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Potability of Well Water near Dumpsite in Keffi Town, Nasarawa State, Nigeria

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Wells close to dumpsites are usually polluted by leachates from the dumps, thus this research assessed the suitability of well water close to dumpsites for domestic purpose in Keffi town, Nasarawa State, Nigeria. The objectives were to analyse the physical and chemical properties of well water close to dumpsites; compare the physical and chemical properties of well water with World Health Organization (WHO) standard for domestic use. Samples of fifteen wells close to dumpsites were collected in 2 litre plastic containers adequately washed and rinsed with sample source. Samples were preserved by storing in ice-filled cooler boxes and transported to the laboratory. Data obtained were analysed using descriptive statistics. Results showed that the pH ranged from 4.19-7.18 and thus fall short of 6.2-9.2 WHO standards for domestic purpose. The electrical conductivity which ranged from 245-730(µs/cm3) is below the WHO standard of 1500(µs/cm3) for domestic purpose. The concentration of total dissolved solids is within the acceptable limit of 1500Mg/l, it ranged from 155 to 484 Mg/l. The total hardness ranged from 62.10-136.52 Mg/l, this concentration is within the WHO acceptable limit of 500Mg/l for domestic use. The concentration of Cl-, NO_3^-, PO_4^-, Ca, Mg, Na, K and N were below WHO limit likewise concentrations of heavy metals (Zn, Cu, Pb, Cd, and Fe) expect iron which exceed the acceptable limit. Water from the sampled wells is not safe and has to be treated for drinking purpose.

Keywords: Well water, Dumpsite, Water pollution, Domestic Water, Leachate.

Introduction

Dumpsites pose significant effect on underground water due to leachates resulting from waste degradation at the site, which penetrates through the soil to the aquifer to pollute underground water. However, underground water like well is usually used for domestic purposes including drinking without any form of treatment. One of the major environmental issues today is groundwater contamination and among the drivers of underground water pollution is uncontrolled waste dumping. Leachates migration from waste sites or landfills and the release of pollutants from sediments pose a high risk to groundwater resource (Ikem *et al*., 2002; Yakubu, 2013).

Water is a resource that is both invaluable and vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of high quality for domestic purposes and economic activities (Okechukwu *et al.*, 2012). Wells especially those cited close to dumpsites are usually polluted by leachates from the dumps. Contrary to widely held theoretical view of groundwater being the "safest" water, wells have been found to be polluted (Gideon, 1999; Amadi *et al*., 2012; Yakubu & Baba, 2010; Folorunsho, 2010; Okechukwu *et al.,* 2012; Sorlini *et al*., 2013; Yakubu, 2013; Samaila *et al.*, 2015). Sorlini *et al.* (2013) found elevated levels of lead both in underground and surface waters. Okechukwu *et al. (*2012) found that some of the water parameters tested were within WHO standard and some were outside the range provided by WHO standard. Among the parameters tested that falls outside the range provided by WHO standard that has significant health implication are coliform and E. coli. Samaila *et al.* (2015) found low pH in well water in Vaneikya, Benue State, Nigeria. Any shortcomings in domestic water have health and societal effects.

Therefore, study on domestic water quality is indispensable to the sustenance of human health and development. Domestic water is used for drinking, cooking, bathing and cleaning, however, access to safe drinking and sanitation is critical in terms of health. For instance, unsafe drinking water contributes to numerous health problems in developing countries such as the one billion or more incidents of diarrhoea that occur annually (Mark *et al*., 2002). Water of good drinking quality is of basic importance to human health and man's continuous existence depends very much on its availability. An average man (of 53 kg – 63 kg body weight), requires about three litres (3l) of water in liquid daily to keep healthy (Onweluzo & Akuagbazie, 2010). This fact apparently accounts for why water is regarded as one of the most indispensable substances in life (Okonko, *et al.,* 2008). The importance of water to man cannot be over emphasized. Human beings can survive longer without food than without water. It is required for cooking, washing, sanitation and drinking and for growing crops and running factories. However, increase in human population has exerted an enormous pressure on the provision of safe water especially in developing countries (Umeh, *et al*., 2005). The provision of good quality water can help in eradicating water-borne diseases and in improving the general sanitation of Nigeria's towns and villages (Omaka *et al*., 2014). Given the potential effects of waste dumpsites on quality of wells and ignorance of the populace on the danger of the direct consumption of such well water, there is enormous benefits to assess the suitability of well water close to dumpsites for domestic purpose. Therefore, this study is significant as it analysed the well water properties and ascertain their safety.

In Keffi town like every other parts of Nigeria, well water is use for domestic purpose including drinking because it looks clean and pure or because is the only available source. While water may appear to be clear and pure, and has no specific taste or odour, it may contain elements that can have undesirable effects on health. The quality of groundwater is determined by testing various parameters of interest on which results is compared with the standard qualities required for water intended for human consumption and use (Yakubu, 2013).

Statement of the Problem

Though, over seventy percent (70%) of the earth surface is made of water (National Geographic Society, 2012) not all water is safe for domestic purpose especially direct consumption. Apart from the fact that only three percent (3%) is fresh water, human activities have continued to pollute and degrade the existing fresh water and man resulted to sourcing underground water which is believed to be safe. However, the underground water is not free from contaminations from human activities like waste dumping. Solid waste can generate toxic materials and pathogenic organisms into the leachate of dumps and landfills (leachate is the liquid discharge of dumps and landfills; it is composed of rotten organic waste, liquid wastes, infiltrated rainwater and extracts of soluble material). If the landfill is unlined, the runoff can contaminate ground water, depending on the drainage system and the composition of the underlying soils. This possible contamination of underground water by leachate from dumpsite are not well understood by the populace in Keffi Local Government area and people comfortably use well water including those located close to dumpsite for drinking and other domestic purposes. Though, there is growing awareness on the effect of dumpsites on water quality globally and dumpsite siting is increasing causing conflicts due to agitation against location close to residential area (ISWA, 2015), it is still the most available method of managing waste in the study area.

Methodology

Data on the physical and chemical properties of well water close to dumpsites in Keffi Local Government Area were collected through purposive sampling of well water located within 200m of three major dumpsites in Keffi. The selection of wells sampled were purposively selected based on proximity to three major dumpsites (Keffi-Lafia Road, Nasarawa Road Keffi and Market/ Emir Palace Road) in the study area. Though, Keffi has up to ten dumpsites capable of causing harm to the natural environment, three dumpsites were selected based on their age, volume and size. Five wells each were sampled within 200m of all the three dumpsites, making a total of 15 wells. Water samples were collected using 2 litre plastic containers which were adequately washed and rinsed with sample source. Samples were preserved by storing in ice-filled cooler boxes and transported to the laboratory. This is to prevent chemical reaction and retain the original quality till laboratory analysis. The following water quality parameters: pH, turbidity, total suspended solids, total dissolve solids and electrical conductivity of water samples were tested in-situ. The concentration of chlorine (Cl-), nitrate (NO_3^-), phosphate (PO_4^-), calcium (Ca), magnesium (Mg), sodium (Na), Potassium (K), nitrogen (N) and total hardness were analysed at the laboratory with the hatch kit and colorimeter. Heavy metals (zinc (Zn), copper (Cu), lead (Pb), cadmium (Cd), and iron (Fe)) were analysed using Atomic Absorption Spectrophotometer (AAS). Results obtained from the laboratory were presented in tables and analysed using descriptive statistics mean range and bar chart.

Result and Discussion

The physical and chemical properties of well water close to dumpsites is presented in table 1. The water samples are both acidic and alkaline as the pH ranged from 4.19-7.18 with mean value of 6.52 and standard deviation ±0.67. The mean value being 6.52 means that the well waters close to dumpsites are slightly acidic based on average. However, the standard deviation being ±0.67 indicate disparity in the concentration of pH among the well water samples. This is clear from the lower range of 4.19 which is strong acidic to the upper range 7.18 which slight alkaline. It therefore means that pH varies significantly among the samples. The variation in the pH is a function of type of waste dumped and other economic activities. Waste containing metals and hydrocarbons reduce pH and causes acidity of soil and water. The pH of water is very important in the determination of water quality since it affects other chemical reactions such as solubility and metal toxicity (Samaila *et al*., 2015).

Table 1 presents the statistical summary of properties of well water close to dumpsites. The well water properties shown in table 1 are discussed as follows:

pH

Electrical Conductivity (EC)

The electrical conductivity of well water samples ranged from 245M/S-730 M/S with mean value of 596.00 M/S and standard deviation ±829.14. The standard deviation being ±829.14 indicates diversity in the electrical conductivity of well water sample. Range of 245-730 µS/cm and thus, in line with the position of Samaila *et al.* (2015) that well water usually has low electrical conductivity. Electrical conductivity of water measures the capacity of water to conduct electric current. It is an indicator of how salt-free, ion-free or impurity free a water sample is.

Solids (Total Dissolved Solids TDs and Total Suspended Solids TSS)

The total dissolved solids is high as it ranged from 155 Mg/l -484 Mg/l with mean value of 262.33Mg/l and standard deviation ±96.87 while the TSS is relatively low as it ranged from 0.3 Mg/l -0.8 Mg/l with mean value of 0.55 Mg/l and standard deviation ±0.12. The standard deviation for TDs being ±96.87 and that of TSS being ± 0.12 shows more diversity in the concentration of TDs than TSS. Wells without cover recorded higher total dissolved solids (TDs) and total suspended solids (TSS) than those with cover.

Table 1: Physical and Chemical the Properties of Well Water Close to Dumpsites

Parameter	Unit	Range	Mean	Standard Deviation
pH		4.19-7.18	6.52	±0.67
E.C	µs/cm3	245-730	596	±829.14
Tds		155-484	262.33	±96.87
TSS		0.3-0.8	0.56	±0.12
Total Hard.		62.1-136.52	88.93	±0.44
Cl		10.59-60.27	35.21	±17.92
NO_3^-		0.12-1.71	0.91	±0.12
PO_4^-		0.036-0.44	0.18	±19.84
Zn		0.00-0.004	0.0014	±0.0012
Cu	**mg/l**	0.0005-0.0035	0.0024	±0.0009
Pb		0.001-0.0095	0.1041	±0.0048
Cd		0.06-0.64	0.19	±0.19
Ca		8.89-76.48	18.87	±22.14
Mg		1.32-24.01	3.59	±7.52
Na		0.105-1.14	0.17	±0.24
K		0.07-0.27	0.19	±0.06
N		0.0035-2.24	1.13	±0.75
Fe		2.17-4.83	2.86	±0.76

Total Hardness

The total hardness ranged from 62.1 Mg/l - 136.52Mg/l with mean value of 88.93 Mg/l and standard deviation ±0.44. On average, the total hardness is lower than the finding of Samaila *et al.* (2015) that reported a range of 40 to 400 Mg/l with mean value of 214Mg/l in hand dug wells. The total hardness also varies among samples. Water hardness is caused by the presence of high concentration of calcium and magnesium ions, with attendant inability to lather excessive soap consummation and scale formation.

Mineral Nutrients (Cl-, NO_3^-, PO_4^-, Ca, Mg, Na, K and N)

The concentrations of these minerals in the well water samples are as follows: Chloride (Cl-) ranged from 10.59 to 60.27Mg/l with mean value of 35.21, nitrogen oxide (NO_3^-) from 0.12 to 1.71 Mg/l with a mean value of 0.91 Mg/l, phosphorous (PO_4^-) from 0.036 to 0.44Mg/l and 0.18Mg/l mean, calcium(Ca) from 8.89 to76.48 Mg/l and 18.87 Mg/l mean value, magnesium(Mg) from 1.323 to 24.0075 with mean value of 3.5921Mg/l, sodium(Na) from 0.105 to 1.125Mg/l with mean value of 0.1734Mg/l, potassium (K)from 0.07-0.267Mg/l with mean value of 0.1886 Mg/l, and Nitrogen (N) from 0.0035 to 2.24Mg/l with mean value of 1.13Mg/l. The average concentrations of these minerals are in the order of Cl-.>Ca>Mg> N> NO_3^- > K> PO^-_4 >Na. Thus, chloride is the most abundant minerals in the well water samples followed by calcium and magnesium and least is sodium (Figure 1).

Heavy Metals (Zn, Cu, Pb, Cd, and Fe)

The concentration of heavy metals (Zn, Cu, Pb, Cd, and Fe) are as follows: Zinc (Zn) ranged from 0.00-0.004Mg/l with mean value of 0.0014, copper (Cu) from0.0005-0.0035 Mg/l with a mean value of 0.0024 Mg/l, lead (Pb) from 0.001-0.0095Mg/l and0.1041Mg/l mean, cadmium(Cd) from 0.06-0.64Mg/l and 0.19Mg/l mean value and iron(Fe) ranged from 2.17-4.83 Mg/l with mean value of 2.86Mg/l. The concentration of heavy metals are in the order of Fe>Cd>Pb>Cu>Zn (Figure 2).

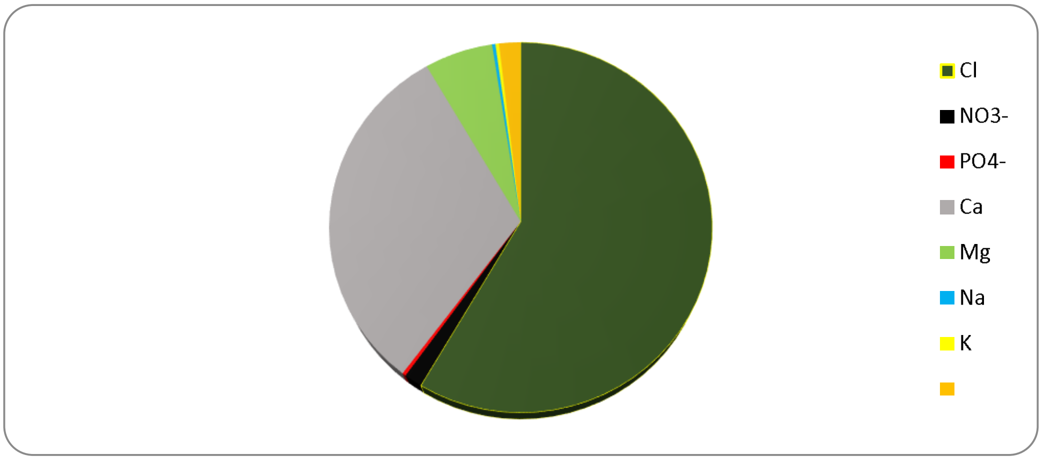

Figure 1: Concentration of Minerals in Well Water Samples

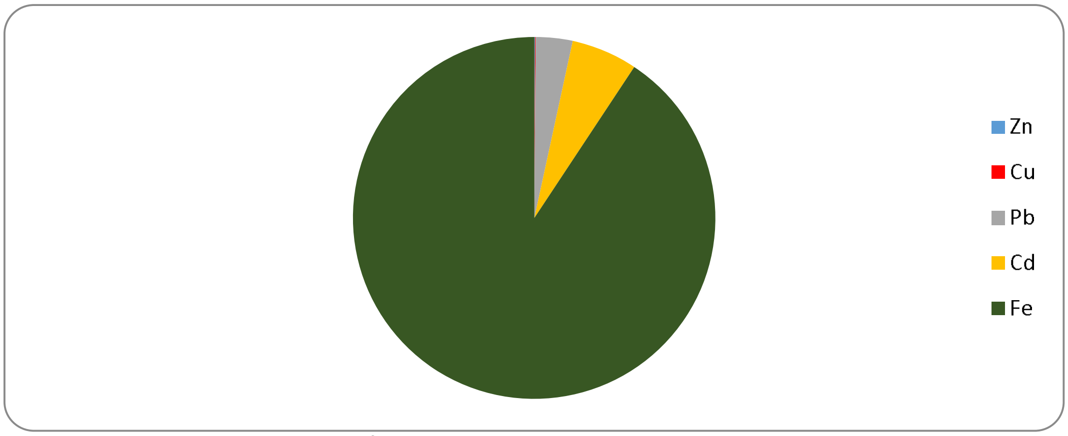

Figure 2: Concentration of Heavy Metals (Zn, Cu, Pb, Cd, and Fe) in Well Water Samples

The Safety of the Physical and Chemical Properties of Water Sample for Domestic Use

Table 2 shows the concentrations of well water physical and chemical properties and the WHO standard for domestic purpose. It shows the well water physical and chemical properties and the WHO standard as follows:

pH

The pH ranged from 4.19-7.18 with mean value of 6.52 while the WHO standard for domestic purpose is 6.2-9.2. Therefore, the mean concentration is within the acceptable range by WHO but the lower value of 4.19 indicate sample(s) fall below the WHO recommended limit for domestic purpose. So the lowest pH (4.195) which is strong acidic was recorded in sample C of Nasarawa Road Keffi dumpsite. Thus, all other samples meet the WHO recommended limit for domestic purpose expect sample C collected close to Nasarawa Road Keffi dumpsite. Thus, the use of well water from sample C collected close to Nasarawa Road Keffi dumpsite needs treatment or should be subjected to other domestic use like flushing toilets.

Table 2: Physical and Chemical Properties of Well Water and WHO Standard for Domestic Purpose

parameters	Unit	Range	Mean	WHO Limit for Domestic Purpose
pH		4.19-7.18	6.52	6.5-9.2
E.C	µS/Cm	245-730	596	1500
TDs		155-484	262.33	1500
TSS		0.3-0.8	0.56	-
Total Hard.		62.1-136.52	88.93	500
Cl		10.59-60.27	35.21	200
NO_3^-		0.12-1.71	0.91	45
PO_4^-		0.036-0.44	0.18	100
Zn		0.00-0.004	0.0014	5
Cu		0.0005-0.0035	0.0024	1
Pb		0.001-0.0095	0.1	0.05
Cd		0.06-0.64	0.19	0.01
Ca	Mg/l	8.89-76.48	18.87	75
Mg		1.32-24.00	3.59	30
Na		0.105-1.125	0.17	60
K		0.07-0.27	0.189	100
N		0.0035-2.24	1.13	-
Fe		2.1655-4.8325	2.86	0.1

Solids and Hardness

The concentration of total dissolved solids was high but within the acceptable limit of 1500Mg/l, it ranged from 155 to 484 Mg/l with mean value of 262.33Mg/l and the total suspended solid were relatively low. The Total hardness ranged from 62.10-136.52 Mg/l with mean value of 88.93 Mg/l. This concentration is within the WHO acceptable limit of 500Mg/l for domestic use.

Mineral Nutrients (Cl-, NO_3^-, PO_4^-, Ca, Mg, Na, K and N)

The concentrations of these minerals in the well water samples were generally lower than their WHO desired limit for domestic purpose. The concentrations are as follows: Chloride (Cl-) ranged from 10.59 to 60.27Mg/l with mean value of 35.21, nitrogen oxide (NO_3^-) from 0.12 to 1.71 Mg/l with a mean value of 0.91 Mg/l, phosphorous (PO_4^-) from 0.036 to 0.44Mg/l and 0.18Mg/l mean, calcium(Ca) from 8.89 to76.48 Mg/l and 18.87 Mg/l mean value, magnesium(Mg) from 1.32 to 24.00 with mean value of 3.59Mg/l, sodium(Na) from 0.105 to 1.125Mg/l with mean value of 0.17Mg/l, potassium (K) from 0.07-0.27Mg/l with mean value of 0.189 Mg/l, and Nitrogen (N) from 0.0035 to 2.24Mg/l with mean value of 1.13Mg/l.

Heavy Metals (Zn, Cu, Pb, Cd, and Fe)

The concentrations of heavy metals (Zn, Cu, Pb, Cd, and Fe) were below their highest acceptable limits except iron which exceed the acceptable limit of 0.1Mg/l (Figure 3).

Figure 3 shows that the concentrations of heavy metals (Zn, Cu, Pb, Cd, and Fe) were all within the WHO standard except iron. Thus, consumption of the well water is not safe in terms of iron. According to the report of WHO (2010), "water with excessive amounts of dissolved minerals such as iron and magnesium can have negative effects on your skin. They can damage healthy skin cells, which can lead to wrinkles".

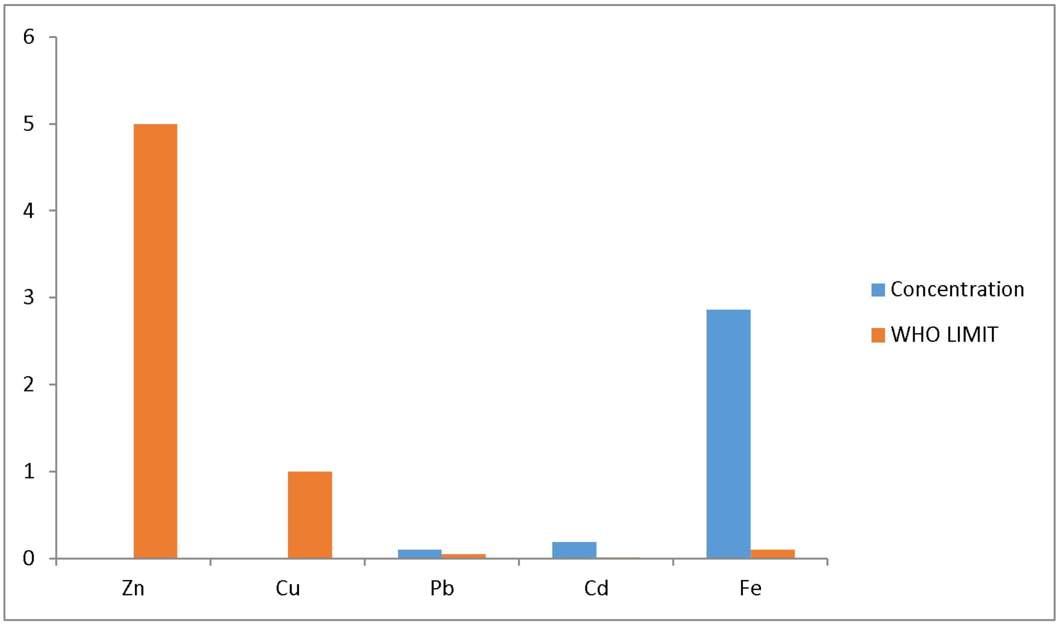

Figure 3: The Concentrations of Heavy Metals and WHO Standard

Conclusion/Recommendation

It was concluded that wastes dumped at dumpsites in Keffi LGA offered some physical and chemical parameters of well water close to dumpsites. High acidity was found in some samples and both total solid and total suspended solids were found in high concentration but within acceptable limit by WHO for domestic purpose. The concentrations of some chemical properties (pH, EC and Fe) of well water close to dumpsites in Keffi Local Government Area fell short of WHO standard for domestic use and as such are not safe for domestic use especially for drinking. It was recommended as follows:

a. Well water close to dumpsite should only be used for cleaning and flushing of toilet. If needed for other purposes such as drinking, further treatment should be carried out.

b. The location of dumpsites should be properly planned and managed to avoid risks to water.

c. Well should not be sited close to dumpsite(s).

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