INTERNATIONAL JOURNAL OF NATURAL AND APPLIED SCIENCES (IJNAS) VOL. 1, No. 1: pp. 30 – 36, 5 TABLES, 1 FIG.

The microbial and physico-chemical survey of Oron mangrove swamp.

M. A. Ekpo[*1] and G. N. Madu[1]

ABSTRACT

The microbial and physico-chemical studies of mangrove swamp ecology of Oron area was carried out. The samples which included water, sediment, Crab, Oyster, Periwinkle and Prop Root from the mangrove swamp revealed significant differences in both the heterotrophic and coliform count within the sample units. The sediment had the highest heterotrophic and coliform count of 2.87 + 0.32 x 10^7 cfu/g and 2.74 + 0.12 x 10^7 cfu/g respectively. The fungi had the lowest count which ranged from 1.45 + 0.22 x 10^4 cfu/g in crab sample and the highest count of 2.6 +0.15 x 10^5 cfu/g in sediment sample. The hydrocarbonoclastic count from different swamp locations though not significantly different, were considerably high. Among the microbial isolates, *Staphyloccus aureus*, *Escherichia coli, Enterococcus faecalis, Vibrio cholerae, Salmonella typhi, Aspergillus flavus, Candida* sp were observed as organisms with health implications in the aquatic ecosystem. The physicochemical analysis revealed normal concentrations except for iron which was above WHO standard. The result revealed high human interactions with the swamp ecology which posses health risk to the riverine dwellers.

Keywords: Mangrove swamp, hydrocarbonoclastic, coliforms, heterotrophic organisms, ecosystem, biodegradation.

INTRODUCTION

Nigeria's wetlands fall into two main categories namely: the saline coastal mangrove swamps and the fresh water floodplains. Mangrove is known to thrive in marine and brackish habitat and may be seen as narrow strips for several kilometers inland, along the bank of the major rivers in the Delta (NEST, 1990). They exist in tropical and subtropical seas and are found on flat land between the high and low marks. Like salt marshes, mangrove swamps are subjected to total inundation during which mud is deposited so that there is a gradual elevation of land height (Chapman, 1976). Moreover, mangrove ecosystem is a complex system comprising swamps, mudflats, mangrove trees and other salt tolerant plants, creeks and drain canal. Within the ecosystem are invertebrate and vertebrate faunas, microorganisms and the interacting physico-chemical factors such as temperature, salinity, tides and chemical constituents of the muddy deposits (Odum, 1971; Moses, 1985). Some microorganisms are transient, entering the water from air, soil, or from other industrial or domestic processes. These organisms and their activities are of great importance in many ways and may affect the health of humans and other animal life (Brock *et al*, 1994). Microorganisms are important as food for soft substratum benthos. They are consumed as food directly, and also help in nutrient recycling in mangrove ecosystem.

The soil of the mangrove swamps have high organic content which is decomposed by bacterial action. Thus releasing mineral nutrients into the water ecosystem. These are known to induce the growth of phytoplankton which form the base (primary producers) of the food chain in the ecosystem (Jeffrey, 1995; Moses, 1985). Bacteria and detritus entering from sewage outfall or runoff sometimes tend to persist rather than being consumed by aquatic ecosystem and therefore result in excessive nutrients. This leads to eutrophication, hence bacteria pollution may become a great health hazard in sediment loaded water-ways (Bernard, 1987). These water-ways among the mangrove are important feeding and nursery area for a variety of juvenile finfish as well as crustaceans, all of which are important sources of protein. Thus the discharge of raw sewage in water-ways not only lead to enteric diseases, it also cause the collapse of aquatic ecosystem because the raw sewage depletes dissolved oxygen in water-ways leading to fishes and shell-fishes suffocation (McGraw – Hill, 1997; Bernard, 1987; Ekanem *et al.*, 1995). Another major problem in our aquatic ecosystem is the incessant pollution from crude oil and drilling additives. It has been reported that these pollutants are not only toxic to microorganisms but also to it number of fishes in the ecosystem (Ekpo and Ekanem, 2000; Ekpo, 2001).

Mangrove in Nigeria is dominated by red mangrove (Rhizosphera spp) in association with white mangrove (*Avicennia)* and *Laguncularia racemosa* with wide spread of Nypa palm because of its stronger root system which spread faster than the native red and white mangrove (NEST, 1990; Ukpong, 1995). Many species show modified root structure such as prop root whereas others have erect

*Corresponding author
Manuscript received by the Editor September 27, 2004; Revised manuscript accepted August 2, 2005.
[1]Department of Microbiology, University of Uyo, P.M.B. 1017, Uyo, Akwa Ibom State, NIGERIA

root structures (Pneumatophores) that facilitates oxygen penetration to the root of these mangrove trees and trapped sediment creates productive habitat for fish, shrimps, crabs, oyster, snails, mussels and other animals living directly or indirectly on the nutrients from fallen mangrove leaves (Witherby, 1987; Samuel and Jane, 1984).

Generally, the available information on the microbial population in the mangrove ecology is very scanty and very little work has been done on the bacterial flora of the mangrove mud (Samuel and Jane, 1984). This work was therefore designed to assess the microbiological status of the mangrove swamp ecology and their distribution within the ecosystem. It was also to correlate the physico-chemical parameters with the pollution levels in the ecosystem.

MATERIALS AND METHODS

Study area / sample collection

The mangrove swamp ecosystem under study is located in Oron Local Government Area of Akwa Ibom State of Nigeria and spans through Idua Asang and Esin Ufot (Fig. 1)

Samples analysed include, water samples, sediment, prop root, the land crab (cardisoma), Oyster (*Ostrea tulioa*), and Periwinkle (*Tympanotomus fuscatus* and *Pachymelania aurita*). They were aseptically and randomly collected from different locations along the swamp using sterile plastic containers; labeled and transported to the microbiology and central research laboratories of University of Uyo, Uyo for microbiological and physicochemical analysis respectively.

Microbiological analysis

The media employed for the isolation and enumeration process were Nutrient Agar for primary isolation of bacteria, Eosin Methylene Blue Agar for coliform count, Malt Extract Agar and Sabouraud Dextrose Agar for fungi spp and Mineral salt medium supplemented with 1% crude oil for total hydrocarbonoclastic count. Pour plate technique was used as described by Cruickshank *et al.* (1975). The fresh shellfish were aseptically deshelled using sterile knife and hammer. The flesh of Oyster, Periwinkle and the gills of the crab were then picked out using a sterile needle into a sterile beaker. They were rinsed with distilled water to remove pieces of shell and were then transferred aseptically into a crucible mortar and homogenized with pistle. Then one gram of each of the homogenized shellfishes and sediments were serially diluted and thereafter plated out in triplicate using the methods of Collins and Lyne (1976); Fawole and Oso (1988).

The prop root sample was rinsed in distilled water using a sterile beaker and the water sample was shaken properly to mix. Thereafter, 1ml of water sample and 1ml of the neat from the rinsed prop root were plated out. The Nutrient Agar and Eosin Methylene Blue Agar were incubated at 37^{o} C for 24 to 48 hours while Sabouraud Dextrose Agar and Malt Extract Agar were incubated at room temperature for 5 days. The plates for hydrocarbon degraders were incubated also at room temperature for 10 days using mineral salt medium supplemented with 1% crude oil. The isolates were examined for their colonial and microscopic morphology. Biochemical tests and

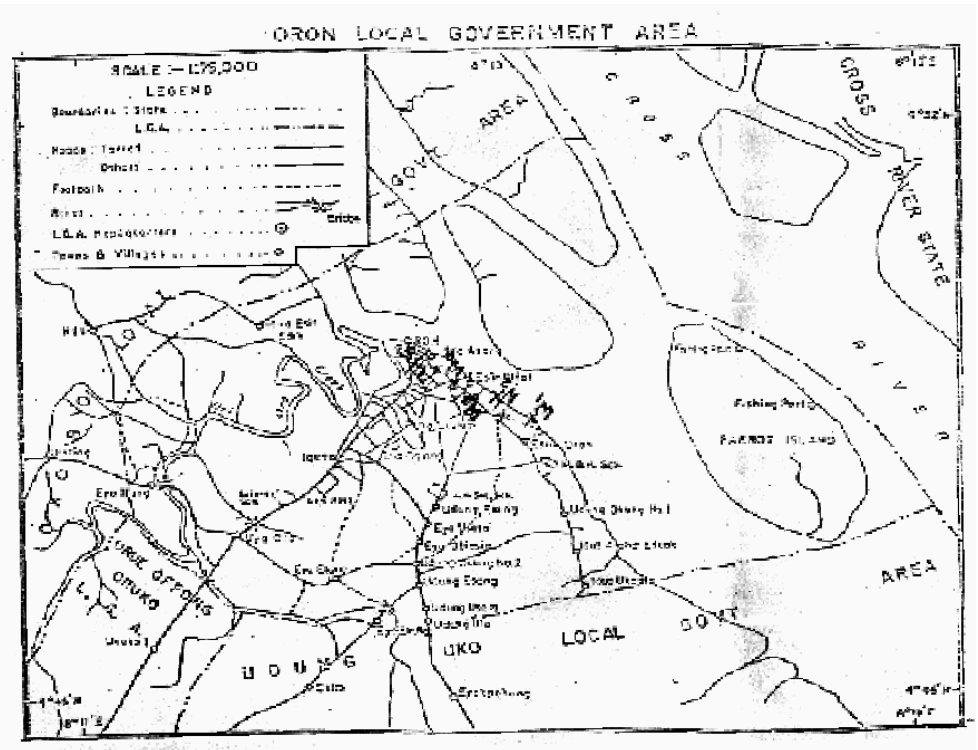

Fig. 1. Map of Oron Local Government Area showing the Oron Mangrove SwampEcology (Sampling area marked W_1, W_2, W_3, W_4, and W_5 at the centre of the map).

characterization were done using the method of John *et al.* (1994); Cowan (1985) and Cruickshank *et at.* (1975).

Physico-chemical analysis of the water sample

Some of the physico-chemical parameters analysed were pH, hardness, electrical conductivity, total dissolved oxygen, iron, copper, magnesium, calcium and potassium. Water shaker U–10 (Horiba) was standardized and used for the detection of pH, conductivity, turbidity, dissolved oxygen and temperature range. Titration method was employed using phenolphthalein potassium dichromate ($K_2Cr_2O_7$) and methyl-red indicator to obtain the alkalinity Chloride and acidity of the water respectively. Ammonium (NH_4^+), Sulphate (SO_4^{2-}), and Phosphate (PO_4^{3-}), were determined with Ultra-Violet photometer while Cu, Fe, Mg and Ca were detected using flame photometer and Atomic Adsorption Spectrophotometer. Salinity of the water was then analysed using electrical conductivity metre.

RESULT

Microbial population studies

The result of the microbiological study of the mangrove swamp ecology is shown in Table I. There was a high microbial count in all the samples analysed with water having the least count of 1.94 + 0.28 x 10^4 cfu/g while sediment had the highest count followed by prop root and other shellfishes as presented in Table1. The gills of the crab showed no fungal growth but only bacterial growth. The sediment had the highest coliform count whereas oyster had the lowest count of Coliform. The hydrocarbonoclastic count of the water samples from different locations within the mangrove showed higher count of bacterial biodegraders than fungi (Table 2).

Microbial species

The percentage occurrence of isolates from the different samples showed that microorganisms are widely distributed within the mangrove ecosystem Table 3. The isolates most widely encountered were *Bacillus* sp., *Staphylococcus aureus, Vibrio cholerae, Micrococcus, varians.* Among the bacteria isolated from the samples were *Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Aerobacter aerogenes, Vibro cholerae, Chromobacterium violeceum, Bacillus polymyxa, , Micrococcus halophilus, Salmonella, typhi, Pseudomonas aeruginosa, Cellulmonas, Micrococcus varians, Caulobacter, Microcystis, Thiothrix nivea, Klebsiella pneumoniae and Flavobacterium* sp. The fungi genera isolated were *Aspergillus, Penicillium, Candida, Cladosporium, Fusarium Phoma,_Mucor* and *Absidia*, Table 4.

Physico-chemical parameters

The physicochemical parameters analysed fell within the standard as recommended by World Health Organization (WHO) and Federal Environmental Protection Agency (FEPA) for aquatic life. Some trace elements were detected except Copper (Cu). The range of pH and temperature were 6.6 – 7.9 and 25.2 - 30^{o}C respectively. A clear presentation of these parameter is shown on Table 5.

DISCUSSION

The microbiological analysis of the mangrove swamp ecology carried out revealed that the variation in microbial load between the shellfishes (Oyster, periwinkle and crab), the prop roots and the water samples, can be attributed to the variations in micro environmental conditioned encountered by these organisms, and the self-purification of the water body. The wetlands (mangrove swamps) are said to be natural purification systems and they mitigate flood effect by absorbing flood waters that might otherwise destroy properties (Turks, 1995).

This study particularly revealed high microbial count in the Oyster, sediment and the prop root which serve as habitat to these marine organisms. The heterotrophic and coliform counts of the sediment samples were found to be significantly higher (P = 0.05) than those of other samples. The deposit feeders (shellfishes) also recorded significant high count especially with the heterotrophic org- anisms. This is so because the deposit feeders are known to ingest sediments and use organic matters and microorganisms in the sediment as food (Jeffrey, 1995). The high count of the heterotophic organisms in the swamp ecology are considered advantageous because they contribute significantly to the microbial decomposition process and use a variety of these compounds as hydrogen acceptors.

The microorganisms isolated from the mangrove swamp such as *Staphylococcus aureus, Escherichia coli, Enterococcus faecalis, Vibrio cholerae*, and *Salmonella typhi* are of public health importance. Most of the bacterial isolates obtained from these sea

Table 1. The microbial count of sample materials from mangrove swamp ecology.

Samples Total	Water (cfu/ml)	Sediment (cfu/q)	Prop Root (cfu/ml)	Crab (cfu/q	Oyster (cfu/q)	Periwinkle (cfu/q)
Heterotrophic Count	1.94 + 0.28 x 10^4	2.87 + 0.32 x 10^7	1.77+ 0.28 x 10^7	5.29+ 0.18 x 10^6	1.20+ 0.20 x 10^7	1.21+ 0.45 x 10^7
Total Coliform Count	1.64+ 0.08 x 10^4	2.74 + 0.12 x 10^5	2.60 + 0.18 x 10^5	1.30 + 0.17 x 10^5	1.12 + 0.17 x 10^4	1.30 + 0.19 x 10^6**4**
Total Fungi Count	1.05+ 0.05 x 10^5	2.60 + 0.15 x 10^5	2.40 + 0.25 x 10^5	1.45 + 0.22 x 10^4	1.58 + 0.15 x 10^4	2.10 + 0.10 x 10^5

LSD - 4.68 x 10^6

Table 2. Total hydrocarbonoclastic count for water samples collected from different locations in the mangrove swamp.

Sample Location	W1	W2	W3	W4	W5	Mean Count
Bacteria (cfu/ml)	2.20 + 0.20 $x10^7$	1.45+ 0.25 $x 10^6$	1.60 + 0.17 $x 10^6$	2.40 + 0.57 $x 10^6$	1.35 + 0.05 $x 10^6$	1.80+ 0.25 $x 10^6$
Fungi (cfu/ml)	9.0 + 0.55 $x 10^4$	1.20 + 0.10 $x10^4$	5.0+ 0.24 $x 10^4$	3.5+ 0.16 $x 10^4$	6.0+ 0.46 $x 10^4$	7.1+ 0.66 $x 10^4$

LSD - 2.44×10^6
Location of samples W1 – W5 are shown on Fig. 1.

Table 3: Distribution of bacterial species in different samples in the mangrove swamp ecology

Microbial Species	Water	Sediment	Prop Root	Crab	Oyster	Periwinkle	Percentage of occurrence
Chromobacterium violaceum	-	-	-	-	-	+	16.6
Proteus rettgeri	+	+	-	-	-	+	50.0
Flavobacterium sp.	-	+	-	+	+	-	50.0
Aerobacter aerogenes	-	+	-	-	-	-	16.6
Bacillus polymyxa	-	-	+	-	-	-	16.6
Listeria sp.	+	+	+	-	-	-	50.0
Escherichia coli	+	-	-	-	+	+	50.0
Staph. aureus	+	+	-	-	+	+	66.6
Micrococcus varians	+	+	-	-	+	+	66.6
Enterococcus faecalis	+	-	-	+	-	+	50.0
Salmonella typhi	-	-	-	+	+	+	50.0
Bacillus subtilis	-	+	+	+	+	-	66.6
Micrococcus halphilus	-	+	-	-	-	-	16.6
Vibrio cholerae	-	+	-	+	+	+	66.6
Pseudomonas aeruginosa	+	+	-	-	+	-	50.0
Bacillus cereus	+	-	-	-	-	+	33.3
Aeromonas hydrophila	-	-	-	+	-	-	16.6
Klebsiella pneumoniae	+	-	-	+	+	+	66.6
Cellulomonas sp	-	+	-	-	-	-	16.6
Thiothrix nivea	-	+	-	+	-	-	33.3

Mean ($\overline{X}$) = 42.46 %
Standard Error of mean (Sx) = 7.74
Standard deviation = 19.85

foods have earlier been reported on other invertebrates found in aquatic environment (Clarke and Bauchop, 1977). The internal organs of these organisms are known to habour a number of microbial species, as their flesh is readily colonized by microorgan isms. The frequency of isolation of most enteric species indicate their wide spread distribution in the mangrove swamp ecosystem. The presence of these indicator organisms revealed that the swamp was polluted with faecal matters. Moreso, the presence of *E. coli* and *Enterococcus faecalis* indicate a recent faecal pollution. This further confirms the report of riverine dwellers using the swamp as improvise domestic waste disposal system. The occurrence of *Vibrio cholerae, Salmonella typhi* and *Staphylococcus aureus* in the samples (water, sediment and shellfishes) is attributed to sewage and faecal contamination (Colwell *et al.*, 1981). The high percentage occurrence of these organisms is a strong evidence of human interaction with the water. This is because *Staph. aureus* is a normal flora of the skin. This incidence constitutes a public health hazard because users of this swamp, especially for bath can accidentally swallow this contaminated water, which can result in outbreak of disease like chloera, typhoid and paratyphoid fever, gastroenteritis and diarrhaea. Some fungal pathogens of man were encontered in this work, namely *Aspergillus niger, A. flavus Penicillium rubrum, P. chrysogenum* and *candida* sp. Alice (1977) reported that *Apergillus niger* is responsible for aspergillosis, usually an infection of the external ear (otomycosis) which may result in ulceration of the linning of the ear canal and perforation of the tympanic membrane. Such fungin ormally live in the ear wax).

Table 4. Distribution of fungal species in different samples in the mangrove swamp ecology

Microbial Species	Water	Sediment	Prop Root	Crab	Oyster	Periwinkle	Percentage of occurrence
Penicillium chrysogenum	+	+	-	-	-	+	50.0
Mucor sp	+	-	-	+	+	-	50.0
Aspergillus niger	+	-	-	-	+	+	50.0
Asp. fumigatus	-	+	-	-	+	-	33.3
Asp. Flavus	+	+	-	-	-	+	50.0
Cladosporium sp	-	-	+	+	-	-	33.3
Phoma sp	-	-	-	+	+	-	33.3
Fusarium sp	-	+	-	+	-	+	50.0
Aspergillus carbonacius	-	-	+	+	-	-	33.3
Penicillium rubrum	-	+	+	-	-	-	33.3
Candida sp	+	+	-	+	-	-	50.0

Mean ($\bar{X}$) - 41.65 %
Standard Error of Mean (Sx) - 2.51
Standard deviation - 8.72

Table 5. Mean physico-chemical analysis of a mangrove swamp ecology

Parameter	Results	FEPA	WHO
pH	6.6-79	6.0 – 9.0	6.5 – 9.2
Conductivity (ms/em)	0.012-0.033	-	-
Turbidity (ntu)	4.0-12	-	25
Dissolved Oxygen (mg/l)	0.01-0.04	20	-
Temperature (^{O}C)	25.2-30.4	20-30	-
Alkalinity (mg/l)	47-53	-	-
Chloride (mg/l)	136-148	250	200
Hardness	75-125	200	500
Total Dissolved substance (mg/l)	90-110	500	1000
Total soluble solute (mg/l)	135-`65	-	-
Biological Oxygen Demand	0.53-.79	4.0	-
Electrical conductivity (ds/m)	3.75-4.43	75 us/cm^3	
Acidity (mg/l)	1.66-1.98	-	-
NH_4^+ - N (mg/l)	0.1-.54	2.2 – 1.37	0.5
SO_4^{2-} (mg/l)	3.05-4.37	500	400
PO_4^{2-} (mg/l)	1.50-4.50	-	-
K^+ (mg/l)	0.422-0.810	-	-
Cu (mg/l)	ND	2.4	1.0
Fe (mg/l)	1.12-1.88	1.0	0.3 – 1.0
Mg (mg/l)	1.00-2.73	-	-
Ca (mg/l)	0.5.1-1.35	-	-

N.D - Not detected

Since most mangrove swamp ecosystem habour sea foods, the use of swamp for faecal disposal and for bath by the inhabitant poses great danger. This is partly because of the level of enlightenment on the danger in which faecal waste disposal into the swamp posses to dwellers. It is also because mangrove swamp have long been used as satisfactory dumping grounds for sewage, domestic waste and heavy metals pollutants without observable significant adverse effect (Wong *et al.* 1995). It is believed that systematic education of the riverine dwellers on the danger and hazards of this disposal system will help to reduce the menace in our swamp ecology.

The population of the hydrocarbonclastic organisms from the water samples were high when compared to the total viable count of the water. Also some microbial genera isolated from the mangrove swamp ecosystem such *as Pseudomonas, Flavobacterium, Bacillus, Micrococcus, Candida, Absidia, Cladosporium, Aspergillus, Penicillium* and *Fusarium* possesses the ability of degrading hydrocarbon. Their presence in the ecosystem indicate oil pollution of the Oron mangrove swamp ecosystem. These organisms have also been reported by Bartha and Atlas (1977) and Sorkhoh *et at.*, (1990) as the dominant hydrocarbon degraders in most marine environment. The presence of these organisms within the mangrove swamp enhance the self purification of the ecosystem becaues they are capable of gradually detoxifying potentially harzadous chemicals and wastes through the process of biodegradation.

The trace elements, e.g., potassium, magnesium and calcium detected in this research are of nutritional importance to man. However, the high concentration of iron obtained in the water may be injurious to human health because iron is a potential dietary antagonist of copper metabolism in the formation of haemoglobin in erythrocytes within the bone marrow. Its excess also has been known to cause cirrhosis in the liver, diabetes and pancreas insufficiency if taken through shellfishes consumption (Nester *et al.*, 1995).

CONCLUSION

The result of microbial and physico-chemical studies of Oron mangrove swamp reveal that the mangrove swamp is highly polluted with faecal matters. This has some health implications sincs manheavily depends on this ecosystem for their protein source. The isolation of indicator organisms and enteric pathogens such as *Escherichia coli, Entercoccus faecalis, Salmonella typhi, Vibrio cholerae* and *Staphylococcus aureus* and the isolation and the high count of crude oil degraders is a cause for concern particularly because the shore is used by both the young and the old.

The physicochemical parameters were moderate except for iron concerntration which was far above the World Health Organization (WHO) and Federal Environmental Protection Agency (FEPA) standards. The Oron mangrove swamp which is polluted as a result of indiscriminate disposal of faecal matters, domestic and industrial waste and also used as a means of transportation in the Nigeria Niger Delta is highly under stress. Measures to reduce the excessive pollution of our mangrove swamp ecology should be instituted and properly monitored in order to reduce the incidence of infection among the coastal dwellers and the society at large.

REFERENCES

Alice, L. S. (1977) *Principles of Microbiology*. 5th Edition. London: C. V. Mosby, pp 661 - 710 .

Bartha, R. and Atlas, R. M. (1977). The microbiology of aquatic oil spills. *Adv. Appl. Microbiology*. 22: 225 – 266.

Bernard, J. N. (1987). *Environmental Science*. Simon and Schuster. Englewood Cliffs, New Jersey pp. 259 – 273.

Brock, T. D; Madigan, M. T; Martinko, J. M and Parker, J. (1994*). Biology of Microorganisms.* Prentice – Hall Inc. A Simon and Schuster Company, Englewood Cliffs, New Jersey 07622. pp. 568 – 638.

Chapman, V. J. (1976*). Coastal Vegetation*. 2nd edition. Pergamon Press Ltd., pp. 217 – 233.

Clarke, R. T. and Bauchop (1977). *Microbial Ecology of the gut.* 4th Edition. Academic Press London pp. 222 – 224.

Collins, C. H. and Lyne, P. M. (1976*). Microbiological Methods*. Butterworths and Company Limited, Great Britain. pp. 159 – 727.

Caldwell, R. R, Sciller, R. J, Kaper, J. J, Joseph, S. H, Remmers, E, Haul, I. and Hug, H. (1981). Occurrence of *Vibrio cholerae* genotype 01. in Maryland and Loisiana Estuaries*. Applied and Environmental Microbiology*. 41: 555 – 558.

Cowan, S. T. (1985). *Cowan and Steel Manual for the Identification of Medical Bacteria*.Cambridge University Press, London. pp 231.

Cruickshank, R, Duguid, J. O, Marmion, B. P. and Swain, R. H. A. (1975). *Medical Microbiology*. Churchill Living Stone, London. 2 : 555 – 667.

Ekanem, Edo; Adegoke, G. O. and Ossai, G. E. A. (1995). Bacteriological and Organoleptic characteristics of Dehydrated West African Clam Meat*. Nigerian Food J.*. 12: 50 – 58.

Ekpo, M. A. and Ekanem, I. J. (2000). Toxicity of Petroleum drilling mud additive (chromelignosulfonate) on micro-organisms and fresh water fish (*Oreochronis niloticus* - Tilapia*). Nigeria J. Microbiology* 14 : 55 – 60.

Ekpo, M. A. (2001). Toxicity of Petroleum drilling mud additive (chromelignosulfonate) on micro-organism and fresh water fish; *Clarias lazera* (Cat Fish*). World J. of Biotechnology,* 2: 195 –202.

Fawole, M. O. and Oso, B. A. (1988*). Laboratory Manual of Microbiology*. Spectrum Book Limited, Ibadan, Nigeria. pp. 34 – 35.

Jeffrey, S. L. (1995*). Marine Biology, Function, Biodiversity, Ecology*. Oxford University Press Inc. pp 394 –399.

John, G. H, Noel, R. K, Peter, A. A. S, James, T . S, Stanley, T. W. (1994). *Bergey's Manual of Determinative bacteriology.* (9th Edition). Williams and Wilkins, 428 East Preston Street Baltimore, Maryland, USA. 787 pp.

McGraw – Hill (1977*). Encyclopedia of Science and Technology*. 10:414 - 415.

Moses, B. S. (1985). Mangrove Swamps as potential food source. *In Mangrove Ecosystem of the Niger Delta.* University of Port Harcourt. pp. 170 – 184.

NEST (1990) *Nigeria's Threatened Environment: A National Profile*. Intec. Printers. pp 139 – 160.

Nester, E. W.' Robert, C. E. and Nester, M. T. (1995). *Microbiology: A Human perspective.* W. C. Brown Publishers, p. 701.

Odum, E. P (1971). *Fundamentals of Ecology*. Sounder Philadelphia p. 574.

Samuel, C. S and Jane, G. S. (1984*). The Mangrove Ecosystem: Research Methods*. UNESCO, United Kingdom. pp 54 – 230.

Sorkhoh, N. A, Ghannoum, M. A, Ibrahim, A. S, Stretton, R. J. and Rdaman, S. S. (1990). Crude Oil and Hydrocarbon degrading strains of *Rhodococcus* strains isolated from soil and marine environments. Kuwait. *Environ. Pollut.* 65 : 1 – 18.

Turk, T . (1995*). Environmental Geoscience* Harcourt Brace and Company pp. 227 – 234.

Ukpong, I. (1995). An Ordination Study of Mangrove Swamp Communities in West Africa*. Vegetation* . 116 : 147 – 151.

Witherby and Co. Ltd. (1987). *Response to Marine Oil Spills.* The International Tanker Owners Pollution Federation Ltd. London, pp. I – IV. 18.

Wong, Y. S, C. Y, Che, S. H, Li, X. R and Tam, N. F. Y. (1995). Effects of waste water discharge on Nutrient contamination of mangrove soil and plants*. Hydrobiologia*. 295: 243 – 254.