Chemsearch Journal 3(2): 26 – 33, December, 2012
Publication of Chemical Society of Nigeria, Kano Chapter
Date Received: September, 2012
Date Accepted: November, 2012
ISSN: 2276 – 707X

LEVELS OF SOME PHYSIOCHEMICAL PARAMETERS IN LEACHATES FROM OPEN DUMPSITES IN LOKOJA, KOGI STATE, NIGERIA.

OLAREWAJU, G.O., SA'ID, M.D. and AYODELE, J.T.
Department of Pure and Industrial Chemistry, Bayero University Kano
P. M. B. 3011 Kano, Nigeria
Email:dayyibmds@yahoo.com

ABSTRACT

Leachates from selected dumpsites and control site in Lokoja municipal were analyzed for physiochemical properties. These parameters were compared with control samples and established international standards FEPA and WHO. Dumpsite leachates contained very high concentration of TDS which ranges between 5180.60±46.51mg/L - 3071.80±38.96mg/L, BOD 1085.60±7.44mg/L - 885.80±5.41mg/L, Alkalinity 2396.20±10.35mg/L - 1271.00±14.61mg/L. COD 4062.04±32.81mg/L - 2926.80±15.65mg/L, Chloride 1912.42±6.32mg/L - 1071.70±16.10mg/L while Ammonia ranges between 711.33±12.15 - 633.00±5.80mg/L. The study revealed that the dumpsite is a major polluting source in the surrounding environment. This underlines the need for appropriate government agency of Kogi State, Nigeria to initiate active remediation process such as phytoremediation in combination with physiochemical methods to recover the dumpsite from contaminants and reduce the level of pollution in the surrounding environment.

KEYWORDS: Dumpsite, Leachates, Physicochemical parameters, Phytoremediation.

INTRODUCTION

There is the increasing awareness to minimize the levels of wastes discharged into the environment. The United Nation Environmental Programme (UNEP) is drawing the attention of nations towards the consequences of waste management (Adewuyi and Opasina 2010). The root cause of environmental pollution has been manĝs tendency to dilute and disperse waste rather than remove them at the source. With ever increasing population, urbanization and industrialization, the environment is considerably polluted even in the developed countries.

Many dumpsites in urban areas have been converted into polluted sites. In most cities in Nigeria, co-disposal of industrial, municipal, domestic and medical wastes in open and unsecured dumpsites and non-sanitary landfills is a common practice (Aluko *et al.,* 2002). Wastes are haphazardly deposited as a result of which adjoining lands get enriched in salts and trace metals thereby posing threat to the environment. Dump site wastes are exposed to precipitation from rain, melted snow or the waste itself. As the liquid flows through the dumpsites, salts, organic and inorganic compounds are transported in the leachates. The wastes gradually release its initial interstitial water and some of its decomposition by products get into water moving through the waste deposit. Such liquid containing organic and inorganic compounds is called ñLeachateò (Christensen *et al.,* 1992). This Leachate accumulates at the bottom of the dumpsite soil of landfill and percolates through the soil. Leachates can move as surface water or percolate through the underlying strata with high polluting potentials.

When water percolates through the waste, it promotes and assists processes of decomposition by bacteria and fungi (Adewale, 2009).

These processes in turn release by-products of decomposition and rapidly use-up any available oxygen creating an anoxic environment. In actively decomposing waste the temperature rises and the pH falls rapidly and many metal ions which are relatively insoluble at neutral pH can become dissolved in the developing leachate. The decomposition processes release further water which adds to the volume of leachate. Leachate reacts with materials that are not prone to decomposition such as fire-ash, cement based building materials and gypsum based materials changing the chemical composition. In sites with large volumes of building wastes, especially those containing gypsum plaster, the reaction of leachates with the gymsum can generate large volume of hydrogen sulphide which may be released in the leachates and may also form a large component of the landfill gas. In dumpsite that receives a mixture of municipal, commercial and industrial wastes, but excludes concentrated specific chemical wastes, dumpsite leachates may be characterized as a water-based solution of four groups of contaminants: dissolved organic matter (alcohols, acids, aldehydes, short chain sugars etc.). Inorganic macro-components (common cations and anions including sulphate, chlorides, iron, zinc and ammonia). Heavy metals, (lead, nickel, copper, cadmium, mercury) and xenobiotic organic compounds such as halogenetad organics (PCBS, dioxins etc.) (Kjeldsen et al., 2002). Leachate can be genotoxic in nature (Sigh, 2007). The physical appearance of leachates from a typical dumpsite is a strongly odoured black, yellow or orange coloured cloudly liquid. The smell is acidic and offensive and may be pervasive because of hydrogen, nitrogen and sulphur rich organic species. Pollution of ground water by leachates from dumpsites have been recognized. (Hem 1989, Clark 2006) described dumpsite practices as the disposal of solid wastes by infilling depression on land. The depressions into which solid wastes are dumped include, valleys, (abandoned) sites of quarries, excavations or sometimes a selected portion within the residential and commercial areas in many urban settlements where the capacity to collect, process, dispose or re-use solid waste in a cost-efficient, safe manner is often limited by available technological and managerial capacities. In developing countries, several metric tons of garbage are left uncollected along the streets, acting as breeding grounds for pests that spread diseases clogging drains and creating a related health and infrastructural problems. The practice of dumpsites system as a method of waste disposal in many countries is usually far from standard recommendations (Adewale, 2009). A standardized dumpsites system involves carefully selected location and are usually constructed and maintained by means of engineering techniques, ensuring minimized pollution of air, water, soil and risks to man and animals. Landfilling involves ñplacingò waste in line pit or a mound with appropriate means of leachate and landfill gas control (Alloway and Ayres, 1997). Dumpsites developing countries context is usually an unlined shallow hollow (often not deeper than 50cm). Zurbragg *et al.,* (2003) referred to it as ñdumpsò which receive solid wastes in a more or less uncontrolled manner, making uneconomical use of the available space which allows free access to waste pickers, animals and flies, and often produce unpleasant and hazardous smoke from slow-burning fire. Besides, it has been revealed that even the lines (protected) dumpsites have been inadequate in the prevention of groundwater contamination (Lee and Lee, 2005). Open dumpsite is almost the available option for solid waste disposal,. Financial and institutional constraints are the reasons for this in developing countries especially where local governments are weak, under financed and rapid population growth persist (Elaigwu *et al.,* 2007). Acidification and nitrification of ground water have been linked to dumpsite around their outlets while a number of dumpsites have been implicated for bacteria contamination of drinking water (Torres et al., 1991) in some cases, causing poisoning, cancer, heart diseases and teratogenic abnormalities (Siasu, 2008). These waste products are dumped in untreated, posing environmental risk to life in the area and the entire population. Landfill is a practice adopted as a substitute to ocean outfall of sewage, domestic and industrial waste, after the outlawing and termination of latter due to its effects on the lives in the ocean. The ocean outfall causes introduction of pollutants into the food-web through bioaccumulation, changes in the biotic diversity and introduction of persistent organic compounds (like PAHS) into the marine environment. However, with the termination of ocean outfall, in USA (1992), as a result of Ocean Disposal Ban Actô of 1988 (Adriano, 2001) and in the European Union under the urban waste water treated and directive (European Union 2000), there has been a growing concern on the environmental safety of landfill application of waste products such as long term building of heavy metals in the soil, effects on groundwater and pathogenic effects (Parson *et al.,* 2004; Karrasch *et al.,* 2006). Lokoja is the capital of Kogi State, in the middle belt region of Nigeria. It is located on latitude $7^0$49ò and longitude $6^0$45ò. Lokoja is experiencing problems of municipal waste management as a result of unplanned developments, rural-urban migration and natural increase within the city. Yet, this remarkable growth rate has not been matched by improvement in the quality of the urban environment. Instead, these demographic expansions coupled with increased industrialization and commercial activities have caused increase in the volume and diversity of solid wastes generated in the city. From the dumpsites, wastes from various sources including domestic, medical and agricultural abound. It was an unsecured dumpsite and leachate from these sites has been implicated in environmental pollution. Fearing further contamination of the environment a pronouncement was made by the State ministry of environment and physical development that some dumpsites be shut down to public to allow the soil and surrounding environment recover from previous contamination. Very few studies have been conducted on the existing and shut dumpsites in the state capital. The aims and objectives of this work are to determine the levels of some physiochemical status of the leachates in dumpsites, to estimate the polluting effects and to suggest a sustainable cost effective and environmental friendly method of treatment.

MATERIALS AND METHODS

In the preparation of reagents, chemicals of analytical grade purity and distilled water were used. All glass wares were washed with detergent and rinsed with distilled water before drying in the oven at 105 ^{o}C. All weighings were on Toledo ABS4 analytical weighing balance.

Sampling

Leachate drains were constructed to collect effluents from the waste mass into a pond by gravity during the rainy season (August-October, 2010). Five dumpsites were identified within Lokoja municipal for this study. They include: Kabawa, Lokongoma phase I, Lokongoma phase II, Otokiti and Adankolo dumpsites. The samples taken from 5 sampling points across each of the 5 dumpsites. Leachate samples were collected in plastic containers previously cleaned by washing in non-ionic detergent, rinsed with tap water and later soaked in 10% HNO_3 for 24 hours and finally rinsed with de-ionized water prior to usage. During sampling, bottles were rinsed with sample leachate three times and then filled to the brim.

Sample Treatment

The sample container (high density polyethylene-HDPE bottles) use to sample for heavy metal analysis, were washed with metal free detergent and rinsed with tap water. They were soaked in 1M HNO_3 for 24 hours and later rinsed with demineralise water and kept in air-tight container till sampling period. All samples collected were kept in ice chest to maintain them at a temperature below 4 ^{o}C during transference from the field to the laboratory.

Determination of Physiochemical Properties of Leachate Sample.

All field meters and equipment were checked and calibrated according to the manufacturerôs specifications. The pH-meter was calibrated using HACH (1997) buffers of pH 4.0, 7.0 and 10.0. Dissolved oxygen (DO) meter was calibrated prior to measurement with the appropriate traceable calibration solution (5% HCl) in accordance with the manufacturerôs instruction.

The dependent variables analyzed were pH, dissolved oxygen (DO), total dissolved solid (TDS), sulphate, chloride, ammonia and heavy metals concentration. Standard methods were followed in determining the above variables (APHA, 1995). Dissolved oxygen was measured with Jenway model 9070 water proof meter. Conductivity/TDS meter HACH model CO150 was used to measure the conductivity and total dissolved solids of the leachate samples.3t. Levels of turbidity and total suspended solid of the leachate samples were determined using standard procedures by (AOAC, 1998).

The biological oxygen demand determination of the leachate sample in mg/l was carried out using standard methods described by Ademoroti (1996), the dissolved oxygen content was determined before and after incubation. Sample incubation was for 5-days at 20 ^{o}C in BOD bottle and BOD was calculated after the incubation periods. Determination of chemical oxygen demands was through using potassium dichromate in an open reflux method. Mercuric sulphate was used to mask chloride interference and silver sulphate dissolved in concentrated suphuric acid and was used as catalyst. The excess dichromate after 2-hours reflux was titrated with standardized ferrous ammonium sulphate and ferroin indicator.

In the determination of chloride, 100cm^3 of the leachate sample was measured into 250cm^3 conical flask and pH was adjusted to 8 with 1M NaOH. 1cm^3 of K_2CrO_4 indicator was then added and titrated with the $AgNO_3$ solution. A blank titration was carried out using distilled water. Chloride (mg/L) was calculated according to Ademoroti,(1996).

RESULTS AND DISCUSSION

The levels of the physiochemical parameters of the leachate samples are presented in Tables 1 and 2. From the result of this study, the levels of pH varied between 8.24 ± 0.08, 8.29 ± 0. 16, 8.63 ± 0.29, 9.35 ± 0.27 and 10.28 ± 0.15 for Otokiti, Lokongoma Phase 1, Adankolo, Lokongoma phase 11 and Kabawa dumpsites respectively (Table 1). The trend in increasing order of pH is Kabawa >Lokongoma Phase 11 >Adankolo >Lokongoma Phase 1>Otokiti. These values are higher than control value of 6.80 ± 0.37 and exceeds Federal Environmental Protection Agency (FEPA, 1991) and World Health Organization (WHO, 1997) regulatory standards of 7.00 respectively. The significance of this pH imbalance is that it can inhibit or completely wipe out all biological processes that may be necessary for the natural treatment of the dumpsite thereby resulting in incomplete natural treatment and consequent pollution of the surrounding environment. Also, from the pH-value it could be inferred that complex varieties of inorganic soluble substances are components of the dumpsite which are easily leached out resulting in the alkaline condition of the leachate. (Futta *et al*., 1997) also observed that the pH of leachate increased with landfill age. This is probably due to the fact that leachates have, to a large extent, witnessed washing away by rain fall or percolated over time into the soil. (Oygard et al., 2007) also observed that the heavy metals leached from the landfill are usually found in the form of frication, dissolved organic compound complex, particulate and colloid. Most of these heavy metals from the surface layer of an open dumpsite usually creeps into the bottom layer of the dumpsite where anaerobic condition prevails (He et al.., 2006; Matensson *et al.,* 1999; Flyhammar, 1998).

Temperature is basically important for its effect on other properties of leachates. The mean temperature of the leachates under investigation are 33.18±0.60; 30.80±0.18; 30.18±0.29; 28.50±0.07 and 27.70±0.22(^{O}C) for Kabawa, Otokiti, Lokongoma Phase II, Lokongoma Phase I, and Adankolo dumpsites respectively (Table 1).

The results indicated that some reactions could be speeded up by the discharge of this leachates into stream. It will also reduce the solubility of oxygen and amplified odour due to anaerobic reaction.

Turbidity ranges between 62.21±1.11NTU and 86.11±0.70 NTU for Adankolo and Otokiti respectively. These values were higher than WHO standard of 5NTU for discharged of waste water into stream.

The conductivity values are 4116.38±105.36; 4616.58±176.00; 5163.60±7.84, 5368.06±43.15 to 5592±60.42 (µSCM^{-1}) for Adankolo; Kabawa, Otokiti, Lokogoma phase II and Lokongoma phase I respectively (Table 1). Conductivity of leachate is a useful indicator of its salinity or total salt content. These values were higher than the control values of 170±55µS/CM and exceeded FEPA and WHO guidelines. These observations revealed that the leachates contain high proportion of pollutants, the significance is that considerable amount of dissolved organic materials are present in the dumpsites; such materials can provide adsorptive sites for certain chemicals and biological agents. This process may eventually foster pollution of surrounding soils, vegetation and underground water within the area of the dumpsite. Such similar trend was observed previously (Aluko *et al.,* 2002).

The mean concentration of the alkalinity of the leachates are presented in (Table 1). The range are within 1271±14.61 to 2396.20±10.35mg/l for Adankolo and Lokongoma phase II dumpsites respectively. These values are considerably higher than the control value of 210±35mg/l and also exceeded FEPA and WHO standards. The high alkalinity value may be attributed to the agedness of the dumpsites and is correlated with its high pH value.

The mean value of chloride determined for the leachates are significantly higher than the control value and far exceeded FEPA and WHO standard as seen in Table II. The range are between 1274.58±4.58mg/l for Kabawa dumpsite and 1912.42±6.32 mg/l for Adankolo dumpsite. Though chloride does not react chemically with species in water and are harmless at relatively low concentration, the higher value observed for the dumpsite leachates is an indication of excess salinity and mineral pollution being active in the dumpsites.

The mean value of ammonia ranges between 633±5.80mg/L to 711.33±12.15mg/L for Adankolo and Otokiti dumpsites respectively (Table I). The high values obtained provides evidence of its release from decomposition of nitrogenous substances in refuse. There is no set standards for ammonia in waste water aimed for discharged into surface waters in Nigeria even though it is highly toxic and lethal to most fish species even at low concentrations.

Sulphate concentration values in the leachates were within permissible limits. The range are between 84.17±2.77mg/L for Otokiti dumpsite and 237.77±9.95mg/l for Adankolo dumpsite respectively as seen in (Table I). These values have not exceeded 250mg/l for the discharge of waste-water into river by WHO standard.

The mean concentration of total dissolved solid (TDS) in mg/l in the leachates are presented in (Table I) The concentration of TDS in the leachates samples ranges between 3071.80±38.96mg/l for Kabawa dumpsite and 5180.60±46.51mg/l for Adankolo dumpsite. The values obtained for TDS in all the sampling points were higher than WHO standard of 2000mg/l for the discharged of waste water into streams.

Dissolved oxygen (DO) values obtained from the dumpsites varied between 3.00±0.2mg/l at Adankolo dumpsite to 7.97±0.21mg/l at Lokongoma phase I dumpsite as shown in (Table I)

The DO is a measure of the degree of pollution by organic matter; the destruction of organic substances as well as the self purification capacity of the water body. The standard for sustaining aquatic life, is stipulated at 5mg/l a concentration below this value adversely affects aquatic biological life, while concentration below 2mg/l may lead to death for most fishes (Chapman,1997). The DO level at the dumpsites were above these levels except for Adankolo and Otokiti dumpsites whose values are 3.00±0.29mg/l and 4.15±0.12mg/l respectively.

An indication organic oxygen demand content of leachates can be obtained by measuring the amount of oxygen requires for its stabilization either as BOD and COD. Biological oxygen demand (BOD) is the measure of the oxygen requires by microorganisms whilst breaking down organic matter; while chemical oxygen demand (COD) is the measure of amount of oxygen required by both potassium dichromate and concentrated sulphuric acid to breakdown both organic and inorganic matters. BOD and COD concentrations of the leachate were measured, as the two parameters were important in unit design process.

The mean concentration of COD in the leachate ranges from 2926±15.65mg/l to 4062.04±32.81mg/l for Kabawa and Lokongoma phase II dumpsites respectively (Table 11). BOD concentration of the leachates obtained from the dumpsites ranges from 885.80±5.41mg/l at Adankolo dumpsite and 1085.60±7.44mg/l at Lokongoma phase II dumpsite. The concentration of BOD and COD in all the sampling points were higher than the WHO values of 50mg/l and 1000mg/l for the discharged of wastewater into stream. The high concentration of COD and BOD observed for the dumpsite leachates showed that the dumpsites are particularly high in organic contaminants. The dumpsites contains actively decomposing waste which include pollutants that are soluble in water. Any surface water ingress into the dumpsites will promote solublization of these pollutants which can accumulate and on the long run contaminate surrounding soil and underground water. Aluko *et al.,* (2002) reported similar trend for leachates from municipal solid waste studied in Ibadan, Nigeria. Generally, BOD and COD are inversely proportional to DO and might change depending on the nature of the system being investigated Aluko *et al.,* (2002) . It could therefore be inferred that the dumpsites cannot support desired aerobic organisms. Leachates that emanates from the dumpsites, may upset water ecosystem if eventually, it is emptied into a receiving stream. This development can lead to proliferation of anaerobic biota that eventually produces anaerobic condition in the nearby stream (Adewuyi and Opasina, 2010)

Table 1: Pliysicochemical Parameters in Leacliates from Open Dumpsites

PARAMETER/ SAMPLING SITES	KABAWA	PHASE I LOKONGOMA	PHASE II LOKONGOMA	OTOKITI	ADANKOLO
PH	10.28±0.15	8.29±0.16	9.35±0.27	824±0.08	8.63±0.29
TEMPERATURE(°C)	33.18±0.60	28.50±0.07	30.18±0.29	30.80±0.18	27.66±0.22
CONDUCTIVITY (us/cm)	4616.58±176	5592±60.42	5368±43.15	5163±7.86	4116..38±105.4
TURBIDITY (NTU)	73.30±1.07	82.50±0.57	82.48±3.74	86.11±0.68	62.21±1.11
DISSOLVED OXYGEN (mg/L)	5.57±0.18	7.97±0.21	6.16±0.092	4.15±0.117	3.00±0.29
BIOLOGICAL OXYGEN DEMAND (mg/L)	971.65±12.71	990.34±3.13	1085.60±7.44	947.26±6.37	885.80±5.41
CHEMICAL OXYGEN DEMAND (mg/L)	2926.80±15.65	3035.74±45.87	4062.04±32.81	3132.90± 44.15	3061.50+13.63
TOTAL DISSOLVED SOLIDS (mg/L)	3071.80±38.96	45 12.40±7.60	4612.80±23.89	4741.17±105.22	5180.60±46.51
SULPHATE (mg/L)	97.50±3.00	200.86±40.81	116.01±2.61	84.17±2.77	237.77±9.95
CHLORIDE (rng/L)	1274.58±4.58	1638.91±7720	1870±55.63	1071±16.10	1912.42±6.32
ALLINiTY(mg/L)	2209±7.18	2279±8.80	2396±10.35	1747.40±5.23	1271+14.61
AMMONIA (mg/L)	708.13±1150	688.20±10.80	659.40±9.25	711.33±12.15	633±5.80

Table 2. Physiochimecial parameters in leachates from control sites, FEPA and WHO Standard

Parameters	Control Values	FEPA & WHO Standard
pH	6.80 ± 0.37	7.00
TEMPERATRE (°C)	27. ± 0.52	Ambient
CONDUCTIVITY (us/cm)	170 ± 55	<5000
ALKALINITY (mg/L)	210 ± 35	<150
TURBIDITY (NTU)	10 ± 3.5	<50
SULPHATE (mg/L)	20.25± 0.50	<500
őTOTAL DISSOLVED SOLIDS (mg/L)	100.40 ± 1.3	<2000
CHLORIDE (mg/L)	65.9 ± 8.7	<600
COD (mg/L)	90.7 ± 20.0	<50
BOD (mg/L)	70.6 ± 25.1	<50
DO (mg/L)	7.0± 2.0	<5

CONCLUSIONS AND RECOMMENDATIONS

Solid wastes management has been a very serious problem in urban centres. Wastes taken to a dumpsite for disposal yield leachates which cause serious problems through contaminating the land and water resources nearby. Developing countries like Nigeria have not been able to address these problems due to high costs involved. This seems to be one of the reasons why contaminated dumpsites are often shut down for natural recovery of the site by Ministry of Environment and Physical Development in the state. The data recorded in this study support the assertion that dumpsites in heavily urbanized society may have been contaminated significantly due to on going human activities. Thus of the various solutions to this problems which are available, an aquatic plant, *ipomoea aquatic forsk* is found to reduce various organic and toxic pollutants to the desired levels. This plant is indigenous, tolerant to tropical climate and toxic chemicals. This phytoremediation technique can also be used in combination with other physio-chemical methods which prove to be viable and economic in keeping the environment safe.

REFERENCES

Ademoroti, C.M.A. (1996**).** *Standard Method for Water and Effluents Analysis*. Foludex press Ltd, Ibadan. pp 22-23, 44-54, 111-112.

Adewale, A.T. (2009). *Waste management towards sustainable development in Nigeria*: A case study of Lagos State Int. NGO J. 4(4): 173-179.

Adewuyi *G*.O and Opatina M.A (2010) . *Physiochemical and Heavy metals assessment of leachates from Aperin abounded dumpsite*. E-journal of Chem. 7(4): 1278-1283

Aluko, O.O; Sridhar, M.K.C and Oluwande P.A. (2002). *Characterization of leachates from municipal solid waste landfill site in Ibadan Nigeria.* Journal of Environmental Health Research 2(1) 32-37.

Adriano, D.C. (2001). *Trace elements in terrestrial environments* 2nd ed. New York; Springer-Verlag pp87-92.

Alloway, B.Jand Ayres, D.C. (1997). *Chemical principle of environmental pollution. In: wastes and their disposal*, 2nd ed, Blackie Acad professional, London UK, pp353-357.

AOAC (1998). *Official Methods of Analysis of the Association of Official Analytical Chemists*, Alexandria, VA: Association of Official Analytical Chemists; 432-444.

APHA (1995). *Standard methods for examination of water and waste water; American Public Health Association*.Pp 23-89.

Chapman, D. (1997). *Water Quality Assessment. A Guide to the use of Biota Sediments and Water in Environmental Monitoring*. 2nd Ed. E & FN Spon, London. File: A//:/Hydrology and water quality of lake merced. htm. Pp 56 - 59

Christensen, T.H.; R. Cossu and R. Stegmann (1992). *Landfilling of Waste Leachate*. London Elsevier Applied Science. 2nd ed, Pp 84 88.

Clark, J. (2006). *Rivers and their catchments: impact of landfill on water quality*. 3rd ed Earth Sci-Branch Scottish Natural Heritage. Pp 2 - 4.

Elaigwu, S.E; Ajibola, V.O and Folarami, F.M. (2007). *Studies on the impact of municipal wastes dumps on surrounding soil and air quality of two cities in Northern Nigeria*. J. Appl. Sci 7(3):421-425.

European Union (2000). *Directive of the European Parliament and of the Council* 2000/60/EC. Establishing a framework for community action in the field of water policy. PE-CONS 3639/1/00 Rev.1

.

FEPA. (1991). *Federal Environmental Protection Agency.* National Guidelines and Standards for Industrial Effluents and Water Quality Tests. FEPA (Nigeria) Official Gazette, Nigeria .

Flyhammar, P (1998). Use of Sequential Extraction on Aerobically Degraded Municipal Solid Waste. *Sci. Total. Environ*, 212 (2-3). 203-215.

Futta, D.; Yocos, C.; Haralambous, K.J and Loizidou, M (1997). An assessment of the effect of landfill leachate on ground water quality. P*roceedings, Sardina 97*. 6th Int. Landfill Symposium. S. Margheria dipule, Gagliari-Italy. 181-187.

He, P.J; Xiao, Z; Shao, L.M; Yu, J.Y and Lee, D.J (2006). In-situ Distribution and Characteristics of Heavy Metals in Full - Scale Landfill Layers. *J. Hazard Master* 137(3): 1385-1394.

Hem, J. D. (1989). Study and Interpretation of the Chemical Characteristics of Natural Water. United State Geological Survey. *Water Supply Paper*, 2254.

Karrash, B; Parra, O; Cid, H; Mehrens, M; Pacheco, P; Urrutia, R; Valdovinos, C and

Zaror; C. (2006**)**. Effects of Pulp and Paper Mill Effluents on the Micro Plankton and Microbial Self - Purification Capacities of the Biobyo River, Chile. *Sci. Total. Environ.* 359(1-3): 194-208.

Kjeldsen P; Barlaz M.A; Rooker A.P; Baun A; Ledin A and Christensen T.H (1992). Present and Long-term Composition of MSW Landfill Leachate*:* A review. *Crit. Rev Environ Sci. Technol*. (32) : 297-336

Lee, G.F and Lee, J.A. (2005). *Municipal Solid Waste Landfills Water Quality Issues:* Water Encyclopedia: Water Quality and Resource Department John Wiley NJ. Pp. 163-169.

Matensson, A.M., Aulin, C., Wahlberg, O. and Agren, S. (1999). Effect of Humic Substances on the Mobility of Toxic Metal in a Mature Landfill. *Waste Management Research*. 17: 296-304.

Oygard J.K. Gjengedal, E and Royset, O. (2007). Size Charge Fraction of Metals in Municipal Solid Waste and Landfill Leachate*; Water Res*. 41(1): 47-54.

Parsons, T.; Maita, Y and Lalli, C. (2004). *A Manual of Chemical and Biological Methods for Seawater Analysis*. 3rd ed. Oxford Pergamon Press.pp 22-85.

Sia Su, G.L. (2008). Assessing the Effect of a Dumpsite to Ground Water Quality in Payatas, Philippines. *Am, J. Environ. Sci*. 4(4): 276-280.

Sigh, A. (2007). Mutagenicity of Leachates from Industrial Solid Wastes using Salmonella Reverse Mutation Assay. *Ecotoxicol Environ*. 66(2): 210-216.

Torres, E; Subida, R and Rabuco, L. (1991). Health profile of child scavengers in snokey maintain, Balut, Tondo, Mnila. German agency for Technical Cooperation International Labour Organization/College of Public Health, University of the Philippians; Manila. 2nd ed, Pp 66 68.

W.H.O. (1997**)**. *Guideline for Drinking Water Quality*, 2nd ed; Vol. 2. Health Criteria and other Supporting Information, World Health Organization, Geneva, 940-949.

Zurbrugg C, SANDEC and EAWAG (2003). Solid Waste Management in Developing Countries; *SWM Introducing Text on www.sanicon.net.* 5.