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The Environmental Effect of Solid Waste Dumpsite on Well Water

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Abstract: This study focused on solid waste and dumpsite wastes on nearby well waters. This study was carried out around Obiagu Area, Enugu, Enugu State, Nigeria. It really specified a minimum safe distance required between a well and solid waste dumpsite. About ten (10) hand-dug wells were selected around that area and the distance ranges from 20 to 120m. Water samples were collected from the wells. Basically, three samplesM_3, M_8 and M_{10} respectively were located at upper part of Obiagu and were used as control wells, because they are upstream placed. The samples of water collected were taken to Project Development Agency (PRODA) for laboratory analysis. The results obtained were compared with the WHO and NAFDAC standard values for safe drinkable water. The analysis showed that the water samples were all colourless without taste and odour. High values of Turbidity, Hardness, Alkalinity, pH, Calcium ion, magnesium, ion, Zinc ion, potassium ion, sodium ion, Iron ion, phosphate ion and E.coli, were observed in most of the water samples (M_1, M_2, M_4, M_5, M_6, M_7 and M_9) making them unfit for drinking, whilst the other control samples (M_3, M_8 and M_{10}) showed acceptable levels and invariably, suitable for drinking. Based on the laboratory analysis results, it is therefore suggested that a minimum safe distance of about (80 metres) be maintained between a well and solid waste dumpsite in order to make the well suitable for drinking.

Key words: Environmental・Leachate・Dumpsite・Solid Waste・Water

INTRODUCTION

Municipal solid waste (MSW) disposal is a global concern, most especially in developing countries across the world, as poverty, population growth and high urbanization rates combine with ineffectual and underfunded governments to prevent efficient management of wastes [1, 2]. The waste produced is dependent on the type of community, the class of individuals living in the community, the occupation or type of industries in the area. However, some kinds of wastes are peculiar to market environs, some to schools, some to hospitals, homes and industries at large. It is therefore a statement of fact that the individuals in a community determine the types of water being generated in it. Solid wastes are disposed off by means of landfills or dumps, whichcould be open or sealed.k At present in developing country like Nigeria, solid waste is usually accumulated in open dumps, where the refuse is piled up without being covered or protected. These dumps are located at any open space, without regard to safety, health hazards and environmental degradation. The situation possesses a problem by polluting soil and waste resources and also possesses potential health hazard to plants, animals and humans [2].

In some cases, infectious wastes from hospitals and clinics can create problems if not properly sterilized before disposal. These wastes decompose after a long period of time, producing a toxic liquid called leachate, by the dissolution of chemicals present in the waste in the water. This liquid then comes in contact with underground water, such as wells, creating pollution effects. Leachate is that liquid formed when water passes through the waste in a dumpsite [3]. Leachate from municipal solid waste landfill sites are often defined as hazardous and heavily polluted wastewaters. Leachate may contain large amounts of organic matter where humic type constitutes an important group [4], as well ammonia nitrogen, heavy metals, chlorinated organic and inorganic salts [5]. Leachate have been identified as potential sources of groundwater contamination as they may percolate through soils and subsoil, causing extensive pollution of

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streams, creeks and water wells if they are not properly collected, treated and safely disposed. Direct ingress of leachate wastes affects the quality of underground water [6]. The composition and concentration of contaminants are influenced by the type of deposited wastes, the quality of refuse, hydro geological factors and mainly by the age of the dumpsite.

Contaminants in the buried refuse may result from the disposal of industrial waste, ash, waste treatment sludge, household hazardous wastes, or from normal waste decomposition. If uncontrolled, dumpsite leachate can be responsible for contaminating well water and surface water. The composition of leachate varies greatly from area to area and can vary within a particular area [6].

Wastes placed in dumpsites are subject to either groundwater underflow or infiltration from precipitation and as water percolates through waste; it picks up a variety of inorganic materials.

As a dumpsite becomes older, there is a shift from a relatively shorter initial aerobic period to a longer time anaerobic decomposition period, which has two distinct sub-phases; an acidic phase followed by a methanogenic one. In practice there are five known biochemical processes that occur in a dumpsite leading to leachate formation. At first, the leachate produce is generated under aerobic conditions and this produces a complex solution with pH of 7.5. This lasts for just a few days or weeks and does not influence the quality of the waste. However, the heat produced during aerobic decomposition can sometimes arise to about 80-90°C as waste decomposition progresses, the oxygen within the waste reduces giving way finally to anaerobic conditions. This tends to create high concentration of soluble degradable organic compounds and acidic pH. Ammonium and metal concentrations also rise during this phase. After several months or years the pH of the leachate changes from acidic to alkaline [7]. When biodegradation is nearly completed, aerobic conditions may return and the leachate may eventually cease to be toxic.

Extensive research work has been carried out on the groundwater contamination, the sources, effects and remedies;needless to say that there are many sources of groundwater pollution. Solid waste dumpsites have also been identified as one of the major sources of groundwater pollution and to more restricted scope, well water pollution. International standards have thus specified that the minimum safe distance that a well and the contaminating source should be apart is 30 meters [7].

The aim of this research work was to evaluate the environmental effect of leachate pollution from solid waste dumpsite in Obiagu, Nigeria on water wells that are adjacent to it and to examine the health hazards of such dumpsites on the community and to suggest solutions/remedies to the ensuing effects from these pollution challenges.

MATERIALS AND METHODS

The study area encompasses a well around Afia Nine market dumpsite in Obiagu Enugu, Enugu State and is within the state capital, Enugu. Theaverage annual rainfall is between 1000 to 2000mm and a temperature range of between 28.1 and 32.2°C [8]. The main occupations of the people of this area are either civil servant or being engaged in petty trading with just a few established in private business. It has been estimated that about 20% of residents in Obiagu live on pipe borne water, 12% on well sunk boreholes, 66% on shallow wells, the rest survive with other unpopular sources. Of these figures only 24% have access to safe drinkable water. 8% get adequate water supply. Hence, the reason or the increase in the number of sachet-water producers is notfar-fetched.

Obiagu in Enugu North Local Government Area was used based on two main reasons, first, the dumpsite is aged and could have effects on nearby wells and secondly many residential buildings around the dumpsite have hand dug-wells considered for the research. Ten different wells were identified, with three of them been upstream to the dumpsite. The full descriptions showing the age distance from the dumpsite, depth and protection of the wells against external influence are as shown in Table 1. With the dumpsite in the Obiagu area, the wastes inthe dumpsite expectedly comprise mainly household and food wastes. The distance of the wells from this dumpsite ranges from 20 to 120 metres.

Water samples were collected from ten different wells, located at radial distances to the dumpsite. The sample collection was made in the early hours of the day and cocked in thoroughly washed 2liter plastic water bottles which were sealed immediately. These samples were labelled as M_1, M_2, to M_{10} respectively from each of the wellsand were then placed in black cellophane bags to minimize the effects of sunlight on it,all the samples were analysed [9]. within 24 hours of collection at the Project Development Agency (PRODA), Enugu.

Basic leachate/pollutants parameters analysed were the physical, chemical, bacteriological and organic characteristics [7] such as the BOD and DO contents. The results obtained were then compared with the safe

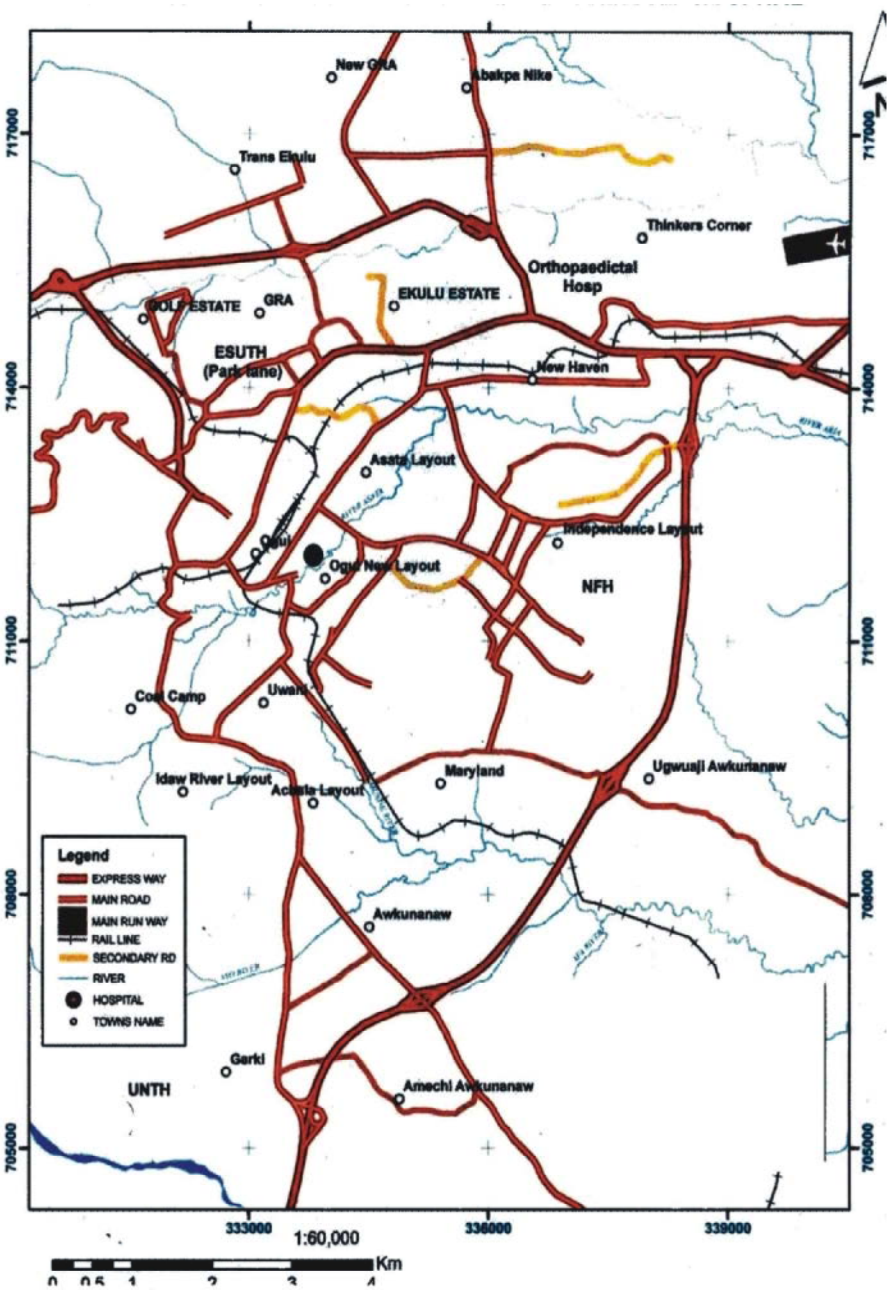

Fig. 1: Map of Enugu Metropolitan Area showing the City LGA &Study Area

Table 1: Identified wells around the dumpsite

Well	Usage	Age (Years)	Distance from dumpsite	Depth (m)	Water Level	Cleanliness	Protection
1	Maternity	7	30	2	High	Clear water	Covered
2	Public	6	42	10	High	Clear water	Covered
3	Public	*U	85	8	High	Unclear water	Unprotected
4	Public	16	20	4	High	Clear water	Covered
5	Public	7	54	10	High	Clear water	Covered
6	Public	4	63	13	High	Clear water	Covered
7	Public	*U	25	25	High	Unclear water	Covered
8	Public	*U	70	2	-	Unclear water	Uncovered
9	Private	20	28	6.5	High	Clear water	Covered
10	Public		120	9.2	High	Unclear water	Uncovered

allowable figures suggested by the World Health Organization (WHO) and National Agency for Food and Drug Administration and Control (NAFDAC) [6]. The physical tests involved those of colour odour, taste, temperature, turbidity and total dissolved solids. The chemical tests on the other hand included tests for the basic leachate parameters like chloride, nitrate, calcium, hardness, pH, total alkalinity, sulphite, phosphate, sodium, potassium, iron, zinc and magnesium, E.coli was also tested for the presence of bacteria.

The Study Area: Enugu metropolis is in the capital of Enugu State of Nigeria. It is located in the South Eastern area of Nigeria.

The city has a moderately undulating terrain with slopes ranging between 1 and 25%, thus enhancing effective drainage as runoffs easily empty into the network of natural drainage channels criss-crossing the city. It is, however important to note that relative to the position of the dominant escarpment, Enugu is a depression. This has made the city relatively susceptible to air/water pollution (Fig. 1).

The residential areas in the city of Enugu known as Layouts include Abakpa Nike, Asata, Trans Ekulu, Thinkers Corner, Emene, Government Reserved Area (GRA) and Iva Valley. The others are Ogui, Coal Camp, Uwani, Gariki, Awkunanaw, City Layout and Independence Layout. Also included are Timber Shed, Ogui New Layout, Obiagu, Artisan Market, New Haven, Achara Layout and Golf Estate. The rest are Ebeano Estate, Relief Market, Ugwuaji and Maryland.

RESULTS AND DISCUSSION

The results of the nineteentests carried out on the water samples in the PRODA were given in Table 2. The values obtained from wells M_3, M_8 and M_{10} were taken as the control, since they were located upstream to the dumpsite.

Table 3 gives the NAFDAC and WHO safe drinking water standards. The results obtained in Table 2 were compared with those of the standards in Table 3.

Colour: All water samples, M_l, to $_0$ showed no significant colour and could be described as clear and colourless. Objectionable colour could lead to unclear water and this may indicate the presence of microorganisms, which may be harmful to health.

Turbidity: The samples tested all gave value of turbidity above the highest desirable level stated by the WHO but it is of note that the values were by far lower than the maximum permissible level of 25 NTU. Thus the turbidity of all the water samples still dwelled within the acceptable range. The turbidity pattern of these samples could be traceable to the level of protection of these wells as a few of the wells were not properly covered. Excessive turbidity responsible for the unattractiveness of water may be due to the presence of dissolved or undissolved particles [9]. This again may likely give an objectionable taste to the water and make it unclear.

Table 2: Result of Laboratory Analysis of the Water Samples

Parameters		M_2	M_3	M_4	M_5	M_6	M_7	M_8	M_9	M_{10}
Turbidity	6.10	6.30	6.00	6.00	5.70	6.10	6.10	6.10	6.10	5.80
Hardness $caco_3$	180	183	141	250	281	267	261	265	243	288
Total Alkalinity$caco_3$	103	181	181	170	167	185	170	168	179	279
Electrical conductivity	981	811	782	688	881	817	818	695	728	800
Total dissolved solids	100	122	151	141	150	171	158	102	361	100
Phosphate	12.0	11.0	7.0	11.0	6.0	6.0	7.0	12.0	12.0	7.5
pH	6.75	6.72	6.76	6.17	6.30	6.37	6.38	6.39	6.71	6.78
Magnesium	12.0	13.0	11.1	11.9	11.1	12.0	11.1	12.0	11.1	9.5
Chloride	122	108	96	117	100	123	140	100	120	140.0
Nitrate mg-1	101	42	101.0	40	112	111	110	130	42	40
Calcium mg-1	111	121	111	110	111	130	136	110	42	40
Sulphite mg-1	120	130	111	119	111	120	111	120	111	95
Zinc mg-1	9.0	0.0	8.0	10.0	0.0	0.00	10.0	11.0	5.0	5.0
BOD mg-1	3.2	2.2	1.2	2.6	2.2	2.0	3.5	1.0	1.2	0.3
E-coli	Nil	0.8	0.9	0.1	Nil	Nil	0.8	Nil	0.95	Nil
Potassium	0.8	0.6	1.0	0.6	0.2	0.2	1.2	0.6	0.5	0.2
Temperature	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
Iron ion mg-1	0.2	0.2	0.7	0.5	0.25	0.23	0.58	0.7	0.19	0.1
Sodium mg-1	100	101	100	111	112	111	110	130	110	100

Sources: Adapted from NAFDAC, WHO [9].

Table 3: NAFDAC and WHODrinking Water Standards

		WHO	
Parameters	NAFDAC	Highest desirable level	Maximum permissible level
Turbidity (NTU)	-	5	25
Total Dissolved Solid	500	500	1500
Temperature (°C)	-	-	40
Electrical Conductivity	-	-	-
pH	6.5-8.5	7.0-8.5	6.5-9.2
Total Alkalinity	100	80	120
Hardness	-	100	500
Chloride	200	200	400
Nitrate	-	45	100
Potassium	10	10	45
Calcium	75	75	200
Iron	-	0.03	0.10
Sulfite	200	200	400
Magnesium	3.0	0.5	0.1
Phosphate	-	10	50
E-coli	0.0	-	-
Zinc	5	5	15

Sources: Adapted from NAFDAC WHO [9].

Taste and Odour: The water samples all showed no significant variations in taste and odour, by physical/visual inspection. Thus they could be said to be unobjectionable. Pungent and objectionable tastes and odours render the water unfit for drinking and domestic use. It may lead to irritation when ingested [9].

Total Dissolved Solid: From the analysis, the total dissolved solid TDS of the water samples gave values less than even the highest desirable level of the WHO. All the water samples have low value of total dissolved solids and thus it does not pose any treat to health of the consumers. This finding was probably due to the fact that most studied sections were deep and converse. Total dissolve solids result from the presence of water soluble materials in the water which may increase the turbidity, thus affecting the taste, odour and colour of the water.

Temperature: The temperature of the water samples stood at a constant figure of 28°C. This value is very minimal compared to the maximum allowable level (40°C) suggested by WHO. Thus the water in the wells does not pose a serious threat to human consumption. When the normal body temperature (37°C) is exceeded in a water sample, it causes burns when ingested.

Hardness: The water samples analysed showed a level of hardness higher than the highest desirable standard (100mg/1), but much less than the maximum permissible level (500mg/1). This is probably due to the presence of Calcium and Magnesium ions in the water samples. The water sample M_3, has a moderate level of hardness; while all the other wells showed levels of hardness that could pose some effects such as scale formation in kettles and longer time required to boil the water. None of these samples however would be detrimental to health, as their hardness values were still below the maximum permissible level stipulated by the WHO.

Total Alkalinity: The water sample M_1 showed a level of alkalinity lower than the maximum permissible level and is still acceptable. The other water samples (M_2 to $_{10}$), showed an alkalinity level higher than the maximum permissible level as quoted by the WHO. All the water samples have alkalinity values higher than the highest desirable (WHO). The water samples M_6 and $_{10}$ showed the highest level of alkalinity and this could probably be due to the exposure conditions of these wells. These water samples could pose adverse effects to human health when ingested [5].

pH: The water samples were all slightly acidic with a pH range of values between 6.75. and 6.79 these values still fall within the maximum permissible level range of 7.0-8.5 recommended by the Standard, thus the pH the water samples do not have any adverse effect on the human body. Although, these values of the water samples are less than neutral (7.0), it is still acceptable for domestic use. The normal blood pH is averaged as 6.5, other figures of pH may lead to imbalance in the homeostatic environment of and could be detrimental to health [7].

Calcium (Ca^{2+}): All the water samples showed a calcium ion level higher than the highest desirable level (75mg/l), but still less than the maximum permissible level (200mg1). Water samples M1, $M_{3,}$ M_4, M_5 and M_8 have calcium ion concentration just a little higher than the highest desirable level, while watersamples M_6 and M_7 have calcium ion concentration as the highest among the water samples while samples M_{67}&M_6have calcium ion concentration as the lowest among the water samplesand have Ca level belowhighest desirable level. These metals when present in high concentration make the water hard. Excessive amounts of calcium and magnesium could lead to Down syndrome in children and deformationof bones and teeth [10].

Nitrate ($N0_3^{2}$): Most of the samples showed a very high level of nitrate ion, except samples M_2, M_4, M_9 and M_{10} which have levels of nitrate ion less than the highest desirable level for drinking. All the other wells have nitrate ion levels higher than the maximum permissible level (l00mg/1) of the WHO standard, the variation of nitrate ion with the distance of wells to the dumpsite. Nitrate could result from the breakdown of plant and animal wastes in the dumpsite. Excessive amounts of nitrate could lead to very fatal blood disorder called methemoglobinemia (blue-baby syndrome) in infants less than six months old. Pregnant women and people with reduced stomach acidity are also susceptible to nitrate induced methentoglobinemia [6]. It has been shown that the presence of bacteria in wells may not pose as much health risk as excessive amount of nitrates [1].

Magnesium (Mg^{3+}): The water samples have extremely high levels of magnesium ion with the least being sample M_2 and the highest being sample $M_5$and all are higher than the permissible level quoted by NAFDAC and WHO. Thus the water samples are prone to very high levels of hardness and could be classified as very hard water. These metals, when present in high concentration make the water hard. Excessive amounts of calcium and magnesium could lead to Down syndrome in children and deformation bones and teeth [10].

Phosphate (P_{04}^{3-}): Water samples M_3, M_5, M_6, M_7 and $_0$ all had acceptable levels of the phosphate ions as quoted by the WHO, while the rest have higher levels of phosphate ion than that the highest desirable level. These other samples could still be used for other domestic purposes aside drinking, as their level of phosphate ion is much less than the maximum permissible by the WHO.

(Zinc Zn^{2+}): Only the samples M_9 and $_0$ gave zinc ion levels acceptable to the WHO standard. Water samples $M_{2,}M_5$ and M_6 were zinc-free and thus quite suitable for human consumption and other domestic uses. All other water samples showed levels of zinc ions higher than the values suggested by the WHO, but much less than the maximum allowable level (15mg/l).

Chloride (CT): All the water samples showed chloride ion levels much less than the highest desirable level by the WHO standard. Generally, the Chloride ion contamination level of water samples is low and still within acceptable standard level; its pattern of distribution in the wells are with respect to distance.

Potassium (K): The water samples also showed a very low level of potassium ion concentration. These levels are relatively lower than the highest desirable levels by the WHO standard. The wells are thus not likely to cause any harmful effect on humans and animal consumptions [7].

Iron (Fe): The water samples, showed iron ion levels much higher than the highest desirable level of WHO, except for $_0$is within the range of the maximum permissible level.

Escherichia coli (E.coli): The water samples showed varying proportions of *E.coli* bacteria. Water samples $M_{1,}$ M_5, M_6 M_8 and $_0$ were all devoid of the presence of E.coli bacteria and are acceptable for drinking according to the NAFDAC standard. The other water samples M_2, M_3, $M_{4,}$ M_7 and M_9 had E.coli concentration at undesirable amounts.

A deficiency of sodium could cause low blood pressure in adults, whereas an excessive amount of sodium in drinkable water could cause high blood pressure [9]. Lead is a very sensitive metal present in drinkable water, offer in low levels. An excessive amount of lead in drinkable water will lead to brain damage and possibly anaemia when the water is ingested [9]. Leachate rich in hydrogen sulphide is also responsible for tarnished silverware and yellow black stains in kitchen fixtures [8]. If water containing hydrogen sulphide is used to cook, the hydrogen sulphide may change the appearance and taste of the water.Sulfite could occur in the leachate, due to the influence of sulphur reducing and sulphur-oxidizing bacteria in the water. The presence of excessive amounts of this in the water gives it a very repulsive odour and could cause nausea when ingested. Excessive amounts of fluoride containing leachate may cause fluorosis.

BOD is an indirect indication of the amount of microorganisms present in the water. Thus a high level of BOD implies a low level of oxygen, which could be detrimental to health, particularly the human respiratory system. The age and size of the Obiagu dumpsite, coupled with its high level of decomposed compacted wastes were the main bases for its selection on this study. The physical parameters of the water samples analysed showed that the taste and odour of the tested samples were objectionable as compared with the WHO standard and the samples were all colourless. All the samples had higher values of turbidity as compared with the WHO standard, thereby rending the wells unfit for drinking. The total dissolved solids in the water samples were all observed to be below the standard values. Samples M_2, has a moderate level of hardness, while the rest indicated risky value of hardness. Sample contained lower level of Alkalinity than the WHO standard, while the rest all had Alkalinity values that exceeded the maximum permissible with the M_6 and $_0$ samples having the highest values. The samples all showed slightly acidic values (values less than 7.0 on the pH scale). The calcium ion was discovered to be in all the samples when compared to the standards. The water samples M_3, M_5, M_6, M_7 and M_8contained excessive amounts ofNitrate ion. Magnesium ion found out to be in excess concentration. The water samples M_2, M_4, M_8 and M_9 all had values of the phosphate ion above the standard value. Only the samples M_5, M_6, M_9 and $_0$ had acceptable zinc ion level, lower than the standard value. The chloride ion levels were all within the desirable range thus the water samples are all acceptable. All water samples had acceptable levels of potassium, in conformity with the standard value. Water samples, M_5, M_8 and $_0$ all showed zero level of *E.coli* making them suitable for drinking purpose, while the other samples all showed varying levels of E.coli, making them unfit for drinking. It was also observed that wells M_3, M_8 and M_{10} which were not less than 70m to the dumpsite generally had less pollution value compared to the other, M_2, M_4, M_6, M_7 and M_9 which were closer to the dump and were heavily polluted M_3, M_8 and M_{10} were the control wells.

CONCLUSION

The overall effect of the excessive concentrations of the leachate parameters is the traumatic sickness/diseases experienced by the habitants of the Obiagu and its environs; disease such as typhoid fever, blood pressure, blood disorders are not uncommon here as discovered from community health centre records of the area. Based on the findings from this study, it is hereby recommended that to minimize the effect of leachate pollution from dumpsites on contiguous wells, a minimum safe distance of about seventy metres is considered appropriate between the dump and the well in the study area. The corollary is that wells near the dumpsites (that is, less than 70m) should be considered unsafe for drinking purposes and as such should be used for other activities like washing, cleaning, irrigation etc. in addition, as much as possible, dumpsites should be sited well away from the residential areas. Finally, the waste should be disposed in such a way that leachate emanating from such could be collected and treated before contaminating the groundwater.

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