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Conditions of available sources of water for domestic use in selected communities in Ado-Ekiti, Ekiti State, Nigeria

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The challenges of high quality water for domestic use and particularly for potability must be overcome in its entire ramification for health and ecological environment. The aim of this study is to identify the conditions of domestic water sources in Ado-Ekiti. One water sample was drawn from the two different sources of water, that is, shallow well and Ureje River at Ureje, and two samples from one water source, that is, borehole at Ilupeju and ABUAD in Ado-Ekiti. Water samples were analyzed in the Laboratory. Parameters including turbidity, pH, jar, hardness, calcium hardness and alkalinity were determined. Results revealed that the water samples drawn from borehole were of good quality following WHO reference guidelines, whereas, for water from well in Ureje and from river in Ureje, the concentration of these parameters exceeded WHO reference guidelines. It can be concluded that water obtained from Ureje River and that from well in Ureje are unsuitable for drinking (based respectively on colour, turbidity, odour, jar and hardness as well as pH, jar, turbidity, colour, and odour). However, pH, calcium and alkalinity are good following WHO reference guidelines. Further, well in Ureje contained water which is suitable for drinking and domestic uses. Samples drawn from borehole were the most suitable following WHO reference guidelines. However, further improvement is required. Detailed studies revealing the underlying reason for drop in quality of deep groundwater in the study area are required.

Key words: Ecological, potability, groundwater, borehole, parameters, wells.

INTRODUCTION

Water is an essential constituent for human life. Access to safe water supply has great influence on the health, economic productivity and good quality of life. Water of the earth is enormous but only about 0.62% of it is naturally good for drinking, occurring in surface sources (rivers, lakes etc.), ground water (shallow and deep), soil moisture and vapour in atmosphere (Gaur, 2008). Access to this available quantity of good water is a major challenge for humans today, with many countries of the world plagued by it, Nigeria not exempted. Nigeria is the most populated nation in Africa with an estimated population of over 190 million. Annual increase is

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estimated to be 2.61% (Worldometers, 2017). Estimates have shown that about 54% do not have access to safe drinking water (FMWR, 2013). This implies that more than 90 million people are exposed to non-potable water sources. The three levels of government (state, local, and federal government) are responsible for the provision of municipal and domestic water supply. Despite the effort of the government, good water is only available to very small fraction of the population. This made the rest of the people to seek alternative water source, where the most available are waters in streams, wells, and boreholes. In locations where the stream is easily accessible because of its surface flow, the waters in wells and boreholes are accessed by boring a hole in the ground. These sources of water receive some levels of contamination and are therefore rendered most times, unfit for domestic usage and for drinking. Lack of access to good water will no doubt impinge on the population and on the economy. Study conducted by the United Nation's Children Fund (UNICEF)/WHO Joint Monitoring Program for Water Supply and Sanitation analysis on Nigeria proved the inadequacy of safe water to the entire population and it was linked to the prevalence of water related diseases such as guinea worm, cholera, diarrhea, dysentery, etc. Premium Times Nigeria of October 6, 2017 report by the federal government showed that over 59,000 Nigeria children under the age of five die annually from preventable water and sanitation related diseases. Water and sanitation in Ekiti State suffer continuous neglect by past and present administration which has led to many indigenes suffering serious health challenges. It is therefore important that adequate check be carried out on the various available sources of water in various communities in the State to know the level of contamination in them and have awareness of the level of treatment required for safe consumption.

Research purpose

The practice of open defecation alongside improper waste handling and disposal suggests the possibility of drop in quality of water available to the people of Ado-Ekiti. The three main water sources (stream, well, and borehole) available in this area have the potential of receiving direct influence of the washing of wastes and contents to the surface water and infiltration into the groundwater. The people of the communities are left with no choice than to find a way of dealing with the contamination in their water and its consequence, hence, they suffer one health issue or the other. This project deals therefore wholly on providing information on the quality level of the water that these people use, which will guide their understanding of the needed treatment for safe and healthy consumption. It is clear that an awareness of a problem informs possible solutions. This research is therefore aimed to examine the purity conditions of the various water sources and determine the most viable water treatment for people in Ado-Ekiti, Ekiti State, Nigeria. The objectives of the study therefore are to provide advice on the best sources of safe drinking water in the community, to determine the physio-chemical composition of domestic water at selected locations, to describe the functions of each treatment process in treating drinking-water, to highlight the environmental and health implications of unsafe drinking water, and to determine safe drinking water treatment/purification management strategies.

Some of the issues driving the interest in decentralized systems, apart from declining local water sources, are financial efficiency, installation timeframe of infra-structures, water security, water loss derived from long distance transport, environmental degradation of aquatic habitats and local community empowerment (Domenech, 2011; Makropoulos and Butler, 2010; Wilderer, 2004).

Most studies have shown that the operational phase of the life cycle has the largest environmental impact, and that electricity consumption for pumping and treatment is a significant contributor to the system's impacts. Assessments of decentralized and/or source separation systems are less common, but have become more frequent in recent years (Gardels, 2011; Glick and Guggemos, 2013; Lam et al., 2015; Lehtoranta et al., 2014; Lemos et al., 2013; Matos et al., 2014; Shehabi et al., 2012; Thibodeau et al., 2014).

Research limitation

This research is specifically limited to the water samples collected from water sources in the study area; Ureje River water, Ureje well water, Ilupeju borehole water and ABUAD borehole water within Ado-Ekiti; their constraints and prospects. It comprises the most common and important water tests which are used to examine water for safe domestic consumption. These fundamental drinking water tests include: turbidity, hardness, colour, jar, odour, pH and alkalinity.

Historical background

The United Nations (UN) set a goal in their Millennium Declaration to reduce the amount of people without safe drinking water by half in the year 2015 (UN, 2000). For water to be safe for human consumption, it should meet the standard guidelines for taste, odour, colour, and chemical concentrations, and must be available in adequate quantities for domestic purposes.

Water sources

The extent of treatment carried out on water depends on the quality of the source of supply and the desired quality in the finished product. The sources of water majorly available in the area of this investigation can be classified into two general categories namely: Groundwater sources (accessible through wells and boreholes) and surface water sources such as rivers, lakes, and impoundments on rivers and streams.

The availability of adequate water supply both in quality and quantity is essential for human existence. With the exponential increase in population, access to improved water remains an important pre-condition for sustaining human life, maintaining eco systems and for achieving sustainable development (Oyebode and Oyegoke, 2015).

Groundwater

The water that fall from rain several decades, hundreds, thousands or in some cases millions of years ago move through layers of soils before getting into the saturated regions in the subsoil. These waters are naturally filtered by soil and rock layers to a high degree of clarity before they get to the saturated zone where they are stored as groundwater. Groundwater emerge as any of springs, artesian springs, or may be extracted or explored through boreholes or wells. Deep ground water is generally of very high acceptable bacteriological quality (that is, pathogenic bacteria or pathogenic protozoa are typically absent), but the water may be rich in dissolved solids, especially of carbonates and sulfates of calcium and magnesium. Improper subsoil repository practice may lead to discharge or ingress of contaminants into the groundwater thereby impairing its quality.

Surface water

Any water that exists on the surface of the ground is called surface water. It is the water that did not seep into the ground where it flows or exists. It exists and/or flows over impermeable ground surfaces normally existing in lower surfaces from the natural human habitable ground level. Surface water exists as stored water in reservoir, ponds, springs, and lakes, as or flowing water in rivers, streams, wetlands, seas and oceans. Other forms of surface water include canals and lowland reservoirs. Surface water is normally recharged by precipitation, runoff from adjoining surfaces, and near-surface subsoil water that could no longer permeate the ground due to meeting impermeable rock. They are usually are more subjected to contamination making the presence of some bacteria, protozoa or algae to be in high level. Surface washing from the ground, and unhealthy practice of release or discharge of waste into the surface water contaminate it.

The impact of water use on our ecosystems should be an intricate issue of special concern in every area of the world as water is the one resource we cannot live without. Also, the financial implication of water loss can be minimized if the management method is improved for maximum effectiveness and optimal benefit (Oyebode, 2014).

Water tests

Turbidity

Turbidity refers to the cloudiness of water sample which is mostly caused by the presence of suspended solids. It is a measure of how ray of light shone on the water is scattered or absorbed. More turbid water sample will scatter and absorb more light than less turbid water sample. According to Spellman (2003), high turbidity causes problems for waterworks operator; components that cause high turbidity can cause taste and odour problems and will reduce the effectiveness of disinfection. Turbidity is undesirable for aesthetic considerations as solids may contain heavy metals, pathogens or other contaminants, and turbidity decreases the effectiveness of water treatment techniques by shielding pathogens from chemical or thermal damage, or in the case of UV (ultra violet) treatment, absorbing the UV light itself (Cheremisinoff, 2002). Turbid water has the tendency of posing health challenges, causing symptoms like nausea, cramps, diarrhoea, and associated headaches. Treatment of water against turbidity requires flocculation, sedimentation, filtration and disinfection process. Alternatively, the water can be boiled at 100°C for at least 30 min, allowed to cool down, filtered, and stored in a clean covered container for consumption. The turbidity is not expected to be greater than 5 NTU.

pH

The pH of a water sample is a measure of the amount of hydrogen ion (H^+) content of the water sample and indicates the acidity and alkalinity of that water. pH value is a scale of 0 to 14 with 7 indicating neutral point while pH less than 7 depicts acidic water and that above 7 depicting basic water. The pH is a very vital content of water as it can dictate chemical activities such as coagulation and corrosion, and can affect how microorganisms thrive in water. pH adjustment is required where the pH level falls outside the permissible range, and such adjustment may include the addition of sodium ash or sodium hydroxide through an injection system to raise the pH level of the water or addition of alum, ferric chloride or ferric sulphate to reduce the pH. Required pH value is between 6.5 and 8.5.

Alkalinity

Alkalinity is the amount of basic content of a water sample; a measure of the extent of acid needed to neutralise the basic content of water. The alkaline contents act as the buffer to changes in the pH; too low

Figure 1. Map of study area (from Google Earth).

alkalinity of value below 80 ppm can allow rapid fluctuations in pH implying insufficient buffer to the pH while high alkalinity of any value above 200 ppm results in the water being too buffered (Spellman, 2003). Acid salts (alum, ferric chloride or ferric sulphate) or basic salts (lime, soda ash, or caustic soda) can be used to regulate the alkalinity of water sample. Alkalinity in water is expected to not be more than 200 mg/L.

Colour and odour

Colour and odour in water are indication of presence of dissolved contents in water. They may be due to metals, minerals from soils, microorganisms (algae and cyanobacteria) and biological reactions, decaying organic contents, and contents of effluents from the industries e.g. phenol, formaldehyde, petrochemical wastes etc. The colour and odour in water can be removed by activated carbon filters, sometimes marketed as taste and odour filters. Applications of oxidizing agents such as chlorine, chlorine dioxide, ozone, and potassium permanganate can also serve right. Another treatment method is coagulation and sedimentation using alum or other chemicals while aeration can remove those due to dissolved gases and volatile organic materials. This process is normally used only in large plants since its complexity often requires the care of a trained water treatment plant operator.

Hardness test

Hardness is said to exist in water when the water fails to form lather with soap; it is known to be caused by the presence of metal ions particularly, magnesium ions (Mg^{2+}) and calcium ions (Ca^{2+}). Hardness in water is mostly due to washing of rocks into groundwater. Hard water is characterised by problematic phenomena for domestic usages like causing skin irritation after bath, taking longer time before boiling, increasing fading of fabrics, producing deposits as scales that could clog hot water pipes and kettles among others. Water required to be available for domestic users is therefore expected to be of no or low hardness; to reduce the amount of soap used, increase the life of water heaters, and to reduce encrustation of pipes. Chemical precipitation (involving pH adjustment) and ion exchange (use of sodium zeolite) are the two hardness removing processes that are most commonly used. While chemical precipitation converts calcium hardness and magnesium hardness to calcium carbonate and magnesium hydroxide respectively through the addition of the lime-soda ash or the caustic soda, ion exchange replaces calcium and magnesium with a non-hardness causing cation, usually sodium by passage through a solids interface (matrix). The permissible hardness is between 80 and 100 mg/L.

METHODOLOGY

Study area

The study area consists of selected communities in eastern Ado Ekiti. This is a city in Southwest Nigeria and is the State capital and administrative headquarters of Ekiti State. It falls within the Ekiti sub-ethnic group of the Yoruba having its geographic location being unique as it is almost equidistant from Nigeria's economic capital, Lagos and the Federal capital, Abuja. It lies approximately between 7°37′16″N and 5°13′17″E 7°31’ with an altitude of 455 m above sea level and a population of 308,621 (NPC, 2006). Ado-Ekiti is characterised with low relief and gentle gradient which favours groundwater depth and access. It has a tropical climate which varies between 70°C and 95°C during the coolest and hottest month of the year with rainfall that is highly seasonal, marked with wet and dry seasons having mean annual rainfall of the area as 1367 mm that is concentrated between the months of April and October with a break in August.

Table 1. Turbidity test result for different samples.

Samples	1	2	3	4	5	Average
Ureje river water	5.58	4.01	8.35	6.19	11.0	7.03
Ureje well water	4.01	5.45	4.83	4.65	4.63	4.71
Ilupeju borehole water	2.27	2.43	2.01	1.90	1.96	2.11
ABUAD borehole water	1.32	0.87	1.56	1.98	1.87	1.52

Table 2. The pH test values of water samples.

Samples	Temperature °C	pH Value
Ureje river water	26.8	**7.33**
Ureje well water	26.8	6.45
Ilupeju borehole water	26.8	6.08
ABUAD borehole water	26.8	6.53

This study was conducted on four water samples of different sources; they are water from Ureje River (latitude 7°37'4.76"N and longitude 5°16'26.88"E), borehole in Ilupeju (latitude 7°36'56.75"N and longitude 5°14'59.83"), well in Ureje (latitude 7°36'55.40"N and longitude 5°15'27.92"E), and borehole in ABUAD (latitude 7°36'18.04"N and longitude 5°18'26.95"E) within Ado-Ekiti. The location map of the study area is presented in Figure 1.

The communities considered for this study were chosen because they are among the most populated in the area (one of which is an institution with a large number of residents), with the sources being in the centre of the communities for good representation; implying that the water sources serve a good number of the people in the study area. Representative samples were taken in good quantity for the various water sources; one from a well that is well utilized, one each from two boreholes and one from a river that is accessible by almost all the people in the area. The collection was done in clean bottles and the samples were taken such that they were in their purest form as the people will want it ensuring that no external contamination was possible. The various tests were then carried out to check the suitability of the water for domestic usage and compared with the World Health Organisation (WHO) standard for good water supply.

RESULTS AND ANALYSES

The results of the various tests that were carried out are thus presented. Turbidity test conducted on five portions from each of the samples taken from all sources are presented with their corresponding averages. The pH values, result of jar test, total hardness, calcium hardness, and alkalinity tests for the samples examined are as presented in Tables 1 to 6.

Summarily, the laboratory experiment conducted showed that, following the WHO standard for drinking water, water from borehole at ABUAD is satisfactory in all tests except in turbidity, that from borehole at Ilupeju satisfied all except for pH and turbidity, while water from well at Ureje and the river water from Ureje showed most unsatisfactory constituents as the water from the well at Ureje only meet requirements in jar test, hardness, and alkalinity, and that from the river water at Ureje satisfied in pH, calcium hardness, and alkalinity, but both failed in all others.

Conclusion

The expected physical and chemical tests for checking the quality of water for potability and safe domestic usage have been carried out. Based on these tests, the most suitable water source for drinking is the borehole; samples from ABUAD borehole water and the Ilupeju borehole water meet the permissible constituent level, meaning satisfactory; notwithstanding, a little more treatment is still required for borehole water in this study area particularly to correct suspended solids and ensure appropriate pH.

To consider water from the other sources for domestic use, we recommend that, further treatments be carried out on them, healthy environmental practice be ensured, and that activities in the study area should minimize contamination of the surface water, open defecation and discharge of waste into the river should be discouraged.

RECOMMENDATIONS

In the following tests, the following should be considered:

Turbidity: The four samples should undergo further flocculation, sedimentation, filtration and disinfection process. Alternatively, the water can be boiled at 100°C for at least 30 min, allowed to cool down, filtered, and stored in a clean covered container for consumption.

Jar test: The Ureje River, Ajebamidele well water and the ABUAD borehole failed in this test because of their turbid level; thus, the amount of coagulant added to the

Table 3. The jar test.

Samples	Amount Of coagulant (g) $Al_2(SO_4)_3$	Turbidity (NTU)
Ureje river water	0.5	5.56
Ureje well water	0.5	1.67
Ilupeju borehole water	0.5	0.93
ABUAD borehole water	0.5	1.08

Table 4. Hardness classification of the water samples.

Sample	mg/L as $CaCO_3$	Classification
Ureje river water	122	Hard
Ureje well water	86	Moderate
Ilupeju borehole water	68	Soft
ABUAD borehole water	57	Soft

Table 5. The content of calcium in the water samples.

Sample	Calcium in mg/L $CaCO_3$
Ureje river water	25.23
Ureje well water	26.83
Ilupeju borehole water	18.82
ABUAD borehole water	6.01

Table 6. The alkalinity level of the water samples.

Sample	Alkalinity mg/L $CaCO_3$
Ureje river water	318
Ureje well water	162
Ilupeju borehole water	114
ABUAD borehole water	134

water sources should be increased or instead a different coagulant e.g. alum, ferric chloride and ferric sulphate should be introduced to the water samples.

An efficient drinking water treatment plant that is suitable for the community should be provided. Research on potable water should be funded by every nation of the world and environmental sustainability should be given optimal priority.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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