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EVALUATION OF HEAVY METALS STATUS IN WATER FROM OKAMINI STREAM IN OBIO/AKPOR, RIVERS STATE, NIGERIA

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Abstract
The contamination/pollution status of surficial water is an issue of global concern. Water samples collected from Okamini Mini Stream were subjected to heavy metals investigation using an atomic absorption spectrophotometer. The result obtained gave mean metals values in mg/L as; Mn (0.382±0.103), Pb (0.829±0.502), Cu (0.815±0.398), Cd (0.022±0.015), Ni (1.590±0.651), Cr (1.32±1.369), Fe (1.457±0.876), Zn (1.353±1.234), As (0.060±0.093) and Co (0.183±0.147). The values obtained from the stream indicated that the levels of the examined metals except Cu and Zn were above the WHO requirement for drinking water. Contamination factor analysis specified that the amount of the metals in surficial water on an individual basis are at variable degrees of pollution except Cu and Zn which are present at contamination levels. Pollution load assessment showed that the water from all examined points was slightly polluted by heavy metals. The contamination degree valuation of the heavy metals revealed the values to be > 32 in all the stations, which showed a very high contamination degree. Modified degree of contamination values were found to fall within the range of 9.336-37.974 (very high degree of contamination - ultra-high degree of contamination). The values of the metals indicated a water system greatly interfered with anthropogenic activities and made the water unhealthy for home purposes.

Keywords: Heavy metals, surface water, pollution indices, contamination, anthropogenic activities

Introduction

Environmental pollution has become a concern of the government, institutions, non-governmental organizations (NGOs) and individuals. Water pollution equally a type of ecological pollution is causing a great alarm to man. Like clean air, it is hard to find quality or clean fresh water (Srivastava, 2008). Water is significantly central to the continued existence of all types of life on the globe, and the quality of water is of utmost significance for aquatic organisms. With population explosion, urbanization and upsurge of industrial activities, water pollution by municipal, agricultural and industrial sources has become a serious concern for the welfare of humanity (Dara, 2005).

According to Horsfall and Spiff (2013), dumping of home, municipal and industrialized wastes into surface water namely; streams, lakes, and rivers has been the main anthropogenic source of pollution of surface water. Anthropogenic activities have largely changed the pristine nature of the water, land (soil) and air environments since the creation of the earth. The proliferation of industries and increasing use of chemicals such as pesticides and synthetic fertilizers in agriculture have enormously resulted in the release, distribution and availability of harmful wastes into the environment. Pollution of the aquatic milieu by way of heavy metals is a global question (Sekabira et al., 2010). These metals are persistent, highly toxic, and abundant and can bioaccumulate, as well as biomagnify in living things (Horsfall & Spiff, 2013; Sarala & Uma, 2013; Lentech, 2019).

Several industrial, agricultural, municipal and domestic activities release various heavy metal pollutants such as Mn, Pb, Cu, Cd, Ni, Cr, Fe, Zn, As, Co and others in wastewater effluents, which eventually find their way into the superficial waterfronts such as streams, watercourses and lagoons (Horsfall & Spiff, 2013). The anthropogenic input of heavy metals as pollutants to the aquatic environment results in water pollution as they adversely affect the quality of water by changing its physicochemical composition and nature, impairing the usefulness of water and damaging marine biota (Dara, 2005; Srivastava, 2008; Sarala & Uma, 2013). These heavy metals do not undergo degradation and continue in the environs and can become bioavailable and toxic to biota, and beyond acceptable limits, they can adversely affect human health and cause ecological risk via food chains from the aquatic ecosystems (Ekpo & Obi, 2017). According to Doss et al (2012), effluents of chemical industries such as metal, electro-plastic mining, finishing and tanneries contain heavy metal pollutants like Pb, Cu, Zn, Hg, NI, Cr, etc. Heavy metals contaminants in aquatic ecosystems can kill fish and other aquatic living things (Singh & Kalamdhad, 2011).

Water is described as polluted if it is impaired and unfit for intended use or for any purpose it is needed (Kobo & Baba, 2004; Edori & Kpee, 2018). Water pollution is a threat to global health. Water pollution can result from natural and anthropogenic means including leaching of soils, weathering of rocks, suspension of spray particles from the atmosphere, agronomic run-offs, many other human-based activities like quarrying, processing of raw materials, the usage of metal centred materials and landfills (Adeyemi & Awokunmi, 2010; Edori et al., 2016).

Surface water for instance streams, rivers, lakes, ponds, seas, and groundwater (boreholes and wells) can be contaminated by various sources like pesticides, agricultural activities, faeces, discharges and industrial effluents (Udosen et al., 1990; Edori & Kpee, 2018), thereby degrading water quality for domestic, agricultural and industrial uses. Anthropogenic sources of heavy metals in aquatic ecosystems also include fossil fuel combustion, atmospheric precipitation or deposition, sewage wastewater and industrial discharges (Linnik & Zuberiko, 2000; Campbell, 2001; Lwanga et al., 2003; Sekabira et al., 2010; Idrees, 2019). Sarala and Uma (2013) classified the origin of different sources of heavy metals in various water bodies to include the terrigenous source (weathering and erosion), biogenic source (organism decays), authigenic (from seawater), volcanogenic source, terrestrial or cosmogonies, and anthropoid source (from humanoid undertakings) due to automation, expansion, food production, and exploitation of natural assets (energy and excavating investigation). Effluents of chemical industries such as finishing and electroplating, metal, battery manufacturing, tanneries and mining contain heavy metals which are named among the major pollutants of surface and groundwater (Cheng, 2003; Chen, 2006; Doss et al., 2012; Wang, 2012; Festus et al., 2016).

The people dwelling near and using the water bodies polluted by human activities must be made aware of the detrimental effects on health stemming from the use of water from such sources. The effects can be regrettably destructive on humans and other forms of life. The local communities settling along the natural water bodies do use it routinely for different purposes like washing, bathing and agricultural activities (Hajisamoh, 2013). Consequently, this work was undertaken to define the status of heavy metals in surface water from Okamini Stream in Obio/Akpsor, Rivers State, Nigeria.

Materials and Methods

Sampling for Heavy Metals

Pre-acid rinsed plastic sample bottles were used to collect the water samples. The plastic vials were first washed using laundry detergent and allowed to dry. The dried bottles were rinsed with 0.1M HNO_3 and allowed to dry. The vessels were cleanly washed by the water at the point to be taken two to three times before filling them with the water (Beyene & Berhe, 2015; Odoemelam et al., 2019). The water samples were collected from designated sample points at undisturbed areas in the streams upstream, midstream and downstream between the hours of 7.00 am to 9.00 am. The sample vials were immersed into the water to a distance of 30 cm to full and capped while inside the water to prevent air from entering into the sample.

Preservation of the water samples was done to maintain the reliability of the water for test before analysis by adding 5ml concentrated nitric acid per litre of samples immediately collected to reduce adsorption of metals on the walls of the sample bottles (Ogbuneke & Ezeibeanu, 2020) and/or to prevent loss of metals and microbial growth such as fungi and bacteria (Harvey, 2016), and to preserve the metals and also to avoid precipitation (Kar *et al*., 2008). The acid-treated water samples were immediately transferred into iced pack containers transported to the laboratory and stored at 4 ^oC in a refrigerator for further processing and analysis (Ikpe *et al*., 2016; Ogbuneke & Ezeibeanu, 2020).

Preparation of Water Samples for Heavy Metals Determination

50cm^3 of water samples were digested using a mixture of three acids (HNO_3, HCl and H_2SO_4) in the ratio of 5:3:2 in a steam bath. The samples were heated until they became clear and colourless. The samples were made up to the initial 50 cm^3 with deionized water.

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Analysis of Samples for Heavy Metals

The digest obtained was used for the analysis of the metals: Fe, Zn, Cu, Cr, Pb, Cd, Co, As, Ni and Mn using a solar thermo atomic elemental absorption spectrophotometer (Model SE- 71906). The characteristic wavelengths used for the determination of the metals were set differently depending on the hollow cathode lamp used and the digested samples were directly aspirated into an air-acetylene flame (Sekabira et al., 2010). The calibration of the instrument was done by the analysis of known concentrations of heavy metals. To minimize error during the analysis, a blank was run after every 10 samples had been analyzed. This was done to check the instrument's performance and effectiveness. Each metal was examined thrice in a given sample and the results were expressed as mean ± standard deviation (Sehgal et al., 2012).

Pollution Assessment for Heavy Metals

The following assessment indices: Contamination factor, pollution index, contamination degree and modified contamination degree were used to assess the extent or level of pollution of the water by the heavy metals.

Contamination Factor/Pollution Index

The contamination factor and pollution index were used to describe the pollution/contamination of water. The contamination factor is a single-factor examination of individual metals, while the pollution index is a concerted or combined assessment model establishing the grade of contamination/toxicity of all the heavy metals under investigation.

The contamination factor was calculated from the expression:

$$\text{Contamination factor } (C_f) = \frac{Cm}{Cb} - \qquad (1)$$

Where Cm = metal content in adulterated water,

Cb = baseline value of metal or highest suggested value of the metal in water.

The pollution index (PI) was evaluated by means of the method projected by Tomilson et al. (1980).

The PI is stated mathematically thus:

$$PI = (CF_1 \times CF_2 \times CF_3 \times \text{------} \times CFn)^{1/n} \qquad (2)$$

Where CF = Contamination factor, n = total amount of metals (ten in the present study).

The implication of intervals of contamination factor/pollution index and contamination index was interpreted from Table 1.

Table 1: Intervals and Implication of Contamination/Pollution Index

CF/PLI	Significance
<0.1	Very slight contamination
0.10-0.25	Slight contamination
0.26-0.5	Moderate contamination
0.15-0.75	Severe contamination
0.76-1.00	Very severe contamination
1.1-2.00	Slight pollution
2.1-4.0	Moderate pollution
4.1-8.0	Severe pollution
8.1-16.0	Very severe pollution
>16.0	Excessive pollution

Adopted from Lacatusu (2000)

Degree of Contamination (Contamination Degree), C_d

Contamination degree is a multiple assessment model which was intended originally to define the sum of the individual contamination factors of the tested metals. It is intended to make available an extent of the grade of total or general impurity in a sample or an environment (Sarala & Uma, 2013). It was projected by Hakanson (1980) to ascertain the combined extent of contamination of an environment by the number of examined metals. The contamination degree is mathematically expressed as:

$$CD = \sum_{i=I}^{n} C_F \quad (3)$$

Or

$$CD = CF_1 + CF_2 + CF_3 + \text{-------------} + CF_n \quad (4)$$

Where, CD = Degree of contamination
C_F = Contamination factor of the specific metal
n = The total of heavy metals explored
The interpretation of the intervals of values for contamination degree is given in Table 2.

Table 2: Interpretation of Intervals of Contamination Degree

Classification of CD	Contamination Level
CD < 8	Low contamination degree
8≤CD<16	Moderate contamination degree
16≤CD<32	Considerable contamination degree
CD > 32	Very high contamination degree

Modified Contamination Degree (mCD or m C_d)

The modified degree of contamination was used for the estimation of the total degree of contamination at any particular location. It is the summation of all the individual contamination factors for a particular group of poisons or contaminants over the number of investigated chemicals or contaminants (Sarala & Uma, 2013). It was suggested by Hakanson (1980). The mathematical expression for mCD is given as;

$$mCD = \frac{1}{N} \sum_{i=I}^{N} C_{F1} \quad (5)$$

Or

$$mCD = \frac{\sum CF_i}{N} = \frac{CF_1 + CF_2 + CF_3 + -------------+ CF_N}{N} \quad - (6)$$

where, N = Numeral quantity of elemental components examined
i = ith chemical (or poison) and
CF = Contamination factor
The interpretation of the values of mC_d is given in Table 3.

Table 3: Classification and Description of mCD

Classification	Description/Interpretation
mCD < 1.5	Nil to very low degree of contamination
1.5 ≤ mCD < 2	Low degree of contamination
2 ≤ mCD < 4	Moderate degree of contamination
4 ≤ mCD < 8	High degree of contamination
8 ≤ mC_d< 16	Very high degree of contamination
16 ≤ mCD <32	Extremely high degree of contamination
mCD ≤ 32	Ultra-high degree of contamination

Results

The results of heavy metals in water samples from the different sample locations from the stream are given in Table 4. The concentrations of manganese in the surface water ranged from 0.272-0.476 mg/L. The mean concentration of Mn in the Okamini Stream was 0.382 ± 0.103 mg/L. the values obtained for Pb in the stream ranged from 1.321-0.318 mg/L, while the mean concentration was 0.829±0.502 mg/L.

The range of values obtained for Cu falls between 0.569-1.274 mg/L and a mean value of 0.815±0.398 mg/L. the values of Cd ranged from 0.008-0.038 mg/L and a mean of 0.022±0.015 mg/L. Ni content in the samples was in the range of 1.036-2.307-1.590±0.651 mg/L and a mean value of 1.590±0.651 mg/L. the values of Cr were in the range of 0.411-2.891 mg/L and a mean value of 1.320±1.369 mg/L.

The values of Fe detected in the samples varied from 0.597-2.349 mg/L and a mean concentration of 1.457±0.876 mg/L. The values of Zn detected in the samples varied from 0.001-2.420 mg/L and a mean concentration of 1.353±1.234 mg/L. The values of As detected in the samples varied from ND-0.167 mg/L and a mean concentration of 0.060±0.093 mg/L. The values of Co in the samples varied from 0.025-0.317 mg/L and a mean concentration of 0.183±0.147 mg/L.

Table 4: Heavy Metals Concentrations (mg/L) in surface water from Okamini Stream

Heavy Metals	Stations			**Mean ± SD**	**WHO Standard**
	1	2	3		
Mn	0.397	0.272	0.476	0.382±0.103	0.05
Pb	0.849	1.321	0.318	0.829±0.502	0.01
Cu	0.569	0.603	1.274	0.815±0.398	2.0
Cd	0.008	0.019	0.038	0.022±0.015	0.003
Ni	1.036	2.307	1.427	1.590±0.651	0.15
Cr	0.411	2.891	0.648	1.320±1.369	0.05
Fe	0.597	1.423	2.349	1.457±0.876	0.3
Zn	0.001	1.637	2.420	1.353±1.234	5.0
As	ND	0.167	0.014	0.060±0.093	0.01
Co	0.207	0.025	0.317	0.183±0.147	0.05

The results of the contamination factor of heavy metals in the Okamini Stream are given in Table 5. The contamination factors of the heavy metals ranged from 5.44 to 9.74 for Mn, 31.8 to 132.1 for Pb, 0.38 to 0.849 for Cu, 2.667 to 12.67 for Cd, 6.91 to 15.38 for Ni, 8.22 to 57.82 for Cr, 1.99 to 7.83 for Fe, 0.0002 to 0.484 for Zn, undetermined to 16.7 for As and 0.5 to 6.34 for Co.

Table 5: Contamination factor Analysis of Heavy Metals Contamination of Water Samples from the different Stations in Okamini Stream

Heavy Metals	**Stations**		
	1	**2**	**3**
Mn	9.74	5.44	9.52
Pb	84.9	132.1	31.8
Cu	0.38	0.402	0.849
Cd	2.667	6.33	12.67
Ni	6.91	15.38	9.51
Cr	8.22	57.82	12.96
Fe	1.99	4.74	7.83
Zn	0.0002	0.33	0.484
As	-	16.7	1.4
Co	4.14	0.5	6.34

The pollution index, degree of contamination and modified degree of contamination of the water from the Okamini Stream is given in Table 6. The pollution load index, degree of contamination and modified degree of contamination of the water samples from the stream varied from 1.613 to 1.811, 93.363 to 379.742 and 9.336 to 37.974 respectively.

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Table 6: Pollution Load index, Contamination degree and Modified Contamination Degree of Water Samples from Okamini Stream

Assessment Index	Stations		
	1	2	3
PLI	1.613	1.811	1.574
CD	118.947	379.742	93.363
mCD	11.895	37.974	9.336

Discussion
Heavy Metals

The investigation or valuation of the levels of heavy metals in any aquatic environment proceeding a general note gives information which reveals the appropriateness of the water for use in homes, agriculture and industries. For such results or observations to be of utmost significance to the users, they must be compared with established values from recognized institutions of national or international importance.

Manganese (Mn)
The values detected for Mn in the different sample locations in Okamini Stream were above the WHO minimum requirement of 0.05 mg/L for consumption.

The reason behind the elevated values of Mn in the stream is not unconnected with the burning of the nearby bush to the stream for farming, in which case the rains washed the metal-rich ashes into the stream, and due to run offs from the existing farms carrying Mn-rich fertilizers applied in the farms into the stream to increase the concentration of Mn in the water (Dara, 2005; Iyama & Edori, 2014).

Lead (Pb)
The observed amounts of Pb in the many points along the Okamini Stream were more than the WHO limit of 0.01 mg/L required for human intake. The high concentrations of Pb in Okamini Stream could be attributed to agricultural runoffs associated with lead arsenate pesticides and other agricultural-associated chemicals used by farmers and horticulturists cultivating the lands along the stream. Another reason may be due to heavy metal-rich leachate from a very big dumpsite at the foot of the bridge across Okamini Stream linking Elioparanwo with Egbelu, and the dust and soil from the busy Elioparanwo–Egbelu road which may contain Pb from automobile emission using leaded gasoline which are washed into the stream by rain.

The average values of Pb from the stream were greater than the average concentrations of Pb (0.11±0.01 mg/L) obtained from Nta-Nwogba Creek in Port Harcourt by Nweke and Ekpete (2003) and lower than the mean concentration of Pb (3.812±1.136 mg/L) obtained by Ekpete *et al.* (2019) in surface water of Silver River in Bayelsa State.

Copper (Cu)
Copper concentrations observed in all the stations in Okamini Stream were below the set standard limits by WHO (2.0 mg/L) and NAFDAC (1.5 mg/L) of the quantity of copper permitted in water for human intake. The concentrations of copper in the three stations from Okamini Stream ranged from 0.569-1.274 mg/L with an average value of 0.815±0.398 mg/L. The presence of copper in the water to the observed level could be due to the recent dredging of the Okamini Stream, which may have suspended particles laden with copper in the sediment to the water matrix, as well as the use of copper-containing pesticides and fertilizers by horticulturists and farmers (making use of the lands along the stream for horticulture and sustenance agriculture) which had been washed into the stream by rainfall.

The observed Cu concentrations in surface water from the streams below the set standard limits by WHO and NAFDAC agreed with the findings of Edori et al. (2019) on the concentration of Cu in surficial water of Elelenwo River, Rivers State, Nigeria.

Cadmium (Cd)
The observed concentrations of Cd in all three stations in Okamini Stream were above the WHO minimum permissible limit of 0.003 mg/L for Cd in potable water. The observed mean concentration of Cd in Okamini Stream was 0.022±0.015 mg/L. The mean concentrations of Cd in the stream were below or less than the average values of Cd (0.40±0.00 mg/L) observed by Nweke and Ekpete (2003) in Nta-Nwogba Creek in Port Harcourt.

Nickel (Ni)
The content of Ni in water from all the locations in Okamini Stream was beyond the WHO and NAFDAC limit of 0.15 mg/L for intake water. The mean concentration of Ni in Okamini Stream was 1.590±0.651 mg/L. The mean amount of Ni in Okamini Stream is more than the average values for Ni content obtained in surface water in Lagos and Ikorodu (Ogbuneke and Ezeibeanu, 2020), though the mean values of Ni obtained in Lagos and Ikorodu also exceeded the WHO limit, thus indicating Ni pollution.
The high concentration of Ni obtained from Okamini Stream may probably be connected with leachates from dumpsites that have been for years along the streams or the geologic nature of the landforms which may have washed them into the water bodies via runoffs, as well as industrial discharge of effluents.

Chromium (Cr)
The quantity of Cr in all three locations along Okamini Stream was 0.411 mg/L, 2.891 mg/L and 0.648 mg/L respectively with an average value of 1.320±1.369 mg/L. Cr concentrations in all the stations in the stream were above the WHO boundary of 0.05 mg/L.
The amount of Cr as detected in the present work exceeded the values found in drinking from water in Aliero Community in Kebbi State (Elinge et al., 2011) and in Lagos and Ikorodu in Lagos State (Ogbuneke and Ezeibeanu, 2020). The excess concentration of Cr in Okamini Stream situated at a residential and agricultural locality may be attributed to land runoffs or erosion of natural deposits (Ogbuneke & Ezeibeanu, 2020), and soaps and detergents containing chromium used for washing and bathing in the stream (Elinge et al., 2011).

Iron (Fe)
The detected content of Fe in all the locations in Okamini Stream was greater than the WHO limit of 0.3 mg/L for accessible water. The mean value of Fe in Okamini Stream was 1.457±0.876 mg/L. The amount of Fe detected in Okamini Stream was greater when compared to the average value of Fe in water reported by Elinge et al. (2011) in a stream in Kebbi State, and Ogbuneke and Ezeibeanu (2020) drinking water from different sources in the centre of Lagos. The high content or value of Fe in Okamini Stream can be ascribed to clay deposits in the area.

Zinc (Zn)
The experimental values of Zn in water samples obtained from the three stations of Okamini Stream were 0.001 mg/L, 1.637 mg/L and 2.420 mg/L. Zn concentrations in all the stations in Okamini Stream, with an average amount of 1.353±0.093 mg/L, were lesser than the WHO permissible boundary of 5.0 mg/L in drinking water.
The mean values of Zn in water samples from Okamini Stream were lower than the WHO permissible boundary for water to be consumed. They were above the mean amount obtained in some selected industrial areas in Kaduna City as reported by Imam et al. (2018).

Arsenic (As)
Arsenic was below the detection limit in station 1 in Okamini Stream, but its concentrations in stations 2 and 3 were 0.167 mg/L and 0.014 mg/L respectively with an average of 0.060±0.093 mg/L. The quantities of As in the tested locations were beyond the WHO standard for drinking of 0.01 mg/L. The high values of As in Okamini probably resulted from some agro-based chemicals such as insect repellent and stimulants used by farmers and horticulturists which were washed by runoffs into the streams.
The average amount of As concentration in sampled water from Okamini Stream obtained in the current study was greater than the concentrations of As detected in water samples from Elelenwo River, where As was not detected (Edori et al., 2019)

Cobalt (Co)
The obtained values of Co in water from the three stations in Okamini Stream are 0.207 mg/L, 0.025 mg/L and 0.317 mg/L respectively, with an average content of 0.183±0.147 mg/L. The concentrations of Co in stations 1 and 3 exceeded the WHO boundary of 0.05 mg/L, while that of station 2 was lesser than the WHO limit.
The average value determined for Co obtained in the present work is lesser than the average amount of Co observed in some water samples within Aliero Community in Kebbi State (Elinge et al., 2011) and in water samples from Elelenwo River (Edori et al., 2019).

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Pollution Indices for Estimation of Heavy Metals Pollution in Water

Contamination Factor

The calculated contamination data obtained from the sampled points in Okamini Stream when deduced on the grounds of contamination projected by Lacatusu (2000), revealed that the water samples were very severely polluted in stations 1 and 3 and severely polluted in station 2 using Mn. The samples were excessively polluted by Pb in stations 1, 2 and 3. The figures calculated for copper in the examined sample positions specified moderate impurity in stations 1 and 2, but very severe impurity in station 3. The values obtained for Cd indicated moderate pollution in station 1, severe pollution in station 2 and very severe pollution in station 3. The values obtained for Ni showed severe pollution in station 1, but very severe pollution in stations 2 and 3. The breakdown of the figures for Cd in the experimental water from stations 1 and 3 points to very severe pollution, but in station 2 showed excessive pollution. The values obtained on analysis of the water samples for Fe showed slight pollution in station 1, but severe pollution in stations 2 and 3. The values obtained for Zn showed very slight contamination in station 1, but moderate contamination in stations 2 and 3. The elucidation of the values gotten for As in the studied water samples disclosed practically no corruption in station 1, excessive pollution in station 2, but slight pollution in station 3. The values gotten for Co in the sampled positions pointed to severe pollution in stations 1 and 3 and reasonable contamination in location 2.

Pollution Index, Contamination Degree and Modified Contamination Degree of Water Samples

The pollution index is a rapid instrument for indicating and comparing the pollution levels of diverse environments/locations (Adebowale et al., 2009) as well as identifying/suggesting the input sources of the pollutants (Sekabira et al., 2010). The pollution index results from the different water samples from all the studied sites from Okamini Stream specified that all the points where samples were taken were polluted by way of heavy metals (PI > 1), suggesting inputs from anthropogenic sources.

The Hakanson (1980) grouping for the explanation and depiction of contamination degree indicated that in Okamini Stream, entire locations exhibited a very high degree of contamination.

The valuation of the result of heavy metals in the sampled water established on the adapted contamination degree estimation as anticipated by Hakanson (1980) point to stations 1 and 3 from Okamini Stream falling in the group of a very high degree of impurity, while station 2 showed an ultra-high degree of impurity.

Conclusion

The experimental figures of heavy metals content of the stream in this study indicated they are present at high concentrations. All the metals examined exceeded the WHO prerequisite for portable water except Cu and Zn. The quantity of the metals in the stream was in the order of Ni>Fe>Zn>Cr>Pb>Cu>Mn>Co>As>Cd. Pollution assessment of the surface water from the stream showed different stages of contamination to pollution via heavy metals. Consequently, the water from the stream should not be consumed by the citizens dwelling around the area. To reduce the amount of heavy metals in the stream, direct discharge of waste into the stream should be discontinued. The wastes from nearby abattoirs, poultry farms and the drainage system into the stream should be adequately managed through constant monitoring and this should be coupled with suitable enlightenment of the local dwellers on the best possible ways to dispose of waste. This will help to forestall increased input of heavy metals into the stream.

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