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Effect of open waste dump on ground water quality at Rukpokwu, Port Harcourt, Nigeria.

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ABSTRACT

This research work reflects the effect of open waste dump on groundwater quality at Rukpokwu, Port Harcourt. Water quality contamination due to open waste disposal has been assuming menacing proportion. In the area in consideration, groundwater is unsafe for drinking due to the alteration that has been caused to the ground water hydrology because of the open waste dumping site. Ground water and leachate samples from the open waste dump site were collected and analyzed in the laboratory for their physical and chemical characteristics. From the results obtained, it was discovered that the mean concentration values of TDS, DO, NH_4^+, SO_4^+, NO_3^- , pH, and TSS are 94.97mg/l, 4.075mg/l, 0.24mg/l 0.446mg/l, 0.67mg/l, 28.36mg/l, 7.12mg/l and 0.172mg/l for leachate samples. Also the mean concentration values for Mn, Cl, Mg in groundwater samples are 60mg/l, 0.10mg/l and 1.09mg/l and for well water samples and 70mg/l, Nil and 2.908mg/l respectively. The mean concentration for measured parameters except COD, BOD, Total Coliform, Manganese, Colour, appearance and odour conform to WHO standard for drinking water.

Introduction

Water is an indispensable resource outside which human existence will become unbearable it is used for various purposes such as for domestic, industrial, agricultural and commercial purposes. Groundwater is the underground water that occurs in the saturated zone of variable thickness and depth, below the Earth's surface. Groundwater comes from precipitation. Precipitated water must filter down through the vadose zone to reach the zone of saturation, where groundwater flow occurs. The rate of infiltration is a function of soil type, rock type, antecedent water and time. Groundwater contains more dissolved constituents than surface waters and the ground water if polluted; treatment to make it safe is difficult and relatively expensive. The rainfall that percolates below the ground surface passes through the voids of the rocks and joins the water table. These voids are generally inter-connected, permitting the movement of the groundwater. The mode of occurrence of groundwater therefore, depends largely upon the type of formation, and hence depends upon the geology of the area (Deju, 1971). The meaning of quality as frequently used in relation to water appears to be confusing to many people. As a result of this confusion drinking water standards have been developed to define the quality of water that is safe and acceptable to the consumer. Most drinking water standard therefore set limits for organisms or chemical substances that are harmful, potentially hazardous or obnoxious to consumers. Materials termed obnoxious are those through harmless to health, has an adverse effect on the use of the water due to its taste, colour, odour, turbidity, corrosivity or other unbearable properties.

Landfills have served for many decades as ultimate disposal sites for all types of wastes: residential, commercial and industrial. Physical, chemical, and biological processes interact simultaneously to bring about the over all decomposition of the wastes. One of the by-products of these mechanisms is chemically laden leachates. The major environmental problem experienced at landfills is the loss of leachates from the site and the subsequent contamination of ground water, (Hem,1970). There are three important attributes that distinguish any source of ground water contamination: the degree of localization, the loading history, and the kinds of contaminants emanating from them. A sanitary landfill is a point source of groundwater pollution and produces a reasonably well-defined plume in many instances.

The loading history describes how the concentration of a contaminant or its rate of production varies as a function of time at the source. Leachates rates at a landfill site are controlled by seasonal factor or by a decline in source strength as components of the waste such as organics biodegrade. Many factors influence leachate composition, these include the types of wastes deposited on the landfill, the amount of precipitation in the area and other site-specific conditions. The rates of biological and chemical activities taking place in the landfill can also affect leachate quality by altering the way that waste dissolves in or migrates with leachates (Akuro, 2004). Open wastes are mainly disposed off to the landfill because it is the simplest, cheapest and most cost effective method of disposing off wastes. In most low to medium income developing nation like ours almost one hundred percent (100%) of generated waste goes to landfill and because of this, landfill is likely to remain a

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relevant source of groundwater contamination in foreseeable future. Understanding the quality of groundwater is as important as that of its quantity as it is the main factor determining its sustainability for drinking, and other major purposes; by considering the pervious studies and by the fact that residents and groundwater are well exposed to pollutants the study site were selected.

The term leachate describes any liquid percolating through the deposited waste and emitted from or constrained within a landfill. The quantity of leachate produced is dependent upon the liquid fraction of wastes, rainfall, and surface water inflow and groundwater intrusions. Leachate breakout is caused by high leachate levels within the waste resulting from uncontrolled ingress of water into the site, or a perched leachate table caused by relatively impermeable layers within the waste. However, on existing sites, leachate may escape through weaknesses in the capping layer, or through the soil covering particularly around the edges of the landfill, or through defects in the lining of containment systems. These are some toxic effects from leachates but in many cases it is the water-logging and anaerobic soil conditions that cause dieback of vegetation. Leachate has also the potential to impact negatively on surface and groundwater thereby affecting water quality for humans and wildlife particularly Rukpokwu and wetland sites. Leachate contain a host of toxic and carcinogenic chemicals, which may cause harm to both humans and the environment. Leachate, contaminated groundwater can adversely affect industrial and agricultural activities that depend on well water. For certain industries, contaminated water may affect product quality, decrease equipment lifetime, or require pre-treatment of water supply, all of which cause additional financial expenditures. The use of contaminated water for irrigation can decrease soil productivity, contaminate crops, and make possibly toxic pollutants up the food chain as animals and humans consume crops grown in an area irrigated with contaminated water (Horsfall, 2001). Open dumpsites are a major problem to the environment, especially on the air that the people inhale. Dumpsites emit obnoxious odours and smoke that cause illness to people living in, around, or closer to them. Dumpsites maybe a source of airborne chemical contamination via off site migration of gases and the particles and chemicals adhering to dust, especially during the period of active operation of the site.

Contamination of soil and groundwater may lead to direct contact or pollution of indoor air for example in the case of volatile organic chemicals into basements of nearby residents and in the case of consumption of home grown vegetables as well. These conditions are worse in the summer because of extreme temperatures, which speed up the rate of bacterial action on biodegradable organic materials. (Wrench 1990). Water is a transparent, colourless liquid (at standard of condition of temperature and pressure) constituting the normal oxide of hydrogen and given the chemical formula H_2O (Howartt and Mc-Cullivray, 2001). It is essential to all forms of life and makes up 50-97% of the weight of all plants and animals and about 70% of all plants body (Phiri and other 2005).

Water quality may be described as water whose characteristics make it suited to the needs of the users. A body of water is said to be polluted when it is adversely affected due to the addition of layer amount of materials to the water. When it is unfit for its intended use, water is considered polluted.

In the most general terms, water quality can be viewed in terms of its physical, chemical and biological parameters. (Phiri, 2005). Ground water is about 210 billion m^2 including recharge through inflection, seepage and evanpotranspiration. Out of this nearly one third is extracted for irrigation, industrial and domestic use, while most of the water is regenerated into rivers (Kudesia, 1985). Sewage and industrial wastes entering an aquifer can pollute groundwater. Groundwater are subject to saline contamination in those areas where salt water is in contact with fresh water or where opportunity exists for such a contact.

Over 98% of the fresh water in the earth lies below the surface. The remaining 2% is what we see in lakes, rivers, streams and reservoirs. Of the fresh water below about 90% satisfies the description of groundwater that is water that occurs in saturated materials below the water table and is essential for plant growth.

Groundwater acts as a reservoir by virtue of large pore space in earth materials as a conduit which can transport water over long distances and as a mechanical filter that improves quality by removing suspended solids and bacterial contamination. It is the source of water for wells and rural domestic use. It is replenished by precipitation through rain, snow etc. (Kudesia, 1985).

Today, human activities are constantly adding industrial, domestic and agricultural wastes to ground water reservoirs at an alarming rate. Groundwater contamination is generally irreversible i.e. Once it is contaminated, it is difficult to restore to the original water quality of the aquifer. Excessive mineralization of ground water degrades water quality producing an objectionable taste, odour and excessive hardness. Although the soil mantle through which water passes, acts as an adsorbent retaining a large part of colloidal and soluble ions with its cation exchange capacity, but ground water is not completely free from the menace of chronic pollution (Kudesia 1985).

The presence of chemicals in groundwater and drinking water is an important factor in determining the risk posed by land fill sites. However, it does not tell us what effect, if any, the consumption of contaminated water has on human health. There are studies of adverse health effects prompted by the contamination of well water used for drinking water and other domestic uses by hazardous substances from waste disposal sites (mainly sites where chemical waste grams (wave buried). For the future planning and regulation of landfill sites it is important to know which types of sites are most likely to entail risks.

Landfill sites may differ enormously in the conditions that render than hazardous, and conditions that determine the exposure to and resulting health risks posed by any waste site are likely to be unique to that particular site. Such conditions may include the types, quantities, and age of the waste present; hydro-geological and meteorolyical factor, and site management and engineering practices. (Kudesia, 1984). The use of polluted groundwater for irrigating agricultural fields severely damages crops and decreases grain production:

Polluted water acutely affects soil fertility by killing bacteria and soil micro-organisms. Groundwater increases alkalinity in the soil. Groundwater pollution affects plants metabolism severely and disturbs the whole ecosystem (Kudesia, 1984). Open dumps is well known to release large amounts of hazardous and otherwise deleterious chemicals to nearby groundwater, surface water and soil also to the air, via leachates and landfill gas. It is known that such releases contain a wide variety of potential carcinogens and potentially toxic chemicals that represent a threat to public health.

Leachates have been implicated as environmental pollutants such as air, soil surface water and groundwater pollution worldwide. The knowledge of the quantity and composition of leachates usually gives an insight into appropriate, effective and sustainable treatment approach. Some studies documented the physical, chemical and trace metals characteristics of leachates from the major repository of municipal solid wastes on different sites. The amount of leachates produced from open waste dump depends on the fill. Once the open wastes has reached its capacity to hold water, the leachate that is formed can create serious water pollution problem.

The study area is located within the Niger Delta in the Southern Portion of Nigeria. Rukpokwu is a community near the oil city of Port Harcourt is where shells facilities were installed in 1963 and intense oil and gas activities have continued to date. The community belongs to the Ikwerre ethnic group. Rukpokwu is in the Obio/Akpor Local Government Area of Rivers State and is located within latitudes 4.9019444, North and longitudes 7.0047222^o East. It is 289miles and covers an area of about 466km^2 south of Abuja and in the North part of Port Harcourt. Rukpokwu is characterized by two district season – the wet and the dry seasons. The wet season last eight months, from mid-March to October that is the period of maximum waste generation while dry season last for flour months from November to February with scanty rainfall.There are four communities in Rukpokwu area of Obio/Akpor in Rivers State – Rumuworu, Rumuwecherolu, Rumuchima and Rumuadiochuka Communities. Water is put to several uses and each usage demands a certain level and quality control, therefore the objectives of this research work are: To draw ultimate solution for the collection and treatment of leachate accurately, to compare the public health risks at the dumping site with the community living further away, to make the results available and give reference data to groundwater impacts assessment, to recommend the instigation measures to tackle the prevailing problem at Rukpokwu Obio-Akpor in Rivers State, Port Harcourt and to indicate the relationship between the dumping site management, ground water and public health risks.

Materials and Methods

Sample Collection

Water samples were collected using 1litre plastic container with screw capped bottles from the existing boreholes near the dumpsite, major hand-dug well around the dumpsite and leachate sample were also collected from the dumpsite vicinities within the study area at Rukpokwu Obio/Akpor Local Government Area in Rivers State. The container of the samples were washed with soap solution and rinsed severally with distilled water before the samples were collected at three different locations very close to the waste dump. To maintain the natural chemistry of the samples it was preserved with preservation methods which includes pH control, refrigerator and protection from sunlight penetration.

Leachate Characteristics and Groundwater Parameters Measured

The following leachate and groundwater parameters were collected for this study. They were temperature, pH, Total Dissolved Solids (TDS), Total Suspended Solids, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate (as N), Ammonia (N), Electrical Conductivity (EC), Total Hardness, Chloride, Magnesium (mg), Iron (fe), Suphate ($S0_4$), Colour, Odour, Feacal Coliforn, oil and Grease, Manganese (Mn).

The samples containers were thoroughly washed with detergents, rinsed with distilled water and allowed to dry before taking to the stations. At the point of collection, each container was rinsed again with the distilled water before sampling.

All the physiochemical parameters were determined based on the American Standard Methods for Examination of water and wastewater. The available standard procedures and apparatuses listed were used. The materials and equipment used include: Distilled water, pH meter, Conductivity meter, Beakers, Volumetric flask, Pipette, Spectrometer, Spectrophotometer, Turbidiometer.

Determination of Electrical Conductivity

This experiment was carried out using a conductivity meter. Some quantity of the sample was measured into a beaker and the conductivity meter was turn on. The electrode of the conductivity meter was immersed into the sample. The reading of the conductivity was displayed on the screen of the conductivity meter and the result was read and recorded. The electrode was then removed from the beaker containing the sample and rinsed with distilled water. This same procedure was repeated for other samples collected and their results read.

Laboratory Experiment on Determination of pH

Apparatus used

pH meter with electrode, thermometer, beaker, stirrer**.** This experiment was carried out using the pH meter, the pH meter was turned on and was standardized with buffer solution of pH 7 at 25^{o}C representing absolute neutrality and pH 14 after the calibration. The electrode was removed and rinsed with distilled water. The electrode was immersed into some quantities of the sample in the beaker. The reading of the result was displayed on the screen of the pH meter and was recorded. The electrode was removed and rinsed with distilled water. This same procedure was repeated for other samples. It was ensured that the pH meter was standardized with buffer solution of pH 7 and pH 14 after the calibration.

Determination of Total Dissolved Solid (TDS)

Apparatus and experimental procedure: Conductivity meter, beaker. This experiment was also carried out using the conductivity meter, some quantity of the sample was measured into the beaker. The meter was switched on and the electrodes were rinsed with distilled water. The electrode of the conductivity was then dipped in sample solution. The exact conductivity is immediately shown on the meter depending on the conductivity of the waste water. The bottom of the total dissolved solid on the conductivity meter was pressed and the reading displayed on the screen of the conductivity meter and the result was read and recorded. The electrode of the conductivity meter was removed and rinsed with distilled water. This same procedure was repeated for other samples.

Determination of Iron (Fe)

This experiment was carried out using spectrophotometer, 50ml of the sample was measured into the volumetric flask, 2ml of diluted hydrochloric acid (HCL), 1ml of hydroxyl amine hydrochloric and 5ml of ammonia acetate were all added to the volumetric flask containing the 50ml of the sample, distilled water was added to the sample containing different reagents to measure up to 100ml mark in the volumetric flask. This procedure was repeated in the other samples. Some quantity of each of these samples were poured into the convex or absorption cells and was placed inside spectrophotometer and reading of the result was displayed on the screen of meter and was recorded.

Determination of Total Hardness

Apparatus and experimental procedure: Beakers, Rubber-tipped stirring rod, 500ml burette, graduated in 0.5ml and Burette support. The Reagents used are Distilled water, Buffer solution, Indicator, EDTA titrates. **Procedures:** 50ml of each samples of water was added into a 250ml beaker and diluted to about 100ml by adding distilled water. 0.5ml of Ammonium buffer was added into the beaker containing the water samples and was stirred. 2 to 3 drops of Eriochrome Black T was added to the beaker and stirred. It was then titrated with EDTA titrate, and was stirred at intervals until the indicator changes colour. The colour changes from reddish to light brown although incandescent lights tend to give the final solution a reddish tinge. The amount of EDTA titrant which was required to reach the endpoint was recorded. The amount of hardness was measured (as ppm CaCO3).

Chloride Determination

Apparatus and procedure: Burette, Pipettes, Erlenmeyer flasks and measuring cylinder. 1ml of potassium dichromate indicator solution was added to the sample and mix. From a burette drop silver nitrate ($AgN0_3$) and titrate until the yellow colour changes to a brownish tine. The solution was titrated with nitrate solution with constant stirring until only the slightest perceptible brownish colouration persists. Add 50ml of the sample and dilute it to 100ml before titration. These Steps were repeated on 100ml distilled water blank to allow for the presence of chloride in any of the reagent and for the solubility of silver chromate.

Calculation:

Chloride as CL^- = $$\frac{100\,(V_1 - V_2)\,mgl}{Volume\ of\ smaple}$$

Where; V_2 = volume of silver nitrate required by the blank (ml)

V_1= volume of silver nitrate required by the sample

Biochemical Oxygen Demand (BOD) Determination

Apparatus and procedure: BOD bottles of 300ml capacity, Air incubator ($20^oC \pm 1^oc$), Stir plate, stir bar, ring stand, burette, 200ml beaker, burette holder and 500ml cylinder. Diluted water was prepared by mixing 1ml of phosphate buffer solution, magnesium sulphate solution, calcium chloride solution and ferric chloride solution in 100ml of water. Then 300ml reagent amber bottles were filled with samples and poured into a 500ml measuring cylinder and the same was filled with diluted water and mixed with the sample in the cylinder. Finally the bottles were filled with the mixed water samples and the dissolved oxygen was determined as described on the dissolved oxygen (DO) determination. The bottle was washed and filled with the remaining solution of the mixed sampled water. This was incubated at 20^oC for 5-days and determined dissolved oxygen.

Dissolved Oxygen (Do) Determination

Apparatus and procedure

Measuring cylinder**,** Conical flaks**,** Burette and burette stand and Small funnel. Fresh samples were opened and 285ml of each was measured into labeled bottle.

1ml of mangauons sulphate solution, 1ml of Alkali-iodine Azide solution, 1ml of concentrated H_2S0_4 was added accordingly and the mixture was swirled very well. About 200ml of all the treated samples were measured and titrated against Na_2SO_3. $5H_20$ until a colourless solution appeared with help of 3 drops of starch indicator. The readings were taken and recorded. This same procedure was repeated for other samples. The titre values are the same.

Determination of Chemical Oxygen Demand (COD)

Apparatus

COD reactor with cover and test tube rack, Spectrophotometer**,** Heat resistant gloves**,** 50ml cylinder**,** Pipettes (5 and 10ml) and pipette bulbs**,** 100ml volumetric flask and 150ml beakers.

Reagents and Chemicals

Standard potassium dichromate solution, 0.0417m (0.25N): dissolve 12.259g of $K_2Cr_2O_7$ was weighed and dried for 2 hours at 103^oC in distilled water and dilute 100ml in the oven. After 2 hours, the $K_2Cr_2O_7$ was dissolved in 100ml of distilled water transferred into a reagent bottle and stored in the refrigerator.

Standard ferrous ammonium sulphate (FAS) or Ammonium iron (11) sulphate titrant approximately 0.25m (0.25N): dissolve 98g of $feS0_4$. $(NH_4)2S0_4.6H_20$ was weighed and dissolved in 1000ml of distilled water. The solution was transferred into a reagent bottle. Add 20ml of concentrated H_2S0_4 cool, (of specific gravity 1.84) was added and the solution was allowed to cool. The solution was diluted to 1000ml and stored in the refrigerator. Standardize daily against $K_2Cr_2O_7$ solution as follows. Dilute 10.0ml standard $K_2\ Cr_2O_7$ to about 100ml and add 30ml of concentrated H_2SO_4 and cool. Titrate with FAS totrant using 0.10 to 0.15ml (2 to 2 drops) ferron indicating. Mercuric sulphate, crystals or powder. Sulphuric acid (specific gravity 1.84). Sulphuric acid – silver sulphate solution 15g of powdered silver sulphate ($Ag2S0_4$) was dissolved in 30ml of concentrated $H2S0_4$. Phenanchroline ferrous sulphate indicator (i.e ferrocene indicator). 1.48g of phenanthroline was weighed + 0.70g of ferrous sulphate. The combination was dissolved in 100ml distilled water and stored in an indicator bottle.

Procedure: Open Reflux Method

50ml of distilled water was measured and poured into a conical flask as the blank. The 50ML of each sample was also measured and transferred into labeled conical flasks. 25ml of $K_2Cr_2O_7$ solution was added to each flask. Approximately 1g mercuric sulphate (Hg_2S0_4) was added. 5ml of concentrated H_2S0_4 containing Ag_2S0_4 was also added into the entire sample (in a bowl of water to avoid excessive heat loss). The reflux apparatus was set and 70ml of concentrated H_2SO_4 was added through the condensers and boiling beeds were added. The mixture was allowed to reflux for 2 hours with small beakers placed over the open and of the condensers to prevent intrusion of foreign materials.

After reflution, each sample was transferred to a 500ml beaker and the mixture was made up to 300ml using distilled water. The conical flasks were rinsed thoroughly. Cool to room temperature under a tap and mix well using 2 to 3 drops of ferrocene (ferron) indicator was added and the solutions were titrated against ferrous ammonium suplhate (FAS). Observation showed that there was sharp colour change from blue-green to reddish brown.

Results and Discussion

The laboratory analysis conducted for the temperature, pH, electrical conductivity, magnesium, ammonium, manganese, iron, chloride and sulphate of leachate and groundwater using standard devices and the result obtained from the measurement for leachate was 31^{o}C that is similar with the ambient temperature and the temperature of well water and spring samples were 30.5^{o}C and 31^{o}C respectively. The pH value of the leachate, well water and borehole water (spring water) in to laboratory were 7.12, 6.68 and 6.78 respectively. The utility of water is limited by its quality, which may make it unsuitable for a particular purpose. Therefore the assessment of water quality is an important aspect of water evaluation and the standard of living of the people.

Below are the results of the analysis of samples of leachate and groundwater (well and borehole water) from different places close to some waste dumpsites within Obio/Akpor Local Government Area in Port Harcourt, Rivers State. Tables 1, 2 and 3 displayed the physiochemical characteristics, nutrient concentration and some important trace heavy metals concentrations with their respective samples.

Table 1. Leachate Samples from Site 1, 2 and 3 Measured in mg/L.

WHO Standard	**Mean + SD**	**Site 3**	**Site 2**	**Site 1**	**Parameter**
7.5	7.63±0.57	7.89	8.03	6.98	pH
2000	89.25±5.85	92.39	82.50	92.86	TDS
250	27.95±1.73	28.07	29.62	26.17	Chloride
250	0.36±0.09	0.46	0.29	0.32	Sulphate
50	13.83±1.53	12.08	14.89	14.52	BOD
400	14.56±1.28	15.01	15.56	13.12	COD
0.02	0.59±0.63	0.27	0.18	1.32	NH4
75	395±9.45	384	404	398	Total Hardness
0.05	51.67±8.5	55	58	42	Manganese
5	0.24±0.07	0.32	0.2	0.19	Oil & Grease

Table 2. Domestic Well Water Samples from Site 1, 2 and 3 measured in mg/L.

WHO Standard	**Mean+SD**	**Site 3**	**Site 2**	**Site 1**	**PARAMETER**
6.5-8.5	6.51±0.24	6.43	6.78	6.31	pH
500	17.76±0.69	16.98	18.28	18.02	TDS
250	28.10±0.80	28.02	28.94	27.34	Chloride
300	0.05±0.06	0.01	0.12	0.03	Sulphate
10	16.20±1.00	15.99	15.32	17.28	BOD
10	18.62±0.31	18.98	18.47	18.41	COD
10	4.94±0.05	4.93	4.89	5	DO
10	0.14±0.05	0.10	0.13	0.19	NH4
1000	35±5.29	39	37	29	Total Hardness
10	58.33±4.04	59	62	54	Manganese
10	1.15±0.12	1.09	1.08	1.29	Magnesium
30	29.67±1.11	28.5	30.7	29.8	Temperature (ºC)
0-2	4.00±1.00	5	4	3	T. Coli

The World Health Organization drinking water standard is presented in tables below which is used as a reference to determine if the tested sample are up to drinking water standard.

The analytical results of physical and chemical parameters of leachate and groundwater were compared with the (ASTM) as recommended by the World Health Organization (WHO) standard to know the suitability of water for drinking.

Table 3. Ground Water Samples from Site 1, 2 and 3 measured in mg/L.

WHO Standard	**Mean+SD**	**Site 3**	**Site 2**	**Site 1**	**PARAMETER**
6.5-8.5	6.92±0.30	6.98	7.19	6.59	pH
500	0.46±0.17	0.41	0.33	0.66	TDS
250	21.74±1.32	21	23.27	20.96	Chloride
300	0.29±0.19	0.49	0.11	0.29	Sulphate
10	13.69±2.52	10.98	14.15	15.93	BOD
10	16.01±0.80	15.99	16.83	15.22	COD
10	4.01±0.12	4.10	3.88	4.07	DO
10	0.26±0.01	0.25	0.27	0.25	NH4
1000	10.00±1.00	9	11	10	Total Hardness
10	62.33±2.52	62	65	60	Manganese
10	2.7±0.34	2.36	2.72	3.03	Magnesium
30	27.17±2.93	26	25	30.5	Temperature (ºC)
0-2	1.33±0.58	1	2	1.0	T. Coli

The study indicates that the water quality parameters exceed the permissible limits for drinking at the location leading the water unsuitable for drinking.

In a view, groundwater contain less amount of suspended impurities due to the presence of different layers of soil, which acts as filter, groundwater however, is normally not exposed to air and thus act as a preservative medium for contaminants. It flows slowly, cleanup is expensive-sometime impossible – once contamination has occurred.

It is undoubtedly clear that open waste generally affects ground water resources. Groundwater is clean, tasteless and odourless, especially if it is from deep wells. The temperature regime of ground water in ranged between 30^{o}C and 31^{o}C. This depends in the environmental condition at the time of collection of samples. The pH level is almost constant at 6.68 and 6.78 with little variation in most cases. The pH ranges between 7.12, 6.68 and 6.78 which are not acceptable for human consumption.

World Health Organization (WHO) recommends higher desirable level of 6.5 to 8.5 as shown in table 4.1 above. The lower pH of 6.68 and 6.78 in groundwater (well and borehole water) may be due to the presence of organ waste, because organic wastes reduces the pH of water to acidic level. This acidity may generally results from the presence of weak acids particularly carbon (IV) oxide (C0$_2$) but sometimes, including protein and fatty acids.

Other parameters analyzed vary from one sample to another. This however may depend on the depth of the boreholes, its distance from dumpsite, the technique used in drilling the borehole which may vary from one place to another.

Table 4.Analysis of Variance between Leachate sample & WHO standard.
ANOVA

F crit	**P-value**	**F**	**MS**	**df**	**SS**	**Source of Variation**
3.178893	0.473906	1.045886049	198923.3119	9	1790309.8	Rows
5.117355	0.243027	1.561047837	296905.008	1	296905.01	Columns
			190195.9703	9	1711763.7	Error
				19	3798978.5	Total

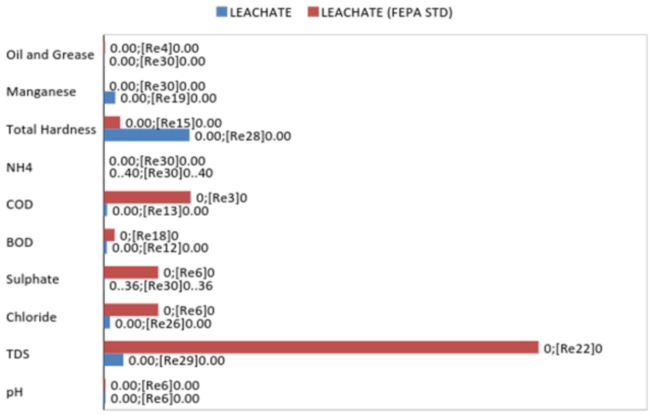

Fig 1. Comparing Leachate values obtained with FEPA/WHO Standard.

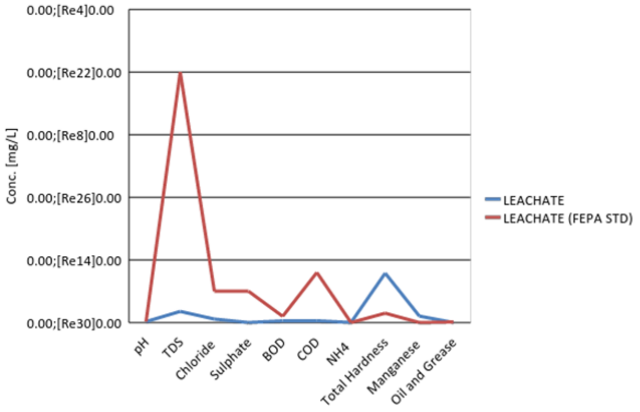

Fig 2. Comparing Analysis of Leachate values Obtained with FEPA Standard .

* FEPA adopts WHO standard

High concentration of pollutants prevailed in leachate and well water leachate and well water produced during sampling higher concentration of pollutant particularly of productivity, suspended solid, total dissolved solids, phosphate, were found this may be due to the emission form mixed waste but BOD and COD of spring water were greater than nearby well water this may be due to contaminant of waste from its catchments area and due to its stagnation. This could be attributed to groundwater and surface water ingress from the dumping site that promote volatilization of pollutants from active decomposition of waste mass in to leachate emanated from disposal site to the nearby groundwater source.

Turbidity

Turbidity, as seen in the sample bottles and suspended solids in well water indicated that the presence of organic and inorganic solids that can provide adsorptive site for certain chemicals and/or biological agents.

Dissolved Oxygen

The dissolved oxygen on the leachate was not detected and in the groundwater was quit low, and cannot support desired aerobic organisms in the study site. This may upset the ecosystem, encouraging development of septic conditions and lead to proliferation of anaerobic biota that may produce anaerobic condition in the groundwater.

Iron (Fe)

All the samples analyzed contains little amount of iron (which range between 0.01 to 00.5mg/L) because iron is common in many aquifers and is found in trace amounts, practically all sediments and rock formations. The iron contents of groundwater are important because small amounts seriously affect water usefulness for some domestic and industrial purposes. World Health Organization (WHO) recommends that the iron content of drinking water should not be greater than 0.3mg/L from the results of the borehole analyzed in Obio/Akpor Local Government Area, the iron content falls within the WHO standards.

Nitrate (N0$_3$)

National concentrations of nitrates in groundwater are very low, since plants take up most of the nitrogen near the ground surface before it can reach the water table. However, background levels of nitrates in the leachate and nearby well recorded at the dumping site relatively high (0.1 to 0.4mg/L). This might be explained by the fact that the land is contaminated by leachate nitrate and that concentration might have been brought by the application of fertilizers from the residents farming land.

Nitrate is a concern because it does not breakdown quickly on the soil and does not stick to soil particles instead, it travels rapidly with the groundwater and can seep a long way from its source. Nitrate enters the groundwater from several sources such as certain plants like legumes. Other sources of soil nitrate are decomposing plant debris, animal wastes, household solid wastes etc; natural nitrate concentration in groundwater range 0.1 to 10mg/L (Adeyemo et. al 2002). Nitrate concentration greater than 45mg/L is undesirable in domestic water supplies.

Phosphorus

The background level of phosphorus in groundwater was not found. The level of phosphorus measured as leachate and well water in and near the dumping site is 6 and 2mg/L which is much exceeded the value of 0.15mg/L.

There is little potential for phosphorus to leach through the soil into the groundwater. This is because soil particles have a large capacity to fix phosphorus in forms that are immobile in soil.

Most soils filter out soluble phosphorus as water passes through the soil profile into groundwater. There is no indication that the amount of phosphorus leached is increasing as were wastes are being added to the landfill since there may be a source for phosphorus from nearby farming land.

Chloride

Chloride can get into the groundwater from open waste disposal when it comes into contact with rain water and then gains entrance into the aquifer. Results of chloride in analysis in the three different samples varied between 21.27 to 28.36mg/L which is also within WHO recommendations.

Analysis of other parameters such as conductivity range from 2.37, 131 and 1480us/cm, total hardness range from 12, 34 and 352mg/CaC0$_3$, dissolved oxygen (D0) range from

Table 5. Analysis of Variance between Domestic well samples, Ground water & WHO standard.

ANOVA

F crit	P-value	F	MS	df	SS	Source of Variation
2.18338	0.456267	1.027645124	29881.54116	12	358578.494	Rows
3.402826	0.051373	3.368084831	97936.10962	2	195872.219	Columns
			29077.68495	24	697864.439	Error
				38	1252315.15	Total

4.075, 5.42 and 4.71mg/L and total dissolved solid (TDS) range from 0.442, 17.407 and 94.974mg/L. However, most of the water parameter falls within World Health Organization (WHO) recommendation. Although open waste dump are known to affect the quality of ground water this is because they produce gases when are decomposing and are washed by percolating and infiltrating rainwater.

In this study, ground water and leachate concentrations of trace metals such as cadmium (Cd), chromium (Cr), head (Pb) and copper were determined in chemical/petrochemical engineering laboratory in unit operation section. As can be seen in table 4.1 these analyses are identified, as have several potential significant groundwater and risk challenges that require urgent attention and additional study. The concentrations for these analyses in leachate and groundwater are shown in table 4.1 for information purposes. Water table of the nearby well depths in this study is 1.8m. Mercury (Hg) and Arsenic (As) were not included in the table because these elements could not be identified in the mentioned laboratory. Lead (Pb) in the leachate and groundwater were greater than the WHO international standard and when I compare the nearby hard-dug well. This may be due to the contamination resulted from the disposal site leachate.

Of these heavy metals analyses, the concentrations of Lead (Pb), chromium (Cr) and cadmium (Cd) in spring water exceed WHO standard based drinking water criteria. This may be due to the dumping mixed wastes such like plastics, oils and pesticides all of which becomes pollutants in the site that includes lead battery and petroleum compound.

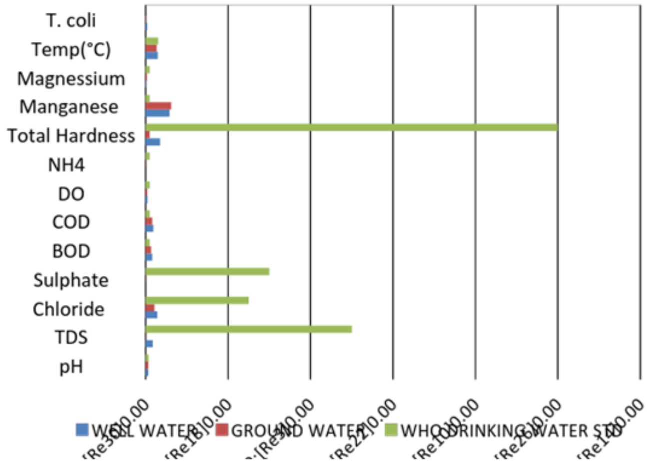

Fig 3. Comparing Ground Water and Domestic well Water with WHO Standard.

Conclusion

The presence of large quantities of mixtures of potentially hazardous chemicals in open wastes dumping sites close to residential area has increasingly caused some significant groundwater and public health concerns. Concerns have led to a substantial study on the quality of ground water and effects associated with open waste dumping site. From this study one can conclude that there is an increase in risk to ground water that is reported near Rukpokwu open waste dumping site.

The findings revealed that high risk are associated with groundwater (well and borehole water) pollution and public health near the dumping site. In general Rukpokwu open waste dumping site, worth nothing to the environment as well as to the public health in its vicinity. From the analysis carried out it was observed that most of the parameters fall within WHO drinking water standard.

Although some agents like dissolved oxygen, total dissolved solids, chloride, nitrate, iron, hardness, phosphates and sulphate contents vary from one sample to another as shown in table 4.1 above. However, their presence in ground water in Rukpokwu Obio/Akpor Local Government Area in Port Harcourt do not cause significant Health Hazards.

Open waste handling, controlling and monitoring techniques must gear towards achieving quality environmental condition for many to live in. This will go a long way to protecting natural resources such as water that are degraded by these open wastes. From this frame work it is possible to articulate a position on thorough environmental management procedures to protect ground water resources in Rukpokwu Obio/Akpor Local Government Area.

The result indicated that the dumping site is producing many potent contaminants to the environment and to the people nearby which has made using the site for a dump is completely unacceptable. The following are therefore recommended.

Recommendations

The Government with other environmental and public health concerned organizations should give prior attention to the problem of open dump site, with regard to public health and ground water risks.

Open 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 recognized. There is need for environmental awareness through enlightenment campaigns, exploration of ground water should be deep and the principles of resources management (reduce, reuse, recycle and responsible disposal) should be adhered to an open waste management.

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

Regulatory bodies such as the Rivers State Minister of Environment and environmental sanitation authority should ensure a sound waste management practice as well as monitor industries.

There should be rules, regulations and scientific standards regarding well engineered landfill design and other means of open waste disposal technology.

The operation of dump site must be stopped as soon as possible so as solve groundwater and public health problems and new engineered landfill should be constructed with proper collection and treatment of leachate. Before closing the present dump site temporary disposal options should be considered and that should be free of environmental pollution and public health risks.

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