Journal of Environment and Earth Science www.iiste.org
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol. 3, No.12, 2013

A Comparative Assessment of the Quality of Harvested Rainwater, Underground Water and Surface Water for Domestic Purposes in Ughelli, Southern Nigeria

Ushurhe Ochuko[1] Origho Thaddeus[2]
1. Delta State Institute of Continuing Education,Ughelli, Delta State, Nigeria
E-mail: ochuksbeloved201@yahoo.com
2. Department of Geography, College of Education,Warri, Delta State, Nigeria.

Abstract
The study compares the quality of harvested rainwater, underground water and surface water for domestic purposes in Ughelli, Southern Nigeria. It is an empirical research study of three sources of water supply in the area. Water samples were collected from harvested rainwater, hand dug wells and from the river and laboratory analysis carried out in line with WHO (2010) threshold for drinking water quality. From the analysis of the water samples, it was discovered that variation exists in the physico-chemical parameters examined in the three sources of water supply in the area. However, parameters such as pH, temperature, TDS, sulphate and zinc are within the WHO (2010) permissible standard. Domestic water sources, such as hand dug wells, rainwater and rivers should be protected and monitored to check impairments in order to safeguard human health.
Keywords: assessment, quality, well water, river water, rain water, harvested.

Introduction

Rain water is the water which is gotten from rainfall. It occurs as a result of condensation of water molecules in the upper atmosphere. When this reaches saturation points, it falls back to the earth's surface as rain water. It is collected from different catchment roofs by man (Origho, 2009). For long term use, rain water can be piped into clean, closed underground tanks for human use. However, rainwater can be contaminated by dirty roofs, dirty containers, and tanks.

Today, increase in population, urbanization and inefficient pipe-borne water supply has made rainwater harvesting a veritable source of water supply (Schiller, 1982). In many developing countries of Africa, where housing standard has improved and impermeable roofs are constructed, rainwater harvesting systems are becoming increasingly used. Rainwater has been successfully harnessed for domestic water requirement in Kenya and Tanzania (Schiller, 1982) and in Sierra Leone (Nissen-Peterson, 1982 and Jayakaran, 1988). In Zimbabwe, between 80 and 85 percent of all measurable rainfall is collected and stored for use (Morgan, 1990).

In Nigeria, the concept of rainwater harvesting or its use during the rainy season is not new particularly as a supplement to water from rivers and streams (Morgan, 1990). Some people in the rural areas and urban centres of Nigeria depend on rainwater. Rainwater according to Efe (2006), is one of the purest sources of water supply if properly collected. But the desire for technological breakthrough and improved standard of living has placed pressure on its use.

While underground water is the water supply which is tapped when we sink a well or a borehole. As rainwater infiltrates into the ground and travels underground, it is filtered by the soil. Underground water is usually clean, plentiful and permanent. Underground water is a popular source of water supply for urban and rural dwellers in Nigeria.

Groundwater supplies drinking water for household uses and feeds most of our lakes, rivers and streams (Korth, 1997). According to Krantz and Kifferstein (2005), about ninety-five percent of all freshwater on earth is groundwater. It is found in natural rock formations and is a vital source for the success and survival of the entire ecosystem. Groundwater is particularly at greatest health related risk especially because it is largely unmonitored and the visual perception of its quality on extraction is usually deceptive (Agbede, Kupulati and Akpokodje, 2003). Thus, measuring the physical and or chemical properties of underground water to determine its contaminant concentrations are frequently monitored to determine if they are increasing, decreasing or remaining at the same range. Monitoring is also performed at and in the vicinity of water supply sources to determine the quality of the water and trends of indicator of water quality.

However, precipitation that falls on the earth's surface either infiltrates into the ground or runs over the surface of the earth into streams, lakes and rivers as surface water (Rozanski, Froelich and Mook, 2000). Surface water is the commonest source of water supply for most people in the developing countries of the world, especially Africa and Nigeria in particular. Surface water is easily accessible to many people and is permanent throughout the year, especially rivers. Rivers are unfortunately the most easily and frequently polluted source of water supply. They are polluted by human activities through industrial waste and agricultural activities such as fertilizer application (Zucker and Brown. 1998).

In his quest for existence, man has continued to tap these water sources (rainwater, underground water and surface water) for domestic and other uses without prior consideration as to its quality as a result of scarcity and technological knowhow. This has resulted in untold hardship culminating in child and infant mortality and morbility in many parts of the word, especially in developing countries and Nigeria in particular. There is the need to assess the physico-chemical and biological indices of these water sources in order to safeguard human health and the ecosystem, hence this study.

Prevailing Trend

Drinking contaminated water can cause various diseases such as typhoid, dysentery and diarrhea (DFID, 2006, Ushurhe and Origho, 2009a). Accordingly, 2.2 million people die each year from diseases related to drinking contaminated water (DFID, 2006). Diarrhea alone claims the lives of nearly 6,000 children a day in developing countries of Africa. According to the World Health Organization (WHO, 1998), drinking water is not available to 75 – 80 percent of the citizens living in rural areas of many developing countries like Nigeria. It is also observed that one out of every four persons in the world especially in developing countries suffer from some type of water borne disease or the other. These observations readily highlight the magnitude of the world water problem.

The life of man depends very much on good supply of water and so, we cannot take potable water for granted. Hence the need for increased water quality for sustainable development has continued to be of great concern to researchers. In Ughelli, the people depend on water supply from hand dug wells(Ushurhe, 2007), boreholes, rainwater (Origho, 2009; Ushurhe and Origho, 2009b) and river as sources of water supply. This water is consumed by the inhabitants of the area without further purification. In an epidemiological report (2006), obtained from the Central Hospital Ughelli as reported by Ushurhe (2007) shows that polluted water is responsible for cases of typhoid, diarrhea and dysentery in the area. This paper therefore sets to assess and compare the quality of harvested rainwater, underground water and surface water in order to ascertain their potability in the light of WHO (2010) drinking water standard to address issues of water borne diseases in the area.

Aim, Objectives and Hypothesis

The study is aimed at a comparative assessment of the quality of harvested rainwater, underground water and surface water for domestic purposes in Ughelli, Southern Nigeria. The specific objectives are:

i. assess the quality of harvested rainwater, underground water and surface water in the area.
ii. compare the quality of harvested rainwater, underground water and surface water in the area.
iii. ascertain the level of variation between the quality of rainwater harvested , underground water and surface water in the area.
iv. suggest ways on how to improve the quality of rainwater harvested , underground water and surface water and hence achieve sustainable water quality supply for domestic purposes in the area

Hypothesis

Given the aim and objectives of this study, the following hypothesis is spelt out:

Ho: There is no significant difference in the quality of harvested rainwater, underground water and surface water in Ughelli, Southern Nigeria.

Research Methods and Procedures

Study Area

Ughelli is located within latitudes $5^0 28'$ North and $5^0 32'$ North of the Equator and longitudes $5^0 58'$ East and $6^0 03'$ East of the Greenwich Mendian. In terms of drainage, the area is drained by River Ase, a tributary of the River Niger (Udo, 1978). The climate of the area is characterized by high, but uniform temperature. The mean daily maximum temperature is about 32^0C. Rainfall intensity ranges between 3000mm to 3500mm (Ajayi, 2003). Within this period, the water table is usually very high in the valley region. The high annual rainfall, high water table and low relief are responsible for poor soil formation in the area.

Research Design and Data Collection Procedure

The study is an empirical research work that adopted field survey, collection of water samples from rainwater, shallow wells and from the river, and laboratory analysis of the water samples collected. The simple random sampling technique was used for choosing the sites for sample collection, while the systematic random sampling technique was used for the collection of water samples along the course of the river, catchment roofs and from shallow wells. The zinc catchment roof popularly used as roofing sheet in the area was chosen for water sample collection. The rainwater samples were collected at the time of rainfall from the month of the gutter (Origho, 2009), while water samples were collected from shallow wells situated at a distance of 30 metres of shallow wells to any polluting source in the area (Ushurhe, 2007) in line with WHO (1998) standard. The samples were collected between the hours of 7am – 10am. In the case of river water, the samples were collected from the surface and sub-surface of the river using 10 – 15 kilometres interval between sampling sites (Ushurhe, 2011). The water samples were collected between the hours of 7am -10am. All samples were collected using sterilized 2-litre plastic cans fitted with information tag for identification. The water samples were collected from four different sites each for harvested rainwater, underground water and surface water. A total of forty-eight (48) water samples were collected. The water samples were collected once in the months of March, April, May and June in 2007, 2009 and 2011 for shallow well water, harvested rainwater and river water respectively. The collected water samples were taken .to the laboratory within 6 hours of their collection for analysis. All samples were allowed to settle down for about 4 hours before any form of laboratory analysis. This was done to eliminate any form of turbidity influence on tests.

Water quality parameters such as pH, temperature, turbidity, DO, BOD, TDS, TSS, sulphate, nitrate, lead, iron and zinc were analysed using Atomic Absorption Spectrophotometer, Digital meters, in addition to titration methods. The results obtained were compared with WHO (2010) threshold. The analysis of variance (ANOVA) was used to test the posited hypothesis.

Results and Discussion

The mean concentration values of the analyzed physico-chemical parameters of rainwater harvested, well water and river water are summarized in table I.

Table 1: Mean values of physico-chemical characteristics of water from hand dug wells, rainwater catchment roofs and river water.

Parameter	*Well water	**Rain water	***River water	WHO Standard (2010)	Remarks
pH	6.96	5.90	6.97	6.5-8.5	Safe
Temperature ^{o}C	26.70	29.69	27.85	29.80	Safe
Turbidity (NTU)	1.02	0.05	8.15	5.00	Safe/Not safe
DO (mg/l)	2.93	7.44	5.49	5.00	Not safe/Safe
BOD (mg/l)	1.76	1.07	3.10	3.00	Safe/Not safe
TDS (mg/l)	23.60	0.02	35.40	5.00	Safe
TSS (mg/l)	0.49	0.03	6.75	5.00	Safe/Not safe
Sulphate (mg/l)	3.59	16.30	1.72	2.00	Safe
Lead (mg/l)	0.025	0.018	0.001	0.01	Not safe/Safe
Iron (mg/l)	0.04	0.59	0.62	0.30	Safe
Zinc (mg/l)	0.29	0.49	0.96	3.00	Safe

Sources: *Ushurhe, 2007; * * Origho, 2009; ***Ushurhe, 2011.

From the analysed samples as shown in table 1, pH mean values were generally low (5.90-6.97) and fell within the WHO (2010) threshold for drinking water quality. Temperature mean values range from 26.70^{o}C for well water, 29.69^{0}C for rain water and 27.85^{0}C for river water. These mean temperature values are within the WHO (2010) threshold for drinking water quality. Mean turbidity values of 1.02 NTV were recorded for well water, 0.05 NTU for harvested rainwater and 8.15 NTU for river water. The recorded values for well water and harvested rainwater were within the WHO (2010) threshold; while that of the river water was above the WHO (2010) acceptable threshold for drinking water quality. All the DO values were above the WHO (2010) threshold except for well water; thereby making the well water unsafe. The high values of DO in the rainwater (7.44mg/l) shows the absence of bacteria and activities; while the low values (2.93mg/l) recorded in water samples from well water shows the presence of bacteria and activities, including water from the river (5.49mg/l). This implies that there is a strong indication of a reducing agent in the water. If such water is consumed without further purification, it may cause instant death in living organisms. BOD mean levels were generally low in well water (1.76mg/l), harvested rainwater (1.07mg/l) and slightly high in river water (3.10mg/l). This implies that the concentration of soluble organics reaching the groundwater and rainwater is generally low but slightly high in surface water.

In total dissolved solids (TDS), all the recorded mean values were generally low and below the WHO (2010) threshold for drinking water quality. A mean value of 23.60 mg/l, 0.2 mg/l and 35.40 mg/l were recorded for well water, rainwater, and river water respectively. In the sampled water, means values of 0.49 mg/l, 0.03 mg/l and 6.75 mg/l were recorded for well water, rainwater, and river water respectively. These values are within the WHO (2010) threshold for drinking water quality except the river water. This implies the presence of silt, clay, plankton, organic waste and inorganic precipitates in the surface water.

Sulphate concentrations in the three sources of water were generally low. A mean value of 3.59mg/l recorded for well water, 16.30 mg/l for rain water and 1.72 mg/l for river water. Although, harvested rainwater has the highest concentration, these values are lower than the 200 mg/l WHO (2010) permissible standard for drinking water quality. Lead, with a mean value of 0.025 mg/l for well water, 0.018mg/l for harvested rainwater and 0.001mg/l for river water are above and within the WHO (2010) threshold for drinking water standard respectively. The implication of this is that lead poisoning is present in all the analysed sources of water supply except river water. Iron mean concentration varies from 0.04 mg/l for well water, 0.59 mg/l for rainwater and 0.62mg/l for river water. These values are above the 0.30mg/l WHO (2010) permissible standard for drinking water quality except for well water with a recorded value of 0.04. Zinc concentration in the analysed water samples for well water was 0.29mg/l and 0.49mg/l for harvested rainwater, while river water recorded a mean value of 0.96mgle. These values are within the 3.00mg/l acceptable WHO (2010) drinking water quality standard.

Test of Hypothesis:

The analysis of variance (ANOVA) was used to test the posited hypothesis, "that there is no significant difference in the quality of harvested rainwater, underground water and surface water in Ughelli, Southern Nigeria".

Table 2: Summary of ANOVA result explaining the level of variation in the quality of water from well, rain and river in the area.

Model	Sum of Squares	Differences	Mean Square	F	Critical	Remarks
Regression	13503.564	3	4501.188	876.778	2.60	Significant Difference
Residual	636.589	124	5.134			Exists
Total	14140.152	127				

From the model summary in table 2, the calculated F-value of 876.778 at 0.05 level of significance is greater than the critical value of 2.60. Since the critical value is less than the calculated F-value the null hypothesis is rejected. Thus, there is significant difference in the quality of water obtained from the shallow wells, rainwater and from the river in the area. The implication of this is that variation exists in the quality of water from the three sources of water supply in the area.

Findings

Based on the aim and objectives of the study and the hypothesis posited, the following findings emerged:

i. Most of the parameters examined such as pH, temperature, TDS, sulphate and zinc showed satisfactory concentration in line with WHO (2010) standard in the three sources of water supply in the area.
ii. The concentration of turbidity, BOD, TSS, and iron were higher in the surface water (river) and hence showed unsatisfactory concentration when compared to well water and harvested rain water that showed satisfactory concentration in those parameters.
iii. The concentration of DO was lowest in well water and hence unsafe, when compared to the concentration found in rainwater and river water.
iv. Lead concentration was lowest in the surface water (river) but lower and low in rainwater and well water respectively in the area.
v. The study also confirmed that the quality of water varies in the three sources of water consumed by the people in the area.

Conclusion

The three sources of water obtained by the people for domestic purposes in the area showed satisfactory concentration in terms of the parameters examined. However, variation exists in some of the parameters, as some of them showed higher concentration when compared to WHO (2010) threshold for drinking water quality. Hence, the water from the three sources (well, rain and river) be purified before drinking in order to safeguard the health of the people.

Recommendations

The following are recommendations for improving on the present state of the water from hand dug wells, rainwater and river water in the area.

i All the sources of water supply in the area should be purified before drinking.

ii Human activities within the vicinities of the sources of water supply should be monitored to check factors responsible for impairment of the water.

iii Domestic groundwater sources such as hard dug wells should be protected from surface run-off, while harvesting of rainwater should be done at least 10-15 minutes of rainfall to minimize impurities from the catchment roofs. While surface water such as rivers should be protected from surface and human discharge of sewage from getting into the river.

References

Agbede, O.A, Kupulati, W.K. and Akpokodje, O.I. (2003) "Failure of on-site sanitary facilities in Nigeria Urban Centres, Ibadan as case Study," Paper presented at the 18th International Conference on Solid Waste Technology and Management, Philadephia, USA, March 23 – 26.

Ajayi, O.(2003) Comprehensive Geography, Lagos, Johnson publishers.

Department for International Development (2006) G8 Gleneagles: One year of Tyrning Talk into Action, United Kingdom, Lime Hous.

Efe, S.I (2006)" Quality of rainwater harvesting for rural communities of Delta State, Nigeria", Environmentalist, 26:175 – 181

Jakarayan, S.C. (1988) "Rural Water Supplu: Sierra Leone Example - A case of Developing World Water," Water Engineering and Development Centre Publication, 10 -1.

Korth R. (1997) Life on the Edge, University of Wisconsin Extension, College of Natural Resources, UW – Stevens Points.

Krantz, D. and Kifferstein, B. (2005) "Water Pollution and Society", Journal of Environmental Law Practice, 4 (1). 1 -2

Morgan, P (1990) Rainwater Harvesting in Rural Water Supply and Sanitation, London, Macmillan Publication

Nissen-Peterson, E (1982) Rain Catchment and Water Supply in Rural Africa, Freetown, Holder Stoughton publisher.

Origho, T. (2009) " Assessment of the quality of rainwater harvesting in Ughelli and its rural areas, Delta State, Niger ", Unpublished M.Sc Dissertation, Delta State University, Abraka, Nigeria.

Rozanski, K, Froehlich, K and Mook, W.G (2000) "Surface Water", in Mook (ed) Hydrological Cycle, Krakow, University Press

Schiller, E.J. (1982) "Rooftop Catchment Rainwater for Drinking" Schiller, E.J and Drosten, R.L. (eds) Water Supply and Sanitation in Developing Countries, Michigan, Arbor Publication.

Udo, R.K. (1978) Geographical Regions of Nigeria, Ibadan, Heinemann.

Ushurhe, O and Origho, T (2009a) " The prevalence of water borne diseases as a result of the impact of septic tank effluent on the quality of water from hand dug wells in Ughelli, Delta State, Nigeria," Nigeria Journal of Research and Production 14 (2): 121 – 138.

Ushurhe, O and Origho, T (2009b) "Assessment of the quality of rainwater collected from different catchment roofs in Ughelli, Delta State, Nigeria," Intellectualism, 2(2): 200 – 209.

Ushurhe, O (20007) " The impact of septic tank effluent on the quality of water from hand dug wells in Ughelli, Delta State," Unpublished M. Sc. Dissertation, Delta State University, Abraka, Nigeria.

Ushurhe, O. (2011) "Comparative Assessment of the Quality of Water from River Ase, Warri and Ethiope in Delta State for Domestic and Agricultural uses," A PhD. Seminar Paper, Delta State University. Abraka, Nigeria.

WHO (2010) International Standard for Drinking Water guidelines for Water Quality, Geneva.

WHO (1998) Importance of Safe Drinking Water Supply, Geneva, 3, 5 – 10.

Zucker, L. A. and Brown, L.C (1998) "Agricultural drainage water quality impacts and subsurface drainage studies in the Mid-West Ohio State University Extension," Bulletin 871, http://ohio-line. osu.edu/b871/. Retrieved on 21 – 4 – 2010 .