DETERMINATION OF SURFACE AND GROUND WATER QUALITY OF INLAND VALLEY IN F.U.T. MINNA MAIN CAMPUS FOR DOMESTIC WATER SUPPLY AND IRRIGATION PURPOSE

BY

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CERTIFICATION

This is to certified that this project is an original work undertaken by Michael S. Jiya Doko PGD/ AGRIC ENG'G /99/2000/77 and has been approved to have met the requirement governing the award of post –Graduate Diploma in Agricultural Engineering of the Federal University of Technology Minna by the under signed.

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DEDICATION

This work is dedicated to my parent Mr. Ezekiel T. Jiya and Mrs. Grace A. Jiya my humble wife Mrs. Alice D. Jiya and my lovely children Samuel and Doris.

ACKNOWLEDGEMENT

I wish to express my sincere gratitude to God almighty for sparing my life up to this day and granting me the strength to make this work a reality.

My profound appreciation goes to Dr. M. G. Yisa on his capacity as my able Head of Department and to Dr. (Engr.) Nosa A. Egharevba as the programme coordinator.

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ABSTRACT

This project work deals with the result obtained from examination carried out on the physio-chemical and bacteriological characteristics of surface and ground water of inland valley in Federal university of Technology (F.U.T) Minna main campus in order to determine their suitability for dry season irrigation farming and domestic water supply. Samples of surface and ground water were collected at different points in and around the inland valley and analyzed.

Using food and agricultural organization (FAO) and world health organization (WHO) guidelines on quality standards for irrigation water and domestic water supply, the physio-chemical properties of all the water sample were found to have met the acceptable limits for domestic water supply.

The bacteriological text on the samples however, shows that they are all contaminated and therefore are unsafe for drinking and other domestic uses. The three water sources under investigation cannot also be used to irrigate crops like vegetables.

The electrical conductivity of the sample are within the acceptable limits for irrigation water and therefore can be used for irrigating most crops on most soils with little or no risk of creating saline soil. Boron content in all the sample are within the acceptable limit, therefore boron non-tolerant crops can be grown.

The nitrate content of ground water were generally low and phosphate concentration of all the water samples were low. If this water sources are to be used for irrigation purpose there is need for addition of phosphate base fertilizer especially for soils lacking these nutrients.

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CHAPER ONE

1.0 INTRODUCTION:

The importance of water to both plant and animal can not be overemphasis. As the population of man increase on earth so also is the need for adequate supply of good quality water.

The F.U.T. main Campus is the permanent site of Federal University of Technology, Minna. The site is among other things expected to accommodate the entire staff and student population of the institution, demonstration farms, laboratories and workshops.

Most of the Communities living around this site are pre-dominantly farmers. They engage mainly in rainy season farming as they attributed non-availability of irrigation facilities and inadequate sources of water to meet the irrigation need to their not practicing dry season irrigation farming.

Main water supply sources in these areas like in most rural communities in Nigeria are springs, streams and Hand dug wells. These water sources are most often countermined as a result of the application of pesticides and chemical fertilizer on the farm, faecal contamination as a result of indecent excretion habits, washing of farm produce such as melon in the body of streams. For the reasons stated above, provision of good quality water has been source of great concern.

.1 AIM OF THE STUDY:

To determine the quality of surface and ground water in F.U.T. Main Campus inland valley for domestic water supply and irrigation purposes.

1.2 OBJECTIVES OF THE STUDY:

i. To determine the physio chemical and bacteriological characteristics of surface and ground water in F.U.T. Main Campus inland valley.

ii. To determine the suitability of surface and ground water in F.U.T. Main Campus inland valley for domestic water supply and irrigation purposes.

1.3 SCOPE OF THE STUDY:

The scope of this study will be limited to the quality of surface and ground water for domestic water supply and irrigation purpose with particular emphasis on F.U.T. Main Campus inland valley.

1.4 DESCRIPTION OF PROJECT AREA:

The F.U.T. Main Campus is situated along Minna – Kataeregi – Bida road. The site is located at some 14km by road to the west of Minna (see sketch map at appendix A)

The rainfall of the area usually begins from March and last up to October. The area normally experience heavy rainfall from June to September. (See rain fall amount of Minna for January to December 1990 to 1999 and for January to July 2001 at Appendix B).

The topography of the area is partly undulating consisting of flat plain and valleys, which form the stream channels.

The area is under lain by sand soil, laterite, clay and rocks.

CHAPTER TWO

2.0 LITERATURE REVIEW:

Water, which is absolutely pure, is not found in nature; even water vapor condensing in the air contains solids, dissolved salts, and dissolved gases (Mcghee 1991). As condensed water falls, it sweeps up other materials from the air, and becomes still more contaminated on reaching the ground, running over the surface and percolating through the various strata of the soil.

Precipitation is presently our only practical source of continuing fresh water supply for all agricultural, industrial, and domestic uses (Schwab & Frevert, 1985). Increasing attention being given to large scale desalination of blackish or salty waters may eventually result in reasonable supplies of water for high value uses in some locations, but precipitation will remain the dominant source of water. The development of water resources involves storage and conveyance of water from the time and place of natural occurrence to the time and place of beneficial use (Schwab & Frevert, 1985).

Water in one or more of its three physical states, solid, liquid, or gaseous is present in greater or lesser quantities in or on virtually all the earth,.

Water, important from the standpoint of water resources development, falls into the categories of atmospheric moisture, surface waters and sub surface waters (Schwab & Frevert, 1985). Atmospheric moisture and resultant precipitation are the source of replenishment of surface and subsurface waters. Surface and subsurface water are the direct source of our developable water resources.

Surface waters exist in natural basins and stream channels, where minimum flow in streams or rivers are large in relation to water demands of

adjacent land, towns and cities, development of surface water is accomplished by direct withdrawal from the flow. On many streams and rivers however, flow fluctuate widely from season to season and from year to year. Further, peak demands from many major rivers occur at seasons of minimum flow and in fact require that as much of the annual flow as possible be conserved and diverted for beneficial use.

Subsurface water available for development is normally referred to as ground water. Groundwater predominantly results from precipitation that has reached the zone of saturation in the earth through infiltration and percolation (Schwab & Frevert, 1985). Ground water is developed for use through wells, springs or dug out ponds.

Water in the natural environment almost always contains some level of impurities. Because water is a nearly universal solvent, it contains dissolved solids and gases. It also is host to a number of microorganisms. The quality of water is defined by the level of its physical, chemical, and biological impurities (Linsley; 1992), water quality is then evaluated relative to the requirements for the waters intended use.

.1 TYPES OF IMPURITIES IN WATER:

The principal impuries found in water and their origins are listed in table 2.1. The impurities are classified as (1) ionic and dissolved, (2) nonionic and undissolved, and (3) gases. Dissolved impurities are further classified into two groups depending on whether the ions are positive or negative. Nonionic and undissolved impurities are often categorized according to size and are identified as suspended if they will settle and colloidal if they will not settle. Color and organic matter can be classified as both ionic and dissolved as well as nonionic and undissolved

In the evaluation of water quality, the impurities in the water are usually classified as physical, chemical and biological. Thus, according to

table 2.1. bacteria that are colloidal, nonionic, and undissolved impurities would be considered biological characteristics with respect to water quality. Where a water is to be used as a public water supply, the physical, chemical, and biological impurities that may be present are also refeerred to as contaminants.

The presence or absence of impurities depends on the source of the water. For example, suspended matter is commonly found in surface water, but it would not be expected in ground water because of the filtering action of the aquifer. To evaluate whether the specific impurities reported in Table 2.1 are harmful. One must determine (1) the nature and amounts of the impurities present. (2) the uses to be made of the water, and (3) the tolerance for various impurities for each use.

Table 2.1 **Principal Impurities in Water and their Origin**

Impurity					
Ionic and Dissolved			***Nonionic and Undissolved***		
Origin	**Positive ions**	**Negative ions**	**Suspended**	**Colloidal**	**Gases**
From minerals, soils, and rocks.	Calcium ca^{2+} Iron, fe^{2+} Magnesium, mg^{2+} Manganese, Mn^{2+} Potassium, K^{+} Sodium, Na^{+} Zinc, Zn^{2+}	Bicarbonete, HCO_3- Carbonate, CO_3^{2-} Chloride, cl_x^{-} Fluoride, F^{-} Nitrate, NO_3^{-} Phosphate PO_4^{3-} Hydroxides , OH^{-} Borates, $H2\backslash\backslash B0_3^{-}$ Silicates, $H_3 SiO_4^{-}$ Sulfate, $S0_4^{2-}$	Clay, Silt, Sand and other inorganic soils.	Clay Silica, Sio_2 Ferric Oxide Fe_20_3 Aluminum Oxide $A1_20_3$ Magnesium dioxide $Mn0_2$	Carbon dioxide, $C0_2$
From the atmosphere	Hydrogen H^{+}	Bicarbonate, $Hc0_3$ Chloride, Cl Sulfate, $S0_4^{2-}$	Dust, Pollen		Carbon dioxide, CO_2 Nitrogen, N_2 Oxygen, 0_2 Sulfur dioxide, O_2

Table 2.1 Cont.

From the decomposition of organic matter	Ammonia, NH_4^+ Hydrogen, H^+ Sodium, Na^+	Chloride, Cl^- Bicarbonete, HCO_3^- Hydroxide, OH^- Nitrite, NO_2^- Nitrate, NO_3^- Sulfide, HS^- Organic radicals	Organic Soil (top soil), organic waste	Vegetable Coloring matter, natural organic compounds including humic substances, and other organic wastes	Ammonia, NH_3 Carbon dioxide, CO_2 Hydrogen sulfide, H_2S Hydrogen, H_2 Methane, CH_4 Nitrogen N_2 Oxygen, 0_2 Other Gases.
From living organism			Algae, diatoms protozoa, helminths, minutes animals, fish, etc.	Viruses, bacteria algae, etc.	Ammonia, NH_3 Carbon dioxide, CO_2 Methane, CH_4
From municipal and industrial sources and other human activities	In organic ions including a variety of heavy metals	In organic ions, organic molecules, color	Clay, silt, grit, and other inorganic solids; organic compounds, oil, corrosion products, protozoa, helminths etc.	In organic constituents; natural and synthetic organic compounds including, VOCs, chlonated organic compounds, and pesticides; viruses, bacteria	Chlorine, Cl_2 Sulfur dioxide, SO_2

Source:- Linsley, (1992)

2.2 EXAMINATION OF WATER:

Water used for domestic or irrigation purposes must be clean and free from objectionable impurities. The quality of water can be judged by the following characteristic:

2.2.1 PHYSICAL CHARACTERISTIC OF WATER:

The principal physical characteristics of water are

(1) total suspended, and dissolved solids

(2) turbidity (3) color (4) tastes and odors and

(5) temperature.

Total solids are determined by evaporating a sample and weighing the dry residue. Suspended solids are found by filtering a sample of water. The difference between total solids and suspended solids represents dissolved solids. Depending on the size of the openings in the filter paper that is used, a portion of the colloidal material will also be measured as suspended solids. Total dissolved solids concentration, in conjunction with a detailed chemical analysis, is used to assess the suitability of various water sources for alternative uses such as industry or agriculture.

Turbidity decreases the clarity of water and results from the finely divided impurities, regardless of source, that may be present in water. Turbidity is usually caused by clay, silt and soil particles and other colloidal impurities. The degree of turbidity depends on the fineness of the particles and their concentration. In the past, the standard of comparison was the Jackson turbidimeter in which turbidity was taken as a measure of depth of water required to cause the image of a candle flame to disappear. Today turbidity is measured

with a turbidimeter by measuring the interference to the passage of light through a water sample. Surface waters in which there is a significant increase in the level of turbidity after a rainfall are often identified as flashing waters (Schmes & Frevert, 1985). Such waters are more difficult to treat than waters in which the level of turbidity remains reasonably constant.

Water sometimes contains considerable color resulting from certain types of dissolved and colloidal organic matter leached from soil or decaying vegetation. The color in tea is an example of organic colloidal color. True color is due to dissolved impurities. Wastes from industrial activities also are often responsible for color in water. Color intensity is measured by visual comparison of the sample with Nessler tubes, glass tubes containing solutions of different standard color intensity.

Tastes and odors in water are caused by the presence of decomposed organic material and volatile chemicals and are measured by diluting the sample until the taste and odor are no longer detectable by a human test. Drinking water should be practically free of color, taste, and odor.

The temperature of water is important in terms of its intended use, its treatment to remove impurities and its transport. The temperature depends on the source of the water. Ground water temperatures will vary depending on the depth and characteristics of the aquifer from which the water is drawn. Temperatures of surface water drawn from a deep reservoir also vary with depth.

2.2.2 CHEMICAL CHARACTERISTICS OF WATER:

The chemical characteristics of water are quantified in terms of the inorganic and organic constituents that may be present. The common tests used to characterize the chemical quality of water are summarized in Table 2.2

2.2.2.1: INORGANIC CONSTITUTENTS

The inorganic constituents found in surface and ground waters are from (1) natural sources (2) the commingling of contaminated waters and waste waters, and (3) the dissolution of materials used for the storage and transport of water (e.g. copper, lead, and asbestos fibres). The inorganic tests identified in Table 2.2 are considered further in the following discussion.

The PH of water is taken as a measure of the acidic or basic nature of the matter and is defined as the logerithm of the reciprocal of the hydrogen-ion concentration in moles per later. Pure water at 24^0c is balanced with respect to H^+ and OH^- ions and contains 10^{-7} mol/L of each type. Thus, the PH of a neutral water is 7. Waters with a PH lower than 7 are acidic and those with a higher PH are basic. The PH of a water is usually found either with a potentiometer that measures the electrical potential exerted by the H^+ ions or with color indicator dyes, such as methyl orange or phenolphthalein.

The dissolved cations and anions reported in Table 2.2 are the principal ones found in most waters through out the world (linsley 1992). The distribution of the specific species will depend on the source of the waters. Some comparative data for two surface waters and two ground waters are given in Table 2.3. If a chemical analysis

of a water sample is correct, the sum of the cations and anions expressed in terms of equivalents or milliequivalents per liter must be the same to satisfy the electroneutrality principle. This rule can be used to check the accuracy of the analysis and to determine if other constituents may be present that have not been identified.

Table 2.2 **Common analysis used to assess the chemical characteristics of water.**

Test	**Abbreviation and definition**	**Use of test result**
	inorganic	Properties
PH	$PH = \log^{1}/(H^{+})$	To measure the acidity or basicity of an aqueous solution
Dissolved cations		
Calcium	Ca^{2+}	To determine the ionic chemical composition of water and to assess the suitability of water for most alternative uses.
Magnesium	Mg^{2+}	
Potassium	K^{+}	
Sodium	Na^{+}	
Dissolved anions		
Bicarbonate	HCO_3^-	
Carbonate	CO_3^{2-}	
Chloride	Cl^-	
Hydroxide	OH^-	
Nitrate	NO_3^-	To measure the capacity of the water to neutralize acids.
Sulfate	SO_4^{2-}	
Alkalinity	$\Sigma\ HCO_3^- + CO_3^{2-} + OH^-$	To Measure the amount of a basic susbstance required to neutralize the water
Acidity		To assess the corrosiveness of

Carbondioxide	CO_2	water and the dosage requirements where chemical treatments is to be used; can be used to estimate PH if the bicarbonate concentration is known
Hardness	Σ Multivalent cations	To measure the soap-consuming capacity and scale-forming tendencies of water.
Conductivity	Umhos (Micromhos)km (at 25^0c)	To estimate the total dissolved solids or check on the results of a complete water analysis [total dissolved solids (TOS) in mg/L = 0.55 to 0.7 x conductivity value of sample in Umhos/cm]
Specific in organic constituents		To asses the suitability of a water for use as a public water supply
	Organic	Properties
Total organic carbon (TOC)		To measure the total amount of organic material in a water supply source.
Total organic halogen (TOX)		To determine the presence of halogenated compounds
Specific organic constituents		To assess the suitability of a water for use as a public water supply.

Source: Linsley, (1992)

Table 2.3 **Typical chemical analysis of surface waters and ground water in the United States.**

Constituent	Concentration mg/L (1)	(2)	(3)	(4)
Silica (SiO_2)	7.2	26	26	7.9
Iron (Fe^{2+})	2.3	0.5	5.5	0.17
Calcium (Ca^{2+})	6.0	53	51	37
Magnesium (Mg^{2+})	1.8	10	7.5	24
Sodium (Na^{+})		47	17	
Potassium (K^{+})	8.4	4.2	9.3	611
Bicarbonate (HCO_3^{-})	12	154	186	429
Sulfate SO_4^{2-})	19	120	43	1010
Chloride (Cl^{-})	4.0	23	6.5	82
Flouride (F^{-})	0.1	0.4	0.2	0.6
Nitrate (NO_3^{-})	0	1.6	3.5	0
Boron (B)	0	0	0.05	0.2
Total Dissolved Solids (TDS)	54	361	267	1980
Total hardness as $Caco_3$	22	173	158	191
PH	-	-	7.0	7.3

1. Hilo Stream, Hawii
2. Rio Grounde at San Acaccua
3. Shalow well in Nebraska
4. Well in Sheridan Country.

Source: Linsley, (1992)

The alkalinity of water is a measure of its capacity to neutralize acids. n natural waters the alkalinity is related to the bicarbonate, and hydioxide concentration. Total alkalinity usually is expressed in terms of equivalent calcium carbonate in milligrams per liter. Acidity is expressed in terms of the amount of calcium carbonate required to neutralize the water.

Carbon dioxide is one of the minor gases present in the atmosphere and is an end product of both aerobic and anaerobic biological decomposition. Rain water and most surface water supplies contain certain small amounts of carbon dioxide (usually less than 5mg/L), but ground water may contain significant amounts resulting from the biological decay of organic matter. The presence of carbon dioxide is significant because it affects the PH of water. It is corrosive to most piping systems and it affects the dosage required where chemical treatment is used.

Calcium and Magnesium are the principal ions that make up the hardness of water. As noted in Table 2.2, other divalent and trivalent dissolved metal ions, such as aluminum, iron, manganese, and Zinc, also contribute to total hardness. Hardness is expressed in milligrams per liter of equivalent calcium carbonate. The hardness of natural waters varies considerably throughout the world. Waters can be approximately classified according to the degree of hardness they contain.

Table 2.4 **Classification of water according to degree of hardness**

Total hardness Mg/L as $caco_3$	**Classification**
Less than 15	very soft water
15 – 60	Soft Water
61 – 120	Medium-hard water
121 – 180	Hard water
Greater than 180	Very hard water

Source: Linsley, (1992).

Ground waters frequently have hardness above 300 mg/L as $CaC0_3$. Natural Surface Waters are usually soft because they do not have as much opportunity for contact with minerals. For satisfactory operation of commercial boilers and laundries, hardness should be less than 50 mg/L as $CaC0_3$.

The conductivity of a water sample is determined by measuring its electrical resistance between two electrodes and comparing this resistance with the resistance of a standard solution of potassium chloride at 25°c. For most waters the concentration of dissolved solids in milligrams per liter is equal to 0.55 to 0.7 times the conductivity in microsiemens per centimeter at 25°c. The exact value of the coefficient depends on the types of salts in the water.

2.2.2.2 ORGANIC CONSTITUENTS:

The organic constituents found in water are derived from

(i) the break down of naturally occuring organic materials

(ii) domestic, commercial, industrial, and agricultural activities and

(iii) constituents that occur in both water and waste water treatment.

Naturally occurring organic materials include humic materials, micro organisms and their metabolites, and aliphatic and aromatic hydrocarbons. Organic materials from man's activities, often identified as synthetic organic compounds (SOCs), include constituents such as pesticides, herbicides degreasers, solvents etc. over a thousand SOCs have been detected in drinking water[2-]. A special class of SOC_s known volatile organic compounds (VOCs) are of concern in public water supplies because many of these compounds are possible or known human carcinogens. Typically, VOCs have a boiling point equal to or less than 100°c and/or a vapor pressure greater than 1mm Hg at 25°c.

2.2.3 BIOLOGICAL CHARACTERISTICS OF WATER:

Microorganisms are commonly present in surface waters, but they are usually absent from most ground waters (as are suspended solids) because of the filtering action of the aquifer. The types of microorganisms that may be found in water are classified as eucaryotes, eubacteria, or archaebacteria, depending on whether the cell contains a true nucleus (See Table 2.6). The most common microorganisms in water are bacteria, algae, fungi, and protozoa, which are not listed, are usually classified separately according to the host they infect.

Table: 2.5 **Classification of Microorganisms**:

Group	Cell Structure	Characterization	Representative members
Eucaryotes	Eucaryotic	Multicellular with extensive differentiation of cells and tissue.	Plants (seed plants, ferms, mosses) Animals (Vertebrates, in vertebrates).
		Unicellular or coenocytic or mycelial; little or no tissue differentiation.	Protists (algae, Fungi, Protozoa)
Eubacteria	Procaryotic	Cell chemistry similar to eucaryotes	
Archaebacteria	Procaryotic	Distinctive Cell Chemistry	Methanogens, halo philes, thermacidopholes.

Source: Linsley, (1992).

2.2.3.1 BACTERIA:

Varying in shape and size from 1 to 4 um, bacteria can not be seen with the naked eye. Disease causing bacteria are called pathogenic bacteria. Non pathogenic bacteria usually are harmless. Aerobic bacteria require oxygen for survival; anaerobic bacteria thrive in the absence of free oxygen.

Esherichia Coli (Colon bacilli or Coliforms) are bacteria that in habit the intestines of warm-blooded animals. These usually harmless bacteria are excreted with feces, and their presence in water is taken as an indication that pathogenic bacteria may be present. Their significance and some of the tests used to determine their presence are discussed in a subsequent section.

2.2.3.2. ALGAE:

Algae (single-celled plants) can be a great nuisance in surface waters because, when conditions are right, they will reproduce rapidly and cover streams, lakes, and reservoirs in large floating colonies called blooms. Algal blooms are usually characteristic of what is called a entrophic lake, or a lake with a high content of the compounds needed for biological growth. The presence of algae affects the value of water for water supply because they often cause taste and odor problems. Algae can also alter the value of surface waters for the growth of certain kinds of fish and other aquatic life, for recreation, and for other beneficial uses.

2.2.3.2 FUNGI:

Fungi are aerobic, multicellular, non-photosynthetic chemoheterotrophic, eucarytic protists. Most fungi are saprophytes, obtaining their food from dead organic matter. Along with bacteria, fungi are the principal organisms responsible for the decomposition of carbon in the biosphere. Ecologically, fungi have two advantages over bacteria, they can grow in low-moisture areas, and they can grow in low PH environments. Without the presence of fungi to break down

organic materials, the carbon cycle would soon cease to exist and organic matter would start to accumulate.

2.2.3.4. PROTOZOA

Protozoa are single celled eucaryotic microorganisms without cell walls. The majority of protozoa are aerobic or Facultatively anaerobic chemoheterotrops, although some anaerobic types are known, Protozoa feed on bacteria and other microscopic microorganisms and are essential in the purification of streams and in the operation of biologic treatment processes because they maintain a natural balance among the different groups of microorganisms. A number of protozoa are also pathogenic Giardia lambilia, the cause of giardiasis (often called hiker's disease), and cryptosporidium, because of its importance as a conservative agent in life. Threatening infections in-patients with acquired immunodeficiency syndrome (AIDS), are of great concern in drinking water supplies.

CHAPTER THREE

3.0 MATERIALS AND METHOD

The analysis were carried out to determine where the various sources of water in F.U.T Minna main campus inland valley meet the WHO and FAO standards for domestic water supply and irrigation water. The samples were collected from the Dam, Bore hole and Hand dug well which represent the three sources of water in and around the inland valley. Samples were collected in sampling bottles that were labeled to indicate the water source. The samples collected were taken to the laboratory within four (4) hours of collection for examination.

3.1 SIZE OF SAMPLE COLLECTION POINTS AND THE DEPTH AT WHICH SAMPLES WERE TAKEN.

Table 3.1 below gives the size of the sample collection points and the depth at which the water samples were taken for laboratory examinations.

Table 3.1 Size of sample collection points and the depth the samples were taken

SAMPLES SOURCE	DIAMETER	DEPTH (MN)	SAMPLES DEPTH (MM)	SAMPLE 2 DEPTH (MM)	SAMPLE 3 DEPTH (MM)
Bore hole	62.5	2,650	2,000	2,500	1,000
Hand dug well	1,087.5	1,300	1,100	1,250	150

3.2 LABORATORY ANALYSIS OF WATER SAMPLES

Consequent to the recent advances in Technology, automated technique for water analyses was used. C100 series multi parameter Bench spectro photometer was used to determine the concentration in the water samples. The concentration of parameters determined include:-

- Temperature
- PH
- Electrical Conductivity
- Turbidity
- Hardness as $CaCo_3$
- Mg hardness

- Nitrate
- Phosphate
- Dissolve oxygen
- Magnesium
- Hydrazine
- Sodium
- Calcium
- Boron
- Chloride

The water samples were also tested for bacteriological quality with the determination of fecal coliform. All the analyses were carried out in conforanity with WHO and FAO guide lines for domestic water supply and irrigation water.

3.2 LIST OF CHEMICAL REAGENTS USED FOR THE ANALYSES

Table 3.2 below gives the names and the code numbers of the chemical reagents used for the chemical analyses of the water samples.

Table 3.2 **Name and Code number of reagents used for chemical analysis.**

S/N	NAME OF REAGENT	CODE NUMBER
1.	DPD	HI 93711 –0
2.	Ca and mg indicator	HI 93719A –0
3.	Alkali solution	HI 93719B –0
4.	EDTA Solution	HI 93719C –0
5.	EGTA Solution	HI 93719D –0
6.	Liquid Reagent	HI 93704 – 0
7.	Ca and Mg indicator	HI 93720A –0
8.	Alkali Solution	HI 93920B –0
9.	EGTA Solution	HI 93720C-0
10.	Powder reagent	HI 93728-0
11.	Reagent A	HI 93732A –0
12.	Reagent B	HI 93732B – 0
13.	Reagent C	HI 93732C-0
14.	Phenol Red	HI 93710-0
15.	Molydbate	HI 9371A – 0
16	Amino Acid	HI 9371B -0

3.4 EXPERIMENTAL PROCEDURES

3.4.1 CHLORIDE DETERMINATION

3.4.2 SPECIFICATIONS

Range	0.00 to 3.50mg/l
Accuracy	± 0.03mg/l ± 3% of reading
Light Source	Light Emitting Diode @ 555nm

3.4.1.2 REQUIRED REAGENTS

Code	Description	Quantity
HI 93711-0	DPD	1 Packet

3.4.1.3 PROCEDURE

- Select the program number corresponding to Total chlorine on secondary LCD by pressing PROGRAM t
- Fill the cuvet up to 1.5cm (3/4") below the rim with 10ml of unreacted sample, and replace the cap
- Place the cuvet into the holder and ensure that the notch on the cap is positioned securely into the groove.
- Press ZERO and SIP" will blink on the display
- Wait for a few seconds and the display will show "0.0". New the meter is zeroed and ready for measurement.
- Remove the cuvet and add 1 packet of HI 93711.0. replace the cap and shake gently.
- Reinsert the cuvet into the instrument.
- Press READ TIMED and the display will show the count down prior to the measurement, or alternatively wait for 2 minutes and 30 seconds and press READ DIRECT. In both cases a blinker "SIP" will blink during measurement.
- The instrument directly, displays concentration in mg/L of total chlorine on the LCD.

3.4.2 **MAGNESIUM HARDNESS DETERMINATION**

3.4.2.1 **SPECIFICATIONS**

Range	0.00 to 2.00 mg/L
Accuracy	+ 0.11mg/L + 5% of reading
Light source	light Emtting Diode @ 555nm

3.4.2.2 REQUIRED REAGENTS

Code	Description	Quantity
HI 93719A-0	Ca & mg indicator	0.5 ML
HI 93719B-0	Alkali Solution	0.5 ML
HI 93719C-0	EDTA Solution	1 drop
HI 93719D-01	EGTA Solution	1 drop

3.4.2.3 PROCEDURE

- Select the program number corresponding to Hardness mg on the secondary LCD by pressing PROGRAM t
- Fill a graduated beaker to the 50 ml mark with the sample.
- Add 0.5 ml of HI 93719A Calcium and magnesium indicator solution the seiri to mix.
- Add 0.5 ml of HI 93719A Calcium magnesium indicator solution the swirl to mix.
- Add 0.5ml of HI 93719B Alkali Solution for calcium and magnesium, then swirl to mix.
- Fill two cuvets up to 1.5 cm (3/4 below the rim with 10ml of sample each.
- Add 1 drop of HI 93719A Solution to one cuvet, replace the cap and swirl the solution. This is the blank.
- Add 1 drop of HI 93719D EGTA Solution to the second cuvet, replace the cap and swirl the solution. This is the sample.
- Place the blank into the holden and ensure that the notch on the cap is positioned securely into groove.
- Press ZERO and "SIP" will blink on the display.
- Wait for a few seconds and the display will show "0.0" now the meter is zeroed and ready for measurement.

- Remove the blank and insert the sample into the instrument, making sure that the notch on the cap is positioned securely into the groove.
- Press READ TIMES and the display will show the count down prior to the measurement. Alternatively wait for exactly 30 seconds and press READ DIRECT, in both cases "SIP" will blink during measurement.
- The instrument directly displays concentration in mg/l (ppm) of magnesium hardness, as CaCO3 on the liquid crystal display. To convert the result to mg/L mg, multiple the result by 0.243.

3.4.3 HYDRAZINE DETERMINATION

3.4.3.1 SPECIFICATIONS

Range	0 to 400 mg/L
Accuracy	+ 3% of full seale
Light source	light emitting Diode @ 470nm

3.4.3.2 REQUIRED REAGENT

Code	Description	Quantity
HI 93704-0	Liquid Reagent	1mL

3.4.3.3 PROCEDURE

- Select the programme number corresponding to Hydrazine on the secondary LCD by pressing PROGRAM t.
- Fill one cuvet up to 1.5cm ¾") below the rim with 10mL of unreacted sample, and replace the cap
- Fill a second cuvet up to 1.5cm (3/4") below the rim with 10 Ml of distilled up to water (this is the blank).
- Add 0.5mL of the HI 93704 reagent to each cuvet. Replace the caps and swirl the solutions.
- Place the blank into the holder and ensure that the notch on the cap is positioned securely into the groove.
- Press ZERO and "SIP" will blink on the display
- Wait for a few seconds and the display will show "-0.0" New the meter is zeroed and ready for measurement.

- Remove the blank and insert the sample into the instrument, making sure that notch on the cap is positioned securely into the groove.
- Press READ TIMED and the display will show the count down prior to the measurement. Alternatively wait for exactly 30 seconds and press READ DIRECT. In both cases "SIP" will blink measurement.
- The instrument directly displays concentration in m/gL of Hydrazine on the LCD.

3.4.4 CALCIUM DETERMINATION

3.4.4.1 SPECIFICATION

Range	0.00 to 2.70 mg/L
Accuracy	I 0.11mg/L + 5% of reading
Height source	Light emitting Diode @ 555nm

3.4.4.2 REQUIRED REAGENT

Code	Description	Quantity
HI 93720A –0	Ca & mg Indicator	0.5 mL
HI 93720B-0	Alkali Solution	0.5ML
HI 93720C-0	EGTA Solution	1 drop

3.4.4.3 PROCEDURE

- Select the program number corresponding to Hardness Ca on the secondary LCD by pressing PROGRAM t
- Fill a graduated beaker to the 50ML mark with the sample.
- Add 0.5ML of HI 93720A Calcium indicator solution and Swirl to mix.
- Add 0.5 ML of Alkali solution for HI 93720B Calcium and Magnesium and swirl to mix.
- Fill two cuvets up to 1.5 cm (3/4") below the rim with 10ML of sample each.
- Add 1 drop of HI 93720C EGTA Solution to one cuvet, replace the cap and swirl the solution, this is the blank.

- Place the blank into the Holder and ensure that the notch on the cap is positioned securely into the groove.
- Press ZERO and "SIP" will blink on the display.
- Wait for a few seconds and the display will show 0.0 now the meter is zeroed and ready for measurement.
- Remove the buffered blank and insert the second cuvet into the instrument.
- Press READ DIRECT "SIP" will blink during measurement.
- The instrument directly displays concentration in mg/L (PPM) of calcium, as CaCo3 on the LCD.
- To convert the result to mg/L Ca multiply by 0.4.

3.4.5 NITRATE DETERMINATION

3.4.5.1 SPECIFICATIONS

Range	0.0 to 30.0 mg/L
Accuracy	± 0.5 MG/l ± 10% reading
Light Source	Light Emitting Diode @ 555nm

3.4.5.2 REQUIRED REAGENTS

CODE	Description	Quantity
HI 93728-0	Powder reagent	1 packet

3.4.5.3 PROCEDURE

- Select the program number corresponding to nitrate on the secondary LCD by pressing PROGRAM t.
- Fill the cuvet up to 1.5cm (3/4") below the rim with 10ML of unreacted sample, and replace the cap.
- Place the cuvet into the holder and ensure that the notch on the cap is positioned securely into the groove.
- Press ZERO and "SIP" will blink on the display.
- Wait for a few seconds and the display will show –0.0 now the meter is zeroed and ready for measurement.
- Remove the cuvet and add the content of one packet of HI 93728 reagents.
- Replace the cap and shake vigorously for exactly 1 minute.

- Reinsert the cuvet into the instrument.
- Press READ TIMED and the display will show the count down prior to the measurement, or alternatively.
- Wait for 4 minutes and 30 seconds and press READ DIRECT. In both cases "SIP" will blink during measurement.
- The instrument directly displays concentration in mg/l of nitrate nitrogen on the LCD.
- To convert the reading to mg/l of nitrate (NO3), multiply by a factor of 4.43.

3.4.6 DISSOLVED OXYGEN DETERMINATION

3.4.6.1 SPECIFICATIONS

Range	0.0 to 10.0 mg/l (ppm)
Accuracy	± 0.4 mg/L ± 3% of reading
Light source	Light Emitting Diode @ 470nm

3.4.6.2 REQUIRED REAGENTS

Code	Description	Quantity
HI 93732 A-0	Reagent A	5 drops
HI 93732B-0	Reagent B	5 drops
HI 93732B-0	Reagent C	10 drops

3.4.6.3 PROCEDURE

- Select the program number corresponding to dissolved oxygen on the secondary LCD by pressing PROGRAM t
- Fill one 60ml BOD bottle completely with the unreacted sample
- Replace the cap and ensure that a small part of the sample Spills over. This is to make sure that no air bubble have been trapped inside.
- Remove the cap and add 5drops of HI 93732A and 5drops of HI 93732B. Replace the cap again and ensure that a part of the sample spills over.
- Swirl the solution. The sample becomes orange and a flocculant agent will appear.

- Let the sample stand and the flocculant agent will stand to settle.
- After approximately 2 minutes, when the upper half of the bottle becomes limpid, add 10 drops of HI 93732C.
- Replace the cap and swirl the solution. The sample is really for measurement when it is yellow and completely limpid.
- Fill the cuvet up to 1.5cm (3/4") below the rim with 10ml of the unreacted (original) sample, and replace the cap. This is the blank.
- Place the cuvet into the holder and ensure that the notch on the cap is positioned securely into the groove.
- Press ZERO and "S\IP" will blink on the display.
- Wait for a few seconds and the display will show 0.0 now the meter is zeroed and ready for measurement.
- Remove the cuvet and dispose of the blank.
- Rinse the cuvet with some of the reacted sample. Then, fill it up to 1.5cm (3/4") below the rim with 10ML of the reacted sample and replace the cap.
- Reinsert the cuvet into the instrument
- Press READ DIRECT and "SIP" will blink during measurement.
- This instrument will then directly display the concentration of dissolved oxygen in mg/L.

3.4.7 PH DETERMINATION

3.4.7.1 SPECIFICATION

Range	5.9 to 8.5
Accuracy	±0.1
Light Source	Light Emitting Diode@ 555 nm

3.4.7.2 REQUIRED REAGENTS

Code	Description	Quantity
HI 93710-0	Phenol red	0.2ML

3.4.7.3 PROCEDURE

- Select the program number corresponding to PH on the secondary LCD by pressing PROGRAM t.
- Fill the cuvet up to 1.5cm (3/4") below the rim with 10ml of unreacted sample, and replace the cap.
- Place the cuvet into the holder and ensure that the notch on the cap is positioned securely into the groove.
- Press ZERO and "SIP" will blink on the display
- Wait for a few seconds and the display will show "0.0". Now the meter is zeroed and ready for measurement.
- Remove the cuvet and add 0.2ML of the HI 93710 phenol Red indicator. Replace the cap and swirl the solution.
- Reinsert the cuvet into the instrument.
- Press the READ DIRECT key and "SIP" will blink on the display during measurement.
- The instrument directly displays the PH measured value on the Liquid crystal display.

3.4.8 PHOSPHATE DETERMINATION

3.4.8.1 SPECIFICATION

Range	0.0 to 30.0mg/L
Accuracy	$\pm$1 mg/L $\pm$ 4% of reading
Light Source	Light Emitting Diode @ 470nm

3.4.8.2 REQUIRED REAGENTS

Code	Description	Quantity
HI 93717A-0	Molybdate	0.5ML
HI 93717B-0	Amino Acid	0.5ML

3.4.8.3 PROCEDURE

- Select the program number corresponding to phosphate on the secondary LCD by pressing PROGRAM t.
- Fill the cuvet up to 1.5cm (3/4") below the rim with 10ML of unreacted sample, and replace the cap.

- Place the cuvet into the holder and ensure that the notch on the cap is positioned securely into the groove.
- Press ZERO and "SIP" will blink on the display.
- Wait for a few seconds and the display will show "0.0" now the meter is zeroed and ready for measurement.
- Remove the cuvet.
- Add 0.5ML of HI 93717A Molybdate reagent
- Add 0.5ML of HI 93717B Amino Acid reagent. Replace the cap and swirl the solution.
- Reinsert the cuvet into the instrument
- Press READ TIMED and the display will show the count down prior to the measurement, or alternatively wait for 5 minutes and press READ DIRECT. In both cases "SIP" will blink during measurement.
- The instrument directly displays concentration in mg/L (ppm) of phosphate (PO_4^{3-}) on the liquid crystal display.

3.4.9 SULPHATE DETERMINATION

3.4.9.1 REQUIRED REAGENT

Description	Quantity
Sulphate No. 1 tablet	1tablet
Sulphate No. 2 tablet	4 tablet

3.4.9.2 PROCEDURE

- The Lovi bond container was rinsed and filled with sample to 50ml mark.
- One sulphate No.1 tablet was added and the container shaken until the tablet is completely dissolved.
- The container was allowed to stand for 15 minutes.
- One sulphate No.2 tablet was added and the container was shaken until the tablet completely dissolved.
- Further addition of sulphate No.2 tablet was done and the container shaken as before and at this stage counting of tablet was started (calling this tablet the first).

- The sulphate No.2 tablets was then added continuously in the same manner as above until the colour changes from purple through grey to green.
- The number of sulphate No.2 required from the start of counting was noted and this was called "N"
- Sulphate concentration was then determined as follows:-
  Sulphate (as mg/L $Na_2 SO_4$) = (14-N) x 20
  To convert mg/L $Na_2 SO_4$ to mg/L S04, multiply by 2/3.

3.5 BACTERIOLOGICAL ANALYSIS OF WATER

3.5.1 STANDARD QUALITATIVE ANALYSIS OF WATER

There are three basic tests to detect coliform bacteria in water:-

- Presumptive Test
- Confirmed Test
- Completed Test.

The tests were performed sequentially on each sample under examination. They detect the presence of coliform bacteria (indicator of fecal contamination).

The search for organisms indicative of fecal pollution instead of pathogens themselves is universally accepted for monitoring the microbial pollution of water supplies.

Ideally; the finding of those indicator bacteria should denote the potential presence of intestinal pathogens.

3.5.1 PRESUMPTIVE TEST AND DETERMINATION OF MOST PROBABLE NUMBER (MPN)

This process determines the presence of coliform bacteria in a water sample and gives some index as to the possible number of organisms present in the sample under analysis.

3.5.1.1 PROCEDURE

Three separate series consisting of three groups making a total of nine Tubes per series in a test tube rack is prepared.

The tubes are labeled as to the sample source and volume of sample inoculated.

The samples were shaked thoroughly, and using a 10ml pipette, 10ml aligouts was inoculated into three tubes labeled LB2x-10ml.

Using a 1ml pipette 1ml of water was inoculated into three tubes labeled LB1X-1ml with subsequent flaming of containers using a 0.1ml pipette 0.1ml of water was transferred to three tubes labeled LB1X-0.1ml.

The procedure was respected for the three samples analysed.

The tubes were incubated for 48 hours at 37°C.

3.6.3 CONFIRMED TEST

This process confirms the presence of coliform bacteria in water sample showing a positive presumptive test. Confirmation of these results is necessary since positive presumptive tests may be the result of organisms of non-coliform origin that are not recognized as indicators of fecal pollution.

The confirmed test requires the selective and differential media such as Eosin Methylene Blue (EMB) or Macconkey Agar be streaked from positive lactose broth tube obtained from the presumptive test. The nature of these differential and selective media may be reviewed briefly. EMB forms a complex that precipitates out onto the coliform colonies.

Producing dark centers and a green metallic sheen. This reaction is characteristic of indicator micro organisms.

3.5.3.1 PROCEDURE

The Eosin Methylene Blue (EMB) plates and macconkey a gar plates were labeled. Using a positive 24 hours lactose broth culture from presumptive test, one EMB plate and one Macconkey agar plate were streaked to obtain discrete colonies. The above-mentioned procedure was repeated for the remaining samples.

All plates were incubated at or inverted position for 24 hours at 37°C.

3.5.4 COMPLETED TEST

The completed test confirms the presence of coliform bacteria in a water sample or if necessary to confirm a suspicious but doubtful

result of the previous test. The completed test is the final analysis of the water sample.

It examines the coliform colonies that appeared on EMB or Macconkey agar plates used in the confirmed test.

3.5.4.1 PROCEDURE

The tubes are labeled as before, one lactose broth and one nutrient agar slant from the isolated colonies obtained from an EMB or Macconkey agar plate from the confirmed test".

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

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 CHEMICAL ANALYSES

The result of the chemical analysis carried out on the three sources of water in and around the F.U.T main campus inland valley are presented in the tables below and their corresponding WHO and FAO acceptable limits for domestic water supply and irrigation water.

Table 4.1 **chemical analysis of the three water sources in first week of April 2001**

RAMETERS	SURFACE WATER	BORE HOLE WATER	HAND DUG WELL	WHO LIMIT	FAO LIMIT
mperature °C	30.5	28.4	26.1	25	-
I	6.9	6.4	7.2	6.5-8.5	6.5 – 8.5
ctrical conductivity (ms/cm)	33.9	21.2	22.7	500	250
rbidity (NTU)	7	3	1	5.0	-
rdness as $CaCO_3$(mg/l)	81	89	140	300	-
g-Hardness (mg/l)	2.0	1.27	1.16	100	-
trate NO_3 (mg/l)	44.3	4.43	4.0	50	-
osphate PO_4 (mg/l)	5.0	0.1	0.0	-	-
ssolve Oxygen (mg/l)	2.5	0.4	0.1	-	-
lphate SO_4 (mg/l)	26.6	6.67	13.3	200	-
agnesium mg (mg/l)	0.49	0.31	0.28	30	-
drazine	10.0	1.0	1.0	-	-
dium Na (mg/l)	1.6	0.4	0.83	-	-
lcium Ca (mg/l)	21.2	30.5	5.8	70	-
ron Br (mg/l)	0.0	0.0	0.0	-	0.5
loride C(mg/l)	0.32	0.21	0.41	200	11.3

Date: 2-3 April 2001

Table 4.2 **Chemical analysis of the three water sources in third week of April, 2001**

ARAMETERS	SURFACE WATER	BORE HOLE WATER	HAND DUG WELL	WHO LIMIT	FAO LIMIT
emperature ^{O}C	29.5	26	28	25°C	
H	7.2	6.1	7.6	6.5-8.5	6.5-8.5
lectrical conductivity (ms/cm)	31	81	24.2	500	250
urbidity NTU	0.0	3.0	0.0	5.0	
ardness as CaCo3 (mg/l)	103	67	150	300	
lg-Hardness (mg/l)	2.0	0.48	0.4	100	
itrate No3 (mg/l)	11.3	30.2	0.0	50	
iosphate PO4 (mg/l)	2.5	3.4	0.3	-	
issolve Oxygen (mg/l)	3.1	0.4	5.1	-	
ulphate SO4 (mg/l)	31.3	7.3	18.5	200	
agnesium mg (mg/l)	0.49	0.12	1.18	30	
H4 – N (mg/l)	0.0	3.0	0.0	-	
dium Na (mg/l)	1.9	0.25	3.2	-	
alcium Ca (mg/l)	23	42.3	4.6	70	
oron (mg/l)	0.0	0.0	0.0	-	0.5
iloride (mg/l)	0.14	3.6	0.4	200	11.3

Date: 20th April, 2001

Table 4.3 **Chemical analysis of the three water sources in third week of July, 2001**

ARAMETERS	SURFACE WATER	BORE HOLE WATER	HAND DUG WELL	WHO LIMIT	FAO LIMIT
mperature	24.8	27.3	26.4	$25^{O}C$	-
I	7.0	6.5	7.3	6.5-8.5	6.5-8.5
ctrical conductivity (ms/cm)	28	15.7	17.3	500	250
rbidity NTU	4	2	3	5.0	-
rdness as CaCo3 (mg/l)	42	58	121	300	
g-Hardness mg (mg/l)	2.10	0.40	2.12	100	
trate No3 (mg/l)	43.5	4.4	1.2	50	
osphate PO4 (mg/l)	3.8	2.1	0.2	-	
ssolve Oxygen 80 (mg/l)	2.4	5.2	4.1	-	
lphate SO4 (mg/l)	20.0	4.3		200	
agnesium mg	0.87	0.10	1.02	30	
drazine (mg/l)	15.2	1.1	0.3	-	
dium Na (mg/l)	2.1	0.3	1.2	-	
lcium Ca (mg/l)	18.2	21.4	3.8	70	
ron Br (mg/l)	0.0	0.0	0.1		0.5
loride Cl (mg/l)	0.2	3.1	0.4	200	11.3

Date: 20th July, 2001

4.1.1 ELECTRICAL CONDUCTIVITY (EC)

The concentration of salt in any water is easily measured by determination of electrical conductivity; it measures the ability of any water to conduct electricity and is expressed as Mhos/cm. The result of the analysis carried out on the water samples reveals that the electrical conductivity values for all the samples range from 18mhs/cm to 33.9mhos/cm, which falls within the acceptable limit for both public water supply and irrigation water.

4.1.2 NITRATE (NO_3) CONCENTRATION

Nitrate is an essential nutrient element, which provide energy and aid growth in both plant and animal. It presence in water serves as a source of protein to both plant and animal. The result of the analysis carried out on the water samples show low level of nitrate content, in ground water but although all three water sources meet the acceptable limit for domestic water supply and irrigation water, ground water would require addition of nitrate base fertilizer for optimum growth of the crops.

4.1.3 PHOSPHORUS (PO_4) CONCENTRATION

Phosphorus is known as one of the primary nutrient elements required by plant and animal. In plant phosphorus works hand in hand with Nitrogen in the formation of many proteins for plant growth while in animal it aid in building strong bones and teeth. The results of the analysis shows that phosphate concentration is generally low in all the water samples analyzed. They are however suitable for domestic water supply and irrigation water, but the irrigation water will require little addition of phosphate base fertilizer for optimum growth of crops.

4.1.4 DISSOLVED OXYGEN (DO)

Oxygen is an essential element required by both plant and animal. It helps in breaking down the organic substances there by provide energy to the body.

The results of analysis on the water samples give the values of dissolved oxygen as ranging from 0.1 to 5.2 mg/l which is quite acceptable for both domestic water supply and irrigation water.

4.1.5 SULPHATE (SO_4) CONCENTRATION

Sulphate is an important nutrient element required for growth in plant and animal. The absence of Sulphate often result in stunted growth. The results of the water analysis carried out shows that the values of Sulphate range from 4.3 to 31.3 mg/l which is within the acceptable limits for both domestic water supply and irrigation water and are therefore suitable for the purposes.

4.1.6 SODIUM (Na) CONCENTRATION

Sodium is widely known as one of the essential nutrient element required by both plant and animal for healthy growth. The results of water analysis carried out shows that the values of sodium in all the samples range from 0.3 to 2.1mg/l, which is acceptable for domestic water supply and irrigation water.

4.1.7 CALCIUM (Ca) CONCENTRATION

Calcium is one of the essential element required for the development of strong bones and teeth by animals. The plants requires this element for the formation of cell wall and thus provides the skeleton of the plant. The results of the analysis carried out on the water samples gives the values of calcium content between 3.8 and 42.3 mg/l which falls within the acceptable limits and are therefore suitable for domestic water supply and irrigation purpose.

4.1.8 MAGNESIUM(Mg) CONCENTRATION

Magnesium is an essential element in the growth of plant and animal. It aids the formation of chlorophyll in plant and helps the activity of enzymes. In animal it aid the formation of protein, which facilitate growth. The results of the analysis on the water samples shows that the magnesium values range from 0.1 to 1.18 mg/l which falls within the limits allowed for domestic water supply and irrigation water and therefore are good for the purposes.

4.1.9 BORON

Boron is very essential in normal growth of plants, but is required only in small amount. The presence of boron in large quantity can affect the growth and yield of boron tolerant crops. The result of the analysis shows that Boron was found in only one of the samples and the concentration is low therefore Boron sensitive crops can be irrigated with this water sources.

4.1.10 PH

PH is the measure of the acidic or basic nature of the water. In the analysis carried out on the three water sources it was detected that the PH values for surface water met the requirement of domestic water supply and irrigation water.

The ground water however, has the PH values lower than the required limits of 6.5-8.5 for domestic water supply and irrigation purposes and therefore requires addition of soda ash or lime to make it suitable for the purposes.

4.1.11 CHLORIDE (CL) CONCENTRATION

The maximum desirable limits of chloride in domestic water supply and irrigation water are 200mg/L and 11.3mg/L respectively. The values of chloride contents detected in the three water sources analyzed range from 0.14mg/L to 3.6mg/L which falls within the acceptable limits, and therefore chloride toxicity could not be a problem to the consumers and the crops.

4.1.12 HARDNESS AS $CaC0_3$

The maximum tolerable limit of Hardness desired for domestic water supply is 300mg/L while that of the irrigation water is not stated. The result of the analysis on the three water sources gives values of CaCo3 hardness as ranging from 42mg/L to 150mg/L. It could also be observe from the result that the water was hard when there was no rain and becomes soft after much rainfall (See rainfall amount of Minna at Appendix B). The three water sources are however suitable for both domestic and irrigation purposes.

4.2 BACTERIOLOGICAL ANALYSIS

All the tubes were examine after 24hours and 48 hours of incubation and results were recorded in a chart as.

i. Positive if 10% or more of gas appears in a tube in 24hours.

ii. Doubtful if gas develops in a tube after 48 hours.

iii. Negative if there is no gas in the tube in the series in 48 hours.

ble 4.4 **bacteriological analysis of the three water sources.**

	ACID AND GAS											
	LB2X-10ml			**LBIX-1.0ml**			**LB1X-0.1ml**			**READING**	**MPN**	**Range 95% probability**
JBE	1	2	3	4	5	6	7	8	9			
JRFACE ATER	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	3-3-3	1,100	150-4,800
)RE HOLE ATER	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	3-3-3	1,100	150-4,800
AND DUG ELL WATER	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	3-3-3	1,100	150-4,800

NOTE:

Since gas appeared in all three tubes labeled LB2X – 10, three tubes labeled LB1X – 1.0 and in three of the tubes labeled LB1X – 0.1, the series was read as 3-3-3. From MPN table, such a reading indicates that there are approximately 1,100 microorganisms per 100ml of water, with a percentage probability that there are between 150 and 4,800 organisms present (See Appendix C).

CHAPTER FIVE

5.1 CONCLUSION

From the laboratory investigations carried out on the three water sources in and around the F.U.T main campus inland valley, the following conclusions can be drawn.

1. Although the Nitrate and Phosphate concentration in the three water sources met the required standards for domestic water supply and irrigation water, the level of Nitrate in ground water is very low and the phosphate concentration in all the three water sources are generally low for irrigation uses.
2. The boron content were at zero level for most of the samples except in one occasion when it was detected in minute quantity. Therefore boron intolerant crops can be grown with these water sources.
3. The PH value of ground water was lower than the required limits for domestic water supply and irrigation water.
4. The Electrical conductivity of the three water sources are within the class one rating, which implies that the three water sources can be used to grow most crops without soil salinity developing.
5. The bacteriological examination of the three water sources shows that all the water sources are contaminated by fecal contamination; but astonishing was the ground water which is surpose to be free from bacteriological contamination because of the filtering effect of the soil strata the water posses through. This might however, be due to the shallowness of the borehole.

5.2 RECOMMENDATION

1. The Nitrate content was low in ground water and phosphate concentration generally low in all the three water sources. Application of NPK Compound Fertilizer is therefore recommended for optimum yield of the crops.
2. The boreholes to be sunk in this area should be at least 30 meters deep.
3. The PH value of the ground water was found to be low, therefore addition of soda ash or lime is recommended to balance the PH.
4. The three water sources can only be use to irrigate some some crops because of the high number of micro organisms present. They should not be use to irrigate vegetables.
5. The three water source should be disinfected before being use for any domestic purpose.

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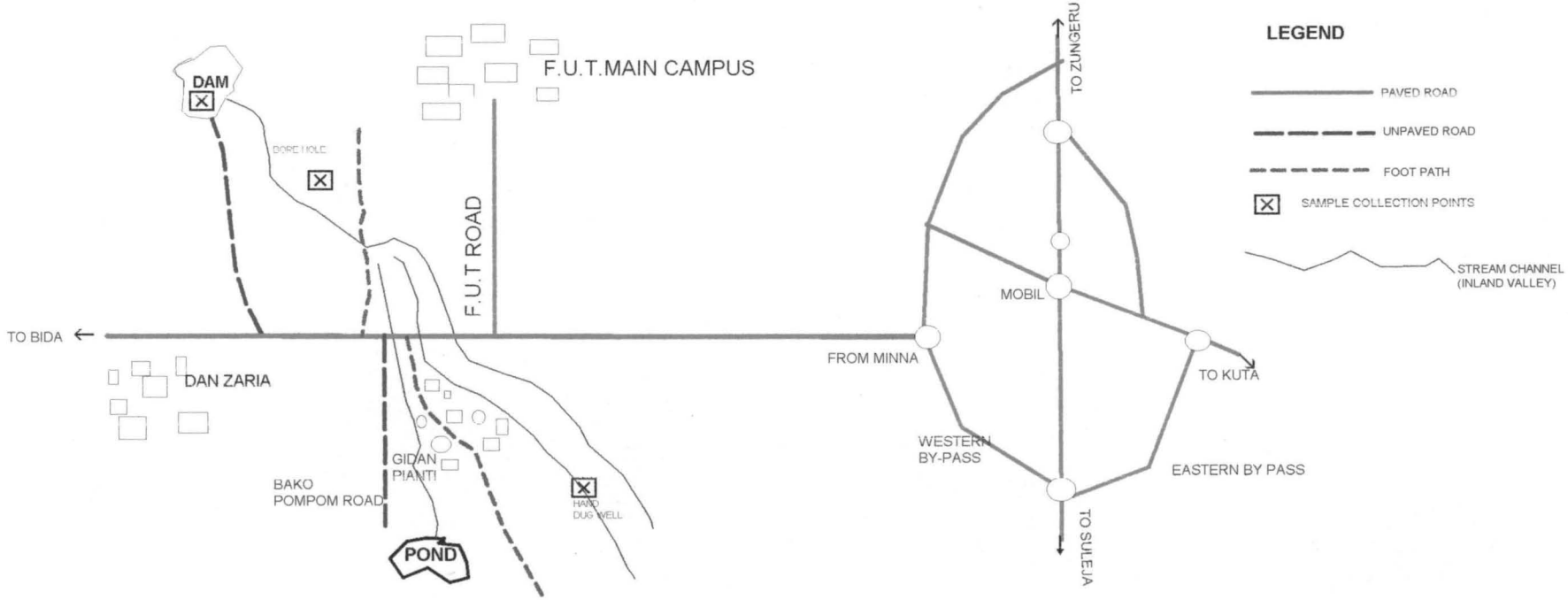
MAP SHOWING F.U.T MAIN CAMPUS AND SAMPLE COLLECTION POINTS



APPENDIX B

Rainfall Amount of Minna in millimeter for January to December, 1990 to 1999 and for January to July, 2001

ONTHS	1990	1991	1992	1993	1994	1994	1996	1997	1998	1999	2001
N	-	-	-	-	-	-	-	-	-	-	-
B	-	-	-	-	-	-	-	-	-	-	-
ARCH	107.4	-	1.3	13.5	7.3	-	-	3.6	-	-	-
PRIL	199.5	114.5	150.2	8.6	72.5	100.5	48.6	128.5	82.5	35.7	93.9
AY	194.4	336.0	176.8	174.4	114.4	123.2	164.9	238.4	121.2	102.8	139.0
NE	198.6	180.1	162.9	170.5	239.0	144.5	225.0	233.0	221.0	164.2	331.7
LY	181.0	192.9	196.4	189.7	142.5	153.7	259.7	172.4	155.1	243.9	244.6
UGUST	187.0	268.5	124.5	271.1	367.2	409.0	257.0	192.7	243.0	245.7	-
PT.	141.4	190.8	230.3	178.3	261.3	189.1	191.1	203.3	201.9	237.1	-
CT.	-	33.9	46.6	63.3	208.1	135.7	127.9	115.0	212.6	212.3	-
OV.	-	-	37.9	-	-	23.6	-	6.1	-	-	-
EC.	-	-	-	-	-	-	-	-	-	-	-

Source: Meteorological Department Airport, Minna.

APPENDIX C

MPN Determination from multiple Tube Test.

Number of tubes giving position reaction out of			MPN index per 100ml	95% Confidence limits	
3 of 10 1ml	3 of 0.1ml each			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	210	35	470
3	3	0	240	36	1,300
3	3	1	460	71	2,400
3	**3**	**2**	**1,100**	**150**	**4,800**

From: Standard methods for the Examination of water and waste water 14th edition (1975).

DEFINATION OF ABBREVATION

F.U.T: Federal University of Technology

N.TU: Non-Tritinium Unit.

DPD: Diethyl Phenylene Diamine

EDTA: Ethylene Diamine Tetra-acetic Acid

EGTA: Ethane Tetra-acetic Acid

MPN: Most Probable Number

FAO: Food and Agricultural Organisation

WHO: World Health Organisation.