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Trends in macrobenthal biotypes of Imo River in a Nigerian Delta region

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Abstract

Dynamics in macrobenthos abundance and diversity in sand-mined Imo River in Etche, South-eastern Nigeria has been investigated. While 14 representative species, comprising 3 classes (insect, oligochaeta, and gastropoda) were earlier identified in 2003, 9 species of these classes and 5 species comprising 2 classes only (insecta and oligochaeta) were identified in 2009 and 2010, respectively. Though Margalef's diversity had increased from 1.67 in 2003 to 2.30 in 2009, it sharply decreased to 0.69 in 2010. Over these periods, entomofauna (class insecta) predominated the faunal assemblages with 8 species from 6 families in 2003, 7 species from 5 families in 2009, and 3 species from 2 families in 2010. Significant spatial variance inequality in macrobenthos abundance was observed at $P<0.05$ [$F_{(240.54)} > Fcrit_{(3.89)}$]. Further, there was variance inequality in means of macrobenthos abundance between 2003, 2009, and 2010 [$F_{(6.54)} > Fcrit_{(4.03)}$] at $P<0.05$. A further structure detection of mean difference revealed that inequality was most accounted for by the larva of the insect- *Sialis luteria* that was conspicuously absent in the 2009 and 2010 identifications. There was generally high interspatial community dissimilarity, except an average similarity of 50% (0.50) recorded between locations 2 and 6, and 3 and 7 in 2009, as well as 50% between locations 1 and 3 and 2 and 6, and 67% between locations 2 and 7, and 3 and 7 in 2010. Benthic sediments were slightly acidic (6.95±0.01), with low nitrate (0.48±0.03), phosphate (0.72±0.04), and sulphate (44.35±1.57) concentrations. We suspect declining macroinvertebrate diversity and abundance in the river, and that ongoing anthropogenic perturbation (sand mining) contributes immensely to this paucity through the excavation and removal of benthal nutrients necessary for a thriving and diverse sediment community.

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Introduction

Many group of organisms have been used as indicators of water quality or environmental changes in freshwater bodies, including algae, macrophytes, protozoa, fish, and other animals. Of these, aquatic invertebrates have been most extensively used, especially in lotic waters (Spaak and Bauchrowitz, 2010).The benthic fauna, which are all those animals that live on or in the bottom sediments of aquatic ecosystems are also important indicators of water quality that are used in a variety of ways to monitor and assess overall health of the aquatic environment. They are good candidates for long-term monitoring programmes relating to anthropogenic impacts (Simboura*et al*., 1995; Bamikole *et al*., 2009).

According to Bamikole *et al*. (2009), based on monitoring perspective, benthos offer three attributes; they are relatively sedentary and long-lived, they occupy an important intermediate trophic position, and they respond differentially to varying environmental conditions. After deposition and settlement, benthos remains within relatively constrained area for their entire adult lives. Therefore, unlike many other biotic or chemical measures, benthos reflects conditions at a specific location. Many benthic species are also relatively long-lived; with life spans ranging from weeks (for some opportunistic worms) to months or years (for larger taxa) leading to a community structure that reflects average condition integrated over a time period of months.

However, benthos vary greatly in their responses to variations in water quality. While some taxa are relatively tolerant to organics, heavy metals, and low dissolved oxygen, others are easily eliminated by adversities created by these pollutants (Simboura *et al*., 1995). Through direct and indirect pathways, increased nutrient inputs and other anthropogenic activities can strongly affect abundances of some species, though others may remain unaffected.

By the foregoing therefore, examining shifts in the benthic communities over time could provide understanding into the major environmental events and processes affecting the resident biota (Heyland *et al*., 1996). The benthos constitutes the food for fishes, and so, leads up to food for the teaming human population as well as serves other economic needs.

Etche, one of the local government areas (LGAs) in Rivers State has three major river systems- Imo, Otamiri, and Oge-Ochie rivers, and of these, the Imo River is most extensive and serves as repository-receiving the Otamiri river (which on its own had earlier confluenced with Oge-Ochie at Nihi) at Umuebulu, a border community to the LGA. Since the discovery of crude oil in the area in 1958, oil and gas, as well as associated urbanization activities have been on the increase. Of these, perhaps the most visible direct impact on the river in recent times is ongoing sand mining in virtually all the riverine communities. Sand is mostly used for buildings and construction of roads and other infrastructure. Coincidentally, local fishermen in the area have reported severe decreased fish catches in recent times; an observation they alluded its cause to traditional belief. This research, armed with the knowledge that macrobenthos serve as food for fishes, investigated trends in macrobenthos abundance and diversity, drawing on an earlier study made by other authors in the recent past in the river.

Materials and methods

Study area

Etche is a southeastern ethnic group located in the tropical rainforest zone of Nigeria; between longitudes 06° 05' and 07° 14' N and latitudes 05° 08' and 04° 45' E (Fig. 1). Ambient temperature varies between 24 and 35°C, with annual precipitation of between 2250 and 2500 mm. A wet season usually last for about 9 months (March-November), with high relative humidity of up to 90%.

The Imo River rises from Okigwe/Awka uplands in the neighbouring Imo State and empties independently into the Atlantic Ocean, after subsequently coursing through Oyigbo, Khana, Opobo/Nkoro, and Andoni LGAs in Rivers State. Socioeconomic activities of the people of Etche include mainly farming, though capture fishing, hunting, gathering from the wild, and trading are also practiced.

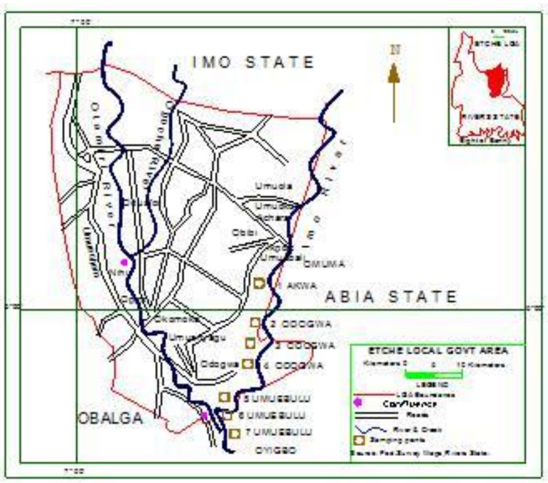

Fig. 1. Location map of Etche showing the sampling locations on Imo River.

Sampling strategy

Sampling was made once monthly from September 2009-August 2010 at seven sampling locations along the course of the river.

Field Sampling

Three replicate benthic samples were collected from each sampling location using a 10 x 12 cm Eckman Grab and composited. Samples were washed using a 0.5 mm mesh screen and retained organisms transferred to labeled plastic containers and preserved with 5% formalin to which Rose Bengal stain had been added. pH of sediment was determined *in situ* with a pre-calibrated (with pH solutions 4 and 10) HACH EC10 pH Meter. Sediment samples for the determination of nutrients were collected in labeled polythene bags.

Laboratory analysis

Macrobenthic invertebrates were sorted from preserved residues in white plastic tray and specimens then identified to their lowest taxonomic levels possible under the light and stereo microscopes using keys provided by Needham (1962), Mellanby (1975), and APHA (1998). Nutrients (nitrate, phosphate, and sulphate) were determined spectrophotometrically according to standard methods of APHA (1998).

Statistical analysis

Variance equality in means of spatial abundance was determined with the One-Way Analysis of Variance (ANOVA) and further structure detection made with means plots. Two biological indices-Margalef's (Margalef, 1961) and SØrensen's (Tingle, 2002), were used to determine species diversity and similarity, respectively.

Result

Of the total of 154 organisms identified in the current work between 2009 and 2010, only 3 classes, comprising 8 families were represented (Table 1). Class insecta dominated the macrobenthal fauna identified (50.6%), while gastropods were least abundant (2.0%). The entomofauna had 7 species, the oligochaetes 2, and the gastropods 1 species representatives. The oligochaeta- *Lumbricus variegates* was the most abundant single species identified (64; 41.6%), while the entomofauna- *Psephenus* and the gastropod- *Amnicola* species were least in abundance (3; 2.0% each). Sampling location 1 recorded the highest numerical abundance (39; 25.3%) while location 6 recorded the least abundance of 9 (5.8%). In 2009, 9 species were represented while in 2010, only 5 species were represented. A test of variance equality in means of species abundance of the macrobenthos between 2003, 2009, and 2010 revealed inequality [$F_{(6.54)}>Fcrit_{(4.03)}$] at $P<0.05$. A further structure detection of group means using the means plots (Figs. 2 and 3) revealed that this inequality was most accounted for by the insect larva of *Sialis luteria* which was conspicuously absent in 2009 and 2010 identifications.

Table 1. Total abundance of macrobenthos of Imo River across the sampling locations (September 2009-August 2010).

Class/Family/Species	Sampling locations							Total abundance	% abundance
	1	2	3	4	5	6	7		
<u>Insecta</u>									
Chironomidae:									
Tanypus sp.[1,2]	7	1	0	3	0	1	3	15	9.7
Corynoneura sp.[1,2]	3	0	2	2	0	1	1	9	5.8
Chronomus ablabesmyia[1]	0	0	1	0	2	0	2	5	3.3
Ephemeridae:									
Hexagenia sp.[1]	1	2	3	0	3	0	0	9	5.8
Gomphidae:									
Hagenius sp.[1,2]	12	2	5	1	4	1	8	33	21.4
Hydrophilidae:									
Hydrophilus sp.[1]	1	1	0	1	0	1	0	4	2.6
Psephenidae:									
Psephenus sp.[1]	0	0	0	2	0	0	1	3	2.0
<u>Oligochaeta</u>									
Lumbricidae:									
Lumbricus variegates[1,2]	14	6	5	8	11	4	16	64	41.6
Tubifidae									
Tubifex sp.[2]	1	0	1	3	0	1	3	9	5.8
<u>Gastropoda</u>									
Amnicolidae:									
Amnicola sp.[1]	0	0	0	2	0	0	1	3	2.0
Total	39	12	17	22	20	9	35	154	

[1] = identified in 2009, [2] = identified in 2010

On the average, Margalef's index of species diversity recorded values of 2.30 in 2009 and 0.69 in 2010, with low interspatial SØrensen's species similarity across the sampling locations (Tables 2 and 3). Average similarity (0.5) was only recorded between sampling locations 2 and 6, and 3 and 7 in 2009, even as same average and 67% (0.67) were recorded between locations 1 and 3, and 2 and 6, as well as between 2 and 7, and 3 and 7, respectively in 2010.

Narrow variations were observed in most of the physicochemical variables (pH, nitrate, and phosphate) measured in the sediments (Table 4), even as sulphate showed wide variation in concentrations of between 44.52 and 55.44mg/kg (48.35 ± 1.57). However, least variation was observed in pH (6.91-6.97; mean = 6.95 ± 0.01).

Table 2. Species similarity in 2009 across the sampling locations.

	Sampling locations					
	1	2	3	4	5	6
2	0.00					
3	0.00	0.00				
4	0.40	0.20	0.00			
5	0.00	0.00	0.00	0.00		
6	0.00	0.50	0.00	0.00	0.00	
7	0.00	0.33	0.50	0.40	0.00	0.00

Table 3. Species similarity in 2010 across the sampling locations.

	Sampling locations					
	1	2	3	4	5	6
2	0.00					
3	0.00	0.00				
4	0.40	0.20	0.00			
5	0.00	0.00	0.00	0.00		
6	0.00	0.50	0.00	0.00	0.00	
7	0.00	0.33	0.50	0.40	0.00	0.00

A comparison of these data with the reference ones show that although 14 representative species, comprising 3 classes (insect, oligochaeta, and gastropoda) were earlier identified in 2003, 9 species of these same classes and 5 species comprising 2 classes only (insect and oligochaeta) were identified in 2009 and 2010, respectively.

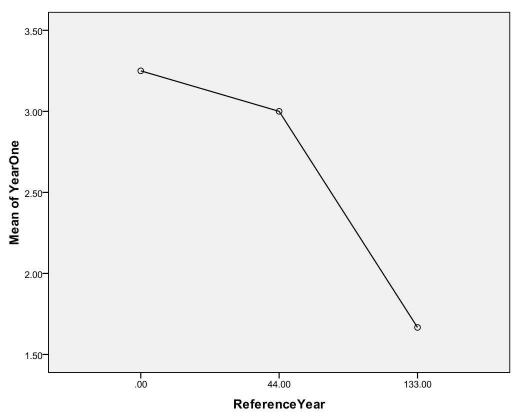

Fig. 2. Means plot between 2003 (Reference year) and 2009 (Year one).

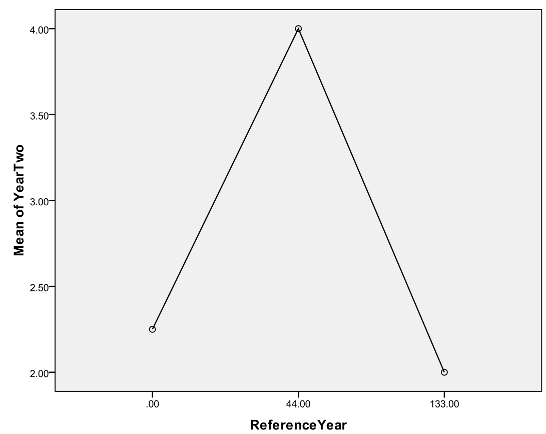

Fig. 3. Means plot between 2003 (Reference year) and 2010 (Year Two).

Over these periods, entomofauna (class insecta) predominated the faunal assemblages with 8 species from 6 families in 2003, 7 species from 5 families in 2009, and 3 species from 2 families in 2010.

Table 4. Variation in physicochemical characteristics of sediment of Imo River (Sep. 2009-Aug. 2010).

Parameter	Minimum	Maximum	Mean	SE
pH	6.91	6.97	6.95	0.01
NO_3^- (mg/kg)	0.36	0.59	0.48	0.03
SO_4^{2-} (mg/kg)	44.52	55.44	48.35	1.57
PO_4^{2-} (mg/kg)	0.62	0.87	0.72	0.04

Discussion

The current study revealed general paucity and decreasing trends in macrofaunal assemblages of the Imo River in the study area. Species abundance and diversity were low, especially when compared with the earlier 2003 reference data (Sikoki and Zabbey, 2006). Between this reference year and 2010, there has been over 100% depletion in species diversity. Other than from natural processes, anthropogenic perturbations have been known to threaten and exacerbate biological diversity losses (Spaak and Bauchrowitz, 2010). Elsewhere, global biodiversity in freshwaters has also been reported to be on the decline (Jokela, 2010), even at rates surpassing those for terrestrial and marine fauna (Ricciardi and Rasmussen, 1999). Of the anthropogenic contributors, Harrison and Stiassny (1999) have identified habitat modification as exerting the most influence on aquatic biodiversity richness. Tamuno (2005) had identified sand mining as a major habitat modifier for aquatic biota. In-stream sand mining could impoverish aquatic sediments of essential nutrients necessary for a healthy and thriving biological community. The low nutrient concentrations recorded in this study may have exerted deleterious effects on the lives of the resident benthal organisms. Worse still, many get excavated by sand miners. The sharp decrease in diversity index reveals the rate of biodiversity loss in the river and possible future trends, especially in the face of an ever increasing human population and the use of the water resource- sand for constructions and urbanization projects. The observed spatial variation reveals the differing severity of mining along the course of the river in the area, even as the low similarity index collaborates this.

Conclusion

This study indicates paucity and decreasing trends in general macrofaunal assemblages of the Imo River in the study area. The low nutrient values could be associated with ongoing in-stream sand mining which alters sediment ecosystems and dislodges macrofaunal residents. Such perturbed and depleted environments are not conducive for thriving biotypes. Future increasing trends could portent the risk of extinction, especially as human populations and its attendant urbanization activities continue to rise. Cumulative losses of biodiversity could further exert negative economic consequences, as there exist trophic relationships among them.

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