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GROUNDWATER POLLUTION IN A RURAL TROPICAL SETTING AT ABBI, NDOKWA WEST LGA, NIGERIA.

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ABSTRACT : *Groundwater constitutes one of major source of water supply especially in most rural communities in Nigeria, in addition to rainwater and surface water bodies. For this reason, there has been a consistent demand for groundwater through the construction of hand dug wells. In spite of this experience, however, there has been an increased concern as to the safety of groundwater for human consumption, following reported cases of the occurrence of heavy metals and several bacteria in groundwater which by nature are injurious to human health. This study in response to this, examined the physico-chemical properties, in groundwater samples taken from three wells locations in Abbi Ndokwa West region of Delta State. Heavy metals such as Iron (Fe), Zinc (Zn), Copper (Cu), Cadmium (Cd), Lead (Pb), Manganese (Mn), and Magnesium (Mg), were analyzed. Result showed that there were heavy occurrences of Zinc and Copper from the sample taken from wells. The levels of heavy metals found in the well samples were outside the limits specified by World Health Organization (WHO). The implications of the result for the management and use of groundwater in the study area were identified and discussed and recommendations preferred that we evaluate the toxic and logical significance of commonly used water for drinking.*

KEYWORDS – *groundwater, pollution, heavy metals, water quality*

I. INTRODUCTION

Ground water pollution can be described as the contamination of ground water by the addition of unwanted physical, chemical and bacteriological substances, which alters natural quality. Ground water in its natural state tends to be relatively free from contaminants in most areas. Because it is a widely used source of drinking water, the pollution of ground water can be a very serious problem.

With the world population growing and the increasing pollution of our natural resources, we are facing a water crisis. The World Health Organization has estimated that over 1 billion people lack access to safe drinking and about 4000 children die every day from water borne disease (Virkutyte and Sillanpa, 2006). Polluted water has direct effect on human health while sewerage and industrial effluents, have indirect effect through consumption of foodstuffs being irrigated with such type of discharge. According to World Health Organization more than 80% human diseases are water borne. In developing countries 80% of the population has no easy excess to pure drinking water and more than 5 million human being die with and early death annually as a result of illness linked to unsafe drinking water unclean domestic environments and improper excreta disposed. Water pollutants mainly consist of heavy metals, microorganism, fertilizer and thousand of toxic organic compounds (WHO, 1999).

Heavy metals, which are contaminants, consist of Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Nickel (Ni),Iron (Fe), Magnesium (Mn), Mercury (Hg), Zinc (Zc), Aluminum (Al), Selenium (Se), as well as metals of group III and IV, which have toxic effect on human physiology. Along with the heavy metals the next most important pollutants of groundwater are microorganisms. These affect water quality by assimilating Nitrate (No_3), Carbon dioxide (Co_2) and also solubilize some heavy metals in water. These also produce toxicants in ground water. They cause many epidemic diseases in human (Khan et al., 2000).

Ground water is the water that occurs beneath the surface of the earth, it is collected in the porous rock strata and soil, and it emerges at surface as rivers, springs, and lakes. It is also called sub- surface water to distinguish it from surface water, which flows over land and rivers (Todd et al, 1999). Recent estimates are that useable ground water amounts to more than 90% of all fresh water on earth. In many dry areas, it is the only reliable source of water; it fills wells and city water supplies.

Ground water pollution may be defined as the artificially induced degradation of natural groundwater quality. Pollution can impair the use of water and can create hazards to public health through toxicity or the spread of disease. Most pollution originates from the disposal of waste water following the use of water for any of a wide variety of purposes.

The objectives of this study include

i. To obtain the physical and chemical parameters of different water sources in the study area.
ii. To ascertain the presence of pollutants and causes and to propose possible solution that can gradually reduce the rate of ground water pollution, as it affects the occupants within the study area.
iii. To ascertain the quality of the water sources and its usability.

II. STUDY LOCATION

The study area is located in the north – east of Delta state at Latitude 5’6^{0}E and Longitude 6’2^{0}N. The study area is accessible by road which is located along Amai-Ogume-Kwale road, Delta State, Nigeria.

The study area is in the rain forest region of the southern part of Nigeria with rivers running in between lands forming several swamps. The area experiences two seasons: the dry season and rainy season. It is very difficult to predict the exact month each season starts. It varies from year to year but mostly, the dry season last from October to March and the rainy season from March to October with August being the peak of the rainy season.

III. METHODOLOGY

This study was carried out in two phases:

a. Field work
b. Laboratory analysis

Field Work

Three water samples (sample A, B and C) were collected from three different wells in the area of study (Abbi, Ndokwa west Delta).

SOURCE OF SAMPLE A: -

Was taken from a well at behind a building. The well is cased with rings of height 3.4m and above the ground level. The well has no cover. The compound is made up of many building with the same people sharing common toilet and bathroom. The well is surrounded with grown grasses and other plants. There is refuse dump located at about 10m away from the well. The well serves as a source of water to the compound for different purposes.

SOURCES OF SAMPLE B: Okwele market Abbi, Ndokwa west

Sample B was collected from a well located behind the market. The well is cased with rings of height 3.9m above the ground level. The well has no cover and it is cased to the water table. About 5m away from the well is a channel constructed with concrete through which sewage water from the public bathroom and toilet flows through. Immediately after the channel there is a refuse dump site that the market uses, water flows from the front of the market to the refuse dump through a channel very close to the well when it rains. The well serves as the only nearby source of water to the market and different individuals use it for different purposes, such as cooking by food sellers, bathing, washing, etc.

SOURCE OF SAMPLE C: Orogun Abbi, Ndokwa west
Was collected from a well located in the middle of a street, the mouth of the well is moulded with cement block, it is an uncovered well, surrounded with dirt. The well is not suitable for drinking, cooking, but only suitable for bathing, washing. It is not case to the water table.

The samples were collected with the aid of a bucket tied to a rope. The rope was used to measure the depth of water from the surface. The bucket was made to float on top of water and the point at which the rope touches the mouth of the ring was marked and measured with a measuring tape. The height of the surface ring from the ground level was also measured. The bucket was now used to collect water from the well by allowing it to deep down the well and bringing it out for appropriate sample to be taken. The samples were collected into an acid wash propylene container, labeled and transported to the laboratory immediately for chemical analysis.

SAMPLE A
Date of collection: 08 May 2015
Time of Collection: 10:49AM
Depth of water from surface ring: 0.32m
Height of surface ring from ground: 3.4m
Depth of water from ground level: 3.1m
Total depth of water from ground level: 3.1m

SAMPLE B
Date of collection: 08 May 2015
Time of collection: 11:23AM
Depth of water from surface ring: 0.2m
Height of surface ring from ground: 3.9m
Depth of water from ground level: 3.7m
Total depth of water from ground level: 3.7m

SAMPLE C
Date of collection: 08 May 2015
Time of collection: 11:38AM
Depth of water from surface ring: 0.2m
Height of surface ring from ground: 3.0m
Depth of water from ground level: 2.8m
Total depth of water from ground level: 2.8m

PHYSICAL ANALYSIS

The three well water samples were tested for physical properties that include: PH, conductivity, and total dissolved solids.

pH

The PH meter was standardized with PH near that of the water sample and then with two others and in order to check the accuracy of the PH meter electrodes. The well water samples were then analyzed by measuring 10ml each of the water samples in a clean beaker and the electrodes were inserted into each of the sample and the PH value were displayed on the LCD screen and were recorded. (AOAC, 2003).

Conductivity

This was determined using conductivity meter by measuring 10ml each of the well water into a 50ml beaker and the conductivity were read from the LCD.

Total Dissolved Solids (TDS)

10ml each of the various well water samples were filtered through a standard glass-fiber filter and the filtrates were evaporated to dryness in a previously weighed dish and were dried to a constant weight at a temperature of 180℃. the change (increase) in weight represents the total dissolved solid in the water samples. Calculation;

$$\text{Mg total dissolved solid/liter} = \frac{(A-B) \times 100}{\text{sample volume (ml)}}$$

A= Weight of dried residue + Dish (mg)
B= Weight of dish (mg).

Chemical Analysis

Dissolved Oxygen (DO)

100ml of each of the well water samples were measure in a 300ml bottle, 2ml of Manganese Sulphate ($MnSO_4$) and 2ml alkali-iodide-azide reagent were added below the surface of the water, they were then stoppered with care to exclude air bubbles and were mixed by inverting the bottle a number of times until a cleared supernatant water were obtained. These were allowed to settle for about 2 minutes then 2ml concentrated H_2SO_4 were added and were also mixed to ensure proper dissolution. 30ml of these solutions were then titrated with 0.0125m Sodium Thiosulphate ($Na_2 S_2O_3.5H_2O$) to a pale straw color followed by 2ml of starch solution and were further filtered until the disappearance of a blue color introduced by the presence of the starch calculation.

Biochemical Oxygen Demand (BOD)

Suitable amounts of the well water sample were measured into BOD bottle in duplicates and were filled to the brim with diluted water and were stoppered without leaving air bubbles. Since the sets of the samples were made duplicates, an initial DO on one set were determined immediately. Blank dilution water and the other set of the duplicates were then incubated for five days in the dark at a temperature of 20℃ in a cooled incubator. At the end of five days, the DO of the incubated samples and the blank were then determined. The five-days BOD was computed from the DO values, initial and five – day DO **Chemical Oxygen Demand (COD)**

2.5ml of the well water sample, 2.5ml digestion solution of 3.5ml Sulphuric acid were measured into a reagent tube and were digested and cooled to room temperature shortly to avoid precipitate formation. The samples were then vented to relieve any pressure generated during digestion.

Samples, blank and standards were then measured of their absorbance. Standards were used to plot calibration curves which were in turn used to establish the concentration of COD from their absorbance. Calculation Since samples, blanks and standards were run under the same condition of volume and optical pathlergit, the COD was calculated as follows:

Chloride (Cl)

10ml each of the well water samples were taken and were added three drops of phenolphthalein indicator and were titrated against 0.05m silver nitrate ($AgNO_3$) till the disappearance of the pink color was noticed and chlorine were determined by the mercuric nitrate method (AOAC 2003, method no. 963.51).

Nitrate (NO_3)

10ml each of the well water sample was distilled with magnesium oxide which was collected in 5ml Boric acid mixed indicator and were then titrated against 0.005m HCL and NO_3 were determined by kjeldnal method (AOAC 2003, method 973.48).

Sulphate (SO_4)

10ml each of the water samples were added with 1ml of 6m Hel followed by 5ml 70% surbitol mixed and added with 1g Barium chloride and again mixed. This was then read on a spectrophotometer at a wavelength of 420nm. Standard were also prepared in the same manner and sulphate were determined by Turbedemetric method. 9AOAC, 2003 method 973.57).

Metals Analysis

Volumes of 100ml each of the water sample were analyzed for heavy metals. The presences of the metals were determined using atomic Absorption spectrophotometer (AAS), (model; Perkin Elmer 2380). Each of the water samples after through preparation were aspirated into the flame through the air stream as a fire mist. The samples passed through a mixing chamber. The air met the fuel gas (acetylene) supplied to the burner at a controlled pressure and the mixture was burnt. The radiation from the resulting flame passed through to the monochromator and then through an optical filters which permits only the radiation characteristics of the element under analysis and finally through the standard solutions of various elements were measured of their standard curves prepared by plotting the absorbance against the concentration of the metals.

IV. RESULTS AND DISCUSSION

Table1. Heavy metals concentration of Abbi well water (mg/l).

Location	CCd	LPb	MMn	IFe	ZZn	CCu
Well 1	0.01	< 0.01	0.01	<0.01	0.02	0.02
Well 2	0.01	< 0.01	0.01	<0.01	0.02	0.02
Well 3	0.01	< 0.01	0.01	<<0.01	0.02	0.02
WHO, 1999	2.00	0.05	0.05	0.03	15	0.01

Table2. Physical analysis of Abbi well water in comparison with WHO standard.

Location	PH	Conductivity(us/cm)	TDS	Dissolved oxygen(mg/l)
Well 1	8.66	197.3	98.6	4.76
Well 2	8.71	225.9	106.3	5.66
Well3	8.83	186.5	93.2	6.17
WHO, 1999	6.50-8.50	1500	500	N/A

Table 3. Mineral and chemical concentrations of Abbi well water in comparison with WHO standard.

	Mg (mg/l)	Ca (mg/l)	NO_3 (mg/l)	SO_4 (mg/l)	Cl (mg/l)	BOD
Well 1	24.33	32.38	6.14	13.17	13.86	7.76
Well 2	20.66	24.74	7.74	13.11	12.11	8.01
Well 3	26.34	28.44	7.17	14.09	12.33	8.29
WHO, 1999	36	100.00	45.00	250	250.0	N/A

Discussion

Heavy Metal Concentrations.

The heavy metals concentration of Abbi well waters recorded mean values of 0.01, <0.01, 0.01, <0.01, 0.02 and 0.02mg/l for cadmium, lead, manganese, iron, zinc and copper respectively. (Table 1).

Lead (Pb).

Lead concentrations in all the water samples analyzed were found to be 0.01 at all the location which falls within the permissible values of WHO for drinking water. Through the results were in conformity with WHO, it should be known that lead concentration varies from place to place. Most lead contamination in drinking water occurs when soft acid water corrodes lead pipes. Lead broadly affects human organs and systems. The most sensitive is the central nervous system particularly in children. Lead also damages kidney immune system. The exposure of unborn children due to mother is also dangerous which results harmful effects include premature birth, smaller babies and decreased mental ability in the infant, learning difficulties and reduced growth in young children (Yang et al, 1999). Through the lead concentration of the analyzed sample fell within limit, over accumulation pose health risk.

Manganese (Mn)

Manganese was found in Abbi wells in the concentration of 0.01mg/l for all locations. This falls in safe limit of WHO of 0.05mg/l. the deficiency of manganese could occur in humans. The symptoms could be weight loss, transient dermatitis, occasional nausea and vomiting, change in hair and in beard colour and slow growth of hair and beard. There is 10-20μg of Mn in the adult human body while serum concentration reported to range from1-200μg/l (Henkin, 1976). Manganese toxicity has been seen in minors as a result of absorption of manganese through the respiratory trait after prolonged exposure of dust. The excess accumulates in the liver and central nervous system. Symptom resembles those found in Parkinson’s and Wilson’s disease (Yarze, 1999).

Iron (Fe).

Iron which is one of the most troublesome element in water supplies were found to be less than 0.01mg/l for all locations and was found in safe limit when compared to WHO value of 0.03. Rainwater, as it infiltrate the soil and underlying geologic formation dissolve iron, causing it to seep into aquifers that serves as sources of ground water for wells.

Iron is essential for good health, helps to transport oxygen in the blood. Dissolved ferrous iron gives disagreeable taste. When the iron combines with tea, coffee and other beverages, it produces a milky, black, appearance and a harsh unacceptable taste.

Zinc (Zn)

Zinc deficiency which results into retardation of growth, anorexia, lesions of the skin and impaired development and function of reproductive organs was formed in Abbi well water in the concentration of 0.02mg/l for all location. WHO limits for Zinc in drinking water in 15mg/l, his means that the water is in safe condition as regard Zinc concentration is exceeded then it causes fever, depression, malaise, cough, vomiting, salvation and headache. However, its toxicity is less than that of other heavy metals like Cadmium, Arsenic.

Copper (Cu)

Copper was found to be 0.02mg/l for all well waters of Abbi. The limit of Copper in drinking water by WHO in 0.01mg/l. it therefore means that the water is polluted with Copper. Though Copper is an essential micronutrient and is required by the body in a very small amount, its level above the permissible limit could cause a bitter metallic taste in eater and blue green stain on plumbing fixtures. Stomach intestinal distress such as nausa, vomiting, diarrhea, stomach cramp and liver and kidney damages are the health problem associated with Copper contaminated drinking water. (Zacarias,2001).

Cadmium

Cadmium concentration was found to be 0.01mg/l for all samples analyzed and it falls with the permissible value of WHO which is 2.0mg/l. The presence of Cadmium in drinking water if consumed would result acute respiratory problem and cardiovascular diseases. Over accumulation in the human body pose serious health risk.

Physical Analysis

pH

The PH of the well water samples were found in the range of 8.66-8.83 with 8.66, 8.71 and 8.83 for well 1, well 2 and well 3 respectively. The WHO limit of PH in water is 6.5-8.5. This therefore means that the well waters are not safe for drinking with respect to their PH concentration. Water with PH greater than 8.5 could indicate that the water is hard. Hard water does not pose a health risk, but can cause aesthetic problems such as formation of sales, or precipitation on piping and fixtures causing water pressure and interior diameter of piping to decrease. It also causes alkali taste to the water and can make coffee taste bitter. Also, water with PH less than 6.5 could be acidic soft and corrosive and such water could leach mental ions such as Iron, manganese, copper, lead and Zinc from the aquifer.

Conductivity

The conductivity of Abbi well waters were found to be 197.3, 225.9, and 186.5us/cm for well 1, well 2, and well 3 respectively. All the samples are in safe limit of 500-1500us/cm. Generally, since electrical current is transported by the ions in solutions, the conductivity increases as the concentration of ions increases. Since conductivity could increase as water dissolved ionic spaces, the total dissolved solids were found to be 98.6, 106.3 and 93.2mg/l which are also in safe limit compare to WHO value of 500mg/l.

Dissolved oxygen

The dissolved oxygen of the well water samples were in the range of 4.76-6.17mg/l. with wells 1, 2, 3 recording values of 4.76, 5.66 and 6.17mg/l respectively.

Mineral and Chemical Analysis

Magnesium (Mg)

Magnesium which is one of the most common element and form highly soluble salt was found to be present in Abbi well waters in the concentration of 24.33, 20.66 and 26.34mg/l for well 1, well 2 and well 3 respectively which are in safe limit recommended by WHO that is 36.45mg/l. high concentration of Magnesium is undesirable in portable water as it causes scale formation and cathartic and diuretic effect.

Calcium (Ca)

Calcium is present in all natural water as its level depends upon the type of rock through which the water passes. It is usually present in the form of Carbonates, Bicarbonates, Sulphates, Chloride and Nitrates and also essential for human diet. Calcium was found present in the Abbi well water in the concentration of 32.38, 24.74 and 28.44mg/l respectively for well 1, 2 and 3. These are in safe limit as recommended by WHO *i.e*., 100mg/l. Calcium consumption in drinking water it reduces the risk of kidney store (Kurze and Morris, 1993). Above the recommended value, it causes deposition in water system and excessive scale formation.(Amjad et al, 2010).

Nitrate (No_3)

Nitrate was found in the well waters analyzed in the range of 6.14 – 7.74mg/l. Each of the well recorded values of 6.14, 7.74 and 7.17mg/l respectively. These values are in conformity with WHO value of 45mg/l. when the level of nitrate exceed the permissible limit in water, then the primary health hazard from drinking water with Nitrate- Nitrogen may occur (A situation where blood lack the ability to carry sufficient oxygen to the individuals body cells causing the veins and skin to appear blue. (Yang et al, 1999).

Sulphate (So_4)

Sulphate concentrations in Abbi well water were found to be 13.17, 13.11 and 14.09mg/l for well 1, 2 and 3 respectively. All the samples conform to WHO value of 250mg/l and the water is therefore safe for domestic use. Sulphate in the combination of sulphur and oxygen and it is a part of naturally occurring minerals in some soil and rock formation that contain water. Though low concentrations were found in the well water, over accumulation could be detrimental to man's health.

Chloride (CL)

Chloride which is a major constituent of most waters and naturally present in low concentration in surface water and in varying amount ground water depending on the surrounding geology was found in Abbi well with concentration of 13.86, 12.11, and 12.33mg/l for well 1, 2 and 3 respectively. These values conform to WHO values of 250mg/l. It should be noted that the presence of chloride in water is generally not harmful to human beings until high concentrations are reached, although, it may be harmful to some people suffering from heart or kidney disease. Its presence in water at high concentration may cause gastrointestinal problems, irritation, diarrhea and dehydration. (WHO, 1999).

Biochemical Oxygen Demand (BOD)

The BOD value of the Abbi well 1, 2 and 3 were 7.76, 8.01 and 8.29mg/l respectively. BOD is a parameter that is used to ascertain the level of pollution of a water system. The values obtain showed some degrees of conformity with monitoring bodies which showed that the water could be said to be contaminated and not polluted.

V. CONCLUSION

The various well water samples from the three wells in Abbi were found to be contaminated with metals, at low and/or high concentration. These could be due to opening of the well that would allow deposition of aerosol from the atmosphere into it; seepage of pesticide, herbicides through erosion. These now contaminate and/or pollute the water by increasing its metal concentration and PH. Well water that are not in conformity with WHO standard are unsafe for human consumption.

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