Environmental variables and benthic macroinvertebrates of Temidire Stream associated with an oil depot, Ibadan, southwest Nigeria

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Abstract

Streams are often recipients of pollution from agricultural, domestic and industrial sources though they are important sources of water supply and habitats of several aquatic species. Regular monitoring is required to protect this fragile but important ecosystem. Therefore, some physico-chemical parameters and macroinvertebrate assemblages of Temidire Stream, a perennial stream that flows through the Nigeria National Petroleum Corporation (NNPC) depot and Temidire community in Apata, Ibadan metropolis were investigated in order to determine the pollution status of the water and sediment and its impact on the biological community. Water and sediment samples were collected from five stations in the stream and from an adjacent stream monthly between August, 2019 and January, 2020 for physico-chemical parameter and benthic macroinvertebrate analyses. Dissolved oxygen, conductivity and total dissolved solids (TDS), and pH were determined *in situ* using EXTECH EC400 and C933 pH meters, respectively. Heavy metals were determined by atomic absorption spectrophotometry. Benthic macroinvertebrates were collected by kick sampling method. The results showed that TDS and conductivity of station 1 differed significantly from the other stations ($p < 0.05$). The concentrations of Pb, Ni and Cd exceeded the recommended levels for surface water and Pb and Cd in water and sediment correlated mostly with PC 1. The average Igeo class for the heavy metals in all the stations was >2 indicating uncontaminated to moderately/heavily contaminated sediment. Ninety-six (96) individuals of macroinvertebrates from seven families and six orders were encountered and aquatic insects were dominant (75%). Taxa richness (0-0.82) and diversity (0-0.59) were lower in all the stations compared to the control site. Exceedance of WHO limits by some heavy metals and paucity of macroinvertebrates, especially pollution-sensitive species in the stream suggests that it is polluted. Regular monitoring of the stream is advocated to minimize pollution.

Keywords: Benthic macroinvertebrates, heavy metals, petroleum products depot, sediment, surface water.

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Introduction

Oil is known as "the blood of industry" and is the world's most important power fuel and chemical raw material (Zhou *et al* 2006). Because petroleum products are flammable, there is need of extreme attention in their storage and transportation (Zhou *et al* 2006). Oil transfer depot is an important node for loading, unloading, transporting and temporary storage of petroleum products, which plays a connecting role between different modes of transportation (Shen and Mu 2018). Oil and petroleum product storage facilities are direct sources of environmental pollution (Gayrabekov *et al* 2020). In the process of "large" and "small" tank breathing and vapor evaporation, atmospheric air pollution occurs (Gayrabekov *et al* 2020). Pollution of soil, ground, surface and groundwater is mainly associated with sewage, storm and meltwater containing petroleum products formed by leaks from processing facilities (Gayrabekov *et al* 2020). Leaks of petroleum products lead to large losses, therefore, oil depots that store petroleum products, based on the sanitary standards of industrial process engineering, can be attributed to the first harm class to the environment (Yakovlev 1987).

Nigeria has been exploring and exploiting crude oil for decades and the consequences of the oil- producing and processing have become highly problematic in the onshore and offshore installations (Uzoekwe and Ogbosanine 2011). The Nigeria National Petroleum Corporation (NNPC) is vested with the exclusive responsibility for upstream and downstream development, which entails exploiting, refining, and marketing Nigeria's crude oil.

The NNPC has evolved different strategies for effective distribution of refined products to different parts of the country. Nigeria has 5000 kilometres of pipeline network, twenty-one (21) storage depots and nine LPG depots (NNPC 2020). The NNPC depot that is located in Apata, Ido Local government area of Oyo State supplies refined petroleum products to consumers in Oyo State

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and some other southwestern states in Nigeria (Adewuyi and Olowu 2012). This depot located in the outskirt of Ibadan is now surrounded by residential estates due to increase in population and urbanization. (Adewuyi and Olowu 2012) showed that the level of total petroleum hydrocarbon, oil, grease, Pb, Cr, Ni, Cu, Cd and Zn in surface and ground water around the NNPC depot were above the World Health Organization (WHO) and National Environmental Standards and Regulations Enforcement Agency (NESREA) recommended permissible limits. This could pose serious, environmental and health hazard.

The proper balance of physical, chemical, and biological properties of water in streams, ponds, lakes and reservoirs is an essential ingredient for successful production of all forms of aquatic life (Mustapha 2005; Ayoade *et al* 2006; Idowu *et al* 2013; Abednego and Ayoade 2016). However, declining water quality due to environmental perturbations threatens the stability of the biotic integrity and therefore hinders the ecosystem services and functions of aquatic ecosystems (Anene 2005; Olanrewaju *et al* 2017).

Heavy metals are toxic, carcinogenic, and could be bioaccumulated in tissues of aquatic organisms and at toxic levels could damage cells and organs (Erasmus *et al* 2020). Furthermore, these metals could be transferred and biomagnified through the food chain to higher trophic levels (Erasmus *et al* 2020). Mercury, Pb, and Cd are comparatively the most toxic heavy metals and are non-degradable naturally (Dewi *et al* 2015).

Benthic macroinvertebrates are potential bioindicators of water quality as they provide the clear picture of past and present health conditions of aquatic bodies (Mir *et al* 2021). The ubiquitous distribution, life cycle of considerable duration, high accumulating capacity and sedentary nature of benthic macroinvertebrates make them a great tool in assessing the health condition of aquatic ecosystems (Mir *et al* 2021). The aim of this study is to examine the effect of the effluents from the NNPC oil depot in Apata on the physico-chemical parameters and benthic macroinvertebrates of Temidire Stream.

Materials and methods

Study area

Temidire Stream is a perennial stream, which flows through the NNPC oil depot (latitude 07°23′26.9′ N and longitude 03º49′02.3′ E) located at Apata, Ido Local Government Area of Ibadan, Oyo State, southwestern Nigeria (Figure 1). The stream flows through the depot and then through the Temidire community (which is a residential area) to join the Odo Ona stream. Temidire stream also receives water from other tributary streams within the community. The climate of the area is characterized by rainy (April-October) and dry (November-March) seasons (Odekunle 2004). For this research, five sampling stations (Figure 1) were selected along the stream outside the depot.

Sampling stations

Station 1 is along the tributary stream, which is adjacent to the Temidire stream. The station's grid coordinates are latitude 007º23′26.05812″N and longitude 03º49′52.1238″E. This point station serves as a putative reference point to all the other sampling points because effluents from the depot does not flow there. It is a shallow stream used as a dumping ground for wastes coming from residential homes. Station 2 is along the Temidire stream (latitude 007º23′43.45692″N and longitude 03 º49′27.99552″E). The location is surrounded with vegetation and there is a nearby solid waste dumping ground. Station 3 (007º23′42.33012″N and longitude 03º49 25′.536″E is about 1km upstream of station 2 immediately after the wooden non-motorable bridge. The location is surrounded by trees at the bank and substratum is sandy. Station 4 (latitude 007º23′ 40.98588 ″N and longitude 03º49′ 20.02188‴E) is about 1km upstream of station 3. The sampling area is surrounded by trees with clear water, poultry cages are located close to this station. Station 5 is located upstream at the point of discharge from the depot just behind the fence of the NNPC depot. The station's grid coordinates are latitude 007º23′39.01812″N and longitude 03 º49′15.7788″ E.

Water sampling and analysis

Water samples were collected and analysed monthly from August, 2019 to January, 2020 at each station. *In-situ* measurements of the surface water temperature with mercury-in-glass thermometer, pH with portable pH meter (Consort C933), and dissolved oxygen (DO), conductivity, and total dissolved solids (TDS) with electrochemical meter (EXTECH EC400) were done at the study stations.

Water samples were collected in three replicates from each site in 200ml sterilised plastic bottles. These bottles were taken to the laboratory in an ice-packed cooler box for further analyses. Surface water samples were analysed for heavy metals (Pb, Ni, Mn, Cd, and Cu) following the methods of APHA (2012). The heavy metals in water were quantified using atomic absorption spectrometry after sample acid digestion.

Sediment analysis

Three replicates of sediment samples were collected monthly from each sampling station using the sediment hand sampler (0.1m diameter). These samples were thoroughly mixed to form integrated samples. The integrated samples were placed in sterilized polyethylene bags and transported to the laboratory. At the laboratory, sediment samples were air-dried at room temperature and brought to a relatively homogenous state by thorough mixing. The samples were then passed through a 0.5mm

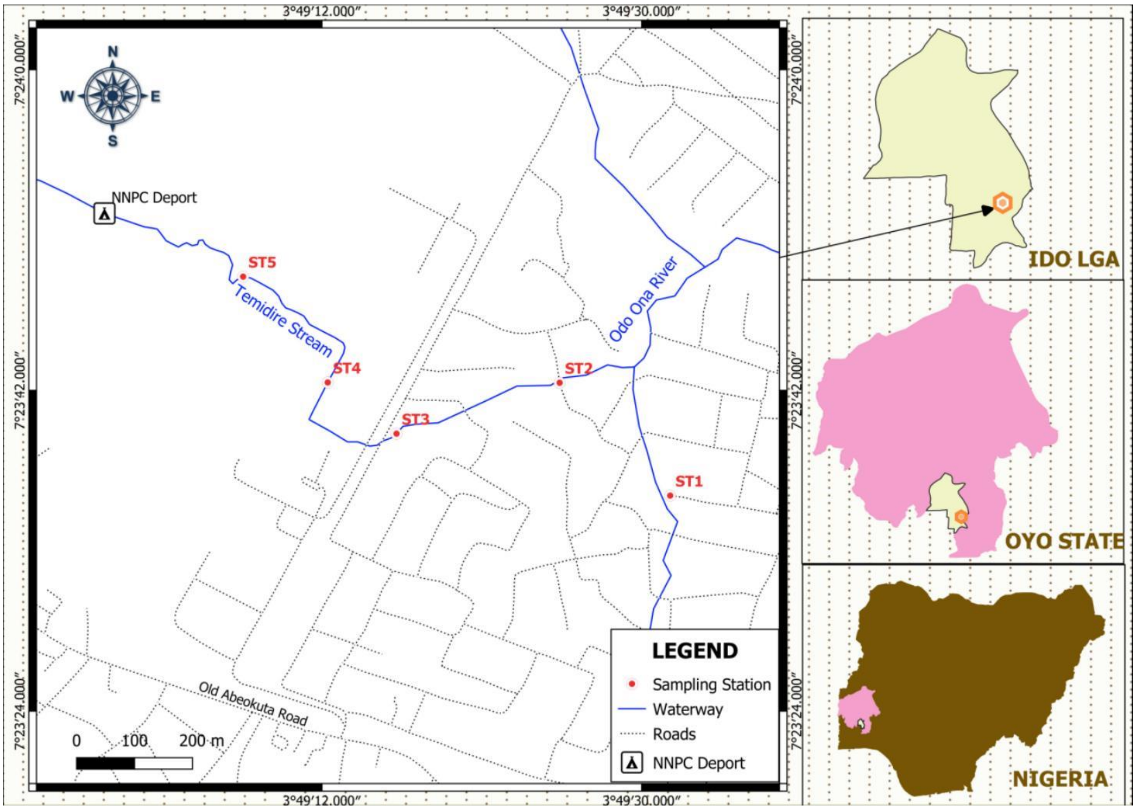

Figure 1. Map showing Temidire Stream and the sampled stations with insert of maps of Ido LGA, Oyo State and Nigeria

sieve to extract fine particles (Salomons and Forstner 1980; Herr and Gray 1997). The samples were oven-dried at 65ºC for 48 hours, digested and the heavy metals (Pb, Ni, Mn, Cd, and Cu) concentrations were analysed using atomic absorption spectrometry (APHA 2012).

Geoaccumulation index was calculated using the formula proposed by Müller (1969) as follows:

Igeo = log2 Cn/1.5Bn

Where, Cn = measured concentration of heavy metal in sediments, Bn = geochemical background concentration of the metal (n) in the Earth's crust.

According to Turekian and Wedepohl (1961), 1.5 = background matrix correction due to terrigenous effect.

There are seven classes of geo-accumulation index ranging from 0-6 (background concentration to extremely contaminated): less than zero, < 0 (Class 0) is background concentration, 0-1 (Class 1) is uncontaminated to moderately contaminated , 1-2 (Class 2) is moderately contaminated, 2-3 (Class 3) is moderately to heavily contaminated, 3- 4 (Class 4) is heavily contaminated, 4-5 (Class 5) is heavily to extremely contaminated, 5-6 (Class 6) is extremely contaminated reported by Shafie *et al* (2013).

Benthic macroinvertebrate sampling and identification

Benthic macroinvertebrates were collected along with benthic samples from the five sample stations with the use of a standard dip-net of mesh size 500µm, using a kick sampling method (Victor and Onomivbori 1996). The sampling time was for 10 minutes at each station per sampling visit. Samples were washed in a 500mm mesh sieve and benthic macroinvertebrates were sorted and fixed in 70% ethanol. In the laboratory, macroinvertebrates were identified using various taxonomic keys (Pennak 1978; Egborge 1995) and enumerated.

Statistical analysis

The results of the analysis were summarized using descriptive statistics and presented as means and standard deviations. Duncan multiple comparison of means was used to measure similarities of physicochemical parameters between sampling stations after analysis of variance (ANOVA). Principal component analysis (PCA) was applied to normalized data to assess associations between variables. Analysis of variance and PCA were performed using statistical package for Social Sciences (SPSS) version 20 and R-statistics (R core Team, 2017). Taxa richness (Margalef 1949), diversity (Shannon and Weaver 1949) and evenness (Pielou 1966) indices were calculated using the computer BASIC program SP DIVERS (Ludwig and Reynolds 1988).

Results

Physicochemical parameters of water

Total dissolved solids and conductivity were significantly higher at station 1 than the other stations ($p<0.05$). The pH of the stream was acidic to neutral and highest at stations 5 and 4 (Table 1). The other variables (DO and temperature) did not vary significantly between stations (p>0.05).

Heavy metals in the surface water and sediment

Surface Water

The mean concentration of Pb was highest in station 1(0.56±0.16mg/l) and least in station 2 (0.14±0.02) as shown in Table 2. Nickel concentration was highest in station 4 (0.22±0.01mg/l) and least in station 2 (0.13±0.04). Cadmium had the lowest mean value in station 1 (0.22±0.02mg/l) and the highest value in station 5 (0.43±0.39). Wide variation occurred in the Mn concentration in the study area. The least mean value of Mn was detected in station 1 (0.372±0.16mg/l) and the highest in station 5 (1.678±0.58 mg/l). Station 5 had the highest mean value (0.292±0.176 mg/l) for Cu, while station 1 recorded the least value (0.102±0.09mg/l) (Table 2). Lead, nickel and cadmium exceeded the WHO and NESEREA permissible limits in all the stations.

Sediments

The highest mean concentration (mg/g) of Pb in the sediment was in station 1 (24.98±7.74) and the lowest in station 4 (14.68±3.54). Station 3 had the highest Ni concentration (14.32±5.82). The highest concentration (mg/g) of Cd, Mn and Cu occurred in stations 4 (1.52±0.67), 2 (427.12±158.11) and 5 (15.82±15.94), respectively. Copper concentration in station 5 differed from other stations (p<0.05).

The geoaccumulation index showed that with respect to most metals analysed except Cd, the stations were moderately polluted (Table 4). However, Cd Igeo values showed that station 4 was moderately/heavily contaminated.

Table 1: Spatial Variation in the mean physicochemical parameters (range) of Temidire Stream, Ibadan, Nigeria

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	NESREA (2011)
Total Dissolved Solids (mg/l)	592.20±12.36[b] (56 –630)	368.00±50.75[a] (240–495)	377.00±64.13[a] (242–560)	367.60± 73.63[a] (212–609)	396.20±88.99[a] (221–667)	<1000
pH	6.65±0.08[a] (6.3–6.8)	5.98±0.55[a] (3.8–6.8)	6.68±0.17[a] (6.3–7.3)	6.74±0.13[a] (6.4–7.2)	6.74±0.18[a] (6.4–7.4)	6.5-8.5
Dissolved Oxygen (mg/l)	4.40±0.39[a] (3.3 – 5.5)	4.26±0.62[a] (3.0–6.1)	4.26±0.92[a] (2.5–6.6)	4.16±1.12 [a] (2.2–7.0)	4.30±1.11[a] (2.4–7.4)	≥5
Temperature (ºC)	26.10±0.58[a] (24–27.3)	26.46±0.72[a] (24–28.4)	26.88±0.72[a] (24.4–28.4)	26.78± 0.656[a] (24. 6–27.7)	27.22±0.80[a] (24.5–29.2)	20-30
Conductivity (µS/cm)	813.00±24.18[b] (760–883)	495.20±58.53[a] (347–657)	540.4±92.43[a] (345–805)	526.80±102.45[a] (346–866)	556.00±124.98[ab] (310–940)	≤1000

Means with the same superscripts across rows are not significantly different (p<0.05); NESREA: National Environmental Standards and Regulatory Enforcement Agency

Table 2: Spatial variation in the heavy metals of surface water of Temidire Stream, Ibadan, Nigeria

Metals (mg/l)	Station 1	Station 2	Station 3	Station 4	Station 5	WHO (2011) Limit (mg/l)
Lead	0.59±0.16[b]	0.14±0.02[a]	0.36±0.15[ab]	0.34±0.09[ab]	0.35±0.11[ab]	0.01
Nickel	0.14±0.05 [a]	0.13±0.04 [a]	0.15±0.03 [a]	0.22±0.05 [a]	0.23±0.05 [a]	0.02
Cadmium	0.22±0.01[a]	0.42±0.38 [a]	0.35±0.31 [a]	0.23±0.19 [a]	0.43±0.39 [a]	0.003
Manganese	0.37±0.16[a]	0.65±0.06 [a]	0.91±0.26 [a]	1.42±0.55 [a]	1.68±0.58 [a]	-
Copper	0.10±0.08[a]	0.13±0.10 [a]	0.15±0.11 [a]	0.12±0.12 [a]	0.29±0.18 [a]	2.00

Means with the same superscripts are not significantly different across rows (p<0.05); WHO - World Health Organization.

Table 3: Spatial variation of heavy metals in sediment of Temidire Stream, Ibadan, Nigeria

parameters (mg/g)	station 1	station 2	station 3	station 4	station 5
lead	24.98±7.74 [a]	16.98±4.16 [a]	22.11±8.42 [a]	14.68±3.54 [a]	17.83±5.90 [a]
nickel	8.11±2.26 [a]	10.32 ± 3.69[a]	14.32±5.82 [a]	10.20± 0.79 [a]	3.44±1.57 [a]
cadmium	1.27±0.57 [a]	1.42±0.66 [a]	1.43±0.59 [a]	1.52±0.67 [a]	1.16±1.44 [a]
manganese	226.06±45.95 [a]	427.12±158.11 [a]	314.30±189.16[a]	342.50±15 [a]	399.48±265 [a]
copper	3.17±1.09 [a]	4.77±2.89 [a]	4.59±3.45 [a]	5.65±2.53 [a]	15.82±15.94 [b]

Means with the same superscripts are not significantly different across rows (p<0.05)

Table 4: Index of geoaccumulation (Igeo) values of heavy metals in Temidire Stream, Ibadan, Nigeria

Station	Pb	Ni	Cd	Mn	Cu	Igeo Class
1	0.16	0.30	1.15	0.01	0.0	0-2
2	0.14	0.03	1.69	0.01	0.03	0-2
3	0.15	0.04	1.72	0.01	0.03	0-2
4	0.13	0.03	2.01	0.01	0.04	0->2
5	0.14	0.02	0.7	0.00	0.06	0-2
Mean	0.14	0.09	1.46	0.01	0.04	0-2
Bn	20	68	0.30	850	45	

Bn=Average Shale, World Geochemical Background Concentration (Turekian and Wedepohl 1961)

Principal component analysis (PCA)

Principal components 1 and 2 accounted for 65.65% of heavy metals variation in the stream water (Table 5). Manganese and Cd were the main contributory metals to PC 1, while Cu and Pb were dominant contributors to PC 2 (Figure 2). The heavy metals varied spatially and temporally (Figure 3). An overlap in September, October and November among the sites indicated no significant difference in the heavy metals concentration in these months. The concentration of heavy metals across sites in January was different from other months (Figure 3). Principal components 1 and 2 accounted for 66.18% of the variation (Table 6) in macroinvertebrate-sediment relationship. Manganese and Pb were the main drivers of heavy metal contamination in sediment in PC 1.

Composition and distribution of benthic macroinvertebrates

A total of 96 individuals distributed among seven taxa in seven families from six orders were observed (Table 6). Members of the Class Insecta constituted 71.4% of the taxa and 75% of the total individuals encountered in the study. Molluscans and crustaceans made up the rest of the fauna. The Order Odonata accounted for 5.2% (two individuals) of the macroinvertebrates collected and was encountered in Station 1 only. Hemiptera was represented by one family, Naucoridae and one taxon that constituted 13.5% of the macroinvertebrates population. Coleoptera was represented by two families, Dysticidae and Gyrinidae, represented by one taxon each. It was the order with the highest abundance as it contributed 53.1%

Table 5: Eigenvalues, percentage variance and cumulative percentage variance explained by each principal components (PC) for surface water

P C	Eigenvalue	Percentage variance	Cumulative percentage variance
1	2.07	41.47	41.47
2	1.20	24.09	65.56
3	0.89	17.80	83.36
4	0.57	11.36	94.72
5	0.26	5.28	100.00

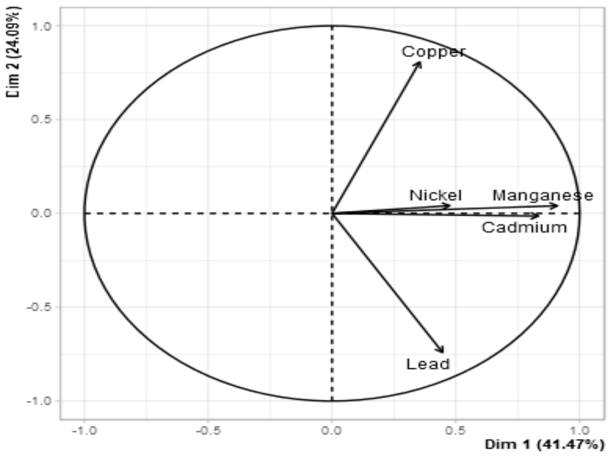

Figure 2. The ordination diagram of principal components for heavy metals in surface water of Temidire Stream, Ibadan

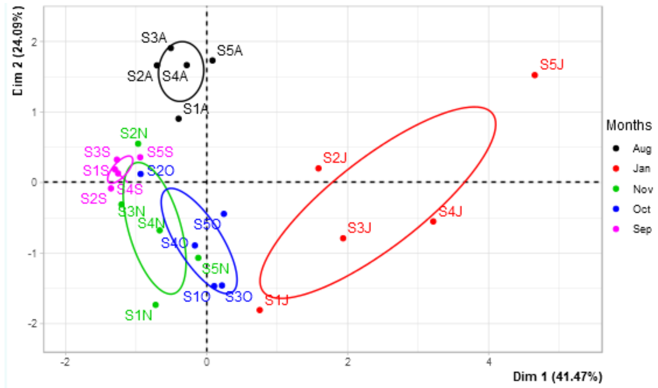

Figure 3. The ordination diagram of principal components for spatial and temporal variations in heavy metals in surface water of Temidire Stream, Ibadan, Sampling locations: S1, S2, S3, S4 and S5, A, S, O, N and J: August, September, October, November and January, respectively

Table 6: Eigenvalues, percentage variance and cumulative percentage variance explained by each principal component (PC) for sediment

PC	Eigenvalue	% variance	Cumulative % variance
1	1.84	36.83	36.83
2	1.47	29.35	66.18
3	0.83	16.50	82.69
4	0.56	11.23	93.92
5	0.30	6.08	100.00

(51 individuals) of the sampled macroinvertebrates (Figure 6). The two Coleopteran taxa were collected in Stations 1-3, while one taxon each was represented in Station 4 (*Gyrinus* sp.) and Station 5 (*Dystiscus dauricus*). *Gyrinus* sp. was the dominant taxon and it represented by 39.6% of the invertebrates collected. The Order Trichoptera had only one representative taxon, *Rhyacophilia* sp. in station 1. Molluscan was encountered only in Stations 1 and 2.

Abundance and diversity indices of benthic macroinvertebrates

The highest species abundance and richness was recorded in station 1 (78 and 7, respectively) and the least in Station 5. Station 1 had the highest taxa richness ((1.66) and Station 5 (0) the least, Shannon-Weiner's index and evenness followed similar trend (Table 7).

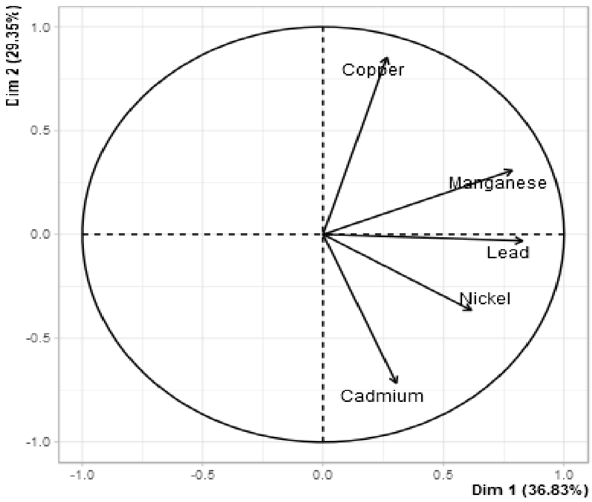

Figure 4. The ordination diagram of principal components for heavy metals in sediment of Temidire Stream

Discussion

This study showed that the water quality of Timidire Stream was poor, with low dissolved oxygen level and high levels of heavy metals (Pb, Ni and Cd). This is probably due to influx of petroleum and domestic wastes from the NNPC depot and the surrounding residences. The surface water temperature of Temidire stream was within the range obtained in previous studies for African lotic systems and fell within the permissible limit of NESREA standard (Ayoade and Olusegun, 2012; Ogbuagu *et al* 2012). Dissolved oxygen, which is necessary for respiration was low in all stations being less than 3.5mg/l in some instances although the mean DO across the stations was within the permissible limit of NESREA (2011).

Lead, Cd and Ni concentrations in the water across all stations exceeded the WHO (2011) recommended limits for surface water. The source of the heavy metals in the stream may be attributed to the nature of catchment areas, petroleum effluents from the NNPC, municipal wastes from surrounding residential homes, and agricultural runoffs as previously suggested by Adewuyi and Olowu (2012). Lead and Cd are among the priority metals that are of great public health significance because of their high degree of toxicity. They are systemic toxicants that are known to induce multiple organ damage, even at lower levels of exposure (Muhammad *et al* 2020). Manganese was also identified as a priority contaminant in the stream, exposure to elevated Mn levels through drinking water may lead to numerous adverse health effects (Frisbie *et al* 2012; Oulhote 2014; Schaefer *et al* 2020).

High values of heavy metals observed in the sediments could be due to deposition from surface water. These could have accumulated over time via complex physical and chemical absorption and dissolution pathway depending on the physico-chemical state of the surface water (Huang *et al* 2014; Bing *et al* 2016). The heavy metals in the sediment however, could be re-suspended in surface water during turbulence or enter the food chain via feeding pathway by benthic organism or benthic feeding pelagic organisms (Davutluoglu *et al* 2011).

The average Igeo class for the sediments in all the stations was 0->2 indicating uncontaminated to moderately/heavily contaminated levels (Müller 1969). The Igeo values give the advantage of not aggregating all the pollutants into one value and therefore treating each heavy metal independently, giving a good picture of the extent of individual heavy metal pollution (Shafie *et al* 2013). Thus, heavy metal contamination of the Temidire stream during this study was mostly due to Cd and Pb.

In running waters, most macroinvertebrate taxa are benthic and spend their entire life on the sediment, making them potential bioindicators of sediment quality where heavy-metal pollutions are identified or suspected (Santoro *et al* 2009; Pallottini *et al* 2015). The seven benthic macroinvertebrates taxa encountered in Temidire stream were relatively low compared to those that have been reported in some polluted tropical streams in different parts of Nigeria (Adakole and Annune 2003; Arimoro and Keke 2016). The paucity of species and the dominance by few species in our study could due to poor water quality leading to the survival of few tolerant species. We also observed that the abundance of macroinvertebrates increased spatially from station 5 to station 1.

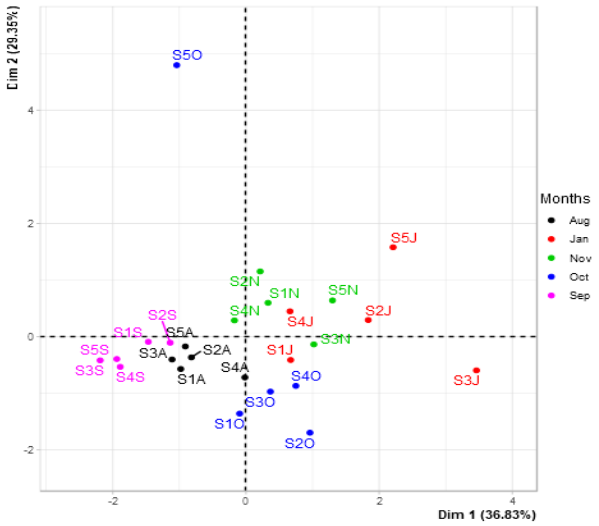

Figure 5. The ordination diagram of principal components for spatial and temporal variations in heavy metals in sediment of Temidire Stream (Sampling locations: S1, S2, S3, S4 and S5; A, S, O, N and J: August, September, October, November and January, respectively)

Table 6: Composition, abundance and distribution of macroinvertebrates in Temidire Stream, Ibadan

Taxa/Station	**1**	**2**	**3**	**4**	**5**	**Total**
ARTHROPODA	**55**	**10**	**4**	**2**	**1**	**72**
Class Insecta						
Order Odonata						
Family Aeshnidae						
Anax junius	5	-	-	-	-	
Order Hemiptera						
Family Naucoridae						
Pelocoris femoratus	13	-	-	-	-	
Order Coleoptera						
Family Dysticidae						
Dystiscus dauricus	8	3	1	-	1	
Family Gyrinidae						
Gyrinus sp.	26	7	3	2	-	
Order Trichoptera						
Family Rhyacophilidae						
Rhyacophilia sp.	3	-	-	-	-	
MOLLUSCA	**9**	**1**	**-**	**-**	**-**	**10**
Class Gastropoda						
Order Hygrophila						
Family Physidae						
Aplexa waterloti	9	1	-	-	-	
ANNELIDA	**14**		**-**	**-**	**-**	**14**
Class Clitellata						
Order Haplotaxida						
Family Haplotaxidae						
Haplotaxis sp.	14	-	-	-	-	
Total no. of taxa/species	**7**	**3**	**2**	**1**	**1**	
Total no of Individuals	**78**	**11**	**4**	**2**	**1**	**96**

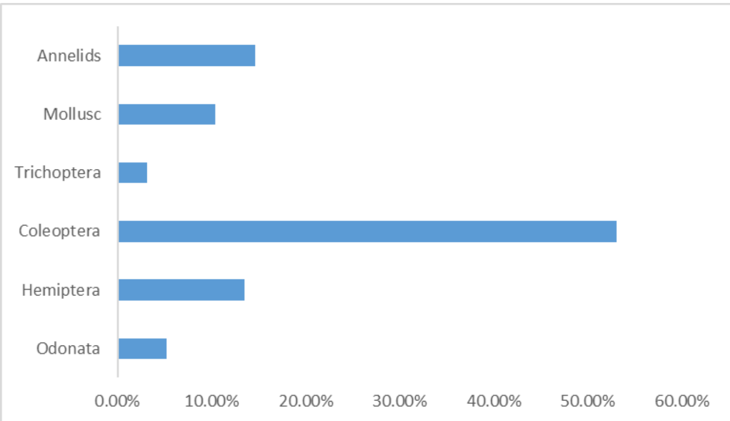

Figure 6. Percentage Abundance of major groups of macroinvertebrates in Temidire Stream

Table 7: Spatial variation in diversity indices of benthic macroinvertebrates of Temidire Stream

Diversity Indices	Station 1	Station 2	Station 3	Station 4	Station 5
No. of taxa/species (S)	7.00	3.00	2.00	1.00	1.00
No. of individuals (N)	78.00	11.00	4.00	2.00	1.00
Taxa richness (d) (Margalef's Index)	1.66	0.52	0.29	0.82	0.00
Shannon diversity (H)	1.44	0.33	0.01	0.59	0.00
Evenness index (E)	0.93	0.37	0.02	0	0.00

This is similar to the findings of Vinson *et al* (2008) that reported that the abundance of living aquatic macroinvertebrates increased along the gradient from a site of severe oil deposit to a site to low oil deposition in Gabon. Land use influences water quality along a river and often the distribution of macroinvertebrate communities (Sponseller *et al* 2001; Moore *et al* 2005).

Arthropoda, especially *Dystiscus dauricus and Gyrinus* sp. were the dominant macroinvertebrate group in Temidire stream. Similarly, Chukwu and Nwachukwu (2005) also reported their dominance in three first order streams impacted by refined petroleum spills in South West Nigeria. Furthermore, Imoobe (2008) and Arimoro *et al* (2015) reported the dominance of aquatic insects in Ologe Lagoon and a southern Nigeria stream. The dominance could be attributed to the capacity of these species of beetle to renew their oxygen supply directly from the atmosphere, so they can survive in water with poor oxygen (Merrit and Cummins 1996). According to Liao *et al* (2020), urbanisation does not reduce the capacity of ponds to support dytiscids, as the number of individuals was unchanged although some species respond negatively to urbanisation. Beetles on the whole are not unusually sensitive to water pollution compared to many other aquatic species. Some, however, are found only in clean, well-oxygenated habitats (Thorps and Rogers 2011). Arimoro and Keke (2016) also associated the abundance of these organisms in Gbako River to clean water conditions. The absence/low relative abundance of the Ephemeroptera-Trichoptera-Plecoptera taxa in all the stations suggested stressed environmental condition of the Temidire stream during the period of study. Generally, the indices and taxon/species richness were low for all the stations compared with Shannon-Wiener diversity (H) values (1.97-2.63), and evenness (E) values (0.357-0.60), obtained in Edion and Omodo Rivers in derived savannah wetlands in southern Nigeria (Olomukoro and Dirisu 2014).

Higher macroinvertebrate richness (4.14-5.85), Shannon-Wiener diversity (2.30-2.88) and evenness (0.50-0.63) were also recorded in Gbako River, Niger State (Arimoro and Keke, 2017). The low Shannon-Wiener, Margalef's and evenness indices recorded in the Temidire stream confirms the poor state of the aquatic health, which may be attributed to contamination by the heavy metals content of the effluents from the NNPC depot.

Conclusion

The water quality and macroinvertebrate assemblage of Temidire Stream have been impacted by the effluents from the Oil depot. Therefore, there should be enforcement of standard environmental management regulations within the depot to protect the aquatic health and surrounding community.

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