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Assessment of Pollution Level of Groundwater in Gariki, Enugu Urban, Nigeria

Eze, H.I. (Ph.D) Ogbuene, E.B. Nwachukwu, U.L.
Centre for Environmental Management, and Control (Cemac), University of Nigeria, Enugu Campus

Abstract
An assessment of the pollution level of groundwater in Gariki residential area, Enugu Urban, Nigeria has been carried out. Six study locations were involved in the study. The water samples collected from the study locations were subjected to physico-chemical and bacteriologic analysis in the laboratory. The P^H meter, turbidmeter and conductivity meter are among the instrument utilized in the analysis of the physical parameters while the concentrations of heavy metals were detected by the use of a spectrophotometer. The approved UNEP (1996b) standard was the method employed in the bacteriological analysis of the water samples. High acidity level of 1.3 was obtained in the GM (Gariki Market) study location and this shows that it requires water treatment. The physico-chemical results fall within the WHO acceptable limit. However, water samples O.S. (Odudukoko Street), A.R (Akwuke Road) and A.B (Army Barracks) show the presence of E. coli and coliform. These study locations also require water treatment because of their bacteriological infections. Proffered measures include, legislative move for general groundwater protection, extension programme on groundwater protection, routine water sample analysis, regular evacuation of septic tanks, sitting of refuse landfills away from residential areas among others. These measures will foster good health which implies great productivity and sustainable development.
Keywords: Pollution, groundwater, physico-chemical, bacteriological.

1.0 INTRODUCTION

Anthropogenic activities are carried out purely for socio-economic growth or development. These activities in turn impact on the environment's air, land and water. The various efforts by governments and Non-Governmental Organizations (NGOs) to preserve and sustain the environment for human health and wellbeing is informed by the adverse effects of these exploitative activities. An array of environmental pollution and degradation problems currently besiege Nigeria and other developing nations. These are occasioned from socio-economic ventures such as oil exploration/exploitation, industrialization, agriculture, and infrastructural development, transportation and solid mineral extraction.

High and intensive rainfall speedens the activities of all facets of soil erosion (Ekop, 2003). This in turn causes flooding, siltation of water bodies and leaching of pollutants into both surface and groundwater sources. However, runoff water from rainfall is not the only factor of water contamination. Anthropogenic activities and underlying geology also play great role in water pollution. In this light, it becomes appropriate to investigate the pollution extent of groundwater from selected hand-dug wells in Gariki, Enugu Urban.

Water is very essential for human existence. Presently, and even more so in the future, the success of our advancements will be principally ascribed to water (Eze, 2010). Doornkamp (1982) and WHO (1984) remarked that virtually all economic, social and health sectors cannot operate without water. The importance of water informed the standards set by World Health Organization and other bodies on water quality. Egereonu and Nwachukwu (2005) and Ibe et al (2002) observed that insufficiency and poor water quality spells poor health conditions and retarded development of the people. Hence this paper intends to investigate the quality of groundwater in the various location of Gariki, the study area.

2.0 LITERATURE REVIEW

Water is supposed to be wholesome. However, man's activities pollute and degrade it. A number of standards have been put in place to serve as control to water quality meant for drinking, domestic, and industrial, recreation and irrigation uses. Pollution puts water out of these uses and this has aroused quite a number of studies on this problem.

A study on the microbiological and physico-chemical properties of drinking water was carried out by Edema and Fapedu (2001) in Abeokuta. It was found out that the water had odour and taste. On filtration to remove very fine particles and colloidal matters which might have escaped from a sedimentation tank, Agunwamba (2001) proffered the use of constructed porous material such as zone graded sand gravel. Application of dehydrated lime (dry powder) is called lime softening. Wright et al (2004) opined that the gradual deposition of calcium carbonate on the filter sand without binding it into lumps can be accepted for stabilizing water and maintaining P^H (disinfection).

About 99% of micro-organisms are gotten rid of during water filtration. The process of disinfection is still needed for destruction of pathogens. Disinfection and sterilization do not exactly carryout the same function

(Agunwamba, 2001). WHO (1989) declares water to be aesthetically wholesome, chemically tolerance and free from bacteria when the p^H is neutral (6.5 to 8.5) and has undergone final quality control check.

The water quality of 5 wells was treated in a study conducted by Inyang (2004) in Ekpri, Nsukkara and envious in Uyo, Akwa Ibom State. The wells failed in the WHO standards. However, physico-chemical parameters such as hardness, total dissolved solids, p^H need the standards. This shows that water quality is best assessed through both the physico-chemical and bacteriological tests. The latter test can show the presence of Coli form bacteria from faecal contamination through failed septic tanks. Coliforms can manifest in various shapes and sizes. Some can be facultative, aerobic, an aerobic, rod like, spores. They all have various effects on water. Acceptable water should not contain more than 3 coliforms organisms in 100mls (Ukpong, 2011).

Natural as well as man-made activities pollute groundwater. Some of these pollutants are responsible for some human ailments and may even cause death. Certain substances in water merely degrade the water through bad aesthetic, taste and odour (Sherwani, 1971).

In course of the percolation of water through the soil and rock, dissolution of substances that contaminate the water take place. The main inorganic chemicals in groundwater are the carbonates, bicarbonates, sulphates and chlorides (Pinder, 1997). Spiff (1998) recounts that heavy metals from industrial areas pollute groundwater with poisonous wastes such as hydrogen sulphate, ammonia salt, phenols, acids, cyanides, phosphates and other solids that generate dangerous gases. Prevention of pollution practices are the most effective management strategies for groundwater. Industrial generated toxic wastes, garbages from homes and markets as well ad other solid wastes should be taken to landfills or dumpsites away from residential areas. The most effective solution to groundwater contamination is prevention (Lutegens et al 1998, Ibe et al 2002 and Egereonu and Nwachukwu, 2005).

Trace metals also find their way into groundwater. They are not biodegradable in nature and their persistence can cause biological amplification in food chains. Ibok et al (1990) and Lopex et al (2002) remarked that they have adverse health effects following long term exposure. Lead which is one of the trace metals can be harmful to neuropsychological development which causes behavioral problems in children. Trace metals such as Copper (Cu), Chromium (Cr), Manganese (Mn)) and Zinc (Zn) have high toxicity level when exposed while Cadmium can affect renal function (Cabejra et al, 1996). Dara 2004 reported on the adverse health effects of trace metals especially Cadmium which causes a disease of Japan called Hai-Hai. This result when people eat rice contaminated with this pollutant. Egan et al (2002) carried out similar studies of the effects of trace metal pollution of groundwater in the United States of America.

The addressed studies in the literature review give insight into works on groundwater pollution causes, incidences, extent as well as measures to alleviate this problem on groundwater resources which is an essential requirement for sustenance of both human and other life forms. The review also throws open vacuums in this area of study and strategies to combat the problem. It then necessitated the investigation of the pollution land of the groundwater so as to know the anthropogenic and human factors of groundwater pollution of the study area. To this end, the physico-chemical and bacteriological tests of the water sample becomes necessary.

3.0 MATERIALS AND METHOD

The study method entails the testing of the physico-chemical and biological (bacteriological) properties of the groundwater. To carryout these tests, water samples were collected from hand-dug wells in Ebony Paint Road, Odudukoko Street, Gariki Market, Akwuke Road, Livestock Market and the Army Barracks. This brings it to a total of six water samples from five hand-dug-wells collected from Gariki residential area in Enugu Urban which is the study area. Half imperial size plastic gallons were used for the water sample collection. The gallons were first properly washed and rinsed with distilled water. Just before the water collection, at the sampling locations, the gallons were rinsed again with the well water. After filling the gallons with the water samples, they were immediately corked to prevent the entry of any other pollutant. Sterilized and disinfected containers were used in collecting water samples for bacteriological tests. They were immediately put in a refrigerator for preservation at ambient condition.

Laboratory Analysis for Physico-Chemical Properties of the Water Samples:

The pH levels of the samples were reassured with the pH meter. This instrument is calibrated for ranges of acidity and alkalinity to be read off. A turbidimeter was utilized in the assessment of the water sample's turbidity. Readings were taken when this equipment had attained steady state. The values for the water sample's conductivity were obtained from measurements made with the conductivity meter. The measurements of the temperature of the samples were carried out with a thermometer and at collection point. To obtain the value of dissolved oxygen in the samples, the dissolved oxygen meter was used. The conductivity meter was employed in the measurement of both the suspended and total dissolved solid. The values were read off from the instrument on attaining of steady state. The detection measurement of the concentration of heavy metals were done with the aid of a spectrophotometer. The heavy metals include Copper (Cu), Chromium (Cr), Cyanide (Cy), Lead (Pb), Zinc (Zn), Barrium (Ba) and Mecury (Hg).

Laboratory Analysis for Bacteriological status of the Water Samples:
The UNEP (1996b) approved standard was the employed laboratory bacteriological analysis method. This method is called the Pour Plate Technique. The incubator, conical flask, autoclave, pipette, spint lamp, test tubes and swab were the appatus and materials involved in the analysis. The reagents utilized are the mackonkey agar and ethanol. The bacteriological tests conducted are the E. coli and Coliform tests. The dilution factor was 101. Table 1 shows the study locations where the water samples were collected for the laboratory analysis.

Table 1: Water sampling location in the study area

SAMPLING LOCATIONS	GROUNDWATER TYPE	LABELING SYMBOLS
Gariki Market	Hand Dug Well	GM
Odudukoko Street	Hand Dug Well	OS
Ebony Paint Road	Hand Dug Well	ER
Akwuke Road	Hand Dug Well	AR
Livestock Market	Hand Dug Well	LM
Army Barracks	Hand Dug Well	AB

(Source: Authors' Fieldwork, 2013)

4.0 RESULTS AND DISCUSSION OF FINDINGS

As has been earlier stated, water is very essential for human sustenance. Hence the hand dug wells in the study area or sampling locations are sources of water supply for people in the entire study area, which is Gariki, Enugu Urban. Table 1 shows the study locations and their labeling symbols. There are minor variations in the results of the physico-chemical properties of the water samples from the various study locations. With an acidity value of 1.3 in study location GM which is Gariki Market, the well water requires treatment. Water samples from wells of study locations: AR (Akwuke Road), LM (Livestock Market), ER (Ebony Paint Road) and OS (Odudukoko Street) do not fall within the acidity standards of WHO (Table 2).s Chemical treatment is required to bring the acidity values to the normal range.

The values of temperature of the water samples does not show any marked difference. However, they all fall within the acceptable WHO range.Laboratory analysis results of the turbidity level showed that most of them are within the WHO permissible range. Study location GM has the highest value which is 9.8 NTU. This is over and above the acceptable range and as such need water treatment. The conductivity tests show marked low values. Sample GM has the highest value followed by OS, LM, AB, AR and ER. The salinity results show very low values. These indicate that there are virtually no salt in the water samples.

The levels of suspended solids are generally low in all the water samples. With the value of 9.77mg/l in the water sample from study location GM, it tops the others in level of suspended solids. There is an alarming low level of dissolved oxygen in the study locations. This is an indication of passive bacterial life in the water samples. The Total Dissolved Solids results from the laboratory analysis fall within the acceptable WHO standard of 500mg/l. Nitrate amount in the water samples are safe and tolerable as they do not come any close to the 50mg/l standard limit. The 3.5mg/l limit of phosphate was met in all the water samples, making them phosphate safe. Copper concentration in the water samples were seen to be tolerant. The WHO limit for iron was met by the entire water samples.

Table 2: Laboratory Results of Physico-Chemical Properties of Water Samples from the Study Locations.

S/NO	TESTS	LABORATORY RESULTS						WHO STANDARDS
		GM	OS	ER	AR	LM	AB	
1.	Electrical conductivity	48.8	19.4	9.3	9.5	17.8	15.3	1000
2.	Temperature	29.3	29.2	29.07	29.09	29.07	29.12	Ambient
3.	Total Dissolved Solid mg/L	22.0	8.3	3.8	4.1	4.9	7.0	500
4.	Turbidity (NTU)	9.8	1.51	1.0	1.22	1.23	1.3	5
5.	Suspended Solid mg/L	9.77	2.02	4.89	5.8	2.92	3.5	<10
6.	Dissolved Oxygen (CO_2)mg/L	0.29	0.39	0.28	0.38	0.48	0.35	
7.	Total Alkalinity	0.78	6.0	5.1	7.0	6.9	5.6	100-200
8.	Acidity	1.3	4.3	4.0	4.3	3.2	4.3	4.5-8.2
9.	Total Hardness mg/L	42	29.0	55	46	37	44	500
10.	Salinity	0.01	0	0.01	0	0	0	0.5
11.	Cadmium (Cd)mg/L	1.97	1.98	1.99	1.	0.98	1.97	0.03
12.	Lead (Pb)mg/L	9.8	4.9	5.9	5.8	6.8	5.4	0.01
13.	Chromium (Cr^{6+})mg/L	0.01	0	0	0.01	0.01	0	0.05
14.	Mecury (Hg)mg/L	0.29	0.19	0.19	0.19	0.19	0.19	0.001
15.	Iron (Fe^{3+})mg/L	0.07	0.01	0.04	0.05	0	0.03	0.3
16.	Zinc (Zn)mg/L	0.02	0	0	0.01	0.01	0	3
17.	Copper (Cu)mg/L	0.03	0.04	0.9	0.9	0.9	0.9	0.9
18.	Fluoride (f)mg/L	UR-0.9	UR-0.04	UR-0.05	UR-0.02	UR-0.06	UR-0.05	1.5
19.	Cyabide (Cn) mg/L	0.001	0.01	0.001	0.001	0.001	0.005	0.01
20.	Barium (Ba)mg/L	1.98	0.01	1.97	2.97	4.95	1.01	
21.	Chloride (Cl)mg/L	0.47	0	0.19	0.19	0.19	0.1	250
22.	Selenium (Se)mg/L	0.01	0	0.01	0.01	0	0	0.05
23.	Aluminum (Al^{3+})mg/L	0.01	0.01	0.01	0.01	0.01	0.01	
24.	Manganese mg/L	0.58	0.09	0.18	0.01	0.19	0.15	<0.1
25.	Nitrate (NO_3)mg/L	1.79	0.58	0.58	0.02	0.09	0.59	50
26.	Phosphate (PO_4^{3-})mg/L	0.002	0.13	0.29	0.034	0.88	0.22	3.5

(Source: Authors' Lab Work, 2013)

Table 3: Laboratory Results of Bacteriological Status of the Water Samples.

TESTS	LABORATORY RESULTS						WHO STANDARDS
	GM	OS	ER	AR	LM	AB	
E. coli per 100ml	0	$9.9 \times 10^1 = 99$	0	$19.7 \times 10^1 = 197$	0	0	
Total Coliform per 100ml	0	$108 \times 10^1 = 108$	0	$20.8 \times 10^1 = 208$	$0.9 \times 0^1 = 9$	0	

(Source: Authors' Lab Work, 2013)

Water samples from study locations GM, ER and AB show that they do have E. coli and Total coliform. They are deemed potable. Water samples from study location LM is potable since it has no E. coli and 9 per 100ml for total coliform. The value of 197 per 100ml was recorded for E. coli and 208 per 100ml for total coliform for water sample AR indicate immense bacteriological infected water. Water sample from study location OS has 99 per 200ml for E. coli and 108 per 100ml for total coliform. This also indicates serious bacteriological or feacal infected water. They are deemed not potable because they are not within the WHO permissible standard.

5.0 RECOMMENDATIONS AND CONCLUSION

The laboratory analysis of the water samples for all the study locations show that they do not have serious physico-chemical pollution except for Gariki Market (GM) study location. The recommendations to be proffered take cognizance of these laboratory analyses and how these recommended measures should adhered in specific locations that have high pollution levels. Anthropogenic activities in the Garki Market is found to be the major cause of the high physico-chemical pollution level in that location.

As a mater of policy, there is need for the local people to move for groundwater protection as a bill in the legislative house. There should be extension education programme to enhance awareness on ground water protection from pollution. Routine analysis of water sample from the hand-dug wells will help in knowing the water status and as such, help in knowing its portability.

Hazardous substance or wastes generated from homes and establishments should not be disposed of in septic tanks because they leach through cracks into groundwater. There should be that general awareness of water treatment so as to nip all problems of drinking polluted water in the bud.

Evacuation of septic tanks every four years will greatly reduce the chances of groundwater pollution by coliform or E. coli. Where the hand-dug well is in the front of the house, the septic tank should be site at the far rear of the house. This is to maintain safe distance to prevent intrusion of sewage from the septic tank. The use of septic tank cleaners should be discouraged. It is better that they are regularly evacuated. Landfills for refuse disposal should be sited far away from wells or residential areas.

Conclusion

Since anthropogenic activities has been found to be the major pollutant of the groundwater in the study area, stringent application of the proffered recommended measures will help to stem this pollution problems. Policy initiatives and awareness programmes help in no small ways in solving water pollution problems that emanate from anthropogenic activities. This should be vigorously pursued because the drinking of safe water means good health. A healthy society implies great productivity and sustainable development.

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