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Human Impact on the Water Quality and Benthic Macro-Invertebrate Compositions in Ogunpa River, Nigeria

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Human activities are important factors that affect the quality of water. The study was conducted to determine the impact of Human activities on the water quality and the Bio-diversity of the river system using benthic macro-invertebrates as indicators. Bottom samples were collected fortnightly from three sampling sites. The study showed that the majority of respondents were men and generated liquid wastes from washing of cars and motorcycles, oils from mechanic activities while the women generated solid wastes from household and domestic activities. The decomposition of such wastes had negative impact on the quality of water evident by high mean values of Biochemical Oxygen Demand (BOD) 20.79±6.82mg/l; Chemical Oxygen Demand (COD) 29.2±1.01mg/l and Nitrate 5.21±0.19mg/L and low Dissolved oxygen 6.10±0.66mg/l concentrations. Surface water temperature of 25.54ºC±0.14ºC, Phosphates 0.008±0.004mg/L and pH 7.85±0.21 were also recorded. The three sites showed significant differences ($p<0.05$) in concentration of Dissolved oxygen, Chemical Oxygen demand, Nitrate and Phosphate. The species diversity of macro-invertebrates was low and seven species namely; *Lymnaea truncatula,* L. *grabla*, *Chironomus* sp. *Tubifex* sp. Whirligig beetle larvae, Dragonfly larvae and leech were observed. The relative abundance of pollution tolerant species are *L. truncatula* (36.03%), *L. grabla* (15.35%) and *Chironomus* sp (14.70%). The study found that high values of BODCOD and high abundance of *L.*

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truncatula, a pollution tolerant macro-invertebrate indicates that the river is likely under pollution stress as a result of the negative impacts of human activities.

Keywords: Human activities; water quality parameters; bio-diversity; ogunpa River.

1. INTRODUCTION

Water quality refers to the physical, chemical and biological characteristics of water that is relative to the requirements of the biotic species composition, its diversity and physiological conditions [1]. Wastes from human industrial and municipal activities are constantly added to water bodies hence the physico-chemical quality of water is affected thereby making it unfit for use by livestock and other organisms. Since the concentration of pollutants varies with time and location, the use of diversity of macro-invertebrates (biological assessment) in assessing the water quality is best reliable unlike physical and chemical monitoring which do not detect non-point source pollution problems. Macro-invertebrates are small animals without a backbone [2] and its diversity and occurrence are governed by the physical, chemical and biological parameters of water. Some are pollution tolerant such as midges, aquatic worms and sowbugs, the nymphs of dragonflies, mayflies, damselflies and caddisflies, are somewhat tolerant to pollution; Pollution intolerant species are stoneflies, alderflies and dobsonflies and are only found in very clean rivers [3]. Based on these, macro-invertebrates can be used to calculate the water quality index of a river [2]. The high rate of Urbanization and resource consumption in Nigeria has led to increased generation of solid and liquid wastes which are discharged indiscriminately into streams, rivers and reservoirs that supply water without any treatment, affecting the aquatic bio-diversity. Based on these, there is need for constant monitoring of health status of water ways to ensure optimal benefits from it and provide information on the changes in the environment due to anthropogenic activities, thus providing warning in order that protective measures should be taken [4]. Activities such as car washing, laundry activities, mechanic activities, trading, horticulture, vulcanizing and weldering are carried out around Ogunpa River.
It is therefore essential to know the present condition of Ogunpa River by assessing the impacts of various these Human activities on the water quality and bio-diversity of the river system.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted between the month of January and March 2014. The sites was located between 7º23'13'' 3º53'9"E.Three sample sites were obtained along the riverat about approximately 400 metres equidistant and both water and bottom sediment samples were collected fortnightly. The map showing the sample sites are shown in Fig. 1.

Site 1 is at Iyana-olopa, Ashi, Bodija. The water flow slow, muddy in colour and substratum is muddy as a result from the construction activities of expansion of river course. Human activities include construction of drainage, car wash activities, auto mechanic works, and horticulture.

Site 2 is at Ayandipo Street in New Bodija Estate. The water is dark in colour and contains a lot of refuse. The substratum is rocky and dense vegetation on the surface of one part of the river. Human activities include horticulture and auto mechanic activities. The area is majorly a residential area.

Site 3 is at Tewogbade area in New Bodija estate. The flow of water is fast, clear in colour and substratum is sandy to coarse sand with a lot of pebbles. Vegetation cover is densely populated with a lot of grasses and duck weeds. The main activity is car washing. The area is also a residential area.

2.2 Impacts of Human Activities

Structured questionnaires were distributed to know the human activities peculiar to each site and its interaction with the river system. A total of 90 structured questionnaires were administered at the three sites at 30 per site.

2.3 Water Quality Parameters

The parameters analyzed were Water temperature, Hydrogen ion concentration (pH), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrates and Phosphates.

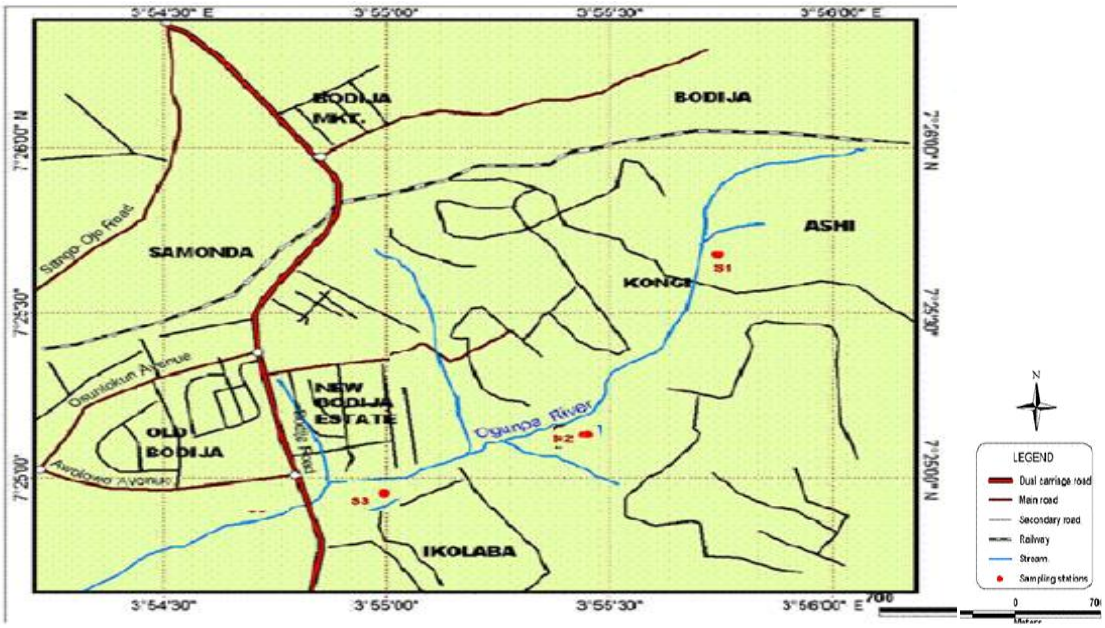

Fig. 1. Map showing sampling stations in Ogunpa River (S1-S3•)
Adapted from Ugwumba et al. [2]

Surface water temperature was measured in situ with degrees centigrade calibrated mecury-in-glass thermometer and was immersed to depth of 10mm for about two minutes as described by Atobatele et al. [5]. The pH was measured using an electronic buffered pH meter Metrohm Herisau E520. The probe was inserted into the samples and readings were taken when meter reading was steady. Dissolved oxygen content was determined using Winklers titrimetric method, as recommended by APHA, AWWA, WEF [6] and expressed in mg/L. The sampling bottle was filled to the brim and Oxygen was fixed *in situ* by adding 2ml of Winklers reagent A (Manganoussulphate solution) and B (Potassium Iodide and Sodium Hydroxide solution). A white precipitate was formed and bottle was covered immediately and transported to the laboratory for further analysis. BOD was measured titrimetrically after a 5-day incubation period. The sample was kept at 20°C in the dark to prevent photosynthesis (and thereby the addition of oxygen) for five days, and the dissolved oxygen was measured again. The difference between the final DO and initial DO is the BOD as stated by APHA, AWWA, WEF, [6]. Chemical oxygen demand (COD) was calculated using the dichromate reflux method. Nitrate and Phosphate were analyzed using a Buck Scientific Atomic Absorption Spectrophotometer (AAS). Alkalinity was also determined titrimetrically.

2.4 Bio-diversity Composition

Samples were collected one per site using a Van-veen grab of 0.5m^2 as stated by George et al. [1] and Ugwumba et al. [2]. Sediment sample was diluted with water, washed and sieved with 0.05mm mesh size. The residuals on the sieves were washed into white tray for sorting. The sorted organisms were preserved in 4% formalin. The individual organisms were identified macroscopically using the guides Stroud Water Research Center [7] sorted into various taxa and counted. The relative numerical and percentage abundance were calculated for each site. Richness (S) and Shannon-weirner diversity index (H) were calculated to determine the structure of the bio-diversity community. The Shannon weirner diversity index was calculated using the formula below:

$$H = -\sum P_i (\ln P_i)$$

Where P_i is the proportion of each species in the sample.

3. RESULTS AND DISCUSSION

3.1 Impacts of Human Activities

It was observed that there was predominance in population of males (70%) which reflected on the increased activities such as washing of cars and

motorcycles and mechanic activities. Women (30%) engaged majorly in trading activities. It was also revealed that majority (61%) of respondents emptied their wastes directly into Ogunpa River with a fraction of 62.2% of respondents generating solid wastes and 37.8% liquid wastes. There was little dependence on the river as source of animal protein (fish) to man; only 2% of respondents were fishermen. Activities such as car washing (16.7%), washing of motorcycles (11.1%), horticulture (8.9%), trading (28.9%) and mechanic activities (6.7%) (Table 1) all amounting to 72.3% posed a negative impact on the river system as evident by reduced DO, increased COD and BOD (Table 2) in some sites along the river. The results conform to the findings of Adeyemo et al. [8] in some River sediments in Ibadan city, Oyo state and Ugwumba et al. [2] in Ogunpa River at Bodija, Ibadan, Oyo state. The results showed significant difference ($p<0.05$) in DO, COD, Nitrate and Phosphate from the three sites.

3.2 Water Quality Parameters

The mean values and standard error are shown in Table 2.

The mean surface water temperature recorded (25.54°C) was within the acceptable range of 20–32°C as recommended by the Federal Environment Protection Agency [9]. It is also within the limits of 24.9–26.8ºC as mean daily minimum and maximum temperature levels as stated by Akin-Oriola, [10], Fig. 2 shows the mean monthly variations of COD from the sites. However, the mean pH value recorded 7.85 (Table 2) is similar to that observed by Atobatele et al. [5] and Ugwumba et al. [2] from Ogunpa River. The values recorded were also within the acceptable range of 6–9 as recommended by the Federal Environment Protection Act [9], Fig. 5 shows the mean monthly variations of pH from the sites. It was observed that DO content in site 1 and 2 was low and below the acceptable limit of 5-8mg/L recommended by the World Health Organisation [11] and Federal Ministry of Environment for aquatic life (Table 2), Fig. 2 shows the mean monthly variations of DO from the sites.

This can be attributed to the high rate of organic decomposition from wastes emptied into the river system as a result of human activities. Similar reports on organic pollution with marked reduction in DO levels includes that of Ugwumba et al. [2] in Ogunpa river at Bodija, Ibadan, Oyo state and also in lower Ogun river caused by organic-rich abattoir effluents. Site 3 recorded the highest DO levels which can be attributed to the fast flow of water and aeration of water by aquatic plants which constantly replenish the oxygen content of the water (Ayoade et al. [12]). The mean BOD values obtained from the river 20.79mg/L (Table 2) agrees with the findings of Atobatele et al. [5] who reported that the BOD concentration in some parts of Ogunpa River that runs through high density and industrial area of Ibadan town and areas where waste are dumped into the river are high. This was also above the standard limit of 4.0mg/L as recommended by the Federal Ministry of Environment for aquatic life. Ogunpa River is heavily polluted because it contains more than 10.0mg/l of BOD as discussed by Ugwumba et al. [2], Fig. 3 shows the mean monthly variations of BOD from the sites. The mean COD value of the river 29.20mg/L (Table 2) was above the standard limit of 20.0mg/L as recommended by the Federal Environmental Protection Agency [9]. According to the classification by Ayoade et al. [12], the COD of Ogunpa River is heavily polluted (>20.0mg/L), Fig. 3 shows the mean monthly variations of COD from the sites.

Table 1. Occupation of respondents

Occupation	Frequency	Percentage	Occupation	Frequency	Percentage
Car washer	15	16.67	Feed miller	1	1.11
Motor cyclist	10	11.11	Student	4	4.44
Vulcanizer	2	2.22	Consultant	1	1.11
Lawyer	2	2.22	Security	1	1.11
Trader	26	28.89	Welder	1	1.11
Launderer	2	2.22	Vendor	4	4.44
Fishermen	4	4.44	Bartender	1	1.11
Barber	1	1.11	Traffic warden	1	1.11
Horticulturist	8	8.89	Mechanic	6	6.67
Total	70	77.77	Total	20	22.21

Table 2. Mean values of water quality parameters of sampling stations

Water quality parameters	Site 1	Site 2	Site 3	Mean	WHO (1994)
Temperature (ºC)	25.25±l.12	25.58±0.13	25.80±0.17	25.54	21–30
pH	7.75±0.22	7.92±0.23	7.89±0.20	7.85	6.6–8.5
Dissolved Oxygen (DO) (mg/L)	3.63±0.45	4.82±1.10	9.85±0.17	6.10	5 - 8
Biochemical Oxygen Demand (BOD) (mg. DO/L)	30.02±10.26	27.66±8.67	4.7±1.52	20.79	8.5–9.0
Chemical Oxygen Demand (COD) (mg/L)	35.10±0.95	33.20±1.49	19.30±0.59	29.20	20-30
Nitrate (mg/L)	5.41±0.18	7.22±0.28	3.01±0.11	5.21	1.00
Phosphate (mg/L)	0.015±0.002	0.006±0.002	0.004±0.008	0.008	0.5

The mean Nitrate values (Fig. 4) recorded from the river, 5.21mg/l (Table 2) was high as reported by Johnson and Covich [13] who stated that levels greater than 1mg/L in not good for aquatic life. The increased levels can be attributed to the decomposition of organic effluent and waste water released into the body (Ugwumba et al. [2]). The Phosphate concentration of the river during the period of study was almost uniform for all the sampling sites; this is because phosphate wash-off from the farmlands around river banks in Nigeria (Ayoade et al. [12]). The increased phosphate level in site 1 (Fig. 4) resulted from wash-off and emptying of fertilizers from horticultural activities situated very close to the river system as compared to other sites. There was no significant differences ($P<0.05$) in Temperature, pH and BOD among the study sites while Dissolved oxygen, COD, Nitrate and Phosphate showed significant differences among the three sites (Table 3).

The result reveals that dissolved oxygen in Site 1 (Ashi, Bodija) and Site 2 (Ayandipo street) were not significantly different ($P>0.05$). However, dissolved oxygen in Site 3 (Tewogbade area), Site 1 (Iyanaolopa) and Site 2 (Ayandipo street) showed signficant differences ($P<0.05$). Similarly, Mean COD in Site 1 (Iyanaolopa) and Site 2 (Ayandipo street) were not significantly different ($P>0.05$) while mean COD for Site 3 (Tewogbade area) Site 1(Iyanaolopa) and Site 2 (Ayandipo street) were significantly ($P<0.05$) different. The mean nitrates for the three sites were significantly different ($P<0.05$). Phosphate concentration indicated significant ($p<0.05$) among the three sites.

3.3 Bio-diversity Composition and Abundance

The abundance of macro-invertebrates encountered in the river during the period of study is shown in Table 4. The sampling sites showed slight variations in abundance of major taxonomic groups. The seven taxons *Lymnaea truncatula, Lymnaea glabra, Chironomus* sp. (midges), *Tubifex* sp. (segmented worms), Whirligig beetle larva, Dragonfly larva, Leeches belonging to 5 families Lymnaeidae, Chironomidae, Tubificidae, Gyrinidae and Odonata were recorded. The highest number of organisms was recorded from site 1 with 215 individuals having 6 species and the lowest was recorded from site 2 with 199 individuals having 6 species.

Table 5 shows the relative abundance and the mollusk *Lymnaea truncatula* was the most abundant contributing 36.03% and the least was leech accounting for 1.29% (Table 3). The high presence of *Chironomus* sp and *Lymnaea* sp in a common feature of organic polluted water bodies as reported by Ugwumba et al. [2] in Ogunpa river at Bodija Ibadan, High abundance of pollution tolerant micro-invertebrates indicates the river is polluted as discussed by Ugwumba et al. [2] in Ogunpa River with high abundance of Pollution tolerant macro-invertebrates, which attributed from the negative impacts of domestic and industrial waste emptied into the river.

Table 3. Results of the LSD tests for Dissolved oxygen, COD, Nitrate and Phosphate in the three sites

	Site	N	Means
Dissolved oxygen	1	6	3.632[a]
	2	6	4.817[a]
	3	6	9.850[b]
COD	1	6	35.118[a]
	2	6	33.200[a]
	3	6	19.310[b]
Nitrate	1	6	5.410[a]
	2	6	7.220[b]
	3	6	3.010[c]
Phosphate	1	6	0.0152[a]
	2	6	0.0058[b]
	3	6	0.0035[b]

** Means with the same alphabet are not significantly different from each other*

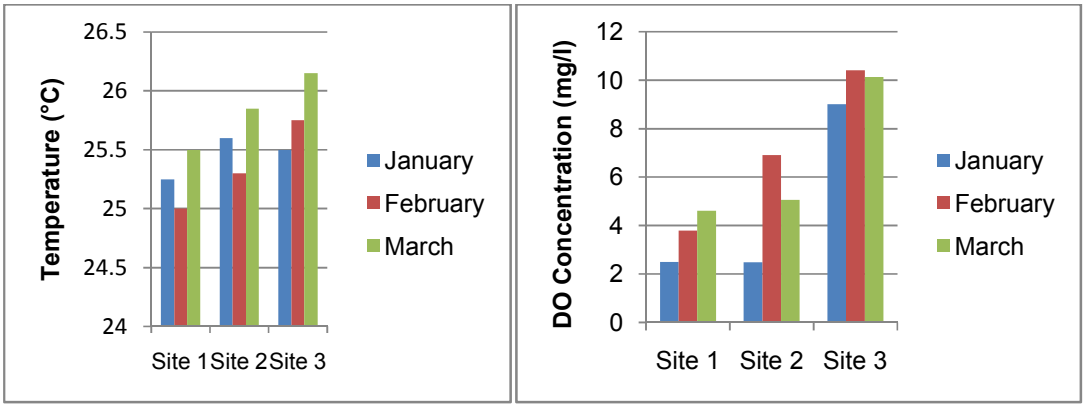

Fig. 2. Mean monthly variation of Temperature (ºC) and DO (mg/L)

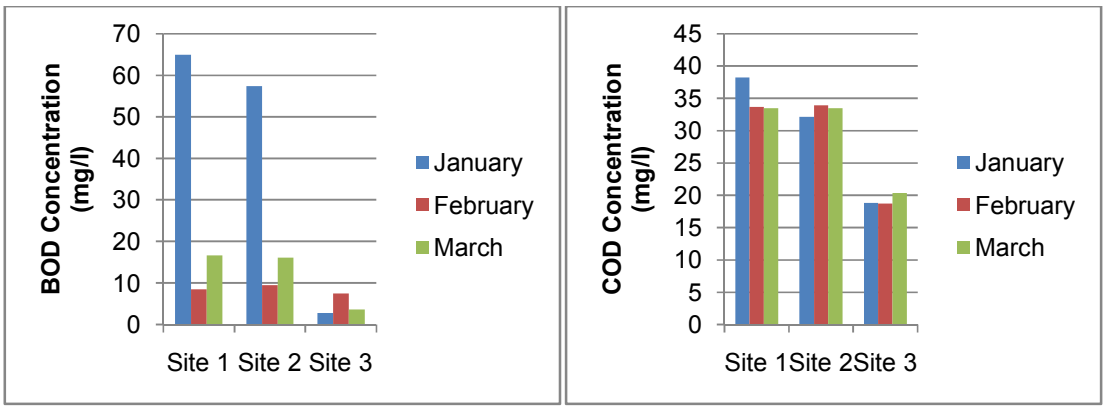

Fig. 3. Mean monthly variation of BOD and COD(mg/L)

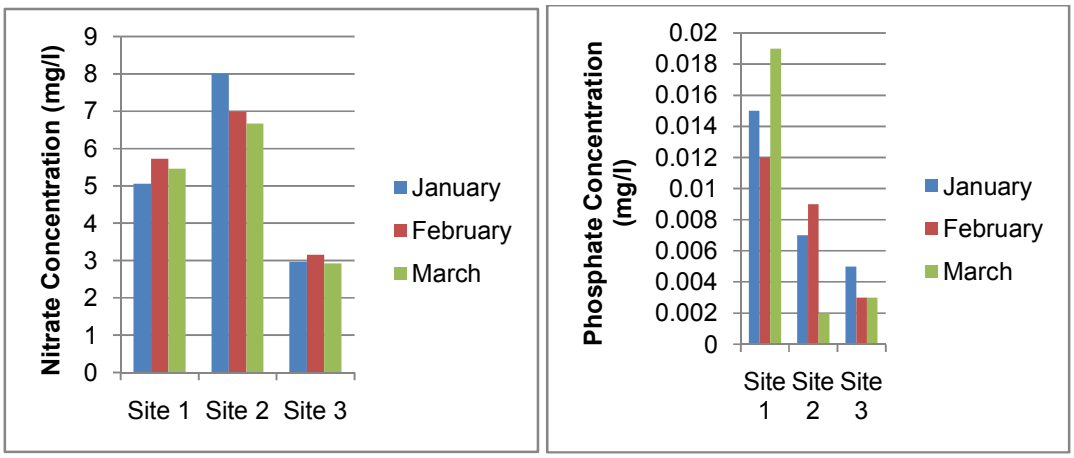

Fig. 4. Mean monthly variation of nitrate and phosphate (mg/L)

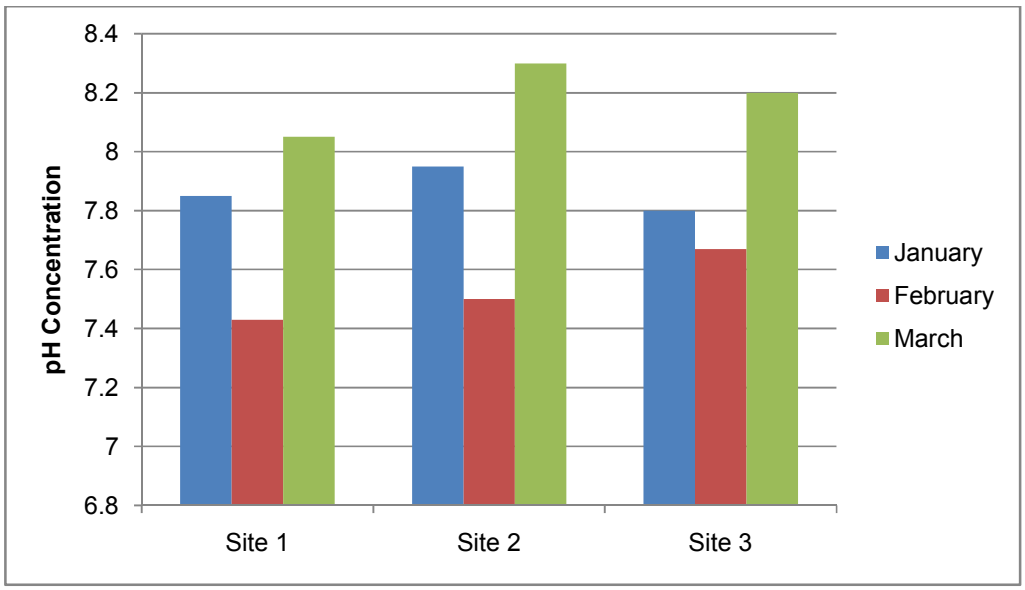

Fig. 5. Mean monthly variations of pH (mg/L)

Table 4. Total number of benthic macro-invertebrates found in each site during the period of study

Names/Taxa	Site 1	Site 2	Site 3	Total
Lymnaea truncatula	79	88	56	223
Lymnaea glabra	36	36	23	95
Chironomus sp. (midges)	39	33	19	91
Tubifex sp. (segmented worms)	32	26	83	141
Whirligig beetle larva	8	6	16	30
Dragonfly larva	21	10	0	31
Leeches	0	0	8	8
∑ (Individuals)	215	199	205	619
∑ (taxa)	6	6	6	

Table 5. Relative abundance and bio-diversity of macro invertebrates in Ogunpa river

Taxa	Total number	Relative abundance (% number)
Family Lymnaeidae		
Lymnaea truncatula	223	36.03
Lymnaea glabra	95	15.35
Family Chironomidae		
Chironomus sp. (midges)	91	14.70
Family Tubificidae		
Tubifex sp. (segmented worms)	141	22.78
Family Gyrinidae		
Whirligig beetle larvae	30	4.85
Order Odonata		
Dragonfly larva	31	5.00
Leeches	8	1.29

3.4 Shannon-wierner Diversity Indices and Evenness Relations

The diversity indices are used to analyze the bio-diversity of benthic macro invertebrates in the river. The Shannon-wierner index (H) has been the most widely used tool in community ecology (Ugwumba et al. [2]) and it expresses the species diversity of organisms. Site 1 had the highest species diversity with H value of 0.70, site 3 had 0.66 value while site 2 had the lowest H value of 0.65 (Table 6). The high value in site 1 explains that it contains more species but does not imply that the water quality is either of good or bad. This site contains more of pollution-tolerant species which indicates that the site 1 organically polluted. Evenness (E) expresses the dominance and even distribution of organisms. It ranges from 0 which indicates no evenness and 1 which indicates complete evenness. Evenness was highest at site 1 (0.39) and least at site 2 (0.36). This indicates that site 1 has the most evenly distributed number of taxa (Table 6). Richness (S) expresses the number of taxa and each sites had a richness of 6 (Table 6).

Table 6. Diversity of benthic macro-invertebrates in Ogunpa river during the study period

Diversity Indices	Site 1	Site 2	Site 3
Richness (S)	6	6	6
Diversity Index (H)	0.70	0.65	0.66
Evenness (E)	0.39	0.36	0.37
Number of individuals	215	199	205

The species richness in the study sites was low as compared with the work of Tyokumbur et al. [14] who reported a total richness of 13 taxa from a single station of Awba stream and reservoir, University of Ibadan; Ugwumba et al. [2] observed 4 taxa in Ogunpa River at Bodija and a total number of 441 benthic macroinverts.

The macro-benthic abundance and composition were low and the more dominant taxonomic groups were molluscs. This could be attributed to some ecological imbalance arising from the alterations of some important factors governing the abundance and distribution of benthic communities such as the presence of chemicals from detergents during car washing and laundry activities, wastes from horticultural activities, grease from mechanic activities all affecting the water chemistry in the study area. Dwivedi et al. [15] reported that human activities affect the water quality and immediate substrates for occupation and food availability.

It appears that the low macro-benthic invertebrate community abundance composition and diversity may have been greatly affected by stress imposed by human activities from land based pollutants such as run-offs from refuse dumps, indiscriminate dumping of refuse and chemical discharges in the study area and collaborated by Odiette [4] who recorded low macro-benthic composition in a West African creek as a result of land based pollutants.

4. CONCLUSION

This study revealed that Ogunpa River is polluted as indicated by low dissolved oxygen (DO), high BOD and COD values and the abundance of pollution tolerant benthic macro-invertebrates and these impacted on the animal protein supply (fish) of river evident by reduced dependency by man. All these resulted from the impacts of various human activities within the area on the river system such as dumping of refuse

and sewage into river, release of discharges from car washing and laundry services. Considering the current level of pollution observed from the study, the results suggest that Research Institutes, government departments and universities must work together with individuals responsible for pollution and other stakeholders, in a coordinated way in development of proper management of river system and strict adherence to waste disposal systems by humans so as to improve the quality of the river.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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