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Appropriate Sanitation Systems for Low-Income Coastal and Water Front Communities in the Niger Delta, Nigeria

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Abstract: A study was carried out in Tunu community of Bayelsa State to determine the extent of Sanitation in the area affected by industrial effluents discharge from oil operations. Presumptive faecal coliform test and physico-chemical analysis of water samples from the river were analysed using standard methods. The water samples were analysed for temperature, pH, dissolved oxygen, biochemical oxygen demand, suspended solids, total dissolved solids, nitrogen, phosphorus, chloride content as well as turbidity, conductivity and alkalinity. The results obtained for faecal colforms indicate that the counts were between 4.0±0.11×104-1.6 ±0.01×10^6 cfu mL^{-1}. Temperature was as low as 28°C while pH showed 6.9, which was nearly neutral. The levels of other physico-chemical parameters were significantly ($p<0.05$) high in varying amounts. The results show that the sulphate content was 275.0±0.36 to 485.0±0.59 mg L^{-1} while Nitrate was 1.28±0.02 to 4.8±0.06 mg L^{-1} for dry and wet seasons, respectively. Phosphorus had 2.13±1.2 to 5.6±1.5 mg L^{-1} while total Nitrogen had 48.0±1.0 to 36.0±1.4 mg L^{-1}. Chloride content showed 860.0±0.92 mg L^{-1} and Total dissolved solids 3256.0±1.25 mg L^{-1} for wet seasons respectively but recorded low values in the dry seasons. In this study, dissolved oxygen content was low while the biochemical oxygen demand was very high. The results suggest that the water body was polluted due to the effluent discharges into the river and therefore may not good for human consumption due to the presence of these contaminants.

Key words: Coastal and waterfront communities, environmental hazard, Microorganisms, Niger Delta, sanitation

INTRODUCTION

Sanitation refers to the safe collection, transportation, treatment and disposal of human wastes (Navarro, 1994). Proper sanitation promotes health, improves the quality of the environment and thus, the quality of life in a community. In developing countries, improvements in practice of disposing of human excreta and other wastes management techniques are crucial to raising levels of public health. However an increasing amount of health associated problems result from lack of sanitation facilities, especially among the rural and the poor who live in over crowded informal settlements. The problem of congestion coupled with the ever- burgeoning population can easily be linked to the daily degradation of the environment (Ayotamuno, 1997). This condition is generally regarded as hazard to health and in particular encourages the spread of infectious diseases such as typhoid and tuberculosis (Onokerhoraye, 1976; Ekugo, 1998). As a result, the negative effects of unsanitary living conditions lower the productive potential of the people who can least afford it.

Coastal and waterfront communities are faced with wide range of problems associated by their location and environment. The disposal of untreated human wastes into water or tidal mudflats along the waterfront communities is viewed from the public health aspect as hazardous (Mc Garry, 1977; Ekugo, 1998). This condition predisposes coastal communities to feco- oral infections transmitted by the consumption of contaminated food and water (Scott and Oni, 2003). The microorganisms that cause these infections are found in the excreta of infected people or animal and surface water becomes contaminated with them from source such as direct defecation into water bodies (Erah *et al*., 2002; Ogbonna *et al*., 2006 a-c). The rivers, lakes and bays over which these communities are built are often the people's source of food and water for drinking, domestic and personal cleaning (Bradley, 1977). In such communities with unsanitary means of waste disposal and constant contact with polluted environment, sanitation becomes a major concern. Therefore, the proper collection, transportation, treatment and disposal of human excreta are crucial in the protection of community health and the improvement of their environment. This

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study will explore pollution prevention options to minimize the harmful environmental impacts of improper waste management practices in those communities.

MATERIALS AND METHODS

Study area: Tunu community is in Ekeremor Local Government Area of Bayelsa State, Nigeria. Tunu is a typical representation of a coastal or waterfront community of the Niger Delta in Nigeria. Bayelsa State has a lot of waterfronts as a result of the rivers, seas and streams that exist in and around the municipality. These waterfronts were first developed by fishermen as temporary residences when they migrated from the riverine areas of the state to sell their fish. They found the waterfronts very convenient and hence built shanties, with shallow wells as their source of potable water.

The inhabitants live in a constantly polluted environment by the oil producing activities of the Shell Petroleum Development Company of Nigeria. The area is made up of a flow station with a field accommodation comprising houseboats, block building on sand filled area and caravan type temporary accommodation. These accommodations produce sewage and wastewater effluents. The inhabitants live about 3 km away from the flow stations; they are often described as squatter settlements because they were attracted to settle there by the presence of the flow station, which provide some means of livelihood for them.

The sanitation system in vogue includes communal toilet, on site technologies such as septic tanks and cesspools and off-site technologies such as the bucket latrine and sewerage system. Problems associated with the use of communal toilets include poor maintenance of the toilet and poor functioning of the treatment systems used which result in non-usage of the facility.

Methods: Two main instruments were used for the study, these involved informal interviews with members of Tunu community and staff members of SPDC Nigeria, associated with oil production activities in the area. Questionnaires were designed to collect information on the experiences of the respondents on the waste generating capacities and disposal practices (Ogbonna *et al*., 2006b).

The probability sampling method of Fink (1995) was used for the community inhabitants. This was done by giving the chosen houses (400 in number) sequential numbers, from 1 to 400. A member of each household was interviewed by the direct oral interview method and in most cases; the use of a literate native was employed in the interpretation. Efforts were also made to thoroughly explain the true purpose of the study so as to disabuse the minds of the natives of unnecessary expectations and therefore prevent any embellishment of the truth as it were. The nature of the fieldwork was of the type that could best be described as participant observation. Water samples from the river were also subjected to microbiological and physico-chemical analyses.

Sample collection: Water samples were collected in duplicate for analysis as a pilot study on the quality. This was twice monthly for a period of 12 months to cover both the dry and rainy seasons, depending on whether the low tide fell between 11.00 am and 1.30 pm on that day (Ogbonna *et al*., 2004; Phiri *et al*., 2005). Samples were collected in duplicate at each sampling point in the months of April to September to cover the rainy season while the dry season sampling covered between October to March. All samples were placed into thoroughly cleaned 1-litre polyethylene bottles and tightly closed. Each bottle was rinsed with the appropriate sample before the final sample collection. The samples were placed in a cooler box and then taken to the laboratory for analysis. All samples were analyzed within 2 h of collection.

Microbiological analysis: One milliliter each of wastewater samples obtained from the water front sites was separately added to 9 mL of 0.1% peptone water diluent to give a 10^{-3} dilution. After through shaking, further serial 10-fold (v/v) dilutions were made by transferring 1 mL of the original solution to freshly prepared peptone water diluent to a range of 10^{-3} dilutions. Aliquots (0.1 mL) of various dilutions were transferred to plates of surface dried Mac Conkey agar in duplicate and inoculated by spreading with flamed glass spreaders. Inoculated plates were incubated for 48 h at 45°C. The presence of fecal coliforms was strictly evaluated using standard procedures (APHA, 1998, Hutton, 1983).

Physico-chemical analysis: A number of physico-chemical parameters of the water samples were determined to ascertain their composition. These include Temperature, pH, dissolved oxygen, biochemical oxygen demand, suspended solids, total dissolved solids, nitrogen, phosphorus and chloride content. All analyses were in accordance with Standard Methods for the Examination of Water and Wastewater (APHA, 1985; AOAC, 2002).

RESULTS AND DISCUSSION

Absence of a municipal sewerage and lack of sanitation facilities: The field studies show that the existing sanitary facilities in the community were either community toilet facilities provided by the local community or private toilet built by individuals. The toilets provided by the local community in Tunu waterfronts were on the elevated platform above the high tide level (Fig. 1). No sanitary means of disposing human waste existed; rather the usual practice was disposal of night soil and other waste materials into the river (Fig. 2). The toilet were simply make shift overhung toilets with human waste directly disposed into the river. Despite the provision of communal toilets for households in several congested residences, there are still a number of families that do not have any toilet facilities. Also, some household beneficiaries of communal toilets do not cooperate in the cleaning and maintenance of such facilities, thus only the families who help in the cleaning lock some of these toilets for use. This indicates that there are still households who dispose their night soil in the rivers and creeks. This indiscriminate dumping or disposal of wastes into the river causes serious environmental hazards and health risks (Ekugo, 1998; Onibokun, 1989; Phiri *et al*., 2005). Rotten and decomposed garbage make neighborhoods filthy, foul smelling and unhealthy, this can be major sources of many diseases. Also, uncontrolled and open dumping clogs urban drainage systems, cause frequent floods and threaten the contamination of water resources.

Contaminated water resources: Water is essential to all forms of life and makes up 50-97% of the weight of all plants and animals and about 70% of human body (Buchholz, 1998). Water is also a vital resource for agriculture, manufacturing, transportation and many other human activities. Despite its importance, water is the most poorly managed resource in the world (Fakayode, 2005). Contamination of the drinking water supply and the absence of sanitation facilities had implications on the health of the people and a negative impact on the environment. This was amplified by other environmental problems caused by the improper disposal of solid waste (Fig. 2). Pollution of surface waters in Tunu waterfront is mainly caused by wastewater and solid waste while siltation is caused by solid waste and solid particles that flow with storm water run-off as well as soil erosion from riverbanks. These wastes may contribute greatly to the poor quality of the water (Chindah *et al*., 2004; Emongor *et al*., 2005; Furtado *et al*., 1998; Ugochukwu, 2004). Other major contributors to pollution of the rivers are the households. This includes the significant number of households that used to throw their night soil into the river but is being reduced because of communal toilets and all the households whose other wastewater eventually end up in the rivers. The study further observed an uncontrolled discharge of industrial effluents and storm water into the Tunu River by the oil company operating in the community. Industrial effluents, if not treated can also pollute ground and surface water resources (Olayinka, 2004). Therefore, both boreholes and rivers generally have poor quality water in the affected areas. Since people use untreated water from these sources, the result is continuous outbreaks of diseases such as cholera, bilharzias, diarrhea and others (Ekugo, 1998; Ogbonna *et al*., 2006a).

Microbiological analysis

Presumptive faecal coliforms: Municipal wastewater can be characterized by its main contaminants, which may have negative impacts on the aqueous environments in which they are discharged. At the same time, treatment systems are often specific i.e., they are meant to remove one class of contaminants and so their overall performances deteriorates in the presence of other contaminants, such as from industrial effluents. In particular, oil, heavy metals, ammonia, sulphide and toxic constituents may damage sewers e.g., by corrosion) and reduce treatment plant performance. Therefore, municipalities may set additional criteria for accepting industrial waste flows into their sewers.

In this study, results obtained for fecal coliforms indicate that the counts were between $4.0\pm0.11\times10^4$ to $1.6\pm0.01\times10^6$ cfu mL^{-1}. This shows a possible severe public health risk through transmission of communicable water- borne disease such as cholera etc (Table 1). Coliforms are a group of bacteria with common characteristics used to indicate unacceptable water quality. Within the total coliform group the *E. coli* bacteria are specifically used to indicate faecal contamination. This is because the presence of certain microorganisms is often undesirable in any drinking water. Their presence can cause decay of the cellular materials of the microorganisms, which may result in the production of by-products, which may adversely affect the quality of the water supply (Erah, *et al*., 2002). This is true for other non-pathogenic bacteria and harmless microorganisms (Rhode and Hartmann, 1980). Both the National and international standard for raw water (FEPA, 1991; WHO, 1998) thus require that wastes effluents be subjected to conventional method of treatment coagulation, filtration and disinfection, before discharge into the environment. FEPA (1991) standards for oil companies operating in Nigeria state that oxidation pond should be used for the biodegradation of organic constituents in the effluent. The agency also approved the use of chemical treatments for raw water to ensure that the physico-chemical quality fall within permissible international standards of WHO (1998).

Table 1: Physico-chemical characteristics of water samples from tunu water front settlements

Parameter	WHO permoissible limits (mg L^{-1})	Dry season (mg L^{-1})	Rainy/wet season (mg L^{-1})
Temperature (°C)	<35°C	32.0±0.02	28.0±0.01
pH	6.5-8.5	9.6±0.06	6.8±0.12
Turbidity (NTU)	<5	54.0±0.12	78.0±0.05
TDS	500	460.0±0.07	3256.0±1.25
Suspended Solids	*	37.0±2.15	97.6±1.25
Conductivity (µS cm^{-1})	2500 at 20°C	1420.0±0.05	2530.0±0.00
Alkalinity as $CaCO_3$ (mg L^{-1})	400	296.0±0.46	17.1±0.06
Acidity as $CaCO_3$ (mg L^{-1})	*	310.0±0.02	254.0 ±0.07
Sulphate (mg L^{-1})	250	275.0±0.30	485.0±0.59
Nitrate (mg L^{-1})	45	1.28±0.02	4.8±0.06
Chloride Cl (mgL^{-1})	250	36.5±0.05	860.0±0.92
DO (mg L^{-1})	6-9.5	4.2±0.06	6.2±0.03
BOD (mg L^{-1})	<500	490.0±0.25	556.0±0.12
Phosphorus (mg L^{-1})	*	2.13±1.2	5.6±1.5
Potassium (mg L^{-1})	*	49.0±0.04	52.9±0.01
Calcium (mg L^{-1})	*	9.2±0.02	28.0±0.00
Total Nitrogen (mg L^{-1})	*	48.0±1.0	36.0±1.4
Faecal Coliform (cfu mL^{-1})	0	4.0±0.11×104	1.6±0.01×106

* Limits not established

Fig. 1: A typical Overhung Toilet (Pier Latrine)

Fig. 2: Disposal of night soil and other wastes into the river

Physico-chemical parameters: The pH values were in the range of 6.8 to 9.6 for rainy and dry seasons, respectively. Most fishes can tolerate pH values of about 5.0 to 9.0 (Hanif *et al*., 2005). The observed pH value was what would be expected of normal river water while temperature was 28 to 32°C in both seasons. In the case of temperature, the insulating effect of the increasing discharge of waste from the oil company and other sources may have contributed to this increase. Temperature may rise due to reduction in dissolved oxygen in such environments. Discharge of pollutants such as oil and grease into water can lead to an increase in the temperature of the receiving waters several degrees above the normal and affect aquatic organisms by affecting rates of solubility of gases and the rates of oxidation (Alabaster and Llyod, 1980; Ekundayo and Fodeke, 2000). Also increase in temperature may cause thermal pollution of the waters and may upset the water body's homeostasis and endanger the biotic components of the aquatic environments (Hodges, 1977; Otokunefor and Obiukwu, 2005).

Conductivity of the receiving waters was found to be slightly above the permissible range for the rainy season (2530.0 ± 0.00^{-1}) but below recommended permissible limit during the dry season (1420.0 ± 0.05^{-1}) (Table 1). This observation could be due to dilution of the waters arising from recharge from the torrential rains characteristic of the coastal areas. Recommended permissible limits for total acidity as $CaCO_3$, phosphorus, potassium, calcium, magnesium and suspended solids are not yet established (Table 1). Turbidity of tested receiving water was observed from 54.0±0.12 to 78.0±0.05 NTU which is quite above recommended permissible limit of <5NTU. Turbidity affects fish and aquatic life by interference with sunlight penetration. The plants in such water environments need light for photosynthesis. If suspended particles/solids block out light, photosynthesis and the production of oxygen for fish and aquatic life will be reduced. If light levels get too low, photosynthesis may stop altogether and algae will die. Similarly when the rate of photosynthesis decreases, then O_2 concentration becomes lower and CO_2 concentration becomes higher (Hanif *et al*., 2005).

Sulphate recorded between 275.0±0.36 to 485.0±0.59 mg L^{-1} above permissible limit of 250 mg L^{-1}. In Nigeria, most pipes used in oil operation suffer rupturing due to age of such materials causing oil spills on vegetations. Such kind of corrosion are also assisted by microorganism notably sulphate reducing bacteria. Therefore the activities of these microorganisms help to release their by-products into the waters there by increasing the sulphate fraction of the waters. This could account for their increase into water bodies through storm runoff. Nitrate content was recorded to be low (1.28±0.02 to 4.8±0.06 mg L^{-1}) below permissible limits (45 mg L^{-1}) in both dry and rainy seasons. Microorganisms might have utilized them adequately in amount that was no longer available to cause pollution of the water because it is an essential limiting nutrient for their metabolism.

Alkalinity is a measure of the substances in water that have acid-neutralizing ability (Ogbonna *et al*., 2006c). Alkalinity is important for fish and aquatic life because it protects or buffers against pH changes and makes water less vulnerable to acid rain. Total alkalinity as $CaCO_3$ was found in the range 17.1±0.06 to 296.0±0.46 mg L^{-1} which was below allowable limits of 400 mg L^{-1}.

The various contaminants evaluated indicate that chloride had 35.6±0.05 mg L^{-1} while total dissolved solids recorded 460.0±0.07 mg L^{-1} for dry season and 3256.0±1.25 mg L^{-1} for rainy season. Thus the higher chloride and TDS levels could be attributed to increased inputs of industrial effluents from the flow station and the subsequent increased soil erosion and surface runoff, thus adding excess nutrients into the rivers and creeks. High levels of TDS (salts) may restrict wastewater use for agricultural irrigation or aquaculture. Values for total nitrogen was 48.0±1.0 and 36.0±1.4 mg L^{-1} and phosphorus content recorded 2.13±1.2 and 5.6± 1.5 mg L^{-1} for dry and rainy seasons, respectively. High levels of nitrogen and phosphorus in surface water will create excessive algal growth (eutrophication). Dying algae can contribute to organic matter content, which may affect the oxygen balance of surface water and can create pollution problems (Ekundayo and Fodeke, 2000). This means that if the oxygen in the water is exhausted, anaerobic conditions, odour formation, fish kills and ecological imbalance will occur. However, the dissolved oxygen levels were significantly ($p<0.05$) low as much as 4.2±0.6 mg L^{-1}. The low dissolved oxygen suggests that the Flow station produce a lot of organic substances, which are of high oxygen demanding wastes (Emongor *et al*., 2005). BOD is used as an approximate measure of the amount of biochemical degradable organic matter present in a sample. The permissible limit is <500 mg L^{-1}. The levels of biochemical oxygen demand (BOD) were 490.0±0.25 and 556.0±0.12 mg L^{-1} for dry and rainy seasons, respectively. The higher values could be due to surface runoff from the surrounding areas operated by the activities of the oil company that might have brought in ionic substances or greater quantities of degradable wastes, which are finally discharged into the rivers. The suspended solids also revealed high concentrations of the substances although there was no permissible limit established in this study. This could be due to the fact that the different effluent from the company was being dumped in a pit behind its surroundings, which might have been washed away by storm water and this therefore affected the quality of water in the river (Phiri *et al*., 2005). This could further be due to synthetic detergents in its operations, which could precipitate ionic species, resulting in high-suspended solids.

The problems associated with lack of adequate water resources threaten to place the health of the inhabitants at risk. Recent World Bank studies (WHO, 1997) suggest that it would cost in excess of USS 10 million a year to correct such problem if ground and surface water contamination goes unchecked. In the long term, the present level of environmental degradation could create health problems from waterborne disease for most of the population.

Appropriate sanitation technologies: Recent studies in sanitation identified several low-cost sanitation technologies (Kalbermatten *et al*., 1980). The excreta disposal systems offer different degrees of user convenience, protection against the spread of diseases and water demand for their operation. They can be classified either on-site or off-site systems. On-site sanitation systems include those in which safe disposal of excreta takes place on or near the plot or site of the toilet. Systems included in this category or classification are overhung latrines, trench latrines, pit latrines, Reed odorless Earth closet (ROEC), ventilated improved pit latrines (VIP), composting latrines, pour flush latrines and septic tanks.

Off-site sanitation systems include those in which excreta are collected from the individual toilets and carried away from the plot to be disposed of. Vault and cartage and bucket latrine are included in this category. It is further suggested under the World Bank Sanitation Programmes that a comparative criteria to introduce putative performance of these technologies is necessary (Kalbermatten *et al*., 1980).

These include water supply service levels, soil condition requirements, cost, housing density, complementary investments, reuse potentials, environmental factors, self-help potential and institutional constraints. Sinnatamby (1990) emphasizes operation, costs, construction, water requirement and urban adaptability as special consideration in the selection of sanitation technologies in developing countries. For existing low-income settlements without adequate sanitation facilities, it is of great importance that small-scale, even individual household installations can be chosen, that in time the individual provisions can be linked up to form a network and that the systems can be upgraded gradually.

In actual sanitation projects, one of the causes of their failure is the overemphasis on technological installations at the expense of behavioral considerations such as latrine usage and upkeep and general hygiene practice of the users.

CONCLUSIONS

The overall analysis of the existing sanitation and environmental condition of a prototypical coastal community observes that the closer a household is to the water zone, the more adverse the ground conditions become and the more limited community services are in terms of access and circulation networks, water supply, wastewater and solid waste collection. Under these options the sanitation options are decreased.

The approach to improve sanitation conditions in coastal and waterfront communities and those in low-lying areas of Niger Delta may involve more than one option or a combination of two or more systems, depending on the location of the proposed facility within the coastal communities.

Household connections for the water supply, for instance, can be made available in some areas of the community, if it is system feasible. Walkways and circulation networks can be upgraded to allow small carts to pass through to provide access for waste or sludge collection and transportation. In cases where access improvement is not possible, improvisation of collection vehicles can be done, such as small hand-drawn or animal driven carts that can pass through the existing walkways.

In any sanitation programme, technologies may be identified as appropriate, but if the application does not involve information, training of community members and mobilization, the project will be a failure. Many sanitation programmes are planned and executed by government bodies and a few are successful due to failure to convince and educate the people on the importance of sanitation and the need for an active cooperation. Education factors play a very important role because it is only through the basic understanding of the need for sanitation can the people be mobilized for its implementation. Critical to the coastal communities is the need to inform community members about the health and environmental hazards caused by their traditional practice of defecating on the surface waters. It is only when they understand the consequences of the unsanitary conditions that they will be willing to change their habits.

REFERENCES

Alabaster, J. S. and R. Lloyd 1980. Water quality for fresh fish. 1st Ed., Butter worths, London, pp: 283.

American Public Health Association (APHA), 1985. Standard Methods for the Exam. of Water and Wastewater, 16th Ed. APHA, New York.

American Public Health Association (APHA), 1998. American water works Association and Water Pollution Control Federation. Standard methods for the exam. of water and waste water. 20th Ed., Washington, DC.

AOAC, 2002. Official methods of analysis. Association of Official Analytical Chemists, Maryland, USA. 17th Ed., Association of Official American Chemists (AOAC).

Ayotamuno, M.J., 1997. Housing situation in Port Harcourt with reference to waterfront settlements. J. Envirn. Edu. Infor., 16: 151-158.

Bradley, D.J., 1977. Health Aspects of Water Supplies in Tropical Countries in Water, Waste and Health in Hot Climates. Richard Feacham, Michael Mc Garry and Duncan Mara (Eds.). London, J. Wiley and sons Ltd., pp: 6-7.

Buchholz, R.A., 1998. Principles of Environmental Management. The Greening of Business. 2nd Prentice Hall, London, UK.

Chindah, A.C., A.S. Braide and O.C. Sibeudu, 2004. Distribution of hydrocarbon and heavy metals in sediment and a crustacean (shrimps-Penaeus notialis) from the Bonny/New Calabar river estuary, Niger Delta. Ajeam- Ragee, 9: 1-14.

Ekugo, E.I., 1998. Public Health and Urban Sanitation. Environ.News, pp: 5-7.

Ekundayo, E.O. and V.O. Fodeke, 2000. Microbial densities and physio chemical qualities of some crude oil flow stations saverpits effluents in the Niger Delta Basin of Southern Nigeria. Environ. Monitoring Assessment, 65: 523-530.

Emongor, V., E. Kealotswe, I. Koorapetse, S. Sankwasa and S. Keikanetswe, 2005. Pollution indicators in Gerone effluent. J. Applied Sci., 5: 147-150.

Erah, P.O., C.N. Akujieze and G.E. Oteze, 2002. The Quality of Groundwater in Benin City: A baseline study of inorganic chemicals and microbial contaminants of health importance in boreholes and open wells. Trop. J. Pharma. Res., 1: 75- 82.

Fakayode, S.O., 2005. Impact of Industrial effluents on water quality of the receiving Alaro River in Ibadan, Nigeria. Ajeam- Ragee, 10: 1-13.

FEPA, 1991. National Environmental Protection (Effluent Limitation) Regulation, Federal Environmental Protection Agency Fink, A; (1995). The Survey Kit 6. How to sample in surveys. SAGE publications California, pp: 15-20

Furtado, A.A.L., R.T. Albuquenque, S.G.F. Leite and R.P. Pecanha, 1998. Effect of hydraulicretention time on nitrification in an airlift biological reactor. Brazillian J. Chem. Engin., 15: 1-7.

Hodges, L., 1977. Environmental Pollution. Holt Rheinhart and Winston, New York, USA., pp: 22.

Hanif, M.A., R. Nadeem, U. Rashid and M.N. Zafar, 2005. Assessing pollution levels in effluents of industries in city of zone of Faisalabad, Pakistan. J. Applied Sci., 5: 1713-1717.

Hutton, L.G., 1983. Testing of water in developing countries, In: Hutton L.G; Water and Waste Engineering for developing countries. Loughourough, Leiceste, U.K. Water Res. Center.

Kalbermatten, J.M., D.A. Julius and C. Gunnerson, 1980. Appropriate Technol, for Water Supply and Sanitation: A Summary of Technical and Economic Options. Washington DC. World Bank, pp: 43-49.

Mc Garry, M.G., 1977. Waste Collection in Hot Climates: A Technical and Economic Appraisal in water, waste and health in hot climates, Richard Feacham, Michael Mc Garry and Duncan Mara (Eds.). London: J. Wiley and Sons Ltd., pp: 247-248.

Navarro, R.G., 1994. Improving sanitation in coastal communities with special to Puerto Princesa. Palawan frorince, Philippines School of Architecture, McGill University Montreal, pp: 1-40.

Ogbonna, D.N., T.G. Oari and G.I. Amson, 2004. Studies on the bacterial population and inorganic content of waste Dumpsites in Okrika Local Government Area of ivers State, Nigeria. J. Nig. Environ. Soc. (JNES), 2: 6-11.

Ogbonna, D.N., M. Bnijie and N.O. Isirimah, 2006a. Studies on the inorganic chemicals and microbial contaminants of health importance in ground water resources in port Harcourt, Rivers State, Nigeria. J. Applied Sci., 6: 2257-262.

Ogbonna, D.N., G.T. Aangabara and T.O. Ekere, 2006b. Urban solid waste generation in port Harcourt metropolis and its implication for waste management. Management of Environmental Quality: Int. J., (In Press).

Ogbonna, D.N., N.A. Benibo and C.K. Wachukwu, 2006c. Bacteriological and physico chemical quality borehole water from borikiri area of port Harcourt, Rivers State, Nigeria. Current Topics Bio. Chem. Res. (In Press).

Olayinka, K.O., 2004. Studies on Industrial pollution in Nigeria: The effect of textile effluents on the quality of ground water in some parts of Lagos. Nig. J. Health Biomed. Sci., 3: 44-50.

Onibokun, A., 1989. Urban Growth and Urban Management in Nigeria. In: African Cities in Crisis: Managing Rapid Urban Growth, Stren, R. and S. White (Eds.). West Inc., Boulder Co.

Onokerhoraye, A.G., 1976. Urban Environmental problems and planning strategies in Tropical Africa: The examples of Nigeria. The Annals Regional Sci., 10: 24- 35.

Otokunefor, T.V. and C. Obiukwu, 2005. Impact of Refinery Effluent on the Physico-chemical properties of a Water body in the Niger Delta. Applied Ecol. Environ. Res., 3: 61-72.

Phiri, O., P. Mumba, B.H.Z. Moyo and W. Kadewa, 2005. Assessment of the impact of industrial effluents on water quality of receiving rivers in urban areas of Malawi. Int. J. Environ. Sci. Tech., 2: 237-244.

Rhode, B. and G. Hartmann, 1980. Introducing Mycology by examples. Schering Ges Aklienells Chalt.

Scott, R.E. and O.O.O. Oni, 2003. Towards the Millennium Development Goals-Actions for Water and Environmental Sanitation: Proceedings of the 29th WEDC Conference Abuja, Nigeria.

Sinnatamby, G., 1990. Low Cost Sanitation. In: The Poor Die Young: Housing and Health in Third World Countries, Eds. Sandy cairncross, Jorge E. Hardsy and David Satterthwaite, London: Earthscan Publisher Limited, pp: 132.

Ugochukwu, C.N.C., 2004. Effluent monitoring of oil servicing company and its impacts on the environment. Ajeam- Ragee, 8: 27-30.

World Health Organization (WHO), 1997. A Guide to the use of water quality managementprinciple. Water Pollution Control, pp: 20-30.

World Health Organization (WHO), 1998. Guidelines for Drinking Water: Health Criteria and other Supporting Information. WHO, Geneva Switzerland.