APPRAISAL OF WATER QUALITY FOR COMSUMPTION. A CASE STUDY OF BOSSO TOWN

BY

ABBA ABDULKAREEM

2003/18008EA

SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL AND BIO-RESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE.

NOVEMBER 2008.

APPRAISAL OF WATER QUALITY FOR COMSUMPTION. A CASE STUDY OF BOSSO TOWN

BY

ABBA ABDULKAREEM

2003/18008EA

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR AWARD OF BACHELOR OF ENGINEERING (B.ENG) IN AGRICULTURAL AND BIO-RESOURCES ENGINEERING.

SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL AND BIO-RESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE.

NOVEMBER 2008.

DECLARATION

I hereby declare that this work was done by me and was not presented in whole or in part for awardof bachelor of engineering anywhere. All literature cited therein has been duly acknowledged in the reference.

.... 21-11-08 ....

Abba Abdulkareem Date

DEDICATION

I dedicate this project to my wonderful parents who afforded me the opportunity to go to school. To my siblings for the noise and choices they gave to my life, my friends and colleagues but most of all, to the One, the maker and breaker, the highest, Who chanced me the gift of life and knowledge. I say Alhamdu-Lil-Lah.

CERTIFICATION

This is to certify that Abba Abdulkareem of Agricultural and Bio-resources Engineering, schoolof Engineering & Engineering technology, Federal University of Technology, Minna, carried out this work on " Appraisal of Water Quality for Consumption. A case study of Bosso town" in partial fulfillment of the requirement in Agricultural and Bio-reesources Engineering.

21/11/08
....
Mallam Adamu Halilu

Project supervisor

21 - 11 - 08
....
Date

....
Engr. Dr Zinash D. Osunde
HOD

2/12/2008
....
Date

....
Engr Prof G.O. Chukwuma
External Supervisor

19-11-08
....
Date

ACKNOWLEDGEMENT

To the Almighty and All-knowing, God; The One and Source, for life, opportunity and the will to learn.

I will like to also immensely, ackowledge my supervisor, mallam Adamu Halilu,your gentle yet effective corrections and suggestions made it worthy.

My parents as always, who have been there financially, psycologically and morally.

To the men behind the scene, lab technitians in FUT Minna and Bida Polythecnic, Mal. Nma Dangana (Yanma coach), my lectures, too numerous to mention.

Lastly to folks and friends... lets leave it at thank you.

ABSTRACT

Three sampleseach of water were collected around Bosso area namely, Tap, Rain and Well waters. They were taken to Gidan Ruwa and Bida Polytechnic laboratories respectively for various analysis. The quality of the Tap samples were found to be fit for consumption. While the Rain and Well samples require treatment for slight Arsenic, Zinc and feacal coli form concentrations. However, the samples fall within WHO and NAFDAC safe limits for drinking water.

TABLE OF CONTENTS

CHAPTER THREE

LIST OF ABBREVIATIONS

Calcium	Ca
Copper	Cu
Degree Celcius	°C
Dissolved Oxygen	DO
Formazin Turbidity Units	FTU
Iron	Fe
Lead	Pb
Less that 75% of saturation concentration	<75
Magnesium	Mg
Micro Siemens per centimeter	µS/cm
Milligram per Litre	mg/l
Not ment.	Not mentioned
Un-obj.	Un-objectionable
Parts per billion	ppb
Platinum- cobalt units	PtCo
Power of Hydrogen Ion Concentration	pH
Total Dissolved Solids	TDS

CHAPTER ONE

1.0 INTRODUCTION

Water is a common chemical substance that is essential for the Survival of all known forms of life. In typical usage, water refers only to its liquid form or state, but the substance also has a solid state, ice, and a gaseous state, water vapour or steam. Water can dissolve many different substances, giving it different tastes and odours. In fact, humans and other animals have developed senses which are, to a degree, able to evaluate the portability of water, avoiding water that is too salty or putrid. Humans also tend to prefer cold water to lukewarm; cold water is likely to contain fewer microbes. The taste advertised in spring water or mineral water derives from the minerals dissolved in it, as pure H_2O is tasteless. As such, purity in spring and mineral water refers to purity from toxins, pollutants, and microbes.

1.1.1 Characteristics of Water

Water is the chemical substance with chemical formula H_2O: one molecule of water has two hydrogen atoms covalently bonded to a single oxygen atom.

Some of the major chemical and physical properties of water are:

- Water is a tasteless, odourless liquid at ambient temperature and pressure.
- Water is transparent, and thus aquatic plants can live within the water because sunlight can reach them.
- The boiling point of water (and all other liquids) is directly related to the barometric pressure.
- Water is a very strong solvent, referred to as the universal solvent, dissolving many types of substances.
- Pure water has a low electrical conductivity, but this increases significantly upon salvation of a small amount of ionic material such as sodium chloride.

1.1.2 The Water Circle

The Earth's water is always in movement, and the water cycle, also known as the hydrologic cycle, describes the continuous movement of water on, above, and below the surface of the Earth. Since the water cycle is truly a "cycle," there is no beginning or end. Water can change states among liquid, vapour, and ice at various places in the water cycle, with these processes happening in the blink of an eye and over millions of years.

The sun, which drives the water cycle, heats water in the oceans. Some of it evaporates as vapour into the air. Ice and snow can sublimate directly into water vapour. Rising air currents take the vapour up into the atmosphere, along with water from evapotranspiration, which is water transpired from plants and evaporated from the soil. The vapour rises into the air where cooler temperatures cause it to condense into clouds. Air currents move clouds around the globe, cloud particles collide, grow, and fall out of the sky as precipitation. Some precipitation falls as snow and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Snow packs in warmer climates often thaw and melt when spring arrives, and the melted water flows overland as snowmelt. Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the landscape, with stream flow moving water towards the oceans. Runoff, and ground-water seepage, accumulate and are stored as freshwater in lakes. Not all runoff flows into rivers. Much of it soaks into the ground as infiltration. Some water infiltrates deep into the ground and replenishes aquifers (saturated subsurface rock), which store huge amounts of freshwater for long periods of time. Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as ground-water discharge, and some ground water finds openings in the land surface and emerges as freshwater springs. Over time, the water continues flowing, some to re-enter the ocean, where the water cycle renews itself.

1.1.3 Uses of Water

There are four main uses of water, namely;

Drinking. Water is taken from different sources and used for drinking. However its portability also depends on the source.

Domestic. Water is used for cooking, washing clothes, in baths, for showers, for washing cars, in hose pipes, in dishwashers, for central heating and other activities in the home.

Industrial. Factories use water for many different things such as cooling, driving machinery and to generate electricity in a hydro-electric power station.

Agriculture. Farmers take water directly from the river or reservoir to water their crops. Irrigation channels carry water from the river to the farmer's crops. Sometimes farmers use pumps or machinery to get this water from the river.

1.2 Water Quality

How well a particular sample or quantity of water is suited for a particular purpose explains water's quality to a lay-man. However, in a broad, scientific and more precise term, water quality is a terminology used to describe the physical, chemical and biological characteristics of water in relationship to a set of standards. Also, usually in respect to it's suitability for different type of water bodies and water body locations per desired uses. The quality of water depends on its origin and history viz-a-viz, climatic, geographic and geologic conditions. Some other factors provide variations in the quality of water obtained from the same type of sources. These variations derive from the opportunities f or water to take substances into solution or to carry them in suspension. Water quality therefore, is unarguably an important is use because its uses covers virtually all corners of life; from personal human consumption to environmental and industrial application and even aquatic matter.

1.3 Statement of Problem

As a result of inadequate consumable water, the need to assess the different sources of water in the locality arise. Also because of the diseases associated with the consumption of contaminated water.

1.4 Objectives of the Study

1. To analyze the different water samples
2. To ascertain their suitability for human consumption

1.5 Significance of the Study

The study is aimed at eliminating any health risk(s) posed by the effect of low quality water through proper assessment and subsequent advice on the most suitable water for consumption.

1.6 Scope of the Study

The study covers the assessment of some of the physical, chemical and biological parameters of three samples of water (tap rain and well).

1.7 Limitations

The limitations suffered by the study include:-

1. Inadequate research laboratories for laboratory water analysis
2. Inadequate and high cost of reagents required for water quality tests.
3. Poor calibrations of the instruments used in quality appraisals.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1.0 Quality Assessment of Water

The quality of water is determined by physical, chemical and bacteriological tests. (A.K. Chatterjee 2001). All are very important and have their distinct indications. Water quality assessment indicates, thereby ensuring the safety of consumer, goods or quality of goods as to ensure suitability of their intended utility. (Ajisegiri 2001).

Assessing a water and subsequent comparison with set out standards for drinking water provides a very good basis for ensuring consumer safety and/or control of water quality degradation. However, quality assessment may be either subjective or objective owing to the mode of assessment. Subjective assessment is basically by the human senses which are/is person dependant (Piggott 1988). While objective assessment entail evaluations made by the implementation of certain instruments to measure certain parameters. These parameters are however standardized so by comparism, human flaws or errors are minimized (Ajisegiri 2001).

The following is a list of indicators often measured by situational category:

Drinking Water.

- Alkalinity
- Colour of water
- pH
- Taste and odour
- Dissolved metals and salts (sodium, chloride, potassium, calcium, manganese, magnesium)
- Microorganisms such as faecal coli form bacteria (*Escherichia coli*), Cryptosporidium, and Giardia lamblia
- Dissolved metals and metalloids (lead, Mercury (element), arsenic, etc.)
- Dissolved organics: Colored Dissolved Organic Matter (CDOM), Dissolved Organic Carbon (DOC)
- Radon
- Heavy Metals
- Pharmaceuticals

- Hormone analogs

Chemical Assessment

- pH
- Conductivity (also see salinity)
- Dissolved Oxygen(DO)
- nitrate-N
- orthophosphates
- Chemical oxygen demand (COD)
- Biochemical oxygen demand (BOD)
- Pesticides

Physical Assessment

- Temperature
- Total suspended solids (TSS)
- Turbidity

(source; www.iowater.net).

Some qualities considered in this study include;

2.1.1 COLOUR

Colour in water can be caused by a number of contaminants such as iron which changes in the presence of oxygen to yellow or red sediment. Colour from iron is referred to as "apparent colour" rather than "*true colour*". True colour is distinguished from apparent colour by filtering the sample. The most common source of true colour however, is decaying organic matter. True colour is mostly found in surface water. although ground water may contain some colour if the aquifer flows through a layer of buried vegetation. such as from a long buried

slough of a river. Colour is not a toxic characteristic, but is largely considered as a secondary (aesthetic) parameter affecting the appearance and palatability of the water. When chlorinated, colour-causing organic matter may form chlorinated organic compounds such as trihalomethanes. Chloroform is a common trihalomethane, and is along with several others, considered to be a potential carcinogen. For this reason, total trihalomethanes (TTHM's) in public water supplies is limited to 0.1 ppm (100 ppb). Colour is measured in units based on a platinum-cobalt standard solution which forms a yellow tint and is limited to 15 units in public water supplies. Colour can be removed by activated carbon filters, sometimes marketed as taste and odour filters. The activated carbon or charcoal must be replaced after a period of time when its capacity for adsorption of the colour is exhausted. Another treatment method is coagulation and sedimentation using alum or other chemicals this process is normally used only in large plants since its complexity requires the care of a trained water treatment plant operator (www.water-research.net). Testing of colour is done by comparison with a standard set of concentrations of a chemical that produces a colour similar to that found in water (Gary W.Heinke,1996).

Table 2.0 Below are some colour conditions and their probable causes;

Milky	Precipitation of carbonates, excessive air, suspended solids
Blackish Tint	Reactions with manganese and possibly iron, IRB/ Slime Bacteria
Yellowish Tint	Presence of humic or fluvic compounds, iron, IRB bacteria
Reddish Tint	Presence of Dissolved or precipitated iron, iron, IRB bacteria

(Source: Driscoll, 1986; Lehr, 1980)

2.1.2 Taste and Odour

Besides colour described above, taste and odour of drinking water are the first clue to the homeowner that there may be a problem with the water. Primary treatment method used to handle taste or odour problems may include softening, reverse osmosis, chlorination and distillation. The type of pre-treatment would depend on the concentration and type of contamination and associated water quality (www.water-research.net). Tastes and odours are caused by the presence of volatile chemicals and decomposing organic matter.

Measurements for these are conducted on the basis of dilution needed to reduce them to a level barely detectable by human observation (J. Glynn Henry, Gary W. Heinke, 1996).

Table 2.1 Tastes and Odour; Associated Potential Problem Taste Problems

Salty-brackish	High sodium
Alkali Taste	High hardness, total dissolved solids, high alkalinity
Metallic Taste	Low pH, high metal content, corrosive water A metallic taste can be caused by inorganic chemicals such as iron (at levels over 0.004 mg/l), copper (2-5 mg/l), and zinc (4-9 mg/l).

Table 2.3 Odour / Smell Problems in Drinking Water

Rotten-Egg Odour Smell Musty Odours Smell Earthy, musty, grassy, fishy, vegetable and cucumber	Hydrogen sulphide, sulphate-reducing bacteria Soft water reactions in electric water heaters, algal bio products algal bio products
Oily Smell	Gasoline or oil contamination, possibly nuisance bacteria
Methane Gas Smell	Organic decomposition or presence of gas in aquifer
Phenolic Smell	Industrial or gasoline contamination
Chemical Smell	Organic chemicals, Industrial

(Source: Driscoll, 1986; Lehr, 1980)

2.1.3 Temperature

Water temperature is very important for water quality. Many of the physical, biological, and chemical characteristics of water are directly affected by temperature. For example, temperature influences:

1. the amount of oxygen that can be dissolved in water;

2. the rate of photosynthesis by algae and larger aquatic plants;

3. the metabolic rates of aquatic organisms;

4. the sensitivity of organisms to toxic wastes, parasites, and diseases.

Cool water can hold more oxygen than warm water, because gases are more easily dissolved in cool water. (www.indiana.edu).

Temperature is measured in either degree Celsius or degree Fahrenheit, where;

$$^{\circ}C = \frac{(^{\circ}F - 32.0)}{1.80}$$

And; $$^{\circ}F = (^{\circ}C \times 1.80) - 32.0$$

2.1.4 Turbidity

Turbidity is a measure of the relative clarity of water: the greater the turbidity, the murkier the water. Turbidity increases as a result of suspended solids in the water that reduce the transmission of light. Suspended solids are varied, ranging from clay, silt, and plankton, to industrial wastes and sewage (www.indiana.edu).

As well as being aesthetically objectionable, it is a health concern because the particles involved could harbour pathogens.(Gary W. Heinke,1996). Water with enough suspended clay particles (as much as 10 turbidity units) will be visually turbid. Turbidity measurements are based on optical properties of the suspension that cause light to be scattered or absorbed rather that transmitted in straight lines through the samples. Results are then compared to those from a standard suspension. (Gary W. Heinke, 1996). Turbidity is measured as nephelometer turbidity units (NTU) using a turbidimeter.

2.1.5 pH

The technical definition of pH is that it is a measure of the activity of the hydrogen ion (H+) and is reported as the reciprocal of the logarithm of the hydrogen ion activity (www.water-research.net). The range goes from 0 - 14, with 7 being neutral. pHs of less than 7 indicate acidity, whereas a pH of greater than 7 indicates a base. pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water. Water that has more free hydrogen ions is acidic, whereas water that has more free hydroxyl ions is basic. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically. pH is reported in "logarithmic units," like the Richter scale, which measures earthquakes. Each number represents a 10-fold change in the acidity/basicness of the water. Water with a pH of 5 is ten times more acidic than water having a pH of six (www.ga.water.usgs.gov).

A pH meter is used to measure the pH of a water sample. The sample is placed in a cup and a glass probe at the end of a retractable arm is placed in the water. Inside a thin glass bulb at the end of the probe there are two electrodes that measure voltage. One electrode is contained in a liquid that has a fixed acidity, or pH. The other electrode responds to the acidity of the water sample. A voltmeter in the probe measures the difference between the voltages of the two electrodes. The meter then translates the voltage difference into pH and displays it on the little screen on the main box (www.ga.water.usgs.gov).

Before taking a pH measurement, the meter must be "calibrated." The probe is immersed in a solution that has a known and stable pH (a "buffer solution"). The knobs on the box are used to adjust the displayed pH value to the known pH of the solution, thus calibrating the meter (www.ga.water.usgs.gov).

2.1.6 Dissolved Oxygen (DO)

A small amount of oxygen, up to about ten molecules of oxygen per million of water, is actually dissolved in water. This dissolved oxygen is breathed by fish and zooplankton and is needed by them to survive. Rapidly moving water, such as in a mountain stream or large river, tends to contain a lot of dissolved oxygen, while stagnant water contains little. Bacteria in water can consume oxygen as organic matter decays. Thus, excess organic material in our waters can cause an oxygen-deficient situation to occur (www.ga.water.usgs.gov).

2.1.7 Conductivity (Specific Conductance)

Specific conductance is a measure of the ability of water to conduct an electrical current. It is highly dependent on the amount of dissolved solids (such as salt) in the water. Pure water, such as distilled water, will have a very low specific conductance, and sea water will have a high specific conductance. Rainwater often dissolves airborne gasses and airborne dust while it is in the air, and thus often has a higher specific conductance than distilled water. Specific conductance is an important water-quality measurement because it gives a good idea of the amount of dissolved material in the water. (www.ga.water.usgs.gov).

2.1.8 Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) is an expression for the combined content of all inorganic and organic substances contained in a liquid which are present in a molecular, ionized or micro-granular suspended form. Generally the operational definition is that the solids must be small enough to survive filtration through a sieve size of two micrometers. Total dissolved solids are normally only discussed for freshwater systems, since salinity comprises some of the ions constituting the definition of TDS. The principal application of TDS is in the study of water quality for streams, rivers and lakes, although TDS is generally considered not as a primary pollutant (e.g. it is not deemed to be associated with health effects), but it is rather used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of presence of a broad array of chemical contaminants (DeZuen J. 1997).

Primary sources for TDS in receiving waters are agricultural runoff, leaching of soil contamination and point source water pollution discharge from industrial or sewage treatment plants. The most common chemical constituents are calcium, phosphates, nitrates, sodium, potassium and chloride (DeZuen J.1997).

Total dissolved solids are differentiated from total suspended solids (TSS), in that the latter cannot pass through a sieve of two micrometers and yet are indefinitely suspended in solution (Boyd, Claude E. 1999).

2.1.9 Hardness

The amount of dissolved calcium and magnesium in water determines its "hardness." Water hardness varies through different water bodies. Hard water can damage equipment, make it difficult for soap to lather in water. Hard water can even shorten the life of fabrics and clothes (www.ga.usgs.gov).

2.1.10 Suspended Solids

Suspended solids refers to small solid particles which remain in suspension in water as a colloid or due to the motion of the water. It is used as one indicator of water quality (Olivia , Moran, Joseph M.; Morgan, Michael D., & Wiersma, James H. 1980).
It is sometimes abbreviated SS, but is not to be confused with settable solids, also abbreviated SS, which contribute to the blocking of sewer pipe s. Sus pended solids are important as pollutants and pathogens are carried on the surface of particles. The smaller the particle size, the greater the surface area per unit mass of particle, and so the greater the pollutant load that is likely to be carried. Removal of suspended solids is generally achieved through the use of sedimentation and/or water filters (usually at a municipal level).By

eliminating most of the suspended solids in a water supply, the significant water is usually rendered close to drinking quality. This is followed by disinfection to ensure that any free floating pathogens, or pathogens associated with the small remaining amount of suspended solids, are rendered ineffective (Olivia , Moran, Joseph M.; Morgan, Michael D., & Wiersma,James H. 1980).

CHAPTER THREE

3.0 MATERIALS AND METHODS.

Project location

The project was done in Minna town of Niger State, with a particular reference to Bosso municipal area. Water samples were thus all collected there in. Analysis of collected samples was carried out in the Niger state water board (Gidan Ruwa) Minna and the Federal Polytechnic Bida laboratories respectively.

3.1 Material Sampling

Three samples each of tap, rain and well waters were collected from their respective sources within bosso area in sterilized one (1) litre plastic bottles and taken for analysis.

The various water samples were labelled thus;

Tap Water	Sample x_1, x_2, x_3
Rain Water	Sample y_1, y_2, y_3
Well Water	Sample z_1, z_2, z_3

3.2 Experimental Procedure

Water samples were collected and analyzed for their different ranges of properties viz-a-viz physical, chemical and micro-bacteriological and aesthetic qualities.

3.3 Materials

(1) Weighing balance
(2) Bunsen burner
(3) Distilled water
(4) DR/2000/direct reading spectrophotometer (BY HACH)
(5) Powder pillow reagents
(6) Conical flask
(7) pH meter
(8) 25 ml sample cell
(9) Colony counter
(10) Pipettes
(11) Masking tape

(12) Volumetric flask

(13) Temperature/conductivity/TDS meter

(14) Ciba corning meter

(15) Auto claves (with sterilizing temperature up to 121^0c)

(16) Plastic Petri dishes

(17) Atomic Absorption Spectrophotometer (AAS)

(18) Syringe and Needle

(19) Peptone water/ Normal saline

3.4.0 Sample Analysis

3.4.1 Test for Temperature

(1) The meter was turned on.

(2) The ^0c button for temperature was pressed.

(3) The meter probe was immersed in a beaker containing Dionized (distilled) water to clear previous readings and also rinse the probe.

(4) The probe was then immersed in each of the samples in each case, it was ensured that the beaker was free from air bubbles and total immersion of the probe beyond the vent holes was guaranteed.

(5) Subsequent temperature readings displayed on the meter were recorded.

3.4.2 Test for Conductivity

(1) The meter was switched on

(2) The CND button for conductivity was pressed.

(3) The probe was rinsed in Dionized (distilled h_20) water

(4) The probe was then immersed in each of the samples. One after the other, up and down movement of the probe and electrode was done. At the same time immersing the probe beyond the vent holes.

(5) Readings displayed on the meter were accurately recorded in micro Siemens per cm (μS/cm).

3.4.3 Test for Total Dissolved Solids (TDS)

(1) The meter was switched on

(2) TDS button was pressed for total dissolve solids determination.

(3) The probe was rinsed in a beaker containing distilled water.

(4) The probe was then immersed in the beakers containing each of the samples. While moving the probe up and down the beaker and gentle tapping its wall to rid off bubbles from the electrode area,

(5) Readings displayed were noted in milligram per litre (mg/l) or gram per litre (g/l).

3.4.4 Test for Suspended Solids

(1) The meter was switched on

(2) The stored program number for suspended solids was entered by pressing 630 and Read/Enter button so that the display showed: DIAL nm to 810

(3) The wavelength dial was rotated until the small display showed: '810nm'.

(4) Read/enter button was then pressed, and the display showed: mg/l suspended solids

(5) 25 mc sample cell containing distilled water (the blank) was placed in the holder and the lights, shield was closed.

(6) The 'zero' button was pressed and the display showed: WAIT, then: 0.mg/l suspended solids.

(7) The prepared samples each filled in a 25 ml sample cell and each placed in the cell holder and the lights shield closed.

(8) Read/enter button was then pressed and the display showed: WAIT, then: the result in mg/l suspended solids was displayed and subsequently noted.

3.4.5 Test for Turbidity

(1) The meter was turned on and the stored program number for turbidity was entered by pressing the 750 then 'Read/Enter' button. The display showed; DAIL nm to 450

(2) The wavelength dial was rotated until the small display showed: 450nm.

(3) 'Read/Enter' button was again pressed and the display showed: FTU TURBIDITY

(4) A 25 ml sample cell was filled with distilled (the blank) water and placed in the cell holder and the light shield was then closed.

(5) The 'zero' button was pressed. The display showed: WAIT. Then: 0.m FTU TURBIDITY.

(6) The prepared samples were poured in 25ml sample cells and immediately place in the cell holder (each in turn) and the light shield was closed.

(7) Read/enter button was pressed. The display showed: WAIT, then; the result in Formazin turbidity units (FTU) was displayed and recorded.

3.4.6 Test for Colour

(1) The stored program number for true colour was entered, by pressing 120, the 'Read/Enter' button. The display showed: DIAL nm to 455.

(2) The wavelength dial was rotated until the small display showed: 455nm.

(3) Read/enter button was again pressed and the display showed: UNITS PtC_0 COLOR

(4) A 25 ml sample cell of distilled water (the blank) was placed into the cell holder and the light shield was closed.

(5) 'ZERO' button was pressed. The display showed: WAIT, then; 0.UNITS PtCo

COLOR.

(6) 25ml sample cells were filled with the samples and each in turn was placed into the cell holder and Read/Enter button was pressed. Then display showed: WAIT and then; the result in platinum-cobalt units.

3.4.7 Test for pH

(1) 2 clean 10ml cuvettes were used for each sample test.

(2) Dionized (distilled) water was filled in one cuvette and served as the blank.

(3) Then each sample was placed in the other cuvette and 1 to 2 drops of phenol red indicator was added.

(4) The probe was rinsed in the blank cuvette

(5) Then immersed in the cuvette containing a sample and rotated for measurement by the meter. The results were all recorded.

3.4.8 Test for Sulphate

(1) The stored program number for sulphate- (So_4^{2-}) - powder pillow was entered by pressing 680 and the 'READ/ENTER' button. The display showed: DIAL nm To 430

(2) The wavelength dial was rotated until the small display showed: 450nm.

(3) Again the 'READ/ENTER' button was pressed. The display Mg/l So_4^{2-}.

(4) Sulfo-Ver 4 reagent powder pillow was added to the samples and then the 'SHIFT and TIMER' button was pressed. A 5-minute reaction period began.

(5) A blank sample was prepared and place into the cell holder and the light shield was closed.

(6) 'ZERO' button was pressed. The display showed: WAIT, then: 0.mg/l so_4^{2-}

(7) Within five minute the timer beeped and then the samples were placed into the cell holder and the light shield was closed.

(8) 'READ/ENTER' button was pressed. The display showed: WAIT, then: the results in mg/l so_4^{2-}.

3.4.9 Test for Nitrate

(1) The stored program number for nitrate was entered by pressing 355 and the 'READ/ENTER' button. The display showed: DIAL nm to 500.

(2) The wavelength dial was rotated until the small display showed: 500 nm.

(3) Again the 'READ/ENTER' button was pressed and the display showed: Mg/l N NO_3^- H.

(4) 25 ml sample cell was filled with distilled (blank) water and placed into the cell holder, and the light shield was closed.

(5) The 'ZERO' button was pressed. The display showed: 'WAIT' then, 0mg/l nitrate.

(6) The samples were filled into 25 ml sample cell and the contents of one NitraVer 5 Nitrate reagent powder pillows each were dissolved in the prepared samples. A 5 minute reaction time was allowed after shaking vigorously.

(7) The samples were then placed into the cell holder and the light shield was closed.

(8) 'READ/ENTER' button was pressed. The display showed: 'WAIT' then, the results in mg/l nitrate which was subsequently recorded.

3.4.10 Test for Dissolved Oxygen

(1) Prepared samples were placed into a conical flask.

(2) The sensor-wetting cap for dissolved oxygen was carefully removed.

(3) The meter was turned on by pressing the Mode/Read/CAL/m button.

(4) The sensor was then placed into the samples solution

(5) The result was displayed digitally on the screen in $Mg/l0_2$.

(6) Distilled water was used to rinse the sensor tip before transferring to the other samples.

(7) Displayed results were noted.

3.4.11 Test for Metals (Fe, Cu, Ca, Mg and Pb)

(1) The Buck Scientific Atomic Absorbsion Spectrophotometer was switched on.

(2) The samples were aspirated into the burning chamber through the capillary tubing.

(3) Oxygen/ acetylene gas were used to ignite the samples to excite the atoms to higher energy levels.

(4) The exited metallic atoms absorbed ultraviolet light at wavelengths characteristic of each metal under investigation from the hollow cathode lamp of the metal.

(5) The absorption of each metal was recorded accordingly.

3.2.12 Test for Odour

(1) samples were poured in 500ml conical flasks

(2) Each was diluted to 200ml with odour free water and shaken to mix.

(3) The solutions temperatures were risen to 40^0-60^0C and the vapours were sniffed.

(4) The sniffing was done by five (5) assessors, with each assessment noted, and recorded.

3.2.13 Test for Microbial Load

The media used was nutrient agar with composition in ml

- Beef Extract 3.0
- Peptone 5.0
- Agar 12.0
- Sodium chloride 8.0

(1) 7.0g of Nutrient Agar was weighed using a weighing balance into 250ml conical flasks each to make 250ml of media.

(2) 250 ml of distilled water was then dispensed into the agar and allowed to stand for 15 minutes to dissolve before it was autoclaved.

(3) The media and peptone water were autoclaved at 121°C for 15 minutes and then allowed to cool to 0°C before bringing out the materials.

(4) Ten-fold serial dilution of the peptone water was prepared using distilled water.

(5) The peptone water was filled into test tubes using syringe and needle, autoclaved and allowed to cool.

(6) Using syringe and needle, the contents of the test labelled test tube were applied to the nutrient agar.

(7) Each sample was then pippetted into the Petri dishes and mixed properly, allowed to jell or solidify and then incubated for 24 hrs at 37°C.

(8) The plates were placed on a colony counter and colony formed were counted, using a punching pen while viewing from the magnifying lens.

(9) Concentrations of bacteria in the original samples were then calculated using; concentration= total no. Of colonies in a plate× the reciprocal of the dilution factor. Expressed in cfu/g or ml. (cfu= Colony Forming Unit).

CHAPTER FOUR

4.0 Results and Discussions

4.1 Results

Three samples each of the three sources of water were analysed for thier physical. chemical andbacteriologicalparameters using standard methods and techniques. The average of each parameter measured for each source of water was determined and is presented inthe following table.

Table 4.1 physical and chemical parameters of samples

PARAMETER	SAMPLE X	SAMPLE Y	SAMPLE Z	STANDARDS WHO	NAFDAC
pH	7.2	7.0	6.6	6.5-8.5	6.5-8.5
Temperature (°C)	29.5	29.0	29.0	Not Mnt.	26^{o}-30^{o}
Conductivity (µs/cm)	53.8	14.0	80.7	250	-
Total Dissolved Solids (mg/l)	42.8	6.3	148.1	1000	-
Suspended Solids (mg/l)	0.1	0.2	0.3	Not Mnt.	-
Turbidity (FTU)	0.18	1.01	1.02	5	-
Colour (PtCo)	5	6	8	15	-
Odour	Un obj.	Un obj.	Un obj.	Un obj.	Un obj.
Taste	Un obj.	Un obj.	Un obj.	Un obj.	Un obj.
Iron (mg/l)	0.0	0.0	0.0	0.3	-
Copper (mg/l)	0.000	0.000	0.003	2	-
Calcium (mg/l)	0.071	0.044	0.973	Not Mnt.	75-150
Magnesium (mg/l)	0.276	0.083	0.345	Not Mnt.	-
Total Hardness (mg/l)	1.140	0.342	1.421	500	75-150
Lead (mg/l)	0.0	0.0	0.0	0.01	-
Nitrite (mg/l)	0.0	0.0	0.0	50	-
Sulphate (mg/l)	0.0	0.0	0.0	500	-
Dissolved Oxygen (mg/l)	8.0	7.0	9.0	<75%	-
Arsenic (mg/l)	0.00	0.01	0.01	0.01	-
Zinc (mg/l)	0.00	1.01	0.00	3	-
Faecal Coli form (cfu/g)	4.0	14.0	28.0	0 in 100	Zero max

4.2.0 DISCUSSIONS

The samples were analysed by adopting standard approved methods for the various physical, chemical and bacteriological parameters. The results are presented in table 4.1.

4.2.1 Conductivity

Electrical conductivity is a rapid and most convenient method for the estimation of various salts in water samples. From table 4.1, the specific conductance of the three samples ranges from 14.0-80.7 µS/cm. All falling within safe limits of drinking water as prescribed by WHO guideline (250). The well water has the highest conductivity perhaps due to more minerals dissolved in underground water.

4.2.2 PH

The pH of the samples were analysed and presented in table 4.1, ranging from 6.6-7.2 All complying with prescribed (WHO& NAFDAC) limits for safe drinking water (6.5-8.5). from the results it could be deducted that the rain sample is neutral (7) and as such can be used as buffer solution to carry out experiments.

4.2.3 Total Dissolved Solids (TDS)

Total Dissolved Solids represent various kinds of minerals in water. The TDS was determined and the values ranges from 6.3-148.1 mg/l all falling within safe limits of drinking water (WHO 1983).

4.2.4 Turbidity

Turbidity is the haziness of fluid that is generally invisible to the naked eye. It is a key test to water's quality. The Turbidityy of the three samples were determined and their values ranges from 0.18-1.02 FTU which is less than 5 and hence falls within limits of WHO guidelines.

4.2.5 Colour

The sample analysed had PtCo numbers that range from 5-8 PtCo but all fall within prescribed limits of 15PtCo (WHO).

4.2.6 Odour and Taste

The three samples were found to have un-objectionable tastes and odours.

4.2.7 Dissolved Oxygen

Dissolved Oxygen measures the amount of gaseous Oxygen dissolved in aqueous solution. Adequate Dissolved Oxygen is necessary for good water quality. The Dissolved Oxygen in the samples analysed range from 7-9 mg/l which is permissible for the saturation concentration as prescribed by WHO.

4.2.8 Arsenic

Traces of Arsenic were found in the rain and one of the well samples collected. Even though exactly on the prescribed WHO limit, it is however a cause for concern for those drinking those particular sources. Arcenic has been classified as a carcinogenic element. The values gotten ranged from 0- 0.01 mg/l.

4.2.9 Microbial Load (E-Coli)

The presence of faecal coli form is an index of biological pollution in water samples. The analytical data of the various samples were well within the limits for safe drinking water of o in 100 mg/l (WHO). However it is evident that they are present and storage of the samples or collection was/is a bit inadequate.

4.2.10 Total Hardness

The total hardness of the sample were found to be within desired limits of WHO standards of 500 mg/l.

4.2.11 Copper

Copper is an element required for the proper nutrition of plants and animal. It is

essentially non toxic at low concentration. The concentration of Cu in all the samples falls with in safer limits of drinking quality as per guide line of World Health

Organization (WHO). The concentration of Cu varies from Nil to 0.003 mg/l. The maximum concentration was detected in the well sample.

4.2.12 lead

Lead is a poisonous element as such has permissible limits of 0.01 mg/l as prescribed by WHO guidelines for safe drinking water. However the three samples analysed were found to have no lead concentrations which is good.

4.2.13 Zinc

The tap and well waters had no trace of Zinc. However the rain samples had little traces of Zinc, probably owing to thier mode of collectionthrough rusty Zinc roofing sheets. In comparism, the concentrations of the Zinc found in the various samples agree to WHOlimits for drinking water.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSION

- The tap sources of water analysed are fit for consumption.
- The rain and well sources are not without treatment potable.
- The concentration of the metals agree to WHO and NAFDAC standards.
- The various parameters are well within acceptable limits of the WHO and NAFDAC guidelines.
- The tap water is best for consumption amongst the three samples analysed.

5.2 RECOMMENDATIONS

From the results obtained. the following recommendations are given so as to ensure that the three sources of water for consumption in Bosso town are of good quality and safe to drink.

- Periodical examination should be carried out on these sources of water. This would help arrest any health risks posed by decrease in their quality.
- Water to be used for consumption purposes should be boiled to eliminate any bacterial risks.
- Water meant for consumption should not be collected in iron containers because of they are prone to corrosion and could affect the quality of a water.
- Waters collected for consumption should be properly covered to disallow any insect or foreign material get inside. This is so because the results obtained showed the presence faecal coli form (though small) which indicates excrement.
- Government should carry out more sensitization programmes to enl ighten the people on the importance of consuming good quality water.
- Government should make readily available on the spot kits for testing various water quality parameters.

REFERENCES

Ajisegiri, E.S.A. (2001) Solar Application in Agricultural and Food preservation. James publishers, Minna, Nigeria.

A.K. Chatterjee. (2001) Water Supply, Waste disposal and Environmental Engineering (including odour, noise, air pollution and its control), Khanna publishers, Delhi, India.

Boyd, Claude E. (1999) Water Quality: An Introduction. Kluwer Academic publishers Group. The Netherlands.

DeZuen J. (1997) Handbook of drinking water Quality. 2nd edition, John Wiley and Sons.

Frank R. Spellman. (2007) Mathematics Manual for Water and Waste Water Treatment Plant Operators. CRC press.

J. Glynn Henry, Gary W. Heinke. (1996) Environmental Science and Engineering.

Olivia, Moran, Joseph M; Morgan, Michael D. & Wiersma, James H. (1980). Introduction to Environmental Science.2nd edition. W. H. Freeman and Company. New York. NY.

Piggott, J. R. (1988) Sensory Analysis of Food. Elsevier Science publishers. New York.

www.epa.nsw.gov.au. "US Clean water Act". (2008)

www.ga.water.usgs.gov. "US Geological survey"(2008)

www.iapws.org/relguida. (2001)

www.indiana.edu. (2008)

www.iowater.net. (2008)

www.water-research.net. (2008)

www.who.int/water_sanitation_health/dwq/guideline/en/. (2003)

APPENDIX A

Calculation of Total Hardness (mg/l) as $CaCO_3$;

Equivalent weights

- $CaCO_3$ = 50.045
- Mg = 12.15
- Ca = 20.04

$$Total\ Hardness\ as\ CaCO3 = (Calcium\ Hardness\ \times Magnisium\ Hardness) as\ CaCO3$$

Expressed as; Total Hardness (mg/l) as $CaCo_3$.

But, Calcium Hardness as $CaCO_3$;

$$\frac{Calcium\ hardness\ as\ CaCO3}{equivalent\ weight\ of\ CaCO3} = \frac{Calcium\ concentration}{equivalent\ weight\ of\ Calcium}$$

Expressed as; X mg/l Ca as $CaCO_3$.

And, Magnesium Hardness as $CaCO_3$;

$$\frac{Magnesium\ hardness\ as\ CaCO3}{equivalent\ weight\ of\ CaCO3} = \frac{Magnesium\ concentration}{equivalent\ weight\ of\ Magnesium}$$

Expressed as; X mg/l Mg as $CaCo_3$.

APPENDIX B

A comparative table of both WHO and EU standards (1993&1998 respectively):

	WHO standards 1993	EU standards 1998
Suspended solids	No guideline	Not mentioned
COD	No guideline	Not mentioned
BOD	No guideline	Not mentioned
Oxidisability		5.0 mg/l O2
Grease/oil	No guideline	Not mentioned
Turbidity	No guideline(1)	Not mentioned
pH	No guideline(2)	Not mentioned
Conductivity	250 microS/cm	250 microS/cm
Colour	No guideline(3)	Not mentioned
Dissolved oxygen	No guideline(4)	Not mentioned
Hardness	No guideline(5)	Not mentioned
TDS	No guideline	Not mentioned
cations (positive ions)		
Aluminium (Al)	0.2 mg/l	0.2 mg/l
Ammonia (NH4)	No guideline	0.50 mg/l
Antimony (Sb)	0.005 mg/l	0.005 mg/l
Arsenic (As)	0.01 mg/l	0.01 mg/l
Barium (Ba)	0.3 mg/l	Not mentioned
Beryllium (Be)	No guideline	Not mentioned
Boron (B)	0.3 mg/l	1.00 mg/l
Bromate (Br)	Not mentioned	0.01 mg/l
Cadmium (Cd)	0.003 mg/l	0.005 mg/l
Chromium (Cr)	0.05 mg/l	0.05 mg/l
Copper (Cu)	2 mg/l	2.0 mg/l
Iron (Fe)	No guideline(6)	0.2
Lead (Pb)	0.01 mg/l	0.01 mg/l
Manganese (Mn)	0.5 mg/l	0.05 mg/l
Mercury (Hg)	0.001 mg/l	0.001 mg/l
Molibdenum (Mo)	0.07 mg/l	Not mentioned
Nickel (Ni)	0.02 mg/l	0.02 mg/l
Nitrogen (total N)	50 mg/l	Not mentioned
Selenium (Se)	0.01 mg/l	0.01 mg/l
Silver (Ag)	No guideline	Not mentioned
Sodium (Na)	200 mg/l	200 mg/l
Tin (Sn) inorganic	No guideline	Not mentioned
Uranium (U)	1.4 mg/l	Not mentioned
Zinc (Zn)	3 mg/l	Not mentioned
anions (negative ions)		
Chloride (Cl)	250 mg/l	250 mg/l
Cyanide (CN)	0.07 mg/l	0.05 mg/l
Fluoride (F)	1.5 mg/l	1.5 mg/l

Sulphate (SO4)	500 mg/l	250 mg/l
Nitrate (NO3)	(See Nitrogen)	50 mg/l
Nitrite (NO2)	(See Nitrogen)	0.50 mg/l
microbiological parameters		
Escherichia coli	Not mentioned	0 in 250 ml
Enterococci	Not mentioned	0 in 250 ml
Pseudomonas aeruginosa	Not mentioned	0 in 250 ml
Clostridium perfringens	Not mentioned	0 in 100 ml
Coli form bacteria	Not mentioned	0 in 100 ml
Colony count 22oC	Not mentioned	100/ml
Colony count 37oC	Not mentioned	20/ml
other parameters		
Acrylamide	Not mentioned	0.0001 mg/l
Benzene (C6H6)	Not mentioned	0.001 mg/l
Benzo(a)pyrene	Not mentioned	0.00001 mg/l
Chlorine dioxide (ClO2)	0.4 mg/l	
1,2-dichloroethane	Not mentioned	0.003 mg/l
Epichlorohydrin	Not mentioned	0.0001 mg/l
Pesticides	Not mentioned	0.0001 mg/l
Pesticides - Total	Not mentioned	0.0005 mg/l
PAHs	Not mentioned	0.0001 mg/l
Tetrachloroethene	Not mentioned	0.01 mg/l
Trichloroethene	Not mentioned	0.01 mg/l
Trihalomethanes	Not mentioned	0.1 mg/l
Tritium (H3)	Not mentioned	100 Bq/l
Vinyl chloride	Not mentioned	0.0005 mg/l

(1) Desirable: Lessthan5 NTU

(2) Desirable: 6.5-8.5

(3) Desirable: 15 mg/l Pt-Co

(4) Desirable: less than 75% of the saturation concentration

(5) Desirable: 150-500 mg/l

(6) Desirable: 0.3 mg/l

APPENDIX C

Table 2.2 Acceptable standard for drinking and irrigation water.

S/no	Physical parameters	Max. acceptable conc (W.H.O)	Max. allowable conc(NAFDAC)	Max. contaminant(NPDWR)
1	pH range	7.0- 8.5	6.5-8.5	6.5- 8.5
2	Turbidity units	5(NTU)	-	5(NTU)
3	Odour	Unobjectable	Unobjectable	Unobjectable
4	Taste	Unobjectable	Unobjectable	Tasteless
5	Temperature	29°C	26°- 30°C	30°C
Inorganic constituents				
6	Alkalinity	100mg/l	100mg/l	100mg/l
7	Iron (Fe)	0.05- 0.3mg/l	-	0.3mg/l
8	Calcium	75- 300mg/l	75 – 150mg/l	75 – 150mg/l
9	Chlorine	200mg/l	200mg/l	200 – 250mg/l
10	Fluorine	1.0mg/l	-	4.0mg/l
11	Phosphate	10mg/l	10mg/l	10mg/l
12	Total hardness	75 – 150mg/l	75 – 150mg/l	60 – 150mg/l
Micro-biological standards				
13	E.coli/nil	No growth	Zero max.	5% samples
14	Bacteria	-	No growth	No growth

Source: NAFDAC (2001)