Determination of Iron, Lead, Chloride and Total Hardness

in Waters around Paikoro Local Government Area

By

NKEMAKOLAM ZEPHNIAH-JOSEPH OKEREKE

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Supervisor: Dr. A. A. Faroq

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ABBREVIATIONS

PG = Water from Paggo village

ADSS = Water from Abubakar Dada Secondary School Paiko town

KW = Water from Kwanayi village

GP = Water from Gami village

SK = Water from Sesita village

TAT = Water from Tatiko village

BW = Water from Popular Biwater bore hole Paiko

UNDP= United Nations Development Programme.

μscm^{-3}= Micro semen's per cubic centimetre.

$\mu g/ml$ = Microgramme per millilitre.

μg = Microgramme $(10^{-6}\,g)$

dm^3 = Cubic decimetre

cm^3 = cubic centimetre

ppm = parts per million

AAS = Atomic Absorption spectrophotometre\atomic absorption spectrophotometry

$mgdm^{-3}$ = Milligramme per cubic decimetre = ppm

Q = $F^* < F_\alpha$, (6,49)

F^* = The value of F calculated.

F_α = The value of F tabulated.

DEDICATION

This work is dedicated first to my parents, Mazi PHILIP OKEREKE and Mrs MERCY OKEREKE whose solid support, love, concern and spiritual maturity have been the primary source of my inspiration all these years and secondly to my beloved wife, Mrs OLUWEMIMO YEJIDE FLORENCE OKEREKE and my two daughters, IJEOMA OLUWADAMILOLA and NNENNA OLUWATOBI, whose love, care and thoughts have in a fascinating way encouraged me to experience meaning and direction in life.

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ABSTRACT

The analysis of water from selected bore holes in the Paikoro Local Government Area was carried out in order to characterise these bore holes to ascertain the extent of underground seepage of metals. The work was undertaken with the use of various analytical methods; Volumetric, AAS , and colorimetry.

The results obtained falls within the WHO recommended limits. Similarly the results compare well with the Ruwatsan values which indicate that no major differences have taken place since these well were dug till date. The concentration of all the parameters analysed was found to be in the following ranges:

Chloride ions:-   11.00ppm   to   28.00ppm

Lead ions   :-   0.0015ppm   to   0.0048ppm

Iron ions   :-   0.01ppm   to   0.25ppm

Total Hardness:-   118.00ppm   to   282.00ppm

CHAPTER ONE

1.1   INTRODUCTION

Water is very important and essential constituent of cells of all living things and life cannot exist without it. Much of water in living things acts as irrigant, helping to distribute nutrients and also removing waste products. It can be noticed that the presence of different sources of water, such as streams, lakes, rivers, oasis or wells has been instrumental to the settlement of communities. Water from these various sources has been put to use in various ways such as cooking, drinking, agriculture, transport, industry and even recreation. It is of utmost importance to note that for what ever purpose it is used, it has long been recognized that its suitability for such purpose is affected by the presence of other substances in it. The superficial study of water suggests that life on earth has been conditioned by its different properties since water was present on this planet long before the evolution of life.[1]

1.2   COMPOSITON OF WATER

Water has been classified as surface water and underground water[2].

Surface water is extremely varied in chemical composition and gross differences in the chemical composition of water are obvious among regions with different geology and climate[3,4,5,6]. Natural freshwater could be defined as containing in addition other substances "dilute solutions of alkali and alkaline earth, bicarbonate and carbonate, sulphate and chloride with a variable quantity of largely undissociated silicic acid which often is present in excess of minor constituents in true solution, some of them being of great biological materials, both inorganic and organic"[3].

Rain water as an example of surface water is slightly acidic because it is saturated with carbon dioxide. Rain water in urban regions may be strongly acidic because sulphur and nitrogen compounds released into the atmosphere by the combustion of fossil oxidize to form sulphuric

and nitric acid[7].

As precipitation falls on the land, it may form into runoffs. The runoffs, in turn flow over soils and rocks dissolving various substances and becoming more highly mineralised. (Although rain water is relatively free of ionic substances, yet as it flows over the land , it dissolves ions from the soil[9].) The degree of mineralization and the types of inorganic substances dissolved by runoffs depend upon the composition and solubility of minerals in formations over which runoffs flow and the contact time between the runoffs and these minerals[4,6]. As runoffs flow through vegetated areas they also dissolve various organic compounds.

Once a run off reaches a lake or pond, the larger particles settle out because there is insufficient turbulence to hold them in suspension.. Biological processes alter the composition of water through uptake of ions and gases and by release of metabolites. In some instances, biological processes are the primary factors regulating concentrations of substances. This water infiltrates downwards through the land surface and percolates there to become ground waters[8].

Ground water exists in the voids among various geologic particles, in solution carvens in lime-stone and in spaces within fractured rocks. Ground water also is mineralised by dissolution of mineral matter in geologic formations. Although many of the same constituents found in surface water occur in ground water, ground water often differs considerably in quality from surface water in the same vicinity. As water infiltrates through the soils and rocks of surface formulations, it accumulates carbon dioxide and losses oxygen. This results from biological activity in the surface layers of the soils. As water infiltrates into the depth table, it stands for long periods in contact with minerals and changes in composition as a result of chemical reactions. Ground water from sand deposits may have high concentrations of dissolved solids. Ground water form limestone deposits will usually have less carbon dioxide because of reactions of carbon dioxide with lime-stone, but it will be high in total dissolved solids. Ground water typically has low dissolved oxygen concentrations. Water from wells often contains ferrous ion and other reduced ions. Ferric hydroxide

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may precipitate from well or spring water when the water contacts air and is reoxygenated . The composition of ground water is more variable than the composition of surface water[8].

Generally, natural water contains a great variety of soluble organic compounds such as sugars, fatty acids, humic acids, tannis, vitamins, amino acids, proteins and urea. The surface water minor substances are listed below[7],

Hydrogen ion	10^{-4}	to	10^{-10}	eq/litre
Hydroxyl ion	10^{-4}	to	10^{-10}	eq/litre
Phosphorus ion	0.005	to	0.5mg/litre	
Nitrate	0.005	to	0.5mg/litre	
Nitrite	0.005	to	1.0mg/litre	
Ammonia	0.01	to	2.0mg/litre	
Total Nitrogen	0.01	to	2.0mg/litre	
Iron	0.01	to	2.0mg/litre	
Manganese	0.01	to	0.2mg/litre	
Copper	0.005	to	0.1mg/litre	
Zinc	0.005	to	0.5mg/litre	
Boron	0.01	to	1.0mg/litre	

The average concentrations of major elements in waters of the world are shown below in ug/litre[6,8].

Bicarbonate	58.4
Sulphate	11.2
Calcium	15.0
Chloride	7.8
Magnesium	4.1
Sodium	6.3
Potassium	2.3

1.3 SOURCES OF WATER AND ITS DISTRIBUTION

The sources of water may be classified as either surface or ground water. Surface water includes rain water collected from structures or prepared catchments and water from rivers, natural lakes, storage's reservoirs and oceans. Ground water sources include natural springs, shallow wells, deep and artesian wells, horizontal galleries and wells. The desalting of sea water and other highly mineralised water, however is being increasingly developed. So is the re-cycling of waste waters. There is a strong tendency for large municipalities to seek surface water sources but ground water lends it self more readily to smaller communities[2].

Ground water is found below the surface of the land. Such water exist in pores between sedimentary particles in the fissures of more solid rocks. Very –deep lying ground water can remain undisturbed for thousands of years. Ground water is of major importance to civilisation because it is the largest reserve of drinkable water in regions where human beings can live. Ground water is often preferable to surface water because it tends to be less contaminated by wastes and organisms[9].An existing survey report shows that the water distribution over the surface of the earth is uneven and less than 0.027% of the total water is fresh, and available for use. Also 94% of water available on earth is found in the large oceans. Oceans cover an area of 3.6×10^8 Km^3 and contain 13×10^8 km^3 of water[1].

1.4 GENERAL REASONS FOR THE EXAMINATION OF WATER

Water is very precious and commonly utilised by man in various ways in order to achieve a desired goal, ranging between cooking, drinking and agricultural uses[10,11].

It is important that water for man's use must be free from organisms and from concentrations of chemical substances that may be hazardous to human health. Also the absence of turbidity, absence of colour or any disagreeable taste or smell is of utmost importance in public water supplies. Therefore, care must be taken to exclude any possible pollution from either the situation,

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construction, operation and suspension of water or its reservoir and its distribution[12].

Water quality from different sources varies widely. Precipitation adsorbs gases from the atmosphere and removes particles from the air .As precipitation strikes the ground it forms into surface water runs off or enters the ground. Surface water flows into larger and larger channels such as ponds, lakes and rivers, while some of it reaches the sea. Along its course, surface water picks up organic materials including bacteria, mineral salts and other soluble substances. Water in lakes and swamps may acquire odour, taste and colour from decaying vegetation, algae and other organic matters . Water that enters the ground pass through earth containing organic and mineral matter and it may absorb minerals and exchange gases. Oxygen is usually lost and carbon dioxide acquired, carbonates, sulphates and hydrogen sulphide and methane may be absorbed. Pathogenic bacteria and viruses must be eliminated in any water supply system. The source of pathogenic bacterial and viruses is the human bodies. These disease organisms are commonly transmitted to water supplies by faecal contamination. The most common water borne diseases are typhoid fever, bacillary dysentery and cholera. Water is also known to carry other specific diseases and is suspected of carrying some of the less well understood viral diseases. Pollution of water by radioactive materials has recently become an increasing cause of concern. Other constituents and characteristics that make water unacceptable include total dissolved solids, content, colour, turbidity, off taste, odour, iron, manganese, copper, zinc, cadmium, magnesium, sulphates of mg^{2-} and Na^+, chloride extract and ethyl benzl sulphonates and other wastes not readily degradable. Products such as detergents, artificial fertilisers and insecticides become pollutants when they get into any water supply system[2,4,6].

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To avoid an out break of water borne diseases, traces of elements or substances which cause these hazards, must be investigated from time to time and their level ascertained[13]. Toxic substances that must be eliminated from water include lead, arsenic, selenium, chloride (above threshold level), cyanide, calcium and barium; Nitrates may be dangerous to infants. Although fluorides in low concentration benefit human health by reducing dental cases but in high concentrations may endanger health[14]

The protection of users of water from an outbreak of diseases is the immediate concern of any government. One of the effective measures government takes is the provision of clean drinking water for the rural populace . This has necessitated the International Drinking Water Supply and Sanitation Decade (IDWSSD) to pay serious attention to the plight of rural and semi-urban dwellers. As parts of the global effects to bring improvements, United Nations Development Programme (UNDP), in conjunction with the World Bank and a number of other major donors have collaborated in projects designed to develop and promote low-cost simple technologies which communities can afford and maintain. The hand pump option is the out come of such programme. The programme has now completed 10 years of testing and monitoring in 17 countries including Nigeria involving some 2,700 individual pumps in 70 different models. The benefits derived from the community water supply (CWS) improvements are immense and highly visible. Access to a convenient source of clean water brings time savings and reduced drugery for the household water carriers, easy availability of water for washing, bathing , cooking , encouraging cleanliness and leading to better living conditions. Other benefits of which the most important is better health may be less immediately apparent and will often depend on additional inputs. Such inputs as sanitation improvement and hygiene education are very desirable if maximum impact is to be obtained from the community water supply improvements[15]. There are number of computational aids and models that are available for predicting or estimating water quality affected by discharge of residue[12].

1.5   AIM AND OBJECTIVES OF THE CURRENT STUDY

The aim of this study is to examine water samples from some of the Ruwatsan bore holes in selected villages under the Paikoro Local Government Area.

1.   It is hoped that the following parameters would be determined vis-à-vis pH, conductivity, temperature, chloride, iron, lead and total hardness.

2.   To compare the result obtained in the current study with those obtained when these bore holes were dug.

3.   To offer possible scientific reasons to any variation in the two results.

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CHAPTER TWO

LITERATURE REVIEW

2.1   A GENERAL PREVIEW

Water analysis involves the determination of the Biochemical properties of substances suspended or dissolved in water, with the aim of providing acceptable explanations for their effect on man , animals, plants and the environment. The ultimate aim is to provide water that is safe for human consumption i.e. unpolluted water.

In order to achieve theses objectives many analytical techniques (instrumentation) have been developed. Most of these techniques are based on colorimetric, conductometric, potentiometric, chelatometric, coulometric and amperometric measurements. Sometimes nephelometric, polarimetric and chromatographic measurements are employed[1].

Water is important not only for its availability and quantity, but also for its quality. The quality determines and supports its biological composition. Studies have shown that the conversion of lotic system into a lacustrine one causes changes in water quality[2,3,4,5].

Water samples are collected and analysed to determine the chemical and physical composition of water body and its suitability for domestic, industrial and agricultural uses. Water samples are analysed to aid in understanding the geochemical and hydrologic relationship in natural systems and to evaluate the influence of man's activities on the systems. Interpretation of the analytical reports from a systematic sampling and analysis program may also indicate the nature, source variability of both dissolved and suspended matter present in the water body[6].

2.2   VARIOUS METHODS EMPLOYED IN WATER ANALYSIS

As a result of the increase in the interest for the methods and instruments for continuous analysis and taking note of pollutants and contaminants in surface water , a lot has been published

on automatic measuring equipment[1]. For instance, those employed in the measurement of total hardness, metals and lead compounds. Therefore, this review of the literature of analytical chemistry on water analysis is an attempt to look at the various methods that have been applied to determine substances which are of interest in this study.

2.2.1 TEMPERATURE

Temperature measurements of water samples have been reviewed[7]. In this study four types of temperature sensors were recommended. e.g. reversing thermometer, thermocouple, thermistors and nickel or platinum resistant element. Out of all these temperature sensors, thermistors are the most widely used since they are cheap not through needing frequent recalibration[8].

Many biological processes are know to be influenced by the changes in the environmental temperature and most chemical substances dissolve more readily as temperature increases, unlike most gases which become less soluble as temperature rises[9,10,11,12,13].

The higher the temperature of the water body, the lower the amount of dissolved oxygen and vice-versa. Temperature has the effect of speeding up chemical reactions, reducing the solubility of gases and amplification of taste and odours[14,15,16,17]. Temperature has been described as a catalyst, a depressant, an activator, a restrictor, a stimulator, a controller a killer, one of the most important and most influential water quality characteristics of life in water[18].

2.2.2 pH

For most practical purposes, the pH of an aqueous solution can be taken as the logarithm to the base of 10 of the reciprocal of the hydrogen ion concentration (more precisely, of the hydrogen ion activity) in moles per dm. The pH of natural water is governed by the carbonates, bicarbonates/carbonate equilibrium which lies between 4.5 and 8.5[14,20,21,22].

There is also a significant difference between dry and wet seasons pH[23]. It is also observed that hard water with high calcium content would have a high pH value and soft water possessing a low calcium content showed a lower pH value. pH influences the toxicity of ammonia, metals pollutants to aquatic organisims[24,25,26,27,28,29,30].

It may be affected by humic substances which results from decomposition of organic matter, sediments type and phytplankton activity are known to influence pH of water bodies[26,31,32,33,34].

Water passing or draining through peat swamps, acidic rocks, or acid sulphide soil, especially during flooding may result in acidic waters[35]; while alkaline waters may result from algal bloom, calcium and silica rich areas and pollution from soft drink and brewing industries. Lower and less variable pH values were recorded in the wet season than in dry season in some rivers especially at the time of low flow[23,36]. Low pH values were associated with rise in concentration of free carbon dioxide and liberation of humic compounds by decomposition of the organic matter of grasses[37,38,39,40].

The determination of pH by conventional chemical means is not practicable and the equilibrium that is involved depends to some extent upon temperature. Therefore the precise scale of pH must be based upon an agreed primary standard. However, the pH of a solution or water sample could be measured by a colorimetric or an electrical method. The electrical method has been found to be more accurate and relatively free from interference. Infact it has been regarded as a reference method and the clorimetric indicator method is employed only when an approximate pH is required[41].

2.2.3 HARDNESS AND ALKALINE EARTH METALS

Hardness of water is the property attributable to the presence of alkaline earth metals;

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calcium and magnesium are the principal alkaline earth in natural waters, where as strontium and barium are usually present in small quantities.

Therefore the total concentration of calcium and magnesium ions in the water is a measure of hardness. It is expressed as calcium carbonate[24,26]. A number of factors such as sources of water and treatment it received could influence the value obtained[21,27,42]. The solubility of certain metals into water body is being governed by the degree of water hardness[21]. Metals are generally known to be less soluble in hard water than in soft water.

Some authors refer to water with high alkalinity as hard waters since alkalinity and hardness are of similar concentrations in most waters[43]. Below are two methods of classification with respect to hardness according to the amount of calcium carbonate or its eqivalent[44,45].

Hardness(ppm $CaCO_3$)	concentration	Hardness(mg/litre)	concentration
0 - 60	soft	0 – 75	soft
61 - 120	moderately hard	75 - 150	moderately hard
121 – 180	hard	150 - 300	hard
more than 181	very hard	300 plus	very hard

2.2.4 ELECTRICAL CONDUCTIVITY

The conductivity or specific conductance of natural water is a measure of its ability to convey an electric current. Different ions vary in their ability to conduct electricity, but in general the greater the concentration of ions in natural water the larger the conductivity[46]. Limnologists have used conductivity as a valuable method of estimating the degree of mineralization of waters. The amount of dissolved ionizable salts in freshwaters is generally considered to be related to their potential biological productivity[26]. The composition of the sediments, water, nature of various dissolved substances and salts with the temperature at which the measurement is carried out affects the electrical conductivity of any waters[17,33,46].

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The conductivity of most fresh water is said to be in the range $5 - 50$ μscm^{-1}. Increase in temperature has been found to cause an appreciable increase in conductivity, the same is true for carbon dioxide[46,47]. While on the other hand low pH increases conductivity due to equivalent conductivity of hydrogen ions[26].

Total dissolved solids (TDS) are filterable residues consisting of inorganic salts, small amount of organic matter and dissolved materials[44,48]. Total dissolved solids of any water is directly related to the conductivity of such water body[12,21,.49].

2.2.5 TRACE ELEMENTS

The source of trace elements is from geological weathering, industrial processing of ore and metals, leaching of metals from garbage and solid waste dumps, minor sources could also be the automobile exhaust. The quantity and quality of trace metals may vary depending on the surrounding parent rock, sediments and water sources[50,51,52,53].

Metals are of special concern because they are non-degradable and therefore persist in the environment. Colloidal and suspended organic matter reduces the availability of heavy metals as a result of the adsorption process. Metal pollution can either be in dissolved or particulate form. For such dissolution the physio-chemical condition of the water body is important. Precipitation of these dissolved forms of metals can be in form of hydroxides, carbonates or other minerals. They can also be adsorbed by iron or manganese oxides and hydroxides to form dissolved organic or inorganic complexes[54,55]. Several workers have noted that there could be erratic fluctuations of metals in water[56].

In recent years, successful determination of trace metal by gas chromatography has received much attention for analysis in a wide variety of sample matrices most of which were converted to an aqueous system prior to the analysis procedure[57].

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2.2.6 CHLORIDE

Most naturally occurring chlorides are very soluble. Chloride concentration in natural waters ranges widely from less than 1 mg/litre in some waters to many thousand mg/litre in brines.

The major anthropogenic sources of chloride in surface water are the de-icing salt, urban and agricultural runoff and discharges from municipal waste water plants, industrial plants and drilling of oils and gas wells[58,59,60,]. A high concentration of chloride imparts a salty taste to the water but the threshold of detection varies with individuals. Although water with a chloride content of 1,000 mg/litre may be physiologically safe for drinking purposes. The U. S. Public service recommends that the concentration should not exceed 250 mg/litre in water or carriers subject to Federal Quarantine regulations. Chloride may accelerate corrosion in pipes, boilers and other fixtures [61,62]. Many crops may be injured by chloride. Chloride is generally about twice as toxic to crops as sulphates[63].

The main problem caused by excessive chloride in water concerns the acceptability of the supply by the people; whilst chlorides are normally detrimental to health, the salt intake (i.e. the common salt) for people suffering from heart or kidney disease has to be restricted. Although the salt intake from drinking water is very small compared to that from food stuffs, it is still desirable to limit the chloride concentration in water[64].

A number of methods are available for the determination of chloride in water. These methods include the argentomeric (Mohr), the mercuric nitrate, the potentiometric and the ferric cyanide methods. The potentiometric method is suitable for coloured (turbid) samples containing ferric ions (if not present in an amount greater than the chloride concentration). However, silver-silver chloride electrodes are suitable for most types of chloride analysis and have the advantage of being cheaper than membrane types[65,66].

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2.2.7 IRON

It is the most abundant metal in the earth crust. Iron is present as ferric hydroxide in suspension is adsorbed as sestonic particles and as a soluble or colloidal iron organic complex, because iron is readily precipitated as hydroxide, it is seldom one of the major constituent in water[67].

The form and solubility of iron in natural waters are strongly dependent upon the pH and the oxidation-reduction of water[21,27,68]. The EPA (1986) has established 0.3 mg/litre as the highest desirable level for iron in domestic water supply[27,61].

Industries tolerance for iron varies but concentrations exceeding 0.1mg/litre are generally not satisfactory[71]. It has been established that iron in irrigation water is of no practical significance to plant growth or soil texture. Iron is determined by atomic-absorption spectroscopy (AAS) or by the bipyridine-reduction procedure[70].

2.2.8 LEAD

Lead is only a minor element in most natural waters; but industrial or mine and smelter effluents may contain relatively large amounts of lead. Although neither metallic lead nor the common lead minerals are classified as soluble in water, they can both be solubilized by some acids; in contrast, some of the lead compounds which are not produced industrially are considered water soluble. Natural lead compounds are not usually mobile in normal ground or surface water because the lead leached from ores become adsorbed by ferric hydroxide or tends to combine with carbonates or sulphate ions to form insoluble compounds[71].

Lead has been recognised as a serious environmental health hazard especially in cities with high traffic density. It is the apparent hazards posed by lead that have caused the dilemma over the use and the amount of lead in petrol. Lead bioaccumulation causes a disease called

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plumbism whose effect includes damage to the brain, central nervous system, kidney, liver and and reproductive system[61,72].

lead concentration are generally higher in freshwater than in sea water. The higher concentration in freshwater results from the atmospheric inputs originating from leaded gasoline or smelting operations[73,74].

The solubility of lead compounds in waters depends heavily on pH and ranges from about 10,000,000µg/litre of lead of pH 5.5 to 1µg/litre at pH 9.0[75]. Lead reaches aquatic environment through precipitation, fallout of lead dust, street runoff, and both industrial and municipal waste water discharges[76].

The maximum lead concentration in drinking water is recommended to be 50µg/litre[27,70]. Lead is determined by atomic-absorption spectrophotometry. The element is chelated with ammonium pyrrolidine dithiocarbamate (APDC) and extracted with methylisobutylketone (MIBK). The extract is aspirated into the flame of the spectrophotometer[65]. None of the substances commonly occurring in natural water interferes with these methods[21].

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CHAPTER THREE

EXPERIMENTAL AND RESULTS

3.1 SELECTION OF SITE FOR SAMPLING

The extent to which the proposal location compliment the overall program of which it is a part, is of primary importance to the selection of water quality sampling site. Wherever possible, the location of sampling station should, be selected to provide data of benefit to basin, regional and national network programs. Samples were taken from various villages in Paikoro Local Government, namely Kwanayi, Paggo, Abubakar Dada Secondary School, Tatiko, Sesita, Gami and the Popular Biwater Bore hole of Paiko town, each represented with the following abbreviations KW, PG, ADSS, TAT, SK, GP AND BW respectively.

3.2 SAMPLING PROCEDURE

Certain factors were taken into consideration, such as breakage, efficiency of closure, size, shape weights, availability and lost. Plastic bottles were used to collect samples. These polyethylene materials did not significantly alter the silica, sodium, total alkalinity, chloride, boron content or the specific conductance, pH or hardness of water during the storage period of about 5 months, if necessary. These polythene bottles were first cleaned by washing with detergent and rinsed. They were then soaked in 1:3 nitric acid for a period of 2days followed by a thorough wash with distilled deionized water acidified with nitric acid to pH 6. The cleansing process removes trace elements from the container walls[1]. Samples were collected from the various points listed above from between 7.00am to 11.00am each day of collection. The period was chosen within which changes in the physical as well as the chemical parameters of the samples were thought to be minimal[2].

The temperature of the samples were taken in situ. The sampling cans were filled completely.

Other parameters such as electrical conductivity and pH were determined immediately after sampling. The samples were directly taken to the laboratory from the sites since the distance to be covered were not much. Also the sampling period lasted for over 8 weeks while each parameter was determined weekly. The glassware used during this period of analysis were always cleaned and soaked in chromic acid, washed and rinsed by distilled deionized water.

3.3   DETERMINATION OF PARAMETERS

3.3.1   pH

Reagents: Analytical grade reagents were always used during this study, the following reagents were employed , sodium tetraoxophosphate v; Sodium heptaoxoborate iii; Potassium hydrogen-phathalate v; Potassium hydrogen tetraoxophosphate v; Potassium chloride.

Procedure: The pH meter Kent EIL model 7045/47 was used for pH determination in conjunction with a glass electrode with a saturated calomel electrode. Freshly prepared buffer solutions were always used. This avoided the growth of mould, Hence contamination[3]. Before taking the measurement the instrument was calibrated using buffer solutions of pH 4.0, 7.0, and 9.0 respectively. Before each buffer solution the electrode were thoroughly rinsed using distilled deionized water. After calibration of the instrument, the pH of the samples was taken. The results are tabulated in table 3.3.1.

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Table 3.3.1   pH of the samples

WEEK	PG	ADSS	KW	GP	SK	BW	TAT
1st	6.8	6.7	7.5	6.8	6.9	6.5	6.6
2nd	6.5	6.7	7.4	6.8	6.8	6.4	6.67
3rd	6.9	6.7	7.2	6.9	6.9	6.5	6.7
4th	6.5	6.78	7.4	6.92	6.92	6.51	6.68
5th	6.7	6.7	7.4	6.78	6.72	6.41	6.68
6th	6.9	6.72	7.4	6.9	6.8	6.51	6.63
7th	6.6	6.7	7.4	6.8	6.92	6.5	6.67
8th	6.5	6.7	7.3	6.8	6.9	6.41	6.64
AVERAGE	6.675	6.7125	7.375	6.8375	6.8575	6.4675	6.65875

3.3.2 DETERMINATION OF ELECTRICAL CONDUCTIVITY

Materials: Large borosilicates, test tubes, bottles, water bath, electrical conductivity measuring set and hot plates.

Procedure: For the current exercise, BBC Brown Boueri Kent EIL Model 5007 Electrolytic Conductivity measuring set, was used for the conductivity measurements.

This experiments requires the use of conductivity water and this was prepared by passing distilled water through a Houseman 2-C deionizer until its conductivity was between 1 and $1.5 uscm^{-1}$. The conductivity cells were stored in a water bath kept aside, whose temperature was at 30^{0C}. Similarly, all the water samples were kept in the same bath for at least 30 minutes in order for all to attain thermal equilibrium.

The conductivity cell was thoroughly washed using the sample to be analysed, after then the cell was filled with the sample. There conductivity values were then read and the results obtained are tabulated in tables 3.3.2a and 3.3.2b. The scale readings obtained for The sample were multiplied by a factor of 1000 so as to obtain the conductivity's of the sample micro semen's per centimetres at 30^{0C}. These values were then converted by calculation to values at 20^{0C} and $25^{o}C$ respectively.

Calculation,

conductivity at 25^{0C}, $K = K_2 * C (1 + 0.00191) (t - 25)$

Where K_2 = measured conductivity in $uscm^{-1}$.

  C = cell constant.

  t = temperature measured in (^{oC}).

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Table 3.3.2a Electrical Conductivity of the samples at $20^{\circ}C$

WEEK	PG	ADSS	KW	GP	SK	BW	TAT
1st	30.8	19.1	82.5	25.7	82.6	28.8	40.1
2nd	32.16	20.2	83.6	26.7	81.6	27.5	39.5
3rd	30.5	21.3	84.5	27.6	82.5	28.8	38.7
4th	33.5	19.5	82.7	28.5	83.6	28.6	40.6
5th	30.4	19.6	83.6	25.3	82.4	25.5	41.5
6th	28.3	18.9	81.5	23.4	81.5	28.4	40.6
7th	29.5	20.2	80.4	25.5	83.6	26.6	41.4
8th	30.5	20.2	81.3	25.6	82.5	28.5	39.5
AVERAGE	30.7075	19.875	82.5125	26.0375	82.5375	27.8375	40.2375

Table 3.3.2b Electrical Conductivity of the samples at 25°C

WEEK	PG	ADSS	KW	GP	SK	BW	TAT
1st	38.4	26.1	82.9	26.8	41.6	30.1	44.1
2nd	38.6	26.6	86.9	26.7	42.5	32	44.5
3rd	37.5	25.6	87.9	25.9	43.5	33.4	44.5
4th	38.6	26.4	87.9	26.7	44.5	35.5	47.5
5th	38.4	26.1	85.9	25	42.5	30.1	47.7
6th	37.4	25.9	86.9	25.5	41.5	32.1	45.6
7th	37.5	26.2	87.9	25.7	42.5	35.6	44.5
8th	38.6	25.8	86.9	25.7	44.5	36.5	45.5
AVERAGE	38.125	26.0875	86.65	26	42.8875	33.1625	45.4875

3.3.3 DETERMINATION OF CHLORIDE[6]

A.   Sodium chloride solution.

1.648g of analytical grade sodium chloride crystals were accurately weighed in a small beaker. A small quantity of distilled deionized water was then added and the solution was quantitatively transferred into one litre volumetric flask, the mark is then made up using distilled deionized water.

B.   Standard silver nitrate solution.

50g of silver nitrate crystals were pulverised in a clean mortar and dried at a temperature between 105^{oC} and 120^{0C}, 23.96g of the dried silver nitrate was accurately weighed in a small beaker. This was then dissolved in a measurable amount of distilled deionized water and the solution was quantitatively transferred into one litre volumetric flask. The mark was made up by adding distilled deionized water. The solution was the stored in a light proof bottle. The solution was standardised using sodium chloride solution.

$100cm^3$ of the above solution was taken in a one litre volumetric flask and the mark made up using distilled deionized water. This solution was stored in a light proof bottle.

C.   Potassium chromate solution.

5g of potassium chromate was accurately weighed in a beaker. $100cm^3$ of distilled deionized water was then added. A little quantity of the diluted silver nitrate was then carefully added until a red silver chromate precipitation developed. The content of then beaker was then covered with a watch glass and allowed to stand overnight. The precipitate was then filtered and the filtrate transferred into a $100cm^3$ volumetric flask and the mark made up using distilled deionized water.

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Procedure:

Approximately 50cm³ of the sample was measured into a conical flask and 5 drops of potassium chromate indicator added. The solution was then titrated with constant stirring using the standard silver nitrate solution.

The end-point of the titration was the appearance of pink-red precipitation of silver chromate which persists for about 10 – 15 seconds.

A reagent blank was established by titrating 100cm³ of distilled deionized water. The amount of chloride ion in each sample was calculated using either of the following formulae

Cl^{-1} in mg /litre $= 1000/cm^3 \times (cm^3$ titrant $- cm^3$ blank$) \times (cm^3 Cl^{-1}$ per cm^3 titrant$)$

<div align="center">OR</div>

$mg/dm^3 Cl^{-1} = (A - B \times N \times 35450)/($ml sample$)$

where   A $=$ volume of titrant required for the sample.

        B $=$ volume of titrant required for the blank.

        C $=$ concentration of silver nitrate solution in mol/dm^3.

The results obtained was collated in table 3.3.3.

Table 3.3.3 Chloride ions concentration in the samples.

WEEK	PG	ADSS	KW	GP	SK	BW	TAT
1st	23	13	29	17	11	29	8
2nd	21.5	12.4	27	16	11.3	28.7	9
3rd	20	13.4	26.1	16.5	11.4	28.5	8.1
4th	20.4	11.6	29.3	15.7	10.6	27.6	7.1
5th	22.5	12.5	28.5	15.58	11.7	26.3	7.2
6th	21.5	11.5	27.4	16.6	12.8	28.4	8.1
7th	21.6	11	27	17.5	11.5	29.5	9.1
8th	22	12	29.4	15.4	11.6	28	8.5
AVERAGE	21.5625	12.175	27.9625	16.285	11.4875	28.25	8.1375

3.3.4   DETERMINATION OF TOTAL HARDNESS

Materials: Motor driven stirrer, $50cm^3$ burette, white tile, pipette.

Reagents: All reagents employed were of analytical grades or GPR and the standard solutions were prepared using distilled deionized water.

i.   Concentrated ammonium hydroxide. (Sp. Gr 0.900)

ii.   Standard calcium solution.

A small quantity of calcium carbonate was taken and dried at 180^{oC} for one hour. 1.00g of the dried calcium carbonate was then accurately weighed in a beaker. Approximately $600cm^3$ of distilled deionized water was being added. In order to aid dissolution a small quantity of dilute solution of hydrochloric acid was added until a clear solution is obtained. The content of the beaker was then quantitatively transferred into a one litre volumetric flask and the mark made up using distilled deionized water.

iii.   Erichrome Black T indicator solution.

0.40g of Erichrome Black T was dissolved in $100cm^3$ of distilled deionized water and diluted to one litre with 95% ethanol solution (it is possible for this indicator to last for 2 months).

iv.   Hydroxylamine hydrogen chloride solution.

30g of hydroxylamine hydrogen chloride was dissolved in distilled deionized water and made up to the $1000cm^3$ mark.

v.   Potassium ferrocyanide crystals.

vi.   Sodium cyanide solution.

(caution :- Sodium cyanide is a deadly poison and the reagent solution must be marked for easy identification.) 2.5g of sodium cyanide crystals was weighed accurately in a beaker and transferred quantitatively into a $100cm^3$ of volumetric flask, the mark was made up using

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distilled deionized water.

vii.   Sodium ethylene diaamine tetraacetate standard solution.

3.72g of sodium ethylene diaamine tetraacetate was dried in a sulphuric acid dessicator and dissolved in distilled deionized water and made up to the $1000cm^3$ mark. This solution was standardised against the standard calcium solution.

Procedure: $50 \, cm^3$ portion of the sampl e was pipetted into $150 \, cm^3$ conical flask. $1cm^3$ of hydroxylamine hydrogen chloride solution was added, this was followed by addition of $1cm^3$ of concentrated solution of ammonium hydroxide and $2cm^3$ of sodium cyanide. (NOTE:- This addition may be omitted, if copper zinc, lead, cobalt and nickel are entirely absent, and if the sample contains less than 0.25 mg Iron and 0.25mg of manganese.) This was followed by addition of one or two small crystals of potassium ferrocyanide hydrated. The solution is stirred and a waiting period of at least 5 minutes is given in order to allow for all the manganese to precipitate as manganese ferrocyanide. One or two drops of Erichrome black T indicator is then added and the resultant solution is titrated with the standard sodium ethylene diaamine tetraacetate solution. The titration is continued until red or purple swirls begin to appear. The end-point of titration is when all the traces of red or purple colouration disappears and the solution becomes clear blue in colour. This colour change occurs rapidly, so the end point of the titration must be approached cautiously.

Then the total hardness (as calcium carbonate) in mg/litre is calculated using the formula[7] below.

Hardness as $CaCO_3$ in mg/litre, $= (1000/cm^3 \, sample) \times cm^3 \, titrant.$

The water samples were treated as above and the results are given in table 3.3.4

Table 3.3.4 Total Hardness concentration in the samlpes.

WEEK	PG	ADSS	KW	GP	SK	BW	TAT
1st	161	87	281	170	119	144	167
2nd	160	88	281	170	118	143	165
3rd	160	87	280	171	118	143	166
4th	159	87	282	171	119	144	167
5th	160	89	282	168	119	145	167
6th	159	88	281	168	120	144	165
7th	158	87	280	171	119	144	165
8th	161	87	291	170	118	145	167
AVERAGE	159.75	87.5	282.25	169.875	118.75	144	166.125

3.3.5   DETERMINATION OF LEAD (COLORIMETRY AT 510nm)[4,8]

Reagents:- Distilled deionized water was used in all the preparations of standards and all reagents used were of analytical grade. (BDH, Analar or GPR).

a.   Sodium Hexametaphosphate solution ($100g/dm^3$)

Dissolution of 10g of sodium hexametaphosphate was made in $100cm^3$ distilled deionized water. In order to remove traces of lead, $1 g/dm^3$ of dithizone solution at pH 9 was employed in the extraction process, later dithizone traces were removed by extracting with chloroform after acidification. The pH was adjusted to 9.5 using aqueous ammonia.

b. $0.5mol. dm^{-3}$ Aqueous Ammonia.

$3.5 cm^3$ Ammonium hydroxide with density $0.88g cm^{-3}$ was pipetted into a $100cm^3$ volumetric flask and made up the mark with distilled deionized water.

c.   Alkaline cyanide solution.

In $170 cm^3$ of aqueous ammonia and $340cm^3$ of water 0.75g of anhydrous GPR sodium sulphite , was dissolved. $15cm^3$ of a $10g dm^{-3}$ of potassium cyanide, was added and shaken thoroughly.

d. i.   Dithizone stock solution ($1g dm^{-3}$ in chloroform.)

0.1g diphenylthocarbazone was accurately weighed and transferred into a small beaker containing a little quantity of chloroform to dissolve. Into the $100cm^3$ volumetric flask , the solution was quantitatively transferred and made up to mark with chloroform. It was kept in the refrigerator for further use.

d. ii.   Dithizone working solution in water.

From the stock solution $6cm^3$ was transferred into a $100cm^3$ separating funnel and $100 cm^3$ of $0.5 mol. dm^{-3}$ aqueous ammonia was added. The out come mixture was shaken

thoroughly. It was left to stand and the chloroform layer was rejected and the aqueous layer was filtered through a wetted filter paper and kept for use.

e. Hydroxylamine hydrogen chloride standard solution.

10g of hydroxylamine hydrogen chloride was dissolved in a little quantity of water in a small beaker and transferred into a one litre volumetric flask and the solution made up to the mark with distilled deonized water.

f. i. Lead standard solution.

1.599g of lead nitrate was accurately weighed and dissolved in distilled deionized water in a one litre volumetric flask. $10cm^3$ of concentrated trioxonitrate (v) acid was added and solution made up to the mark .(1mg lead is contained in $1cm^3$ of solution).

f. ii. Lead working solution.

From the lead standard solution $10cm^3$ of the solution was pipetted into a litre volumetric flask and then made up to the mark with distilled deionized water. ($1cm^3$ of the solution contains 10mg of lead).

Procedure:-

In the water samples the organic matter was destroyed first[7,8]. It was achieved by mixing $50cm^3$ of the well mixed sample with $5cm^3$ of concentrated trioxonitrate (v) acid solution into a beaker. It was placed on a hot plate and this evaporated to near dryness. (without allowing the sample to boil). When it was cooled, $5cm^3$ of concentrated trioxonitrate (v) acid was added again and then covered with a watch glass. It was then returned to the hot plate. The evaporation continued until a gentle refluxing action occurred. Then more acid was introduced at random until a light coloured residue was obtained, $2cm^3$ of acid was then added and warmed gently until the residue dissolved. The beaker and the watch glass were then washed down with distilled deionized water. Sintered glass filter crucible was used to filter the sample. Later the volume of the sample was adjusted to $50cm^3$.

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SOLVENT EXTRACTION:

From the standard solution, siral dilutions of concentrations ranging from 0 - 20ug/dm^3 were prepared. Since tin and (or bismuth) could interfere, then the preliminary extraction procedure was done at pH 2 – 2.5 . As a result of the above procedure, the standards were also subjected to the same extraction as the samples.

To every 50cm^3 portion of the standards or samples in a separating funnel, 20 cm^3 dithizone stock solution in chloroform was added. At intermittent periods of shaking the mixture, the stopper was opened to release the pressure. After shaking the mixture vigorously and with the replaced, the mixture was allowed to stand. The lower layer which is the chloroform layer was discarded. A further 5cm^3 of the dithizone stock solution was added and the extraction was repeated with the subsequent discarding of the chloroform layer. Then the aqueous layer was washed with 5cm^3 of chloroform and the phases allowed to separate, the chloroform layer discarded. As a result of several washing of the aqueous layer with chloroform, its pH was adjusted to 9 and the following reagents were added with thorough mixing after each addition:- 1.0cm^3 of sodium hexametaphosphate solution, 1.0cm^3 hydroxylamine hydochloride solution, 30cm^3 of alkaline cyanide solution (it fumes a lot so would be advisable to be done in the fume cupboard), 0.5cm^3 of the dithizone working solution in water (added from a micro pipette) and 10cm^3 of chloroform. It was thoroughly mixed by shaking vigorously for 1 minute and the phases were allowed to separate. The steam of the funnel was dried with filter paper after about 2cm^3 of the chloroform layer was allowed to run to waste. The absorbance of the remaining chloroform layer was determined at 510nm using corning colorimeter model 253. The reference cell contained chloroform.

A calibration graph was prepared and the lead concentration values were obtained from the calibration graph. The results obtained are collated in table 3.3.5

Table 3.3.5 Concentration of Lead in the samples.

WEEK	PG	ADSS	KW	GP	SK	BW	TAT
1st	0.005	0.001	0.002	0.003	0.004	0.005	0.001
2nd	0.006	0.001	0.002	0.003	0.004	0.005	0.001
3rd	0.004	0.002	0.001	0.003	0.004	0.006	0.002
4th	0.005	0.001	0.003	0.004	0.005	0.005	0.001
5th	0.006	0.001	0.002	0.005	0.006	0.004	0.001
6th	0.004	0.002	0.001	0.004	0.005	0.005	0.002
7th	0.004	0.003	0.002	0.003	0.004	0.006	0.002
8th	0.004	0.003	0.003	0.005	0.004	0.005	0.002
AVERAGE	0.00475	0.00175	0.002	0.00375	0.0045	0.005125	0.0015

3.3.6   DETERMINATION OF IRON

Materials:- Atomic Absorption Spectrophotometer Perkin – Elmer Model 253 at 248.3nm

Reagents: The reagents used in this study were all of analytical grade, hence further

purification was not necessary.

Calibration graph.

A calibration graph for iron was prepared. This was done by dissolving 0.100g of

iron wire which has been cleared in dilute acid rinsed and dried. This was then dissolved

in a small quantity of hydrochloric and in a small beaker. The solution was quantitatively

transferred into a one litre volumetric flask and the mark made up using distilled deionized

water.

From the above stock solution, standard solution containing between 0 to 15ppm

were prepared by taking appropriate volumes of the stock solution in $100cm^3$ volumetric flask

and the mark made up using distilled deionized water.

The standard solutions were then aspirated into the atomic absorption spectrophotometer with

the wavelength set at 248.3nm. The aspiration was done in descending order, and with each

aspiration distilled deionized water was aspirated into the system in order to clear the flame of

the previous solution.

The values obtained were used to draw a calibration graph (appendix 5.) and the concentrations

of iron in the various samples were obtained from the calibration graph . The results obtained are

collated in table 3.3.6.

Table 3.3.6 Concentration of iron in the samples.

WEEK	PG	ADSS	KW	GP	SK	BW	TAT
1st	0.18	0.09	0.05	0.25	0.36	0.28	0.03
2nd	0.17	0.08	0.05	0.26	0.37	0.27	0.01
3rd	0.18	0.09	0.05	0.25	0.36	0.28	0.01
4th	0.19	0.09	0.05	0.26	0.36	0.28	0.03
5th	0.17	0.08	0.04	0.25	0.37	0.27	0.03
6th	0.17	0.08	0.06	0.26	0.36	0.28	0.03
7th	0.18	0.09	0.04	0.25	0.37	0.27	0.01
8th	0.19	0.09	0.06	0.26	0.36	0.27	0.02
AVERAGE	0.17875	0.08625	0.05	0.255	0.36375	0.275	0.02125

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CHAPTER FOUR

DISCUSSION OF RESULTS

4.1.0 INTRODUCTION

It is relevant to make this deduction that since waters from bore holes and deep wells have the same geological formulations through which they resulted, it is expected that they would have similar characteristics. As a result, the are liable to contain such dissolved solids as iron, magnesium, etc. The amount of total dissolved solids (TDS) and carbon dioxide is expected to be low, and in this situation, the water from bore holes should be safe for drinking without pretreatment. It is important to note that these bore holes understudy are expected to have similar characteristics, although if there are differences it could be attained to the different geographical locations and hence the geochemical composition of the sources may differ.

As a result of many sampling methods carried out, average values of these results were taken and where there were variances, they were ignored due to the random way the sampling was undertaken. The differences observed were used as bases for the discussion of these results obtained. In all cases of discussion, statistical significance of parameters was established at 0.05 (95%) level.

Results were compared according to sites not within specific weeks, since differences between consecutive values within the weeks occur in some parameters and the differences had no statistical significance.

4.1.1 TEMPERATURE OF SAMPLES

Temperature readings were taken in situ, at the time of water collection. The importance of this cannot be over emphasised because temperature affects the dissociation coefficient and the solubility of carbon dioxide.

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The bar chart showing the dispositions of the average temperatures of the various water samples analysed is shown on figure 4.1.1.

In general the temperature for the various samples fall between the average value of $26..85^\circ$ C and 28.12^0 C. Also checking the average value of the temperature for the samples taken by Ruwatsan it would be 30.31^0 C which is slightly above the averages of the study area. Looking at the ANOVA (Appendix 2) where Q = -0.0014 < 2.29 . It shows that irrespective of the treatment (Temperature) of the various bore holes, and not withstanding the number of replications(weeks) it is confirmed from the result that they are all of equal temperatures.
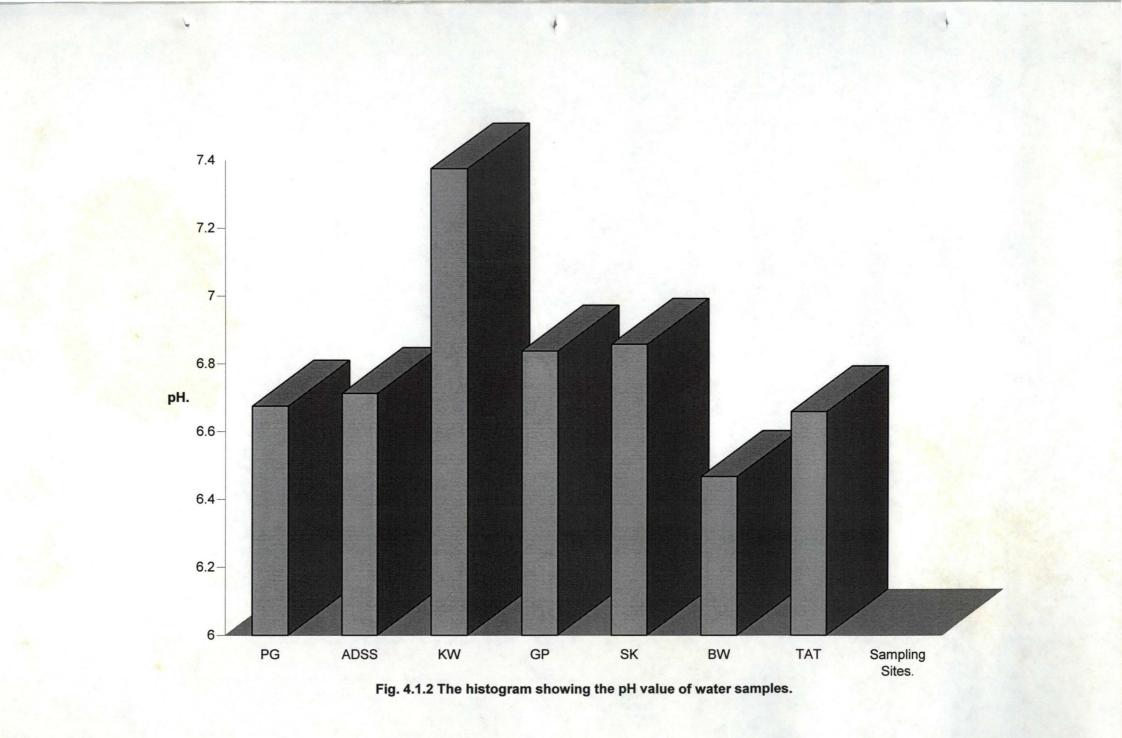
4.1.2 pH OF SAMPLES

It is an established fact that natural waters have values of pH in the ranges of 4 to 9, while the maximum permissible values are from 6.5 to 8.5. In this study the maximum value obtained from the selected bore holes is 7.50 while the minimum value is 6.40. A plot of values is shown in a bar chart figure 4.1.2. From the result tabulated in table 3.3.1. there is none that showed a marked deviation from the WHO (1971) recommended value for potable waters, which varies between 6.5 and 8.5.

A review of the values of the pH obtained from the bore holes investigated shows that they fall within the range. It is an indication that these waters probably never passed through rocks of varied minerals while they percolate through the soil. Besides, the minerals, if present never altered the pH level of the waters.

The closeness of the pH values may be as a result of the minimal agricultural or industrial activities going on very close to the sites of the bore holes, it is widely believed that certain industrial activities affect the pH of the soil, which in turn affect the pH of the ground waters in such areas.

Taking the ANOVA (appendix 2) into consideration, the result which shows that $Q = 1.2098 < 2.29$, gives the indication that these bore holes were all of equal pH value.

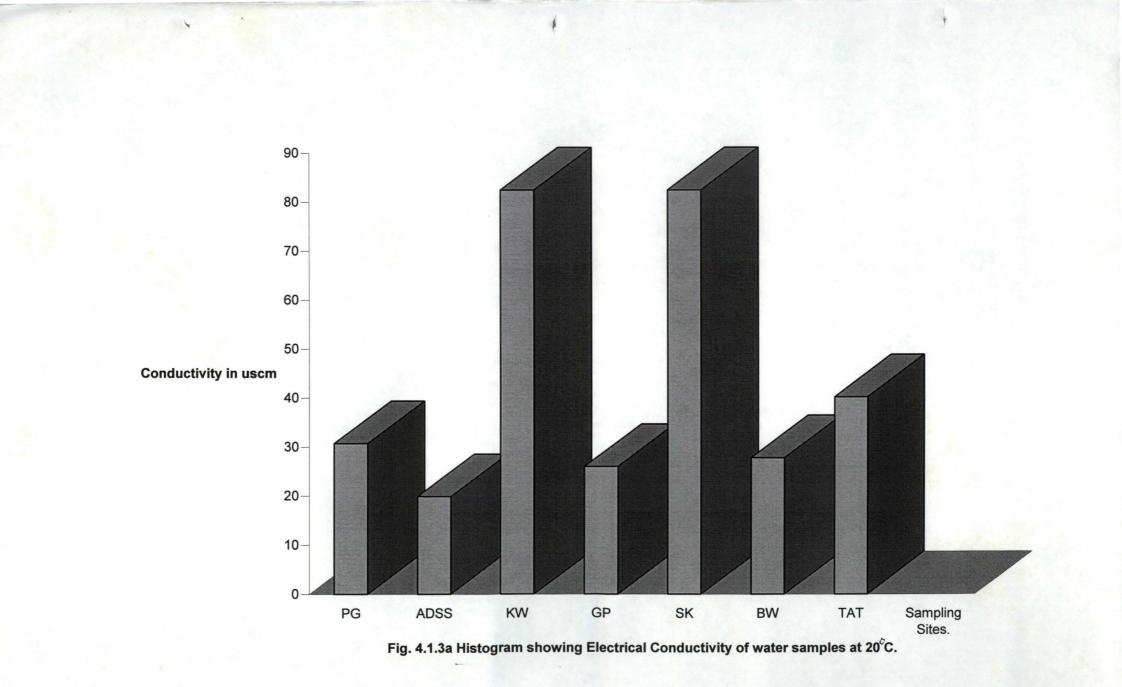Fig. 4.1.2 The histogram showing the pH value of water samples.
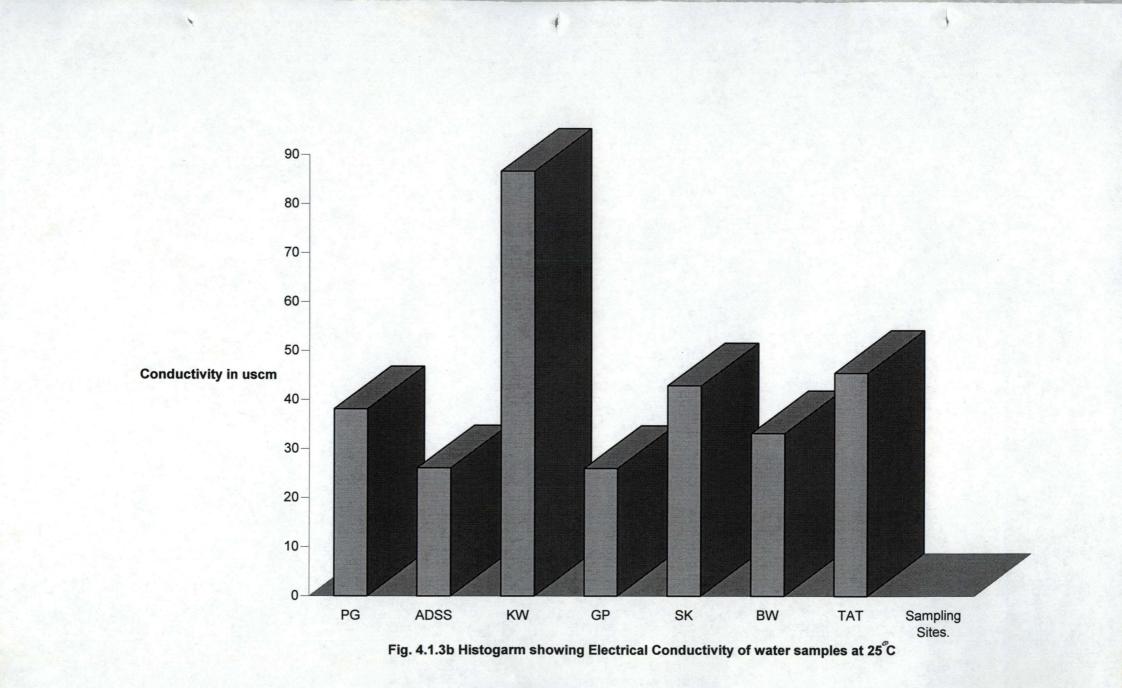
4.1.3 ELECTRICAL CONDUCTIVITY (E. C.)

It is necessary to obtain the electrical conductivity of the samples at two different temperatures. i.e. (20^0 C and 25^0 C).

From the bar chart in figure 4.1.3a (at 20^0 C) the average values can be seen to be temperature dependent. As temperature increases the corresponding electrical conductivity increases. The minimum value at 20^0 C is 19.87 μscm^{-1} while the maximum is 82.52 μscm^{-1}. The electrical conductivity of the samples from Kwanayi and Sesita gave a very high value as compared to the other sites, this may be as a result of many dissolved solids . From the electrical conductivity bar chart figure 4. 1.3b (20^0 C) only Kwanayi showed a marked difference from the rest.

Although the various result from the electrical conductivitys at 20^0 C and 25^0 C does not seem to be same, the analysis of variance (appendix 2) $Q = -17.98 < 2.29$ concludes that they are all of equal conductivity.

Recent findings show that samples from Abuja are similar in value to the ones obtained from bore holes in the Paikoro Local Government Area[1].

Fig. 4.1.3a Histogram showing Electrical Conductivity of water samples at 20°C.

Fig. 4.1.3b Histogarm showing Electrical Conductivity of water samples at 25°C
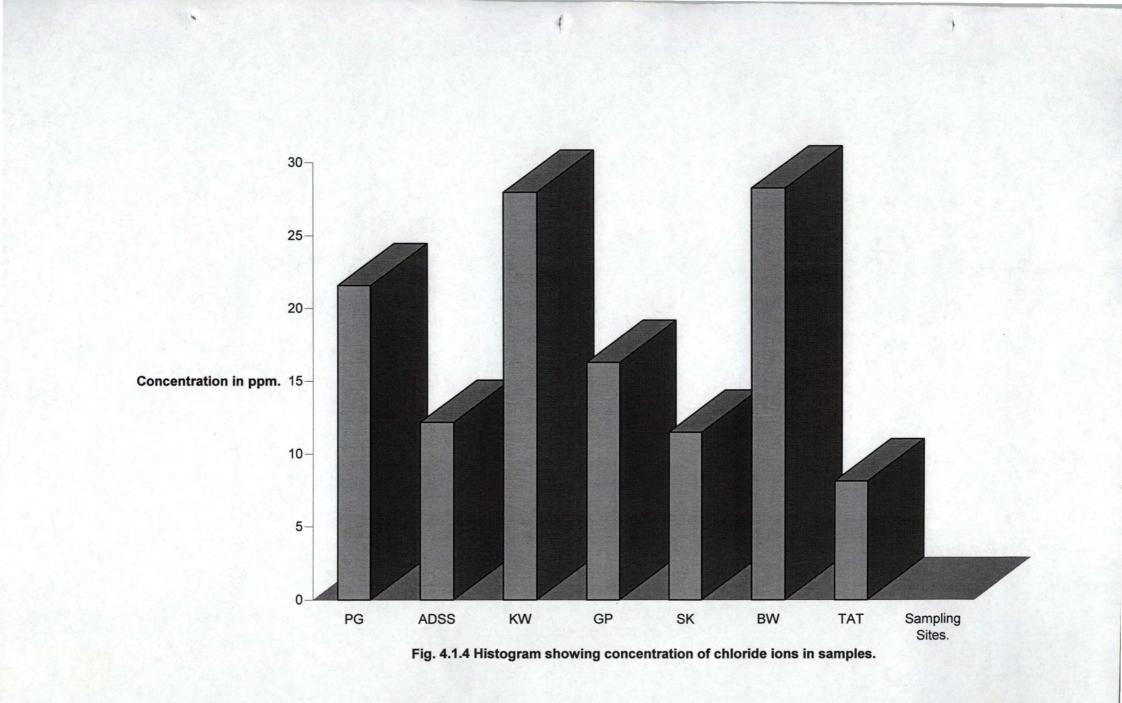
4.1.4   CHLORIDE CONCENTRATION

Chloride are often present in natural waters. The WHO (1971) standard for drinking water is 600ppm (Excessive limit = 600ppm, permissible limit = 200ppm). Throughout this analysis all the values obtained from samples were much lower than the stated standards. If higher values were obtained, it would have resulted from chloride containing geological formations, otherwise a high concentration show pollution resulting from sewage or some industrial waste, an intrusion of sea or some other saline waters[2].

The result of the analysis obtained shows that the average chloride ion concentration varies between 8.13ppm and 29.50ppm. The bar chart figure 4.1.4 shows the dispositions of the chloride ion concentrations of the various bore holes analysed.

The value of 8.13ppm form Tatiko bore hole would be indication that the underlying rocks do not contain much chloride salts, since most naturally occurring chlorides are very soluble. The high values obtained are especially from the popular Paiko Biwater scheme. The design is such that water from various bore holes are connected through a pipeline network to a central distribution point. Therefore the chloride ion concentration value obtained is the resultant value from the various bore holes.

From the calculations of ANOVA (appendix 2) $Q = -0.71160 < 2.29$, it would be concluded that the samples are all of equal chloride ion concentrations.

Fig. 4.1.4 Histogram showing concentration of chloride ions in samples.
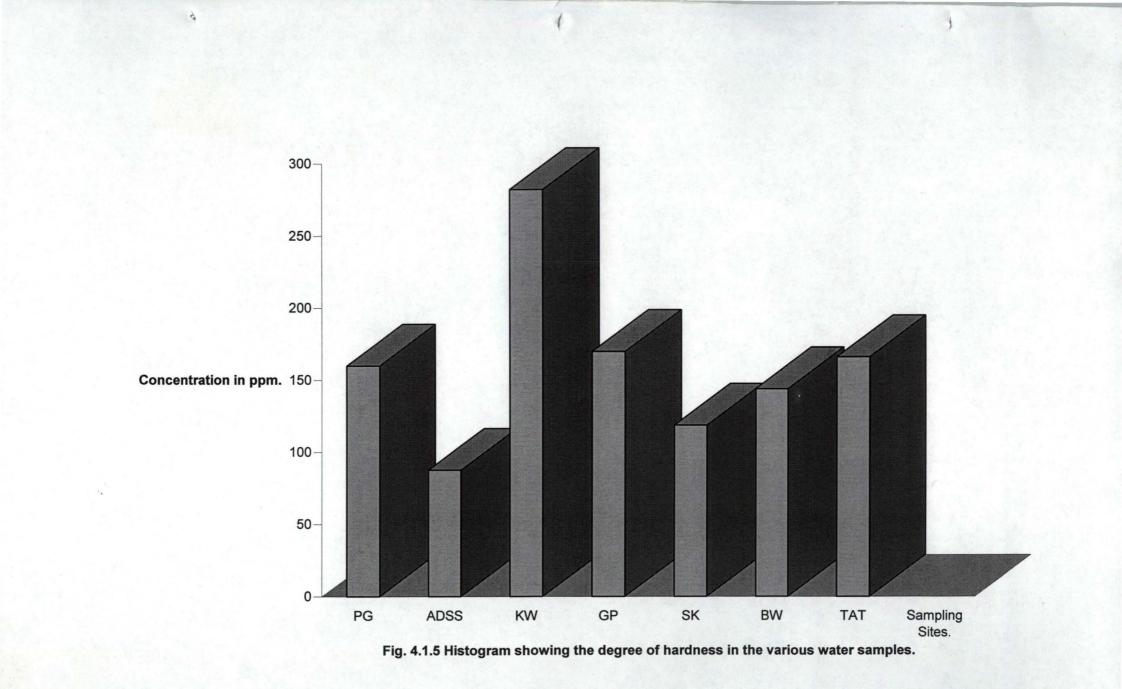
4.1.5   TOTAL HARDNESS

The hardness of water originally referred to the capacity of water to destroy the lather of soap and was determined by a titration with a standard soap solution. The most common cause of the destruction of the lather is the presence of calcium and magnesium salts in the water and over the years the term "Water Hardness" has been generally accepted. [3,4].According to the WHO (1971) the permissible and excessive limits are 100ppm and 500 ppm respectively. The U.S. Geological Survey has also classified the degree of water hardness[5], shown in table 4.1.5 below,

Title: Classification of degree of water hardness

Hardness	ppm as calcium carbonate
Soft	0 – 60
Moderately hard	61 – 121
Hard	121 – 180
Very Hard	> 181

The current study indicates that water from Kwanayi bore hole is "very hard", while the remaining bore holes including the Popular Paiko Biwater scheme fall into the "hard" water level of classification and the water from Abubakar Dada Secondary School is "moderately hard". These results compared very well with those obtained by Ruwatsan when the wells were dug. The bar chart figure 4.1.5 shows the dispositions of the degree of hardness for the various bore holes investigated.

Even though the waters from these bore holes have been classified in this study as being either soft, moderately hard, hard or very hard; the statistical analysis using ANOVA (appendix 2) indicates that $Q = -8.977 < 2.29$ leading to the conclusion that they are all of equal degree of hardness.
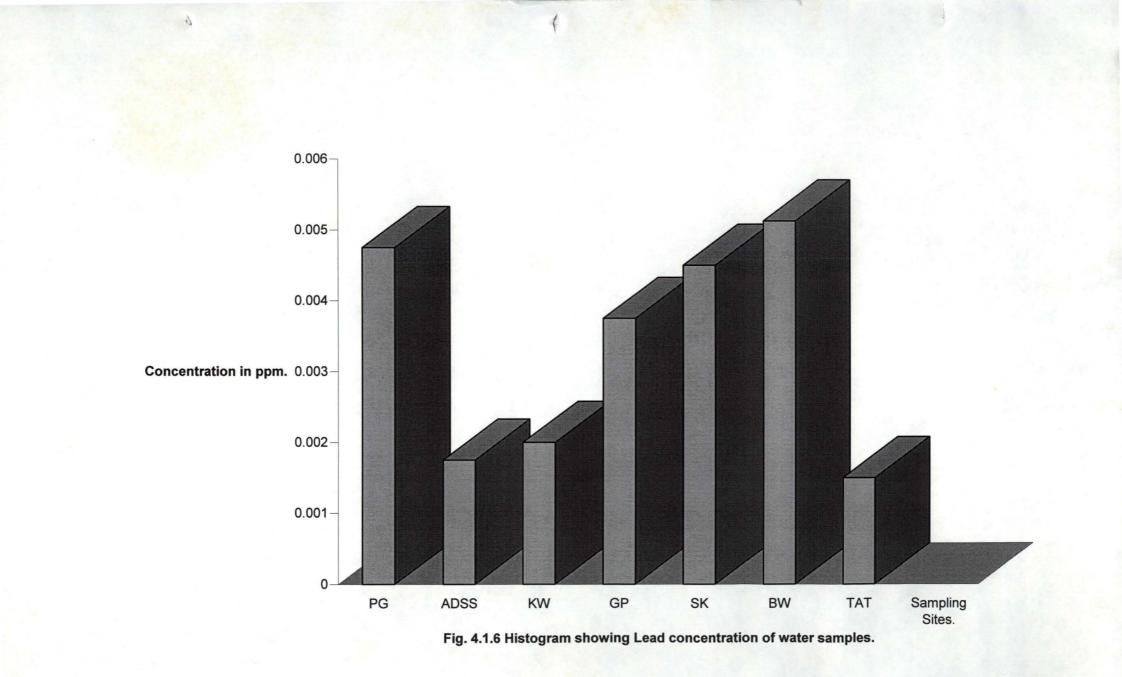
Fig. 4.1.5 Histogram showing the degree of hardness in the various water samples.

4.1.6   LEAD CONTENT OF THE SAMPLES

Lead is a minor element in most of our natural waters[6]. The maximum limit recommended by WHO (1971) is $0.1mg/dm^3$ in drinking water, while the maximum safe limit for animal watering has been reported to be $0.5mg/dm^3$.

From the bar chart figure 4.1.6 the concentrations of lead in the various samples of the bore holes analysed ranges between 0.0015ppm and 0.0048ppm. From these values, it is observed that Pago and Paiko Popular Biwater scheme have higher values of lead concentration than the other bore holes. The reason for this may be due to heavy traffic around these areas , since it is believed that heavy traffic activities do increase the concentration of lead in such environment. Kwanayi, Tatiko and Abubakar Dada secondary school have considerably low values of lead concentration in their bore holes.

An examination of the result obtained using ANOVA (appendix 2) Q = 0.01411 < 2.29 shows that irrespective of the bore hole analysed, they are all of equal lead concentrations.

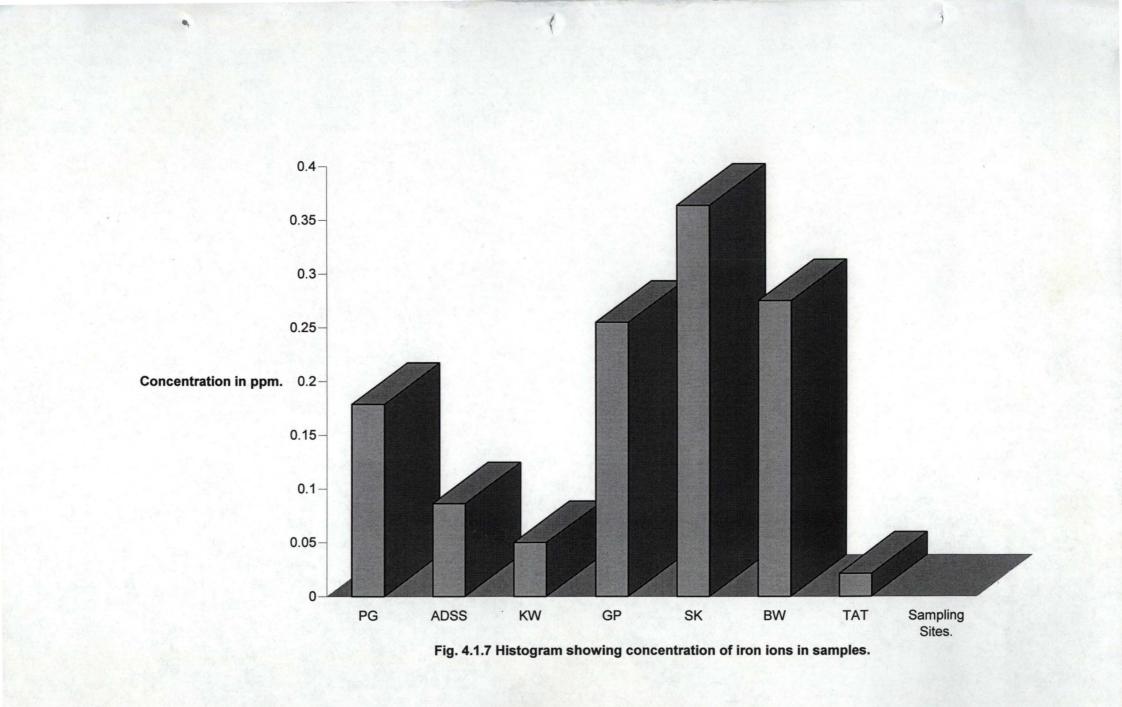**Fig. 4.1.6 Histogram showing Lead concentration of water samples.**

4.1.7   IRON CONTENT OF THE SAMPLES

Iron is seldom one of the most major constituents in water. Its solubility in natural water is governed by pH, redox potential and concentration of hydrogen trioxocarbonate (v) and sulphide[8,9,10].

Concentrations which are higher than 1mg of iron per litre are in alkaline surface water, however higher concentrations are common in ground water and acidic surface water[6].

The permissible and excessive limits of iron in water are given as 0.3 mg/litre and 1.0mg/litre respectively by the WHO (1971). This recommended limit is not based on toxicity not on aesthetic and taste considerations.

It would be observed that bore holes from Tatiko, Kwanayi and Abubakar Dada secondary school, fall below the permissible limit. The bar chart figure 4.1.7 shows the dispositions of the concentrations of iron from the various bore holes analysed. The statistical analysis ANOVA (appendix 2) where $Q = -37.39166 < 2.29$, shows that these bore holes were all of equal iron concentrations irrespective of the bore hole and its location.
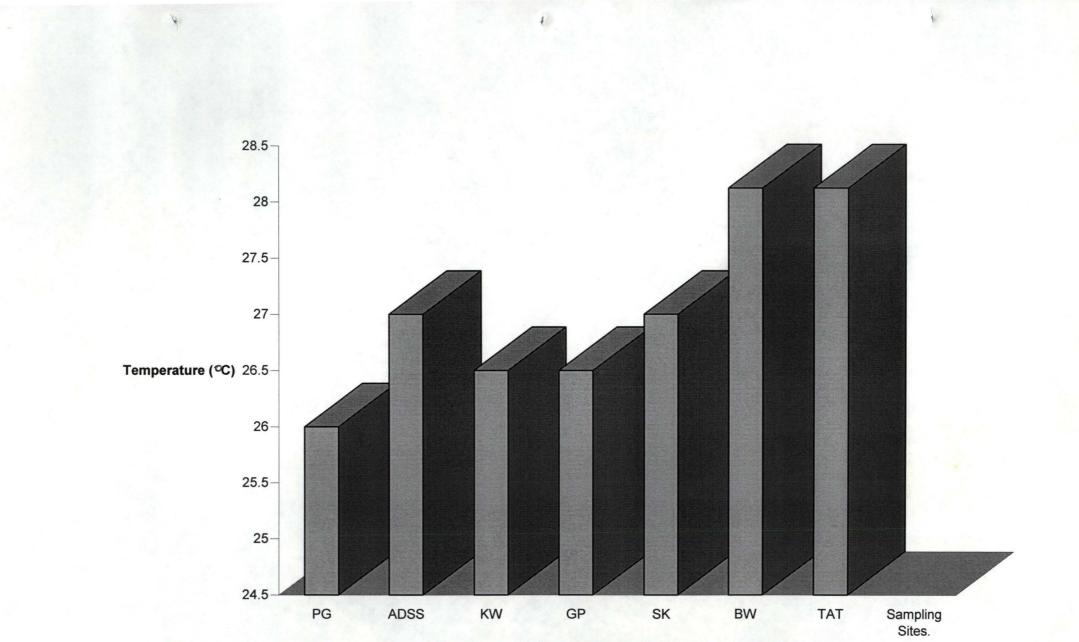
Fig. 4.1.7 Histogram showing concentration of iron ions in samples.

Fig. 4.1.1 Histogram showing dispositions of temperature of water samples.

4.1.8 CONCLUSION

In conclusion, it may be relevant to point out that in the course of this study I have discovered that some how all the studies carried out in our University have been limited to Minna and its environs.

In view of this, I would wish to suggest that the scope of future studies on the characterisation of bore holes be widened to cover local government areas in the rest of Niger state, i.e. precisely the areas where this study has not yet been undertaken.

This, it seems, would help to provide the best vantage position for determining whether geologic formulations have been able to affect the metals present in the water in these areas. Besides, the availability of such studies would provide ready tools for use by the institution and the governments (whether Federal, State or Local) in boosting rural and urban water development and of the expansion of the existing schemes.

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APPENDIX 1: WHO INTERNATIONAL STANDARDS FOR DRINKING WATER[1,2,3].

Parameter	Permissible Limit(ppm)	Excessive Limit(ppm)	Maximum Limit (ppm)	Recommended Limit(ppm)	Tolerable Limit(ppm)
Ammonia (NH_3)	-	-	-	0.5	-
Arsenic[a]	-	-	0.05	0.01	0.05
Cadmium[a]	-	-	-	-	0.01
Calcium	75	200	-	-	-
Chloride	200	600	-	350	-
Chromium[a](hexavalent)	-	-	0.05	-	0.05
Copper	1.0	1.5	-	3.0	-
Cyanide[a]	-	-	0.05	-	0.01
Fluoride	-	-	-	1.5	-
Iron	0.3	1.0	-	0.1	-
Lead[a]	-	-	0.1	-	-
Magnesium	50	150	-	125**	-
Manganese* sodium sulphate	500	1000	-	-	-
Nitrate as NO_3	-	4.5	-	4.5	-
Dissolved Oxygen (Minimum)	-	-	-	5.0	-
Phenolic Comp. as phenol[a] -	0.001	0.002	-	-	-
Polynuclear hydronuclide (PHC)	-	0.2	-	-	-
Radioclides gross A activity	-	$3 pci\ dm^{-3}$	-	-	-
Radionuclides gross B activity	-	$3 pci\ dm^{-3}$	-	-	-

Sulphates	200	400	-	250	-
Total hardness	100	500	-	-	-
Total solids	500	1500	-	-	-
Zinc	5.0	15	-	-	-

*   For water samples entering the distribution system, the concentration of copper should be less than 0.5 ppm. But after 16 hours contact with new pipes, concentration up to 1.0 ppm are permissible.

**   The concentration of magnesium should not exceed 30 ppm in the presence of sulphates whose concentration is up to 250 ppm.

a   Highly toxic.

b   Hazardous to health (1 pci $= 1.0 \times 10^{-12}$ curie)

APPENDIX 2:   ANOVA (ANALYSIS OF VARIANCE)[4]

CONDUCTIVITY AT 25^{0C}

Week	PG	ADSS	KW	GP	SK	BW	TAT	
1	38.40	26.10	82.90	26.80	41.60	30.10	44.10	
2	38.60	25.30	86.90	26.70	42.50	32.00	44.50	
3	37.50	25.60	87.90	25.90	43.50	32.00	45.60	
4	38.60	26.40	87.90	26.70	44.50	35.50	44.50	
5	38.40	26.10	85.90	25.00	42.50	30.10	47.50	
6	37.40	25.90	86.90	25.50	41.50	32.10	47.70	
7	37.50	26.20	87.90	25.70	42.50	35.60	47.70	
8	38.60	25.80	86.90	25.70	44.50	36.50	44.50	
Total	305.00	208.00	693.20	208.00	343.10	265.30	364.00	2387.20
Mean	38.13	26.08	86.65	26.00	42.89	33.16	45.50	42.63

ANALYSIS.

H_o :   The liquids are of equal conductivity at 25^{oC}.

H_i: The liquids are not of equal conductivity at 25^{oC}.

Significant level. $\alpha = 0.95$

Decision : Reject H_o if $F_{cal.} < F_\alpha$ otherwise reject H_i.

Computations.

$$SST = \Sigma \chi^2_{ij} - (T^2 \div N)$$

$$SST = [(38.40)^2 + (26.10)^2 + (82.90)^2 + \ldots\ldots\ldots\ldots\ldots\ldots + (44.50)^2] - \{(2387.20)^2 \div 56 \}$$

$$SST = 122708.48 - 101762.93 = 20945.53$$

$$SSC = [\Sigma_i T_i^2 \div n_i] - \{T^2 \div N \}$$

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$$SSC = [\{(305.00)^2 + (208.60)^2 + \ldots\ldots\ldots\ldots\ldots + (364.00)\}^2 \div 7] - [(2387.20)^2 \div 56]$$

$$SSC = 140132.41 - 101762.93 = 38369.48$$

$$SSE = SST - SSC = 20945.53 - 38369.48 = -17423.95$$

ANOVA   TABLE

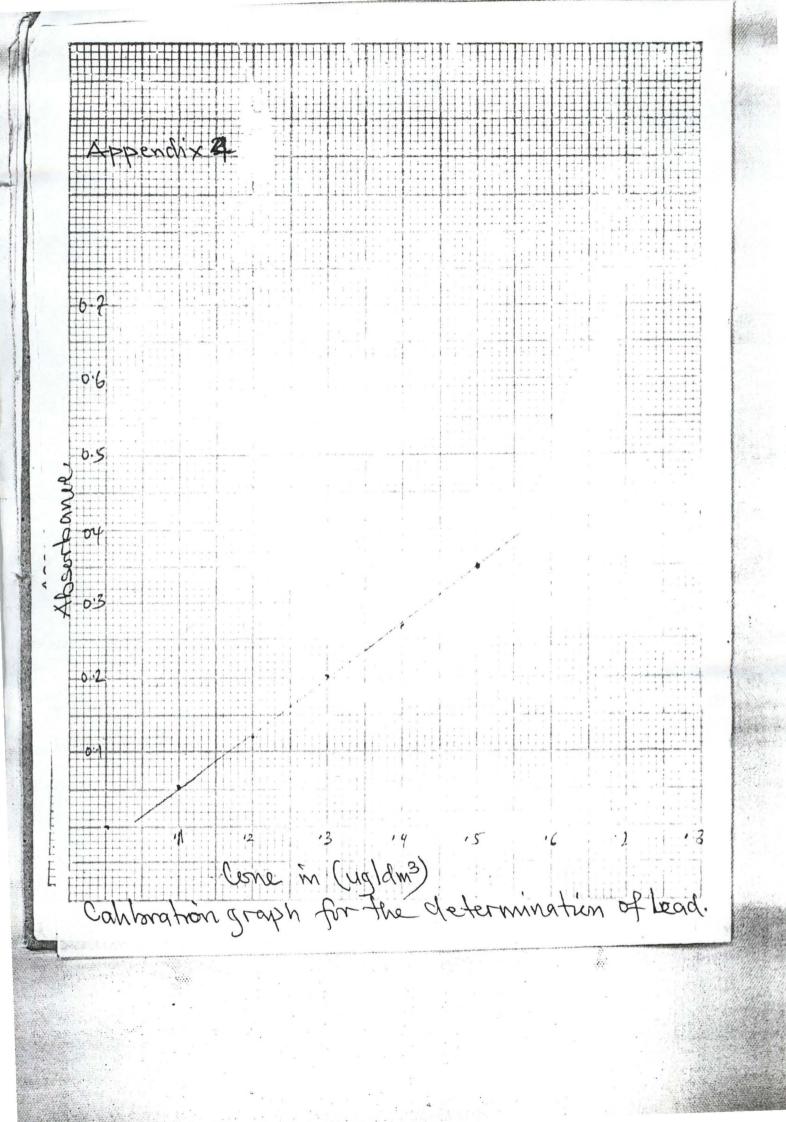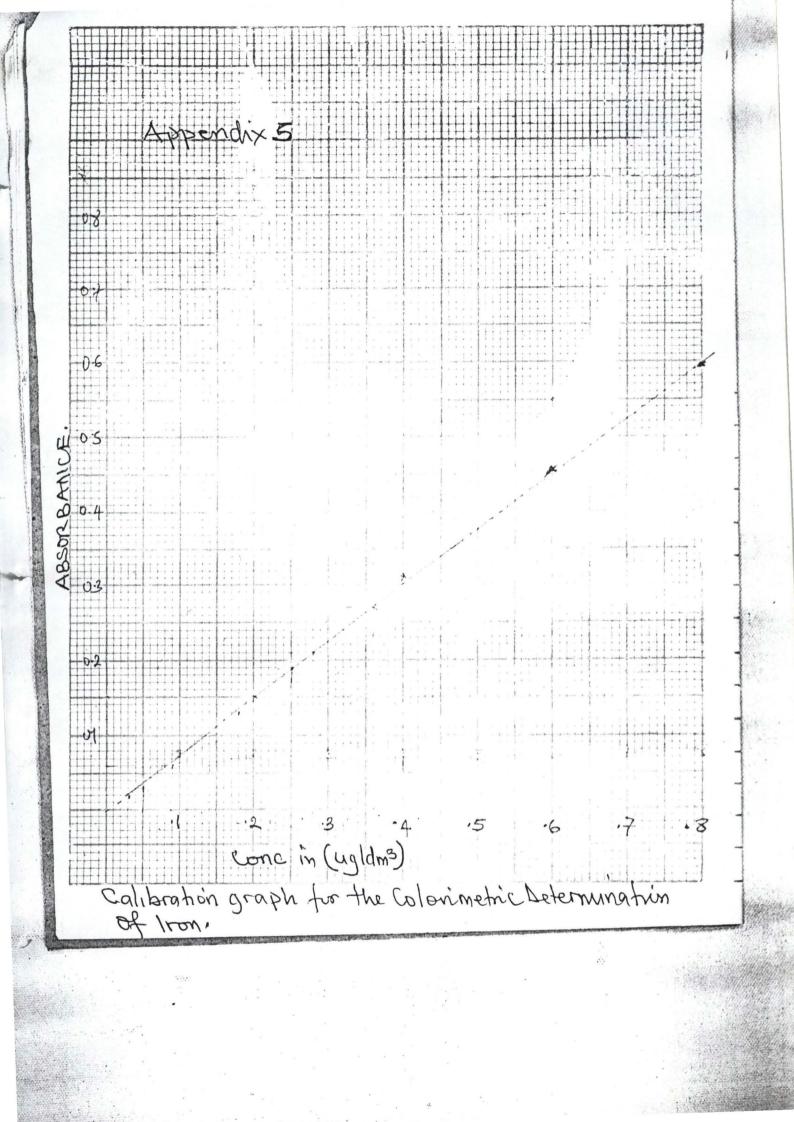| Source of variation	Sum of squares (ss)	Degrees of freedom (df)	Mean of squares (ms)	$F^* = (ssc/k-1) \div [sse/k(n-1)]$
SSC	38369..48	k-1 = 7 –1 = 6	38369.48/6 = 6394.91	-(6394.48/355.59) = -17.98
SSE	-17423.95	k(n-1) = 7(8-1) = 7x7 = 49	(-17423.95)/49 - 355.59	
SST	20945.53	kn – 1 = 56 – 1 = 55.		

CONCLUSION.

Since $F^* < F_\alpha, (6, 49) = -17.98 < 2.29$, we reject H_i and conclude that all the liquids are of equal conductivity at 25^{oC}.

Appendix 3.   Ruwantsan results for the area covered.

	pH	Conductivity	Chloride	Hardness	Iron	Temp.	Lead
PG	6.8	38.4	23.0	161.0	0.10	30.2	-
ADSS	7.5	87.9	99.0	282.0	0.05	32.4	-
KW	6.7	26.1	13.0	87.0	0.09	32.7	-
GP	6.7	33.3	9.0	254.0	0.09	25.0	-
SK	6.5	30.0	1.0	78.0	1.60	31.0	-
TAT	6.3	22.4	49.0	93.0	0.25	30.6	-

Note : Temperature is in degrees celsius, while concentrations are in ppm.

Appendix 2

Calibration graph for the determination of Lead.

Appendix 5

Calibration graph for the Colorimetric Determination
of Iron.

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