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Preliminary Assessment of Anthropogenic Impact on Some Ecological Components of Abesan River, Lagos, Nigeria

Julius I. Agboola[1], Abiodun A. B. Denloye[2]
[1]*Department of Fisheries, Faculty of Science, Lagos State University, Lagos, Nigeria*
[2]*Department of Zoology, Faculty of Science, Lagos State University, Lagos, Nigeria*
E-mail: *jb_agboola@yahoo.com*
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Abstract

The impact of anthropogenic disturbances on water quality parameters, diversity of macrophytes and benthic macro fauna of Abesan River, Lagos, Nigeria is reported. Some physico-chemical and biological assessment were carried out at three sampling stations located at downstream (AR-1), midstream (AR-2) and upstream (AR-3) with different levels of disturbance. Results of measured physico-chemical parameters showed that there was no significant difference ($P > 0.05$) in temperature, total acidity and chloride values between the sampling stations. Although, Total solids, conductivity, DO, Sulphate, BOD and COD were significantly higher ($P < 0.05$) at Stn.AR-1 than at Stns. AR-2 and AR-3, all physico-chemical parameters measured were within the limits of the Lagos State Environmental Protection Agency (LASEPA) and the World Health Organization (WHO) regulatory standards except for high COD concentration in downstream station. Aquatic vegetation (macrophyte) diversity was relatively abundant at upstream and downstream stations, suggesting possible impact of human activities on macrophyte diversity at midstream station where highest level of disturbance occurred. Chironomid larvae were the most abundant invertebrate fauna found in all three sampling stations but more abundant at sampling station AR-2 which corresponds to point of effluent entry to river where human activities is most intense. There is evidence that anthropogenic activities impact on the water quality of Abesan River. Biotic indices such as Sorensenen's Index of Similarity and Margalef Index show that Abesan River is lightly polluted. The implications of these results and the need to monitor the water quality of Abesan River are highlighted.

Keywords: Bioindicators, Biotic Index, Anthropogenic Impact, River, Africa

1. Introduction

In the face of global environment change uncertainties, fore-knowledge on how anthropogenic activities impact on rivers and the biota they support is of importance to freshwater biologist. However, to measure anthropogenic influence on a certain ecosystem, a good knowledge of the system natural variability is a necessary requisite [1,2], which is one of the goals of this study.

In Africa, the bane of water bodies is the paucity of information relating to them and Abesan River is not an exception. Limnological studies in West Africa especially Lagos has concentrated on large water bodies such as the Lagos Lagoon [3-5] and River Sasa [6] However, there are many small rivers which study would make significant contribution to our knowledge of tropical aquatic ecosystems and the impact of anthropogenic activities on them [6,7]. Abesan River in Lagos, southwestern Nigeria, is one of such small rivers. The river is used daily by the rural folks and communities for washing, bathing, drinking, cooking and spiritual activities. It receives run-off water and effluents from nearby manufacturing industries. The foregoing points to the inadvertent introduction of pollutants into Abesan River, which could impact on the water quality as well as availability and distribution of benthic macrofauna.

Like other water bodies, they generally possess ability for self-purification when inundated with organic inclusions [8]. The mechanism of self-purification however wanes (or fails totally) with the introduction products of anthropogenic activities, among others. There is therefore deterioration in water quality.

Pollutant accumulation in lakes, rivers and other natural water bodies are hazardous to autotrophic and heterotrophic benthic organism via accumulation or biomagnifications along the food chain [9,10]. The pollutants of the Lagos water systems include inorganic such as metals from industries, detergents, organics such as sewage (including human and animal excreta), most of which are sources of water borne diseases [11-13]. Of the over 5,000 industries in Nigeria, 60% are sited in and around Lagos metropolis [14]. Many of these industries discharge their effluents without treatment through drains and canals into the nearest water bodies such as streams and rivers which flow through towns and villages. According to United State Environmental Protection Agency (USEPA) [15] healthy water bodies exhibit ecological integrity, representing a natural or undisturbed state. Alteration in water quality results in a redistribution of macro fauna in the aquatic environment. Thus, some emigrate and immigrate while others are indifferent; in which case they adapt or die.

In the assessment of freshwater bodies receiving industrial and domestic wastewaters especially rivers, chemical and biological methods are often employed. Freshwater macro-invertebrates (invertebrate animals that do not pass 0.5 mm mesh size) are one of the most popular tools in biological freshwater quality estimation. Macro-invertebrates reveal low mobility, long life-span and high diversity with respect to pollution tolerance that make them useful bioindicators. Very many investigators, over several decades, have found that there is a good relation between water quality and the presence or absence of certain benthic invertebrates depending on their sensitivities [16-18]. For an example, nymphs of the Plecoptera (stonefly) an insect family is the most sensitive to organic and other forms of water pollution of recipient rivers, lakes and streams, followed by nymphs of the Ephemeroptera (mayflies) and so on. Tubificid worms and the larvae of the midge Chironomus tolerate organically polluted waters.

The present study therefore aims to explore more explicitly the impact of human activities taking advantage of three sampling stations with different levels of disturbance in Abesan River. This will help determine how anthropogenic activities impact on the river water quality and the biota they support. There will therefore be a basis for comparison in the event of water quality changes vis a vis human use and expected growth in the number of industry.

2. Materials and Method

2.1. Study Area

Abesan River is an inland freshwater body located in Lagos, Nigeria; ~20 km off the Atlantic coast (**Figure 1**). Annual rainfall in this region occurs from April to October with a characteristic break in August [19]. Abesan River is a tributary of Ogun River with maxi- mum depth of ~3 m and flows through residential estates into the Lagos Lagoon via Ologe Lagoon. It is flanked on both sides by modified tropical rainforest vegetation made of aquatic macrophytes including *Raphia hookeri, Certophylum,* and bamboo.

2.2. Sampling and Analyses

Based on three different levels of disturbance observed in Abesan River, sampling stations- AR-1, AR-2, and AR-3 were allocated along the river course. Station AR-1 is located downstream (moderate level of human disturbance) flowing towards Ologe lagoon, whereas, Stn. AR-2 is located mid-stream (highest level of human disturbance) flowing towards AR-1 and Stn.AR-3 is located upstream as the control station (little or no human disturbance). Water and sediment samples were collected fortnightly from September to November 2000 from the sampling stations. Water samples were collected in 1.5 L plastic bottles immersed 6-10 cm into the water. Each sample was stored at 4℃ in a refrigerator prior to laboratory analysis for physic-chemical analyses. Temperature was determined in-situ using mercury-in-glass thermometer. Dissolved Oxygen and pH were determined using oxygen meter and Seibold® pH meter respectively. Other physiochemical parameters were determined at the laboratory of the Lagos State Environ- mental Protection Agency (LASEPA), Lagos, Nigeria following the methods of the American Public Health Association [20].

Macrophytes samples on water surface and riverbank were collected at each sampling station, labeled and transported for identification at the herbarium of Lagos State University.

Benthic macrofauna were obtained from sediments

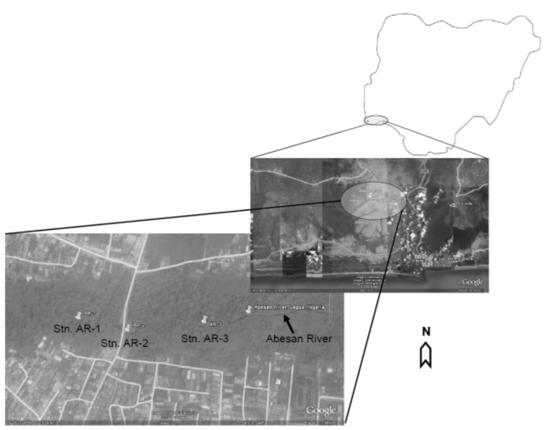

Figure 1. Map of abesan river showing stations AR-I, AR-2 and AR-3 (from Google map).

collected with D-framed aquatic net scooped at each sampling station. Each collection was transferred in a labeled polythene bag to the laboratory for sorting and subsequent identification. Each benthos was stored in specimen bottle and preserved with 10% ethanol [21] and was identified using keys provided by Macan [22].

2.3. Data Analyses

Data were analyzed to determine water quality, relative abundance of species, and species composition between sampling stations was compared. Water quality was determined by using the Biotic Index Standard table of Tuffery and Vernaux [23,24]. Relative abundance of species was determined by using Marglef's Diversity Index using the following formular:

$$d = \frac{S - L}{Log_e N} \quad (1)$$

where:

d = Community species diversity

S = Number of species

N = Total number of individuals

Log_e = Natural logarithm.

We compared species composition between the sampling sites using Sorensenen's Index of Similarity [25]. Similarity values (expressed in percentage) were calculated by comparing all stations (Stns.AR-1 and AR-2, Stns.AR-1 and AR-3, and Stns.AR-2 and AR-3) using the following equation.

For Stns.AR-1 and AR-2, Similarity Index is given as:

$$SI = \frac{2K}{A + B} \times 100 \quad (2)$$

where

A = Total Number of species common to Stn.AR-1

B = Total Number of species common to Stn.AR-2

K = Total Number of species common to Stns.AR-1 and AR-2

Differences in values of physico-chemical properties between sampling stations were determined by Duncan's Multiple Range Test following Analysis of Variance (ANOVA).

3. Results

3.1. Physico-Chemical Parameters

The three sampling stations AR-1 (downstream), AR-2 (midstream) and AR-3 (upstream) have uniform visual appearance. Water surface in stn.AR-2 (midstream) is exclusively characterized with floating debris, plastic bags, cans, and bottle. Bottom sediments at stn.AR-1 (downstream) is of coarse sandy particles, whereas, stn.AR-2 (midstream) is muddy clay mixed with sand particles and decaying plant materials. Stn.AR-3 (upstream) bottom sediment is composed of silt with decomposing plant materials.

Total Solids, Total Alkalinity, Nitrate, phosphates, Dissolved oxygen (DO), Sulphate, Chemical Oxygen Demand (COD), and Biological Oxygen Demand (BOD) showed wide variations between sampling stations (**Table 1**), whereas, trace metals—copper, Iron, and chromium showed similar trend across stations. There was no significant difference ($P > 0.05$) in temperature, total acidity and chloride values between the sampling stations. The pH (7.0) values were constant at the sampling stations. BOD (Biochemical Oxygen Demand) values ranged between 5.77 and 27.55 mgL^{-1}, dissolved oxygen (DO) values between 2.03 and 2.44 mgL^{-1} and total solid values ranged between 56 and 113 mgL^{-1}.

Although, Total solids, conductivity, DO, Sulphate, BOD and COD were significantly higher ($P < 0.05$) at Stn.AR-1 (downstream) than at Stns. AR-2 and AR-3, all physico-chemical parameters measured were within the standards set by LASEPA.

3.2. Macrophytes and Macrofauna Assemblages

Here, we gave an assessment of the macrophyte community (floras) in relative magnitude terms. Aquatic vegetation (macrophyte) diversity decreased from six species at upstream (Stn.AR-3) and downstream (Stn.AR-1) stations to four species at midstream (Stn.AR-2) station. At upstream and downstream stations, *Raphia hookeri* (Raphia palm) and Bamboo trees species were relatively abundant (**Table 2**), suggesting possible impact of human activities on macrophyte diversity at midstream station.

Also, a total of 129 benthos belonging to three phyla (Arthropoda, Mollusca and Chordata) and four taxa (Arthropoda, Mollusca, Pisces and Amphibia) were collected (**Table 3**). Macro invertebrates relative abundance was highest for *Chironomus* species (47) followed by *Rana* species (22) especially at Stn.AR-2. Macrofauna individual was highest (64) at Stn. AR-2 and lowest (27) at Stn. AR-3 (**Figure 2**).

3.3. Margalef, Sorensenen's and Biotic Indices

Species Diversity Index [26] and Similarity Index obtained in this study by deploying the Sorensenen's Index of Similarity [25] is presented in **Table 4**. Data analyses for Margalef's Index shows that Stn.AR-1 had highest species diversity, (5.74) followed by Stn.AR-2 (5.54) and Stn.AR-3 with lowest value (4.89). All systematic units collected were found at Stn.AR-2. At Stn.AR-1, *Physa* was not collected, and at Stn.AR-3 Chironomidae, Gom-

Table 1. Physico-chemical properties of Abesan River and LASEPA standards.

Parameters	Sampling Stations			
	AR-1	AR-2	AR-3	LASEPA
Temperature (°C)	28.50^a	29.00^a	28.73^a	38-40
pH	7.0^a	7.00^a	7.00^a	6.0-8.0
Total Solids (mgL^{-1})	113.00^a	56.00^b	85.00^c	2030
Conductivity (μScm^{-1})	161.40^a	43.90^b	104.1^c	Not specified
Total Acidity	11.00^a	10.00^a	9.00^a	Not specified
Total alkalinity	110.00^a	105.00^a	95.00^b	Not specified
Chloride (mgL^{-1})	12.00^a	10.00^a	12.00^a	250.00
Nitrate (mgL^{-1})	0.50^a	0.80^b	0.00^c	Not specified
Phosphate (mgL^{-1})	5.56^a	3.38^b	2.60^b	Not specified
Dissolved Oxygen (mgL^{-1})	2.44^a	2.03^b	2.24^a	> 2
Sulphate (mgL^{-1})	7.00^a	13.00^b	3.00^a	Not specified
Chemical Oxygen Demand (mgL^{-1})	110.00^a	26.00^b	57.00^a	50
Biological Oxygen Demand (mgL^{-1})	27.52^a	5.77^b	12.95^c	200
Copper (mgL^{-1})	0.12^a	0.06^b	0.03^b	< 1.00
Iron (mgL^{-1})	1.03^a	1.85^b	1.75^b	10.00
Chromium (mgL^{-1})	0.01^a	0.01^a	0.05^b	1.00

Row means bearing the same superscripts are not statistically different by Duncan's Multiple Range test ($P < 0$).

Table 2. Macrophytes (Flora) distribution at Sampling Stations.

TAXON	Sampling Points		
	AR-1	AR-2	AR-3
Raphia palm (*Daphnia hookeri*)	A	NA	A
Floating weed (*Ceratophyllum*)	O	A	NA
Bamboo tree	A	NA	D

NA: Not Available; A: Abundant
O: Occasional; D: Dominant

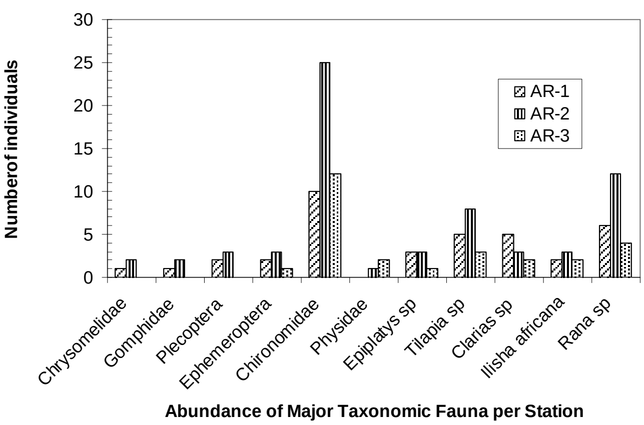

Figure 2. Distribution of biological indicators per station.

Table 3. Benthic macrofauna and systematic units collected in sampling stations AR-1, AR-2 and AR-3 in abesan river.

Taxa	Sampling Stations				
	AR-1	AR-2	AR-3	Total	Mean ± SD
Arthropoda					
Chrysomelidae	1	2	0	3	1.00 ± 0.82
Gomphidae	1	2	0	3	1.00 ± 0.82
Plecoptera	2	3	0	5	1.67 ± 1.53
Ephemeroptera	2	3	1	6	1.67 ± 1.53
Chironomidae	10	25	12	47	15.67 ± 8.14
Mollusca					
Physidae (Gastropoda)	0	1	2	3	1.00 ± 0.82
Pisces					
Epiplatys sp	3	3	1	7	2.67 ± 0.58
Tilapia sp	5	8	3	16	4.67 ± 3.51
Clarias sp	5	3	2	10	3.67 ± 1.51
Ilisha africana	2	3	2	7	2.33 ± 0.57
Amphibian					
Rana sp	6	12	4	22	6.67 ± 5.03
Number of systematic units	10	11	8	11	
Total number of individual	37	67	27	129	
Biotic index (0-10)	9 LP/UP	8 LP	8 LP		

LP/UP = Lightly Polluted or Unpolluted; LP = Lightly Polluted

phidae and Plecoptera were not collected. The upstream (control) station corresponded with lowest specie diversity index of bioindicator (pollution tolerant) organisms, suggesting a little or no occurrence of pollutants on this axis

Table 4. Ecological indices of macrofauna in Sampling Stations AR-1, AR-2 and AR-3 in Abesan River.

Statistics/Indices	Sampling Stations		
	AR-1	AR-2	AR-3
Number of individuals	37	64	27
Number of species	10	11	8
Margalef's index	5.74	5.54	4.9
Biotic index	9	8	8
Compared stations	AR-1 and AR-2	AR-1 and AR-3	AR-2 and AR-3
Sorensenen's index	0.95	0.89	0.84
Similarity index (%)	95	89	84

of Abesan River where little or no human disturbance occurred.

The biotic index calculated for sampling stations AR-1, AR-2 and AR-3 shows values of 9, 8, and 8 respectively (**Table 4**). This result is based on the biotic index standard table [23]. According to the biotic index interpretation table, sampling station AR-1 is lightly or unpolluted, whereas, Stations AR-2 and AR-3 are slightly polluted.

4. Discussion

This study assesses the impact of anthropogenic disturbances on water quality parameters, diversity of macrophytes and benthic macro fauna of Abesan River, Lagos, Nigeria. Results of measured physico-chemical parameters from sampling stations AR-1, AR-2 and AR-3 indicate that Abesan River is only lightly polluted and concentrations are within the WHO [27], FEPA and LASEPA regulatory standards. Thus, in accordance with the classification of polluted rivers earlier advanced [28] and cited [29], analyzed data shows that Abesan River is slightly polluted (beta mesosaprobic). This further corresponds with the calculated biotic index for the three sampling station (**Table 3**), which shows that the Stn.AR-1 (downstream) is lightly or unpolluted with a biotic index of 9, whereas, Stns.AR-2 and AR-3 are slightly polluted with corresponding biotic indices of 8 apiece.

Biological indices are usually specific for certain types of pollution since they are based on the presence or absence of indicator organisms (bioindicators), which are unlikely to be equally sensitive to all types of pollution. In this study, we used macroinvertebrate population because they can be more easily and reliably collected, handled and identified. There is often more ecological information available for such taxonomic groups. Odiete describes a river as slightly polluted as when there are fewer nymphs of plecotera and ephemeroptera while other benthic groups of organism are present [17]. The presence of a few plecoptera and ephemeroptera in sampling station AR-1(downstream) indicate absence of heavy pollution, corresponding to observed moderate level of disturbance, possible water renewal and shorter residence time of pollutants due to water flow. Stations AR-2 with highest level of disturbance along the river course had more nymphs of plecoptera and ephemeroptera and may be regarded as slightly polluted. On the contrary, Stn.AR-3 (upstream) had only an individual of ephemeroptera and none of plecoptera, possibly as a result of little or no human disturbance observed along this axis of Abesan River.

In addition, bioindicators are classified as Exploiters or Opportunists- Species, which tolerate pollution or environmental disturbances when other species cannot [30]. For example, the presence of many Chironomid, Eristalis larvae or Tubificid worms indicates polluted conditions in freshwater bodies. In this study, Chironomidae were found in all stations with highest number being at Stns.AR-2 (**Table 3**). Station AR-2 is closely located where the people of Ipaja community carry out their chores such as washing, bathing and effluent discharges, thus, it has the highest human disturbance level in relation to other stations. Close to this station also is a depot of disused plastics; metals and other substances picked by dump scavengers and a nearby hair attachment producing industry which discharges its effluents into Abesan River. The influx of these effluents and seepages from the depot as well as the introduction of materials by the people who use the river for their needs may have contributed to the pollution indicated by the high presence of chironomids at this sampling station. This, if not curtailed may have broader implication on the ecological integrity of this water body in the near future.

Further to the foregoing, the highest number of individuals was recorded at stn.AR-2, and Chironomidae being the highest taxonomic group found in all the three stations (**Figure 2)**. This confirms the biotic index obtained from the analyses of the data that revealed a lightly polluted station. However, species such as syrphidae (Eristalis sp), Tubifex and Ephydreadae (Brahydeutera sp), which are tolerant to heavy pollution were absent, suggesting that Abesan River is only lightly polluted [17].

Although, the Abesan River was also found to be lightly polluted upstream (AR-3), this may be due to the influx of polluted water flowing from the upper area beyond the Ipaja axis, suggesting the needs for further investigation. Also the effect of putrefying organisms and their activities resulting in silt bottom sediment may have contributed to the slightly pollution observed for the station.

5. Conclusions

In this study, all physico-chemical parameters measured were within the limits of the Lagos State Environmental Protection Agency (LASEPA) and the World Health Organization (WHO) regulatory standards except for high COD concentration in downstream station. Also, high presence of chironomids at the downstream station (AR-2) suggests potential pollution. Whilst the presence of indicator organisms cannot prove the existence of heavy pollution, the absence of sensitive species, which would otherwise be expected in a river receiving such load from the surrounding environment, may be significant and therefore warrants further investigation.

6. Acknowledgements

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