Comparative study of the macroinvertebrate community composition and water quality of Ona and Opa rivers, Southwestern Nigeria

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Abstract

Macroinvertebrate samples of Ona and Opa rivers were taken fortnightly between April and August, 2013 with the aid of a dip net of 500µm mesh size with the aim of evaluating the macroinvertebrate community composition and the water quality of the rivers. A total of 617 individuals macroinvertebrate belonging to 29 species were collected. Ona River was dominated by Chironomid larvae while Opa River was dominated by Trichoptera species. Margalef' species richness and Shannon-wiener's species diversity indices both revealed that Opa River is higher in terms of species richness and diversity. The physico-chemical parameters of the two water bodies showed a slightly marked variation, especially for Dissolved Oxygen, Conductivity and Total Dissolved Solids. Ona River was relatively lower in DO level but showed a higher TDS level than Opa River. The species composition and the water quality both indicated that Ona River is more stressed than Opa River due to greater impacts of anthropogenic activities which brought about the observed organically-induced pollution in the water body.

INTRODUCTION

All around the world, most freshwater habitats are subjected to appreciable levels of human disturbance (Saunders *et al.*, 2002). Several environmental health stressors significantly deplete the biodiversity of aquatic ecosystems. Also, freshwater habitats and their inhabitants are among the most severely impacted and environmentally threatened because these surface waters receive and amplify abuses to the landscape, including the effects of both point sources (e.g sewage and used water) and non-point sources (e.g. erosion and agricultural leaching). As a result of these anthropogenic activities, most rivers and streams in developing countries, Nigeria inclusive, are subjected to increasing pollution load, thereby depleting the quality of such water bodies.

Macroinvertebrates are important components of the aquatic ecosystem which have been used extensively to evaluate these disturbances and overall water quality of streams. Their preference as environmental indicators is based on their ability of their diversity and abundance to respond to changes in a variety of environmental variables such as sediment quality, water quality, hydrological conditions, shading and biological factors (Rosenberg & Resh, 1993; Chessman, 1995; Bonada *et al.,* 2006). Most importantly, aquatic insects are very good and most commonly used indicators of water qualities since they have various environmental disturbance tolerance levels (Arimoro & Ikomi, 2008).

In Nigeria, biological richness of aquatic macroinvertebrate fauna has not been extensively documented. Also, a review of studies on the use of macroinvertebrates for assessing the environmental health status of water bodies revealed that such studies in tropical Africa are not extensive (Ogbogu & Akinya, 2001; Dobson *et al.*, 2002; Mafuya et al., 2004; Deliz-Quinones, 2005; Arimiro & Ikomi, 2008). Ogbogu (2001) further reported that although few studies on aquatic ecosystem impairment have been done in Nigeria (e.g. Ogbeibu 1985; Ogbogu & Hassan, 1996), the number is far from being adequate. Moreover, the task of balancing the compelling demands for water use is sometimes difficult for management agencies because they lack information needed to make sound decisions, especially for fish and wildlife benefits (Ezekiel et al., 2011). Therefore, the aim of this study is to assess the water quality of Ona River, Ibadan and Opa River, Ile-Ife through the evaluation of the richness of the macroinvertebrate populations and the measurement of the physico-chemical parameters of the water bodies. This is necessary in order to determine and compare the extent of disturbance in these freshwater bodies as both sites are subjected to varying degrees of anthropogenic activities. This will further contribute to the knowledge of the use of macroinvertebrates in assessing water quality. The information gathered in this study will also serve as baseline information for management policies and for future studies on these waterbodies.

MATERIALS AND METHODS

Study Area

The study was carried out between April and August, 2013 at Ona and Opa rivers which are located in two contiguous states in southwestern Nigeria. The Ona River (Fig. 1) (07^{0} 26`N, $003^{0}$ 54`E) is in University of Ibadan, Oyo State while Opa River (Fig. 2), which drains a catchment area of 116 km and extends from longitude 04^{0} 31` to $004^{0}$ 34`E and latitude 07^{0} 21` to $07^{0}$ 35`N in Obafemi Awolowo University, Ile-Ife, is in Osun State (Ogbogu, 2001). University of Ibadan is situated about five miles (8 Kilometers) from the centre of the city of Ibadan. Ona River has characteristic aquatic vegetation growing on its surface where some macroinvertebrates like whirligig beetles do retreat (plate 1) and it is one of the two major rivers draining the city of Ibadan. As it flows through the city, it receives a lot of waste materials from industrial, agricultural and domestic sources in both organic and inorganic forms (Adjarho *et al.,* 2013). Andem *et al.* (2012) reported that the Ona river is often used as 'latrine'. The Opa River on the other hand is the major source of water to the Opa reservoir inside Obafemi Awolowo University campus. It flows southward from the reservoir's auxiliary spillway through a channel, crossing the major road to the campus and has a substratum that is made of large stone bed (Cobbles) at the upper portion and a sand at the lower portion (plate 2).

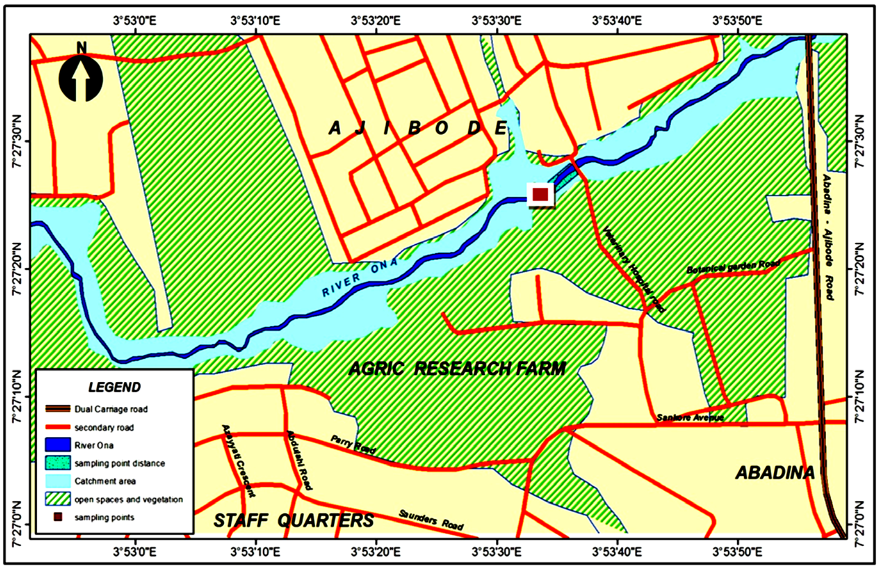

Fig 1: A section of the University of Ibadan showing the sampling station on Ona River

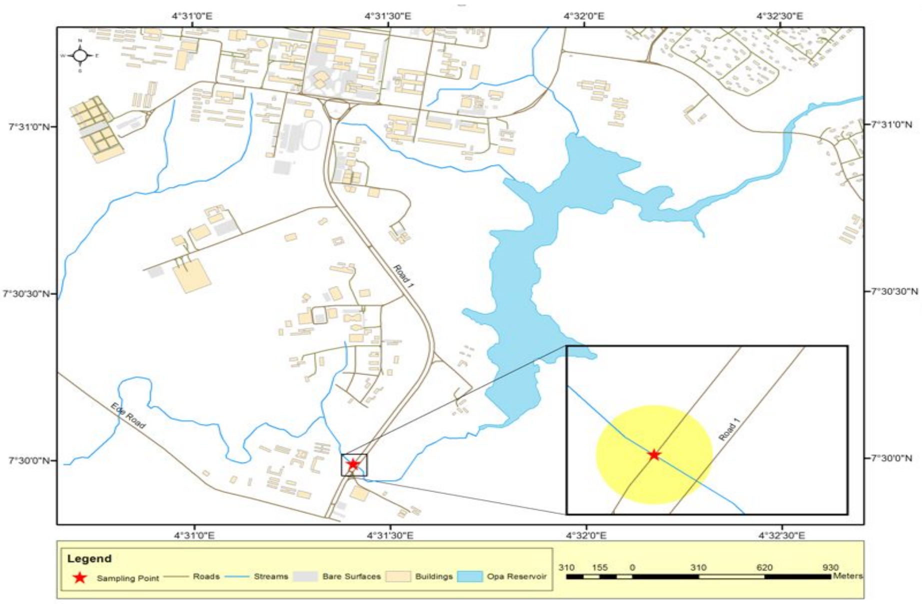

Figure 2: A section of Obafemi Awolowo University showing the sampling station (starred) on Opa River

cobble-sized stones in the sampling area and scrubbing them with a brush to collect the organisms attached to them. The stones were also generally inspected for any other remaining macroinvertebrates which were removed generally by handpicking. Sampling was carried out between the hours of 8 am-11am each sampling day. The essence of fixed timing for sampling is to avoid temporal and spatial variations in the quality of the water because the quality of the water and biota will

Collection of macroinvertebrates

Macroinvertebrates were sampled in both rivers every two weeks from April to August, 2013. A standard dip-net of 500 µm mesh size was used for the collection of the macroinvertebrates over a distance of 86 m and 69 m on Ona River and Opa River respectively, so the populations were expressed as numbers per unit area of sampling (ind/m^2). These collections were supplemented by manually turning over the

Plate 1: Ona River bed and aquatic plants growing on its surfaces.

Plate 2: Cobble-sized stony substratum of Opa River, Ile – Ife, southwestern Nigeria

vary over time.

Sorting, preservation and storage of samples

Sorting of collected macroinvertebrates was done immediately on site and in situations where sorting could not be done, the samples were washed into bowls and taken to the laboratory for sorting. The sorted samples were then put in small vials and preserved in 70% ethyl alcohol for identification.

Identification of macroinvertebrates

Identification of specimens was done using the Guide to Freshwater Invertebrates of Southern Africa (WRC, 2002/2003). Most specimens were identified to the species level but where it was not possible, identification was limited to the family level. Only whole specimens were counted to avoid the occurrence of double counting

Determination of physico-chemical parameters of the water

Water samples were collected in 1 litre sample bottles for analysis of some physico-chemical parameters of the water (Temperature, Dissolved oxygen (DO), Biological oxygen demand (BOD), pH, Conductivity, Total dissolved solids (TDS), Salinity, and Dissolved ions). The sample bottles were rinsed thoroughly with water and then dipped below the water surface. The water samples were fixed on site with preservatives to prevent changes in the intrinsic quality of the water samples. Dissolved oxygen (DO) was determined using titrimetric method with Winkler reagents. Biological oxygen demand (BOD) was calculated by subtracting DO_5 from DO_1 (i.e BOD (mg/L) = DO_1- DO_5) (DO_1- 1st day DO of diluted sample; DO5 - 5th day DO of diluted sample). Air and water temperatures were determined on site using a mercury-in-glass thermometer. The pH, Total Dissolved Solid (TDS), Conductivity, Salinity and Dissolved ions were determined on site using the consort C933 multiple parameter electrochemical analyzer.

Data analysis

Margalef's index was used to measure the species richness according to equation 1:

$$d = S -1 / \ln N \text{……..…Equation 1}$$

(Chima *et al*., 2013)

Where;

d = species richness index

S = number of species in a population

N = total number of individuals in sampled species.

Shannon Wiener's diversity index (Hs) (Equation 2) was used to measure the fauna diversity:

$$Hs = \{NlogN - EPi\ logPi\}/ N \ldots\ldots \text{Equation 2}$$

Where;

Hs = diversity index

Pi = number of individuals of a species

log Pi = natural log of Pi

N = total number of individuals in sampled species.

Pearson correlation was used to determine the relationship among the physico-chemical parameters of the water bodies.

Sorenson similarity (SS) index was calculated using the formula;

$$S_S = 2a/ (2a + b + c) \ldots\ldots \text{Equation 3}$$

Where;

a = number of species common to Opa and Ona Rivers,

b = number of species unique to Opa River

c = number of species unique to Ona River

RESULTS

The population density of macroinvertebrates recorded for the two sites was 617 individual/ m^2 Ona River and Opa River accounted for 281 ind/m2 (46%) and 336 ind/m2 (54%) individuals respectively. In Ona River, 12 species were recorded with Chironominae (Diptera) having the highest abundance with 146 ind/m^2, representing 51.95% of the total collection in the river (Fig. 3).

This was followed by Tanypodinae (Diptera) with 58 ind/m^2 (20.64%) and Tubifex worm (Oligochaetae) with 43 ind/m^2 (15.30%) individuals.

The other groups collected include Dineutus (Coleoptera) 9 ind/m^2 (3.20%), Orthocladinae (Diptera) 6 ind/m^2 (2.13%), Zygoptera (Odonata) 5 ind/m^2 (1.772%) *Physa acuta* (Mollusca) 3 ind/m^2 (1.06%) *Bulinus affricanus* (Mollusca) 3 ind/m^2 (1.06%), *Terebralia palustris* (Mollusca) 3 ind/m^2 (1.06) *Bulinus forskalii* (Mollusca) 2 ind/m^2 (0.71%), Glossophonidae (Annelida) 1 ind/m^2 (0.35%) and Pleidae (Hemiptera) 1 ind/m^2 (0.35%) (Table 1).

The 336 ind/m2 macroinvertebrates collected in Opa River are distributed in 19 species.

Trichoptera had the highest diversity and abundance (Fig. 4) with the 215 individuals belonging to 17 species. *Melanoides tuberculata* (Mollusca) occurred with the highest number of individuals with 115 ind/m^2 (34.22%) followed by *Macrostemum capense* (Trichoptera) with 100 ind/m^2 (29.76%). Other species that occurred in reasonable number include; *Athripsodes corniculans* (Trichoptera) 25 ind/m^2 (7.44%) and *Amphipsyche scottae* (Trichoptera) 17 ind/m^2 (5.05%). The least occurring species are; *Psychomyiellodes dentatus* (Trichoptera) 2 ind/m^2 (0.59%), *Hydroptilla cruciata* (Trichoptera) 2 ind/m^2 (0.59%), *Leptecho helicotheca* (Trichoptera) 1 ind/m^2 (0.29%) and *Homilia knysnaensis* (Trichoptera) 1 ind/m^2 (0.29%) (Table 2).

It is worth noting that only Molluscs and Gyrinus sp (Coleoptera) overlap between the two rivers. The Sorenson similarity index (Ss) obtained for the two rivers was 12.5%. This showed that the level of similarity is very low in terms of macroinvertebrates species composition.

In terms of diversity, Opa River had higher species richness with Margalef's index value

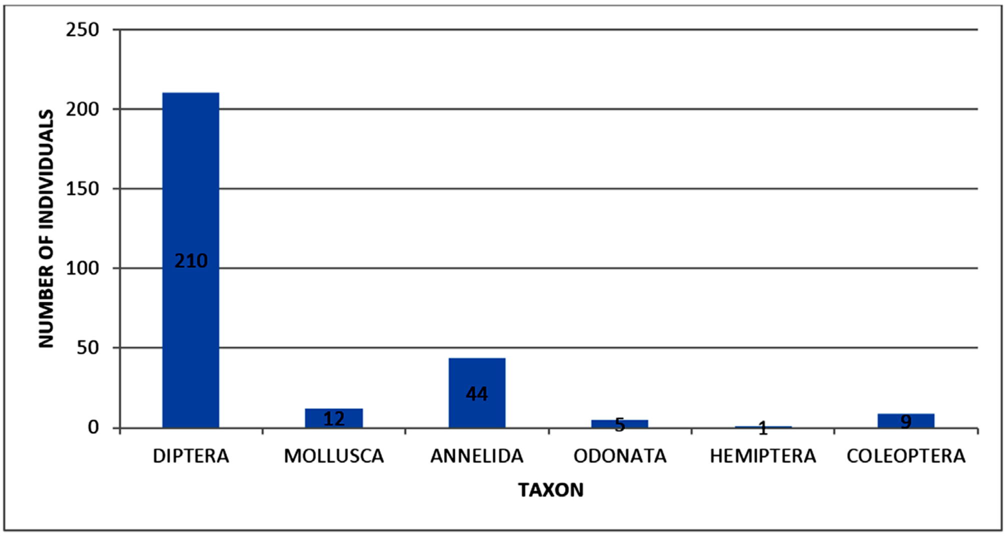

Figure 3: Population density of macroinvertebrate taxa in Ona River, Ibadan, Southwestern Nigeria

TABLE 1
Community Composition and abundance of macroinvertebrates from Ona River in Ibadan, Southwestern Nigeria

Taxon	**Population density (ind/m^2)**
Chironominae	146(51.95%)
Tanypodinae	58(20.64%)
Orthocladinae	6(2.13%)
Potamididae - *Terebralia palustris*	3(1.06%)
Planorbidae - *Bulinus forskalii*	2(0.71%)
Bulinus africanus	3(1.06%)
Physidae *Physa acuta*	4(1.42%)
Leech(Glossophonidae)	1(0.35%)
Oligochaetae (*Tubifex sp*)	43(15.30%)
Damsel fly (Zygoptera)	5(1.77%)
Pleidae	1(0.35%)
Gyrinidae (Dineutus)	9(3.20%)

of 7.52 while Ona River had 4.49. Opa River also had a higher Shannon-weiner's diversity index value of 0.87 compared to Ona River's value of 0.63 (Table 3). This is an indication that Opa River had higher species richness and diversity than Ona River.

Most of the investigated physico-chemical parameters of the two water bodies showed slight variations; TDS (Fig. 5) and conductivity (Fig.6). The pH range for Ona and Opa Rivers were between 7.69 – 8.04 and 7.19 – 8.23 respectively (Fig 7). Opa River was generally higher in dissolved oxygen and BOD than Ona River (Fig. 8). The mean dissolved oxygen for Opa River was 3.217 mg/L while that for Ona River was 2.096 mg/L (Table 4). There was a sharp drop in the dissolved oxygen concentration in Opa River after June. There

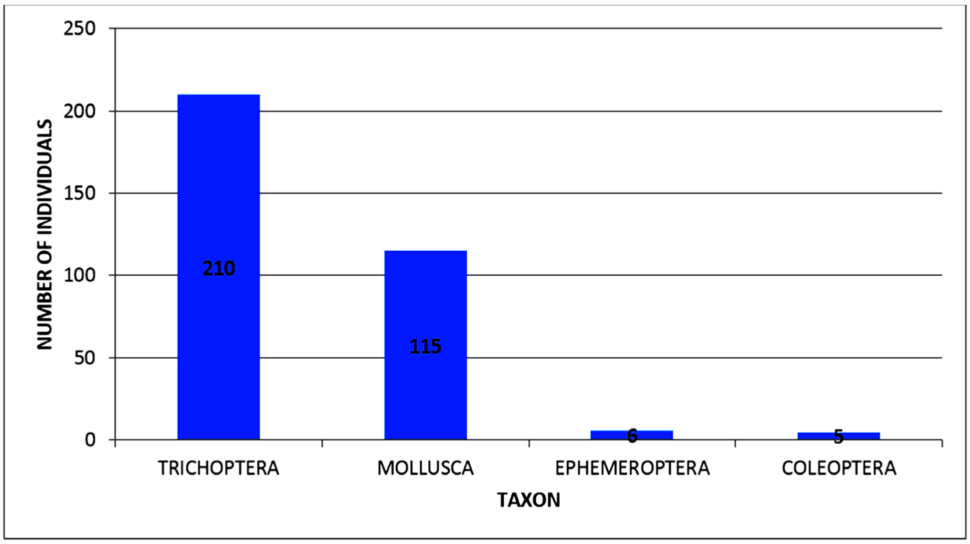

Figure 4: Population density of macroinvertebrate taxa in Opa River, Ile–Ife, Southwestern Nigeria.

TABLE 2
Community Composition and abundance of macroinvertebrates from Opa River in Ile-Ife, Southwestern Nigeria

Taxon	**Population density (ind/m^2)**
Macrostemum capense	100(29.76%)
Hydropsyche longifurca	15(4.46%)
Cheumatopsyche thomasseti	8(2.38%)
Amphipsyche scottae	17(5.05%)
Leptonema natalense	5(1.48%)
Protomacronema pubescens	3(0.89%)
Aethaloptera maxima	4(1.19%)
Sciadorus obtusus	10(2.97%)
Orthotrichia sp	3(0.89%)
Hydroptila cruciata	2(0.59%)
Ecnomus thomasseti	5(1.48%)
Psychomyiellodes dentatus	2(0.59%)
Athripsodes corniculans	25(7.44%)
Homilia knysnaensis	1(0.29%)
Trichosetodes sp	3(0.89%)
Leptecho helicotheca	1(0.29%)
Goeridae	6(1.78%)
Baetidae	6(1.78%)
Melanoides tuberculata	115(34.22%)
Gyrinidae (Gyrinus)	5(1.48%)

was no significant difference between the BODs of the two water bodies. Throughout the sampling period, the conductivity and TDS values obtained for Ona River were higher than those of Opa River (Fig. 9).

Pearson correlation analysis of the physico-chemical parameters showed significant correlation between Conductivity and TDS ($r = 0.999$, $p \leq 0.05$); DO and BOD ($r = 0.667$, $p \leq 0.05$) in Ona River. Water temperature had positive significant correlations with the following parameters; DO ($r = 0.688$, $p \leq 0.05$), BOD ($r = 0.645$, $p \leq 0.05$), TDS ($r = 0.611$, $p \leq 0.05$) and conductivity ($r = 0.607$,

TABLE 3

Community Composition of macroinvertebrates in Ona and Opa Rivers, Southwestern, Nigeria

Taxon	Ona river (Ibadan) (Ind/ m^2)	Opa river (Ife) (Ind/ m^2)	Total no of individuals/ m^2
DIPTERA	**210(74.7%)**	**0**	**210**
Chironominae	146	0	
Tanypodinae	58	0	
Orthocladinae	6	0	
MOLLUSCA	**12(4.27%)**	**115 (34.22%)**	**127**
Potamididae-*Terebralia palustris*	3	0	
Planorbidae-*Bulinus forskalii*	2	0	
Bulinus africanus	3	0	
physidae *Physa acuta*	4	-0	
Thiaridae (*melanoides tuberculata*)	0	115	
ANNELIDA	**44(15.65%)**	**0**	**44**
Leech(Glossophonidae)	1	0	
Oligochaetae (*Tubifex sp*)	43	0	
ODONATA	**5(1.77%)**	**0**	**5**
Damsel fly (Zygoptera)	5	0	
HEMIPTERA	**1(0.35%)**	**0**	**1**
Pleidae	1	0	
COLEOPTERA	**9(3.20%)**	**5(1.48%)**	**14**
Gyrinidae (Gyrinus)	0	5	
Gyrinidae (Dineutus)	9	0	
TRICHOPTERA	**0**	**210(62.5%)**	**210**
Hydropsychidae	**0**	**162**	
Macrostemum capense	0	100	
Hydropsyche longifurca	0	15	
Cheumatopsyche thomasseti	0	8	
Amphipsyche scottae	0	17	
Leptonema natalense	0	5	
Protomacronema pubescens	0	3	
Aethaloptera maxima	0	4	
Sciadorus obtusus	0	10	
Hydroptilidae	**0**	**5**	
Orthotrichia sp	0	3	
Hydroptila cruciata	0	2	
Ecnomidae	**0**	**7**	
Ecnomus thomasseti	0	5	
Psychomyiellodes dentatus	0	2	
Leptoceridae	**0**	**30**	
Athripsodes corniculans	0	25	
Homilia knysnaensis	0	1	
Trichosetodes sp	0	3	
Leptecho helicotheca	0	1	
Goeridae	**0**	**6**	
EPHEMEROPTERA	**0**	**6(1.78%)**	**6**
Baetidae	**0**	**6**	
TOTAL no of individuals	**281**	**336**	**617**
Margalef index	**4.49**	**7.52**	
Shannon-Weiner's index	**0.63**	**0.87**	

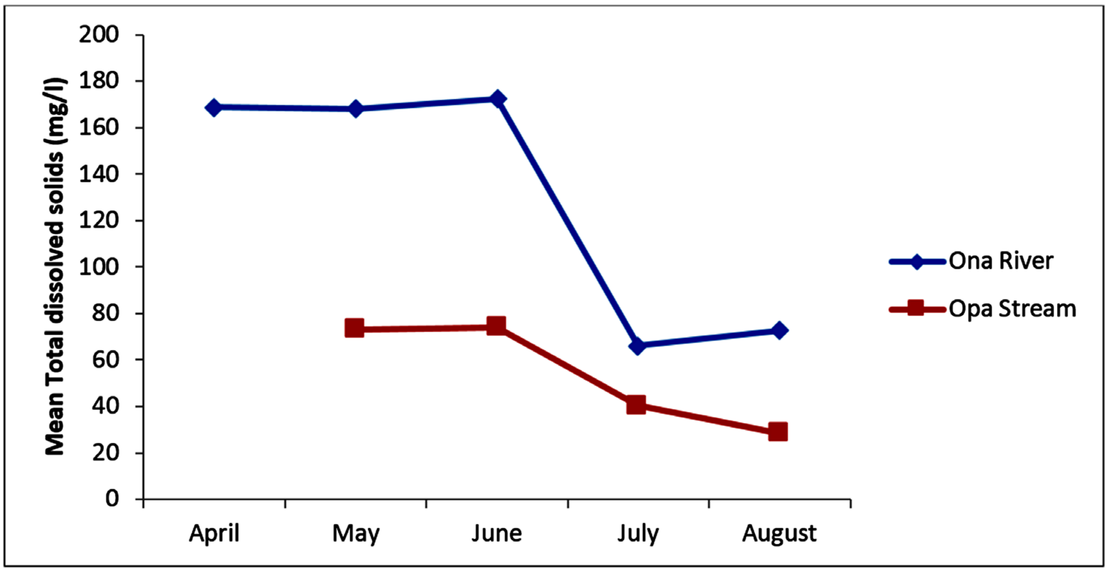

Figure 5: Mean monthly variation in TDS in Ona and Opa rivers, Southwestern Nigeria

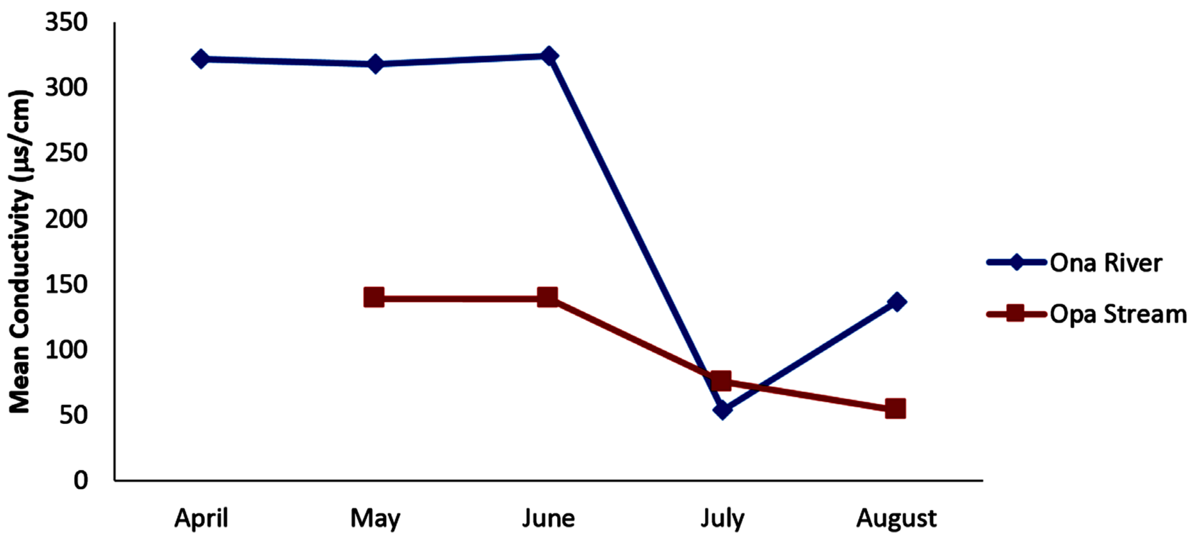

Figure 6: Mean monthly variation in Conductivity values in Ona and Opa rivers, Southwestern Nigeria

$p \leq 0.05$). In Opa River, positive significant correlations existed between DO and the following parameters; BOD ($r = 0.844$, $p \leq 0.05$), Conductivity ($r = 0.713$, $p \leq 0.05$) and TDS ($r = 0.716$, $p \leq 0.05$) (Table 4). Student t-test also revealed that there were significant differences ($P < 0.05$) in the Conductivity, TDS, Dissolved ions and Air Temperature obtained for the two rivers. Although, there were variations in the other parameters (DO, BOD, pH and Water temperature) as well but the differences were not statistically significant ($P > 0.05$) (Table 4).

DISCUSSION

Observations from the results obtained in this study indicated that there was a varying degree of anthropogenic impact on both Opa and Ona rivers. This was reflected in the values of the water quality parameters and the faunal composition of the macroinvertebrates collected from the sites. For instance, Ona

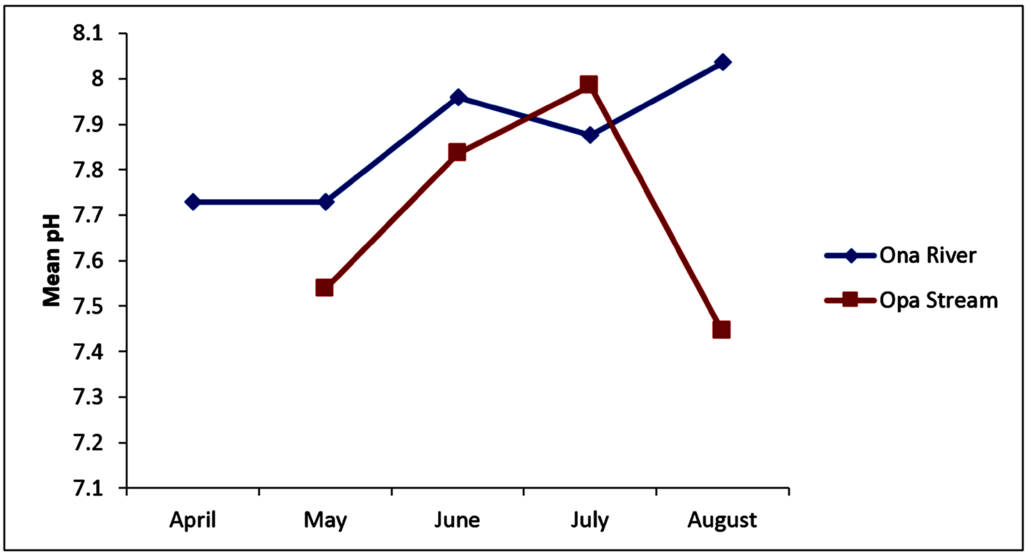

Figure 7: Mean monthly variation in pH values in Ona and Opa rivers, Southwestern Nigeria

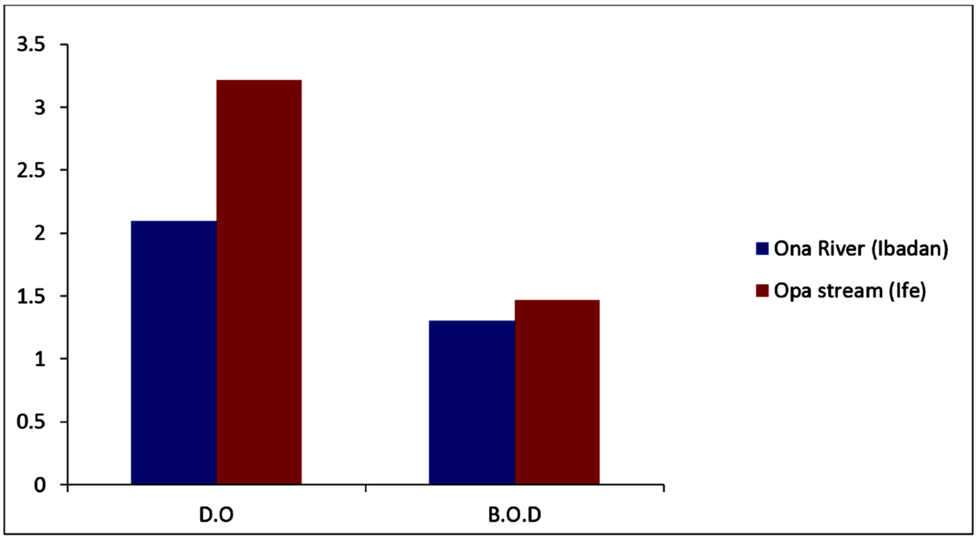

Figure 8: Comparison of the mean DO and BOD values for Ona and Opa rivers, Southwestern Nigeria

TABLE 4

Mean of physico-chemical parameters of Ona River and Opa River, Southwestern Nigeria

Parameters	Sites			
	Ona	Opa	F	p
DO (mg/l)	2.096 ± 0.53 (0.66 – 4.87)	3.21 ± 0.74 (1.2 – 6.91)	0.452	0.351
BOD (mg/l)	1.303 ± 0.47 (0.17 – 4.16)	1.47 ± 0.41 (0.18 – 4.51)	0.610	0.474
pH	7.89 ± 0.04 (7.69 – 8.04)	7.71 ±0.12 (7.19 – 8.23)	0.131	0.515
Conductivity (µS/cm)	231.19 ± 40.05 (49.2 – 337)	102.71 ± 14.45 (42.3 – 145.9)	6.764	0.036*
Salinity	0.13 ± 0.02 (0 – 0.2)	0.06 ± 0.16 (0 – 0.1)	1.032	0.512
TDS (mg/l)	129.95 ± 18.82 (25.4 – 179)	54.6 ± 7.63 (22.6 – 77.5)	2.130	0.042*
Dissolved ions	1.083 ± 0.09 (0.331 – 1.51)	3.16 ± 1.77 (1.15 – 19.1)	0.921	0.041*
Air Temperature (°C)	27 ± 1.57 (21.9 – 35)	24.87 ± 1.10 (20.2 – 31)	0.983	0.034*
Water temperature (°C)	24.79 ± 0.64 (22.4 – 28)	24.6 ± 0.605 (20.6 – 27)	0.042	0.871

*Significant at $p < 0.05$

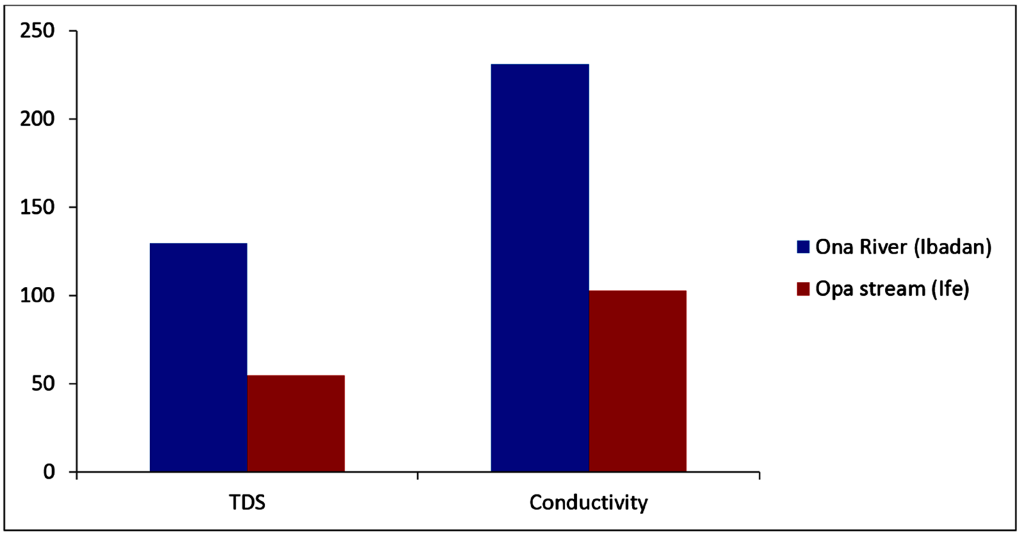

Figure 9: Comparison of the mean TDS and Conductivity values forOna and Opa rivers, Southwestern Nigeria

River was dominated by Chironomous larva (Chironominae, Tanypodinae and Orthocladinae) which have been known to be pollution-tolerant species (Tyokumbor *et al.*, 2002; Andem *et al.*, 2012). The chironomids dominated in terms of the number of species and abundance in Ona River. These species have the ability to thrive well in oxygen-depleted environments and this attribute may enhance their proliferation and dominance in such habitats (Adeogun & Fafioye, 2011). The high abundance of chironomid larva in this waterbody could probably be an indication of the poor quality of the water in terms of its relatively low dissolved oxygen content. This is a major factor that could have been responsible for their diversity and abundance of in Ona River.

Previous studies on Ona River have also reported similar findings. Andem et al. (2012) in a study on this river at the Apata area of Ibadan recorded the highest numerical abundance of Chironomus larvae. The study concluded that the presence of these species suggested organic pollution from anthropogenic sources. Also, Adjarho *et al.* (2013) in a study on the same river at Oluyole area concluded that the presence of indicator species such as Chironomus larvae was deemed a confirmation of pollution in the water from (both domestic and industrial) wastes. The Tubifex worm (Annelida) which was also reported as another relatively abundant species in Ona River is generally known to be tolerant of alkaline and anoxic conditions (Adeogun & Fafioye, 2011). In this study, the population of Tubifex sp showed significant negative correlation with dissolved oxygen (DO), implying that this organism probably had preference for extremes of organic pollution. The presence of Tubifex worms in typically low dissolved oxygen conditions such as that observed in this study may well explain its abundance alongside the Chironomus larvae. This finding corroborates Andem et al. (2012) who also reported Tubifex worm as the second highest abundant macroinvertebrate species in a study on Ona River. Furthermore, the occurrence of other pollution tolerant species such as Physa sp and Bulinus sp could be an indication of pollution from domestic waste and sewage discharged into the water as suggested by Andem *et al.* (2012). The presence of these gastropods in water bodies has been related to their wide range ability to tolerate some levels of pollution (Adeogun & Fafioye, 2011). However, the occurrence of certain members of aquatic insect orders such as; Odonata, Coleoptera and Hemiptera in this river could possibly be considered to be an indication of different levels of pollution in the water body (Popoola & Otalekor, 2011). These insect orders are known to be pollution sensitive species but their occurrence in such a waterbody deemed to be polluted is rather not strange. It could possibly be that certain areas of the waterbody are not as polluted as the other areas.

In contrast, Opa River was observed to be dominated by pollution sensitive species ranging from Trichoptera (which occurred with the highest abundance) to Ephemeroptera. The Trichoptera and Ephemeroptera larva have been known to be good indicators of habitat condition in freshwater ecosystem because they live in or on bottom sediments where exposure to contaminants and oxygen stress are more frequent (Dohet, 2002). Members of these orders have been used successfully as part of the insect orders comprising Ephemeroptera-Plecoptera-Trichoptera (EPT) index commonly used in assessments of water quality and integrity (Barbour *et al.*, 1999). The Hydropsychidae (net-spinning Trichoptera) which has been described as a somewhat pollution tolerant family occurred with the highest abundance in the river. This could be attributed to the fact that species in this family have been known to show a wider range of tolerance to climatic, physical and chemical conditions and they are more tolerant to mild pollution of various kinds than are most other Trichoptera species (MDNR, 2002). Another possible reason for the greater number of hydropsychids in Opa River is that the river is fast flowing, especially during the rainy season. The high current supports thorough mixing of the water. This is one of the conditions usually preferred by the hydropsychids as they are known to thrive well in streams with high current velocity (Mackay and Wiggins, 1978). Their high abundance can be understood when considered alongside with the existence of another somewhat tolerant species Gyrinidae (Coleoptera), which was also recorded in this study. The high occurrence of *Melanoides tuberculata* (Thiaridae) in Opa River could be attributed to their ability to thrive well in the tropical waters (Derraik, 2008) and the sandy/muddy nature of the sediment in the part of the river from where they were collected (De Kock & Wolmaran, 2009). The diversity indices calculated for the waterbodies suggested that diversity and species richness was higher in Opa River.

There were variations in the physico-chemical parameters of the rivers determined, although only four (4) of the parameters (Conductivity, TDS, Dissolved ions, and Air temperature) showed significant differences. However, most of the values obtained fell within standards and recommended ranges for tropical waterbodies. The surface water temperatures determined for both water bodies however fell within the range (21-32^{o}C) expected of tropical freshwaters (Ayodele & Ajani, 1998) and WHO stipulated range for aquatic organisms (WHO, 1984). Also, the pH values recorded for both sites fell within the WHO recommended range of 6.5 – 9.0 suitable for aquatic life (WHO, 1984). The pH range obtained for the two rivers indicated that both waterbodies were slightly alkaline. Similar reports of slightly high pH values have been made by Ogidiaka (2012) in Ogunpa River and Adjarho *et al.* (2013) on Ona River. Opa River was generally higher in dissolved oxygen and BOD than Ona River, although the differences were not statistically significant ($p < 0.05$). However, the relatively higher dissolved oxygen concentration in Opa River might have been responsible for the presence of more pollution sensitive species in the river than in Ona River which in contrast was dominated by pollution tolerant species. Low DO concentration has been known to be an indication of deterioration of water quality mainly as a result of various anthropogenic activities (Popoola & Otalekor, 2011; Yakub, 2004). Furthermore, a sharp drop was observed in the dissolved oxygen concentration in Opa River after June. This could be attributed to Carbonaceous Biochemical Oxygen Demand (CBOD) as a result of increased alga growth in the water. As the algae die and decompose, the process consumes oxygen so this could be responsible for the sharp drop in dissolved oxygen in this period (MPCA, 2009).

Although, there was no significant difference between the BODs recorded for the two water bodies. but the relatively high BOD recorded for the rivers was an indication of organic pollution in the two water bodies. Ogidiaka (2012) reported the presence of pollution indicator species in stations of high BOD in Ogunpa River. The abundance of such pollution indicator species has been reported to be a common feature of organically polluted water bodies (Ogbogu & Olajide, 2002; Tyokumbur *et al.*, 2002; Atobatele *et al.*, 2005). The mean conductivity and TDS values obtained for Ona River in this study are similar to those that have been previously recorded elsewhere along the same river (Adjarho *et al.*, 2013). Throughout the sampling period, the Conductivity and TDS values obtained for Ona River were higher than those of Opa River . The lower conductivity values recorded for Opa river could be due to the granite bedrock nature of the river bed. Granite is composed of more inert materials that do not ionize (dissolve into organic components) when washed into the water (Gupta and Paul, 2010). Whereas rivers that run through clay soils tend to have higher conductivity because of materials that ionize when washed into the water. The higher TDS values recorded for Ona river may be attributed to higher loads of organic matter from waste treatment, decaying plant and animal matters, and stirred up bottom sediment (Bhateria and Jain, 2016).

Osibanjo *et al.* (2011) pointed out that one of the most critical problems of developing countries is improper management of vast amount of wastes generated by various anthropogenic activities. Omoleke (2004) also noted that the current open and indiscriminate dumping of solid wastes in drainages and river banks is one of the most critical problems facing the city of Ibadan in which Ona river is located. The situation with Opa river is relatively better because the waterbody is located within the University campus where wastes including sewage treatment are well managed, as such Opa river does not get as much pollution load as Ona river does.

Conclusively, the species composition and the water quality of the two investigated rivers (located in the same ecological zones) have provided information on the ecological status of the two ecosystems. Although, they are both being exposed to varying degrees of anthropogenic activities, it can be deduced that Ona River is a slightly more stressed site than Opa River.

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Competing Interest

The authors declare that they have no competing interest.

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