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Effects of Solid Waste on the Quality of Underground Water in Benin Metropolis, Nigeria

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ABSTRACT This research paper examines the effects of solid waste on the quality of underground water in Benin metropolis, Nigeria. The study was bore out of the unregulated manner in which both domestic and industrial wastes are deposited in the streets, river courses, buried, burnt and discarded in refuse heaps. Solid waste commonly generated in Benin metropolis includes papers and cartons, food remnants, glass and bottles, plastic and polythene, tin and metals, ashes and dust, textile and rags, aluminium and other minerals. The analysis of physical, chemical and biological parameters of raw water from eight wells collected around the metropolis close to refuse dumps shows that these wastes produces leachates and gases when they are descomposing and are washed by percolating and infiltrating rain water into ground water. However, most of the water parameters tested fall within WHO recommendations while some are not. And recommendations are made to remedy the situations which include encouraging analysis of raw water, the need for enlightenment campaign, ground water exploration in Benin metropolis should be deep and the principle of resource management should be adhered to. These are Reduced, Reuse, Recycle and Restoration of damage resources and environment

I. INTRODUCTION

Waste is anything, which is no longer of use to the disposer. It can also be defined as any unavoidable material resulting from an activity, which has no immediate economic demand and which must be disposed of (NISP 2003). Waste is commonly classified into three. These are solid, liquid and gaseous wastes. Solid wastes are residual from homes, businesses and institutions and referred to as trash, garbage, rubbish, refuse, discards and throwaways that are no longer of any relevance to the disposer. For example, broken bricks, broken glass and bottles, can, plastics, paper, battery casings, plantain skin, and nylon (Adedibu 1982). Liquid wastes are waste dissolved in water emanating from industrial processes known as effluent, domestic liquid, acid waste and waste oil from workshop (NISP 2003). Gaseous Wastes are waste substances like air neither solid nor liquid) that move freely to fill any available space. Examples are wastes resulting from gas flaring, particulate dust, waste gases from stack, cement factories, stone crushing excavation activities, lime dust, asbestos dust, acid fumes and cigarette fumes (NISP 2003).

Solid waste also means unwanted materials or substances that are left or discarded after use, also included are by-products of process lines or materials that may be required by law to be disposed of (Okecha 2000). Solid waste can be classified in a number of ways, on the basis of source, environmental risks, utility and physical property. On the basis of source which is commonly used, solid wastes are classified as: municipal solid wastes, industrial solid wastes, agricultural solid wastes, mining and mineral wastes, construction and demolition wastes, healthcare wastes, radioactive (Nuclear) wastes, human and animal wastes.

The generation of solid waste from household, industries, markets, abattoir and shops result in improving the standard of living of the inhabitants. These solid wastes can as well contaminate ground water (Meadows 1995). These leachates consist largely of solids, microbial organisms and in some situations chemicals and shallow wells are more dangerously polluted (Meadows 1995).

This work present findings on the quality of water of eight wells sited within and around Benin metropolis especially those close to refuse dumps to determine the effects of solid waste on ground water quality. These wells also serve as sources of drinking water and production of goods and services in Benin metropolis. Eight wells were assessed using their physical, chemical and biological parameters as indices. Assessment of water quality and some Compounds that affect ground water quality are considered with the analysis of these physical, chemical and biological parameters of ground water in Benin metropolis.

The paper discusses the effects of solid waste on underground water

II. THE STUDY AREA

Benin metropolis is made up of three Local Government Areas of Oredo, Egor and Ikpoba Okhae and it is the capital of Edo state (Fig. 1). Benin City lies between Latitudes 6^0 20'N and 6^0 31'N and between longitudes 5^0 35' East and 5^0 41' East of the Greenwich meridian. By its tropical location, it has a temperature of about 27^0c and an annual rainfall of over 2000mm (Orubu 1965). It has two seasons, the wet and the dry seasons. The wet season last eight months, March to October that is the period of maximum solid waste generation while the dry season is from November to February with scanty rainfall.

III. ASSESSMENT OF GROUNDWATER QUALITY IN BENIN METROPOLIS

The utility of water is limited by its quality, which may make it unsuitable for a particular purpose. Therefore, assessment of water quality is an important aspect of water evaluation and the standard of living of the people. Most of the data used in this research were collected from the State Urban Water Corporation. These are the analysis of boreholes and wells close to most of the waste dumps sites. These are raw water from borehole in which the physical, chemical and biological characteristics were analyzed. Physical characteristics include colour, clarity, taste, odour, temperature and amount of suspended solids. Chemical characteristics include reaction, amount of dissolved solids, hardness, amount of

Table 1: World Health Organization standard for drinking water

Substances and characteristics	*Undesirable effect that may be produced*	*Highest desirable level*	*Maximum permissible level*
Substances causing discolouration	Discoloration	5 unit	50 units
Substances causing taste	Taste	Unobjectionable	Unobjectionable
Substances causing odour	Odour	Unobjectionable	Unobjectionable
Suspended matter	Gastro intestinal irritation turbidity	5unit	25umt
Total solid	Taste, gastro intestinal irritation	500mg / l	1500mg/ l
P h	Taste, corrosion	7.0 – 8.5	6.5 – 9.2
Total hardness	Excessive scale formation	100mg/$caco_3$	500mg/l $caco_3$
Calcium	Excessive scale formation	75mg/l	200mg/l
Chloride	Taste corrosion in hot water system	200mg/l	600mg/l
Copper (cu)	A stringent taste, discoloration, corrosion of pipes & utensils	0.05mg/l	1.5mg/l
Iron (fe)	Taste, discouloration, deposit and growth of iron bacteria turbidity	0.1mg/l	1.0mg/l
Manganese	Taste, discouloration, turbidity	0.05mg/l	0.5mg/l
Sulphate	Gastro intestinal irritation when ca and mg are present	200mg/l	400mg/l
Magnesium	Hardness / gastro intestinal irritation if S_{04} is present	Not more than 3 0mgl with so_4	150mg/l
Fluoride		0.7mg/l	<10.0
Nitrate and nitrite		Absent	0.5
Ammonia		Absent	I7mg/l
Arsenic		<0.01	0.05
Barium		Absent	1.0
Boron		Absent	1.0
Manganese		Absent	0.05
Dissolved oxygen		Air Saturation	<4.0
Lead		Absent	0.05
Phosphorous		10mg - 50mg/l	10mg/l
Selenium		Absent	0.01
Silver		Absent	0.01

Source: Edo State Water Corporation, Benin City.

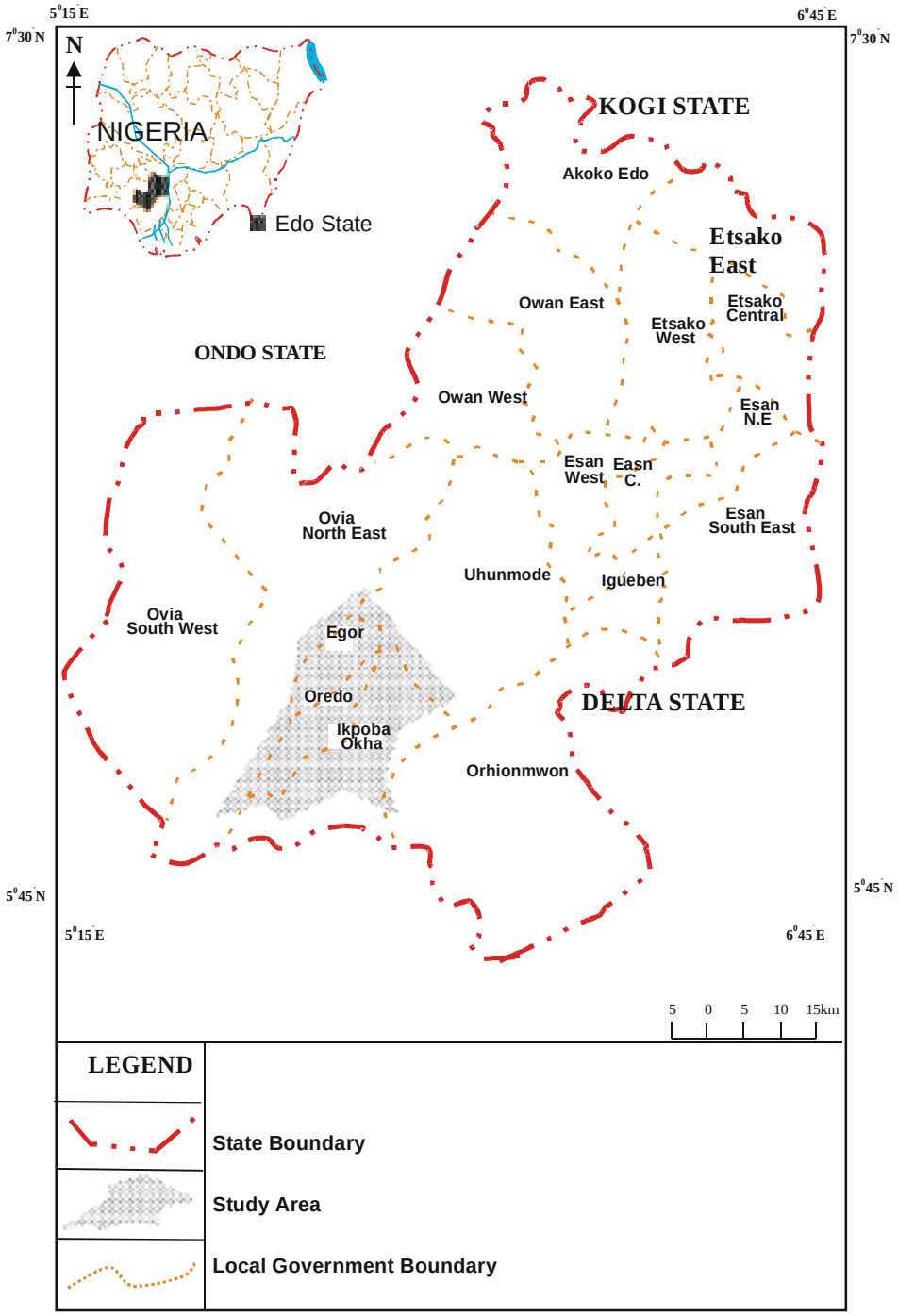

Fig. 1. Map of Edo-State
Source: Ministry of Lands and Surveys, Benin City

nitrogenous matter and the biological characteristics are bacteriological content, amount of dissolved oxygen and biochemical oxygen demand.

The World Health Organization (WHO) standard requirement for potable water is presented in Table 1.

Most of the water analysis carried out by the Edo State Water Board close to these refuse dumps and that for Nigerian Bottling Company, Benin City regarding the physical, chemical and biological parameters of groundwater quality are shown in Tables 2 and 3.

The point of reference commonly used as a measure of comparing water samples analysed in Benin metropolis by the State Water Board is in Table 4. It states the amount of milligram per liter of water (Mg/l) required for each parameter tested except for Ph and the expected limit required for each parameter.

From the results above, it is undoubtedly clear that solid waste generated affect ground water resources in Benin metropolis. Generally, analysis of ground water resources in Benin metropolis shows a marked difference in quality depending on the location of source. From the results obtained, groundwater is clear, tasteless and odourless, especially if it is from deep wells. It also contain low amount of solids owing to filtration through the rocks but sometimes alkaline in reaction and highly mineralized for the same reason. The temperature regime of groundwater in Benin metropolis is virtually constant throughout and ranged between 26^0C and 28^0C. This depends on the environmental condition at the time of collection of samples and there is a decrease in the already low dissolved oxygen content of water underground. The ph level is almost constant at 6.0 with little variations in most cases. For instance the ph level of Edo College borehole water is 8.2, which is acceptable for human consumption as WHO recommends higher desirable level of 7.0-8.5 as shown in Table 1. Other parameters analysed are in Tables 2 and 3. They vary from one well to another. This however, depends on the depth of the boreholes, its distance from landfills or toilet and excavations, technique used in drilling the borehole and the hydrological soil strata that vary from one place to another at close distance of less than 50 meters (Alonge 1991).

From Table 2 and 3 most of the elements considered are Calcium hardness, total hardness, magnesium hardness, chloride, Nitrate, total iron,

Table 2: Analysis of borehole water sample from commercials.

Lab No 110/112	FILE NO		REF:	
S. No. *Chemical Parameters*	*Mr. P.N Adam*	*Mr Edo Lawani*	*J. Osatohanmwen*	*NBC*
1 Appearance	Clear	Clear	Clear	Clear
2 Colour	5.0	5.0	5.0	5.0
3 Temp	260c	260c	260c	28^0
4 Ph	6.0	6.0	6.2	6.2
5 Acidity	5.0	18.0	7.0	28.0
6 Alkalinity	11.0	10.0	11.0	6.0
7 Calcium hardness	21.4	14.29	14.29	5.71
8 Total hardness	32.04	28.48	28.48	21.36
9 Magnesium hardness	10.64	14.19	14.9	15.7
10 Chloride	19.9	24.80	14.20	24.81
11 Nitrate	0.0	-	-	0.0
12 Total iron	0.0	0.0	0.0	0.2
13 Manganese	0.0	0.0	0.0	0.004
14 Sulphate	0.0	0.0	0.0	0.0
15 Phosphate	0.0	0.1	0.2	0.0
16 Silica	12.5	22.5	10.0	12.5
17 D.O	8.0	16.0	8.0	16.0
18 BOD	0.0	-	0.0	-
19 COD	0.34	0.42	0.25	0.0
20 TS	0.0	0.0	0.0	0.0
21 SS	0.0	0.0	0.0	0.0
22 TDS	0.0	0.0	0.0	0.0
23 Chloride residual				2.5

Source: Edo State Water Corporation, Benin City.

Table 3: Analysis of raw borehole water samples brought to lab by commercials.

S. No.	*Chemical parameters*	*Mr. Aihie*	*Amedu Christopher*	*Edo College*	*Chief A. Mamedu*
1	Appearance	Clear	Clear	Clear	Clear
2	Colour	5.0	5.0	5.0	5.0
3	Temp	26^0c	26^0c	26^0c	26^0c
4	Ph	6.0	6.0	8.2	6.0
5	Acidity	7.0	7.0	15.0	14.0
6	Alkalinity	5.0	5.0	45.0	5.0
7	Calcium hardness	7.15	14.29	63.3	7.15
8	Total hardness	17.8	21.36	185.12	17.8
9	Magnessium hardness	10.65	7.07	121.82	10.62
10	Chloride	1.64	10.64	31.91	17.73
11	Nitrate	0.0	0.0	0.0	0.0
12	Total iron	0.0	0.1	0.25	0.3
13	Manganese	0.12	0.012	0.024	0.008
14	Sulphate	0.0	0.0	0.0	0.0
15	Phosphate	0.1	0.1	0.1	0.1
16	Silica	22.5	22.5	22.5	22.5
17	D.O	8.0	8.0	16.0	8.0
18	BOD	0.0	0.0	0.0	0.0
19	COD	0.34	0.26	0.56	0.34
20	T.S	0.0	0.0	0.0	0.0
21	S.S	0.0	0.0	0.0	0.0
22	TDS	0.0	0.0	0.0	0.0
23	Lab No	QC 18^A	QC 16^A	QC15^A	QC17^A
24	File Ref. No	Edlab23/17	Ed lab 23/115	Ed lab 23/114	Ed lab 23/116

Source: Edo State Water Corporation, Benin City.

manganese, sulphate, phosphate silica, dissolved oxygen, biology oxygen dissolved, chemical oxygen dissolved, total solids, suspended solids and total dissolved solids. Calcium hardness varies between 7.15, 63.3, 21.4 and 14.29 while total hardness varies from 17.8, 21.36, 185.12, 32.04 and 28.48. Magnesium hardness varies from 10.65, 7.07, 121.82, 13.19, 7.07, 212.82 and 10.62. Chloride varies from 24.80, 1.64, 10.64, 31.91 and 17.73. For nitrate no record was found. Total iron ranges from 0.1, 0.25 and 0.3 while most of the wells were not analysed for manganese but the ones analysed showed a variation of 0.12, 0.012, 0.024, and 0.008. Sulphate was 0.0, for phosphate, it was 0.1 and 0.2 for most of the boreholes. Other parameters tested for are dissolved oxygen 8.0 and 16.0, Biologically dissolved oxygen was 0.0 in most cases while Chemically oxygen dissolved ranged from 0.34, 0.42, 0.25, 0.26, and 0.56. Suspended solids and total dissolved solid are usually 0.0. See Tables 1, 2, 3 and 4 for detailed laboratory analysis and WHO requirement for potable drinking water. However, most of the water parameters fall within WHO recommendations while some are not. Field investigation and analysis revealed that waste affect significantly the quality of ground water resources in Benin metropolis. This is because they produce gases when they are decomposing and are washed by percolating and infiltrating rainwater.

The total concentration of dissolved solids in water is a general indication of its suitability for any particular purpose or use. Total dissolved solids may be determined from the weight of residue remaining after a sample of water has evaporated. It may also be calculated by adding the concentrations of all ions in the water. Water that contains abundant mineral matter is not suitable for certain uses. Categories of general use of groundwater include domestic and municipal water supplies, irrigation water and industrial water used in manufacturing, mining and power generation. In Benin metropolis, Benin Owena River Basin Development Authority located at Obayantor, along Sapele Road, commonly use ground water for irrigation apart from domestic purpose. However, water that contains less than 500 mg/L of dissolved solid is generally satisfactory for domestic use and many industrial purposes. Water that contains more than 1000 mg/L of dissolved solids usually contains minerals that give it a distinctive taste or make it unsuitable for human consumption.

The substances discussed below are some of the natural compounds of groundwater whose concentrations may cause problem in operating wells.

Table 4: Water parameters, amount of milligram level and expected limit.

Parameter	*Amt. Mg/l Except Ph*	*Expected limit*
Colour	Colourless	Colourless
Odour	Odourless	Odourless
Taste	Tasteless	Tasteless
Ph at room Temp	8.5	7.0 - 8.5
Solid	33.5	500
Carbonate	20.8	300 - 500
Sulphate	4.8	200
Nitrate	1.2	45
Chlroride	11.8	200
Calcium	8.9	70
Magnesium	1.6	30
Magnesium	Nil	0.5
Chromium	Nil	0.05
Cadmium	Nil	0.01
Copper	Nil	1.00
Lead	Nil	0.05
Iron	0.07	0.30
Arsenic	Nil	0.05
Zinc	0.6	5.00
Nitrate	0.0	0.0
Microbiological Analysis		
Organism	Count [cfu/ml]	Limit
Aerobic mesophilic	Nil	10.0
Yeast & mould	Nil	0.0
Coliform	Nil	0.0
E.coli	Nil	0.0
Salmonsella	Nil	0.0

Source: Edo State Water Corporation, Benin City.

Iron (Fe2+)

Most groundwater supplies contain some iron because iron is common in many aquifers and is found in trace amounts in practically all sediments and rock formations. The iron content of groundwater is important because small amounts seriously affect water's usefulness for some domestic and industrial purposes. The World Health Organization recommends that the iron content of drinking water should not be greater than 0.3mg/L because iron in water stains plumbing fixtures, stains cloths during laundering, incrusts well screens and clogs pipes (Deutsch 2003). In Benin metropolis, the Urban Water Board recommends 0.3mg/l of iron as the maximum expected limit. All the wells analysed in Benin metropolis falls within the range except that of Edo College which is 0.25mg/l.

Manganese (Mn^2)

Manganese resembles iron in its chemical behaviour and it's occurrence in groundwater is less abundant than iron. It is found to be lower than iron although in deep wells manganese may reach concentrations as high as 2 to 3 milligram per liter. Solid waste when dissolved usually contains abundant manganese (Hughes 2004).

Manganese is objectionable in water in the same way as iron. It occurs as soluble manganese bicarbonate, which changes to insoluble manganese hydroxide when it reacts with atmospheric oxygen. Stains carried by manganese are more objectionable and harder to remove than iron. Therefore drinking water regulations limit manganese concentrations to 0.05mg/l to avoid manganese staining. In Benin metropolis, the manganese level of most of the wells are within WHO's recommendation while some are not. For instance, the marganese level recorded in Table 3 shows 0.12 for Mr. Aihie, 0.012 for Mr. Christopher Amedu and 0.024 for Edo College borehole. Both iron and manganese can be kept in solution by adding a small amount of sodium hexameta-phosphate to the water (Wilham, et al. 2005).

Nitrate (NO_3)

Nitrogen enters the ground from several sources. Certain plants such as legumes, fix atmospheric nitrogen and transfer it to the soil where it is used by plants. Some of the surplus nitrogen is removed in solution by downward percolating soil water. Other sources of soil nitrogen are decomposing plant debris, animal waste, household solid waste and nitrogen fertilizers. Additional nitrogen may enter groundwater from sewage discharge on land. Also, many industrial solid wastes contain high concentrations of nitrogen. Natural nitrate concentrations in groundwater range from 0.1 to 10 mg/l (Adeyemo et al. 2002).

Nitrate in concentration greater than 45mg/l is undesirable in domestic water supplies because of the potential toxic effect on young infants. Methemoglobinemia is a disease caused by nitrate, which is converted to nitrite in the intestines (Adeyemo et al. 2002). The safe nitrate limit for domestic water is set at 45mg/l by WHO (1984). Nitrate cannot be removed from water by boiling but must be treated by distillation. Nitrate was absent in most of the wells in Benin metropolis.

Chloride (Cl)

Water that contains less than 150mg/l chloride

is satisfactory for most purposes. A chloride content of more than 250mg/l is generally objectionable for a municipal use and water containing more than 350mg/l is objectionable for most irrigation and industrial uses. Chlorides can travel a great distance in groundwater (Hughes 2004). Chloride can get into groundwater from solid waste when it comes in contact with rainwater and then gain entrance into aquifer. Groundwater in Benin metropolis varies considerably in chloride content. From available data obtained from the results of water analysis, some wells contain 1.64, 10.64, 39.91 and 17.73 which shows variations in the amount of chlorine in water in Benin metropolis.

RECOMMENDATIONS

In this particular study, the following statements summarises the major findings:

Pathogens in water are agents that cause diseases in groundwater system. To an extent, these agents like dissolved oxygen, biologically dissolved oxygen, suspended solids, total dissolved solids, bacterial, virus, fungi, chloride, nitrate, iron, manganese, hardness, sulphate, phosphate, silical and chemical oxygen dissolve vary from one well to another. See Tables 2 and 3. However, their presence in groundwater in Benin metropolis do not cause significant health hazards despite the presence of these pathogens in water.

Solid waste handling, controlling and monitoring techniques in Benin metropolis must be geared towards achieving quality environmental condition for man to live in. This will go a long way to protecting natural resources such as water that are degraded by these solid wastes. From this framework, it is possible to articulate a position on thorough environmental management procedures to protect groundwater resources in Benin metropolis. Thus the following recommendations have been suggested:

Solid waste should be recycled instead of taking them to dump sites unless if otherwise, waste collection and management authority that is Ministry of Environment and Waste Management Board should be properly reorganized. There is need for environmental awareness through enlightenment campaigns, exploration of groundwater should be deep, analysis of groundwater should be encouraged at both government and individual levels to know the side effects associated with groundwater explored before it is consumed, the principle of resource management should be adopted and applied at all times. These are Reduce, Reuse, Recycle and Restoration of damaged resources or environment. People should be forced to use waste bins and other facilities provided by waste managers for disposing of their waste. Research into sources reduction should aim at deflating the volume of solid waste generated from our peculiar food preparation and consumption habits and the singular functional roles of traditional rulers and community leaders in the environmental education programme should be encouraged.

REFERENCES

Adedibu AA 1982. *Spatial Pattern of Solid Waste Generation in Ilorin.* Paper presented at the annual conference of Nigerian Geographical Association, Ibadan, Nigeria.

Adeyemo OK, Ayodeji IO, Aiki-Raji CO 2002. The Water Quality and Sanitary Conditions in a Major Abbatoir (Bodija) in Ibadan, Nigeria. *Africa Journal of Biomedical Research. Ibadan Biomedical Communications Group*, 1-2: 51 – 55.

Alonge DO 1991. *Textbook of Meat Hygene in the Tropics*. Farmcoe, Ibadan, Nigeria, p 58.

Deutsch M 2003. Natural controls involved in shallow Aquifer contamination. *Ground Water* 3.U.S Environmental Protection Agency, pp 37 – 40.

Fonseca LFL 2000. C*oncentration of Hardness, Alkalinity and Nitrate in Water Used for Cleaning Milk Equipment in Brazilian Diary Farms*. Isah Maustricht, The Netherlands, pp 100 – 103.

Hughes JL 2004. Evaluation of groundwater Degradation Result from Waste Disposal to Alluvium Near Barstow, California. *U.S. Geological survey professional Paper 878.*

Ministry of Land and Survey 2005. *Report Magazine 5*. Benin City, Nigeria.

Nigerian Institute of Safety Professionals 2003. *Contractor Employee HSE Training Manual*, Level 3, ECNEL Ltd, Port Harcourt, Nigeria.

Okecha SA 2000. *Pollution and Conservation of Nigeria Environment*. T' Afrique International Associates, Oweri, Nigeria.

Orubu AO 1965. *A Short Geography of Bendel State*. Offset Lithography, University of Ibadan, Press, Nigeria.

Wilham JL, Doris TC 2005. Biological Parameters for Water Quality Criteria. *Bioscience* 18(8): 477 – 481.