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Quality Assessment of Ground Water in Selected Waste Dumpsites Areas in Warri, Nigeria

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Abstract: Ground water and leachates samples from three dumpsites located in Warri were studied to assess the impact of solid waste on ground water resources in the area. Ground water samples were collected from holes drilled to depth of 3 m in all three dumpsites. Leachate samples were collected from the dumpsite vicinities while water samples were collected from 17 existing boreholes and 8 open hand-dug wells within the study areas. The depth to water table in the study area ranged between 1.5-3.0 m. The water samples in all three locations have mild to high iron concentrations (0.01-0.9 mg L^{-1}) and mild to high acidity (4.47-6.95). The high acidity in almost all water samples is related to products of anaerobic decomposition of waste while the high iron concentration noticed in most samples which is higher than WHO limit of 0.1 mg L^{-1} can be attributed to the location of such boreholes and wells close to such source as dumpsites. The presence of such dumpsites, therefore is a potential source of pollution to the ground water because of shallow depth of water table and the closeness of dumpsites to source of drinking water.

Key words: Ground water quality, contamination, leachates, dumpsite, assessment, Nigeria

INTRODUCTION

The contamination of drinking water in developing countries have been the subject of many reports (Feachem *et al*., 1983; Ramteke *et al*., 1992; Edema *et al*., 2001; Ikem *et al*., 2002; Akpomedaye and Ejechi, 2003). The fact that warri plays host to most multinational oil and gas industries has promoted the generation of both industrial and domestic waste which are direct threat to the quality of the environment especially ground water resources. In warri, where uncontrolled open dumping of waste is the norm, leachates generated during the rains may eventually contaminate the ground water.

At present, the effect of dumpsites on the quality of ground water in warri is not assessed which explains the rational for this research. Industrial pollutants, agrochemical applications, erosions and disposal of solid waste are sources that degrade drinking water quality standards thereby degenerating into prohibitive water pollution situations. Consequently, water borne diseases such as typhoid, cholera, diarrhoea and dysentery become potentially communicable (Musa, 1996). Drinking water must be within tolerable use limits for human consumption. Water taste, colour, odour, SAR, PH and salinity status must satisfy recommended drinking water standards (Schewab *et al*., 1992). This research was carried out in three different residential areas of warri town where open solid waste dumps are situated and where people live and abstract water from bore holes drilled around the dumpsites. One of the major reasons why ground water in densely populated areas in Nigeria is seriously at risk is because of indiscriminate dumping of waste.

MATERIALS AND METHODS

Site location and characteristics: The study area is located within the Niger Delta in the southern portion of Nigeria. Warri is between latitude $5^{0}32^{I}$N and $5^{0}40^{I}$N and longitude $5^{0}42^{I}$E and $5^{0}50^{I}$E (Fig. 1). The Niger delta region is underlain by quaternary to recent sedimentary formations (Short and Stauble, 1967; Weber and Daukuro, 1975). The topmost of these formations generally consists of fine to coarse sands with occasional intercalations of conglomeratic horizons. The coarse sands and conglomeratic beds are of good to excellent aquifer characteristics but are predominantly unconfined thus making them vulnerable to surface source contaminants especially from such sources as dumpsites.

The vulnerability is bound to increase with the tropical heavy rainfall typical of the area of study. In this area, the aquifer is near surface where the pristine earth filtering ability is limited by depth and aquifer type characteristics. Therefore, it is of public health concern that the ground water quality be accessed since the area understudy is influenced by increased urbanisation due to oil and gas exploration and exploitation.

Sample collection and analysis: Water samples were collected from the hand augured holes, domestic bore

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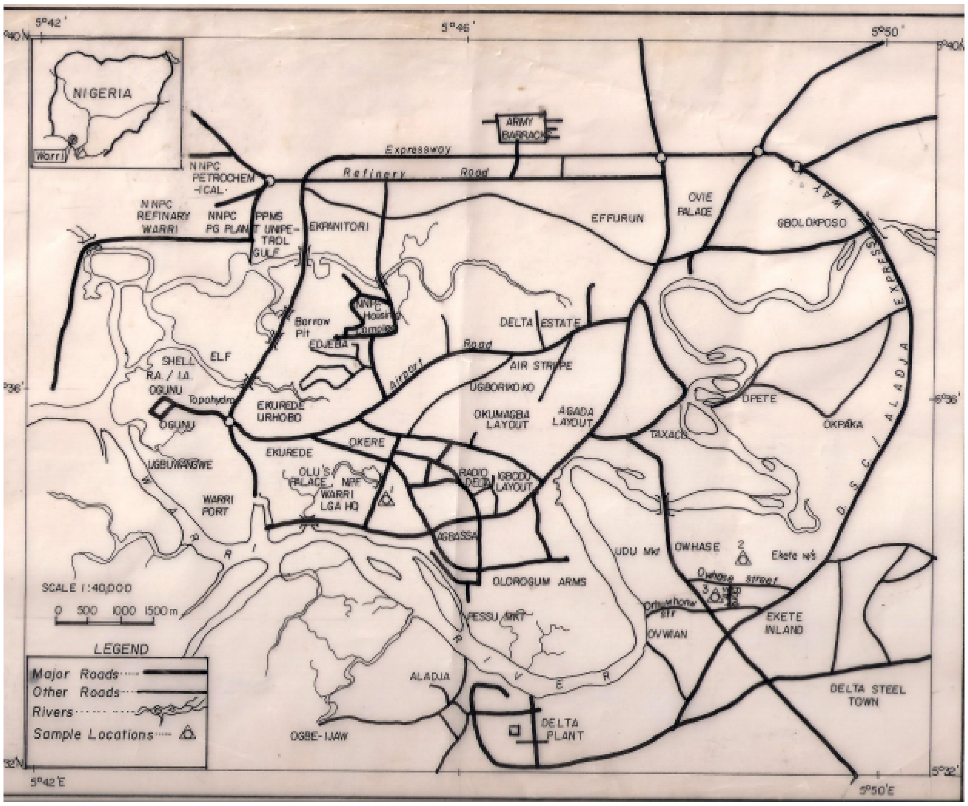

Fig. 1: Location of study area

holes and hand dug wells around the dumpsites. Leachates were also collected around the dumpsites. Ground water in this research refers to the 3 m deep augured boreholes, drilled directly in the dumpsites: boreholes refer to domestic boreholes while well waters refer to open hand dug wells in the area. Unstable parameters such as PH were measured *in situ* using ATI-Orion pH meter. Parameters such as sulphates, copper, iron, zinc were determined using DR-2000 spectrophotometer.

Titrimetric method was utilized for determination of total hardness, chloride, bicarbonates dissolved carbon IV oxide, total alkalinity and total dissolved solids. A laboratory turbidimeter (Model 2100A) was used to determine turbidity and closed reflux titrimetric method was used to determine chemical oxygen demand. All of these analyses were done following the standard methods specified in American Public Health Association. Sodium Adsorption Ratio (SAR) was computed using the chemical formula:

$$\frac{Na}{\sqrt{Ca + {}^{mg}/_{2}}}$$

RESULTS AND DISCUSSION

Results on physical and chemical contaminants in ground water, leachates, bore boles and hand-dug wells are shown in Table 1-3. The pH of the leachates and ground water samples in all three areas (Esisi, Owhase and Boro) falls within the WHO (1971) recommended limit of 6.5-8.5. The non significant variations are consistent with the very little cleansing that takes place once the water has reached saturation (Domenico, 1972). The range of pH values shows mild to slightly acidic concentrations with mean values of 5.98, 5.29 and 5.30 for Esisi Bore holes, Owhase hand dug wells and Boro Boreholes, respectively. The mild to slight acidity noticed in the water samples may be partly attributed to the presence of an organic matter. Low pH levels obtained in well water may be traced to the acidity produced by organic waste decomposing under partially reducing conditions into organic acids (Richardson, 1991).

Turbidity values in leachates and groundwater (3 m) are too high compared to WHO acceptable limit of 5.0 Ntu. This is due to the fact that leachates are contaminated water within the dumpsite vicinity and the 3 m deep ground water is also very close to the waste, bringing about interaction between the two. The mean

Table 1: Results of physical and chemical analysis of the 3 m bore holes ground water and leachates at the three dumpsites

Parameters	sUnits	EDG	EDL	ODG	ODL	BDG	BDL
pH	N/A	6.54	7.43	7.04	7.40	7.30	6.99
Turbidity	Ntu	69,500.00	128.00	49,850.00	148.00	7,828.00	58.00
Dissolved CO_2	mg L^{-1}	88.00	79.00	97.00	53.00	44.00	75.00
Total Dis. Solids	mg L^{-1}	1,587.00	3,887.00	1,286.00	1,376.00	895.00	847.00
Total hardness	mg L^{-1}	264.00	524.00	505.00	153.00	88.00	109.00
Total alkalinity	mg L^{-1}	730.00	1,810.00	695.00	620.00	435.00	420.00
Chem. Oxy. Demand	mg L^{-1}	1,120.00	1,320.00	1,600.00	60.00	100.00	2,780.00
Salinity	mg L^{-1}	353.00	653.00	154.00	346.00	170.00	147.00
Iron	mg L^{-1}	0.08	12.00	10.50	1.14	2.12	0.42
Calcium	mg L^{-1}	86.00	138.00	50.00	38.00	16.00	20.00
Magnesium	mg L^{-1}	13.00	43.00	91.00	14.00	11.00	14.00
Copper	mg L^{-1}	0.33	0.17	0.25	0.18	0.09	0.09
Zinc	mg L^{-1}	0.02	0.04	0.23	0.05	0.10	0.05
Sodium	mg L^{-1}	361.00	932.00	166.00	354.00	230.00	210.00
Chlorides	mg L^{-1}	214.00	396.00	94.00	210.00	103.00	89.00
Sulphates	mg L^{-1}	22.00	170.00	35.00	4.00	4.00	2.00
Bicarbonates	mg L^{-1}	891.00	2,208.00	848.00	756.00	531.00	512.00
SAR	N/A	51.30	98.00	19.80	69.40	62.70	51.00

EDG = Esisi Dumpsite Ground water, EDL = Esisi Dumpsite Leachates, ODG = Owhase Dumpsite Groundwater, ODL = Boro Dumpsite Leachates, BDG = Boro Dumpsite Ground water, BDL = Boro Dumpsite Leachates, SAR = Sodium Adsorption Ratio

Table 2: Range of values of analysis results of Boreholes and well water from the three Dumpsites areas

Parameters	Units	Esisi bore holes (N = 9)	Owhase hand-dug wells (N = 8)	Boro boreholes (N = 8)
pH	N/A	4.59-6.95	4.93-5.83	4.47-5.87
Turbidity	Ntu	0.1-37	0.49-14.5	0.25-6.44
Dissolved CO_2	mg L^{-1}	18-136	26-66	26-81
Total Dis. Solids	mg L^{-1}	222-768	178-255	101-244
Total hardness	mg L^{-1}	60-142	31-75	27-47
Total alkalinity	mg L^{-1}	58-293	65-95	78-155
Chem. Oxy. Demand	mg L^{-1}	40-340	48-436	12-580
Salinity	mg L^{-1}	0.01-0.37	33-94	25-128
Iron	mg L^{-1}	0.16-184	0.16-0.92	0.09-0.78
Calcium	mg L^{-1}	14-52	7-13	4-10
Magnesium	mg L^{-1}	1-11	2-10	1-7
Copper	mg L^{-1}	0.01-0.54	0.02-0.13	0.01-0.09
Zinc	mg L^{-1}	0.01-0.25	0.09-0.22	0.02-0.2
Sodium	mg L^{-1}	39-209	37-83	23-64
Chlorides	mg L^{-1}	41-112	20-57	15-77
Sulphates	mg L^{-1}	3-75	2-9	1-50
Bicarbonates	mg L^{-1}	70-357	79-116	46-107
SAR	N/A	10.8-66.1	13.0-30.3	9.8-24.2

N = Number of samples

Table 3: Mean concentrations of water quality variables obtained from Boreholes and wells in the three dumpsite areas

Parameters	Units	Esisi bore holes (N = 9)	Owhase hand-dug wells (N = 8)	Boro boreholes (N = 8)
pH	N/A	5.9800	5.2900	5.3000
Turbidity	Ntu	9.4700	3.7500	1.8300
Dissolved CO^2	mg L^{-1}	64.560	46.380	51.250
Total Dis. Solids	mg L^{-1}	439.00	212.13	167.75
Total hardness	mg L^{-1}	89.670	43.750	35.880
Total alkalinity	mg L^{-1}	155.89	79.880	75.250
Chem. Oxy. demand	mg L^{-1}	199.00	222.29	152.00
Salinity	mg L^{-1}	124.22	64.880	60.880
Iron	mg L^{-1}	0.1900	0.4100	0.2400
Calcium	mg L^{-1}	27.000	9.6300	7.3800
Magnesium	mg L^{-1}	5.3300	4.6300	4.1300
Copper	mg L^{-1}	0.1900	0.0700	0.0500
Zinc	mg L^{-1}	0.1200	0.1700	0.1800
Sodium	mg L^{-1}	100.33	52.750	39.250
Chlorides	mg L^{-1}	75.220	39.250	37.000
Sulphates	mg L^{-1}	40.440	7.8800	4.8800
Bicarbonates	mg L^{-1}	191.22	97.380	75.130
SAR	N/A	25.580	20.180	16.280

N = Number of samples

turbidity values for boreholes in Boro and Wells in Owhase are slightly below WHO limit while for Esisi bore holes (9.47 Ntu) it is slightly higher than WHO limit which may be attributed to the local geology of the area. The values of Total Dissolved Solids (TDS) in leachates and ground water samples are all higher than WHO limit (500 mg L^{-1}). The higher values obtained are due to leaching of contaminants from the dumpsites towards the ground water source or the presence of high dissolved mineral matter. In boreholes and well water samples in all three locations, TDS is slightly lower than WHO limit due probably to the filtering effect of the soil as the contaminants move towards the boreholes and wells. Salinity and chlorides are slightly lower than the WHO limit (200 mg L^{-1}) in leachates and ground water except for Esisi dumpsite leachates and ground water and Owhase dumpsite leachates which are slightly higher. Although chlorine is scarce in soil, it is a common constituent of well water because of its mobility hence, it is being used as a measure of pollution diffusion in ground water (Kaufman and Orlob, 1995).

Salinity and chloride from borehole and well water in all three sites are below WHO limit. Levels of iron in leachates and ground water are generally higher than the WHO limit of 0.1 mg L^{-1} except for Esisi dumpsite ground water (0.08 mg L^{-1}). Mean concentration of iron in boreholes and wells are equally higher than WHO limit. The high level of iron in these samples can be attributed to location near such source as dumpsites, a trend already observed by researchers (Sonumacher *et al.*, 1993). Low level of other heavy metals like zinc and copper were observed in all water samples including leachates. High levels of chemical oxygen demand were noticed in all water samples including leachates.

A high chemical oxygen demand levels indicate that there is inadequate oxygen available in the water samples. The depletion of oxygen in the water samples is due greatly to microbial activities related to the dumpsites. Levels of sulphates detected in all water samples and leachates are low except for Esisi dumpsite leachates (170 mg L^{-1}). The difference in the sulphate levels noticed in leachates may be to an extent attributed to the hydrogen sulphide gas emitted from the dumpsite where constant contact with water surface could have contributed to the high dissolved sulphate in the water (Cihacek and Bremner, 1993).

Result of the calculated Sodium Adsorption Ratio (SAR) in leachates and ground water are quite high. Levels in boreholes and ground water is equally high and exceeds WHO limit of 3 mg L^{-1}. SAR values of such levels is normally related to human activities such as fertilizer application, dumping of waste, septic systems etc. These likely contributed to the salinity and cloudy water observed. This agrees with United States Department of Agriculture (1998) and Madison and Brunnet (1985) that nitrates are the common pollutants of water.

CONCLUSION

The results reveal that the qualities of ground water were affected by the condition of the immediate environment. The oil exploration, exploitation and refining activities in the study area accelerated urbanisation which now outpaced growth of public facilities and waste disposal system. The result is increase in number of illegal open dumpsites which compromise safety standards. All of these should be of public health and environmental concerns because of the shallow and permeable nature of aquifers being tapped.

It is recommended that detailed monitoring of ground water should be carried out especially during the two seasons (Dry and Wet) of the year. Water from the boreholes in the study area should be treated especially to neutralize acidity and eliminate high iron content and salinity.

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