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Full Length Research Paper

Assessment of bottled water potability in Effurun, Delta State

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ABSTRACT: This study was carried out to access the Physico-chemical and microbiological quality of three brands of bottled water (A, B, and C), by comparing the compliance of each brand with W.H.O standards. A total of 15 parameters were analyzed: the pH, conductivity, temperature, total dissolved solids, total suspended solids, turbidity, chloride, sulphate, biochemical oxygen demand, total coliform, sodium, iron, lead, and cadmium, using the standard method at Dukoria laboratory. The results obtained for sample A, B and C were; Ph (6.20-7.28), Conductivity(65.67-102.57µs/cm), temperature (27.9-28.7^{0}c),Total Dissolved solids (36.78-57.40mg/l), Total suspended solids (0.00-0.50mg/l), Turbidity (0.00-1.00mg/l), Chloride (11.40-18.50mg/l), Sulphate (0.04-0.06mg/l), Dissolved oxygen (4.71-5.81mg/l), Biology Oxygen Demand (0.50-0.92mg/l), Total coliform (<0.031), respectively, Sodium (6.50-9.60mg/l), Iron (<0.001mg/l - 0.006mg/l), Lead (<0.001mg/l) respectively and Cadmium(<0.001mg/l) respectively. From the 15 parameters analyzed, all the samples were in line with the permissible limits except for the pH of brands A and C having 6.45 and 6.20 respectively. The coliform bacteriological count of the samples complied with WHO standard 0cfu/100ml making the water potable for drinking. The concentration of heavy metals in all samples complies with the W.H.O standard, making the water safe for drinking. Proper treatment should be embarked on so as to improve water quality and suitability for human consumption.

Keywords: Potable bottled water, quality, Warri

INTRODUCTION

Water is incredibly important aspects of our daily lives as it also serve variety of purpose (http://allaboutwater.org/ Accessed on 5/3/2015). Even with the importance water holds in our lives, we still do not know or have a whole idea about the water we use each day as we fail to recognize the serious threat this water may pose to our health (http://allaboutwater.org/, 2004 Accessed on 5/3/2015). A reliable supply of clean wholesome water is highly essential in a bid to promoting healthy living amongst the inhabitants of any defined geological region (Mustapha and Adam, 1991). Water is a transparent fluid which forms the world's streams, lakes, oceans and rain, and is the major constituent of the fluids of living things (http://en.m.wikepedia.org/wiki/Water Accessed on 3/3/2015). Everyone needs water to survive especially when up to 60% of the human body is composed of water (USGS, 2009). Approximately 75% of the earth's surface is covered by water, but only about 1% of that is drinkable (Soecthig, 2009). Throughout history, humanity has struggled to provide suitable water of sufficient quality for use. The availability of large amounts of water is not sufficient to ensure that the water is potable. The presence of objectionable taste, odor, color, and harmful substances in such water, regardless of its abundance, renders it unsuitable for domestic and other uses (Okeke and Igbonna 2003). Safe drinking water is essential to humans and other life forms even though it provides no calories or organic nutrient. Due to the risk unsafe tap water poses on health, it has brought about dependency on bottled water. Bottled water is seen as water that is sealed in food grade bottles and intended for human consumption. Bottled water can come from a variety of sources including groundwater or surface water from a protected spring (http://unl.edu/enviro/water/ww10_04.shtml Accessed on 9/53/2015). Bottled water we all know could be bought for different reasons including, taste, convenience, poor tap water quality safety concerns, health concerns and as substitute for surgery drinks. It is seen by many that bottle water serve as a safe alternative to municipal water supplies that could be contaminated with pathogens like cholera and typhoid (http://wikipedia.org/wiki/bottled. water Accessed on 4/3/2015). For a water to be potable, used for human consumption, it must meet certain requirements. It must be free of all diseases causing microorganisms, low in concentration of compounds that are acutely toxic or have serious long term effect on health. The guideline for drinking water quality by W.H.O are intended for use by countries as a basis for the development of national standards which if properly implemented will ensure safe drinking water supply. To make sure that water is safe to drink, sets of standards are provided by World Health Organization (WHO 2011).

Consequently access to safe water is recognized to be the foundation for sound health (Kuma and Younger 2000; Rakesh, 2006). Hence this study is essential to monitor water quality used for drinking purposes. Water serves as a major constituent of the human body for physiological and chemical processes and thus essential for health and life as its availability and consumption is very vital for mans' survival and sustainability (Sobsey, 2002). Since drinking water plays an important role for health and well being of human, several epidemiological investigation over the last half century have demonstrated a relation between risk for cardiovascular disease and drinking water hardness (Rylander, 2008). However on a global scale, 783 million people roughly one in ten of the world's populations do not have access to safe water (UNICEF and WHO, 2012). Consequently, access to safe water is recognized to be the foundation for sound health (Kuma and Younger 2000; Rakesh, 2006). Unsafe water is a global intoxication and a worldwide public health threat endangering people to diarrhea and other diseases as well as intoxication of chemical. In Africa, it is estimated that every child has five episodes of diarrhea per year and that 800,000 children die each year from diarrhea and dehydration (WHO, 2000). Apart from water born disease heavy metal contamination in water has also been responsible for mortality and morbidity in human due to intoxication and constitutes public health problem (Ibrahim et al, 2006; Cabrera et al; 2005). In many developing countries availability of water has become a critical and urgent problem and it is a matter of great concern to families and communities. As a result, the World Health Organization (WHO), Food and Agriculture Organization (FAO), United States Environmental Protection Agency (USEPA), as well as the Nigeria Industrial Standard for drinking water have set up standard for heavy metal contamination to ensure the quality and safety of potable water (USEPA, 2011; WHO, 2011; NIS, 2007, FAO, 1997). The quality of drinking water has attracted great affection worldwide because of its implied health impacts. Today, the easy accessibility to drinking water in packaged forms, has resulted in a big and thriving water industry with several hundreds of millions liters of these products consume every year by Nigerians (Ogundipe, 2008). In Nigeria as in some other developing countries, the gap between the demand for safe and potable water and its supply is being filled by private vendors selling packaged sachet and bottled water (Ajay et al 2008; Sholer et al., 2012). Bottled water are usually manufactured and marked by standard companies, both local and multinational. Bottle water is seen by many as safe alternative to municipal water supplies that could be contaminated with pathogens like cholera and typhoid. Bottled water we all know could be bought for different reasons including, taste, convenience, poor tap water quality, safety concerns, and health concerns and as substitute for surgery drinks. However, the source of the water, container safety, and environmental impact remain major concerns for people, as this water may be laced with polyethylene terephthalate (PET) and bisphenol A (BPA) that has leached from the plastic container that holds it, causing serious health problems. Most bottled water manufacturers in Nigeria also produce sachet water and source their raw water primarily from municipal piped water or well water. Adherence to production and analytical standards are doubtful as most of the factories are observed to lack the appropriate technology for achieving these. Despite this, the sale and consumption of bottled water continues to grow rapidly in Nigeria and most countries in the world (Oyedeji et al, 2009). Water has to meet up with certain physical, chemical and microbiological standards, that is, it must be free from diseases producing microorganisms and chemical substance perilous to health before it can be termed potable (Afolabi et al., 2012). In Nigeria the National Agency for Food and Drug Administration and control (NAFDAC) is the parastatal under the ministry of Health charged with the responsibility for the regulation and control of imported and locally processed food and water products (Omogayo et al., 2012). To ensure strict adherence to international standard, NAFDAC'S regulation for bottled and sachet packed water in Nigeria has been put at the standards established by the World Health Organization (WHO). According to these standards, potable water for human consumption must be free of microbial indicators of faecal contamination and coliform count per 100ml of drinking water must be zero (WHO, 1997; PIERE, 1999). Water exists in three states which are: solid, liquid and gaseous. Liquid water is found in many places, it is seen from faucet, when it rains and running in a river. Pure liquid water is free of salt, soil and garbage. Water in liquid state may change to water in the gaseous state. Water evaporates to turn into a gas and this is possible with the help of heat. Liquid water freezes at 0 degrees Celsius forming solid state (ice, snow, icicles e.t.c) (http://www.nyu.edu/pages/mathmol/texbook/slg.html).The changes from a solid to a liquid to a gas or from gas to liquid to a solid are called phase changes. When this occurs, its physical properties change, but not its chemical properties. Melting, freezing, condensation, and evaporation are examples of phase changes (http://www.nyu.edu/pages/mathmol/texbook/slg.html).

Sources of water

Rain water

Its main components are chlorides, nitrates, sulphates, sodium, potassium and ammonic. The rain can be collected from roofs and prepared water sheds which could exist in polluting and making it one of the most unfit sources of water for drinking. (http://www.caritasuni.edu.ng).

Ground Water

Ground water are said to have emanated from the melting of meteoric water (rain, snow and hailstone), into the ground. They have served as source of domestic water supply. It offers cheaper and purer supply. This includes natural springs, wells and boreholes. As it percolates into the earth it is subjected to some purification action by the numerous chains of pervious and impervious rock state or layers. It reaches surface through wells, shafts, springs, borehole. (http://www.caritasuni.edu.ng).

Surface water

This includes streams, ponds and lakes, its main ionic compounds include chlorides, nitrates, sulphates magnesium and calcium. The concentration of components here are more than those in rain water and ground water. The salt content in it is so much that it cannot be used as drinking water because it would take the body a lot of work to flush out excess salt before usage for metabolism, it is also inadequate in the machinery use as it rust machines, it kills most crops and frequently carry suspended solids. (http://www.caritasuni.edu.ng).

Occurrence of water

Water is an essential element to life on planet earth. Everyone needs it to survive especially when up to 60% of the human body is composed of it (USGS, 2009). Human bones constitute 25% of water. Water covers three quarter of the earth surface and constitutes organic materials, as eggs contain 74% water, water melon contains 92%, and cucumber contains 94%. Naturally occurring water is never entirely pure. The purest water is distilled water (Agada, 1998). In small quantity water appears colourless but water actually has an intrinsic blue colour coursed by slight absorption of light at red wave length (Stephen S. Zumdahl, 2013).

Quality of bottled water

The Canadian Bottled Water Association (CBWA) defines bottled water as water that meets all federal and provincial regulations for potable water; it is sealed in a sanitary container and sold for human consumption. Potable water means the water is safe for drinking or consumption. The quality of bottled water can be substantially varied among brand as well as with time and with different production runs depending on its source, treatment technology, manufacturing operation, packaging material and shelf-life before use. Although bottled water should have a shelf life of 30 days unopened. Under prolonged storage of packaged water a favourable environmental conditions, total aerobic heterotrophic bacteria can grow to levels that may be harmful to human (War Burton et al, 1992). Some of the total aerobic heterotrophic bacteria have been identified as opportunistic pathogen (Rusin et al 1997). Thus, consumption of water containing large numbers of total aerobic heterotrophic bacteria can lead to diseases such as Gastroenteritis and mucous membrane infections particularly in persons whose immune systems are compromised by AIDs and organ transplantation (Grabow 1996; Rusin et al 1997). Although, bottled water has an impressive safety record, since there is no major out breaks of illness or serious safety concerns associated with bottled water. But it therefore not means we should have our fingers crossed. There should be a strict regulatory body and regulations to ascertain contaminated free water for consumers (http://wiki.org/Bottled-water).

Properties of water

Physical properties

Water has several physical properties. Water has a molar mass of 18.0151grams per mole. It has a boiling point of 100ºC and a melting point 0.00ºC. Water has a vapour pressure of 23.75torr and density of 1.0 grams per cubic centimeter, surface tension of 71.97dynes per centimeter. The viscosity of water is 0.8903 centipoises.

Chemical properties

1. Water reacts with oxides of non-metal to produce acids

$SO_3 + H_2O \longrightarrow H_2SO_4$ (tetraoxosulphate (vi) acid)

2. Water reacts of metal to form basic

$CaO + H_2O \longrightarrow Ca(OH)$

$Na_2O + H_2O \longrightarrow 2NAOH$

3. Water reacts with metals in number of various to liberate hydrogen

$2NA_{(s)} + 2H_2O_{(g)} \longrightarrow NAOH(aq) + H_2\ (g)$

Other chemical properties of water are oxidation and reduction. Water is not a strong oxidizing agent although it enhances the oxidizing of water is its reaction with the alkali and alkali earth metals even in the cold (Gregoria, 2002).

Hardness of water

Hard water does not form lather when mixed with soap on like soft water. This hardness in water is caused by dissolved magnesium and calcium ions. These can get into the water when it comes into contact with limestone and other calcium containing rocks (GCSE Bitesize science-hardness of water_Revision pg 2014).

Temporary hardness

This is caused by dissolved calcium hydrogen carbonate $Ca(HCO_3)_2$. Rainwater is naturally acidic because it contains dissolve carbon dioxide from the air. It reacts with calcium carbonate in rocks to form calcium hydrogen carbonate. Calcium carbonate + water + carbon dioxide→Calcium hydrogen carbonate Temporary hardness is removed by boiling the water. When this happens, soluble calcium hydrogen carbonate decomposes to form calcium carbonate (insoluble), water and carbon dioxide. (GCSE Bitesize science-hardness of water_Revision pg 2014).

$Ca(HCO_3)_2 \rightarrow Ca(1)_3 + H_2O + CO_2$

Permanent hardness

This is caused by dissolved calcium sulphate. Unlike temporary hardness it is not removed by boiling the water. Sodium hydroxide can be used to soft hard water as shown below: (GCSE Bitesize science-hardness of water_Revision pg 2014).

$2NaOH + MgSO_4(aq) \rightarrow Mg(OH)_2(s) + Na_2SO_4(aq)$

Importance of water

Water is very necessary and it is required by both nature and human for domestic and industrial purpose.

Water plays an important role in the world as it functions as a solvent for variety of chemical substance and facilities, industrial cooling and transportation. Domestic use of water includes; cooling, washing of clothes, to shower, drinking and washing away waste water for industrial purpose can be used for cooling of machinery to prevent over heating as in vehicle radiators, power plants etc.

Contaminant

A contaminant is a substance that is where it should not be. It is an undesirable substance (physical, chemical or biological). That may have harmful effects at high levels. It may be found in soil, plants, air, water, sea animals, land animals etc.

Pollutant

This is referred to as any substance whether in a liquid, solid or gaseous form which directly or indirectly adversely altars or destroys the quality of water or environment (Ministry Of Irrigation and Water Development, 2005). Pollutant can be seen to be physical pollutant (silt, clay, weeds, discarded object, decaying organ material) which affect the aseptic quality of water, chemical pollutants (lead, cadmium and mercury etc.) which are non-biodegradable toxic heavy metals, and microbial pollutants which arise from the discharge of effluents from domestic sources and manufacturing industries into surface water.

Water pollution

Water pollution is the contamination of water bodies such as lakes, river, oceans and groundwater. All water pollution affects organisms and plants that live in these water bodies and in almost all cases the effect is damaging either to individuals, species or to the natural biological communities. It occurs when pollutants are discharged directly (point source) or indirectly (non-point source) into water bodies without adequate treatment to remove harmful constituents.

Water quality criteria

These represent the best efforts of knowledgeable groups to define specific quality characteristics that are necessary to support various water uses, bases for judging whether environment quality in a resource is suitable for its proposed uses and, if not, what specific changes might be necessary to make it so. Criteria are not absolute values but judgment calls that include safety margins and are subject to change as new knowledge and conditions develop. Acceptable water quality criteria for drinking water are based on acceptable national objective of producing safe acceptable and economically useful water supplies. In a similar way, for wastewater, it must be based on the acceptable national objective of removing wastewaters economically, safely and without nuisance or adverse side effects. Hence such quality criteria must have reference to:

1. The aesthetic enjoyment of natural waters and their furtherance of aquatic recreation such as boating, bathing, camping and fishing.
2. The protection of aquatic and related wildlife in terms of fisheries, shellfish culture and game. In practice, a comparison of data for the water question with the appropriate published (periodically) criteria provides a basis for judging probability that the resource would be satisfactory for beneficial uses that are under consideration and if not, what changes in quality would be necessary to make it suitable for those purposes. For example, if the goal for a stream is to be used for irrigation of crops, for that to be feasible, the water should have certain quality characteristics, including limited boron content. A panel of experts, working on experience has proposed a set of criteria which indicates that boron must be about 750mg/l or less for good crops. Thus, the quality criterion of 750mg/l Boron can be used to judge the suitability of that water for irrigation (Kotz 2005).

Water quality standard

Water should meet different quality specification on the particular use. For example, potable and domestic water should be harmless for the health of man, have proper organoleptic properties and be suitable for domestic use (Taras, 1989).

Effect of impurities in water

Some of these impurities are the intrinsic property of the source itself and are present in the water since its origin from that particular source; on the other hand, some of the following enlisted impurities are introduced in the water after its origin. Among these impurities, some are introduced by humans as a result of our day-to-day activity from factories and industries and some are introduced in the water source by cattle, livestock and other animals. Some of the impurities are also introduced by dead and rotten fauna. So, the following list considers impurities that originate from all these sources and enlists the appearing impurities in the decreasing order of their severity (http://listdose.com/top-10-impuritis-badwater-can-have-2/accessed on 6/06/2015.

Microorganisms

Microorganisms are perhaps the most important and deadly impurities present in water. Living organisms like algae, bacteria, protozoa and several kinds of virus like rhino-virus, echo-virus etc. can present a variety of diseases that can even be transmitted by water and are therefore called water borne diseases. Some of the water borne diseases is cholera, diarrhea, giardia etc. The most common bacterium found in water is Escherichia Coli or e-coli and is considered to be one of the first microorganisms ever to infect water. Some of the pathogens can cause gastroenteritis and dysentery that can cause destruction on a large scale. Several methods have been prescribed by doctors and specialists to counter this problem of microorganisms in water and make the water potable. One of the methods is ultra-filtration which consists of filtering the impure water through a filter that has microscopic pores, typically in the range of 0.1 micron. Chlorine and other halogens are used to disinfect the water from microorganisms in many applications. Treatment with chlorine has proved to be very worthwhile and has shown very good results (http://listdose.com/top-10-impuritis-badwater-can-have-2/).

Colloids

Colloids are distinct from true solutions in the sense that colloidal solutions show various properties like scattering of light and particles show Brownian movement. The particles of the colloidal solutions have the property of selectively absorbing ions and result in pollution of the water. As a result of this it is very important to remove these impurities to make the water potable (http://listdose.com/top-10-impuritis-badwater-can-have-2/).

Dissolved gases

Several dissolved gasses in potable water can cause a lot of problems and health issues. Excess oxygen and nitrogen dissolved in water not only may cause water pollution but also it can cause soil pollution when it seeps into the ground. As a result, it results in damaging the plants and trees. One can therefore firmly say that getting rid of the dissolved gasses is an essential part of the process of purification of water (http://listdose.com/top-10-impuritis-badwater-can-have-2/).

Heavy metals

In the United States of America alone, heavy metal poisoning accounts for a big proportion of the deaths in a year. Some of the heavy metals that can get into the water are Iron, Lead, Cadmium, and Arsenic etc. Heavy metal poisoning is not only harmful by it, but also it can pair up with other health problems and can lead to deadly consequences if not treated properly. Heavy metals can be present in the surface of the earth and get into the flowing stream of a water body. Essential steps should be taken to treat the water that contains heavy metals to render it safe for use (http://listdose.com/top-10-impuritis-badwater-can-have-2/).

Hard metals

Hard metals like Calcium and Magnesium lead to the hardness of the water and cause what we know as hard water. When dissolved in water these metals split into Ca++ and Mg++ ions that account for the hardness of the water. For washing purposes, the harness can be treated by Na_2CO_3 or washing soda or it can be passed through ion exchange softener (http://listdose.com/top-10-impuritis-badwater-can-have-2/).

Human waste

We as humans are very much aware about the damage that we can cause to nature and all the natural resources available to us. But history is the witness that we are programmed to be careless and we by our own actions sometimes cause our downfall. Human wastes that tend to pollute the water include wastes from defecation, wastes from unused food and materials, plastic wastes and other suspended matter. In fact most of the impurities that are present in the water listed below (even some of the major ones) are present as a result of the human activities. Most of the suspended human wastes can be removed by crude filtering, however, only removing the human wastes does not render the water fit for use either by humans themselves or by cattle and livestock. For that we have to consider other and more deadly impurities that are or may be present in the water source. Some of them are enlisted below (http://listdose.com/top-10-impuritis-badwater-can-have-2/).

Suspended impurities

Suspended impurities can originate from humans, animals and plants etc. But some of the suspended impurities can be inherent to the water and can originate from the source as well as it can get into the water body anywhere in its course. Suspended impurities can make the water hazy and impure. Some of the suspended impurities like sand, mud and clay tend to pollute the water. Most of these settle down over time but some may remain suspended and can only be removed after they have been filtered. However filtering, by itself does not result in usable water and for that purpose one has to use other methods of purification (http://listdose.com/top-10-impuritis-badwater-can-have-2/).

Parameters for accessing water quality

The fate and transport of many pollutant and determined by not only hydrological cycles, but also by a parameter know as physic-chemical process (which is the physical and chemical parameter present in the water body). In order to mitigate the impact human societies have on natural waters, it is becoming increase important to implement comprehensive monitoring bodies such as FEPA (federal Government Agency) and W.H.O (Alpha, 1998) some of this physico-chemical parameter are:

Colour

In natural water colour is due to the presence of humic acids, fulvic acids, metallicious, suspended matter, weeds, plantation and industrial effluents. Colour is removed to make water suitable for general and industrial applications and is determined by visual component of the sample with distilled water http://www/accounts/1000/shared/download/limnology/html.

Temperature

Temperature plays a very important role in wetland dynamism affecting the various parameters such as alkalinity, salinity, dissolve oxygen, conductivity etc. in an aquatic system these parameters affect the chemical, and biological reactions and physiological reactions of organism etc. water temperature of drinking water has an influence on its taste http://www/accounts/1000/shared/download/limnology/html.

Turbidity

This is an expression of optical property, where in light is scattered by suspended particles present in water (tyndall effect) and is measured using a nephelometer. Suspended and colloidal water such as that, finely divided organic and micro organic matter, plantation and other microscopic organism cause turbidity in water. Turbidity affects light scattered absorption properties and aethectic appearance in a water body. Increases in the intensity of scattered light result in higher value of turbidity http://www/accounts/1000/shared/download/limnology/html.

Taste and Odour

Are associated with the presence of living microscopic organisms; or decaying organic matter including weeds, algae; or industrial wastes containing ammonia, phenols, halogens, hydrocarbons. This taste is imparted to fish, rendering them unpalatable. While chlorination dilutes odour and taste caused by some contaminants, it generates a foul odour itself when added to waters polluted with detergents, algae and some other wastes.

(water quality monitoring, standard and treatment) http://www/accounts/1000/shared/download/limnology/html.

Chemical parameters

Biological oxygen demand

BOD is the amount of oxygen acquired by microorganism for stabilizing biological decomposable organic matter (carbonaceous) in water under aerobic conditions. The test is used to determine the pollution load of waste water, the degree of pollution and efficiency of waste water treatment methods. 5 – day BOD test being a bioassay(procedure involving measurement of oxygen consumed by bacterial for degrading the organic matter under aerobic conditions) requires the addition of nutrient and maintaining the standard condition of pH and temperature and absence of microbial growth inhibiting substances http://www/accounts/1000/shared/download/limnology/html.

pH

The pH is a measure of free hydrogen ion and hydroxylions which maintain acidic and basic property in the water system pH is an important indicator of water which is altering chemically because it can be affected by chemicals in the water. The standard value of pH for drinking is 6.5-8.5 according to BIS. pH value ranges from 0-14. A neutral solution has a pH of 7. A solution with pH below 7 is acidic while that of solution with a pH above 7 is alkaline.

Conductivity

Conductivity is the measure of the ability of an aqueous solution to convey an electric current which is used an indicator of total concentration of ion in water solution. There is a high degree of correlation between EC and TDS as both signify the amount of dissolved solid.

Total dissolved solids (TDS)

Total dissolved solids is the measure of constitute concentration which indicate the salinity behavior of groundwater. Water containing more than 500 mg/L of TDs is not considered desirable for drinking water supplies, but in unavoidable cases 1500 mg/L is also allowed. Dissolved solids are solids that are in dissolved state in solution. Waters with high dissolved solids generally are of inferior palatability and may induce an unfavourable physiological reaction in the transient consumer.

Total hardness (TH)

Hardness is the property of water which prevents the lather formation with soap by formation of complex with calcium, magnesium present on water. So hardness depends upon calcium or magnesium or both. Carbonates and bicarbonates of calcium and magnesium cause temporary hardness. Sulphates and chlorides cause permanent hardness.

Biochemical oxygen demand (BOD)

BOD measures the quantity of oxygen consumption by microorganisms during decomposition of organic matter. Though it is not a precise quantitative test, it is widely used as an indicator of organic quality of water. The high BOD may indicate fecal and organic waste contamination from human and animal sources and restricts the use of water for drinking and domestic use. An increase BOD asserts a potential health threat to the people those who are using the water with high BOD for drinking. Thus it is important to monitor BOD to identify areas posing a threat to health, to identify sources of contamination and ensure adequate action for remedial measures.

Chemical Oxygen Demand (COD)

COD determines indirect measure of the number of organic compounds present in water. This is a very good indicator of water quality and a check commonly used by Municipalities and governing bodies to assess water quality. High COD may be a consequence of sewage contamination. Dissolve oxygen is consumed in the oxidation-reduction reactions of introduced compounds such as nitrate(NO_3^{1-}), ammonium(NH_4^{1+}), sulphate (SO_4^{2-}), sulphite (SO_3^{1-}), ferrous (Fe^{2+}) and ferric (Fe^{3+}) ions.

Alkalinity

Alkalinity of the water has the capacity to neutralize the strong acids due to presence of carbonate, bicarbonate compounds of calcium, magnesium etc. it is expressed in terms of parts per million or mg/litre. Alkalinity is actually needed for the effective water softening and corrosion control.

Total solids

Total solids are considered to be the sum of dissolved and suspended solids. In water sources the dissolved solid which usually predominate, consist mainly of inorganic salts, small amount of organic matter and dissolved gases. The suspended solid contents much of organic matter any increase there of renders to increase the degrees of pollution of water, if used for public health purpose. The upper limit 500ppm has been sent in order to control undesirable taste and diarrhea. The permissible limit of TDS suitable for drinking is 500mg/l (W.H.O). the Total Dissolved Solid values of water sample in study area ranged from 920 to 2800mg/l.

Lead

Lead is soft, silver bluish white metal. It is in the fourth group of the periodic table with atomic weight of 207.2 and atomic number of 82. All lead compounds are serious cumulative body poisons; acute Lead poisoning usually affects the gastro intestinal tracts or the nervous system or both. This can led to severe headache, vomiting sweetish metallic taste burning in the mouth, anorexia (loss of appetite for food) Nausea (sickness inclination of vomit) natural water contains less than 0.1mg/l of Lead (Pb) (Weine, 2000).

Sodium (Na^+)

Sodium ranks sixth among the element in order of abundance, therefore it is present in most natural water, its major source is from the weathering of feldspars, evaporates and clay.

A concentration of 3.0×10^{-6}ppm is recommended for feed water destined for high pressure boiler. It is removed by the hydrogen-ion exchange process or by distillation. A person affected with certain disease requires water with a low concentration of Sodium (Gregoria, 2002).

Cadmium (Cd^{2+})

Cadmium is highly toxic and has been implicated in some case of poisoning through food. Minute quantities of Cadmium are suspected of being responsible for adverse charges in arteries of human kidneys Cadmium also cause some certain cancers. The concentration of 200mg/l of Cadmium is toxic to certain fish. It enters water as a result of industrial discharges or the deterioration of galvanized pipes (Gregoria, 2002).

Chloride (Cl^-)

The presence of chlorides in water gives it a salty taste and this varies in accordance with the quality of Sodium ions. Very small quantity of dissolved Sodium ion gives water a sharp taste than some quantity of ions of Calcium and Magnesium which is not noticeable. The chloride concentration should not exceed 250mg/l, however more than this value is not harmful to human being but it will only make the undesirable for drinking. The presence of chloride in water may be as a result of pollution by human excreta, sewage, effluents, industrial and dissolution of chloride contain in top soil by percolation and infiltration of rain water (Gregoria, 2002).

Bacteriological count

This is a measure of concentration of coliform bacteria in water. Coliform group of bacteria is made up of Escherichia coli, streptococcus faecalis, colitridium perfingens and bacteriophages. Coliform bacteria are common in the environment and are generally harmful. The presence of these bacteria in drinking water is usually as a result of problem with the treatment system or the pipe which distributes water and indicates that the water has been contaminated with germs that cause diseases. Fecal coliform and E.coli are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes can cause short term effects such as diarrhea, cramps, nausea, headache or other symptoms. Their presence in water implies that pollution has occurred in the water. It is therefore recommended by the World Health Organization, that potable water should be free from coliform group of bacteria (Weine, 2000).

Monitoring of contamination

Unlike tap water quality, which is subject to strict governmental regulatory standards, in most countries bottled water is regarded as a food product and regulated as such. Commercial foodstuff is subject to less restricting regulations and enforcement methods. Emphasize is mostly put on truthful labeling, sanitary processing and transport condition.

Purposes for monitoring

Monitoring can be conducted for the following purposes

- Characterize waters and identify changes or trends in water quality over time.
- Identify specific existing or emerging water quality problems.
- Gather information to design specific pollution prevention or remediation programs.
- Determine whether program goals-such as compliance with pollution regulations or implementation of effective pollution control actions are being met.
- Response to emergences, such as spills and floods.

Water as a direct vehicle for disease transmission

Research has confirmed at least thirty-six infection diseases that probably can be transmitted directly by water. They include twelve diseases caused by bacteria, four by viruses, nineteen by protozoa and other parasites and one by several different infections agents. Example are amebiasis, balantidiasis, giardiasis and caused by protozoan; angiostrongyliasis, anisakiasis, hepatic capillariasis and gnathostomiasis caused by nematodes; cholera, enteropathogenicdiarrhes leptospirosis salmonallosis and typhoid fever caused by bacteria; hepatitis A and poliomyelitis caused viruses; fascioliasis, paragonimiasis and schistosomiasis caused by trematodes etc. There are termed “Water-borne” diseases (Gleick 1993).

The relationship between water and health

The relationships between water and health are divided into four categories as follows:

i. Water often plays an important role as a vehicle for the direct transmission of microorganisms that cause infectious diseases.
ii. In other circumstances, water may have an indirect role by serving as the habitat for mosquitoes and other vectors that transmit disease producing organisms.
iii. Water can also be an important vehicle for transmitting many types of chemical toxicants.
iv. Water can also be of important and beneficial effects on health, either because of its use in general sanitation or because of its chemical constituents (Kulshashtha, 1998).

Beneficial health effects of water

i. Satisfying our metabolic needs for water, without which life can only continue for a short time. It is crucial for survival.
ii. Several chemicals in water are beneficial:
iii. Fluoride reduces dental caries among young people
iv. Iodine prevents goiter
v. Calcium and magnesium offset negative effects of sodium in hypertension and heart disease.

MATERIALS AND METHODS

The brands of bottled water with NAFDAC numbers were collected at random from various bottled water companies in Warri and sent to the laboratory for analysis. The names of these bottled waters were not revealed in the assessment for the safety of the companies involved and consumers. The American Standard Test Method was used in the laboratory to assess water potability (Tables 1 and 2).

Determination of pH ASTM-D1293-78

The instrument was plugged to a socket and the pH was powered on. The electrode was rinse with distilled water and the instrument was calibrated with buffer solution (4, 7, 10). The electrode was re-rinsed and cleaned up with tissue paper. 100ml of sample was poured into clean beaker and the electrode was inserted into the sample without allowing the electrode to touch the beaker.

Determination of conductivity ASTM-D2624-09

The electrode of the conductivity meter was rinsed with distilled water and cleaned with tissue paper. 100ml of sample water was then poured into a clean beaker.
The electrode was the inserted in the sample without allowing it touch the beaker, readings were read from the screen of the conductivity meter after few minutes and it was then recorded.

Determination of temperature ASTM C106417-08

The pH meter comprising of a thermometer was plugged on and the thermometer was rinsed with distilled water and later with the sample. It was then adjusted to temperature mode and inserted in the water sample while the indicator blinks until it stopped and readings were taken from the screen and recorded in degree Celsius and the thermometer was removed and placed in distilled water after rinsing.

Determination of turbidity ASTM-D6855-12

The turbid meter was first calibrated using the stock turbidity standard of non values after which the various sample were analyzed. The sample was stirred for few minutes and air bubbles were allowed to disappear. The sample bottle was first rinsed with each water sample before analyzing each of them. The value of turbidity for samples was read from the screen of the instrument and results were recorded in NTU unit.

Determination of total dissolved solid ASTM-1888

Total dissolved solid was determined by evaporation of the particulate and the dissolved solid was separated by filtration and was individually evaluated with the particulate matter was dried. Being free from oil matter by extracting, it was dried again and weighed. The solution of dissolved matted was evaporated to dryness using a dish provided with a constant level control. Sufficient accuracy for the measurement, and a sampling material was provided for other analytical requirements. The residue was dried and weighed. The volatile matter in any of the three classifications was subsequently removed by ignition. The total particulate dissolved, volatile or fixed

Table 1: Materials and equipment.

Materials / Equipment	Model
pH meter	pH meter (JENWAY. 3510)
Tturbid meter	Tturbid meter (HACH 2100N)
Test tube	Pyrex
Beaker	Pyrex
Pipette	Pyrex
Measuring cylinder	Pyrex
Spatula	Stainless
Conical flask	Borosilicate
Retort stands	Fisher
Conductivity meter	Conductivity meter (JENWAY, 3510
Magnetic stirrer	(OHAUS) Model GT 4000v
UV/visible spectrophotometer	UV/Vis cecil 5000
Buck Scientific AAS	200A
Membrane Filtration apparatus	Gallenhamp incubator size one
Incubator	Gallenkhamp incubator size one
Plastic stirrer	Gerad
Burette	Pyrex
Volumetric Flask	Pyrex
Conical flask	Pyrex
Binocular lenses	Olympus
Funnel	Pyrex
Petridis	Pyrex
Vacuum pump	Gallenkhamp
Absorbent pad	Millipore coporation
Filter paper (size 0.45µm)	What man

Table 2: Chemical/reagents and sources.

CHEMICAL/REAGENTS	SOURCES
Distilled water	Locally prepared
Water samples	Locally prepared
Dilute hydrochloric acid	M&B Ltd England
Hydroxylamine	M&B Ltd England
Phenanthroline	M&B Ltd England
Ammonium acetic acid (NH_4OH)	M&B Ltd England
Ammonium Chloride (NH_4Cl)	M&B Ltd England
Enchrome T black indicator	BDH chem. Ltd pool England
Ethyl Diamine Tetra Acetate (EDTA)	M&B Ltd England
Sodium hydroxide (NaOH)	M&B Ltd England
Murexide indicator	BDH Chem. Ltd pool England
Nitric acid	BDH Chem. Ltd pool England
Diphenyl Carbazone Indicator	BDH Chem. Ltd pool England
Mercuric Nitrate	BDH Chem. Ltd pool England
Concentrated Hydrochloric acid	M&B Ltd. England
o-toluedine	BDH Chem. Ltd pool England
Ammonium Molybdate	BDH Chem. Ltd pool England
Oxalic acid	BDH Chem. Ltd pool England
M-Endo medium	Oxide Ltd. Basingstock Hampshire England
Alcohol	BDH Chem. Ltd pool England
Trioxonitrate (v) acid (HNO_3)	BDH Chem. Ltd pool England

matter is then calculated from the various weights obtained.

Calculation

$$\text{Total dissolved solids/L} = \frac{(A-B) \times 1000}{\text{Sample volume (ml)}}$$

Where A= weight of dried residue + dish (mg)
B= weight of dish (mg)

Determination of dissolved oxygen ASTM-D1252

The samples were transferred to a BOD bottle, with care to minimize exposure to air. A tube was use to introduce water to the bottom of the bottle, it was removed slowly while the bottle overflows. 2ml of $MgSO_4$ reagent was added with a dropper. Similarly, 2ml of Sodium oxide solution was introduced followed by 2ml of NaOH solution. In each case the tip of the pipette should be 2.5cm below the neck of the bottle so that the 2ml quantities are discharged into the back of the contents. A stopper was the placed in the bottle ensuring that air was entrapped. The bottle was inverted to distribute the precipitate uniformly. When the precipitate has settled for at least 3cm below the stopper, 1ml of concentrated H_2SO_4 was introduce. The stopper was replaced and the solution was mixed until the precipitate dissolves. Using a graduated cylinder, 200ml of the acidified sample was measured into a 500ml conical flask.

Determination of total coliform (presumptive test)

5 tubes each containing 10ml sterile double strength laurey tryptose broth inoculated with 10ml of aliquot of water sample. Another set of 5 tubes each containing 5ml of single strength medium with 0.1ml of aliquot of water was also prepared. All inoculated tubes were then incubated aerobically at 37^{o}C for 48 hours. All tubes showing yellow coloration are cid positive while air bubbles seen at the Durham tubes are gas positive. The results obtained were then compared with McCrady's table for most probable number per 100ml of water sample.

Determination of sulphate ASTM-D516

50ml of sample was measured into a 200ml beaker and 10ml of glycerin solution was added and also 5ml of Sodium chloride solution was added with about 0.3g of Barium chloride ($BaCl_2$) crystals was included while being stirred with a magnetic stirrer for 1 minute. The solution was allowed to stand for 4 minutes and stirred again for 15 minutes. The blank was run and samples were also calibrated with uv/vis spectrometer at 420nm.

Determination of heavy metals (Wet oxidation method) USING AAS Machine (SPECTRO AA 220)

- About a 100ml of well mixed water sample was measured into 150ml beaker.
- 5.0ml of concentrated HNO3 was added
- The solution was evaporated to near dryness on a hot plate, making sure that the sample does not boil (using low to medium heat).
- The beater and the content were allowed to cool.
- Another 5.0ml of concentration HNO_3 was added to the beaker
- The beaker was immediately covered with a watch glass
- The beaker was returned to the hot plate and a gentle reflux action of the solution was set by increasing the temperature of the hot plate (medium to high)
- A continuous heating with the addition of HNO_3 as necessary was done until a light-color residue was obtained (digestion completed)
- 1-2ml of concentration HNO_3 was added to residue
- Washed with distilled water
- It was filtered in 100ml volumetric flask to remove silicate and other insoluble materials
- The solution was stored in 25ml polypropylene bottle

Determination of chloride (Mercurimetric titration method) ASTM-D512-89

A 100ml of sample was measured into 250ml conical flask. Then, 1ml HNO_3 solution was added, following the addition of 0.5ml of mixed indicator solution and the mixture (solution) was shaken. Then, the solution was titrated with 0.025m mercuric nitrate solution until the colour changes from yellow to blue-violet.

Determination of total dissolved solid in water with conductivity meter ASTM-D1125-82

The electrode of the conductivity meter was thoroughly rinsed with distilled water. 100ml of the sample as then poured into a very clean beaker. The electrode was immersed into the water. The conductivity meter was then switched on; the reading was taken from the meter after five minutes.

Table 3: Result bottle water potability.

PARAMETERS	SAMPLE A	SAMPLE B	SAMPLE C	W.H.O Permissible Limit
pH	6.45	7.28	6.20	6.5-8.5
Conductivity (us/cm)	72.50	65.67	102.75	N/S
Temperature (ºC)	27.9	28.7	28.5	
Total Dissolved Solids (mg/l)	40.60	36.78	57.40	500
Total Suspended Solids (mg/l)	0.00	0.00	0.50	5
Turbidity (mg/l)	1.00	0.00	0.00	5
Chloride (mg/l)	11.40	15.60	18.50	600
Sulphate (mg/l)	0.04	0.06	0.06	N/S
Dissolved Oxygen (mg/l)	4.72	5.81	4.71	N/S
Biochemical Oxygen Demand (mg/l)	0.50	0.70	0.92	10
Total Coliform (Cfu/100ml)	<0.03	<0.03	<0.03	0
Sodium (mg/l)	7.42	9.60	6.50	<20
Iron (mg/l)	<0.001	<0.001	<0.006	1
Lead (mg/l)	<0.001	<0.001	<0.001	0.003
Cadmium (mg/l)	<0.001	<0.001	<0.001	<0.001

Determination of biochemical oxygen demand APHA-507

The sample analyzed was diluted in BOD dilution water and kept in the dark at a temperature of 20ºC for five days at the end which the dissolved oxygen left was determined and the BOD calculated from the initial BOD and the final BOD of the diluted sample was taken into cognizance of diluted factor sample.

RESULTS AND DISCUSSION

Table 3 shows the result obtained from the analysis compared with the World Health Organization (W.H.O) standard for potable water. From the table, the following were observed. The pH of sample B (7.28) is higher than that of sample A (6.45) and C (6.20), indicating that sample A and C do not fall under the range of the WHO permissible limit (6.5-8.5) and it is acidic, unlike sample B (7.28) which is in accordance with the W.H.O standard. The level of conductivity of sample C (102.2 us/cm) is seen to be higher than that of sample A (72.50 us/cm) and sample B (65.67 us/cm), although they all conform to W.H.O standard for drinking water. The temperature of the three brands; A (27.9^{o}C), B (28.7^{o}C) and C (28.5^{o}C) correlates with W.H.O standard for potable drinking water 25-30ºC. The value of the Total Dissolved Solid for the samples A, B and C range from 36.78mg/l to 57.40mg/l which is lower than the permissible limit compared to W.H.O. This shows that the water is not harmful for consumption. The Total Suspended Solid found in the water in the course of this analysis for the three samples A (0.00mg/l), B (0.00mg/l), and C, (0.50mg/l). It was seen to be in conformity to the W.H.O standard for drinking water and it is also fit for drinking. The turbidity for sample B and C was 0.00mg/l respectively but that of sample A was 1.00. although when compared to W.H.O standard for drinking water, all samples were within the permissible limit which makes them all safe for drinking. The chloride content of the sample A (11.40mg/l), B (15.60mg/l), and C (18.50mg/l) are seen to be very low below the W.H.O permissible limit (600mg/l), for drinking water. The Sulphate in samples A (0.04mg/l), B (0.06mg/l), and C (0.06mg/l) is seen to be in low concentration, making it fit for drinking, because Sulphate in water at high concentration when ingested may result in diarrhea. The Dissolved Oxygen for samples A (4.72mg/l), B (5.81mg/l) and C (4.71mg/l) were seen to be within the WHO permissible limit for drinking water. The Biochemical Oxygen Demand for the samples A (0.50mg/l), B (0.07mg/l) and C (0.92mg/l) are seen to be low and they meet the W.H.O permissible limit for drinking water (10mg/l).

The result obtained for Coliform bacteria show that sample A, B and C have <0.03cfu/100ml when compared with the W.H.O standard (0cfu/100ml) making the water free from coliform group of bacteria consisting of Escherichia coli, Streptococcus faecalis and Clostridium perfringens. The concentration of sodium in the various samples A (7.42mg/l), B (9.60mg/l) and C (6.50mg/l) are below the official limit (200mg/l) i.e. WHO permissible limit. Sodium is beneficial and needed for the body, but can be harmful to people with certain disease such as Ulcer. Hence it is harmful. The concentration of iron in the samples A, B, and C are <0.001mg/l, <0.001mg/l and 0.006mg/l. respectively which fall within the range stipulated by W.H.O specification for drinking water. Although iron is essential for health because it transports oxygen in the blood in as much as higher concentration of iron is not hazardous to human health; it is not permitted in potable water because it is considered a secondary or aesthetic contaminant. The Lead content in all samples A, B, and C was <0.001mg/l, which is less than the permissible limit (0.003mg/l) for drinking water as recommended by W.H.O. If such water is consumed, the accumulative body poisoning is reduced. The value for the analysis of Cadmium for various samples A, B, and C were seen to be <0.001mg/l for each of the samples which is in line with internationally prescribe standard by W.H.O. The risk of illness via consumption of the water is therefore drastically reduced.

CONCLUSION

This study determined the potability of three different brand of bottled water. The compliance of each sample type with W.H.O standard for given parameter was analyzed. The aim of the evaluation of these different brands of bottled water was to ascertain the quality of the three bottled water. The observation from the analysis carried out revealed that the three bottled water brands were in compliance with the permissible limit for drinking water by W.H.O. The sample A was seen to have a pH of 6.45 and that of B was 6.20 which were very close to the standard value for pH (6.5-8.5) for drinking water unlike that of sample B (7.28). On the other hand, the values for the other parameters for the three bottled water brands were seen to be within the W.H.O permissible limits, revealing that the water is fit for consumption.

RECOMMENDATION

It has been that since the existence of bottled water, there have not been any records of illness/ disease outbreak from bottled water. Since this is true about bottled water, it is necessary to keep up with the good record of bottled water. As such, there should be regular monitoring to ensure conformity to W.H.O standard and to assure the public of a safe and potable drinking water. Routine analysis should also be carried out at interval to ensure that the pH value falls within the range of the permissible limit (6.5-8.5). more also these bottled water industries should ensure a good hygiene in the process of filling and packaging their water, as this will ensure a safe drinking water for consumers.

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