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COMPARATIVE ANALYSIS OF WATER QUALITY FROM HAND DUG WELLS AND BORED HOLES IN UYO, AKWA IBOM STATE, NIGERIA.

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ABSTRACT

Water quality analysis was conducted using the physical, chemical and biological analysis methods of water treatment for samples randomly selected from three (3) boreholes and three (3) hand dug wells in Uyo metropolis to determine their suitability for drinking in comparison of the WHO standards for drinking water. After the analysis, one (1) of the boreholes was found to be slightly acidic (pH 6.3) while others were within limit of WHO standards. The mean D.O for borehole (4.161mgl/l) were less than that of wells and did not meet the WHO limit. (5-14mg/l). The BOD of all samples did not satisfy the WHO limit of 2-4mg/l. lead concentrations in bored holes were slightly above WHO limits of 0.01mg/l. the concentration of ions (Fe^4, Ca^{2+} and mg^{2+}), sulphate, and Nitrate fell within the WHO limit. From analysis, it will be concluded that the different water sources are good sources of drinking water.

Keywords: Water quality, Hand Dug Wells, Bored Holes

1.0 INTRODUCTION

1.0.1 BACKGROUND OF STUDY

According to WHO (2006), about 1.1 billion people lack access to improve drinking water supply. In most cities, towns and villages in Nigeria, valuable man-hours are spent on seeking and fetching water, often of doubt quality from distant sources (Efe, 2005). Uyo is a densely populated city Akwa-Ibom State, in south-eastern area of' Nigeria. The high population density. Poor sanitation habits and lack of enforcement of environmental Sanitation laws have contributed immensely to the pollution of water sources. Pollutants in groundwater can be from various sources mainly municipal (i.e. leakages from liquid waste and solid waste from land fill), industrial (i.e. liquid waste tanks and pipeline leakages, oil field and brines) and agricultural sources (i.e. irrigation return flow which are sometimes saline). These problems of acute water supply have resulted in the rapid increase or hand dug wells and boreholes with some located within the proximity of soak away and pit latrines.

The quality of groundwater resource depends on the management of' human waste as well as the natural physic-chemical characteristics of' the catchments areas (Efe et al, 2005 Saha and Baba, 2004). Also, depending on the geology of an area. underground waters are typically rich in dissolved solids especially carbonates and sulphates ot' calcium and magnesium. Other ions may also he present including chlorides and bicarbonates (Wikipedia, 2010). Hence, it is necessary to obtain physic-chemical characteristics of the groundwater so as to compare and monitor water quality and to determine the type of treatment that may be required before use.

Generally, borehole water is considered to have better microbial quality than that of hand dug well water because borehole water is from deep aquifer while hand dug well water is from shallow aquifers which makes it more susceptible to microbial pollution (Linsley and others, 1979; Chilton, 1996).

1.1 STATEMENT OF PROBLEM

Groundwater sources are being increasingly used as drinking water yet, testing to see whether the water is of' good quality is almost non-existent. Although, it is true that soils generally Function to reduce the effect of microorganisms by a simple filtration mechanism, especially larger bacterial and protozoa, pollution of groundwater by micro-organisms, especially the located near septic tanks or landfills significantly do occur.

1.2 OBJECTIVE OF THE STUDY

The objective of this study is carrying out water quality analysis on waler samples obtained from randomly selected hand dug wells and boreholes in iyo metropolis in order to ascertain;

i) The level of some physical, chemical and bacteriological parameters present in the sample,

ii) The level of suitability of the different sources to Who standards for drinking water quality.

1.3 SCOPE OF THE STUDY

The scope of this research work covers water quality analysis of water samples obtained from three randomly selected hand dug wells from Itak Mbak. Anua, and Nung Udoe and boreholes from Udoh Street, Oron Road and Ibiaku within Uyo metropolis.

1.4 LIMITATIONS

Usually, the metropolis has numerous hand dug wells and boreholes which make this research work restricted to the randomly selected boreholes and hand dug wells to represent the study area. This choice is due to the financial constraint that will be experience in carrying out analysis of water sample gotten from the different sources for the whole city. The research work is also limited to laboratory analysis carried out on water samples to obtain results.

1.5 SIGNIFICANCE OF THE STUDY

The importance of this study is to identify the groundwater quality conditions from various sources in Uyo metropolis. The major activity is the necessity to provide data and information on the level of physical properties. Chemical properties and bacteriological properties of hand dug wells and boreholes' water samples in the Uyo metropolis of Akwa-Ibom State. It also gives a summary of the level of these properties investigated in the randomly selected sites within the study area.

2.0 LITERATURE REVIEW

2.0.1 REVIEW OF RELATED LITERATURE

According to Kolo, groundwater usage is based on the postulation that groundwater, being precluded from the atmosphere, is less susceptible to pollution. However, groundwater are sometimes known to be vulnerable to quality problems that may have serious impact on human health. But water, which is the most precious natural, needed for life after oxygen and "key" to health, should be qualitative before being used (Umara et al 2007). The quality of water varies with its purpose, thus the quality required for it is therefore affected by Landfill of solid wastes from domestic, industrial and irrigation purposes. Polluted waters, irrespective of the pollutants, when consumed, may lead to variety of diseases, such as cholera, typhoid, dysentery, skin and mental disorders, etc.

To safeguard the health of people and to reduce to the barest minimum of ugly experiences of drinking and/or using of low quality waters, it is necessary that the quality of water should be monitored with the view to finding lasting solution to health problems associated with the use and drinking of low quality waters. Both liquid and solid wastes materials dumped either on soil surface or buried are known to decompose to produce leachete that penetrate aquifers and contaminate the groundwater thereby raising the potential toxicity of the water to consumers. Burying and surface dumping of both industrial and domestic waste are nowadays a common practice among rural and urban dwellers.

The quality of groundwater however, principally depends on the element (s) present in it while seeping down. The world health organization WHO has set a quality guideline for drinking water and recommends that the properties of every drinking water should fall within the acceptable limit set by it. This chapter looks at hand dug wells and boreholes, effects of contaminants in groundwater quality standards.

2.1.1 BOREHOLE AND HAND DUG WELL WATER

2.1.1 BOREHOLE WATER

Usually, water from the boreholes may be free from danger pathogens for humans like cholera, typhoid, dysentery guinea worm and many others. Borehole water is groundwater available in an aquifer obtained by installing a pump to draw the water to the consumers. Any contaminated surface water with pathogen that infiltrates into the soil and become groundwater would be filtered by the soil profile before reaching the depth of aquifer. An aquifer is saturated water bearing stratum that is capable of holding, transmitting and yield sufficient water in underground to well. The major problem of boreholes is chemical content of the ground water, which must be analyzed to ascertain if these dissolved products are within the permissible limits for consumption propose by the authorities, in this case the World Health Organization (WHO)

2.1.2 HAND-DUG WELL WATER

Hand-dug wells are excavations with diameter large enough to accommodate one or more persons with shovels digging down to below the water table. They can be lined with laid stones or bricks; extending this lining upwards above the ground surface to form a around the well serves to reduce both contamination and injuries by falling into the well. A well digging team digs under a cutting ring and the well column slowly sinks into the aquifer whilst protecting the team from collapse of the well bore.

Hand-dug wells provide a cheap and low-tech solution to accessing ground water in semi-urban location within Uyo. They have low operational and maintenance costs, in part because water can be extracted by hand bailing, without a pump. Because they exploit shallow aquifers, the well may be susceptible to yield fluctuations and possible contamination from surface water including sewage, leachete, etc. Contamination of well water may be from anthropogenic activities, the materials used in the construction of the well and the type of soil in which the well is constructed, or/and non-protection of the well.

2.2 EFFECTS OF CONTAMINANTS IN GROUNDWATER QUALITY

Since groundwater often occurs in association with geological materials containing soluble minerals, higher concentrations of dissolved salts are normally expected in groundwater relative to surface water. The type and concentration of salts depends on the geological environment and the source and movement of the water. The following paragraphs outline the main ways in which the natural characteristics of groundwater affect water quality for different uses.

The natural chemical quality of groundwater is generally good, but elevated concentrations of a number of constituents can cause problems for water use. The types and relative concentrations of the chemical constituents in groundwater provide information on the evolution of groundwater, age (residence time), solubility, rates of movement, flow, history, and sources of recharge. Older groundwater for example is generally more mineralized than younger groundwater. Fresh groundwater is normally associated with recharge areas whereas groundwater in discharge areas are more mineralized.

According to Chilton (1996), High iron levels in groundwater are widely reported from developing countries, where they are often an important water quality issue. Consumers may reject untreated groundwater from pump supplies if it has a high iron concentration in favour of unprotected groundwater sources with low iron levels but which may have gross bacteriological pollution. The situation is made worse in many areas by the corrosion of ferrous well linings and pump components. Obtaining representative samples for iron in groundwater presents particular difficulties because of the transformations brought about by the change in oxidation/reduction status which occurs on lifting the water from the aquifer to ground level. According to WHO (2006), anaerobic (without oxygen) groundwater may contain ferrous iron at concentrations of up to several milligram per litre without discoloration or turbidity in the water when directly pumped from a well. On exposure to the atmosphere, however, the ferrous iron oxidizes to ferric iron,

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giving an objectionable reddis-brown colour to the water.

The dissolved oxygen content of water is influenced by the source, raw water temperature, treatment and chmical or biological processes taking place in the distribution system. According to WHO (2006), Depletion of dissolved oxygen in water supplies can encourage the microbial reduction of nitrate to nitrite and sulfate to sulfide. It can also cause an increase in the concentration of ferrous iron in solution, with subsequent discoloration at the tap when the water is aerated.

Although ph usually has no direct impact on consumers, it is one of the most important operational water quality parameters. Lower-ph water is likely to be corrosive. Alkalinity and calcium management also contribute to the stability of water and control its aggressiveness to pipe and appliance. Failure to minimize corrosion can result in the contamination of drinking-water and in adverse effects on its taste and appearance. The optimum ph required will vary in different supplies according to the composition of the water and the nature of the construction materials used in the distribution system, but it is usually in the range 6.5-8. Extreme values of ph can result from accidental spills, treatment breakdowns and insufficiently cured cement mortar pipe linings or cement mortar linings applied when the alkalinity of the water is low (WHO, 2006).

2.2.2 EFFECTS OF MICROBIAL CONTAMINANTS IN GROUNDWATER QUALITY

Groundwater quality can be influenced directly and indirectly by microbiological processes, which can transform both inorganic and organic constituents of groundwater. According to Mathess (1982), single and multi-celled organisms have organisms have become adapted to using the dissolved materials and suspended solids in the water and solid matter in the aquifer in their metabolism, and then releasing the metabolic products back into the water. There is practically no geological environment at, or near, the earth's surface where the ph condition will not support some form of organic life (Chilton and West, 1992). In addition to groups tolerating extremes of ph, there are groups of microbes which prefer low temperatures (thermophiles), and yet others which are tolerant of high pressures. However, the most biologically favourable environments generally occur in warm, humid conditions.

Micro-organisms do not affect the direction of reactions governed by the thermodynamic constraints of the system, but they do affect their rate. Sulphides, for example, can be oxidized without microbial help, but mircrobial processes can greatly speed up oxidation to the extent that, under optimum moisture and temperature conditions, they become dominant over physical and chemical factors.

All organic compounds can act as potential sources of energy for organisms. Most organisms require oxygen for respiration (aerobic respiration) and the breakdown of organic matter, but when oxygen concentrations are depleted some bacteria can use alternatives, such as nitrate, sulphate and carbon dioxide (anaerobic respiration). Chiroma (2008) stated that organisms which can live in the presence of oxygen (or without it) are known as facultative anaerobes. In contrast, obligate anaerobes are organisms which do not like oxygen. He presence or absence of oxygen is, therefore one of the most important factors affecting microbial activity, but not the only one. For an organism to grow and multiply, nutrients must be supplied in an appropriate mix, which satisfies carbon, energy, nitrogen and mineral requirements (Foster and Hirata, 1988).

Most micro-organisms grow on solid surfaces and, therefore, coat the grains of the soil are aquifer. They attach themselves with extra-cellular polysaccharides, forming a protective biofilm which can be very difficult to remove. Up to 95 per cent of the bacterial population may be attached in this way rather than being in the groundwater itself.

However, transport in the flowing groundwater is also possible. The population density of micro-organisms depends on the supply of nutrients and removal of harmful metabolic products. Thus, in general terms, higher rates of groundwater flow supply more nutrients and remove the metabolic products more readily. Microbe populations are largest in the nutrient-rich humus upper parts of the soil, and decline with decreasing nutrient supply and oxygen availability at greater depths. Many sub-surface microbes, however, prefer lower nutrient conditions (Ayantobo, 2012). In the presence of energy sources, such as organic material, anaerobic microbial activity can take place far below the soil and has been observed at depths of hundreds and even thousands of metres. The depth to which such activity is possible is determined by the nutrient supply and, in addition, ph, salt content, groundwater temperature and the permeability of the aquifer,

Microbiological activities primarily affects compounds of nitrogen and sulphur, and some of the metals, principally iron and manganese. Sulphate reduction by obligate aerobes is one of the most important biological processes in groundwater. Nitrogen compounds are affected by both nitrifying and denitrifying bacteria. Reduction of nitrate by denitrifying bacteria occurs in the presence of organic material in anaerobic conditions, leading to the production of nitrite which is then broken down further to elemental further to elemental nitrogen. Hem (1989) stated that the possibility of enhancing natural identification is currently receiving attention in relation to the problem of nitrate in groundwater. Under aerobic conditions, ammonia (which may be produced during the decomposition of organic matter) is oxidized to nitrite and nitrate. Likewise iron can be subjected to either reduction or oxidation, depending on the ph conditions of the groundwater. In favourable microbiological environments, massive growth of iron bacteria can cause clogging of well screens and loss of permeability of aquifer material close to wells, and may require special monitoring and remedial action. Micro-organisms can break down complex organic materials dissolved in groundwater.

Under anaerobic conditions, Mathess (1982) observed that microbial breakdown proceeds either as methane fermentation or byu reduction of sulphate and nitrate. Microbial decomposition has been demonstrated for a whole range of organic compounds, including fuel hydrocarbons, chlorinated solvents and pesticides. Under ideal conditions, all organic materials would eventually be converted to the simplest inorganic compounds. In practice, complete break down is never reached, and intermediate products of equal or even greater toxicity and persistence may be produced (Kafia and others, 2008).

A principal microbiological concern in groundwater is the health hazard posed by faecal contamination. Of the four types of pathogens (viruses, bacteria, protozoa, and parasite) contained in human excreta, only bacteria and viruses are likely to be small enough to be transmitted through the soul and aquifer matrix to groundwater bodies (Chilton, 1996; Agunwamba, 2008). The soil has long been recognized as a most effective defense against groundwater contamination by faecal organisms, and a number of processes combine to remove pathogens from infiltrating water on its way to the water table. Not all soils are equally effective in this respect. In addition, many human activities which can cause groundwater pollution involve the removal of the soil altogether. Bacteriological contamination of groundwater remains a major concern, especially where many dispersed, shallow dug wells or boreholes provide protected but untreated domestic water supplies.

In summary, microbiological processes may influence groundwater quality both positively and negatively (Chilton, 1996). The former include reducing nitrate and sulphate contents of groundwater, and removal of organic pollutants. The later include the production of hydrogen sulphide and soluble metals, production of gas and biofilm fouling of well screens and distribution pipes.

2.2.3 EFFECT OF ROCK BEARING STRATA ON GROUNDWATER QUALITY

Atmospheric precipitation infiltrating through the soil dissolves $C0_2$ produced by biological activity. The resulting solution of weak carbonic acid dissolves soluble minerals from the underlying rock . a second process operating during passage through the soil is the consumption by soil organisms of the oxygen which was dissolved in the rainfall. These reactions occur in the soil and the top few metres of the underlying rock. In temperate and humid climates with significant recharge, groundwater moves continuously and relatively rapidly through the outcrop area of an aquifer; hence contact time with the rock matrix is relatively short. Readily soluble minerals will be removed, but insufficient contact time exists for less soluble minerals to be taken up. Groundwater in the outcrop areas of aquifers is likely to be low in overall mineralization, with the natural constituents depending on the materials of which the rocks are made (Chilton, 1996).

In igneous rocks, the restricted opportunity for reactions to take place is single out by the fact that groundwater storage and flow is predominantly in fissures, giving short residence times and low contact surface area. Groundwater in igneous rocks is, therefore often exceptionally lightly mineralized, although characterized by high silica contents (Hem, 1989). Pure siliceous sands or sandstones without soluble cement also contain ground-water with very low total dissolved solids (Matthess, 1982). In such aquifers, the dissolved constituents that are present come mainly from other sources, such as rainfall and dry deposition, especially sodium, chloride and sulphate which, in coastal regions, may exceed calcium, magnesium and bicarbonate. Sulphate may also be produced by the oxidation of metallic sulphides which are present in small amounts in many rock types. The presence of soluble cement may produce increased concentrations of the major ions. Ground-waters in carbonate rocks have ph values above 7, and mineral contents usually dominated by bicarbonate and calcium. In many small and/or shallow aquifers the hydrochemistry does not evolve further. It, however, an aquifer dips below a confining layer, a sequence of hydorchemical processes occurs with progressive distance down gradient from the outcrop.

2.2.4 REACTIONS RELATED TO ANTHROPOGENIC EFFECTS

Physico-chemical reactions between soil or rock and water are of considerable importance when evaluating or predicting the nature of anthropogenic impacts on groundwater quality. In this respect the unsaturated zone, and particularly the soil, deserves special attention since it represents the first and most important natural defense against groundwater pollution (Foster, 1985; Matthess and others, 1985). This is as a result of its position between the land surface and the water table and because a number of processes of pollutant attenuation are more favoured by the environments of the soil and the unsaturated zone.

Water movement in the unsaturated zone is largely vertical and normally slow. The chemical condition is usually aerobic and frequently alkaline. Thus, as suggested by Foster and Hirata (1988), there is considerable potential for:

i) Interception, sorption and elimination of pathogenic bacteria and viruses.
ii) Attenuation of trace elements and other inorganic compounds by precipitation, sorption or cation exchange, and
iii) Sorption and biodegradation of many hydrocarbons and synthetic organic compounds.

However, many activities which can cause groundwater pollution involve the complete removal, or by-passing, of the soil zone. The characteristics of the soil also influence the scope for nutrient nd pesticide leaching from a given agricultural activity and whether acid aerial deposition is neutralized. The continuation of these processes at greater depths, albeit to a lesser degree, is more likely in sedimentary materials (in which flow is largely restricted to fissures). Some of these processes are applicable to a range of possible constituents of percolating groundwater, while others are more restricted in their effects.

2.2.5 WATER-QUALITY STANDARDS

The quality of water is assessed in terms of its physical, chemical, biological characteristics, and its intended uses. For example, although distilled water is physically, chemically, and bacteriologically pure, its taste is rather bland and it is highly corrosive (Agunwamba, 2008). It has been demonstrated repeatedly that water containing some dissolved constituents is far more palatable than pure water (Linsely and others, 1979). Water quality varies for different purpose in every daily activity. Water quality standards are standards established to determine whether water of a certain quality is suitable for its intended use. All portable water must conform to these standards.

According to Linsley and others (1979), water quality standards adopted by water quality regulatory agencies like WHO are usually based on one or more of the following:

1) Established or current practice
2) Attainability (the standard must be easily attainable or reasonable technologically or economically)
3) Educated guess, using the best information available
4) Experimentation (e.g. animal exposure)
5) Experience based on human exposure
   a. Taking advantage of an occurring catastrophe
   b. Experimenting with humans directly
6) Mathematical model (e.g., probability, mode, percentile, most probable number of coliforms)

The standards used to check the portability of any water source include World Health Organization (WHO), Federal Environmental Pollution Agency (FEPA), standard organization of Nigeria (SON), European Union (EU) standards (Agunwamba, 2008). For this study standard is adopted to compare the quality of water obtained from hand dug wells and borehole.

Dietvorst (2013) carried out a water quality study in rural Cambodia which showed that a shallow aquifer was chemically less of a health risk than a deep aquifer; however, microbial contamination was considerable for both open and rope-pump shallow wells. The presence of iron and manganese may lead to the formation of incrustations of pipe mains by the deposition of ferric hydroxide and manganese oxide. Chloride concentration in excess of 250 mg/l may have an undesirable taste. Sulphate concentrations in excess of 250 mg/l may have a laxative effect on humans. Linsley and others (1979) stated that the concentrations of the various constituents in excess of the approval limits for human health constitute grounds for rejection of water supply. Nevertheless, contaminants present in shallow wells may readily be removed by simple household treatment.

3.0 METHODOLOGY.

3.1 THE STUDY AREA

Uyo metropolis comprises of Uruan, Itu, Ibesikpo Asutan (L.G.As) in Akwa-Ibom State has an estimated land area of about 115km^2. It is situated at coordinates $5^0$1'24"N $7^0$55'26"E, with an altitude ranging from 150-2 l0ft above mean sea level (MSL). Rainy season starts from March-April and ends in mid November (about 8 months of rainy season). Rainfall is between 1,500mm to 2000mm with July-September as the wettest months and December as the driest. Temperature is moderately high throughout the year with a low range. The mean annual maximum and minimum temperature are 36°C and 26°C respectively. Duration of rainy season has a positive effect on the groundwater while during the dry season (November — February) the reverse is the case.

The study area has rainforest vegetation. The topography is gently undulating sandy plains. The area is underlain with sedimentary formations of late tertiary and Holocene ages consisting of coastal plain sands, now weathered into lateritic layers, quartzite complexes. Quartz is the sole framework element, and monocrystalline quartz constitutes about two-thirds of the quartz varieties.

The study area is populated with 1,400/km2 and population of 409,303 (NPC 2006). Dwellings are compacted together. Buying and selling is an important economic activity. Many markets are located within the area (i.e. Itam, Urua-Uyo, Useh, etc markets). Due to problem of physical planning wastes are not properly disposed off. They are dumped indiscriminately along Streets, open places and inside drainages.

3.2 SAMPLING AND SAMPLING TECHNIQUE

The well/borehole water samples are the main experimental materials. Three (3) wells and Three (3) boreholes are randomly selected to represent the study area. Table 3.1 shows the location of the wells and boreholes and their sample number.

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Table 3.1 Locations of the wells and boreholes

Well/Borehole Sample No.	Location
Borehole I (B 1)	Udoh Street
Borehole 2 (B2)	Oron Road
Borehole 3 (B3)	Ibiaku
Well I (WI)	Itak Mbak
Well 2 (W2)	Anua
Well 3 (W3)	Nung Udoe

3.3 SAMPLE COLLECTION

The water samples are collected using hard plastic and screw-capped bottles that have been sterilized to avoid contamination by any physical, chemical or microbial means. The collected well/borehole water samples are aseptically transferred into sterile containers. Samples for bacteriological analyses will be kept in screw-capped bottles that have been sterilized in an autoclave for 15 minutes at 121°C. Samples will then be transferred to the laboratory where they will be stored in the refrigerator for microbial analysis.

Water Sample Analysis

Analysis of water samples will be carried out at the Department of Soil Science Laboratory, Faculty of Agriculture, University of Uyo. The physical and chemical characteristics will be determined using the standard method given by WHO guidelines (2006). The physical parameters measured are: turbidity, and temperature while the chemical parameters include; magnesium, lead, iron, sodium, nitrate, sulphate, pH, total dissolved oxygen, total dissolved solids (TDS) and total suspended solids (TSS). Bacteriological test is important to determine if the water contain pathogens that can cause diseases to man. Wells and Boreholes will be sampled for bacteriological test to determine Coli form count (E. Coli bacteria).

Sensitive parameters such as temperature and ph will be measured immediately after collection of the water samples. A Jenway 4015 pH meter and mercury thermometer will be used for ph and temperature measurements, respectively. The conductivities of the well and borehole water samples will be measured using a WPA cm - 35 electrical conductivity meter. To determine the total dissolved solids, about 100 ml of each sample will be filtered, and the filtrate will be measured in clean dried evaporating dish, which had its initial weight noted. The filtrate will be evaporated to dryness on a hot water bath. The evaporating dish will be cooled in desiccators for about 10 minutes and weighed with its content. The weighing was accomplished using a digital analytical balance with a sensitivity of 0.00 1g.

Trace and heavy metals in the well/borehole water samples are determined by Atomic Absorption spectro-photometer, Pye Unicom SP 9 (AAS) using appropriate wave length for each metal (Fe, Zn, Pb). The turbidity of the samples will also be determined using a turbidity meter.

The bacteriological analysis for the presence of microbial and faecal contamination will be examined. Microbial organism to be examined include total coliforms. The organisms are cultured for 5 days using nutrient agar, a general- purpose agar for the culture of non-fastidious organisms and Mac Conkey agar, which is a selective medium for the isolation and differentiation of enteric organisms. The colonies are counted using plate count method as described in Agunwamba (2008).

3.4 METHOD OF DATA ANALYSIS

The method of data presentation used will be tables because it ensures all parameters analyzed in water samples are effectively recorded and presented accurately. This will help in comparing the groundwater quality obtained from each sources so as to examine the suitability with the water quality standards set out by WHO (2006) guidelines for drinking water quality.

4.0 RESULTS AND DISCUSSION

This chapter discusses the results of various tests that were carried out in the previous chapter.

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4.1 WATER QUALITY ANALYSIS RESULTS

The result of the water quality analysis carried out on the water samples from boreholes and hand dug wells from different locations are presented in Tables 4.1, 4.2, 4.3. The World Health Organization WHO (2006) standard for drinking water was used as the baseline to compare the water quality from the different sources.

TABLE 4.1: Some Physical and Chemical Properties of the Different Sources

	Borehole 1 (B1)	Borehole 2 (B2)	Borehole 3 (B3)	Well 1 (W1)	Well 2 (W2)	Well 3 (W3)	WHO limits – 2006	Remarks
parameters	UDOH STR	ORON ROAD	IBIAKU	ITAK MBAK	ANUA	NUNG UDOE		
hardness (Mg/L)	66.11	71.03	58.92	83.2	61.99	81.46	150	WL
ph	6.3	7.34	7.1	8.21	8.1	8.22	6.5 – 8.5	B1 < L; others WL
E/C (us/cm)	0.27	0.02	0.006	0.14	0.01	1.66	1000	WL
turbidity (Mg/L)	2	3.44	2.49	4.99	4.64	3.66	10	WL
TDS (Mg/L)	0.31	0.3	0.01	0.08	0.17	0.133	500	WL
temperature ^{0}C	29	29	30	32	30	30		No limit

4.1.1 HARDNESS

The results of hardness parameter analyzed for boreholes and wells are shown in table 4.1. Bi (66.11mg/i), B2 (71.03mg/i), B3 (58.92mg/i) and W2 (61.99mg/i) are relatively in the soft category of hardness of 0-75mg/i while W1 (83.2mg/i) and W3 (81.46mg/I) are in moderately hard water category of 75-120mg/i which can be treated by simple boiling. On average, from table 4.1(a), water from boreholes are relative softer than water from hand dug wells. However, all samples analyzed met the WHO acceptable limit of 150mg/I.

4.1.2 PH

The ph of the samples analyzed is shown in table 4.1. The P1 of the sample was generally within the 6.5-8.5 as recommended by WHO. But the Ph of

Bi (6.3) shows that it is mildly acidic. Acidity increases the capacity of the water to attack geological materials and leach toxic trace metals into the water making it potentially harmful for human consumption. This can be treated with lime. Thus, the moderate acidity of this water suggests that the water was susceptible to some degree of trace metal pollution, possibly present in the rock matrix through which the water percolated. On average, both water from hand dug wells and boreholes fall within the WHO acceptable limits of 6.5-8.5 (Table 4.1).

4.1.3 ELECTRICAL CONDUCTIVITY

The electrical conductivity of the samples analyzed is shown in table 4.1. The electrical conductivity of all the samples from the different sources was within the WHO acceptable limits.

4.1.4 TURBIDITY

The results for the turbidity of each sample are shown in table 4.1. Turbidity indicates the estimate of suspended matter. The WHO acceptable limit for turbidity is 10NTU and all sample investigated fell within this limit.

4.1.5 TOTAL DISSOLVED SOLIDS (TDS)

The result for the TDS of the sample is shown in table 4.1. The values for all samples were within the WHO acceptable limits.

4.1.6 TEMPERATURE

The values for the temperature of each sample are shown in table 4.1. The temperatures of the samples from the various sources varied from 29^{0}C to 32^{0}C with an average of 30^{0}C. Temperatures of samples from wells were slightly higher than that from boreholes. There is no guideline value recommended by WHO with regards to temperature of drinking water.

parameters	Borehole (B1) UDOH STR	1Borehole (B2) ORON ROAD	2Borehole (B3) IBIAKU	3Well (W1) ITAK MBAK	1Well (W2) ANUA	2Well 3 (W3) NUNG UDOE	WHO limits – 2006	Remarks
Do (mg/L)	4.039	4.31	4.133	5.81	5.1	4.93	5-14	(B1, B2, B3, W3 < L; W1, W2 are WL)
BOD (Mg/L)	16.21	15.91	14.99	20.41	19.91	19.09	2-4	Not WL
So_4^{-3}	4.6	4.98	3.79	4.66	3.99	3.93	50	WL
No^3 (Mg/L)	1.021	0.099	1.031	2.418	2.1	2.34	50	WL
TCC (Mg/L)	0.01	0.03	0.01	0.03	0.03	0.03	0	Slight above L

4.1.7 DISSOLVED OXYGEN (DO)

The value for the DO of each source analyzed is shown in table 4.2. Samples Bi (4.039mg/i), B2 (4.31mg/i), B3 (4.133mg/i) and W3 (4.93mg/l) did not meet the WHO limits of 5-14mg/i while Wi (5.81mg/l), W2 (5.1mg/i) were within the WI-TO acceptable limits.

4.1.8 BIOCHEMICAL OXYGEN DEMAND (BOD)

The values for the BOD of each source are shown in table 4.2. All samples did not meet the acceptable standard of 2-4mg/i set out by WHO. High B.O.D. means that there is less of oxygen to support life and indicates organic pollution. It denotes the amount of oxygen needed by micro-organisms for stabilization of decomposable organic matter under aerobic conditions. They do not actually indicate water quality but potential for removing oxygen from water.

4.1.9 SULPHATE (SO43)

The concentrations of sulphate in the various sources are shown in table 4.2. Boreholes B1, B2, and B3 had values of 4.6mg/l, 4.98mg/l, and 3.79mg/l while wells W1, W2 and W3 had values of 4.66mg/l, 3.99mg/i and 3.93mg/l. These values met the WHO acceptable limit of 50mg/l. High sulphate concentrations may have laxative effects on consumers if ingested.

4.1.10 NITRATE (N031)

The results of nitrate are shown in table 4.2. All samples analyzed met the WHO acceptable limits of 50mg/i. Elevated nitrate concentrations are often caused by run-off from barnyards or feediots, excessive use of fertilizers, or septic systems.

4.1.11 TOTAL COLIFORMS COUNT (TCC)

The WHO acceptable for TCC in any drinking water is 0.00mg/i as shown in table 4.2. All samples under examination were slightly above this limit with boreholes B 1, B2, and B3 having values of 0.01mg/i, 0.03mg/i, and 0.01mg/i respectively while wells Wi, W2, and W3 had mean value of 0.03mg/i each. Presence of coliforms means presence of microbial faecal contamination.

Table 4.3: Concentrations Fe, Zn, Pb, $Ca^{+2,}$ and Mg^{+2} of the Different sources

parameters	Borehole (B1) UDOH STR	1Borehole (B2) ORON ROAD	2Borehole (B3) IBIAKU	3Well (W1) ITAK MBAK	1Well (W2) ANUA	2Well 3 (W3) NUNG UDOE	WHO limits – 2006	Remarks
Fe (Mg/L)	0.003	0.001	0.002	0.0002	0	0.003	0.1	WL
Zn (Mg/L)	0.009	0.005	0.005	0.021	0.026	0.03	3	WL
Pb (Mg/L)	0.04	0.04	0.04	0.01	0.03	0.01	0.01	B1, B2, B3, W2 > L WL, W3 are WL
Ca (Mg/L)	0.046	0.032	0.071	0.066	0.074	0.064	200	W.L
Mg (Mg/L)	1.166	3.21	2	2.88	1.96	1.63	125	WL

4.1.12 HEAVY METALS

The heavy metals analyzed included iron (Fe), zinc (Zn), lead (Pb), calcium (Ca), and magnesium (Mg). Their concentrations in the various sources are shown in table 4.3. Iron (Fe), zinc (Zn), calcium (Ca), and magnesium (Mg) concentrations of the different sources are within the WHO acceptable limits of 0.1mg/I, 3mg/I, 200mg/I and 150mg/I respectively. The behaviour of heavy metals in natural water is a function of the substrate sediment composition and water chemistry (Kafia at al, 2008)

For lead (Pb) concentrations, Samples from Bi (0.04mg/i), B2 (0.04mg/l), B3 (0.04mg/I), and W2 (0.03mg/I) did not meet the WHO acceptable limit of 0.01mg/I while W1 (0.01mg/i), and W3 (0.01mg/i) were within the acceptable limits. However the concentrations here are not of health risk to the consumers.

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This study has provided data on the level of physico-chemical properties of water from hand dug wells and boreholes in Uyo metropolis. The study was set out to compare the level of these properties from the various sources with WHO standard for drinking water. Considering the results obtained from the investigation, the following conclusions are drawn:

1) Water from hand dug well is harder than that from boreholes which can be soften by boiling.
2) The dissolved oxygen of boreholes did not meet the standard set out by WHO.
3) The biochemical oxygen demand of boreholes and wells were far above the limit set out by WHO.
4) Sulphate and Nitrate concentrations met the WHO standards.
5) Total coliforms count was slightly above the WHO limits for water from well than in boreholes.
6) All heavy metals analyzed for fell within the WHO limits apart from lead which was slightly above the WHO limits for water from boreholes.

5.2 RECOMMENDATION

From the results obtained from the analysis conducted in the study on the comparative analysis of water from hand dug wells and boreholes in uyo metropolis, the following recommendations are made:

It is therefore recommended that standard measures be taken by the appropriate authorities to ensure proper treatment of the waters to safeguard the health of the innocent consumers with regard to pH, total coliforms, and lead in the affected sites. Analysis of this nature should be carried out on regular basis. Hygienically approved methods for waste disposal (both solid and liquid) should be explored and adopted to check the possibilities of indiscriminate land-dumping of potentially hazardous waste materials. Water users should also be on watch and to report every high level of any physical or chemical properties to the appropriate authorities in order to sustain water quality for consumption

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