The artificial substrate preference of invertebrates in Ogbe Creek, Lagos, Nigeria

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Abstract

The colonisation patterns of the invertebrates of Ogbe Creek on four different types of artificial substrates (Kakaban, gravel bucket, glass and wood) was investigated within the period of September and November, 2002. A total number of 100,700/cm invertebrates comprising of 33 species were harvested. The gravel bucket supported the highest number of invertebrates, 46,740/cm comprising 17 species, while the glass substrate had the lowest number of invertebrate's 2,100 /cm comprising 11 species ($P < 0.05$). The Kakaban substrate had the highest species richness (5.55) while the wood had the lowest (2.78). The four artificial substrates showed selectivity with respects to the organism that colonised them. The ability of the invertebrates to colonise artificial substrates was found to be influenced by the nature and permanence of the substrate. [Life Science Journal. 2007; 4(3): 77 – 81] (ISSN: 1097 – 8135).

Keywords: artificial substrate; invertebrates; Kakaban; Ogbe Creek; Nigeria

1 Introduction

Artificial substrates are devices made of natural or artificial materials of various composition and configuration that are placed in water for a predetermined period of exposure and depth for the colonization of indigenous macroinvertebrate communities (Klemm *et al*, 1990). Artificial substrates are a manipulation or imitation of the natural substrate characteristics (Allan, 1995).

The main advantage of using artificial substrates to survey aquatic macroinvertebrates and algae is that it minimizes the effects of physical variation between sites (such as substrate type, depth and light penetration), thus making it more likely that differences in the fauna or flora are due to water quality rather than habitat. They also allow benthic invertebrate sampling at locations that cannot be sampled effectively by other means (Weber, 1973; Boothroyd & Dickie, 1989; Voshell *et al*, 1989). They can also be used instead of conventional sampling to avoid disturbing or exhausting the indigenous community (Layton & Voshell, 1991).

Investigations on the colonisation of artificial substrates have been conducted during the past decade in several aquatic ecosystems. Polyurethane foam units were used to collect and characterize the protozoan community of two McMurdo dry valley lakes (Kepner & Wharton, 1998). Artificial substrates have been used to assess periphyton assemblages: these substrates include benthic substrates (rocks, bricks, claytiles, glass or plastic rods and wood dowels) and suspended substrates (stryrofoam and periphytometers) that hold glass or plexiglass slides or cover slips (Aloi, 1990). Artificial substrates have also been used to assess the periphyton in the Sheyenne River, America (Jaskowiak *et al*, 1999).

The study was carried out to determine the abundance and species diversity of invertebrates on the artificial substrates in Ogbe Creek and to determine the effectiveness of artificial substrate for bio monitoring in Ogbe Creek. As the benthic African freshwater fauna and flora are poorly documented; this study fills a lack of data concerning the African macroinvertebrate's communities.

Ogbe Creek is located within the University of Lagos campus between latitude 6° 30' N and longitude 3° 29' E. The catchment area is approximately 77,400 m². It is a sluggish nontidal, eutrophic body of water that drains into the Lagos Lagoon (Nwankwo & Akinsoji, 1989). The

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Creek experiences seasonal flooding which introduces a lot of detritus and pollutants from the land. It also serves as a major drainage channel receiving domestic wastes as well as industrial effluents from industries in the area.

2 Materials and Methods

The colonisation patterns of the invertebrates of Ogbe Creek on four different types of artificial substrates (Kakaban, gravel bucket, glass and wood) was investigated within the period of September and November 2002.

Creek water quality was surveyed on four occasions at fortnightly intervals for physicochemical parameters. Surface temperature was taken by mercury in glass thermometer, pH by using a pH meter model E512, conductivity by conductometer model CM25, dissolved oxygen by the Winkler's titrimetric method. Total dissolved solids, total suspended solids, salinity, phosphates, nitrates, and biological oxygen demand were analysed as described by APHA (1976).

2.1 Description of the artificial substrates

Each artificial substrate was used to survey the macro invertebrate community in the Creek.

2.2 Kakaban

The major frame of the Kakaban comprises of a wooden quadrat of area 50 cm^2. 4 twine ropes spaced at intervals of 10 cm from each other, ran from the dorsal to the ventral edge of the frame to form a grid. Raffia palms (*Elaesis guinensis*) were interwoven across the twine ropes to form an air-tight, mesh (Marilyn, 1976).

2.3 Gravel bucket

A 3 L plastic bucket was filled up with 200 pieces of gravel with a medium diameter of 1.3 cm. The diameter of the gravel was measured by using a vernier calliper.

2.4 Glass substrate

Each glass substrate was 30 cm long, 30 cm wide and 3 mm thick. A hole was drilled at each edge for suspension purposes.

2.5 Wooden substrate

A piece of mahogany, 30 cm long, 30 cm wide and 10 mm thick, was used as the wooden substrate. A hole was drilled at each edge for suspension purposes.

2.6 Planting and harvesting of artificial substrates

The Kakaban and the gravel bucket were placed on the Creek bed. The Kakaban was secured with stones, so as to prevent floating. The glass and wooden substrates were secured by ropes running through the drilled holes at the edges to trees at the edges of the Creek.

All the substrates were harvested two weeks after placement. Preliminary investigations in the Creek had shown that colonisation of phytoplankton and macroinvertebrates occurred on the substrates within two weeks. The glass and wooden substrates were covered by a piece of glass of equal size prior to harvesting, so as to prevent loss of organisms from their surfaces when being removed from the water.

The contents of each substrate was washed into a laboratory dissecting tray, preserved in 4% formalin and then transferred to the laboratory for sorting, identification and counting. The organisms were identified to the lowest possible taxonomic levels using keys by Mellanby (1938), Ward and Whipple (1950) and Pennak (1953).

The diversity index and species richness of organisms found on each substrate was determined as described by Margalef (1958).

$d = (S - 1)/\ln N$

d = community species diversity

S = number of species

N = total number of individuals

ln = natural logarithm

The various artificial substrates were subjected to T-tests, to find out if there was any significant difference between the invertebrate populations colonising them.

3 Results and Discussion

The physicochemical parameters of Ogbe Creek are presented in Table 1. The surface water of the Creek was characterised by high total dissolved solids, total suspended solids, conductivity, nitrates and phosphates.

A total of 100,710/cm macro invertebrates comprising of 33 species were harvested from the 4 artificial substrates planted in Ogbe Creek (Table 2). The gravel bucket supported the highest number of macroinvertebrates 46,740 individuals comprising 17 taxa. The glass substrate had the lowest number of invertebrates 2,100 individuals comprising 11 taxa ($P < 0.05$). The Kakaban substrate had the highest species richness (5.55) while wood had the lowest (2.78).Twenty species of algae and 12 species of macroinvertebrates were harvested from the four substrates (Table 3, Table 4). The gravel bucket was the only substrate to support the algae *Anacystis* and *Opalina*. However species such as *Navicula*, *Chlorella*, *Closterium* and *Cladophora* were not represented on this particular substrate. *Nitzschia*, *Anacystis*, *Zygnema* and

Opalina were also not found on the Kakaban, while *Fragilaria*, *Anacystis*, *Cladophora*, *Chaetophora*, *Zygnema*, *Mesotaenium* and *Opalina* were not found on the wood and *Navicula*, *Pinnularia*, *Cymbella*, *Fragillaria*, *Anacystis*, *Chaetophora*, *Euglena*, *Phacus* and *Opalina* were not found on the glass substrate.

The glass substrate supported no macroinvertebrates while the wood and gravel substrates each supported only one taxon, this being *Argyronecta aquatica* and *Gerris* respectively.

The algae and macroinvertebrates harvested with the four different artificial substrates comprised mainly of pollution tolerant species. Taylor and Kovats (1999) had earlier reported that the invertebrate community of an artificial substrate is an indicator of water quality. The high values of dissolved solids, total suspended solids, conductivity, phosphates and nitrates indicated that the Creek was organically polluted.

Table 1. Physicochemical parameters of Ogbe Creek

Physico chemical parameters	Sampling period			
	1	2	3	4
Nitrate (mg/L)	450.00	410.00	3.70	3.20
Phosphate (mg/L)	12.00	10.45	9.50	8.00
Dissolved oxygen (mg/L)	6.90	6.95	7.10	7.20
Biological oxygen demand (mg/L)	3.70	3.75	3.70	3.60
Total dissolved solids (mg/L)	286.00	250.00	205.00	136.00
Total suspended solids (mg/L)	399.00	300.00	210.00	109.00
Salinity (mg/L)	35.45	34.05	30.50	28.30
Conductivity (us/cm)	274.00	292.00	305.00	315.00
pH	7.30	7.20	7.00	6.90
Temperature (°C)	26.00	27.00	29.00	29.00

The physical, chemical and biological characters of the Creek seem to strongly influence the colonisation dynamics of the organisms. Boulton *et al* (1988), similarly reported that food availability may not be that important for many species compared with physical habitat, shelter from currents and refuges from predators.

Table 2. Abundance and species diversity of organisms in Ogbe Creek

Substrate type	Abundance number/cm	Number of species	Margalefs index $d = (S-1) \ln N$
Kakaban	46480	27	5.55
Gravel	46740	17	4.28
Wood	5390	14	2.78
Glass	2100	11	3.01

Table 3. The composition of algae found on four different artificial substrates in Ogbe Creek

Algae		Kakaban	Gravel	Wood	Glass
I: Bacillariophyceae (Diatoms)	*Nitzschia*	–	+	+	+
	Synedra	+	+	+	+
	Navicula	+	–	+	–
	Tabellaria	+	+	+	+
	Pinnularia	+	+	+	–
	Cymbella	+	+	+	–
	Fragilaria	+	+	–	–
II: Cyanophyceae (Blue green algae)	*Anabaena*	+	+	+	+
	Oscillatoria	+	+	+	+
	Anacystis	–	+	–	–
	Oedogonium	+	+	+	+
III: Chlorophyceae (Green algae)	*Chlorella*	+	–	+	+
	Closterium	+	–	+	+
	Cladophora	+	–	–	+
	Chaetophora	+	+	–	–
	Zygnema	–	+	–	+
	Mesotaenium	+	+	–	+
	Euglena	+	+	+	–
	Phacus	+	+	+	–
	Opalina	–	+	–	–

+: Present; – : Absent

The gravel bucket harvested the largest number of organisms (46,740/cm). Artificial substrates that have gravel, stone and rock fills have been known to collect larger number of invertebrates with low variation among replicate samples (Shaw & Minshall, 1980; Clements, 1989; Clements, 1991). The preference for gravels by invertebrates is because they provide abundant microhabitats for colonisation (Taylor *et al*, 1999), have the ability to trap organic matter (Boulton *et al*, 1988), the size of the particles (Mackay, 1992) and the permanent nature of the gravel. Species diversity and abundance increase with substrate stability (Allan, 1995). Although the gravel bucket supported the highest number of invertebrates they recorded lower species richness than the Kakaban. Minshall (1984) noticed a decline in diversity in stones with a median particle size of 1 – 2 cm (MPS of gravel = 1.3 cm).

Table 4. The composition of macroinvertebrates found on the four different artificial substrates in Ogbe Creek

Macroinvertebrates	Kakaban	Gravel	Wood	Glass
Physa fontinalis	+	–	–	–
Hydrophilus sp	+	–	–	–
Planorbis sp	+	–	–	–
Gyrinus	+	–	–	–
Lumbriculus	+	–	–	–
Belostoma	+	–	–	–
Chironomous	+	–	–	–
Gerris	–	+	–	–
Dytiscus larvae	+	–	–	–
Tubifera	+	–	–	–
Argyroneta aquatica	+	–	+	–
Eristalis	+	–	–	–

+: Present; –: Absent

The glass substrate supported the lowest number of invertebrates (2,100/cm). This was due to its surface texture which was very smooth. Hart (1978) found diversity and abundance to be greater on irregular surfaces than on smoother surfaces of substrates similarly Minshall (1984) found out that more invertebrate's colonised granite with a rough surface than quartzite with a smooth surface.

The Kakaban showed the highest species richness (5.55). This was because it was made of leaves, which served as food source for many of the invertebrates. Marilyn (1976) described the Kakaban as the best artificial substrate because it allows sediments to settle on the leaves, thus promoting algal growth and other macroinvertebrates.

The four artificial substrates showed selectivity with respect to the organisms that colonize them. Selectivity by artificial substrates has been reported repeatedly by Rosenberg & Resh (1982). In standing waters, artificial substrates collect mostly littoral zone organisms (Tsui & Breedlove, 1978). Cover & Harrel (1978) also found out that when artificial substrates such as rock filled baskets are placed in depositional zones or suspended in the water columns in a Texas canal, Chironomids, and other insects dominated. The glass substrate supported no macroinvertebrates however they were colonised by algae. Nwankwo *et al* (1987) had earlier reported the trapping of fouling algae using glass slides.

The ability of invertebrates to colonize the artificial substrates was majorly influenced by the nature and permanence of the substrate.

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