ASSESSMENT OF QUALITY PARAMETERS OF CHANCHAGA WATER SUPPLY AND DISTRIBUTION SYSTEM

BY

SANI KASHIM
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A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF POST GRADUATE DIPLOMA IN AGRICULTURAL ENGINEERING.

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APPROVAL PAGE

The project is an original work of Kasim Sani (PGD/Agric. Eng. /2004/190) under the supervision of Mr. Adeoye P. A. and Mrs. Mustapha H.I of agricultural Engineering Department, Federal University of Technology Minna.

This project has been prepared, in accordance with the standards, for the preparation of post-graduate Diploma in Agricultural Engineering. It is submitted in partial fulfillment of the requirement for the award of post-graduate Diploma certificate in agricultural engineering. It is hereby accepted and approved.

MR. ADEOYE P.A.
SUPERVISOR

DATE

MRS. MUSTAPHA H. I.
SUPERVISOR

DATE

ENGR. DR. (MRS) Z.D. OSUNDE
H.O.D, AGRIC. ENGINEERING

DATE

CERTIFICATION

This is to certify that, this project titled "Assessment of Quality Parameters of Chanchaga Water Supply and Distribution System" was carried out by me (Kasim Sani, PGD/AGRIC.ENG/2004/190) under the supervision of Mr. Adeoye P. A. and Mrs. Mustapha H.I. of Agricultural Engineering Department, Federal University of Technology, Minna, Nigeria.

All authors whose works were used in this thesis have been duly acknowledged.

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KASHIM SANI DATE.

DEDICATION

This project is sincerely dedicated to the orphans and the less privilege in the society who are struggling to make ends meet without violating the rights of others.

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My profound gratitude goes to the Almighty God for granting me the privilege and the most needed spiritual guidance, care, human and material support to accomplished this programme.

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I would not forget the contributions of late Engr. Bashir Mohammed who died in the course of making this report a reality. May his soul rest in perfect piece with Almighty Allah (Amen).

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Mr. Kehinde Bello and late Mr. Garus Barnabas who died in the course of this programme. I appreciate you all.

ABSTRACT

Four water samples [raw, treated, distributed with leakage free and distributed with leaks pipe line] comprising about 70% of the total sources available to the residents of the rapidly expanding town of Chanchaga and its environs were selected. It was analyzed for changes in physical, chemical and bacteriological quality during distribution. The parameters considered include; physical- turbidity, odour, taste, colour, temperature, total dissolved solids, suspended solids; chemical – pH, alkalinity, total hardness, iron contents, calcium, phosphorous, potassium, sodium, chlorine residue, Electrical conductivity and Biological parameters which include Escherichia Coli (E. Coli). The results showed that, the treated water and distributed water with leak free condition complied with the set standard by WHO, APHA and NAFDAC. Although, the distribution with leaking pipes was contaminated, the concentrations of contaminating agents are still within tolerable limits that can cause disease. In addition, the coliforms were not of the E. Coli type. The raw water sources were highly contaminated with the presence of E.Coli. In this instance, there is a great risk in the consumption of the raw water by the villagers. However, if they must consume it raw, it should be boiled and chlorinated.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Water is essential for a variety of human activities including consumption, sanitation, recreation, the manufacture of industrial goods and the production of food and fibre. For this reasons, chanchaga, like any other towns in Nigeria has been provided with many water supplies ranging from the fully treated large municipal supply, to the small-untreated supply serving a community of less than hundred (100). However, the assessment of the quality parameters of this water becomes imperative in view of the fact that studies over the years have proven beyond doubt that municipal water supplies have contributed significantly to the transmission of human disease (Berger and Argaman, 1983, WHO 1993 and Singh, 2001).

In accordance with this assertion, the physical, chemical and more importantly, the microbiological qualities of drinking water is now a major concern to consumers, water suppliers, regulators and public health authorities.

It is worthy of note that, the potential of drinking water and water distribution system to transport microbial pathogens to great

number of people, causing illness and subsequent death is well documented in countries at all level of economics development (Allen et al; 2000). The establishment of typhoid fever as a distinct clinical entity in the late 19th century provides a good example. In 1994, for instance 26, 55, 000 cases (incidence: 500 cases per 1000,000) were reported from Africa with1,30,000 deaths (Singh, 2001).

Endemic and epidemic cholera still occur, transmitted through contaminated drinking worker as demonstrated in South Africa (Ainsworth, 2002) and in peru (Anderson, 1991). The Latest number of water borne cholera cases from the World Health Organization is for the year 2000: 137, 071 cases and almost 5,000 deaths. It should be noted that, this figure does not include any cases from Bangladesh or Pakistan where cholera is endemic (Draft Guidelines for Drinking-water Quality Management for New Zealand, 2005). It is obvious that infection is the main, but not the only problem associated with microorganisms in drinking water. Certain algae can produce toxins that affect humans and which may remain in the water even when the algae responsible have been removed. Other nuisance organisms can cause problems of taste, odour or

colour, and while they may not cause disease, they are aesthetically unacceptable.

With these therefore, it is clear that, water borne disease however, remain a constant threat to public health and the needs for this important research.

The recent implementation of bacteriological surveillance programmes to ensure the delivery of safe water has resulted in a dramatic decrease in the occurrence of water-related illness. The occasional occurrence of water borne disease outbreaks, however, points out the continuing importance of strict supervision and control over the quality of public and private water supplies.

Contamination by sewage or human, animal and occasional bird excrement present the greatest danger to public health associated with drinking water, and bacteriological testing continues to provide most sensitive means for the detection of such pollution. Although, modern microbiological techniques have made possible the detection of pathogenic bacteria, viruses and protozoa in sewage and sewage effluents, it is not practical to attempt to isolate them as a routine procedure from samples of drinking water. Pathogens present in water are usually greatly outnumbered by normal intestinal bacteria, which are easier to isolate and identify.

The presence of such organisms indicate that pathogens could be present; if they are absent, disease producing organisms are probably also absent.

It should be emphasized that no bacteriological analysis of water can take the place of a complete knowledge of the conditions at the sources of supply and throughout a system. Contamination is often intermittent and may not be revealed by the examination of a single sample. The most a bacteriological report can prove is that, at the time of examination, bacteria indicating feacal pollution did or did not grow under laboratory conditions from a sample of water. Therefore, if a sanitary inspection shows that, a well is subjected to contamination or that water is inadequately treated or subject to contamination during storage or distribution, then the water should be considered unsafe irrespective of the results of bacteriological examination.

1.2 THE OBJECTIVE OF THE STUDY

The objectives of the study are:-

To determine the suitability of water supply by the chanchaga distribution system for human consumption.

To study and detect the sources of contamination in the distribution system if any,

To profer solutions to the problems of contamination of water supply within and outside the distribution system.

1.3 PROBLEM OF STUDY

Presently, it is not that particular water borne disease is endemic in the study area, but the project is undertaken to take care of the occasional occurrence of such diseases that is usually associated with the public and private water supplies.

1.4 SCOPE OF THE STUDY

This project is limited to the assessment of quality parameters of Chanchaga water supply and distribution system.

1.5 JUSTIFICATION

All over the world, the assessment of the quality of water supply and distribution system is of utmost importance. This becomes imperative in view of the fact that clean potable water supply is essential for the overall development and good health of any community and the nation at large.

In view of this, it is envisaged that, the successful completion of this research will help in finding lasting solution to the occasional occurrence of waterborne disease in the study area. In addition to this, the study will attempt to provide additional information on the process and factors, which influence the quality of water supply. It

will equally guide the residents within the area of investigation on the safe precaution of water supply before consumption.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 SOURCES OF WATER

Generally, the main sources of water in Nigerian are surface and underground water that are chiefly supplied by rain. Examples of surface water common in this Ares are rivers; lake, Ocean Sea and streams while that of underground water are wells, springs and bore- holes (sangodoyin, 1993). However, the subsurface water supplies are much purer than the surface water as they are relatively free from pollution. They can sometimes be polluted in a situation where by the disposal of waste is not properly taken care of (khanna, 1981).

2.2 RURAL WATER SUPPLY AND TREATMENT

Rural water supply is the collection or harvesting of water from rivers, lakes, springs, wells, rainwater, ponds or other source to be used in various homes which in African context is largely regarded as the responsibility of women (sangodoyin, 1993).

Water may be of potable standard either as a result of judicious selection of the source or by purification after collection. Women in rural areas perform various water purification processes, of which the removal of sediments or filtration is the simplest.

Although disinfections by boiling is sometimes done, Oluwande (1988) observed that, the quantity of water subjected to heat treatments is usually small when compared with the total amount of water needed by a household for domestic and other uses. In addition to this, the use of alum in water treatment is very common in the rural areas.

2.3 MUNICIPAL WATER TREATMENT

Water uses varies from place to place, depending on the climate, characteristics of the environment, population and other factors. It also varies from season to season, day to day, hour to hour. However, the most common uses of water according to Williamson and Mann (1986) are for Domestic, commercial and public use.

Municipal waters require treatment for the removal of germs of diseases, solid impurities, taste, odour, colour, iron and mineral salts (Khanna, 1981). In general, the treatment given to water is adjusted suitably to the characteristic of the raw water and the nature of impurities to be dealt with. The chief treatment required for municipal waters is for contamination, turbidity, taste, colour etc and the treatments in most cases include the screening, aeration, sedimentation, flocculation, coagulation, filtration,

Disinfections, precipitation, Adsorption and oxidation (Williamson and Mann, 1986).

2.4 WATER AND CONTAMINATION

Khanna (1981) defined contaminated water as water that contains the bacteria, which cause diseases.

Kirkwood (1998) stated that water for human consumption should have the following characteristics.

- It should be free from microbiological contamination.
- It should not be polluted
- It should not have chemical concentrations greater than prescribed units by world health organization (WHO).
- It should meet local standards for taste, odour and appearance.

He further stated that, microbiological contamination is the most common reason for water to be deemed unsafe and is usually detected by testing for indicator – bacteria such as feacal coliforms.

However, the 16th edition of the standard methods for the examination of water and waste water (1985) and the world Health Organization WHO, 1993) pointed out that, drinking water for human consumption must fulfill the following conditions which are

incompliance with the total coliform Maximum Acceptable Concentration (MAC);

- No sample of drinking water should contain more than the (10) total coliform organisms per 100mL, and non of which should be feacal coliforms.
- No consecutive samples of drinking water from the same site should show the presence of coliform organisms.
- For community drinking water supplies;
  (a) Not more than 10% of the samples based on a minimum of ten samples should show the presence of coliform organisms.
  (b) Not more than one sample from a set of samples taken from the community on a given day should show the presence of coliform organisms.

It was equally stated that, if any of the above criteria is exceeded or violated by the available water supply within and outside the distribution system, the water is said be in a state of contamination.

2.5 CAUSES OF WATER CONTAMINATION

Sangodoyin (1993) observed that, water initially drawn may be reasonably acceptable and potable at source, but due to unclean storage, it usually becomes contaminated. Frequently the same cup

is used for scooping and drinking especially where the water source is a spring or pond.

Also, sandy et al; (1980) postulated that, the entrance of faecal matter through leaks in the distribution system hasten contamination.

2.6 ASSESSMENT OF POTABLE WATER QUALITY

Potable water is defined as the water delivered to the consumers that can be safely used for drinking, cooking and washing (Williamson and Mann, 1986). Such water must meet the physical, chemical and bacteriological parameters standards. It must have palatability be within reasonable limit of temperature and gain the confidence of consumers. It can also be defined as water, which is clean, and contain nothing injurious to health.

In conjunction with this, Sandy et al; (1980) observed that, an examination of water quality is basically an assessment of the physicals, chemicals and organisms, which the water contains in order to determine its sanitary quality and its suitability for human consumption.

Okafor (1985) stated that the sanitary quality of water is the relative extent of the absence of suspended matter, colour, taste,

unwanted dissolved chemical and bacteria indicative of feacal pollution.

Also, wright and vernom (1976) in their own findings pointed out that, drinking water supplies liable to contamination with sewage or other matters are the vehicles of water borne diseases such as cholera, Typhoid fever, diarrhea, dysentery, skin and eye infections, parasitic warms etc. Therefore, in safe guarding the quality of water supplies, public health authorities should rely on the information obtained from the results of the physical, chemical and the bacteriological tests being carried out as well as the reports of the sanitary inspections.

2.7 WATER QUALITY PARAMETERS

2.7.1 PHYSICAL PARAMETERS

2.7.1.1 TURBIDITY

According to Khanna (1981), turbidity is a water quality parameter that decreases the density of water and results from the finely divided impurities or suspended solids that may be present in water. It is usually caused by clay, silt and other colloidal impurities.

Turbidity is measured using turbidimeter or by comparing the sample with standard solution by optical means. Another simple

method is that, water, which is clear and bright in a 300mm tube, may be registered as "clear and bright". Other method for measuring turbidity includes the use of Spectrophotometer (WHO, 1993). It is worthy of note that, the turbidity limit for drinking water is based on health consideration as it relates to chlorination treatment.

2.7.1.2 TASTE AND ODOUR

According to the 16th edition of the standard methods for the examination of water and waste water (1985), these two qualities parameters can present in raw water sources; it can as well be formed during treatment, particularly by chlorination or can be introduced into the water during distribution. They are usually caused by the presence of decomposed organic materials and volatile chemical. Although, there are no quantitative tests for tastes and odors, recent study has shown that they can be measured by diluting the water sample until the taste and odor is no longer detectable by human test, (Williamson and Mann, 1983).

2.7.1.3 COLOUR

Drinking water derived from ground water can contain high quantities of fulvic and humic acids of natural vegetable origin, giving the water a yellowish or brownish colour (Khanna 1981). It

can also be coloured due to the presence of small algae that have passed through the filters of a plant (Sandy et al 1980). Furthermore, it can equally be caused by industrial compounds discharge into the source of the water. Colour can be measured using spectrophotometer (WHO, 1993).

2.7.1.4 TOTAL SOLIDS

The total solid are determined by evaporating a sample of water and weighing the dry residue, or they may be more quickly estimated from the conductivity of water using the conductivity meter (WHO, 1993).

2.7.1.5 SUSPENDED SOLIDS

These are simply determined by just filtering the samples of water and then weighing the residue. The recent method is the use of spectrophotometer (WHO, 1993)

2.7.1.6 DISSOLVED SOLIDS

The difference in weight between the total solids and, the suspended solids represent the dissolved solids.

2.7.2 CHEMICAL PARAMETERS

These are quantified in terms of the organic and inorganic constituents that may be present in water. The inorganic constituents in water are: pH, cat ions, Anions, alkalinity, carbon

dioxide etc and the organic constituents found in water are derived from commercial activities. They are synthetic organic compound, volatile organic compound etc.

2.7.2.1 pH

The pH value is a measure of acidity or alkalinity of water Khanna (1981). Potable water for human consumption does not consist of water only, but also contain a relatively small amount of negative hydroxyl ions, OH-. Neutral water has a pH of 7.0 or 7.1 (Twort et al. 1974). However, according to (WHO) standard, pure water has a PH of 7.0 – 8.5.

2.7.2.2 HARDNESS

Twort et al (1974), stated that hardness in water is as a result of the presence of calcium salts and or magnesium salts in solution. Whereas, total hardness is equal to the sum of the two i.e. the total concentration of divalent metal ions (Ca and Mg) in water. It is normally expressed as the equivalent concentration in milligrams per liter of $CaC0_3$

2.7.2.3 ELECTRICAL CONDUCTIVITY

The electrical conductivity of water body is its ability to conduct an electric current, which in turn is related to the total concentration of ions that is charged solutes. It was further pointed

out that different ions vary in their ability to conduct electricity, but in general, the greater the concentrations of ions in the natural water, the higher the conductivity (sterling, 1985). Also Adebiyi;(1982) emphasized that the determination of electrical conductivity provides a rapid and convenient means of estimating the concentration of electrolytes. The electrical conductivity of most potable water is in the range of 5- 50msm^{-1}.

Other quality parameters that could be determined in line with the quality standards include; Iron content, Calcium, Chlorine, Phosphate.

2.7.3 MICRO-ORGANISMS IN DRINKING WATER

The pathogenic organisms of concern include bacteria, viruses, protozoa and algae. The diseases they cause vary from mild gastroenteritis, to severe and sometimes fatal diarrhea, dysentery, hepatitis, cholera, typhoid fever and campylobacteriosis to mention but a few. However, sandy et al., (1980) stated that it is not practicable to test water for all these organisms, instead, water is tested for bacteria which are excreted in large numbers by animals and humans and whose presence is indicatives of feacal pollution.

2.7.3.1. POLLUTION OR MICROBIAL INDICATOR ORGANISMS

These are microorganisms that, are while not themselves pathogenic, indicate potential issues of microbiological water quality.

It is worthy of note that the detection of specific pathogens, including bacteria, viruses, protozoa and parasite is usually complex, expensive, time – consuming, and currently aften not practically possible. It may take weeks to determine whether a sample actually contains a particular pathogen.

Therefore in monitoring microbiological quality, reliance is placed relatively quick and simple tests for the presence of indicator organisms. According to the draft guidelines for drinking water quality management for new Zealand (2005), the drinking – water industry commonly use the following indicator organisms-

- Total coliforms
- Faecal coliforms (thermo tolerant coliforms)
- Escherichia coli (E. coli)
- Heterotrophic plate count (standard plate count, mesophilic plate count, aerobic plate count).

2.7.3.1.1 THE COLIFORIM GROUP

According to the 16th edition of standard methods for the examination of water and waste water (1985) the coliform group of bacteria was fist isolates from feaces in the late 19th centuries and since then, it has been used as an indicator of the bacteriological safety of water. This book further stated that the coliform group merits consideration as an indicator of pollution because these bacteria are always present in the intestinal tracts of human and other warm-blooded animals and are excreted in large numbers in feacal wastes.

Also, WHO (1993) observed that, among the various coliform group escherichia coli, otherwise called E-Coli is the parameter of choice for monitoring drinking water quality or the integrity of the distribution or storage system (with thermo tolerant coliform as an alternative). Water is not a natural medium for coliform organisms, and their presence must at least be regarded as indicative of pollution in its widest sense.

Finally, faecally derived coliform, thermo tolerant coliform and or E. coli though have several drawbacks, they have historically been very usefully and they are, undoubtedly, the most commonly used microbial parameters for testing drinking water quality. Their

use has led to significant improvement in the safety of drinking water worldwide and they have been adopted in the world Health Organization (WHO) drinking water quality guideline and all National drinking water quality standards.

2.7.3.1.2 DIFFERENTIATION OF COLIFORM ORGANISMS

It was recognized at an early date that some strains included in the total coliform group were not common in faecal material. Organisms of the Klebsiella, Enterobacter and citrobacter genera (intermediate aerogenes- cloacae [IAC] subgroups) have been found in soils, vegetations and in feaces, however, they are present in much smaller numbers than E. coli, which is characteristically the predominant coliform in warm blooded animals intestines (WHO, 1993). Attempts have therefore been made differentiate members of the coliform group and to relate their physical and biochemical characteristics to their natural sources of habitats.

Geldreich and Rice (1987) defined the aerogenes group on the basis of fermentative reactions with five sugars and the ability to produce acetylmethylcarbinol in the voges proskauer (VP) reaction. Coliforms can also be differentiated by the ratio of carbon dioxide to hydrogen produced. Coliforms derived from non-faecal sources produced two or more times as much as carbon dioxide as

hydrogen; in faeces-derived stains, the ratio was 1:1. A second approach to coliform differentation is the elevated temperature test originafly proposed by Eijkman, in which it was stated that 44.5°C was the best temperature for separation of the faecal coliform group.

A new method to differentiate coliform is based o the selective ability of E. coli to metabolized 4-methyl-umbelliferyl-B-D-glucuronide (MUG). According to feng and Hartman (1982), when MUG is used both as the sole source of energy and the indicator in a medium, it is hydrolyze by E. coli to form 4-methyl-lumbelliferone, which fluoresces under long wave ultraviolet light.

2.7.3.1.3 COLIFORM: SURVIVAL AND AFTER GROWTH

Although all the Coliform genera (Esherichia, Klebsiella, Citrobacter and Enterobacter) are present in fresh faeces and in fresh pollution from faecal sources, they may not all persist in water for the same length of time. The 16th edition of the standard methods for the examination of water and waste water (1985) states that, Eschericia Coli, for example, is generally most sensitive to environmental stresses and least likely to grow in the environment. Klebsiella, Citrobacter and Enterobacter, on the other hand, are more likely to persist and to grow on organic rich materials or in

organic – rich waters. They may also form a biofilm within the distribution system that is resistant to chlorination and other eradication measures. Martin et al, (1982) as well as Gelderich and Rice (1987) observed that, regrowth of Coliforms in the distribution systems presents a serious problem to water purveyors. The sporadic positive Coliform results makes it difficult to assess the true hygienic status of the water. Although identification to species of positive Coliform tests should be performed, the presence of organisms apparently the presence of organisms apparently as a result of "after growth" should not be ignored. Corrective action in such cases is required in order to maintain the usefulness of the coliform indicator system.

2.7.3.1.4 COLIFORM APPLICATIONS TO WATER STUDIES

The faecal coliform tests has been shown to be an indicatorof the potential presence of enteric pathogens in water. A relationship between the faecal Cliform density and the frequency of salmonella detection has been demonstrated. Geldreich (1985) as well as van Donsel and Geldreich (1984) stated that, at faecal coliform densities of 1 to 200 CFU (Colony-forming units) per 100mL, Salmonella was detected in 28% of the water samples examined; this frequency rose to 98% in waters with a faecal Coliform count above 2000 CFU per

100ml. Studies on survival in river water, well water and septic tank water have shown that faecal Coliforms persist longer than Salmonella organisms. Because it is relatively specific for faecal contamination, the faecal Coliform measurement is preferred for monitoring raw water quality and for indicating the potential presence of pathogens at source. It is also of value in testing untreated drinking water supplies. Any untreated supply that contains faecal Coliform should receive disinfection.

The total Coliform test, on the other hand, is less reliable as an indicator of faecal pollution. However, because of its superior survival characteristics, the total Coliform group is preferred as an indicator of treatment adequacy in drinking water supply systems. The presence of any type of Coliform organism in treated water suggests either inadequate treatment or contamination and therefore should not be tolerated.

2.8 CHARACTERISTICS OF INDICATOR ORGANISMS

The Draft Guideline for Drinking Water Quality Management for New Zealand {2005} state that, an effective indicator for detecting feacal contamination of water should-

- Always be present when feacal pathogens are present.

- Be present in feaces in large numbers so that the organisms can be detected after considerable dilution.
- Be relatively easy and quick to detect.
- Survived in water as long as waterborne pathogens of feacal origins are present.
- Be as sensitive as pathogens to disinfection.

2.9 METHODS FOR DETECTING COLIFORM ORGANISMS IN DRINKING WATER

Three methods are currently in use for the detection of Coliform organisms in water: they include: the Multiple Tube Fermentation (MTF) method, the Membrane Filter (MF) technique and a Presence - Absence (P-A) method. The three methods do not give strictly comparable results. At low Coliform levels, the confidence limits of both the MTF and MF methods are large; therefore separate Maximum Acceptable Concentrations are not recommended for each method. The P-A method is a qualitative measure of contamination (WHO 1993)

2.10 WATER – BORNE DISEASES

These are diseases that are transmitted through contaminated water (Sandy et al; 1980 and Singh, 2001). They are normally caused by the presence of microbiological parameters in water

(Draft Guidelines for Drinking – Water Quality Management for New Zealand, 2005). However, the absence of such parameters as pathogenic bacteria, viruses etc. would not guarantee that the water is safe (Singh, 2001). The prevention of waterborne disease is therefore left to many precautions to be taken from the source of raw water to the ultimate consumer (WHO, 1993). Some of these water – borne diseases are cholera, Typhoid fever, Diarrhea, Dysentery, skin and eye infection, parasitic worms, campylobacteriosis etc. (Sandy et al, 1980).

2.11 BACTERIAL PATHOGENS ASSOCIATION WITH WATER BORNE DISEASES

2.11.1 Salmonella and Shigella

These are organisms that cause typhoid fever. The survival characteristics in water and the susceptibility to disinfection of these organisms have been demonstrated to be similar to those of Colifrom bacteria (DGWQM 2005). Therefore, routine monitoring to ensure the absence of Coliforms should be adequate to protect drinking water from most contamination situations involving these organisms. However, instances have been reported in which these pathogens were isolated from drinking water in the absence of Coliforms (Borning 1971). Coliform suppression by elevated

heterotrophic plate counts and poor recovery of stressed coliforms seem to be most plausible explanations for these discrepancies. The combines used of Coliform and HPC guidelines for treated water should provide an adequate indication of the presence of these pathogens.

2.11.2 Campylobacter Jejuni and Yersinia Enterocolitica

These are bacteria responsible for the waterborne outbreaks of gastroenteritis. McNeill et al; {1981 and sacks et al; 1986}. However, many reports of their Isolation from surface and well water as well as water supply distribution system have been presented (Blaser et al; 1980, and Weagant el at; 1983). Moreover, Since the realization that, water can be a potential route of campylobacteriosis and yersiniosis, isolation and enumeration methods have been developed (Washington, DC, 1985). In addition to this, Rollins and Colwell (1986) recently described the presence of viable but non-culturable states of C. jejuni in the aquatic environment. They further suggested that, this non-culturable type could be one reason why campylobacter is not always insolated from water during a waterborne outbreak of campylobacteriosis.

According to Berger and Argaman (1983), the survival characteristics of C. jejuni are similar to those of Coliforms, but the

frequency of Isolation of Yersinia enterocolitic is higher in winter months, indicating that, it can survive for extended periods and perhaps even multiplied when water temperatures are low.

2.11.3 Legionella Pneumophila

This organism is the causative agent of legionellosis and Pontiac fever. It has been recovered in low concentrations in the drinking water of a number of Canadian Cities (Tobin et al; 1986 and Dutka et al; 1984). However, it is not a major component of the bacteria populations of the relatively cold surface waters in Canada. This organism can colonize various niches in buildings (such as cooling towers, hot water tanks, shower heads, aerators) and contaminate the air and potable water.

2.12 SAMPLING FOR BACTERIOLOGICAL EXAMINATION

2.12.1 SAMPLES SIZE

A minimum volume of 100ml should be examined by the MTF procedure in order to obtain a reliable estimate of the Means Probable Number of Coliform organisms at the expected low levels in treated drinking water. A test series consisting of one 50-ml volume and five 10ml volumes is suggested in the world Health Organization's international standards for Drinking water for water expected to be good quality (WHO, 1993). Smaller volumes,

dilutions or other combinations of tubes may be more appropriate for water of doubtful quality.

With the MF method, if the sample is expected to contain less than 100 coliform organisms per 100ml, the filtration of 100ml is necessary. For more polluted samples, the volume should be chosen to give an MF count between 10 and 100. If the volume to be filtered is less than 10ml, the sample should be diluted with sterile water or buffer so that a minimum of 100ml is filtered.

Although a minimum sample volume of 100ml is recommended with both procedures, examination of larger volumes, which is practical with the MF method, will increase both the test sensitivity and reliability.

2.12.2 FREQUENCY OF SAMPLING

The world Health Organisms lists the following factors that should be taken into account when determining sampling frequency (WHO, 1993)

- Past frequency of unsatisfactory samples.
- Source water quality;
- The number of raw water sources;
- The adequacy of treatment and capacity of the treatment plant;

- ❖ The size and complexity of the distribution system; and
- ❖ The practice of disinfections.

The frequency of sampling should therefore be established by the control agency after due consideration of local conditions. It is recommended, however, that a minimum of four samples per month be examined for water supply system. For practical and economic reasons, sampling of private's wells should be restricted to times when the risk of contamination is greatest.

Further more, experts at a 1981 U.S EPA workshop recommended a minimum sampling frequency of five per month. This value was based on the calculation that, if at least 60 samples per year are collected and 95% of these do not contained Coliforms, then there is a 95% probability that the fraction of water distributed during the year containing Coliforms is less than 10%.

If disinfections are practiced in water supply systems where the source is or could be contaminated, failure of the disinfection system could result in a serious health hazard. Constant monitoring of the disinfectant residual concentration and bacteriological quality is therefore necessary to ensure that immediate remedial action can be taken if water of doubtful quality enters the distribution system. A check on the disinfection process

and bacteriological examination of water entering the distribution system should be made daily (WHO, 1971 and WHO, 1976). Where this is impractical, For example, in the smallest supplies- reliance may have to be placed on residual chlorine determinations. This does apply to supplies served by sources of excellent quality in which disinfection is practiced to increase the safety margin.

2.12.3 LOCATION OF SAMPLING POINTS

The location of sampling points in a distribution system must be decided by the surveillance agency. In view of this Sandy et al; (1980) observed that, samples could be taken from the source, the entry to the storage tank, the exit from the storage tank, and at several taps on the distribution system. They equally emphasized that; samples should also be collected from water after it has been drawn from the tap. Suitable sampling points under this condition as indicated by them include: the tap, the container (e.g bucket etc) immediately after filling, the container after it has arrived home, the water storage vessel at the house at various time.

Ainsworth (2002), in his own findings observed that, samples should be taken at the point where the water enters the system and from representative points throughout the network, although not necessarily the same points on each occasion. If the water supply is

obtained from more than one source, the location of sampling points in the distribution system should ensure that water from each source is periodically sampled. The majority of samples should be taken in potential problem areas: low- pressure zones, reservoirs, dead ends, areas at the periphery of the system farthest from the treatment plant and areas with a poor previous records. Although this practice is recommended, pipes and Christian (1982) found no significant differences in the frequency of Coliform occurrences between peripheral and non-peripheral sampling locations in a distribution system.

2.12.4 HANDLING OF SAMPLES

Proper procedures for collecting samples must be observed to ensure that the sample is representative of the water being examined. As the way in which samples are collected has an important bearing on the results of their examination, sample collectors should be properly trained for the work.

To avoid unpredictable changes in the bacteria flora of the sample, examination should be started as soon as possible after collection. The sample should be transported to the laboratory in an iced cooler. The interval between collection of the sample and the beginning of its examination should not exceed 24 hours. When

greater delays are anticipated, a delayed incubation procedure should be employed. The delayed incubation procedure, described in standard methods for the examination of water and waste water (1985), is a modification of the standard MF technique, which permit transport of the membrane, after filtration, to a distant laboratory for incubation and completion of the test. Alternatively, if transportation time exceeds 24 hours, the sample should be processed and arrangements made to have another sample collected as soon as the first sample is received. Thus, if the late sample contains Coliforms, a repeat sample will already have been received or will be in transit. Reports by Dutka and El-Shaarawi (1980) and McDaniels et al; (1985) support the belief that samples should be stored under refrigeration to minimize changes in populations and concentrations. Samples should be identified with the date, location and any special conditions. When examination will be delayed, it is particularly important to record the time and temperature of storage, as this information should be considered in the interpretation of results.

CHAPTER THREE

3.0 DESCRIPTION OF THE STUDY AREA

3.1 LOCATIONS

For this study, chanchaga water scheme located in Minna West Local Government Area of Niger State, Nigeria was chosen. Chanchaga reputed to be one of the native towns is dominated by Gwari, Nupe, Hausa and the Yoruba speaking peoples of Nigeria.

The town, along side with the entire Minna city and the paiko community is served by the Municipal water supply owned by the Niger State Government. This water works abstract raw water from the Tagwai River. The river is dammed for this purpose. The water treatment and processing as it is being carried out here involves, the addition of dosing Alum solution into the raw water, in the dosage tank. This is followed by coagulation, flocculation, sedimentation, filtration and chlorination.

3.2 SCREENING

The screens used at the Tagwai river intakes to screen out the coarser solids and floating matter were of two types. These include; the bar screens with openings 25 to 75 mm and the fine screens with 3 to 10mm openings; the two types are operated in series.

Coarse screens are located at the opening in the intake structures and fine screen at the entrance to the treatment plant.

3.3 ALUM DOSAGE TANK

As the raw water gets into the treatment plant, it is sent directly into the Alum dosage tank where a dosing of Alum in solution is poured into the raw water to enhance coagulation, flocculation and sedimentation. The dosing of alum into the raw water depends on the turbidity of raw water. However, the normal amount in practice varies between 15 to 20 grams per 1000 liters. The addition of alum as a coagulant into the raw water result in the formations of heavier flocculent precipitate, as floc, thereby allowing very fine and suspended matter in water which may causes colour and turbidity to settle after a period of detention.

3.4 SEDIMENTATION

This is carried out by giving the water a period of rest, thereby permitting the heavy suspended matter to settle at the bottom of the sedimentation tank or basin by gravity.

3.5 FILTRATION

This is carried out to traps down suspended and colloidal matter in the water, which could not be removed through sedimentation.

3.6 STERILIZATION

This is the last stage in the treatment practice carried out by Chanchaga water scheme. It involves the addition of chlorine to water in the right amount to kill the suspected pathogenic bacteria of waterborne diseases to make the water safe for human consumption. From this point, the water is sent to the storage reservoir.

3.7 VOLUME OF WATER PER HOUR PER DAY

The volume of water distributed to the consumers depends on the number of pumping machines that are in operation per hour per day. Presently, Chanchaga water works is having three pumping machines with each pumping 558M^3/hr.

i.e. 1 pumping machine = 558m^3/hr

3 " " = 3x558M^3/hr

= 1674M^3/hr

∴ For a day = 24 x 1674M^3/hr

= 40176M^3/day

But, 1L = 1000m = 40,176,000L/day

Therefore, 40176000L/day water is required to be distributed by Chanchaga water scheme to the consumers per day using three pumping machines.

3.8 INVESTIGATION OF PARAMETERS

The investigation of parameters as they affect water quality was carried out with samples from different sources. These are:-

(i) Raw water from Tagwai river (SI)

(ii) Treated water from the storage reservoir (S2)

(iii) Public water tap from house one (1) along the street with distribution line free of leakage (S3)

(iv) Public water tap from house two (2) along the street with leaks distribution line (S4)

3.9 COLLECTION OF SAMPLES

Samples for bacteriological laboratory studies were collected in thoroughly cleaned sterilized bottles, measuring approximately 1000ml.

Also samples for physical and chemical laboratory studies were equally collected in cleaned non sterilized plastic bottles measuring approximately 1000ml.

At each location, two samples each were taken for analysis.

3.10 PROCEDURE FOR SAMPLING

At the raw source, the bottles were deep into the mass of water and filled to the brim on different occasions and covered with stopper and the protective foil paper as the case may be.

The following steps were taken when sampling from the tap.

(1) A white clean cloth was used to wipe the outlet of the tap in order to remove any dirt.

(2) The tap was turned on at maximum flow rate to let the water flow for 1-2 minutes.

(3) The tap was sterilized for a minute using a gas burner.

(4) The tap was then carefully turned on, and allowed the water to flow for 1-2 minutes at a medium flow rate.

(5) The sterilized bottle was opened. Sample was collected and the bottle finally covered with stopper and the protective foil paper.

3.11 LABORATORY ANALYSIS

Information Sought from water analysis include: turbidity, odour, taste, colour, temperature, total dissolved solids, suspended solids, pH, alkalinity, Hardness (Ca) as $CaCO_3$, Hardness (mg) as mgco, Total hardness, iron content, Calcium, chlorine residual,

phosphate as phosphorus, Electrical conductivity, potassium, sodium, and the indicator bacteria e.g. Escherichia coli.

All these parameters were analyzed and the results gave useful information on the quality of water studied.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

Some substances or dissolved constituents are needed in allowable concentration in both public and private water supply in order to preserves a wholesome and palatable supply (Khanna, 1981, Williamson and Mann, 1986 WHO, NAFDAC and NPDWR).

The tests carried out reveals the following

4.1 RESULTS OF THE LABORATORY ANALYSIS

Table 4.1: PHYSICAL PARAMETERS OF THE WATER SAMPLES

Test sample	Turbidity	Colour P_t co	Odour	Taste	TDS (mg/L)	SS (mg/L)	Temp. (°C)
S1	17.0	88.0	Present	Present	50.0	4.0	26.8
S2	0.0	0.0	free	free	50.0	0.0	26.0
S3	1.0	1.0	free	free	60.0	0.0	26.9
S4	1.0	2.0	free	free	61.0	1.0	26.0

Table 4.2: CHEMICAL PARAMETERS OF THE WATER SAMPLE

ıple	pH	Alkalinity (mg/L)	Hardness ($CaCO_3$)	Hardness ($mgco_3$) (mg/l)	Total Hardness mg/l	Fe (mg/l)	Ca (mg/l)	P (mg/l)	K (mg/l)	Na (mg/l)	Residual Chlorine (mg/l)	Elect. Conductivity Ч ohms/cm
	7.5	o.o	14.4	21.6	36.0	0.75	5.76	0.51	0.094	14.30	0.00	100
	6.8	0.0	14.0	21.0	35.0	0.02	5.60	0.30	0.087	19.50	0.11	110
	6.8	0.0	15.6	23.4	39.0	0.04	6.24	0.30	0.089	20.10	0.10	120
	6.4	0.0	14.2	21.8	36.0	0.04	6.30	0.30	0.086	18.50	0.09	120

Table 4.3: COLIFORM TEST

Test Sample	Number of Coliforms per 100mL
S1	180 +
S2	0
S3	0
S4	3

Table 4.4: MOST PROBABLE NUMBER (MPN) OF ESCHERICHIA COLI (E. Coli)

Test Sample	Number of E. Coli per 100mL
S1	28
S2	0
S3	0
S4	0

4.2 DISCUSSIONS

The results obtained from the analysis of the physical parameters for S2, S3, and S4 showed that, the tested samples satisfied established set standard of the various organizations (WHO, NAFDAC, NPDWR, APHA). However, most of the violations in S1 were due to the exposed nature of the raw water sources to various human activities. Though, the little turbidity in S3 and S4 still fall within standards, it is attributed to the chlorine residual in the distributed water. Moreover, Khanna (1981), WHO (2004) and the Draft Guidelines for Drinking water Quality Management for New Zealand (2005) stated that Chlorine residual offers a lot of benefits to water in the distribution system.

The results of the chemical analysis indicated that, almost all the parameters tested for the various samples fall within set standards with little exceptions. The changing quality of water as it

starts from the raw water through the treated stage and finally to the consumers can be observed from the table 4.2. The pH value appears to be largely unchanged, having an average pH of 6.975. The observation shows that the number of hydrogen ions in solution is not significantly affected throughout the samples. Although, the slight increase in pH to 7.5 of the raw water was due to the exposure of the water which results in the absorption of carbon dioxide ($C0_2$).

WHO (2004) recommended an upper limit of 200ppm for sodium. The general concentration of sodium in the various samples ranges from 14 – 21ppm, averaging 8.75ppm, which is extremely low in comparison with, prescribed limit. Too little or excessive sodium is objectionable to most living things. The moderately high minerals contents especially of calcium and sodium along the distribution may be due to the absorption of such minerals from the distribution networks, while the increase in concentration of ion in the raw water could be caused by some industrial discharges (Sangodoyin et al; 1988). Another parameter used in assessing the quality of water is the potassium content. The drinking water from the public tap and the storage reservoir understandably contain very low levels of this element. Incidentally,

it can be observed that, slight levels of potassium were recorded in the raw water sources. Some of which have sometime been used for drinking in rural settlements without any treatment. Sangodoyin et al; (1988) have however observed that the levels, recorded (<30mg/l) present little or no immediate health problem for home use.

The mean levels of total hardness for all the samples are within the highest desirable levels for drinking water as recommended by NAFDAC (2001) and WHO (2004). However, high values are reflection of contaminations and pollutions by various human activities including laundry, bathing and defecation (Sangodoyin, et al; 1988).

Conductivity values are an indication of total dissolved salts content. Table 4.2 shows the progressive change in electrical conductivity of the various water samples. There has once been some concern about the elevated levels of electrical conductivity especially for water used in industry (Sarma and Swamy, 1981). The relative increase in electrical conductivity value from S1 – S4 is consistent with dissolved solid content (table 4.1).

The results of the bacteriological tests showed that, the sample from the raw water is contaminated or heavily polluted, which resulted in the high count E. coli per 100ml of water

sampled. The recorded value could be attributed to an excretal pollution of humans, animals or birds at the source of supply (Draft Guidelines for Drinking water Quality Management for New Zealand, 2005). Therefore, in accordance to the NAFDAC {2001} and WHO {2004}, the raw water is unsafe for human consumption.

S2 and S3 were free of Coliforms of any kinds confirming the safety of the treated water for human use.

However, S4 with leaks distribution line was observed to contain some Coliforms, but the confirmation test showed that, it is neither Escherichia coli (E. coli) nor faecal Coliform. This could be any of the nuisance organisms introduced into the water at the site of leaks.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Since all the various health agencies and organizations responsible for monitoring and controlling drinking water quality standards have generally specified that, water is safe for human uses, provided all the physical and chemical constituents are within the allowable concentration. And that testing for bacteriological quality in a specified manner does not reveal more than an average of one coliform organism per 100L of water sampled, it is therefore concluded that, the treated water from chanchaga water scheme is good for human consumptions having satisfied, all the criteria set by the various agencies and organizations (NAFDAC, 2001, WHO,2004 and Draft Guidelines for drinking water Quality Management for New Zealand, 2005).

5.2 RECOMMENDATIONS

- The continuous contamination of surface water by garbage, industrial waste dump and discharges and chemical infiltration, which are carelessly handled nationwide, must be controlled.

- People should be frequently informed through jingles and cinema shows of the health implications of defecating in or around the raw water source. However, close monitoring of all aspects of the raw water quality is required so that treatment processes can be adjusted in accordance with any variation detected. Because it is specific for enteric pollution, the feacal coliform test is preferred for assessing the microbial quality of raw water. The presence of faecal coliform organisms should be regarded as indicative of hazardous contamination.

- Distribution pipe of high quality should be used in the networking irrespective of the cost as this cannot be quantified to life that could be lost to disease outbreaks.

- Regular monitoring of the distribution networking should be undertaking to detect any broken pipes and effect repairs or installation immediately.

- If by chances, the raw water is found to contain more than ten (10) total coliforms or faecal coliform organisms per 100mL,

corrective measure should be taken immediately, in consultation with the local control agencies. The most common immediate actions include increasing chlorine dosage, flushing water mains, using alternative source of water and advising consumers to boil drinking water.

- In addition to this, free chlorine residual should be maintained throughout the distribution system. This is because maintenance and monitoring of chlorine residual offers two benefits. First, a trace of chlorine will suppress the growth of organisms within the system and may afford some protection against contamination from without; second, the disappearance of the residual provides an immediate indication of the entry of oxidize able matter into the system or of a malfunction of the treatment process.

APPENDIX A

LABORATORY METHOD OF WATER ANALYSIS

DETERMINATION OF TURBIDITY USING SPECTROPHOTOMETER

(a) The stored programme number for turbidity was entered.

750 READ/ENTER was pressed.

The display showed, DIAL nm to 450.

(b) The wavelength dial was rotated until the small display shows: 450nm.

(c) READ/ENTER was pressed. The display showed: FTU Turbidity 25ml of deionized water (the blank) was poured into a sample cell.

(d) The blank was placed into the cell holder. The light shield was closed. Zero was pressed.

(e) The display showed: WAIT.

(f) There after, O. Formazin Turbidity unit (FTU) was shown.

[g] 25ml of sample water to be determined was poured into another cell immediately. The sample cell was placed into the cell holder. The light shield was closed

[h] Read/ENTER was pressed

[i] The display showed: WAIT

[j] There after, the results in Forzmazin Turbidity unit (FUT) were displayed.

[k] When the displayed finally Stabilizes, the results were recorded.

[l] The above procedures were repeated for all the samples.

DETERMINATION OF COLOUR USING SPECTROPHOTOMETER

[1] The stored program number to determine the true colour was entered.

[2] 120 READ/Enter was pressed.

[3] The display showed: Dial nm to 455

[4] The wave length dial was rotated until the small display shows 455nm.

[5] READ/ENTER was pressed.

[6] The display shows: platinum cobalt (p_tCo)

[7] A sample cell (the blank) was filled with 25ml of deionized water.

[8] The blank was placed into water cell holder: The light sheield was closed.

[9] Zero was pressed.

[10] The display showed: WAIT.

[11] There after O. Unit P_t Co Colour was shown.

[12] The prepared sample of water to be determined was placed into the cell holder. The light shield was closed.

[13] READ/ENTER was pressed

[14] The display showed: WAIT

[15] There after, the results in plantinum-cobalt units were displayed.

[16] When the display finally stabilizes, the result was recorded.

[17] The above procedures were repeated for the other samples.

DETERMINATION OF IRON CONTENT USING SPECTROPHOTOMETER

[1] The stored program number for determines iron was entered.

[2] READ/Enter was pressed.

[3] The display showed: Dial nm to 510.

[4] The wavelength dial was rotated until the small display shows 510nm.

[5] READ/ENTER was pressed.

[6] The display shows mg/l fe

[7] A clean sample cell was filled with 25ml of sample water.

[8] The content of one ferrover iron regent powder pillow was added to the sample (the prepared sample). It was then swirled to mix. An orange colour indicates the presence of iron.

[9] There after, shift time was pressed: 3 minutes reaction period began. The cell was allowed to stand undisturbed.

[10] When the 3 minutes elapse, the timer beeps. The display showed: mg/l fe.

[11] Another sample cell was filled with 25ml of sample water (the blank).

[12] The blank was placed into the cell holder. The light shield was closed.

[13] Zero was pressed. And displayed showed: WAIT.

[14] Then 0.00 mg/l fe.

[15] After the timer beeped, the prepared sample was placed into the cell holder. The light shield was closed.

[16] READ/ENTER was pressed.

[17] The display showed: WAIT.

[18] There after, the result in mg/l iron was displayed.

[19] These procedures were repeated for the other samples.

DETERMINATION OF SODIUM AND POTASSIUM

1000ppm stock solutions of sodium (Na) and potassium (K) were prepared as described in the corning 410 flame photometer instruction manual and various dilutions made for the preparation of the calibration curves.

To obtain maximum linearity, corning recommends that the highest standard concentration does not exceed 30ppm for sodium (Na) and 10ppm for potassium (K). Both standard solutions for Na and K were aspirated starting with the highest concentration standard. The value of each standard was noted and the results plotted no a graph against standard concentration on linear graph paper.

The sample and the blank were also aspirated using a flame photometer with filters of sodium and potassium. The value of respective elements was evaluated by extrapolating from the standard graph (Appendices).

DETERMINATION OF TEMPERATURE USING CONDUCTIVITY METER

(a) Temperature/conductivity/T.D.S meter was switch on by pressing the appropriate button.

(b) The probe was immersed in the beaker containing the deionized water to rinse.

(c) The probe was immersed in the water beaker containing the water sample, and then moved up the down and taped on the beaker to free any bubbles from the electrode area. The probe was immersed beyond vent holes.

(d) The reading was recorded in degree Celsius (^{o}C).

DETERMINATION OF TOTAL DISSOLVED SOLIDS (TDS) USING CONDUCTIVITY METER

[a] The meter was switched on using the appropriate botton.

[b] The probe was immersed in a beaker containing the deionized water to rinse the probe.

[c] The probe was immersed in the beaker containing the sample. The probe was moved up and down and taped it on the beaker to free any bubbles from the electrode area. The probe was immersed beyond vent holes.

[d] The reading was recorded in milligram per litre (mg/l) or grams per litre.

DETERMINATION OF SUSPENDED SOLIDS USING SPECTROPHOTOMETER

(1) The stored program number was entered for suspended solids.

(2) 630 READ/Enter was pressed.

(3) The display showed: Dial nm to 810.

(4) The wavelength dail was trotated until the small display shows: 810nm.

(5) READ/Enter was Pressed.

(6) The display shows: Mg/l suspended solids.

(7) The sample cell with 25ml of deionized water (the blank) was filled.

(8) The blank was placed into the cell holder. The light was closed.

(9) Zero was pressed.

(10) The display shows: WAIT.

(11) There after, O.mg/l suspended solids was shown.

(12) The prepared sample cell was swirled to remove any gas bubbles and uniformly suspended residues.

(13) The prepared sample was placed into the cell holder. The light shield was closed.

(14) READ/ENTER was pressed.

(15) The display showed: WAIT.

(16) Thereafter, the result in mg/l suspended solids was displayed and read.

DETERMINATION OF ALKALINITY

100ml of the sample was selected and Tetra-oxosulphate (VI) acid (H_2 SO_4) Titration Cartridge corresponding to the expected alkalinity concentration in mg/l was chosen.

Clean delivery tube was inserted into titration cartridge. The cartridge was inserted into the titrator body.

Digital Titrator was held with the cartridge tip pointing up and the delivery knob was turned to eject air and few drops of titrant. The counter was reset to zero and the tip was wiped.

A graduated cylinder was used to measure the sample volume.

One phenolphthalein indicator powder pillow was added and swirled to mix.

The content were then titrated to a colourless and point with the tetraoxo sulphate (VI) acid (H_2SO_4). While titrating, the flask was swirled to mix. The digits were then recorded.

One Bromo cresol Green methyl Red indicator powder pillow was added to the contents and swirled to mix.

The titration was continued with tetra-oxosulphate (VI) (H_2SO_4) to a light greenish blue-grey, a light grey or a light pink colour as required.

Total digits required x Digit multiplier = mg/l total alkalinity.

DETERMINATION OF TOTAL HARDNESS, MAGNESIUM AND CALCIUM

(a) 100ml of water sample was poured in a 100ml graduated mixing cylinder.

(b) 1.0ml of Calcium and magnesium indicator solutions using a 1.0ml- measuring dropper was added. It was inserted several times to mix.

(c) 25ml of solution was purred into each of the sample cells.

(d) One drop of 1 MEDTA solutions was added to one cell (cell blank). It was swirled to mix.

(e) One drop of EGTA solution was added to another cell (the prepared sample) and swirled to mix.

(f) A stored program. Number for magnesium was entered.

(g) 225 READ/Enter was pressed. For units of mg/l mg as $mgC0_3$.

(h) This display showed: DIAL nm to 522,

(i) The wavelength dial was rotated until the small display shows: 522nm.

(j) READ/ENTER was pressed.

(k) The blank was placed into the cell holder. The light shield was closed zero was pressed.

(l) The display showed: WAIT thereafter 0.00mg/l $CaCO_3$ mg

The prepared sample was placed into the cell holder

The light shield was closed.

(m) READ/ENTRE was pressed.

(n) The display showed: WAIT.

(o) Thereafter, the result in mg/l as $CaCo_3$ was recorded.

(p) CONFIG/METH was pressed two times.

(q) A stored programm number for calcium was entered.

(r) 220 READ/ENTER for units of mg/l Ca as $CaCo_3$ was pressed.

(s) The display showed: DIAL nm to 522.

(t) READ/ENTER was pressed the display shows: mg/l CaCo.

(u) zero was pressed.

(v) The display showed: WAIT place the third sample cell intc the cell holder.

(w) READ/ENTER was pressed.

(x) The display showed: WAIT therefore, the result in mg/l as $CaCo_3$ was displayed.

However, it is worthy of note that mg/l hardness equal mg/l ca as $CaCo_3$ plus mg/l mg as $mgCo_3$.

The conversion factors for determination of the total hardiness are shown in the table below.

APPENDIX B CONVERSION FACTORS FROM TOTAL HARDINESS DETERMINATION

To convert From		to	Multiply by
Mg/l	Ca as $CaCo_3$	mg/l Ca	0.400
Mg/l	mg as $CaCo_3$	mg/l $mgCo_3$	0.842
Mg/l	$MgCO_3$	mg/l Mg	0.29
Mg/l	Mg as $CaCo_3$	mg/l mg	0.243

APPENDIX C:- SUMMARY OF ACCEPTABLE QUALITY STANDARD TO MAKE A WATER SAMPLE USEFUL FOR HUMAN USE.

Table 1:

S/No	Parameters	Maximum Acceptable Concentration WHO	Maximum Allowable Concentration (NAFDAC)	Maximum Concentration Level NPDWR
	Physical			
	Turbidity unit	5(NTU)	-	5NTU
	odour	unobjectionable	unobjectionable	unobjectionable
	Taste	unobjectionable	unobjectionable	Tasteless
	Temperature	29^{0}C	26-30^{0}C	30^{0}C
	ORGANIC Constituents			
	pH	7.0 – 8.5	6.5 –8.5	6.5 – 8.5
	Alkalinity	100mg/l	100mg/l	100mg/l
	Iron	0.05 – 0.3mg/l	-	0.3mg/l
	Calcium	75 – 300mg/l	75-150mg/l	75-150mg/l
	Chorine	200mg/l	200mg/l	200-250mg/l
	Fluorine	1.5mg/l	-	4.0mg/l
	Phosphate	10mg/l	10mg/l	10mg/l
	Total hardiness	75-150mg/l	75-150mg/l	60-120mg/l
	MICROBIOLO -GICAL STANDARDS			
	E.Coli/mg	No growth	O(Max)	5% Sample
	Bacteria	-	No growth	No growth

Source: NAFDAC 2001

Appendix 4.E Part of the world Health Organization Standard, for (2004)

S/No	Substances or Characteristics	Unit	Symbol	Guideline Value
1.	Chromium	mg/l	Cr	0.1
2	Lead	mg/l	Pb	0
3.	Nickel	mg/l	Ni	N/A
4.	Nitrates	mg/l	NO_3	10
5.	Calcium	mg/l	Ca	N/A
6.	Chloride	mg/l	CL	250
7.	Copper	mg/l	CU	1.0
8.	Iron	mg/l	Fe	0.3
9.	Magnesium	mg/l	Mg	30
10.	Nitrite	mg/l	No_2	1
11.	Potassium	mg/l	K	N/A
12.	Sodium	mg/l	Na	200
13.	Sulphate	mg/l	SO_4	250
14.	Total dissolved solids	mg/l		500
15.	Conductivity	us/cm		N/A
16.	Total hardness as $caco_3$	mg/l		500
17.	Colour	P_tC_o		15
18.	Odour			Inoffensive
19.	Taste			Inoffensive
20.	Suspendul solids	mg/l		N/A
21.	Turbidity	FTU		5
22.	P^H			6.5-8.5
23.	Zinc	mg/l	Zn	5
24.	Biochemical Oxygen demand	mg/l	BOD	0
25.	Dissolved oxygen	mg/l	DO	5
26.	Chemical oxygen	mg/l	COD	N/A

N/A= Not Available.
FTU= Formazin Turbidity Unit
P_tC_o = Platinum Cobolt

Appendix 4.D World Health Organization Standards for (1983)

S/No	Substances or Characteristics	Unit	Symbol	Guideline Value
1.	Chromium	mg/l	Cr	0.05
2	Lead	mg/l	Pb	0.05
3.	Nickel	mg/l	Ni	0.001
4.	Nitrates	mg/l	NO_3	10asN
5.	Calcium	mg/l	Ca	N/A
6.	Chloride	mg/l	CL	250
7.	Copper	mg/l	CU	0.05
8.	Iron	mg/l	Fe	0.30
9.	Magnesium	mg/l	Mg	30
10.	Nitrite	mg/l	No_2	1
11.	Potassium	mg/l	K	N/A
12.	Sodium	mg/l	Na	200
13.	Sulphate	mg/l	SO_4	400
14.	Total dissolved solids	mg/l		1000
15.	Conductivity	mg/l		N/A
16.	Total hardness as $caco_3$	mg/l		500
17.	Colour	P_tC_o		15
18.	Odour			Inoffensive
19.	Taste			Inoffensive
20.	Suspendul solids	mg/l		N/A
21.	Turbidity	FTU		5
22.	P^H			8.5
23.	Zinc	mg/l		N/A

N/A= Not Available.
FTU= Formazin Turbidity Unit
P_tC_o = Platinum Cobolt

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