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Biodiversity and Environmental Integrity of Some Rivers in Derived Savannah Belt in Edo-North, Southern Nigeria

Abdul-Rahman Dirisu and John Ovie Olomukoro

Abstract

Investigative study on macroinvertebrates and pollution tolerance index of four rivers in the derived savannah belt of Edo-North in Southern Nigeria was carried out from January to December, 2010. The study involved monthly field sampling and laboratory analysis of macrofauna. The objectives of the study were to evaluate the biodiversity status and importantly, the environmental integrity of the four selected rivers. Two dominant macroinvertebrate families were recorded; Baetidae and Chironomidae while, 53 macroinvertebrate taxa were identified across the rivers. The highest number of species (12) was recorded for Diptera, while, Hirudinea, Nematoda and Arachnida each had 1 species in the population. General diversity indices ranged from 2.02 to 2.78 with the least and highest recorded in Edion and Etuno Rivers, respectively. The fauna evenness index indicated that the water bodies had values less than 1.0. Meanwhile, Pollution tolerance index revealed spatial and seasonal variations in water quality conditions but only Edion River exhibited poor water quality in all the months of study.

Keywords: macroinvertebrate taxa, water quality, species richness, pollution sensitive

1. Introduction

Over the years, degradation of water quality has remained a major issue in most parts of the world, including the Niger Delta region of Nigeria. This has continued to pose a threat to health and economic development in Nigeria and other countries alike [1], with about 60% of the rural and urban populace depending on ponds, streams and shallow wells for domestic water supply in some developing countries [2, 3]. The increasing concern for the level of pollutants in surface and groundwater makes water monitoring very essential [3–5].

Macroinvertebrates are highly useful bioindicators in understanding the ecological health of aquatic ecosystems, which could be more accurate than chemical and microbiological data, which exhibit short-term fluctuations [6–8]. Benthic macroinvertebrates include all bottom-dwelling plants and animals in water bodies and are found either crawling, burrowing or attached to various kinds of objects such as wood, stone, and organic matter [9]. These organisms play a vital role in the circulation and recirculation of nutrients in aquatic ecosystems.

Macroinvertebrates sampling is one technique used to determine the health of a stream, as they are subjected to day to day and longer term changes in pollution, oxygen and acidity levels. They can be used to monitor stream quality conditions over a broad area or they can be used to determine the effects of point source discharges, such as sewage treatment plants and factories, on a site-specific basis [3]. The advantages of this is that, unlike fish, benthos cannot move around as much, so they are less able to escape the effects of sediment and other pollutants that diminish water quality. Therefore, macroinvertebrates can give reliable information on stream, river and lake water quality. Their long life cycles allow studies conducted by aquatic ecologist to determine any decline in environment quality.

A Pollution Tolerance Index (PTI) is a method that is used to rate stream quality based on macroinvertebrate communities [10]. The three major tolerance categories of macroinvertebrate used in assessing the rivers water quality conditions are sensitive, facultative (or somewhat pollution tolerance) and pollution tolerant groups [11]. The aim of this study was to determine the quality of surface waters in Edo-North of Edo State in Southern Nigeria (using macrofauna as bioindicators), where anthropogenic factors and other human activities including uncontrolled waste disposal practices have placed immense stress on the quality of the water resources. The study determined the composition, abundance and the distribution of benthic macrofauna in the rivers; investigated the full biodiversity value of macrofauna as indices of pollution; and determined the Pollution Tolerance Index of the rivers, using macroinvertebrates.

2. Materials and methods

2.1 Study area

The sampled locations which are located within Edo State of Nigeria (**Figure 1**) were carefully chosen to monitor the water quality and pollution tolerance index of selected fresh water bodies in Edo-North. There are two distinct tropical seasons in this area, viz.; the rainy season, which occurs usually between April and October with its peak between July and August and dry the season, which occurs between November and March. The rainy season period is usually characterised by high relative humidity and low atmospheric temperatures. The four selected fresh water ecosystems locations are in the derived savannah zone. The spread was such that all ecological niches and areas of human activities were covered (**Table 1**). The GPS readings of the sampled sites were determined using GPS 12 Garmin model (serial number 36209488). Etuno River runs through Igarra community and takes its source from Kukuruku hill in Akoko-Edo area. There are cesspools in this catchment during the dry season, but the flood velocity increases in the wet season, ranging from 0.97 to 5.6 m² s⁻¹. On the other hand, Orli, Omodo and Edion Rivers flow through Agbede communities. The first two rivers are murky brown in colour particularly during the wet season. There are variations in their flow velocity throughout the year, which ranged from 0.1 to 14.71 m² s⁻¹. Two sampling points each (from upstream and downstream) were chosen along the stretch of the four rivers.

2.2 Sampling for macroinvertebrates

The substrates at the bottom of the selected stations were sampled for macrofauna which consists of invertebrates in the sediment and the roots of floating macrophytes. The modified grab [12] and kicking sampling techniques [13] were



Figure 1.
 Map of Edo state indicating the sampled locations.

Station ID	Station/river	Town	Coordinates		Land use pattern
1	Etuno	Igharra	N 7° 16'	E 6° 7'	Agricultural/ human settlements, stone crushing activities
2	Orlie	Agbede	N 6° 58'	E 6° 16'	Agricultural/human settlements
3	Edion	Agbede	N 6° 55'	E 6° 16'	Agricultural/ human settlements
4	Omodo	Agbede	N 6° 52'	E 6° 17'	Agricultural/ human settlements

Table 1.
 GPS coordinates and land use pattern of sampled locations.

used to collect sediment cores. The kicking method caused vigorous disturbance and movement of substratum and emergent vegetation from upstream. The animals disturbed from the stream bed were washed by the current and collected by a hand-net held down-stream. Each “kicking activity” lasted for 10 minutes and collected samples were preserved using 10% formaldehyde. All samples were sorted in the laboratory using the American binocular dissecting microscope, and organisms were preserved in 4% formaldehyde in specimen bottles. Identifications of organisms were made using relevant key manuals and literature [14, 15].

2.3 Analysis of data

Using the Paleontological Statistics tool (PAST 1.99 version), basic diversity indices such as relative abundance, taxa richness and species diversity were

computed to describe the macrofauna community structure [16]. These indices provide a convenient means of comparing differences within ecological communities and also for monitoring temporal changes. Pollution tolerance of macroinvertebrate organisms to pollutants was assessed using the Pollution Tolerance Index (PTI) model. Specimens were taken and examined for the presence and abundance of the different types of organisms. Their values were inputted in an equation, which gave an overall value to the stream. Tolerance values were assigned to the sensitive, facultative and pollution tolerant macroinvertebrate groups as adopted from Klemm et al. [17] and Olomukro and Dirisu [18].

3. Results

3.1 Macroinvertebrates and community structure

Fifty three macroinvertebrates taxa were identified during the study (**Table 2**). Ephemeroptera and Diptera were represented by four families each in the studied water bodies. The former was dominated by the family Baetidae and the latter group by the family Chironomidae. These two groups comprised over 70% of the macroinvertebrate communities in each water body.

The density of occurrence of Decapoda was highest in Omodo compared to the other rivers while, Atyidae was observed to be most dominant in the group. Other groups such as Odonata, Coleoptera, Trichoptera, Hemiptera and Mollusca were subdominant, common or rare in the various water bodies (**Table 2**).

3.2 Etuno river

Diptera was the dominant group in this river, while Ephemeroptera, Odonata (dragon fly), Coleoptera and Mollusca were the subdominant. Dipterans represented 61.8% of the total number of individuals (**Table 3**). Species richness index ranged from 0 to 2.84, with Dipterans having the highest richness among the groups.

3.3 Orlie river

Ephemeroptera (with 4 taxa) which is the dominant group in this station comprised Baetidae as the only family found, with 71% population density (**Table 3**). Species richness ranged between 0 and 2.23 indexes, with Diptera also having the highest species richness while Oligochaeta, Coleoptera, Trichoptera and Mollusca had the least diversity.

3.4 Edion river

A total of sixteen taxa were recorded for the macrofauna. The dominant and most frequently encountered was the Ephemeropterans which accounted for about 65% of the population followed by Decapoda (19.3%) and Diptera (13.7%). Species richness ranged between 0 and 1.44, with Trichoptera having the highest species richness and the least were Odonatans and Molluscans.

3.5 Omodo river

A total of 21 taxa were identified and categorised into five major groups as shown in **Table 3**. The dominant groups comprised Decapoda (42.6%) and Diptera

Nematoda (Aquatic Worms)	Decapoda (Freshwater shrimp)	Ephemeroptera (Mayfly)	Odonata	Hemiptera (True Bug)	Coleoptera (Beetles)	Trichoptera (Caddis flies)	Diptera	Mollusca (Water snails)
<i>Rhabdolaimus</i> spp.	<i>Caridina africana</i>	<i>Adenophlebiodes</i> spp.	<i>Anisoptera</i> (Dragon Fly)	<i>Lethocerus</i> spp.	<i>Acilius</i> <i>sulcatus</i>	<i>Leptoceric</i> spp.	<i>Chironomidae</i> (Midge fly)	<i>Ancycastrum</i> spp.
Other nematodes	<i>Caridina</i> <i>gaboneusis</i>	<i>Baetis</i> spp.	<i>Libellula</i> spp.	<i>Nepa</i> spp.	<i>Dytiscus</i> spp.	<i>Limnophilus</i> spp.	<i>Chironomus</i> <i>fractilobus</i>	<i>Hydrobia</i> spp.
OLIGOCHAETA (Aquatic Worms)	<i>Desmocariss</i> <i>trispinosa</i>	<i>Centroptilum</i> spp.	<i>Aphylla</i> spp.		<i>Dytiscus</i> <i>marginalis</i>	<i>Polycentropus</i> spp.	<i>Chironomus</i> <i>travaalensis</i>	<i>Hydrobia</i> <i>guyenoti</i>
<i>Nais</i> spp.	<i>Macrobrachium</i> spp.	<i>Cloeon</i> spp.	<i>Plathemis</i> spp.				<i>Chironomus</i> sp.	<i>Hydrobia lineate</i>
	<i>Potamalpheops</i> <i>monodi</i>	<i>Cloeon</i> <i>cylindroculum</i>	Zygoptera (Damsel Fly)				<i>Pseudochironomus</i> spp.	<i>Potanorbis crista</i>
	<i>Gammarus</i> spp.	<i>Dicerconyzon</i> spp.	<i>Coenagrion</i> spp.				<i>Tanypus</i> spp.	<i>Pitar tumeus</i>
	Larva	<i>Ephemerella ignita</i>	<i>Enallagma</i> spp.				<i>Tanytarsus</i> spp.	<i>Tympanotonus</i> <i>radula</i>
	<i>Cardiosoma</i> spp. (crab)	<i>Habrophlebia</i> spp.	<i>Hesperangrion</i> <i>heterodoxum</i>				<i>Chinotanypus</i> spp.	
	Unidentified (crab)	<i>Psuedocloeon</i> spp.	<i>Lestes</i> spp.				<i>Cricotopus</i> spp.	
							<i>Pentaneura</i> spp.	
							<i>Culex</i> spp.	
							Insect larva	

Table 2.
The macrofauna found in four Rivers in Edo-north, Edo state, southern Nigeria.

Group	Etuno river			Orlie river		
	Individuals/No	%Composition	Diversity index (D)	Individuals/No	%Composition	Diversity index (D)
Nematoda	1(1)	0.9	0	—	—	—
Oligochaeta	2 (1)	1.8	0	1(1)	1	0
Hirudinea	—	—	—	—	—	—
Decapoda	—	—	—	—	—	—
Ephemeroptera	10 (2)	9.1	0.4343	71 (4)	71	0.7038
Odonata	9 (3)	8.2	0.91024	13 (6)	13	0.9494
Hemiptera	3 (2)	2.7	0.91024	—	—	—
Coleoptera	8 (2)	7.3	0.4809	2 (1)	2	0
Tricheoptera	2 (1)	2.7	0	1(1)	1	0
Diptera	68 (13)	61.8	2.8439	6 (5)	6	2.2324
Mollusca	7 (1)	6.4	0	6 (1)	6	0
	Edion river			Omodo river		
Nematoda	—	—	—	—	—	—
Oligochaeta	—	—	—	6 (1)	4.4	0
Hirudinea	—	—	—	—	—	—
Decapoda	38 (3)	19.3	0.5498	58 (5)	42.6	0.9851
Ephemeroptera	128 (4)	65	0.6183	17 (4)	12.5	1.0587
Odonata	1(1)	0.5	0	7 (3)	5.1	1.0278
Hemiptera	—	—	—	—	—	—
Coleoptera	—	—	—	—	—	—
Tricheoptera	2 (2)	1.0	1.4427	—	—	—
Diptera	27 (5)	13.7	1.2137	48 (8)	35.3	1.8082
Mollusca	1(1)	0.5	0	—	—	—

Table 3.
The number of individuals and diversity of the major taxonomic groups in the sampled locations (number of taxa in parenthesis).

Water body	No. of species	Abundance	Magalef (D)	Shannon_H	Evenness	Dominance
Etuno	24	104	4.95	2.78	0.67	0.08728
Orlie	20	88	4.24	2.46	0.59	0.118
Edion	16	219	2.78	2.02	0.47	0.189
Omodo	24	176	4.45	2.45	0.48	0.1532

Table 4.
Water bodies with their number of species, abundance and diversity indices.

(35.3%), and the subdominant were the Ephemeropterans with 12.5% density. Species richness ranged from 0 to 1.808 indexes, with Dipterans having the highest species richness and Oligochaetans the least.

3.6 Macroinvertebrate biodiversity

Biodiversity is the number and the distribution of species of living organisms. Change in biodiversity over time is the measure that can be used to assess the health of an ecosystem [10]. As biodiversity is lost, it is believed that the health and viability of an ecosystem declines. The highest biomass was reported in Edion River (219 individuals m^{-2}) while, Orlie and Omodo rivers had <105 individuals m^{-2} (Table 4). Shannon-Wiener diversity indices showed that values ranged from 2.02 to 2.78 with the highest in Etuno River at Igarra, while the least diversity index was in Edion River. The macrofauna evenness index indicated that most of the water bodies had values less than 1.00, the highest being for Etuno (0.67) while the least was recorded in Edion (0.472).

4. Pollution tolerance index (PTI)

Pollution Tolerance Index (PTI) values were determined at monthly interval for each rivers using the available macroinvertebrate populations in the aquatic ecosystems. There was spatial and seasonal variation in water quality conditions in the water bodies. The sampled rivers revealed moderate water quality in March, July and December 2010 most importantly, while the other months of the year indicated poor water quality (Table 5, Figures 2–5).

5. Discussion

A decrease in diversity and corresponding increase in abundance of a limited number of species is a common community response to environmental disturbance. The high diversity indices observed in the rivers indicated that many species had equal or near equal opportunity of co-existence. However, the macroinvertebrates were not evenly distributed across the sampled rivers, which is bound in most aquatic ecosystems [3, 19].

The abundance of Ephemeroptera group which is a clean water representative and is generally intolerant to contaminated aquatic ecosystems, clearly revealed that most of the rivers had moderate water quality with the exception of Etuno River. The water quality status was confirmed by the PTI estimation for the rivers. Monthly variations of PTI were observed in all the rivers. Unfortunately, there were no PTI values recorded for 5 months (August to December, 2010) in Etuno

River	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall	Health status
Etuno	10	4	6	8	2	—	—	—	—	—	14	Moderate
Orlie	10	1	1	3	7	4	—	5	8	7	16	Moderate
Edion	3	4	6	7	6	5	6	6	3	6	12	Moderate
Omodo	1	7	8	3	8	5	7	5	4	11	11	Moderate

Table 5.
Monthly variation and overall pollution tolerance index (PTI) of the sampled rivers.

Etuno

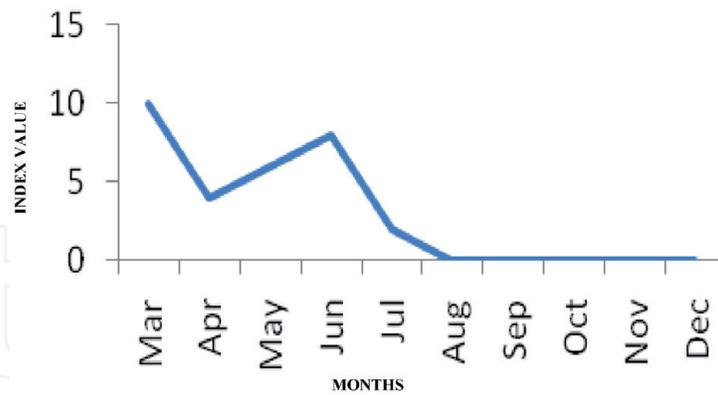


Figure 2.
The spatial and seasonal variation in pollution tolerance index (PTI) of the Etuno river.

Orlie

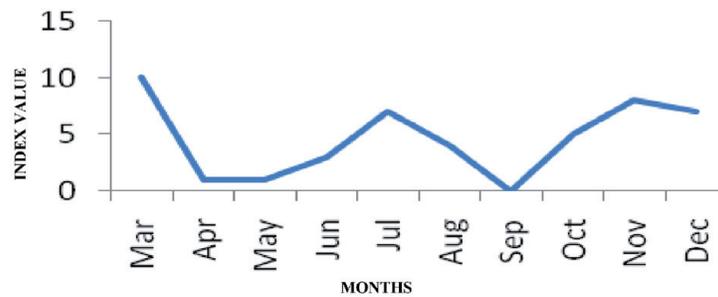


Figure 3.
The spatial and seasonal variation in pollution tolerance index (PTI) of the Orlie river.

Edion

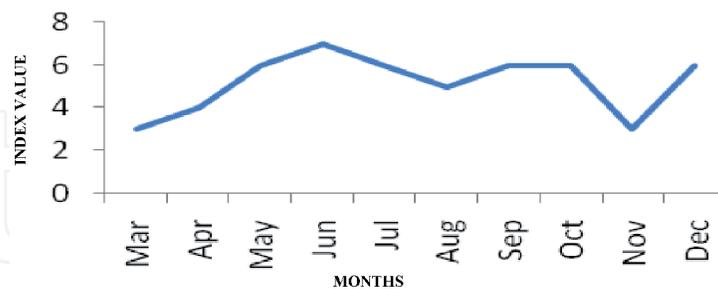


Figure 4.
The spatial and seasonal variation in pollution tolerance index (PTI) of the Edion river.

Omodo

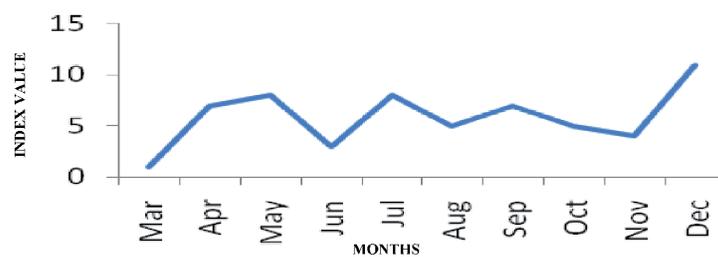


Figure 5.
The spatial and seasonal variation in pollution tolerance index (PTI) of the Omodo river.

River as the various PTI groups were completely absent, a situation that could not be explained. Though, surface run offs and inundation do greatly affect and destabilise the colonisation patterns of substrates by macrofauna, this was not the case as rainfall had diminished in those months. However, the water quality status were generally moderate, an indication that the water bodies had not been seriously compromised.

6. Conclusion

The presence of a species is more valuable than its absence in aquatic ecosystems. Therefore, factors limiting diversity of macrofauna should be discouraged around water bodies. It is important that the different sources of pollutants, ranging from industrial through municipal to domestic activities be controlled during siting in the Edo-North with particular reference to the small factories located on the banks of Etuno River as contaminants are eroded and transported downstream with ease.

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Author details

Abdul-Rahman Dirisu* and John Ovie Olomukoro
Department of Animal and Environmental Biology, Faculty of Life Sciences,
University of Benin, Benin City, Nigeria

*Address all correspondence to: dedonrahman10@yahoo.com

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