CHEMICAL AND BACTERIOLOGICAL ANALYSIS OF POTABLE WATER

BY

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A dissertation submitted to the Department of Chemistry \ Federal University of Technology Minna, Nigeria, in partial fulfilment of the requirements for the award of the degree of Masters of Technology in Analytical Chemistry.

JUNE, 1998

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. Information are derived from the published and unpblished work of others and they are acknowledged by means of references.

ZULAIHAT ABDULHAMID (MRS)

CERTIFICATION

The research has been carefully read through and approved as meeting the requirement of the Department of chemistry, Federal University of Technology, Minna, for award of Masters of Technology in Analytical Chemistry.

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DEDICATION

To little Kalim, Ibrahim and Zahra

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ACKNOWLEDGEMENT

All praise be to Allah (God) the first, the last the Hidden and the Manifest. I am indeed grateful to my supervisor Dr. A.A. Farouq whose advice, suggestions, constructive criticism, guidance and encouragement were instrumental to the success of this work.

First and foremost, I shall always remain grateful to my dear husband Kasim u. Isah for his encouragement, advice and his understanding throughout the time of this project. I am also thankful to my parents Mr. and Mrs. Abdullhamid Dauda for their prayers and to my Senior brother Daoud Abdullhamid for his encouragement. Special mention must be made of my sister Asiya Abdulhamid, my children Zahra, Ibrahim and little Kalim for their understanding during the time I stayed in the laboratory.

My profound gratitute also goes to Mallam Abdullahi, Mrs. Akinbode, Mr. Bala and Mr. Emmanuel of the chemistry laboratory for making available the facilities used in this project as well for their efforts and technical assistance throughout the work. My sincere appreciation also goes to Prof. Gbodi of Biological Science Department for assisting me with his personal Zinc cathode lamp and some literatures. Also to Ibrahim Kasim of microbiology laboratory I say thank you.

I am also grateful to my sisters Ramatu Abdulhamid and Murjanatu Abdulhamid, my friend Mrs. Fatima Farouq and my course mates: Mr. Shina Sanya, Mr. Yakubu Gado, Mr. Jonathan Yisa and Mr. Odega Samuel for their support and encouragement.

I shall always remain thankful to Dr. M.A.T. Suleiman, the student affairs officer for his guidance and encouragement.

Last, but not the least I am most grateful to Mallam Habib Aliyu Garba of Computer Centre, Federal University of Technology, Minna for typing the manuscripts.

ABSTRACT

The present studies involve the chemical and Bacteriological analysis of potable water around Minna municipal. The samples were taken from borehole, hand dug wells, raw and treated water.

The parameters explored were: pH; electrical conductivity; temperature; potassuim; Zinc and Iron using various analytical techniques.

The average values of the parameters determined lies between the ranges: - pH 6.5-6.9; electrical conductivity 34.0 – 95.0 μscm^{-1} and temperature 26-28^{o}C; while the average concentrations range between: Potassium 1.8 - 11.7ppm; Zinc 0.15 - 0.37 ppm and Iron 0.05-0.13 ppm. Bacteriological analysis results reveal that all the samples analysed are potable.

The results acquired for chemical and bacteriological analysis are all within the limit set by the World Health Organization (WHO).

ABBREVIATIONS

TW(1)	Tunga well 1
TW(2)	Tunga well 2
COET	College of Education Tap
TT	Tunga Tap
COEBH	College of Education borehole
RWC	Raw water Chanchaga
AAS	Atomic Absorption Spectorophotometer
PPM	Parts per million
PPB	Parts per billion
AR	Analytical Grade Reagent
μscm^{-1}	Microsiemens per centimetre
Cm3	Cubic centimetre
dm3	Cubic decimetre
ml	Milli litre
E.coli	Escherichia coli
MPN	Multiple probable Number
LB2X	Lactose broth double strength
LB1X	Lactose broth single strength
EMB	Eosin Methylene Blue
A/G	Acid and Gas
+Ve	positive
-Ve	Negative

CHAPTER ONE

1.0 INTRODUCTION

Pure water is a clear, colourless, tasteless and adourless liquid with a boiling point of 100°C, a freezing point of 0°C at atmospheric pressure and maximum density of 1 gcm^{-3} at 4°C.

There are two types of water: Natural and treated water. Natural water includes rain water, lake water and sea water. Rain water is the purest form of natural water because it is formed as a result of the condensation of water vapour in the atmosphere!. Spring water contains a considerable amount of mineral salts but very little suspended impurities such as dust and bacteria. Well water contains alot of clay and other mineral salts. River, lake and sea water contains alot of dissolved air, mineral salts, bacteria and organic remains. Treated water is usually prepared for special purposes.

Pollution of water affects the lives of many people throughout the world, especially those living in industrialized areas. Among the causes of pollution are the large volumes of waste water originating from highly populated cities, the discharge of untreated effluents by industrial complexes, and the use of a wide variety of chemical fertilizers and pesticides in agriculture. Excessive water pollution for example by heavy metals can jeopadize health, while certain types of pollution e.g. oil spillage may even render the affected areas unfit for normal habitation and therefore, constitute a serious obstacle to socioeconomic

development. Hence many national, regional and city administrators are now faced with public demands for stricter control over water pollution.

All programmes to reduce pollution or to improve the quality of water used for human consumption depend on reliable analytical measurements. A large variety of analytical methods have been developed to determine important chemical and microbial determinands, and some biological survey methods have evolved to estimate the quality of surface water. Some of the analytical methods used in the assessment of pollution are not concerned with the concentration of specific substances but measure a general property of the water. These methods of which the measurement of biochemical oxygen demand is an example, are empirical, but are carried out under carefully standardized conditions. Therefore the results obtained for a given test will depend on conditions employed. However even when determinands are made of specific constituents, results may vary according to the particular analytical method used. The number of published methods and variants of methods for any one determinand is often so large that different methods are apt to be used in different countries[2].

For water to be used as a healthful fluid for human consumption, it must be free from organisms that are capable of causing disease and from minerals and organic substances that could produce adverse physiological effects. Drinking water should be free from apparent turbidity, colour, odour and any objectionable taste. It should also have a reasonable temperature and pH. Water

meeting these conditions is termed "Potable", meaning that it may be consumed in any amount without fear of adverse effects on health[3].

1.1 HISTORICAL DEVELOPMENT IN WATER QUALITY CRITERIA

Historically, organizations began and centered within regions of abundant water supplies. Water quality was not very well documented and people knew relatively little about disease as it relates to water quality. Early historical treatment was performed only for the improvement of. The appearance and taste of the water. No definite standards of quality other than general clarity or palatability were recorded by ancient civilizations. It was claimed that the first drinking water standards were issued atleast 4000 years ago[3].

Apparently ancient poeple deduced by observation that certains waters promoted good health, while others produced infection. Although they knew nothing about the cause of disease, they were able to recognise the health-giving properties of pure and wholesome water. Unfortunately such information had to be acquired as a result of illness and death of many people.

By the eighteenth century, filtration of particles from water was established as an effetive means of clarifying water. The general practice of making water clean was well recognized by that time, but the degree of clarity was not measurable. The first municipal water filtration plant started operations in 1832 in Paisley, Scotland[4]. Apart from the frequent references of concern for the aesthetic properties of water, historical records indicate

that standards for water quality were notably absent up to and including much of the nineteenth century.

With the realization that various epidemics e.g. cholera and typhoid had been caused and spread by water contamination, people saw that the quality of drinking water could not be accurately judged by sensory perception. Reliance on taste and smell was not an accurate means of judging the acceptability of water, more stringent quality critieria would be a necessary historical development. As a result in 1852 a law was passed stating that all waters should be filtered[4]. In 1855, epidemiologist Dr. John snow was able to prove empirically that cholera was a water-borne disease. In the late 1880s, Pasteur demonstrated the particulate germ theory of disease, which was based upon the new science of bacteriology. Only after a century of generalized public observations of deaths due to water-borne disease was this cause-and-effect relationship firmly established.

As a result of the prevalent acute water borne diseases of biological origin in certain part of the world, e.g. USA, slow sand filters were introduced in Massachusetts. Empirical observations showed that this improved the aesthetics of water quality. Later development in water treatment combine coagulation with rapid sand filtration, this significantly reduce turbidity and bacteria in the water. The next major milestone in drinking water technology was the use of Chlorine as a disinfectant. Chlorination was first used in 1908 and was introduced in a large number of water systems

shortly thereafter. Despite improvements in disinfection and other types of water treatment outbreaks of water-borne disease still occur, particularly in smaller communities[5].

1.2 CHEMICAL POLLUTANTS IN WATER

Over 1000 synthetic organic chemicals (Socs) have been detected in drinking water at one time or another. Most are probably of no consequence, but some may pose a potential health risk to consumers. Some SOCs are considered toxicants as well as suspected human carcinogens.

The extent and significance of organic chemical contamination of drinking water or drinking water sources first came to public attention in 1972, when a report "Industrial Pollution" was published[6]. Although the report did not show that trihalomethanes (THMs) were formed during treatment, it provided the first evidence of the presence of THMs in drinking water supplies as well as showed that SOCs from industrial pollution were present in drinking water at low levels.

A follow-up study in 1974 was conducted primarily for the purpose of determining how widespread and serious the SOC contamination of drinking water was. In the united states of America, a comprehensive study of public water and drinking water sources to determine the nature, extent, sources and means of control of contamination by substances suspected of being carcinogenic was conducted by the enviromental protection agency[7]. The result of the study showed that chloroform and other

halogenated methanes are formed during the water chlorination process. An indepedent study provided an insight into the organic precursors that might be responsible for the formation of THMs[8]. The findings of this independent study prompted the U.S. Environmental Protection Agency to conduct the National Organics Reconnaissance survey, NORs, for halogenated organics. This survey was designed to determine the extent of the presence of four THMs: Chloroform, bromodichloromethane, dibromochloromethane and bromoform, along with carbontetrachloride and 1,2-dichloroethane[9]. In addition the survey examined the effect water sources and water treatment practices had on the formation of these compounds.

Concerns about SOCs in drinking water were related to contamination of groundwater supplies by a class of chemicals termed volatile organic chemicsl (VOCs) that are commonly used as solvents. The VOCs pose a possible health risk because a number of them are probable or known human carcinogens. This concern lead to the sampling of nearly 1000 public water systems of groundwater contamination problem.[10] Approximately one-fourth of the systems contained atleast one VOC at concentrations above detection limit (i.e 0.2 µg/l). The vast majority of VOCs were present at very low levels, but because these are man-made chemicals, their detection indicates that a pollution incident has occured in a resource that was once thought to be invulnerable.

Monitoring for inorganic chemicals has shown that possibly 1500 to 3000 systems have concentrations for one or more contaminants above the current standards[11]. Inorganics are mostly

problems in groundwaters, and their removal can be difficult and relatively expensive on a percapita basis for small public water systems. Problems continue primarily with arsenic, barium, lead, natural fluoride and to an increasing degree nitrate. Lead is known to occur widely as a result of lead plumbing materials.

1.3 LITERATURE REVIEW

Several review articles which deal with analysis of water have appeared. Many of them deal with instrumental methods of water analysis.

An indirect colorimetric method for lithium sodium and potassium using ionexchange resins have been described[12]. Water samples are first treated with ionexchange resins, from which they are eluted separately astheChlorides. After evaporation of excess hydrochloric acid, the residues are dissolved in water and the corresponding amount of chloride is determined by reaction with mercuric thiocyanite and ferric ammonium sulphate solutions.

A method for determining Copper and Zinc in a single sample was proposed by Kolesnikova[13]. Sodium-potassium tartrate and acetate buffer (pH 5.5) are added and Copper is extracted with a Chloroform solution of lead diethyldithiocarbamate. The absorbance of the organic layer was measured.

Methods for determining trace amount of iron, Copper, Chromium, Nickel and silica in power plant condensates were evaluated by Levendusky and Megahan[14]. In some these methods concentration of the sample by evaporation or extraction is

necessary. In a related studies, Herre[15] compared several colorometric methods for determining iron in condensates. Some of these methods could be used for routine analysis of these metal ions, and to determine the ions in the concentration range of between 0-20 parts per billion.

Instrumentation available for continuous water analysis has appeared in a review article by Jones and Joyce[16,17]. This article emphasises principles and application of several types of instruments based on colorimetric, coulorometric, amperometric, conductometric, potentiometric and polarographic measurements. Commercially available instruments for automatic or continuous measurements of dissolved oxygen, surface tension, residual chlorine, turbidity and certain impurities such as silica, hardness, Iron, and Copper that can be determined colorimetrically have been reviewed by serfass and Scheider[18].

Advances in instrumental techniques and effluent analysis have been made. These were described in a reviewed article by Malz[19]. This article contains a discussion of gas-Chromatographic methods for identifying phenols, and photometric, colorimetric, chelatometric, polarographic and microanalytical methods for a number of other constituents.

In water analysis, sample collection and handling before analysis is carried out is very important. This aspect is contained in a reviewed article by Rainwater and Thatcher[19]. The article dealt with sample collection, the handling of sample before analysis, general laboratory equipment, instruments, and the

general techniques, as well as several detailed laboratory procedures for determining over fourty water properties.

Methods useful for the analysis of micronutrients and particulate organic matter in sea water can be found in a review article by Strickland and Persons[20]. Determination of fluoride, bromide, iodide, alkalinity, acidity, potassium, calcium, magnesium, iron and arsenic were developed at the U.S. Bureau of Mines. Details can be found in the article by collins et al[21]. Photometric methods for determining most of the common anions and cations, and special substances such as chlorine, phenol, and hydrazine in drinking water and in waste water, were described in detail in a manual edited by Zimmerman[22]. Methods for the complete chemical and physical analysis of fresh waters has been prepared by Alekin[23].

Flamephotometer is widely used for the determination of alkali metals Dojlido and Koziorowski have reviewed flame photometric methods for the determination of sodium and Potassium in surface waters[24]. A subcommittee of the American water works Association proposed revision of standard methods for the flame photometric determination of sodium and potassium in water[25]. The proposed revision includes details of the three recommended procedure: a direct entensity measurement, an internal standard method and a bracketting approach. A discussion of the principles of the methods as well as interferences, sensitivity and accuracy is also included.

1.4 AIM AND OBJECTIVE OF THE PROJECT

The various processes involved in water analysis may be divided into four groups. these are physical, chemical, bateriological, microscopical and biological. For the purpose of this project:-

(1) some physical, chemical and bacteriological analysis will be carried out on the water samples to be analysed

(2) Various analytical techniques will be used to achieve the said goal in (1), and to determine whether any of the method could be used for routine analysis

(3) to compare the results obtained with the published World Health Organization (WHO) standards for potable water.

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CHAPTER TWO

2.0 INSTRUMENTATION

2.1 FLAME PHOTOMETER

2.1.1. INTRODUCTION

Flamephotometer is a simple and quick method of analysis. A substance is dissolved and finely sprayed into a non-luminous flame and burnt. This result in an intensification and colouring of the flame because of the excitation of the atoms.

The more atoms available, the stronger the emitted light. By measuring the brightness of the flame, it is therefore possible to determine the concentration of the solution. The colour of the emitted light i.e. the wavelength of the radiation will depend on the structure of the emitting atoms. Every element emits its own fixed wavelength and gives up a characteristic colour due to the disruption of its atoms. If several elements are simultaneously present in a substance, they can be selectively determined by using optical filters. Each filter is receptive to one specific element, so that only the emission from this particular element will pass through and the emission from the remaining element held back. If therefore a series of filters is used, it is possible by progressive elimination to determine all the elements that are simultaneously present in a substance.

In practice, relative measurements are made by comparing deflection given by an unknown with that given by a known concentration. This type of measurement, which is essentially easy and practical, gives the greatest reliability and accuracy only

under the best working condition and when measuring routine is strictly adhered to.

The flamephotometer basically consist of six parts:

(a) Pressure regulators for the fuel gas and oxidizing gas supply

(b) The atomiser

(c) The optical system

(d) The burner

(e) The photosensitive device

(f) The instrument indicating the output.

A Schematic diagram of flame photometer is shown in fig 2.0. More details about this instrument can be found in references 1-4

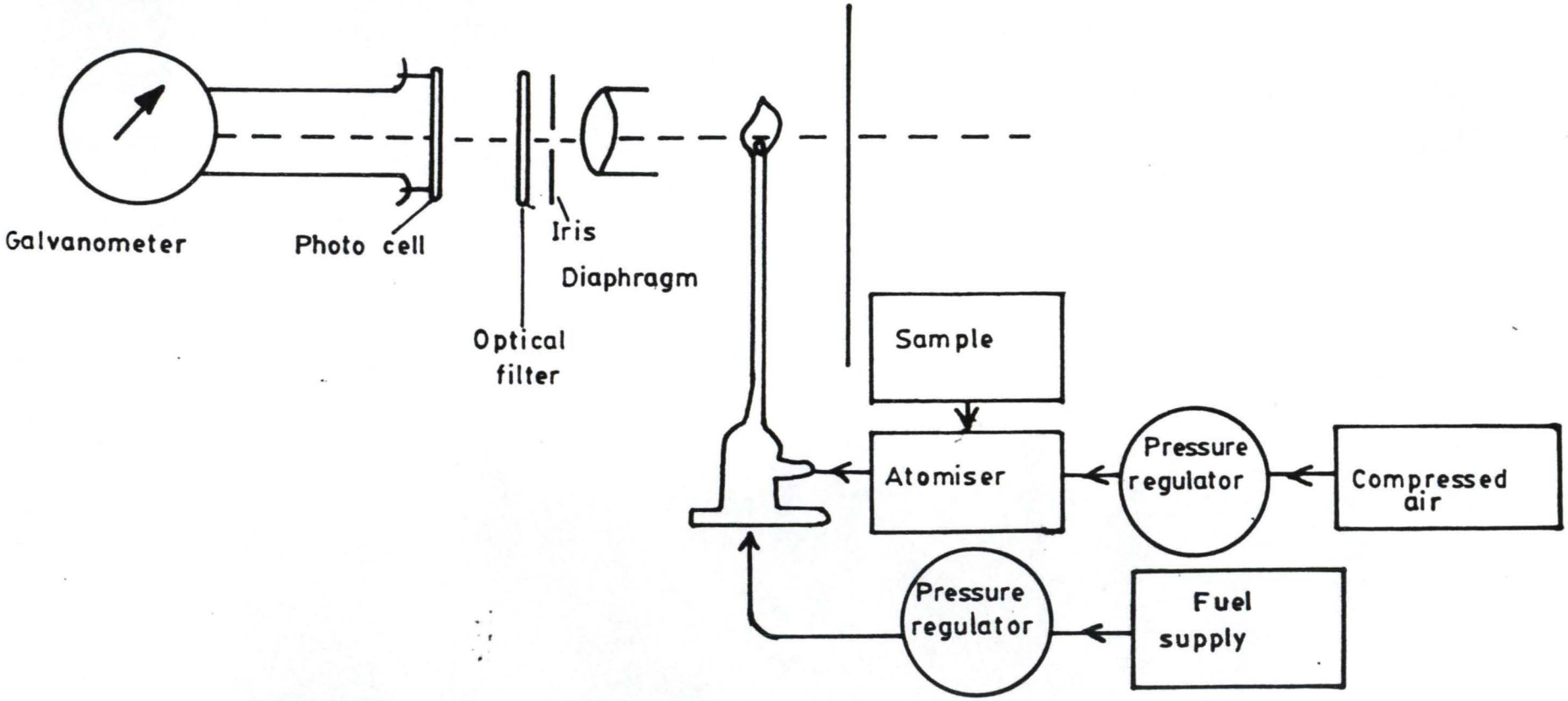

Fig. 2.0 A LAY OUT OF A SIMPLE FLAME PHOTOMETER.

2.2 ATOMIC ABSORPTION:

2.2.1. INTRODUCTION

The principle of atomic absorption is by no means new. In 1860, Kirchhoff concluded that the black lines in the spectrum of the sun were due to absorption by elements in its outer atmosphere. Little practical application was made of Kirchhoff's work until the mid 1950s when Alan Walsh, the Australian physicist developed the first practical absorption spectrometer. The technique is now in daily use for elemental analysis in many Laboratories throughout the world.

Atomic absorption spectrometer (AAs) is an analytical instrument used for the determination of trace elements concentration in parts per million (ppm) or parts per billion (ppb). The atomic absorption methods offer the analyst considerable advantages of speed, ease of sample handling, provision and general freedom from interference[2,5]. It has, therefore, rapidly established itself as a highly sensitive and specific method. It may be used to determine more than sixty elements in a wide variety of samples.

The versatility of this instrument means it could be used for both routine and research analysis in the field of atmospheric, clinical and biological analysis, metallurgical, soils, plants and fertilizers, water and effluents, food and beverages, petroleum and petroleum products[1,5.6].

Careful design of efficient nebulizer and cloud chamber system which reduces the sample solution to a fine aerosol of small,

uniformly sized droplets ensures high standards of performance and accuracy obtained from the instrument. The aerosol which is fed to the burner ensures a high degree of flame stability.

The instrument is extremely flexible, in order to obtain maximum performance for a wide variety of element. It may be operated with a number of flames using air or nitrous oxide as the oxidant gas and propane, hydrogen/argon or acetylene as fuel. The nitrous oxide/acetylene flame is used for a higher flame temperature than that attainable by burning air/acetylene gas mixtures. The hotter flame allows the sensitive analysis of elements such as "the refractory oxides" e.g. aluminium oxide, calcium oxide, magnesium oxide etc.

2.2.2 PRINCIPLES OF OPERATION

In atomic absorption spectrometry technique, a fine spray of the sample solution is introduced into a flame where it is desolvated, vapourised and atomized.

The use of solution spray permits a uniform distribution of sample throughout the body of the flame and the introduction of a representative portion of each sample into the flame.

An appropriate hollow cathode lamp mounted in a convinient rapid focus holder passes radiation from an external source. This radiation emits the spectral lines that corresponds to the energy required for an electronic transition from the ground state to an

excited state[7]. The radiation beam is focused through the flame where it is quantitatively absorbed by the atoms of the element under analysis and the beam passes through the monochromator onto the photomultiplier detector. The lamp power supply is modulated and the amplifier tuned to the same frequency in order to minimize the background and flame inteferences.

2.2.3. SETTING UP OF AAS

In order to be able to make measurements with AAS, it is necessary to device an experimental assembly which will convert the material under examination as efficiently as possible to a population of ground state atoms, and then pass resonance radiation of the element to be measured through that population. Ideally, the light measuring device "See only the wavelength" which is being absorbed, since the presence of other radiation will lower the proportion of absorbed radiation, and thus decrease the sensitivity of the measurement, hence the light source should be monochromatic in character. A schematic diagram of atomic absorption spectrometer is shown in figure 2.1.

2.2.4. RESONANCE LINE SOURCE

Light source used in AAS must provide a sharp line specturm characteristic of the desired elements. These sources should be stable, bright and have long operating life[8]. The light source is generally a hollow cathode lamp, which consists of an anode and a cylindrical cathode enclosed in a gas tight chamber as shown in figure 2.2

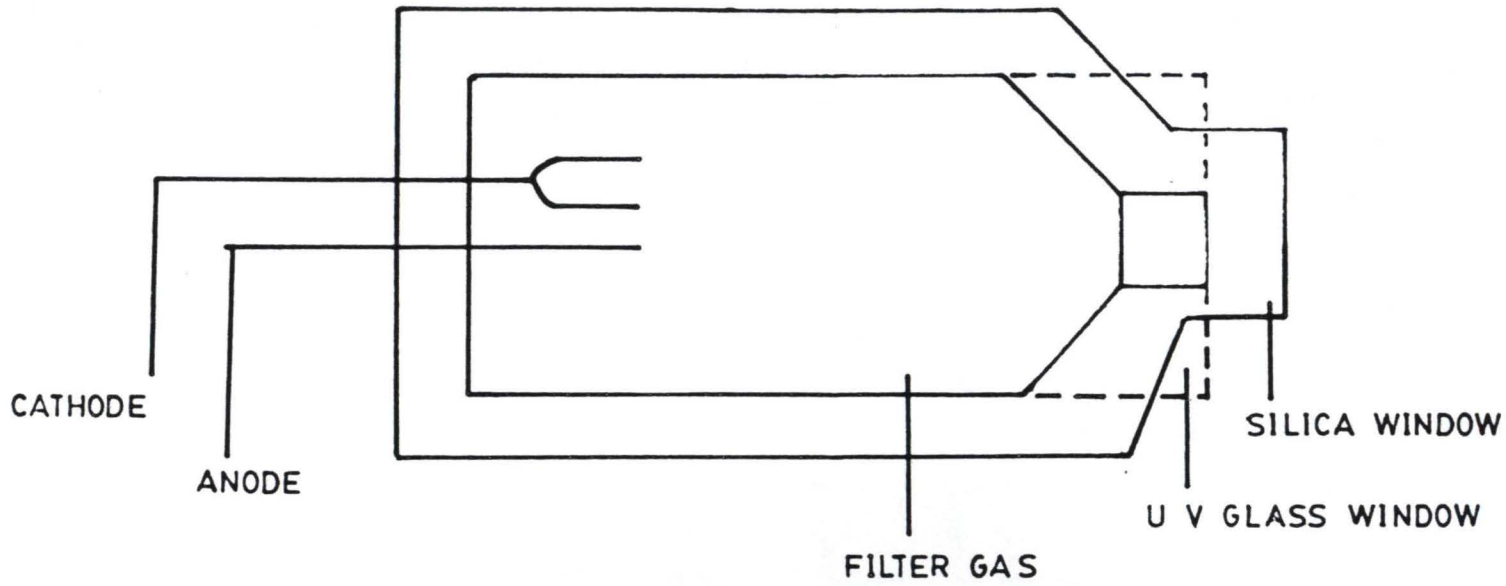

Fig.2.2: SCHEMATIC DIAGRAM OF HOLLOW CATHODE LAMP.

The tube is evacuated and filled with an ultrapure monochromatic carrier (or filter) gas at a pressure of about 1-5 torr[2]. Neon and argon are the two most frequently used, and the correct choice influences the intensity of spectral radiation and any interfering spectral lines.

2.2.5 NEBULIZER BURNER SYSTEM

The most important component of AAS is the nebulizer burner system. This system converts the test substance in the sample solution to atomic vapour and excites the neutral atoms or molecules to emit their characteristic radiation.

Two types of burner have been widely used in AAS: the earlier type being the turbulent flow burner and on most recent commercial instruments, the premix burnners have been incorporated. A schematic diagram of the slot burner nebulizer and spray chamber is shown in figure 2.3. The draw back in the use of the turbulent flow burner is that it can produce turbulence and hence an uneven distribution of atoms in the light path. It also tends to produce an uneven droplet size which may mean that energy is reflected rather than absorbed.

The premix burner system produces a more stable flame and a more even population of atoms in the light path. Light scattering is considerably reduced because in the premix chamber, larger and heavier droplets fall out of the earosol prior to entry into the flame.

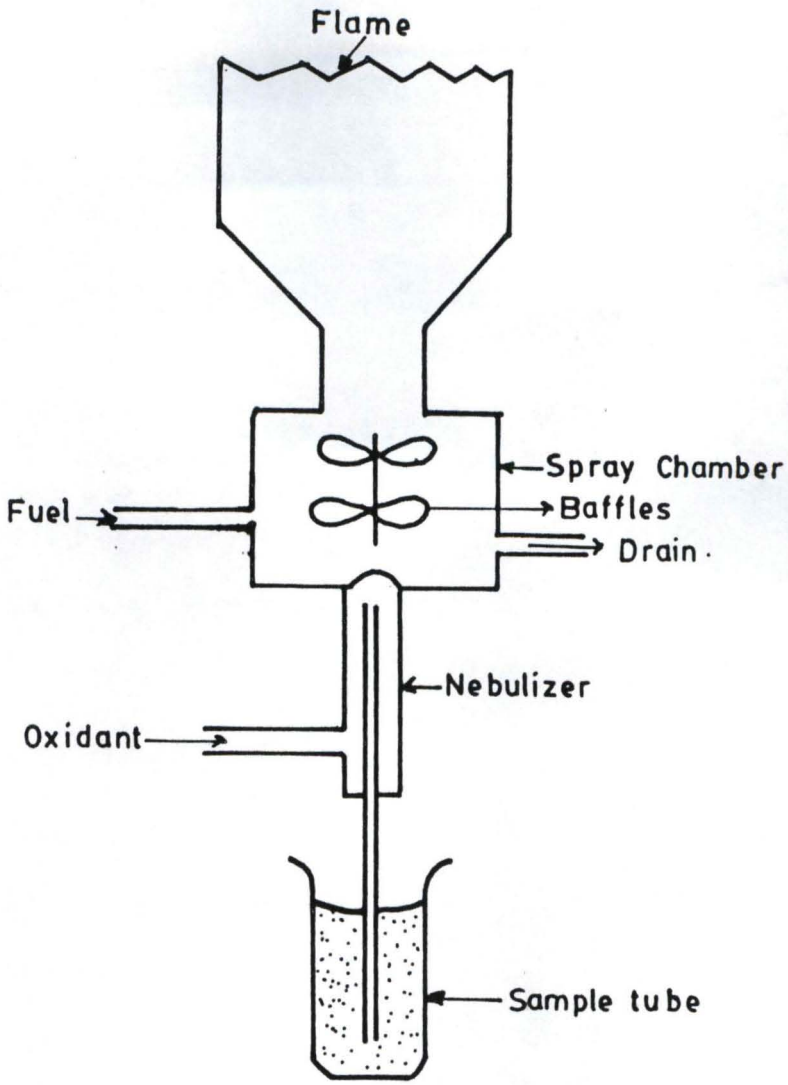

Fig. 2.3 : NEBULIZER BURNER SYSTEM

2.3 COLORIMETER

2.3.1 INTRODUCTION

The basic principle of most colorimetric measurements consist in comparing under well defined conditions the colour produced by a substance in an unknown amount of material being determined.

The variation of the colour of the system with change in concentration of some component, forms the basis of colorimetric analysis. The colour is usually due to the formation of a coloured component by the addition of an appropriate reagent or it may be inherent in the desired constitutuent itself. The intensity of the colour is then compared with that obtained by treating a known amount of substance in the same manner.

Coloured objects or substances have the ability of selective absorption of certain wavelength of incident light. The other wavelengths are either reflected or transmitted according to the nature of the object or substance. The selected wavelength for a particular assay is chosen so that the material of interest will absorb light at this wavelength; in such situation absorption will be as little affected as possible by interfering substances or variations in the procedures. For more details See references 1,2,3 & 5.

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CHAPTER THREE

3.0 EXPERIMENTAL AND RESULTS

3.1 SAMPLING

Samples were collected in two litres plastic containers washed with hydrochloric acid (1 mole per litre) and rinsed with distilled deionized water. Samples were collected in the morning between 9.00 a.m. and 11.00 a.m. Sample containers were rinsed twice with sample before filling[1]. Before collecting a sample, the container was partially filled and shaken to note the frothing and odour of sample[2]. When sampling from taps, the water was allowed to run to waste for a few minutes. This reduces the possibility of contamination of the sample by materials that have been deposited in the sampling lines.

The colour of each sample was noted and the temperatures of the samples were taken using a thermometer. The sample containers were then completely filled and covered immediately to avoid dissolution of gases.

The pH and the electrical conductivity were determined immediately after sampling in the laboratory. Preservative (concentrated nitirc acid) was then added to the samples and refrigerated for the determination of other parameters (Potassium was determined before adding preservative).

Samples were collected for a period of twelve weeks and each parameter was determined at a weeks interval.

Chromic acid was used for washing all the glass wares used for

the analysis. All reagents used were of analytical grade (AR).

3.2. DETERMINATION OF PARAMETERS

3.2.1 ELECTRICAL CONDUCTIVITY[1]

APPARATUS: Electrical conductivity measuring set, (BBC Brown Boueri. Kent EIL model 5007), water bath, test tubes beakers.

REAGENTS: Distilled deionized water, standard potassium chloride solution (0.01 $moldm^{-3}$) prepared by dissolving 0.7456g of anhydrons potassium chloride (dried at 105°C).

PROCEDURE:

The conductivity cells and the samples were thermally equilibrated by placing them on water bath kept at 20°C for atleast thirty minutes. The electrodes were calibrated using the standard potassium chloride solution (0.01 mol dm^{-3}). The cell was thoroughly rinsed with the sample and then filled. The thermal conductivity of each sample was then taken and the values tabulated in table 3.2.1.

TABLE 3.2.1. ELECTRICAL CONDUCTIVITY OF SAMPLES (in $\mu s\ Cm^{-1}$)

Week/Site	TW(1)	TW(2)	COE(T)	TT	COEBH	RWC
1	76.0	74.0	90.0	88.0	33.0	93.0
2	78.0	73.0	89.0	89.0	34.0	95.0
3	77.0	75.0	89.0	89.0	34.0	94.0
4	78.0	77.0	91.0	88.0	33.0	94.0
5	78.0	76.0	90.0	90.0	35.0	96.0
6	76.0	76.0	92.0	88.0	32.0	97.0
7	77.0	77.0	89.0	91.0	36.0	96.0
8	76.0	74.0	38.0	90.0	35.0	93.0
9	77.0	73.0	39.0	88.0	35.0	96.0
10	79.0	76.0	91.0	90.0	33.0	97.0
11	78.0	76.0	90.0	90.0	33.0	95.0
12	78.0	77.0	92.0	87.0	35.0	94.0
AVE	77.3	75.0	90.0	89.0	34.0	95.0

3.2.2 pH[1]

APPARATUS: pH meters Kent EIL 7045/46 with glass electrode in conjuction with a saturated calomel reference electrode.

REAGENTS: pH tablets (pH 4,7 and 9.2), distilled deionized water

PROCEDURE:

pH tablets of pH values 4,7 and 9.2 were carefully dissolved in three separate beakers. The solutions were quantitatively transfered into separate $100cm^3$ volumetric flasks and the marks made up using distilled deionized water. These buffer solutions were then used to standardized the pH meter; by placing the glass electrode in the solution of pH 4, 9.2 and 7 respectively.

The pH of the samples were then taken. Between each sample the electrodes were thoroughly rinsed using distilled deionized water. The determinations were made in unstirred solutions in order to avoid loss of carbondioxide or volatile components which will alter pH values. The reading were tabulated in table 3.2.2.

TABLE 3.2.2. pH VALUES FOR SAMPLES

Week/Site	TW(1)	TW(2)	COE(T)	TT	COEBH	RWC
1	6.7	6.9	6.6	6.9	6.5	6.9
2	6.5	6.8	6.9	6.6	6.5	7.0
3	6.6	6.9	6.8	6.7	6.6	7.1
4	6.7	6.6	6.7	6.6	6.6	6.9
5	6.6	6.8	6.6	6.8	6.5	6.9
6	6.6	6.8	6.8	6.8	6.6	6.8
7	6.7	6.8	6.7	6.7	6.5	6.9
8	6.7	6.9	6.7	6.9	6.5	6.8
9	6.5	6.8	6.9	6.8	6.0	6.9
10	6.6	6.9	6.8	6.9	6.6	6.9
11	6.5	6.8	6.9	6.8	6.5	6.8
12	6.7	6.9	6.9	6.9	6.5	6.7
AVE	6.6	6.8	6.7	6.7	6.5	6.9

3.2.3 ZINC (AAS METHOD)1

REAGENTS: Distilled deionized water, Zinc metal, concentrated nitric acid.

PROCEDURE: Standard Zinc solution was prepared by dissolving 1.0000g of pure zinc metal in $10cm^3$ of concetrated nitric acid. The solution was quantitatively transfered into $1dm^3$ volumetric flask and the mark made up with distilled deionized water.

Series of standards encompassing the concentration range of between 1ppm and 5ppm were prepared using the standard zinc solution. The blank; prepared by taking 1.5ml of concentrated nitric acid in one dm^3 volumetric flask and the mark made up was used to zero the instrument. The standard solutions prepared were aspirated into the flame and their absorbance recorded. These readings were used to draw a calibration curve which was found to be linear. The samples were then aspirated into the flame and their absorbane taken. The concentration of zinc in each of the sample was obtained from the calibration graph. Between each of the samples, the atomizer was rinsed with the blank solution. The absorbance readings obtained were tabulated in table 3.2.3

TABLE 3.2.3. CONCENTRATION OF ZINC IN SAMPLES BY AAS (PPM)

Week/Site	TW(1)	TW(2)	COE(T)	TT	COEBH	RWC
1	0.35	0.32	0.16	0.13	0.65	0.22
2	0.36	0.33	0.15	0.15	0.67	0.21
3	0.38	0.35	0.15	0.14	0.66	0.20
4	0.37	0.35	0.17	0.14	0.64	0.24
5	0.39	0.36	0.15	0.17	0.67	0.25
6	0.38	0.33	0.18	0.16	0.68	0.26
7	0.37	0.34	0.16	0.16	0.67	0.26
8	0.36	0.36	0.18	0.14	0.66	0.25
9	0.35	0.33	0.15	0.15	0.65	0.24
10	0.36	0.33	0.15	0.14	0.65	0.25
11	0.39	0.33	0.17	0.16	0.65	0.24
12	0.38	0.35	0.15	0.16	0.67	0.26
AVE	0.37	0.34	0.16	0.15	0.66	0.24

3.2.4. IRON (PHENANTHROLINE METHOD)[1]

REAGENTS:

3.2.4.1a IRON STOCK SOLUTION:

This was prepared by weighing accurately 200mg of Iron metal and dissolving it with 20.0cm^3 of 3 mol dm^{-3} sulphuric acid. The solution was quantitatively transfered into 1dm^3 volumetric flask and diluted to the mark with distilled deionized water.

50.0cm^3 of the stock solution was accurately pipetted into a dm^3 volumetric flask, and 1.5cm^3 of concentrated nitric acid added. The solution was then diluted to the mark with distilled deionized water. This served as the standard solution.

3.2.4.2a PHENANTHROLINE SOLUTION:

100mg of 1,10-phenanthroline monohydrate was accurately weighed. This was then dissolved in 100cm^3 distilled deionized water. Two drops of concentrated hydrochloric acid was added and the solution stirred to aid dissolution of phenanthroline.

3.2.4.3a HYDROXYLAMINE HYDROCHLORIC ACID:

10.00g of hydroxyl amine hydrochloride was accurately weighed into a small beaker. Small quantity of distilled deionized water was then added and the solution was quantitatively transfered into 100cm^3 volumetric flask and the mark made up using distilled deionized water.

3.2.4.4a AMMONIUM ACETATEBUFFER

This was prepared by weighing 250g of ammonium acetate into a beaker. 150cm^3 of distilled deionized water and 700cm^3 of concentrated glacial acetic acid were then added.

3.2.4.5a BLANK SOLUTION:

This solution was prepared by measuring accurately into a beaker 2.0cm^3 of concentrated hydrochloric acid, 1.0cm^3 of hydroxyl amine hydrochloride, 10.0cm^3 of ammonium acetate buffer and 2.0cm^3 of phenanthroline solution. The resultant solution was then quantitatively transfered into a 100cm^3 volumetric flask and diluted to the mark with distilled deionized water.

3.2.4.6 PROCEDURE:

0.1cm^3, 0.2cm^3, 0.3cm^3, 0.4cm^3 and 0.5cm^3 of Iron standard solution were placed each in a separate 100cm^3 volumetric flask. Added to each flask were 2.0cm^3 concentrated hydrochloric acid, 1.0cm^3 hydroxyl amine hydrochloride, 10.0cm^3 of ammonium acetate and 2.0cm^3 of phenanthroline. The resultant solutions were then diluted to the mark with distilled deionized water.

The instrument was zeroed against distilled water. The absorbance reading of the blank and the standards were taken. The absorbance of the blank was subtracted from that of the standard to get the net absorbance. A calibration curve was then prepared.

$2.5cm^3$ of each sample was accurately measured into a beaker, $50.0cm^3$ of distilled deinozied water, $2.0cm^3$ concentrated hydrochloric acid and $1.0cm^3$ of hydroxyl amine hydrochloride were added. A few glass beads were then added and the sample boiled using a water bath until the volume reduced to about $20.0cm^3$.

The content of the beaker was then removed from the water bath and allowed to cool to room temperature. This was quantitatively transfered into $100cm^3$ volumetric flask. $10.0cm^3$ of ammonium acetate buffer and $2.0cm^3$ of phenanthroline solution were added and the solution diluted to the mark with distilled deionized water. The flask was thoroughly shaken and then allowed to stand for about 10-15 minutes to achieve full colour development. The colour intensity was measured at 510nm using a colorimeter. The total Iron concentration in each of the samples were obtained from the calibration graph. The results were tabulated in table 3.2.4a

TABLE 3.2.4a. CONCENTRATION OF IRON BY COLORIMETRY (PPM)

Week/Site	TW(1)	TW(2)	COE(T)	TT	COEBH	RWC
1	0.07	0.11	0.12	0.13	0.10	0.02
2	0.05	0.09	0.13	0.10	0.80	0.03
3	0.06	0.08	0.13	0.10	0.09	0.04
4	0.06	0.10	0.11	0.12	0.07	0.05
5	0.04	0.08	0.10	0.10	0.10	0.06
6	0.05	0.11	0.10	0.11	0.09	0.07
7	0.04	0.11	0.12	0.13	0.07	0.03
8	0.04	0.09	0.10	0.12	0.10	0.02
9	0.06	0.11	0.10	0.11	0.09	0.04
10	0.05	0.12	0.10	0.10	0.10	0.03
11	0.05	0.12	0.10	0.10	0.10	0.04
12	0.04	0.12	0.10	0.10	0.10	0.05
AVE	0.05	0.10	0.11	0.11	0.09	0.05

3.2.4b IRON (BY AAS METHOD)[1,3]

3.2.4.1b REAGENTS: Stock Iron solution was prepared by dissolving 1.000g of Iron metal in 500cm^3 of concentrated nitric acid (1+1), and diluted the 1 dm^3 with deionized water.

3.2.4.2b CALIBRATION GRAPH

A series of standards covering the range of between 1-5ppm were prepared in 100cm^3 volumetric flask. A calibration curve relating measured absorbance to the concentration of standard Iron solution was prepared. A straight line graph was obtained; and all absorbance reading were taken, at a wavelength of 248.3nm.

3.2.4.3b SAMPLE DIGESTION:

50.0cm^3 of each water sample was placed in a beaker and 15.0cm^3 of concentrated nitric acid added. The beakers were covered with a watch glass and then placed on a water bath. The solution was evaporated to about 25.0cm^3. This was then quantitatively transfered into a volumetric flask and the volume made up using distilled deionized water.

3.2.4.4b ABSORBANCE READING:

The samples were taken in turn and aspirated into the flame. The absorbance readings were recorded and the corresponding concentration of total iron taken from the calibration graph. Between each sample, a small quantity of acidified water (1.5cm^3 of

concentrated nitric acid in 998.5cm^3 of distilled deionized water) was aspirated. The results obtained are tabulated in table 3.2.4b.

TABLE 3.2.4b. CONCENTRATION OF IRON BY AAS (PPM)

Week/Site	TW(1)	TW(2)	COE(T)	TT	COEBH	RWC
1	0.08	0.07	0.11	0.11	0.08	0.08
2	0.06	0.07	0.12	0.12	0.06	0.05
3	0.08	0.09	0.11	0.13	0.08	0.07
4	0.07	0.10	0.13	0.12	0.07	0.06
5	0.06	0.10	0.13	0.14	0.09	0.05
6	0.08	0.08	0.12	0.14	0.08	0.04
7	0.05	0.09	0.12	0.13	0.09	0.04
8	0.07	0.09	0.11	0.14	0.09	0.04
9	0.06	0.10	0.13	0.13	0.06	0.06
10	0.08	0.10	0.11	0.14	0.08	0.05
11	0.07	0.09	0.12	0.13	0.09	0.03
12	0.08	0.10	0.13	0.13	0.09	0.03
Ave	0.07	0.09	0.12	0.13	0.08	0.05

3.2.5a POTASSIUM (BY FLAME PHOTOMETER)[1]

3.2.5.1a REAGENTS: Potassium Chloride dried at 110°C, distilled deionized water.

3.2.5.2a CALIBRATION GRAPH:

The stock solution of potassium chloride dried at 110°C was prepared. This was done by accurately weighing 1.907g of the potassium chloride into a small beaker, a small quantity of distilled deionized water was added and the solution quantitatively transfered into $1dm^3$ volumetric flask and the mark made up with distilled deionized water.

Standard solutions covering the range of between 1-10ppm were prepared. The most concentrated standard solution was used to set the instrument to its maximum deflection. Distilled deionized water was used to zero the instrument.

The absorbance readings of the standard solutions were taken and used for the preparation of a calibration graph. A straight line graph was obtained.

3.2.5.3a **SAMPLES**

The concentration of potassium in each sample was determined by aspirating them into the flame. The absorbance reading were taken and the concentration obtained from the calibration graph. The results are tabulated in table 3.2.5a.

For some samples dilutions were carried out. For such samples

the final concentrations were obtained by multiplying their concentrations with the dilution factor.

$$\text{Dilution factor} = \frac{\text{ml of sample + ml of deionized water}}{\text{ml of sample}}$$

The readings were taken using a wavelength of 768nm.

TABLE 3.2.5a. CONCENTRATION OF POTASSIUM BY FLAMEPHOTOMETRY (PPM)

Week/Site	TW(1)	TW(2)	COE(T)	TT	COEBH	RWC
1	11.5	9.8	2.0	1.7	3.9	2.5
2	11.0	9.7	2.2	1.7	3.8	2.5
3	11.0	10.0	2.1	1.8	3.7	3.0
4	12.0	10.2	2.0	1.9	3.8	3.5
5	11.0	10.0	1.9	1.8	3.9	3.0
6	12.0	10.1	1.9	1.9	3.9	3.5
7	11.5	10.2	1.8	1.9	3.6	2.5
8	11.5	9.9	2.1	1.9	3.6	3.0
9	12.5	9.9	2.0	1.8	3.8	3.5
10	11.5	10.1	2.2	1.7	3.7	2.5
11	11.5	10.0	1.9	1.8	3.9	3.0
12	10.5	10.1	1.9	1.7	3.9	2.5
AVE	11.5	10.0	2.0	1.8	3.8	3.0

3.2.5b POTASSIUM (BY AAS METHOD)[1]

3.2.5.1b CALIBRATION GRAPH:

A stock solution was prepared as desccribed in section 3.2.5.2a. Similarly series of standard solutions were prepared from the stock solution as described in section 3.2.5.2a. The absorbance readings were taken and the values used to draw a calibration graph.

3.2.5.2b SAMPLES:

The samples were taken in turn and aspirated into the flame. The absorbance readings were recorded at 769.9nm and the concentrations read off from the calibration graph. The results are tabulated in table 3.2.5b. Between each sample distilled deionized water was aspirated into the flame.

TABLE 3.2.5b. CONCENTRATION OF POTASSIUM BY AAS (PPM)

Week/Site	TW(1)	TW(2)	COE(T)	TT	COEBH	RWC
1	11.8	9.7	2.1	1.7	3.7	3.0
2	11.8	9.9	2.3	1.8	3.9	3.2
3	11.7	9.9	2.0	1.7	4.0	3.1
4	11.6	9.8	2.5	1.7	4.0	3.2
5	11.6	10.0	2.0	1.9	3.8	3.1
6	11.9	10.1	2.4	1.9	3.7	3.0
7	11.7	10.2	2.5	1.8	4.1	8.0
8	11.9	10.1	2.4	1.9	4.0	3.2
9	11.5	10.2	2.4	1.8	3.9	3.1
10	11.6	10.1	2.4	1.8	3.9	3.1
11	11.7	10.0	2.3	1.7	4.0	3.0
12	11.6	10.0	2.2	1.9	3.8	3.2
AVE	11.7	10.0	2.3	1.8	3.9	3.1

3.2.6 BACTERIOLOGICAL EXAMINATION[4]

3.2.6.1 INTRODUCTION:

There are three basic test to detect coliform bacteria in water. These are presumptive, confirmed and completed test (Figure 3.2.6). The tests are performed sequentially on each sample to be analysed. They detect the presence of coliform bacteria (indicators of fecal contamination). The coliform bacteria are the gram-negative, nonspore forming bacilli that ferment lactose with the production of acid and gas that is detectable following a 24-hour incubation period at 37°C.

3.2.6.2 PRESUMPTIVE TEST: (DETERMINATION OF THE MOST PROBABLE NUMBER)

The purpose of this test is to determine the presence of coliform bacteria in a water sample. And also to obtain some index as to the possible number of organisms present in the sample under analysis.

3.2.6.2.1. PRINCIPLE:

The presumptive test is specific for detection of coliform bacteria. Measured aliquots of the water to be tested are added to a lactose fermentation broth containing an inverted gas vial. These bacteria are capable of using lactose as a carbon source while other enteric organisms are not, therefore their detection is facilitated by the use of this medium. In addition to lactose, the medium also contains a surface tension depressant, bile salt, and a pH indicator for the detection of acid. These latter two

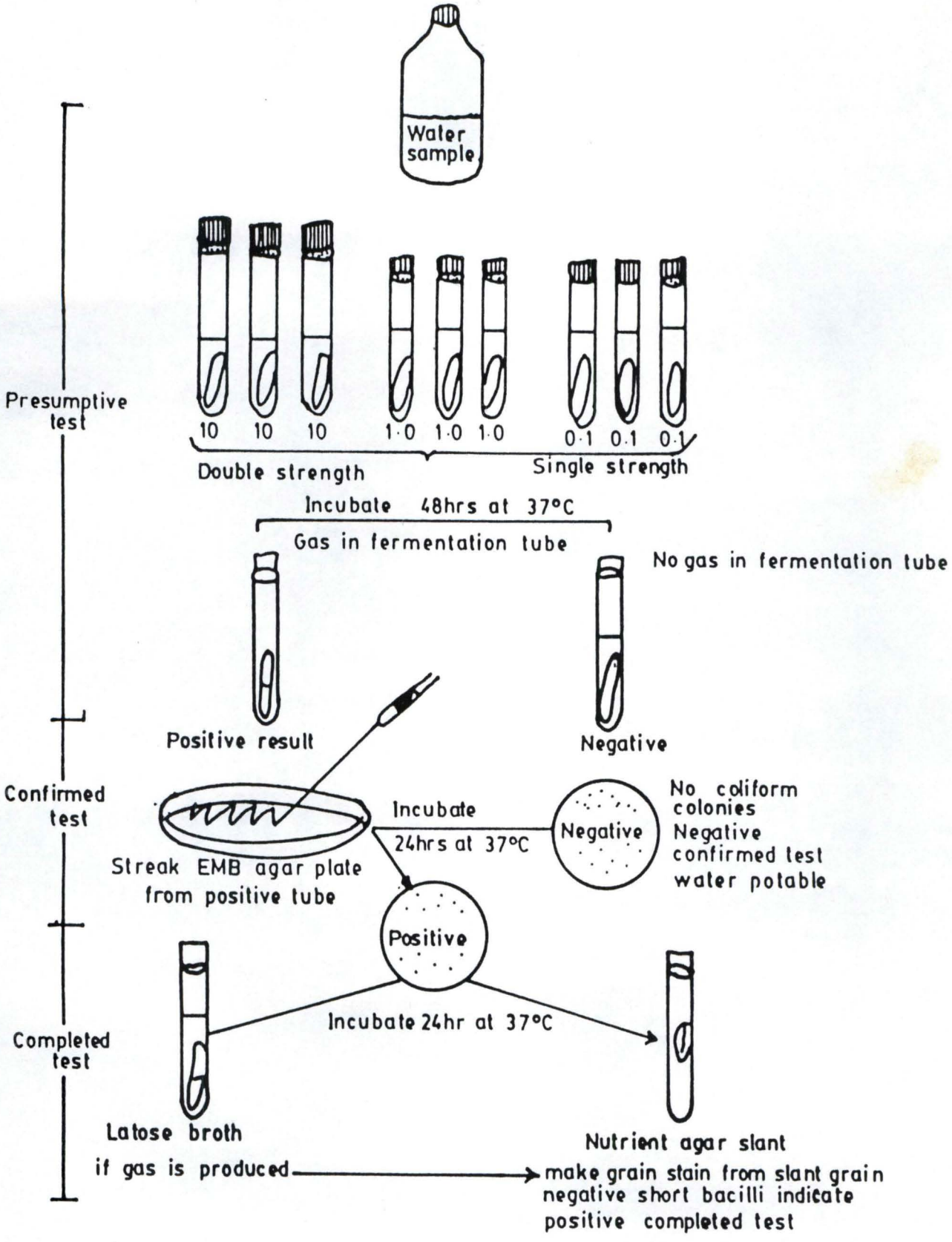

Fig. 3.3.6: STANDARD METHODS FOR BACTERIOLOGICAL WATER ANALYSIS

ingredients are used to suppress the growth of organisms other than coliform bacteria.

Tubes of this lactose medium are inoculated with 10ml, 1.0ml and 0.1ml a liquots of the water sample. The series consist of at least three groups, each composed of three tubes of the specified medium. The tubes are then inoculated with the designated volume of the water sample. The greater the number of tubes per group, the greater the sensitivity of the test. Development of gas in any one of the tubes is presumptive evidence of the presence of coliform bacteria in the sample. The presumptive test also enables the analyst to obtain some idea of the number of organisms present by means of the most probable number test, MPN. The MPN is estimated by determining the number of tube in each group that show gas following the incubation period. (See table 3.2.6.2.)

3.2.6.2.2 MATERIALS

Cultures

Water samples

Media: double strength lactose fermentation broth (LB2x) and single strength lactose fermentation broth (LBIX). Equipment: Burnsen burner, sterile 10-ml pipettes, sterile 1ml, pipettes, and sterile 0.1 ml pipettes.

3.2.6.2.3 PROCEDURE:

A total of nine tubes per water sample were set up in a test-tube rack. The tubes were labelled as to the source and volume of the water sample inoculated.

coli, the major indicator of fecal pollution. Endo agar is a nutrient medium containing the dye fuchsin, which is present in the decolorized state. In the presence of acid produced by the coliform bacteria, Fuchsion forms a dark pink complex that turns the E-coli colonies and the surrounding medium pink.

3.2.6.3.2 MATERIALS

Cultures

One 24-hour-old positive lactose broth culture from each of the three series from the presumptive test.

Eosin methylene blue agar plates and endoagar plates

Equipment:

Burnsen burner, wax pencil and inoculating loop.

3.2.6.3.3.PROCEDURE

The covers of the three EMB plates and three endo agar plates were labelled as to the source of the water sample.

Using a positive 24-hour lactose broth culture from the presumptive test, the surface of one EMB, and one endo agar plate was streaked to obtain discrete colonies. This was done for all the positive 24-hour lactose broth cultures from the presumptive test.

All plates were incubated in an inverted position for 24 hours at 37°C. The results are shown in table 3.2.6.3.3.

3.2.6.4. COMPLETED TEST

The purpose of this is confirm the presence of coliform bacteria in a water sample, or if necessary to confirm a suspicious but doubtful result of the previous test.

3.2.6.4.1. PRINCIPLE

The completed test is the final analysis of the water sample . It examines the coliform colonies that appeared on the EMB or endo agar plates used in the confirmed test. An isolated colony is picked from the confirmatory test plate and inoculated into a tube of lactose broth and streaked on a nutrient agar slant to perform a Gram stain. Following inoculation and incubation, tubes showing acid and gas in the lactose broth and the presence of gram-negative bacilli in Microsco pic examination are further confirmation to the presence of E.Coli, and indicative of a positive completed test.

3.2.6.4.2 MATERIALS

Cultures:

One 24-hour coliform-positive EMB or endo agar culture from each of the three series of the confirmed tests.

Media:

nutrient agar slants and lactose fermentation broths.

Reagents

Crystal violet, Gram's rodine. 95% ethyl alcohol, and safranin.

Equipment.

Burnsen burner, staining tray, inoculating loop, lens paper, bibulous paper and microscope.

3.2.6.4.3. PROCEDURE:

All tubes were labelled, as to the source of water. One lactose broth and one nutrient agar slant from the same isolated E.coli colony obtained from an EMB or an endo agar plate from each

of the experimental water samples were inoculated.

All tubes were incubated for 24 hours at 37°C.

A Gram stain using the nutrient agar slant cultures of the organisms that showed a positive result was prepared. The slides were examined microscopically for the presence of gram-negative, short bacilli which are indicative of E.coli and thus nonpotable water. The results are shown in table 3.2.6.4.3.

Table 3.2.6.2 MPN DETERMINATION FROM MULTIPLE TUBE TEST

Number of tubes giving Positive reaction out of				95% Confidence limits	
3 of 10 ml each	3 of 1 ml each	3 of 0.1 l each	MPN INDEX FOR 100 Ml	Lower	Upper
0	0	1	3	<0.5	9
0	1	0	3	<0.5	13
1	0	0	4	<0.5	20
1	0	1	7	1	21
1	1	0	7	1	23
1	1	1	11	3	36
1	2	0	11	3	36
2	0	0	9	1	36
2	0	1	14	3	37
2	1	0	15	3	44
2	1	1	20	7	89
2	2	0	21	4	47
2	2	1	28	10	150
3	0	0	23	4	120
3	0	1	39	7	130
3	0	2	64	15	380
3	1	0	43	7	210
3	1	1	75	14	230
3	1	2	120	30	380
3	2	0	93	15	380
3	2	1	150	30	440
3	2	2	110	35	470
3	3	0	240	36	1300
3	3	1	460	71	2400
3	3	2	1100	150	4800

From: Standards Methods for the examination of water and waste water, 14th Edition. American Public Health Association. American Water works Association, Water pollution control Federation, Washington, D.C., 1975.

TABLE 3.2.6.2.2 PRESUMPTIVE TEST RESULTS

WATER AMPLE	ACID AND GAS									READING	MPN Per 100ml	RANGE 95% PROBABILITY
	LB 2X - 10			LB1X-1			LB1X-0.1					
TUBE	1	2	3	4	5	6	7	8	9			
RWC	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	333	1100	150-4,800
COE(BH)	+ve	+ve	+ve	-ve	-ve	-ve	-ve	-ve	-ve	200	009	1-36
TW(1)	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	333	1100	150-4,800
TW(2)	+ve	+ve	+ve	+ve	+ve	+ve	+ve	-ve	-ve	331	460	71-2,400
COE(T)	+ve	+ve	+ve	+ve	+ve	-ve	+ve	-ve	-ve	321	150	30 - 440
TT	+ve	+ve	+ve	-ve	+ve	+ve	-ve	+ve	-ve	321	150	30 - 440

TABLE 3.2.6.3.3. CONFIRMED TEST RESULTS

	COLIFORMS	
WATER SAMPLE	EMB PLATE	ENDO AGAR PLATE
RWC	Growth	Growth Pink Colonies
COE(BH)	No Growth	Growth Pink Colonies
TW(1)	No Growth	Growth Pink Colonies
TW(2)	No Growth	Growth Pink Colonies
COET	No Growth	Growth Pink Colonies
TT	No Growth	Growth Pink Colonies

TABLE 3.2.6.4.3. COMPLETED TEST RESULTS

WATER SAMPLE	LACTOSE BROTH A/G(+) or (-)	GRAM STAIN REACTION MORPHOLOGY
RWC	A/G +	Gram +ve short rods, Gram -ve bacilli.
COE(BH)	A/G +	Gram +ve Cocci and +ve short rod shapes
TW(1)	A/G +	Gram +ve short rods, Gram +ve long rods and moulds (yeast)
TW(2)	A/G +	Gram +ve long rods Gram +ve short rods.
COE(T)	A/G +	Gram +ve, long chains streptoCocci
TT	A/G +	Gram +ve, long chains streptococci

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CHAPTER FOUR

4.0. DISCUSSION AND SUGGESTIONS

4.1 TEMPERATURE

Temperature is of great interest in a chemical analysis of water[1] It has been observed that multiplication of bacteria is more rapid in waters with higher temperature than in water with lower temperature[2]. However, the highest temperature recorded during the period of analysis was 28^{O}C which is very close to room temperature. Therefore the effect of multiplication of bacteria may not be of much singificance in this case.

Temperature is one of the factors influencing the presence of oxygen in water[3]. The scope of this analysis does not involve the determination of oxygen in water.

The RWC has an average temperature of 28^{o}C, followed by Tunga well (1) and tunga well (2) with 27^{o}C. The college of Education borehole and tap, and the Tunga tap had average value of 26^{o}C.

4.2 ELECTRICAL CONDUCTIVITY (E.C)

The electrical conductivity of a water sample is related to the nature of the various dissolved substances, it varies with temperature and depends on the ionic strength of the water[4].

The raw water Chanchaga has the highest average E.C value of 95.0 μscm^{-1}, followed by college of education tap with an average value of 90.0 μscm^{-1} and Tunga tap having an average value of 89.0 μscm^{-1}. The Tunga well (1), Tunga well (2) and College of

Education borehole has 77.3, 75.0 and 34.0μscm^{-1} respectively.

Looking at the average pH values obtained for the water samples, the raw water from Chanchaga has the highest pH and has the highest E.C and the college of Education borehole has the lowest pH and also the lowest E.C values. The result thereforre shows that the higher the pH, which depends on the hydrogen ions, the higher the E.C and vice versa.

The E.C of the two wells in Tunga are similar. This may be because E.C of samples within the same geographical region are expected to be similar. The low value of the college of Education borehole compared with the wells could be due to the fact that the borehole is deeper than the wells and the water is not coming in contact with other foreign materials. The high value for the raw water in Chanchaga may also be due to the fact that many substances are being deposited into the water by erosion. The treated water samples have similar values. This is expected because treated water samples are supposed to have similar electrical conductivity.

4.3 pH

The pH of water is a measure of the hydrogen ion concentration on a scale of 0 (very acidic) to 14 (very alkaline) with pH 7 being the neutral point. The pH is a measure of the concentration of hydrogen ions in the water. It is defined as the negative logarithm of the hydrogen ion concenctration[3].

The result of the analysis show that college of Education borehole has the lowest average pH value of 6.5, followed by Tunga well (1) having 6.6. College of Education tap and Tunga tap has an

average value of 6.8 each. The raw water in chanchaga has the highest average pH value of 6.9.

None of the samples has pH values that could be described as being detrimental to its consumers, i.e. below 6.5 or above 8.5 set aside by WHO as the maximum permissible values for drinking water. The treated water samples have the same pH. This is expected because treated water samples should have the same pH. There was no industrial work taking place near the studied areas which affect the pH of the soil, which in turn may affect the pH of the ground water of the areas.

4.4 ZINC

Zinc enters water from industrial wastes, metalplating and plumbing works. It is an essential element in many metalloenzymes and aids in wound healing. It is toxic to plants at higher levels and a major component of sewage sludge[5].

The result of the current analysis shows that the water samples from the taps had the lowest average concentration of Zinc i.e. 0.16ppm and 0.15 ppm for college of education tap and tunga tap respectively. The raw water in Chanchaga is next with an average value of 0.24ppm. Tunga well (1) and Tunga well (2) has average values of 0.37ppm and 0.34ppm respectively. The College of Education borehole has the highest average concentration of 0.66ppm.

The college of Education borehole may have been constructed with galvanized iron pipes which may be the reason for the higher

value of Zinc compared to others. The bore hole water which is a bit acidic may strip Zinc from the galvanized iron pipes. The tap water samples i.e. College of Education tap and the Tunga tap have lower concentration than the raw water. This may be due to the fact that although it has been stated that treatment is not likely to alter the concentrtion of some determinants that were present in original raw water, one cannot conclude confidently, for there must be a change in concentration of these substances as the water passes through tank and piping materials[6]. The values for the wells do not differ much, this could be due to the wells being in the same geographical area.

The WHO has established 5ppm as the highest desirable level and 15ppm as the maximum permissable level for Zinc. None of the water samples has up to 1ppm of Zinc. However the food we consume can compensate for the low concentration of Zinc in the water samples. This is because the normal daily adult in take is estimated at 12 milligrammes and the amount required to balance metabolic loss is about 10 milligrammes[7].

4.5 IRON

Iron is an abundant element in the earth's crust, but exist generally minor concentrations in natural water systems[4]. The sources of iron in water are corroded metal, industrial wastes, acid-mine drainage etc.

The result of the analysis shows that the water samples from college of Education tap and Tunga tap had the highest average

concentration of iron, 0.11ppm each using the colorometric method. This could be due to the fact that the water storage tanks and the pipes are all made of iron which may rust. The Tunga well (2) is next with 0.10ppm while the Tunga well (1) has an average of 0.05ppm. The two wells being in the same geographical area should have almost similar values of iron, but the result did not show that. The difference could be due to the fact that water is drawn from Tunga well (2) using an iron container which may rust, while a platic container is used to draw water form Tunga well (1).

The college of Education bore hole has an average value of 0.09ppm. The raw water in Chanchaga has an average value of 0.04ppm which is the lowest. This may be due to the fact that most of the iron will be present in the form of organic complex compounds or fine dispersed suspensions[7].

The result also shows the same using the atomic absorption. However, the atomic absorption method gave a little bit higher values than the colometric methods. This is due to the fact that the atomic absorption spectrometry is more sensitive than the colorimeter. All the values obtained during the analysis fall within the range set aside by WHO which established 0.1ppm as the highest desirable level and 1.0ppm as the highest maximum permissable level for water intended for domestic use[4].

4.6 POTASSIUM

Potassium ranks seventh in the elemental abundance, it's concentration in most natural waters remain relatively low, seldom

reaching 20ppm in drinking water. Potassium is important as a component of total disolved solids.

The results of the analysis show that tunga well(1) and Tunga well (2) have the highest concentration of potassium. Tunga well (1) has 11.5ppm and Tunga well (2) has 10.0ppm using flamephotometry, while the values for tunga well (1) is 11.7ppm and Tunga well (2) is 10.00ppm using the atomic absorption. The similarities in the values may be due to their geographical locations i.e. the same geographical area. The college of Education borehole has an average value of 3.8ppm and 3.9ppm using flamephotometry and atomic absorption respetively. College of Education tap and Tunga tap had average values of 2.0ppm and 1.8ppm respectively using flamephometry and 2.3ppm and 1.8ppm respectively using the atomic absorption. The raw water in Chanchaga has an average value of 3.0ppm and 3.1ppm using flamephotometry and atomic absorption respectively.

All the values obtained fall within the WHO standard which is 20ppm

The well waters in Tunga could be used for irrigation since their concentrations is reasonably high compared to others.

4.7. BACTERIOLOGICAL EXAMINATION

Contamination by sewage or by human or animal excrement is the greatest danger associated with water for drinking - whether it occurs as the result of inadequate treatment or during distribution. This is because sewage from human or animal sources may contain the causative organisms of many communicable diseases

such as typhoid fever, dysentry etc.

Escherichia coli (E.Coli) is the most abundant coliform organisms present in the normal human and animal intestine. It is rarely found in soil, vegetation or water in the absence of excremental contamination. The presence of E.Coli in a water sample always indicates potentially dangerous contamination of either human or animal origin. High counts indicate heavy or recent pollution; low counts, slight or relatively remote pollution[8].

From the results of the analysis, the presumptive test shows that in the raw water from chanchaga, gas appeared in all the three tubes labelled LB2x-0.1. The series is read as 3-3-3 from the multiple probable number (MPN) table. such a reading indicate that there are about 1100 microorganism per 100ml of water with 95% probability that there are between 150-4500 organisms present. Tunga well (1) also has the same result as the raw water. Tunga well (2) has about 460 organisms per 100ml of water with 95% probability that there are 71-2,400 organisms. The higher results for tunga well (1) could be due to the fact that it is very close to a pit toilet. The tap water samples had about 150 organisms per 100ml of water with a 95% probability that there are 30-460 organisms. The college of Education borehole has the least number of 9 organisms per 100ml of water with 95% probability that there 1-36 organisms.

For the confirmed test, all the water samples show no growth on the eosin methylene blue (EMB) plate, except the raw water while

growth of pink colonies were observed.

For the completed test, all the water samples show evidence of contamination and some of these isolates are potentially pathogenic. However Tunga well (2) and college of Education borehole are free from indicator organisms but all the other water samples are polluted with some e.Coli and faecal streptococci.

From the results of the three tests, it can be said that the college of Education borehole water samples is the safest in terms of the number of bacteria present. This could be due to the fact that the borehole is sunk very deep and the water is not coming in contact with external surrounding. The college of Education tap and the tunga tap show some evidence of pollution with E.Coli. This could be due to insufficient chlorine added to disinfect water or there may be a leakage on the water pipes, thereby allowing the water to come in contanct with foreign bodies it is also expected that the raw water sample should contain alot of E.Coli bacteria since wind and rain carries both human and animal excreta into it. From the result we can deduce that it is only the raw water from chanchaga that is not safe for drinking since it contained gram negative bacilli

4.8 SUGGESITONS

The field of water analysis, particularly drinking water is still young in Nigeria. Much still has to be done if the public must be supplied with a good quality water.

People should be adviced to stop using metallic containers for drawing water from wells. Plastic containers which will not increase the concentration of metallic ions should be encouraged. This will give more market to the plastic industry.

The research could be taken some steps forward by determining certain other parameters e.g. chromium, Nitrate, cyanide etc.

In order to ensure the supply of good water quality, to the pbulic, a legislation on water pollution control and sewage disposal is necessary.

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APPENDIX I: WHO INTERNATIONAL STANDARDS FOR DIRNKING WATER

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]	-	-	0.05	-	0.05
(hexavalent) 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	-	0.1
Magnesium	50	150	-	125	-
Manganese+	500	1000	-	-	-
Sodium Sulphate					
Nitrate(Hi)	-	4.5	-	4.5	-
Dissolved	-	-	-	5.0	-
Oxygen (Minimum)					
Phenolic Comp. as Phenol[a]	0.001	0.002	-	0.001	-
Polynuclear hydronuclides(PHC)	-	0.2	-	-	-
Radio clides gross A activity	-	3pci dm^{-3}	-	-	-
Sulphates	200	400	-	250	-
Total hardness	100	500	-	-	-
Total Solids	500	1500	-	-	-
Zinc	5.0	15	-	-	-
Bacteria					10 in 100ml

* For water samples entering the distribution system, the concentrationof copper should be less than 0.05 PPm. But after 16 hours contact with new pipes, concentration up to 1.0ppm 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 = 1.0×10^{-12} curie)

International standards for Drinking Water, 2nd Edition. Published by Pergamon Press on behalf of world Health Organisation, Geneva 1968