The Macrobenthos And The Fishes Of A Tropical Estuarine Creek In Lagos, South-Western Nigeria

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Abstract: The physico – chemical parameters, macrobenthos and the fishes of Abule Agege creek were examined between January and July 2004. The creek exhibited the usual alkaline properties with pH values ranging between 7.30 and 9.20.The physical and chemical and sediment parameters exhibited known ranges and regimes for a tropical estuarine system. Five species belonging to the phyla mollusca and annelida were recorded. The species richness or evenness for the macrobenthos was highest in July (0.73) and the least value was recorded in April (0.38). Furthermore, Margalef's species richness was highest in January (1.12) and lowest in May and June (0.54). Likewise, the species diversity was highest in January (1.11) and lowest in April (0.61). The most abundant fin fish was *Sarotherodon melanotheron* (70.34%) and the least occurring were *Clarias gariepinus*, *Parachanna obscura*, *Citharus linguatula* and *Liza falcipinnus* which all recorded 0.13% each. The most abundant shell fish was *Callinectes amnicola* (4.82 %) and the lowest occurred was *Penaeus notialis* (1.27%) of the overall catch. The effect of anthropogenic induced stressors had resulted in an unstable physically controlled environment characterized by a low density of species for both macrobenthos and fish species. [Report and Opinion. 2010;2(1):6-13]. (ISSN: 1553-9873).

Keywords: Estuarine creek, alkaline, diversity, anthropogenic, induced stressors.

INTRODUCTION

The West African Coastal zone is rich in estuaries and lagoons. Estuaries are abundant in the area from the mouth of Senegal to Guinea (e.g. Sine Saloum, Casemance). Lagoons are generally present from Cote d'Ivoire to the Niger Delta in Nigeria (e.g. Ebrie Lagoon, Porto Novo Lagoon, Lagos Lagoon) (Teugels and Falk, 2000). As a result of their important diversity, it is difficult to give their physical and biological definitions. They are all, however characterized by a typical and rich fish species composition.

Several studies have emphasized the role of estuaries (Claridge *et al.*, 1986; Lenanton, and Potter, 1987; Thiel *et al.*, 1995) and Coastal Lagoons (Antures *et al.*, 1988 as nurseries for juveniles of a variety of marine fishes. This role has also been recognized for several marine coastal habitats (Biagi *et al.*, 1998).

As a result of the horizontal and vertical oscillations of temperature and salinity, estuary biotopes are inhabited exclusively by highly tolerant eurythermal and euryhaline species. For some of these species, estuaries are essential habitat while for others they represent one phase in the species' inshore-offshore migratory life pattern (Tzeng and Wang, 1992).

Leveque *et al.*, (1992) reported over 40 fish families, mostly of marine origin in the West African Coastal waters. Albaret and Diouf (1994) compared the species diversity in these coastal zones and found that the species number ranged between 79 (Lagos Lagoon) and 153 (Ebrie Lagoon). The species in their pristine state in estuaries are notably poorer in number of species than surrounding marine and freshwater areas but richer in number of individuals (Allen, 1982).

The estuarine Lagos Lagoon system in southwestern Nigeria consists of numerous lagoons, mangrove swamps, rivers, creeks and creeklets (FAO, 1969, Ogunwenmo and Osuala, 2004). Macrobenthic fauna, of these creeks are similar to those found in Virgin mangrove swamps (Brown and Kolabanjo, 1998; Ogunwenmo and Osuala, 2004).

Benthic macro-invertebrates are organisms that inhabit the bottom substrate (i.e. sediments, debris, logs, aquatic macrophytes, flamentous algae) in aquatic habitat for at least part of their life cycle (Ajao and Fagade, 2002). Macro-invertebrates are those retained by mesh sizes greater than 200µm but less than 50µm (Slack *et al.*, 1973).

Benthic macro-infauna species are important as food for economically important fish and shell fish species in most aquatic environment where they are the major secondary producers (Fagade, 1971; Fagade and Olaniyan, 1973). They have been employed as indicators of organic pollution and other human-induced stress factors in Lagos Lagoon (Ajao and Fagade, 1990; Ajao and Fagade, 2002).

This research investigates the changes in physico-chemical parameters, sediment type, and the community structure in terms of the fishes and macro-benthos of Abule - Agege creek between January and July, 2004.

MATERIAL AND METHODS

The brackish water creek under study is situated within the University of Lagos, Akoka Campus, Nigeria and is linked to the Lagos Lagoon (Figure 1). The creek is shallow (≤1m) tidal and sheltered (Emmanuel and Onyema, 2007). It is fed by water from the adjoining Lagos Lagoon at high tide and at low tide the water ebbs into the lagoon. The region is located in south-western Nigeria and hence exposed to two distinct seasons, the wet (May – October) and Dry season (November – April) (Nwankwo, 1996).

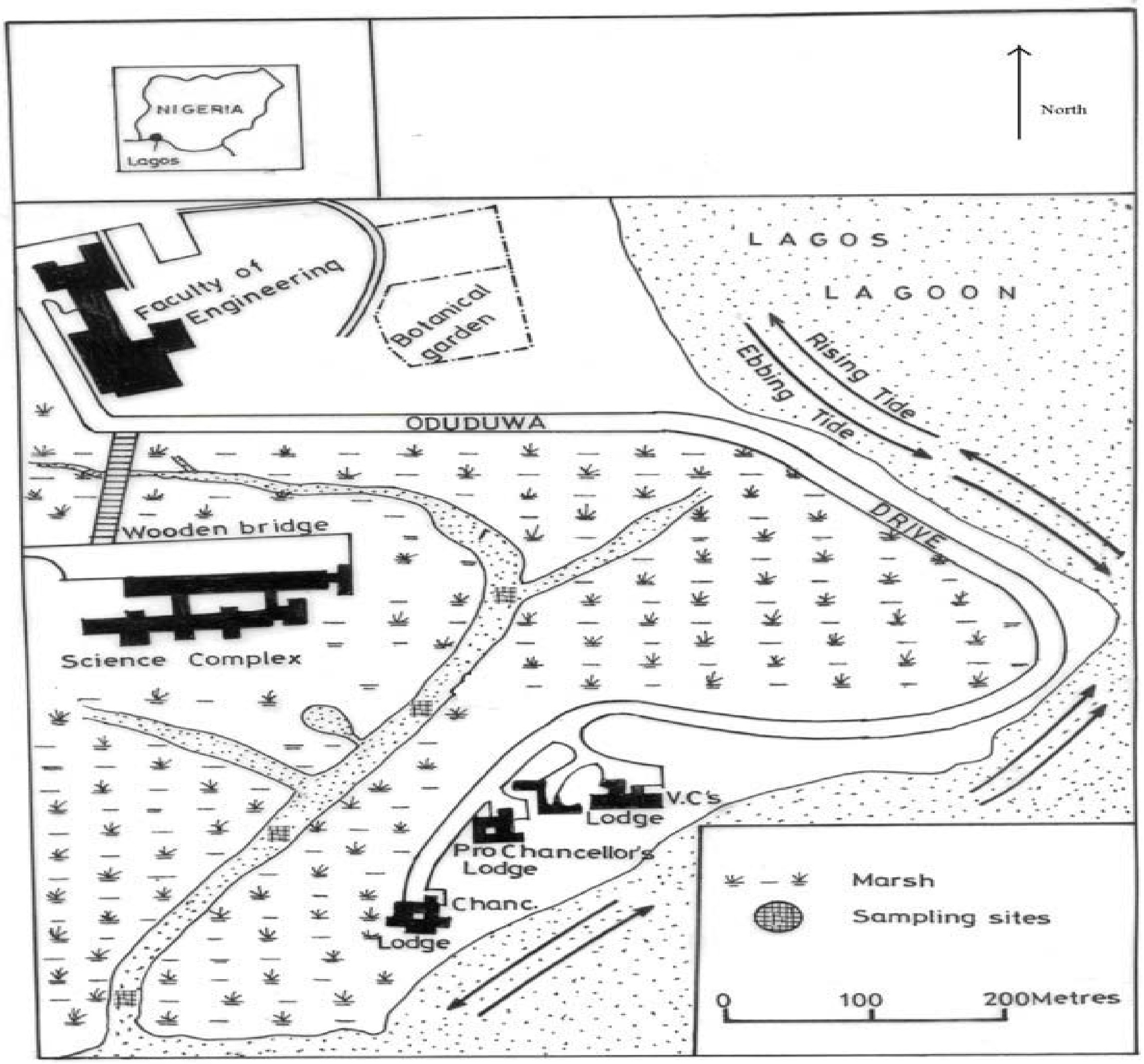

Figure 1. Map of the Abule Agege creek showing sampling sites.

The creek meanders thorough a riparian mangrove swamp, which is inundated at high tide and partially exposed at low tide. Notable riparian flora of the creek includes: *Paspalum orbiquilare, Acrotiscum aureum, Phoenix reclinata, Rhizophora racemosa, Avicenia nitida, Drepanocarpus lunatus* and *Cyperus articulatus*.Notable fauna includes *Periopthalmus sp Balanus pallidus Chthamalus sp, Uca tangeri Seserma huzardi, Gryhea gazar, Typanotonus fuscatus* var *radula* and herons that feeds on exposed invertebrates at low tide (Emmanuel, samples were collected monthly between 10 and 13hr for seven months (January – July, 2004). Atmospheric and surface water temperatures were obtained using a mercury-in-glass.

Collection of Water and Benthic Samples

Water samples for physico-chemical and benthic: Water samples were collected in well labeled 200ml glass bottles with screw caps and were analyzed on getting to the laboratory on the same day in the laboratory. Benthic samples were taken using a $0.1m^2$ Van-veen grab from an anchored planked canoe on each sampling date. Each haul was sieved in the site with a 0.5mm mesh sieve and presented in 4% formalin, and then taken to the laboratory for sorting. The top portion of the sediment of the first haul at each station was preserved for sediment analysis.

Collection of Fish Samples

For fish sampling purposes, the creek was divided into three areas, the upper, middle and lower courses. Fishing was done by means of wire gauze traps with one non-return value with 10cm diameter opening (Emmanuel, 2008) and a castnet designed and constructed with polyamide material (0.24mm diameter) with hanging ratio of 1:2, three panel and 31mm mesh size.

Fish hauls were done at low and high tide for the cast net while the traps were set overnight (18 – 06hr) on each sampling day. The fish samples were transported to the laboratory for preservation in a deep freezer immediately after appropriate labeling and identification were made with the aid of relevant texts (Fischer *et al.,* 1981; Powell, 1982; Schneider, 1990; Raji and Olaosebikan, 1998). The measurement (in centimeter) of the fish (standard and total length), the shrimp (carapace length) and the crab (carapace length and carapace width) species was taken using the method described by Adetayo and Kusemiju (1994) and Emmanuel and Kusemiju (2005). The specimens were also weighed to the nearest gram.

Physical and Chemical Analysis

The surface water salinity was measured using salinity bridge meter (Model EES 13-135). Where as pH was determined with a Griffin pH meter (Model 80), dissolved oxygen and estimated using a Griffin oxygen meter (Model 40) and biological oxygen demand was measured using methods according to APHA (1998) for water analysis. Calorimetric methods using a lovibond Nesslerier were adopted for the determination of phosphate and nitrate, while sulphates were analysed using the gravimetric method. The evaporation method was used to determine total solids. Chemical Oxygen Demand (COD) was determined using the Redox method and density with a density meter.

Sediment type was measured using the sediment profile method, and total organic matter using the method described by Oyenekan (1981). The percentage combustible material in sediment was estimated as:

$$\frac{\text{Loss of weight of ignition}}{\text{Initial weight before ignition}} \times 100$$

Fauna preserved in the field was washed and sorted into taxonomic groups with suitable text (Olaniyan, 1968; Campbell, 1977; Edmund, 1978), classified and counted. Margalef's Index (Shannon and Wiener, 1963) and Equitability/ Evenness (Lloyd and Ghellardi, 1964) were used to classify the environment.

RESULTS

Physico-Chemical Characteristics

Results on the regime of physico-chemical characteristics at the study site are shown in **Table 1**. The salinity ranged between 2.28 and 23.38‰ in the creek. Atmospheric temperature was between 20 (May) and 34^0C (June) while surface water temperature was highest (34^0C) in April and lowest June and July (28^0C).

The depth ranged between 69 (April) and 110cm (March), phosphate values ranged between 0.110 and 0.81mg/l. Nitrate values ranged from 2.68 to 6.20mg/l and sulphate values were between 284 and 6509.8mg/l. The pH values ranged between 7.3 and 9.2. Chemical oxygen demand Values were lowest (35.0mg/l) in January and highest (51mg/l) in February, while Dissolved oxygen values was lowest (3.4mg/l) in January and highest (4.5mg/l) in May. The density values ranged from 0.971 to $1.581g/cm^2$. Biological oxygen demand values ranged from 24mg/l (February) and 50mg/l (May), while transparency ranged between 10 and 29 cm.

Silt was comprised 68% in January and April, 70% in March, May and June, 72% in February and 74% in July (Table 2). Macrobenthic fauna comprised of annelids molluscs and arthropods. *Nereis succinea* was absent in May and June. *Typanotonus fuscatus var radula* ranked highest in number followed by *Pachymelania aurita, Neritina glabrata,* and *Aloidis trigona*

Variation in Physico-Chemical Parameters in Abule-Agege Creek

Sediment in the creek consisted of mud made up of silt and clay. Clay content was lowest (26%) in July and highest (32%) in January and April.

Table 1: Physico-chemical characteristics at the study site between January – July, 2004

Parameter	January	February	March	April	May	June	July
Salinity (‰)	21.62	23.37	21.62	20.56	16.48	5.45	2.28
Atmosphere temp ^{0}C	28	28	28	33	20	34	30
Surface water temp(^{0}C)	29	29	32	34	31	28	28
Density (g/cm^3)	1.010	1.581	1.016	0.971	0.976	1.001	1.010
Transparency (cm)	20	18	16	10	12	29	16
Depth (cm)	95	86	110	69	105	87	100
Phosphate (mg/L)	0.81	0.47	0.32	0.32	0.34	0.110	0.092
Nitrate (mg/L)	4.69	6.20	5.63	5.40	5.62	2.86	2.68
Sulphate (mg/L)	3162	2770	6509.8	3975.9	2756.4	284	813.7
pH	7.3	9.2	9.0	9.2	9.0	8.20	8.3
Chemical oxygen demand (mg/L)	35.0	51	49	47	43	42	40
Dissolved oxygen (mg/L)	3.4	3.5	4.0	4.4	4.5	3.5	4.0
Biological oxygen demand (mg/L)	26	24	31	27	60	35	40

Table 2: Sediment analysis for Abule Agege Creek for January – July, 2004

Parameter	January	February	March	April	May	June	July
TOC %	13.5	18.1	13.9	13.4	16.8	14.3	21.1
Clay %	32	28	30	32	30	30	26
Silt %	68	72	70	68	70	70	74

Table 3: Composition and abundance of macrobenthic fauna per 0.5m^2 collected from Abule Agege Creek for January – July, 2004

Family/Species	January	February	March	April	May	June	July
Tympanotonus fuscastus var radula	23	71	135	100	200	191	38
Pachymelina aurita	3	5	18	12	35	38	25
Neritina glabrata	6	10	8	6	8	10	8
Aloidis trigona	2	1	4	2	5	8	5
Nereis succinea	2	2	3	1	-	-	-

Table 4: Diversity indices for Abule Agege Creek for January – July, 2004

Index	January	February	March	April	May	June	July
Margalef (d)	1.12	0.89	0.78	0.83	0.54	0.54	0.92
Shannon/Wiener (H)	1.11	0.72	0.72	0.61	0.64	0.73	1.18
Equitability/Evenness (E)	0.69	0.45	0.45	0.38	0.46	0.46	0.73

The species richness or evenness was 0.69 in January, 0.45 in February and March, 0.38 in April 0.46 in May and June and 0.73 in July. The Margalef's species richness was highest in January (1.12) and lowest in May and June (0.54). The species diversity measured by Shannon and Wiener Index (H) was highest in January (1.11) and lowest in April (0.61).

Fin and Shell Fish Composition in the Creek

Fin and shell fish species, their size ranges and weight ranges are presented in **Table 5**. Fourteen fin fish and four shell fish were encountered in the creek during the survey. Fin fish species with the highest relative abundance were *Sarotherodon melanotheron* (Ruppell), 70.34%; *Hemichromis fasciatus* (Peters) 6.21%; *Bathygobius soporator* (Valenciennes), 3.42%; and *Eleotris vittata* (Dumeril), 3.30%, shellfish species with highest relative abundance were *Callinectes amnicola* (DeRocheburne), 4.82%; *Macrobrachium vollenhoevenii* (Herklots), 3.80% and *Macrobrachium macrobrachion* (Herklots), 3.42%. The least relative fin fish species abundance were *heterobranchus bidorsahs* (Geoffrey St Hiland), 0.25%; *Chrysichthys nigrodigitatus* (Lacepede) 0.25%; *Caranx hippos* (Linnaeus) 0.25%; *Mugil cephalus* (Linnaeus), 0.25%; *Clarias gariepinus* (Burchell), 0.13%; *Parachanma obscura* (0.13%); *Cithanus linguatula* (Linnaeus) 0.13% and *Liza falcipinnis* (Valenciennes), 0.13%. The least abundance shell fish was *Penaeus notialis* (Perez-farfante), 1.27%.

Table 5: Fin Fish and Shell Fish Caught in Abule-Agege Creek for January – July, 2004

Class/Suborder/Family/Species	Number (Percentage occurence)	Total Length Range (cm)	Weight Range (g)
Actinopterigii Labroidei Cichlidae *Sarotherodon melanotheron* (Ruppell)	555 (70.34)	5.40 – 16.50	3.59 – 74.27
Hemichromis fasciatus (Peters)	49 (6.21)	6.30 – 13.90	3.63 – 42.63
Tilapia guineensis (Bleekers)	20 (2.53)	8.60 – 15.20	10.53 – 133.08
Actinopterigii Gobioidei Gobiidae *Bathygobius soporata* (Valenciennes)	27 (3.42)	12.90 – 14.60	24.76 – 40.00
Eleotris vittata (Dumeril)	26 (3.30)	12.60 – 15.60	24.50 – 42.00
Actinopterigii Knerioidei Clariidae *Clarias gariepinus* (Burchell)	1 (0.13)	26.10	80.8
Heterobranchus bidorsalis (Georffrey) Sturt Hilaire	2 (0.25)	20.0 – 22.0	60.10 – 70.10
Actinoptenigii Kneriodei Bagridae *Chrysichthys nigrodigitatus* (Lacepede)	2(0.25)	15.0 – 16.10	50.50 – 53.00
Actinopterigii Percoidei Carangidae *Caranx hippos* (Linnaeus)	2(0.25)	8.00 – 8.56	16.00 – 18.00
Actinopterigii Channoidei Channidae *Perraachanna obscura* (Steindachner)	1(0.13)	16.80	70.80
Actinopterigii Pleuronecoidei Citharidae *Citharus linguatula* (Linnaeus)	1(0.13)	12.90	23.76
Actinopterigii Ogcocephalioidei Mugilidae *Mugil cephalus* (Linnaeus)	2(0.25)	14.10 – 14.50	22.78 – 23.23
Liza falcipinnus (Valenciennes)	1(0.13)	12.90	23.76
Malacostraca Pleocyemata Palaemonidae *Macrobrachium vollenhoevenii* (Herklots)	30(3.80)	5.50 – 10.00	5.68 – 12.6
Macrobrachium macrobrachion (Herklots)	27(3.42)	4.90 – 9.00	5.00 – 11.90
Malacostraca Dendrobranchiata Penaeidae *Penacus notialis* (Perez-Farfante)	10(1.27)	4.90 – 8.50	4.68 – 6.56
Malacostraca Pleocyemata Portunidae *Callinectes amnicola* (De Rocheburne)	38(4.82)	3.30 – 10.50**	3.22 – 65.53

DISCUSSION

The present information on the hydrological characteristics of this tidal creek was in consonance with earlier observation in the adjoining Lagos lagoon. The regime of ecological characteristics operating in the Lagos lagoon has been documented by several authors (Webb, 1958; Hill and Webb, 1958; Olaniyan, 1969; Fagade, 1979; Oyenekan, 1987; Ajao and Fagade, 1990; Emmanuel and Onyema, 2007). The salinity was brackish throughout the survey (Hill and Webb, 1958; Sandison, 1966; Brown and Oyenekan, 1998; Ogunwenmo and Osuala, 2003). The creek exhibited the usual alkaline properties with pH values ranging between 7.30 and 9.20. This disagreed with the report of Brown and Kola-Banjo (1998) on the same creek during the same season where an acidic pH between 5.0 and 6.6 was recorded.

High atmospheric and surface water temperatures recorded during the study are typical for the region (Nwankwo *et al.*, 2003; Emmanuel and Onyema, 2007). The biological oxygen demand value on the other hand may be a reflection of the amount human induced stressors (decompositional materials) within the creek. This was also reported by Emmanuel and Onyema (2007) for the same creek.

Sediment type was clayey-silt in the creek representing the black loamy sediment of the mangrove swamp. This agreed with Duke 91987) who reported that the entire creek bottom was muddy with average silt content of 65.8% while 34.25 was clay.

Annelids, mollusks and arthropods are reported which is unusual being dominated by mollusks. Ajao and Fagade (2002) reported that gastropods and bivalves are relatively tolerant of physical and chemical variations in the environment and are present in a broad range of habitat. The occurrence of *T. fuscatus* has been ascribed to the amphibious mode of life of this species and its preference for mudflat of mangrove swamps at low tide (Onyenekan, 1979; Egonmwan, 1980; Ajao and Fagade, 2002). Change in benthic composition as reported by Zabi and Lelocuff (1993), Ogunwenmo and Osuala (2003) is important as variations of faunistical composition, densities and biomass of organisms are used in biotype mapping to zone habitats in estuaries like the Bonny River in Niger Delta.

Diversity indices in this study signified low density and diversity of macrobenthic fauna. The result of Margalef's, Shannon/Wiener and Equitability/Evenness showed low diversity and density of species in the creek. This has been previously reported in the creek by Ogunwenmo and Osuala (2003) and is Senegambia Rivers (Zabi ad Leloeuff, 1993).

The low fish diversity of fourteen fin fish and four shell fish species recorded in this study is a good indicator of a possibly stressed ecosystem (Leveque, 1995; Emmanuel and Onyema, 2007). The faunas of this creek were depaudepate containing less species than the species found to be present in the adjacent open lagoon. This was particularly so in relation to the shallow vegetated habitats (Ajao and Fagade 2002).

All the fish species encountered in this study agreed with species reported for the adjacent Lagos lagoon (Solarin, 1998). This is an indication that there is a link between the creek and the lagoon. The creek also shows a number of physical and chemical similarities with the adjoining Lagos lagoon (Emmanuel and Onyema, 2007).

The creek showed less species compared to Lagos Lagoon (Fagade and Olaniyan, 1974; Solarin, 1998). However, the system appears to be more stable due to the influx from the adjacent land which carries with it some nutrients and it seems to offer favourable conditions for benthic species that do not migrate. The occurrence of marine species like *M. cephalus* species into the creek supported the view of Layman *et al* (2004) that some marine species periodically enter estuarine areas to feed and juveniles of others species utilize these areas as nursery grounds.

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REFERENCES

1. Tengels GG and Falk T M. Major fishes of West African Coastal Waters and their morphological characterization with emphasis on *Sarotherodon melanotheron* (Teleostei, cichlidae). In: Biodiversity and sustainable use of fish in the Coastal Zone, Abban, E.K., Casal, C.M.V., Falk, T.M. and Pullin, R.S.V. (eds). ICLARM Conf. Proc. 2000 . 63, 71p.
2. Claridge PN, Potter IC. Distribution, abundance and size composition of mullet populations in the Severn Estuary and Bristol Channel. *J. Mar. Biol. Assoc.* 1985. 65: 325 – 335.
3. Lenanton R C J, Potter I C. Contribution of estuaries to commercial fisheries in temperate Western Australia and the concept of estuarine dependence. *Estuaries.* 1987. 10: 8 – 35.

4. Thiel R, Sepulveda A, Kafemann R, Nellen W. Environmental factors as forces structuring the fish community of the Elbe estuary. *J. Fish. Biol.* 1995. 46: 47 – 69.

5. Antunes M M, Cunha P L, Duarte AP, Mendonca E P. Ria de Alvor as a spawning place and nursery ground. *J. Fish Biol.* 1988., 33: 185 – 190.

6. Biagi F, Gambaccini S, Zazzeta M. Settlement and recruitment in fishes: the role of coastal areas. *Ital. J. Zool*. 1998. 65: 269 – 274.

7. Tzeng W N, Wang YT. Structure, composition and seasonal dynamics of the larval and juvenile fish community in the mangrove estuary of Tanshui River, Taiwan. *Mar. Biol.* 1992. 113: 481 – 490.

8. Lévêque C, Paugy D, Teugels GGFaunedes poissons déus dauces etsaumâtre d'Afrique del'Ouest. Vol. II Faune Tropical no. 1992. XXVIII.

9. Albaret J J, Diouf E S. Diversity des poisons des lagunes et des estuaries Quest-Africains, In: Biological diversity of African fresh and brackish water fishes Tengels, G.G. Guegan, J.E. and Albaret, J.J. (eds). Ann. Mus. Roy. Afri. Centr. 1994. 275.

10. Allen L G. Seasonal abundance, composition and productivity of fish assemblage in upper Newport Bay. California. *Fish. Bull. US,* 1982. 80: 769 – 790.

11. FAO. Fisheries survey in the western and mid western region of Nigeria. UNDP/FAO Rome SF: 74/NIR 6. 1969. 142pp

12. Ogunwenmo C A, Osuala I A. Physico-chemical parameters and macrobenthos of estuarine creek and an artificial pond in Lagos, southwestern Nigeria. Acta SATECH, 2004. 1 (2): 128 – 132

13. Brown CA, Kolabanjo OO. The *ecology of an estuarine creek and ponds in southern Nigeria.* Unpublished Research survey. Department of Marine Sciences, University of Lagos. 1998.

14. Ajao EA, Fagade SO. The benthic macrofauna of Lagos lagoon. The Zoologist, 2002. 1(2): 1-15

15. [15] Fagade S 0. The food and feeding habit of *Tilapia* species in the Lagos lagoon. Fish. BioI. 1971.3, 151-156.

16. Ajao E A, Fagade SO. The Ecology of *Capitella capitata* in Lagos Lagoon, Nigeria. *Arch. Hydrobiol*., 1990. 120(2): 229 – 239.

17. Emmanuel B E, Onyema I C. The plankton and fishes of a tropical creek in south – western Nigeria. *Turkish Journal of Fisheries and Aquatic Sciences*. 2007. 7 (2):105 – 113

18. Nwankwo DI. Phytoplankton density and succession in Lagos lagoon, Nigeria. *Arch. Fur. Hydrobiol*. 1996. 135 (4): 524 – 542.

19. Emmanuel BE. Day and night variations in castnet catches in a brackish water pond. M.Sc. Fisheries, University of Lagos.2004. 61pp

20. Emmanuel B E, Kusemiju K. Variations in castnet catch in a tropical brackishwater pond. *Journal of Science Technology and Environmental.* 2005. **5** (1&2): 6-14

21. Emmanuel B E. The fishery and the bionomics of the swimming crab, *Callinectes amnicola* (DeRocheburne, 1883) from lagos lagoon and its adjacent creek, Southwestern, Nigeria. *Journal of Fisheries and Aquatic Science*. 2008. 3(2):114-125

22. Fischer W, Bianchi G, Scott WB. Species identification sheets for fishery purposes.East Central Atlantic. Fishing Areas 34, 47 (in part). Arranged by Food and Agricultural Organisation of the United Nations and the Department of Fisheries and Oceans, Ottawa, Canada. 1981. 1: 1 -8.

23. Powell CB. Freshwater and brackish water shrimps of economic importance in the Niger Delta. 2nd Conf. Fish Soc. Nigeria, Calabar, 1982. 254–288.

24. Schneider W. FAO species identification sheets for fishery purpose. Field guide to the commercial marine resources of the Gulf of Guinea. FAO, Rome. 1990. 268pp

25. Olaosebikan BD, Raji A. Field guide to Nigerian freshwater fishes. Federal College Freshwater Fisheries Technology, New Bussa, Niger State, Nigeria.1998. 106pp

26. Adetayo JA, Kusemiju K. Some aspects of the biology of the pink shrimp, *Penaeus notialis* (Perez - farfante) in the Lagos lagoon Nigeria. J. Sci. Res. Dev. 1994. 1 (1): 80 -84

27. Oyenekan JA. Community structure and production of benthic macrofauna of Southampton water. Ph.D. Thesis University of Southampton. 1981. 351pp

28. Olaniyan, C. I. O. (1968). *An introduction to West African animal ecology*. Heinmann Educational Books Ltd. London & Ibadan. 167pp.

29. Campbell AC. *The Hamlyn Guide to Seashore and Shallow Seas of Britain and Europe*. Hamlym, London. 1977. 320pp

30. Edmunds J. Sea shells and other mollusks found on West African shores and estuaries. Ghana University Press, Accra,1978.146pp

31. Shannon C E, Weaver W W. *The mathematical Theory of Communication.* University of Illinois Press, Urbana. 1963. 125pp.
32. Lloyd M, Ghellardi R J. A table for calculating the equitability component for species diversity. *J. Anim. Ecol.* 1964. 33: 217 – 225.
33. Webb JE. The ecology of Lagos lagoon. 1: The lagoons of Guinea coast. Pil. Transc. Roy. Soc. Lond Ser.B. 1958.307 – 318
34. Hill M B, Webb J E.The ecology of Lagos lagoon II. The topography and physical features of Lagos harbour and Lagos lagoon. *Phil. Trans. Roy. Soc. Lond.* 1958. 683(241)**:** 319-449.
35. Fagade SO. Studies on the biology of some fishes and the fisheries of the Lagos lagoon. Ph.D.Thesis University of Lagos. 1969. 385pp
36. Sandison EE. The effect of salinity flunctuations on the life cycle of *Balanus pallidus strusburi* (Darwin), in Lagos harbour, Nigeria. *J. Animal Ecol.* 1966. 35: 363 – 378.
37. Brown CA, Oyenekan JA. Temporal Variability in the structure of benthic macrofuana communities of the Lagos Lagoon and Harbour, Nigeria. *Pol. Arch Hydrobiol.* 1998. 45(1):45–54
38. Nwankwo DI, Onyema IC, Adesalu TA. A survey of harmful algae in coastal waters of south western Nigeria. Journal of Nigerian Environmental Society. 2003. 1 (2): 241 -246
39. Duke EOE. Species variation and food of fishes in brackish water pond. M.Sc. Thesis, University of Lagos. 105pp
40. Oyenekan JA. Benthic macrofaunal communities of Lagos Lagoon, Nigeria. *Nig. J. Sci.* 1987. 21: 45 – 51
41. Egonmwan RI. On the biology of A.
42. *Tympanotonous fuscatus var radula* (Gastropoda: a Prosobranchia: Potamididae). Proc. 8th Inter. Congr. Malacologia. Budapest. 1980
43. Zabi G SF, Leloeuff P. Benthic Fauna in Margi-no - littoral system of West Africa, a review. Part 2. Fauna and Biotopes. *Rev. Hydrobiol. Trop.* 1993. **26**: 19 – 51.
44. Solarin BB. The hydrobiology, fishes and fisheries of the Lagos lagoon, Nigeria. Ph.D Thesis, University of Lagos.1998. 235pp
45. Fagade S O, Olaniyan C IO. Seasonal distribution of the fish fauna of the Lagos lagoon. *Bulletin de I' L F.A.N. T.XXXVI, Ser A.* 1974. 244 - 252.
46. Margalef R. La Teoria de la information en ecologia (Barcelona). *Mems R. Acad. Cienc.* (3rd Ser.) 1957. 32: 373 – 449.
47. Layman C A, Arrington DA, Langerhans R B. Silliman BR. Degree of fragmentation affects fish assemblage structure in Andros Island (Bahamas) estuaries. *Caribean Journal of Science*. 2004. 40 (2): 232 – 244.

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