). A linear positive correlation exist between nickel and other heavy metals in the Omi Asoro sediment and it indicates that nickel exhibits a strong positive correlation with manganese and lead (r = 0.847 and 0.824) and a weak correlation with zinc (r =0.441) at p<0.01 in (Table 4.). ANOVA showed that F statistical of (0.152) is less than F critical of (4.737) for the concentration of nickel at the upstream, discharge point and downstream sediment. Hence there is no significant difference in the distribution of the metal.

It has been documented in the USEPA sediment quality guidelines for PEL that Zn concentration must be greater than 271mg/kg for it to be contaminated. All the concentration of Zn in the sediments was lower than this limit except for the UPS1 with 396 mg/kg level of Zn. This may be as a result of the use of fertilizer and pesticide for the farming activities being practiced around the sampling point. The overall average concentration of 158 ± 102 mg/kg of the Omi Asoro stream obtained was also higher than the sediment quality guideline levels of < 100 mg/kg presented by Salomons and Forstner and USPHS (Table 3.). A linear positive correlation exist between zinc and other heavy metals in the Omi Asoro sediment and it indicates that zinc exhibits a moderate positive correlation with manganese (r = 0.629) and a no correlation with chromium (r = 0.063) at p<0.01 in (Table 4.). ANOVA showed that F statistical of (1.287) is less than F critical of (4.737) for the concentration of zinc at the upstream, discharge point and downstream sediment. Hence there is no significant difference in the distribution of the metal.

The level of lead accumulated in the Omi Asoro sediment falls within the range 0.38 mg/kg to 16.8 mg/kg with an average value of 4.75 ± 5.13 mg/kg. This level is less than the (TEL) and (PEL) level of 30.2 mg/kg and 112 mg/kg established by USEPA, and the permissible limit of 20 mg/kg to 30 mg/kg of the sediment quality guidelines cited by Salomons and Forstner, and Abdo and Nasharty (2010) in (Table 3.). A linear positive correlation exist between lead and other heavy metals in the Omi Asoro sediment and it exhibits a strong positive correlation with chromium (r = 0.953) and a moderate correlation with manganese (r = 0.651) at p<0.01 in

(Table 4.). ANOVA showed that F statistical of (1.135) is less than F critical of (4.737) for the concentration of lead at the upstream, discharge point and downstream of the sediment. Hence there is no significant difference in the distribution of the metal.

The level of Cr in the sediments ranges from 0.98 mg/kg to 20.2 mg/kg with an average level of 13.0 ± 10.0 mg/kg (Table 2.). The USEPA (TEL and PEL) maximum permissible limits are 52.3 mg/kg and 160 mg/kg. The Chromium level in the sediment obtained from this present study is far below this limit (Table 2.). A linear moderate positive correlation exist between chromium and manganese in the Omi Asoro sediment ($r = 0.521$) at $p<0.01$ in (Table 4.). ANOVA showed that F statistical of (1.135) is less than F critical of (4.737) for the concentration of chromium at the upstream, discharge point and downstream of the sediment. Hence there is no significant difference in the distribution of the metal.

The level of manganese accumulated in the sediment of Omi-Asoro ranged from 270 mg/kg to 2190 mg/kg with an average level of 840 ± 651 mg/kg (Table 2). A linear correlation does not exist between manganese and other heavy metals in the Omi-Asoro sediment. ANOVA showed that F statistical of (0.236) is less than F critical of (4.737) for the concentration of manganese at the upstream, discharge point and downstream of the stream sediment. Hence there is no significant difference in the distribution of the metal.

RECOMMENDATION

It will be recommended that further studies and monitoring will be useful to ascertain and to assess future effects on the anthropogenic input on other environmental matrices like fauna and flora in the Omi-Asoro Stream, Ilesa, Osun State, Nigeria.

CONCLUSION

The presence and position of heavy metals in the sediment of Omi-Asoro streams has shown significance difference in their distribution. The results obtained shows that the trend in the distribution of the heavy metals in the sediment might be to the untreated or partially treated discharge of effluent into the Omi-Asoro. The sediment is vulnerable to pollution and these can affect the growth of both Fauna and Flora in the environment.

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