Original Article

Microbial Assessments of Soil Sediments of Foma River, Ita-Nmo, Ilorin, Nigeria.

Agbabiaka, T. O. and Oyeyiola, G. P.

Department of Microbiology, University of Ilorin, Ilorin, Nigeria.

Submitted: Dec. 30, 2011; Accepted: Nov. 12, 2012; Published: Dec. 17, 2012.

ABSTRACT

The microbial and physicochemical characteristics of soil sample sediments obtained from Foma River, Ita-Nmo, Ilorin, Nigeria was determined over a period of fifteen months at four designated sampling points using standard methods. pH ranged from 5.65 to 7.83 while organic matter content ranged from 6.0 to 88% and water holding capacity ranged from 0.125 mg/l to 1.682 mg/l. The percentage composition of sand to clay to silt in samples A, B, C and D was 85: 2: 13, 34: 12: 54, 21: 63: 16 and 55: 23: 22 of the sampling points indicating the predominance of loamy sand, silt loam, clay and sandy clay loam at the points. The total bacterial counts ranged from 4.0×10^2 to 2.03×10^4cfu/g while the fungal counts ranged from 2.0×10^2 to 6.6×10^3 cfu/g. The genera of bacteria isolated included *Corynebacterium*, *Escherichia*, *Bacillus*, *Enterobacter*, *Klebsiella*, *Staphylococcus*, *Micrococcus*, *Acinetobacter*, *Pseudomonas*, *Aeromonas*, *Salmonella*, *Streptococcus*, *Proteus* and *Erwinia* while the genera of fungi isolated included *Curvularia*, *Aspergillus*, *Penicillium*, *Saccharomyces*, *Cladosporium*, *Geotrichum*, *Trichoderma*, *Mucor*, *Rhizopus*, *Fusarium* and *Mortierella*. The level of biological pollution of the soil sediments could be of great risk due to the presence of potential pathogens in the sediments hence the water and soil sediments of this river need treatment to make it potable and safe for both domestic and recreational activities.

Keywords: Bacteria, Fungi, Pollution, Soil, Physicochemical Parameters.

* **Corresponding Author:** agbabiaka.toyin.toyin@gmail.com

INTRODUCTION

The term soil refers to the outer, loose material of the earth's surface, a layer distinctly different from the underlying bedrock (Alexander, 1977).

Soil is composed of five major components: mineral matter, water, air, organic matter and living organisms (Alexander, 1977) and the texture is determined on the basis of the soil's content of sand, silt and clay and the

textural class is ascertained from the textural triangle (Olaitan and Lombin, 1984).

Sediment is any material that settles to the bottom of a lake, river or ocean and sediments is composed of dead and living organisms, dust from the air, soil eroded from the continents and chemical solids as well as water and nutrients (Alexopolous, 1983, Carla, 1997, Robert and Stanley, 2000). Sediments differ from soil but they both provide different environments for microorganisms and play different roles in the ecosystem of a wetland.

Sediment could be autochthonous or allochthonous, however, most of the microorganisms found in soil are also known to be present in sediment as a result of run-off from soils and microorganisms cultured from sediments at the bottom of deep oceans, and are similar to those from surface soils (Prescott *et al*., 2002).

The combination of living and dead materials suspended in water, which finally lead to the formation of sediment. It is composed of; Fine particles of mineral matters originating on land but get transported into water; Detritus which is the inorganic and organic materials in water in very fine forms; Plankton; plant and animal creatures of small size floating in water.

Environmental factors such as temperature, pH, available moisture, organic matter content, degree of aeration, available nutrients have profound influence on fungal and other microbial lives (Brown, 1973, Frenchel and Reidl, 1970, Robert, 1995).

Pollutant in sediments imparts 'objectionables' that adversely affect life and also have influence on microbes in sediments and this is as a result of pollution. This means that as water gets polluted sediments in it also get polluted (Olayemi, 1994). The enrichment of sediment is also brought about by deposition of organic matter which may be derived from many sources; sewage, either discharged as domestic or industrial effluent to inter-tidal and in some areas or as sludge dumped to sub tidal areas (Figueras *et al*., 2000, Prescott *et al*., 2002).

An examination of particulate matter at the sediment-water interface in shallow water indicated that some 61% of the particles were potential food, being 43% organic mineral aggregation, 3.8% faecal matter, 2.3% skeletal elements, 1.9% micro-algae and fungi, and 0.7% non-algae plant fragments (Sieburth, 1979).

Foma River is a good source of domestic water for some neighbouring villages such as Ogundele, Mahdi and others, and during collection of water from this river, some of the sediments do get into the fetched water. The sediments also mix thoroughly with water during swimming activity by the school pupils from near-by primary and secondary schools.

There is therefore the need to study the level of pollution and determine the microbial load of soil sediments resulting from human activities and run-off from land because of its potential health hazard.

MATERIALS AND METHODS

Sampling Site

Foma River is located about seven kilometres from central part of Ilorin on Latitude N 08.49574 and Longitude E 004.5107. It is a free-flowing freshwater during the rainy season while slow-moving at the onset of dry season, some areas along the course of the river have very little quantity of slow-moving water at the height of dry season period. It has its source from Asa River and is one of the tributaries. It flows through Akerebiata, Oloje,

Airforce Quarters, Ita-Nmo, Yebumot hotel, Hajj Camp, all within Ilorin Metropolis.

Sample Collection

Soil sediments samples were collected from the four sampling points in sterile polythene bags labelled A, B, C and D once a month for a period of fifteen months. The samples were immediately transferred to and analyzed in the Microbiology laboratory, University of Ilorin, Ilorin not more than one hour after collection using standard methods as described by Fawole and Oso (2001).

Determination of Physicochemical parameters of Soil sediments of Foma River

The pH, organic matter and water holding capacity of the soil sediments were all determined using standard methods as described by Pramer and Schmidt (1984) while standard methods of Awolumate (1977) and Olaitan and Lombin (1984) were used in determination of soil texture.

Isolation and Estimation of Bacteria from soil sediments

Pour plate method was used for isolation of bacteria using standard method for the examination of water and wastewater (A.P.H.A., 2002, Dubey and Maheshwari, 2004, Olaitan and Lombin, 1984). The plates were then incubated at 37^0C for 24-48 hours.

Isolation and Estimation of Fungi from soil sediments

Potato Dextrose Agar was used for isolation of fungi using pour plate method and serial dilution of 10^2 as described by A.P.H.A. (2002) and Cheesebrough, (1993). The plates were incubated at 25^0C for about 72 hours (Fawole and Oso, 2001).

Purification and Identification of isolates

Pure cultures of bacterial isolates were obtained, and then characterized and identified using Bergey's Manual of Determinative Bacteriology (Buchanan and Gibbons, 1974).

Pure cultures of fungi isolates were also obtained before characterization and identification using standard methods of Alabi (1994), Alexopolous (1983), Fawole and Oso (2001) and Onions *et al*. (1981).

RESULTS AND DISCUSSION

pH of Soil Sediment

The pH of the soil sediments ranged from 5.65 to 7.83 in sample B and D respectively. This indicates variation in pH from acidity to alkalinity in the sample depending on the season of the year (Figure 1).

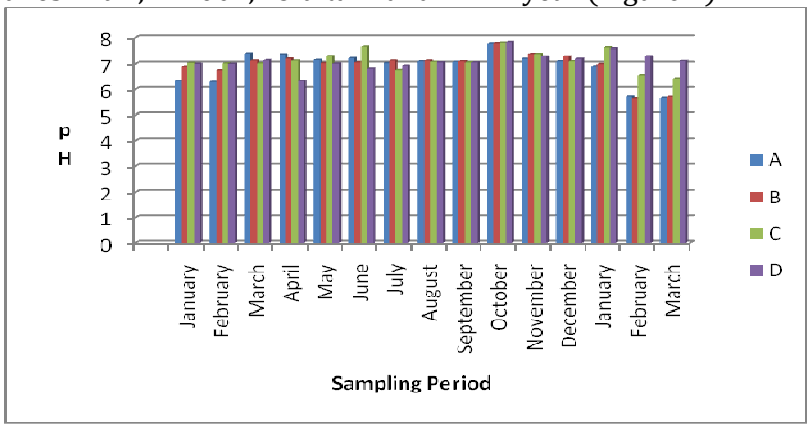

Figure 1: The pH of Soil Sediment Samples of Foma River, Ilorin.

In a similar study of freshwater, Tamaki *et al.*, (2005) obtained pH 6.4 in a similar study of freshwater sediment while Yeung-Cheug, (2009)) obtained pH range of 6.8-7.0 in her study.

Soil Texture of Soil Sediment

The texture of the soil sediment of Foma River is composed of sand, clay and silt and there are more of sand particles in sample A and D while silt particle predominates in sample B and clay content is very high in sample C as shown in Figure 2 .

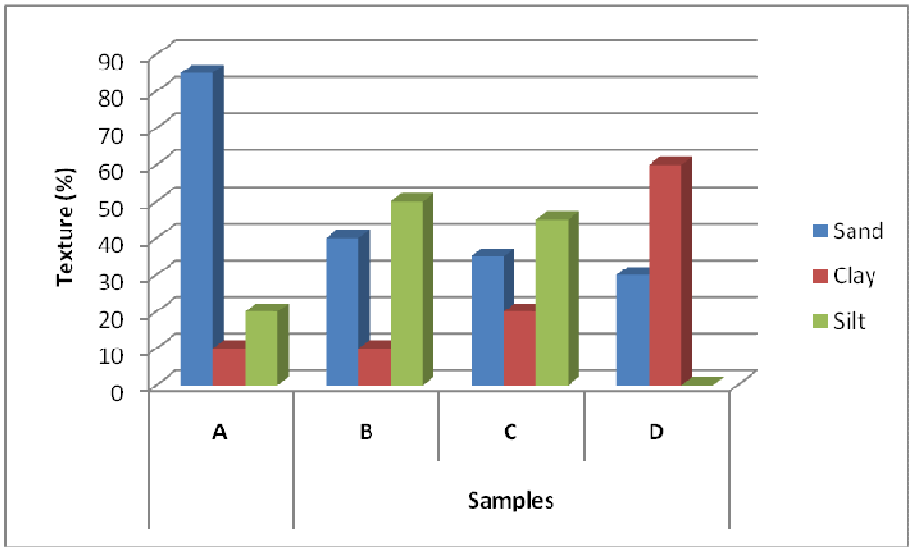

Figure 2: Soil Texture of Soil Sediments of Foma River, Ilorin.

This result is consistent with the finding of Morgan (2010), Olaitan and Lombin (1984) and Robert (1994) which stated that the texture of a soil is not readily subject to change, so it is considered a basic property of a soil.

Organic Matter of Soil Sediment

The Organic matter of the soil sediment samples of Foma River expressed in percentage ranged from 6.0 to 88.0 in sample B (Table 1) in January of first year indicating that biological activity was highest in the month of January of the first year and availability and utilization of nutrients was at its maximum in that month. This result is different from the one obtained by Shaffer and Ernst, 1999 in wetlands of Oregon due to level of pollution and soil types but conforms to that of Robert and Stanley, 2000.

Table 1 : Percentage Organic Matter of Soil sediment of Foma River , Ilorin.

	Sampling point			
Sampling Period	A	B	C	D
January	60.00±0.006 c	88.00±0.006 d	8.00±0.0060 b	6.00±0.006 a
February	56.00±0.006 c	66.00±0.006 d	18.00±0.006 b	6.00±0.000 a
March	28.00±0.006 d	16.00±0.006 a	18.00±0.000 b	20.00±0.006 c
April	8.08±0.006 a	18.38±0.006 d	16.54±0.006 c	9.88±0.006 b
May	13.76±0.006 a	20.58±0.006 b	25.32±0.006 c	40.48±0.006 d
June	29.66±0.006 b	53.20±0.006 d	28.88±0.006 a	30.08±0.006 c
July	26.16±0.006 c	54.56±0.006 d	23.38±0.006 b	17.40±0.000 a
August	19.36±0.006 d	15.72±0.006 b	17.72±0.006 c	13.30±0.006 a
September	21.36±0.006 a	30.70±0.006 c	21.36±0.006 a	25.08±0.006 b
October	20.98±0.006 c	63.84±0.006 d	13.46±0.006 a	16.90±0.006 b
November	25.18±0.006 d	17.58±0.006 a	20.74±0.006 c	17.74±0.006 b
December	22.72±0.006 c	27.38±0.006 d	17.56±0.006 a	22.58±0.006 b
January	26.88±0.006 b	27.68±0.006 c	19.68±0.006 a	30.36±0.006 d
13th month				
February	28.40±0.006 c	37.46±0.006 d	7.98±0.000 b	7.22±0.006 a
14th month				
March	29.30±0.006 c	34.24±0.006 d	6.79±0.006 a	7.11±0.000 b
15th month				

Values represents means ± Standard Error of mean. Values in the same row followed by the same letters are not significantly different using Duncan's multiple range test at $p<0.05$

Water Holding Capacity of Soil Sediment

The Water Holding Capacity of soil sediment samples of Foma River was very low in March of the first year with a value of 0.125 ml/g in sample C and highest in August of that same year with a value of 1.682 ml/g in sample B (Table 2). This result is similar to the result got

by Adegunwa (2003) and Agricultural Bureau of South Australia, 2011).

Table 2 : Water Holding Capacity (ml/g) of Soil sediment of Foma River, Ilorin.

	Sampling point			
Sampling Period	A	B	C	D
January	0.569±0.006 c	0.407±0.000 b	0.364±0.006 a	0.365±0.000 a
February	0.548±0.006 c	0.383±0.006 b	0.377±0.006 a	0.378±0.006 a
March	0.260±0.006 c	0.177±0.000 b	0.125±0.000 a	0.262±0.006 d
April	0.317±0.006 c	0.288±0.006 a	0.376±0.006 d	0.311±0.006 b
May	1.412±0.006 d	0.619±0.006 c	0.283±0.000 a	0.406±0.034 b
June	0.226±0.006 a	0.641±0.006 d	0.289±0.006 b	0.406±0.000 c
July	0.866±0.006 a	1.562±0.006 d	1.220±0.006 b	1.223±0.006 c
August	0.863±0.006 a	1.682±0.006 d	1.318±0.006 c	1.253±0.006 b
September	0.892±0.006 a	1.612±0.006 d	1.236±0.006 c	1.208±0.006 b
October	0.257±0.006 a	0.499±0.000 d	0.451±0.006 c	0.385±0.006 b
November	0.590±0.000 d	0.520±0.006 c	0.400±0.000 b	0.379±0.000 a
December	0.603±0.006 c	0.792±0.000 d	0.286±0.006 a	0.464±0.006 b
January 13th month	0.625±0.006 c	0.769±0.006 d	0.284±0.006 a	0.415±0.006 b
February 14th month	0.836±0.006 d	0.678±0.000 c	0.372±0.000 a	0.466±0.000 b
March 15th month	0.983±0.000 d	0.735±0.006 c	0.415±0.006 a	0.478±0.006 b

Values represents means ± Standard Error of mean. Values in the same row followed by the same letters are not significantly different using Duncan's multiple range test at $p<0.05$

Bacterial Isolates of Soil Sediment

A total of twenty-seven bacteria were isolated from the soil sediment samples within the period of analysis, though some of these bacteria occurred frequently than the others. The bacteria isolated include *Corynebacterium pseudotuberculosis, Corynebacterium renale, Corynebacterium kutscheri, Corynebacterium diphtheriae, Escherichia coli, Bacillus megaterium, Bacillus pasteurii, Bacillus subtilis, Bacillus licheniformis, Bacillus sphaericus, Bacillus cereus, Enterobacter aerogenes, Klebsiella pneumoniae, Staphylococcus aureus, Staphylococcus epidermidis, Micrococcus luteus, Micrococcus varians, Acinetobacter calcoaceticus, Pseudomonas aeruginosa, Pseudomonas putida, Aeromonas hydrophila, Aeromonas punctata, Salmonella enteritidis, Streptococcus faecalis, Proteus vulgaris, Proteus mirabilis* and *Erwinia amylovora*.

Escherichia coli, Enterobacter aerogenes, Micrococcus varians and *Salmonella enteritidis* occurred in the four samples and occurred more than once. The presence of *Escherichia coli* in soil sediments of Foma River as well as water sample earlier investigated had been reported by Adegunwa (2003), Akpata and Ekundayo (1978), Ishii *et al*. (2006) and Olayemi (1994) in similar research work on freshwater.

Erah *et al.* (2011) in their study of quality of underground water in Benin found *Escherichia coli* and *Streptococcus faecalis* to be the major contaminants at abnormal levels.

The bacterial isolates from Foma River were similar to those obtained by Ogbonna *et al*. (2011) on Orashi River, Nigeria.

The presence of *Enterobacter* species and *Bacillus* species in drinking water and reservoir tanks in a study by Nwachukwu and Otokunefor (2006) is supportive of those organisms being found in water and soil sediments of the river. Total Bacterial Counts expressed in cfu/g is shown in Figure 3.

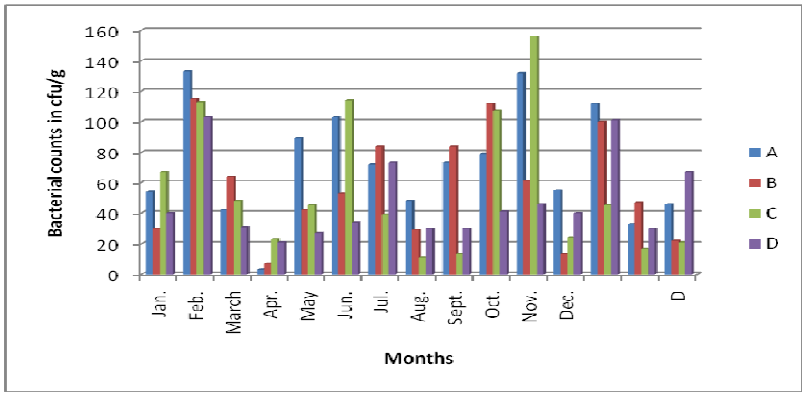

Figure 3: Bacterial Counts of soil sediments of Foma River, Ilorin.

Fungal Isolates of Soil Sediment

A total of twenty-two fungi were isolated which included *Curvularia geniculata, Aspergillus niger, Aspergillus terreus, Aspergillus parasiticus, Aspergillus fumigatus, Aspergillus*

nidulans, Aspergillus flavus, Aspergillus versicolor, Penicillium lapidosum, Penicillium spinolosum, Penicillium frequentas, Penicillium chrysogenum, Saccharomyces cerevisiae, Cladosporium herbarum, Geotrichum candidum, Trichoderma koningii, Mucor mucedo, Mucor racemosus, Mucor plumbeus, Rhizopus stolonifer, Fusarium oxysporum and *Mortierella ramanniana.*

Aspergillus niger was the most frequently isolated fungus occurring in all the samples in almost all the months that samples were collected. *Penicillium* species also occurred abundantly in the samples and some of those occurring conform to those obtained by Alabi (1994).

Variation in occurrence of fungi with season was obtained by Akpata and Ekundayo (1983) in Lagos which is similar to our finding.

Total Fungal Counts expressed in cfu/g is shown in Figure 4 below.

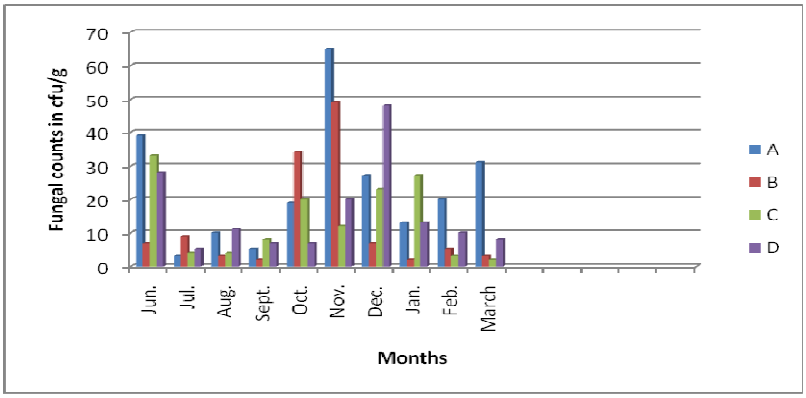

Figure 4 : Fungal counts of soil sediments of Foma River, Ilorin.

Sanitary Surveillance

Human activities found by the bank of the river are three cement block-making industries. The river also serves as recreational swimming pool for small children. Various types of birds including ducks, pigeons and egrets were seen on the river.

The agricultural activities as well as other human activities need constant monitoring so that the level of pollution is reduced to the minimum as observed by Environment Canada, (2010) and Figueras *et al.* (2000).

The observed sanitary surveillance of the sampling points of Foma River is as shown in Table 3 below.

Table 3: Sanitary Surveillance of the bank of the river near each sampling point

Sampling sites	Solid waste dump	Cow dung	Animals and fowls droppings	Domestic waste droppings
A	+	-	+	+
B	-	+	-	+
C	+	+	-	-
D	+	-	+	+

Key: + present; - absent

Soil sediments of Foma River, Ilorin is a favourable environment for microorganisms as it contains large population of both bacteria and fungi hence water from this river is not safe for direct consumption because of presence of pathogenic bacteria in the soil sediments hence need treatment to make it potable and safe for domestic and recreational activities.

REFERENCES

APHA. (2002). *Standard Methods for the Examination of Water and Wastewater*. 20th Edition. American Public Health Association, Washington DC.

Adegunwa, A. (2003). Microorganisms in Sediments of River Oyun and a Pond. 35p. (B.Sc. Dissertation, University of Ilorin, Ilorin, Nigeria).

Agricultural Bureau of South Australia. (2011). Soil Water holding Capacity. *Dept. of Agric. Bulletin* 462, 1960. Available at *http://www.soilwater.com.au* Accessed 19 October 2011.

Akpata, T. V. I., Ekundayo, J. A. (1978). Faecal Pollution of Lagos. *Nigerian Journal of Science,* 12(182):39-52.

Akpata, T. V. I., Ekundayo, J. A. (1983). Occurrence and Periodicity of some fungal population in Lagos Lagoon. *Transactions of British Mycoogical Society*, 80:347-352.

Alabi,R.O. (1994). Some Lower Aquatic Phycomycetes from River Oyun. *Centre Point* 4(1):1-14.

Alexander, M. (1977). *Introduction to Soil Microbiology*. 2nd Edition. John Wiley & Sons. New York. p. 3-63.

Alexopoulos, C. J. (1983). *Introductory Mycology.* John Wiley & Sons Inc. New York, London, p. 100-214.

Awolumate, O. (1977). Selected methods for soil and plant analysis. Central Analytical Laboratories. *Cocoa Res. Inst. of Nig.,* 58-60.

Brown, M. E. (1973). Soil bacteria sensitive to bacterotasis. *Canadian Journal of Microbiology,* 19:195-199.

Bucchanan, R.E. and Gibbons, N.E. (1974). Bergey's Manual of Determinative Bacteriology. 8th edition. William and Wilkins Co., Baltimore.

Carla, W. M. (1997). *Fundamentals of Geology.* Third Edition. WM. C. Brown Publishers, U.K. p. 339.

Cheesbrough, M. (1993). *Culturing of Microorganisms*. In: Medical Laboratory manual for tropical countries. Vol. II. Butterworth Heinemann Ltd, Great Britain, p. 40-50.

Dubey, R. C. and Maheshwari, D. K. (2004). *Practical Microbiology.* S. Chad & Company, New Delhi. p. 162-301.

Environment Canada (2010). Fresh Water Quality Monitoring- *Environment Canada surveillance. www.ec.gc.ca*

Erah, P. O., Akujieze, C. N. and Oteze, G. E. (2011). The Quality of Groundwater in Benin City: A baseline study on inorganic chemicals and microbial contaminants of health importance in boreholes and open wells. *Tropical Journal of Pharmaceutical Resources,* 1(2): 75-82.

Fawole, M. O. and Oso, B. A. (2001). *Laboratory Manual of Microbiology*. Spectrum Books Limited, Ibadan, Nigeria. p 71-80.

Figueras, M. J., Borrego, J. J., Pike, E. B., Robertson, W. and Ashbolt, N. (2000).

Sanitary Inspection and Microbiological Water Quality. In: Bartram, J. and Rees, G. (eds.). Monitoring Bathing Waters- A Practical Guide to the Design and Implementation of Assessments and Monitoring Programmes. McGraw-Hill, New York. p. 1-35.

Frenchel, T. M. and Reidl, R. J. (1970). The sulphide system: a new biotic community underneath the oxidized layer of marine sand bottom. *Marine Biology,* 7: 225-268.

Ishii, S., Ksoll, W. B., Hicks, R. E. and Sadowsky, M. J. (2006). Presence and Growth of Naturalized *Escherichia coli* in Temperate Soils from Lake Superior Watersheds. *Applied and Environmental Microbiology,* 72(1): 612-621.

Morgan, K.C. (2010). What Are the Types of Soil in Freshwater Biomes? *http://www.list_7471707_types-soil-freshwater-biomes.html*

Nwachukwu, C. I. and Otokunefor, T. V. (2006). Bacteriological quality of drinking water supplies in the University of Port Harcourt, Nigeria. *Nigerian Journal of Microbiology*, 20(3):1383-1388.

Ogbonna, C. E., Njoku, H. O., Onyeagba, R. A. and Nwaugo, V. O. (2010). Effects of Flooding and Seepage from drilling burrow pit wastes on Orashi river, Egbema, Rivers State, Nigeria. *Nigerian Journal of Microbiology*, 24(1): 1993-2000.

Olaitan, S. O. and Lombin, C. (1984). *Introduction to Tropical Soil Science*. Onazi, O. C. (ed.). Macmillian Publisher Ltd, London. p. 18-19.

Olayemi, A. B. (1994). Bacteriological Water Assessment of an Urban River in Nigeria. *International Journal of Environmental Health Resources*, 4:156-164.

Onions, A. H. S., Allsopp, D. and Eggins, H. O. W. (1981). *Smith's Introduction to Industrial Mycology*. Seventh Edition. Edward Arnold, London.

Pramer, D. E. and Schmidt, J. (1984). *Experimental Soil Microbiology*. Burges Publication Company, Minneapolis. p. 11-15.

Prescott, L. M., Harley, J. P. and Klein, D. A. (2002). *Microbiology.* Fifth edition. McGraw Hill, New York. p. 595-696.

Robert, L. T. (1995). *Soil Microbiology*. John Wiley and Sons, Inc., New Jersey. 398p.

Robert, E. R. and Stanley, M. A. (2000). *Microbial Sediments*. Second Edition. McGraw-Hill, New York. p. 65-87.

Shaffer, P. W. and Ernst, T. L. (1999). Distribution of soil organic matter in freshwater emergent/open water wetlands in the Portland, Oregon metropolitan area. *Wetlands,* 19(3): 505-516.

Sieburth, J. M. (1979). *Sea Microbes*. Oxford University Press, New York. p. 46-48.

Tamaki, H., Sekiguchi, Y., Hanada, S., Nakamura, K. , Nomura, N. ,Matsumura, M. and Kamagata, Y. (2005). Comparative analysis of Bacterial Diversity in Freshwater Sediment of a Shallow Eutrophic Lake by Molecular and Improved Cultivation-Based Techniques. *Applied Environmental Microbiology,* 71(4): 2162-216.

Yeung-Cheung, A. K. (2009). Comparison of Bacterial Levels from Water and Sediments among Upper and

lower Areas of Guion Creek. *International Journal of Soil, Sediment* 6 and *Water* 2(3): 1-16