A COMPARATIVE ANALYSIS OF BACTERIOLOGICAL QUALITY OF WATER SUPPLY SOURCES AND HEALTH PROFILE OF THE RESIDENTS OF KONGO CAMPUS, AHMADU BELLO UNIVERSITY, ZARIA.

BY

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DECLARATION

I hereby declare that this thesis has been written by me and it is a record of my research work carried out under the supervision of DR. E.S. ESSIEN. It has not been presented in any previous application for higher degree. The work of other investigators are acknowledged and referred to accordingly.

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CERTIFICATION

This thesis entitled "A comparative analysis of bacteriological quality of water supply sources and health profile of the residents of Kongo campus, Ahmadu Bello University, Zaria by Akim Abdul Yussuff, meets the regulations governing the award of the degree of masters of public Health of Ahmadu Bello University, Zaria and is approved for its contribution to science and literary presentation

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ABSTRACT

A Comparative analysis of the bacteriological quality of water supply sources and heath profile of the residents of Kongo Campus, Ahmadu Bello University was carried out. The study involved the determination of the faecal coliform count and residual chlorine concentrations of water samples in accordance with the steps laid down in Standard Methods (APHA 1990).

It also involved the determination of the incidence of diarrhoeal diseases among water consumers using the medical records of patients attending the school clinic and with the use of questionnaires administered on 300 respondents randomly selected from among staff and students using stratified sampling technique.

Generally, the result showed that all the water samples were heavily contaminated. A minimum coliform count of $1x10^2$ was determined for tap water at the treatment site and the maximum count of $8x10^2$ was recorded at a distance of 2km from the treatment site. None of the water supply sources (well, tap water, and bore hole) available to the residents meets the standard set by World Health organisation (WHO) for drinking water which states that "Drinking water must be free from microbial contamination and the coliform count must be zero or less than I per l00mls of treated water" (WHO 1972).

The high coliform counts of tap water samples may have resulted from the inadequate treatment of water observed at the treatment plant and the possibility of additional pollution within the distribution system. It was observed that the heavy contamination of well water supplies are likely due to improper construction and poor protection of the wells. In addition, the poor drainage and waste disposal pattern of the

campus which frequently leads to flooding during rainy season may have contributed to well water contamination from sewage and animal wastes.

The findings also revealed that the residual chlorine levels diminishes as water flows away from the treatment plant with a corresponding increase in faecal coliform counts. Hence the residual chlorine concentrations persistently failed to meet the standard requirement of l.0mg/L at the treatment plant and 0.2mg/L in the distribution system (Freedmen 1977). These finding compare well with previously published Data (Buelow and Walton, 1970, White, 1975, Yusuf, 1983).

A high incidence of diarrhoeal diseases was observed in the study especially during the months of July and August at the peak of rainy season with majority (61.4%) occurring in children under 3 years of age. Only 4 % of the respondents, were found to be treating their water before consumption despite the fact that a significant proportion (58 or 19%) of these respondents source water from both wells and tap. The importance of water availability as the most important factor in the control of morbidity and mortality from diarrhoeal diseases has been highlighted in other studies (Watt et al, 1966, WHO, 1969, Osuhoretal, 1978, Essien, 1980, WHO,1987).

The X^2 test done to determine whether there is a significant relationship between the incidence of diarrhoea diseases and the type of water sources used for drinking purposes revealed a strong association between water pollution and diarrhoeal diseases. This finding is similar to previously published work in which socio-demographic factors including the quality of water supplies and availability of good latrines were found to be associated with the incidence of diarrhoeal diseases in developing countries (Essien 1980; Stanton and Clemens 1987; Young and Brisco 1988).

Education and health messages were also recommended for the improvement of available water supply sources.

TABLE OF CONTENTS

	Page
Title page	i
Declaration	ii
Certification	iii
Dedication	iv
Acknowledgment	v
Abstract	vi
Table of Contents	viii
List of Tables	x
List of Appendices	xi
Abbreviations	xii
Chapter One –Introduction	
1.1 Introduction	1
1.2 Definition of Safe or Potable Water	2
1.3 Drinking Water Quality and Sanitation	2
1.4 Problems of Water Supply in Kongo Campus	3
1.5 Justification for the Study	5
1.6 Study objectives	6
Chapter Two-Literature Review	
2.1 Water Supply Sources	7
2.2 Sources of Water Pollution	8
2.3 Public Health Importance of Water Pollution	9
2.4 Drinking Water Quality and Standards	12
2.5 Water Testing and Purification	12
2.6 Membrane Filtration Method	13
2.7 Most Probable Number Method	14
2.8 Purification of Water	14
Chapter Three- Materials and Method	
3.1 Back Ground information to the Study	16
3.2 Methodology	17
3.2.1 Sample Size and Sampling Sites	17
3.2.2 Sampling Technique	17
3.2.3 Residual Chlorine Determination	18
3.2.4 Bacteriological Analysis	18
3.2.5 Data on the incidence of Diarrhoeal Diseases among Residents	19
3.3 Data Analysis	20
3.4 Limitations of the Study	20

Chapter Four –Result s

4.1 Bacteriological Analysis of Water Samples 22
4.2 Residual Chlorine Concentration 23
4.3 Diarrhoeal Diseases Among Residents 24

Chapter Five-Discussion

5.1 Discussion 27
5.2 Recommendation and Health Education Messages 29
References 31
Appendices. 34

LIST OF TABLES

TABLE		PAGE
1.	Faecal coliform counts of well and tap water samples from different sampling sites	23
2.	Faecal coliform counts of bore hole and tap water samples with their corresponding residual chlorine estimation	23
3.	Incidence of diarrhoeal diseases among residents of Kongo Campus, Ahmadu Bello University, Zaria.	24
4.	Age and Sex Distribution of Diarrhoeal diseases among residents of Kongo Campus.	25
5.	Type of treatment given to water sources before consumption	25
6.	2 x 2 contingency table showing the relationship between sources of drinking water and incidence of diarrhoeal diseases	26

LIST OF APPENDICES

		PAGE
1.	Sampling sites and their distance in km from the water treatment plant.	34
2.	Questionnaire on drinking water supply sources and diarrhoeal diseases	35
3.	A sketch map of the campus showing the various sampling sites.	36

ABBREVIATIONS

Abbreviation	Full Meaning
APHA	American Public Health Association
BSC	Bachelor of Science
°C	Degree Centigrade
et al	and others
KM.	Kilometer
MF	membrane Filtration
Mg/L	Milligram per liter
MM	Millimeter
MPN	Most Probably number
-um	Micro Meter
UNDP	United Nation Development Programme
WHO	World Health Organisation
X^2	Chi- Square

CHAPTER ONE

1.1 *INTRODUCTION*

Water is one of the most abundant commodities in the planet earth occupying 70% of the earth's surface. It is indispensable for the survival of man and all living things on earth. It constitutes 90% of the plasma, 80% of muscles and over half of both plants and animal tissues. Water is in fact indispensable for normal physiological functioning of all living things including man (Essien, 2000).

The World Health Organisation (WHO, 1984) estimate a minimum water requirement of a male individual per day to be 35 to 50 liters for rural areas to maintain good health. Water is also known to have so many uses in man's activities. This includes drinking, laundry, bathing, fire protection, recreational purposes like swimming, gardening, hydroelectric power generation and industrial use like in refining industries. It is also an important carrier of both domestic and industrial wastes, a source of food for animal life such as fish that inhabits water bodies like streams, lakes, rivers, seas and ocean. Water is also the most efficient universal solvent and it is a natural habitat for a wide variety of microscopic organisms including viruses, bacteria, protozoa, algae, helminthes and fungi etc. This has therefore created a serious problem for man as far as availability and potability of water is concerned. It is in realization of this important function of water that the United Nations (UN) set a decade (1981-1990) for potable water and sanitation to be made available for all human populace. The target for Nigeria was to make water available to 75.4 million Nigerians, while 83.8million Nigerians were targeted to get access to good sanitation. Thus for the usefulness of water to be fully exploited, it must be available, adequate and safe. If inadequate and unsafe, water can cause a lot of

health problems. For instance, in less developed countries, 80% of ill health result from lack of safe and inadequate water supplies (Essien, 2000).

1.2 *WHAT IS SAFE OR POTABLE WATER?*

Safe water is that which is wholesome and not prejudicial to health, safe water is also free from microbial or disease-producing contaminants, mostly from faecal matter. It should also not have chemical concentrations greater than the permissible level and should be available in sufficient quantities for human and animal use. It should also meet the local standards for taste, odour and appearance. Microbial contamination is the most common reason for water to be deemed unsafe as it is considered foreign to the water. Detection is usually by testing for indicator bacteria such as Faecal Coliform (WHO, 1972). WHO standard guidelines for pipe borne water are strict and usually state that 100mls of water should be completely free of faecal coliforms (WHO, 1984). The standards for unprotected water supplies in rural and suburban areas is less clear and requires judgement and common sense. WHO guidelines (1984) stated that unprotected water supplies should not contain more than 10 faecal coliforms per 100mls. Unfortunately, most Nigerians especially those in rural areas drink water with over 1000 faecal coliform load per 100mls of water (Essien, 2000).

1.3 *DRINKING WATER QUALITY AND SANITATION*

As mentioned, water is essential to sustain life as it is in use everyday. But reasonable access to safe water is still a problem for the vast majority of rural and suburban populations of Nigeria who are forsaken. The importance of water as a vehicle for the spread of disease has long been recognized. In fact the adverse effect of poor water supplies for human use is clearly demonstrated by the fact that most of the illnesses and their debilitating effects occur in developing countries where water supply and sanitation

are deficient. This includes infectious diseases caused by viruses, bacteria, protozoa and helminthes. The prevention of any of these communicable diseases therefore, requires that the cycle of disease transmission be broken.

Depending on the principal transmission route, different interventions in water supply and sanitation may be required. Bacterial and viral diarrhoeal diseases and epidemics of cholera and typhoid are frequently transmitted primarily via drinking water, thus making the quality of drinking water a crucial health factor. However, improvement in personal and domestic hygiene can, of course, often be even more important in halting the spread of pathogens and diseases (WHO, 1985).

1.4 *PROBLEMS OF WATER SUPPLY IN KONGO CAMPUS*

The Institute of Administration, Ahmadu Bello University Zaria, houses the faculties of Administration and Law. The campus also provides accommodation, for the center for Islamic legal studies, Local Government studies and the A. B. U. staff school. It houses about a third of the over 25,000 students and 10,000 staff population of the University and their dependants. The campus is located in the suburb of Tundunwada, a distinct settlement which constitutes one of the wards in Zaria local government area of Kaduna state. The area is a slum surrounded by squatter apartments mostly of mud houses and enclosed compounds. The surface drainage pattern is poor and this flows towards a large stream that cuts through the campus often resulting in flooding of the entire campus. Many farms and gardens are also found within and around the vicinity of the campus.

Water supply in the area is limited to a few shallow wells, 5 to 12 meters deep and erratic water supply through the public taps from Zaria water works. This has resulted in the high incidence of typhoid fever and cholera outbreaks, the origin which seem to lie in contaminated food and water supplies and unsanitary manner of refuse disposal system in the community.

Because of the increasing scarcity of water supplies in the campus, the demand for water became persistent. To solve the problem, the management of the university embarked on construction of wells in strategic locations around the academic and hostel environment. A bore- hole was also constructed and linked to the pipe system. However, the major danger associated with some of these sources of water is the possibility of its contamination by sewage or human and animal wastes. In such a situation, cases of carriers of infectious diseases such as typhoid, cholera, dysentry and amoebiasis coming in contact with the water sources may result in further spread of the disease.

1.5 *JUSTIFICATION FOR THE STUDY*

Potable water has become a critical National problem in Nigeria and this has been a matter of special concern to individuals, families, communities and government. In view of the importance of water as an essential necessity for life and the desire to ensure its safety for human consumption, it is necessary to test the sanitary quality of all water sources and supplies before human consumption. To achieve this, a quality control laboratory is usually required. Such facilities are in most cases non existent in rural and many urban communities of developing countries. This study, therefore, seeks to carry out a comparative analysis of the sanitary quality of water supply sources in Kongo campus of Ahmadu Bello University, Zaria. It will provide a base line data, which could be used for subsequent surveillance and monitoring of these water sources against potentially hazardous situations or faecal contamination. It is, also, hoped that the findings of the study will assist in providing basis for water hygiene awareness campaigns among the community.

1.6 *STUDY OBJECTIVES*

The general objective of this study is to assess the quality of water supply sources in the campus and to compare the findings with the incidence of diarrhoeal diseases among water consumers. The specific objective therefore includes, To:

(1) Conduct on site level of residual chlorine to assess the quality of treatment given to various water supplies sources in the campus.

(2) Test the various water supply sources in use for the presence or absence of faecal Coliform bacteria.

(3) Compare the level of faecal coliform contamination of the water sources with the level of health in terms of the incidence of diarrhoeal diseases among water consumers in the campus.

(4) Prepare education and health messages to sensitize water consumers in the campus on the importance of consuming safe and unpolluted water.

CHAPTER TWO

LITERATURE REVIEW

2.1 *WATER SUPPLY SOURCES*

Water is essential for life and human communities must have some kind of water source. It may be dirty, it may be inadequate in volume and it may be several hours' walk away but, nevertheless, some water must be available.

A suitable source of water should provide the resource that is adequate, safe and acceptable. A minimum of 20 to 40 liters per person per day is required. The requirement is much higher in modern industrial urban areas (120 to 500 liters per person per day).

The World Health Organization's figures for 1988 showed that among the urban population of the developing countries, only about 65% have house connections and an additional 20% have access to public taps; about a half of these supplies are intermittent. Of the rural population, only about 60% have access to safe water, and few of these have house connections (WHO, 1988).

Generally speaking, life in rural and sub urban environment of developing countries is substandard and sympathetic. Thus, 73% of the villages in the Savannah zone of Nigeria suffer from water related diseases. The people living in these rural areas have many sources of water supply. This includes rain, surface waters like flowing streams, rivers, ponds and lakes, and underground water such as deep wells, bore holes and springs, while in urban areas, a convenient, high quality and reliable pipe borne water supply are being enjoyed. These traditional water supply sources fill up during the wet season but dry up during the dry season lasting more than 6 months. (Akintola et al., 1979). Invariably, the rural people are aware of the danger of drinking unsafe water. The saying that "the dirt of water cannot kill" is just a consolatory message since they usually consider water

quantity before deciding on its safety and acceptability when there is very little they can do to improve their water quality (Akintola et al., 1979).

2.2 *SOURCES OF WATER POLLUTION*

Pollution of water arises from any activity of man such as discharge of domestic sewerage, waste water from industrial and agricultural processes that makes water unsuitable for any purpose for which it was suitable in its natural condition (WHO, 1968). Pollution of water is a natural problem that concerns people all over the world. The problem has deep roots and complex ramifications. It arises from population growth, economic prosperity, and a tradition of free and virtually unregulated use of water and waste disposal. Water can be classified as potable, contaminated and polluted.

Potable water is that which is free of microbial and other injurious agents. It is pleasing in taste, odour and appearance. Contaminated water is that which contains dangerous microorganisms and chemical agents, though it may or may not have a pleasing taste, odour and appearance. Polluted water is one of unpleasant appearance, taste and odour. It may or may not contain dangerous microorganisms and chemical agents. Because of its contents, it is unclear and unsafe for human use (Smith, 1969).

Generally, water supply contamination can occur at various points in the water supply system including streams, channels, wells, springs, water treatment plants, storage reservoir, distribution systems and public stand points (WHO,1975). Although ground water such as those obtained from deep wells are said to be protected from bacterial contamination by impervious strata and therefore do not need disinfection, such protection depends on the geological nature of the strata. In shallow wells this protection is usually not adequate. However, ground water is becoming increasingly contaminated and the resulting hazard requires special surveillance. The high frequency of contamination is believed to be mostly due to shallow, uncovered and proximity of wells to latrines and

other waste disposal sites which are mostly found in rural and suburban areas (WHO, 1975).

The most common sources of contamination of well water are soil, improper construction and improper use of wells. In case of tap water, it is usually from improper treatment, contamination along the service line and unhygienic storage facilities. The soil is also known to harbor such organisms as Clostridium perfringes, Pseudomonas auriginosa and many other non-enteric coliforms (Faechem and Mara, 1974). During rainfall and domestic washings done around the wells, these organisms are drained into the well. In such area like the study area where most of the wells are shallow, there is a greater chance of contamination of ground water with bacteria resulting from seepage (WHO, 1969; Akintola et al., 1979).

Other factors that may contribute to poor water quality includes lack of automated chlorination equipment or an insufficient supply to maintain an acceptable level of residual chlorine in the inlet and outlet points of the distribution system. Improper chlorination allows microbes to multiply in the water-soluble nutrients (Seidler et al., 1979). Contamination of water treatment plants by infected operators and pollution arising from defective systems is also possible. As no water distribution system is leak proof, the risk of contamination is always present particularly where the supply is intermittent or the system is operated at low pressure (Helmer, 1975). Further more, the presence of human dwellings within water sources can be a source of hazard. Defective latrines, septic tank discharges, manure piles, indiscriminate and unsanitary disposal of excreta may be responsible for extensive water pollution (Helmer, 1975).

2.3 *PUBLIC HEALTH IMPORTANCE OF WATER POLLUTION*

Water is the most universally used single solvent and the commonest route of transmitting diseases. Water pollution can affect adversely every use of water such as

public supply, industrial use, the production of fish and other aquatic products, irrigation, stock watering, transport, recreational activities and amenity. The water borne microorganisms comprises bacteria, viruses, fungi, molds and protozoa. Most of the organisms are pathogenic and their presence in water indicates that the water has been contaminated (Green et al, 1971). At present, the majority of the population in developing countries rely on untreated ground and surface waters for drinking and other purposes, a situation aggravated by high population growth rates, which result in rapidly increasing demands for water supplies and accelerated generation of wastes and waste waters. Only substantial efforts in the field of wastewater treatment can, therefore, prevent an increasing health hazard from biological contaminants discharged into natural water sources.

The valuable lesson to be learned from the experience of the highly industrialized countries where water pollution problems are most acute is that the water economy of a country must be planned and pollution control measures implemented as early as possible in the process of urbanization and industrialization. (WHO, 1975).

Man's health may be affected by the ingestion of contaminated water, either directly through food or by the use of contaminated water for purposes of personal hygiene and recreation. Health hazards are also associated with various industrial and agricultural applications (WHO, 1975).

Water plays a predominant role in the transmission of certain bacterial infections such as typhoid and paratyphoid fevers, bacillary dysentery, cholera, gastroenteritis, infantile diarrhoea, leptospiroses and tularaemia (Holmer, 1975;WHO, 1975). Water has an indirect role in the transmission of such diseases like malaria, filariasis, and several other vector borne infections. Water polluted by virus of infective hepatitis has also been shown to be responsible for a major epidemic of 29,000 cases in India (WHO, 1966). The importance of availability of water in the control of diarrhea diseases has also been

highlighted by several investigators (Wagner, Lenoix 1969; WHO, 1969; WHO, 1987). Watt et al, (1966) indicates that water availability may be the most important environmental factor in areas where the risk of death from diarrhoeal diseases is high. Mollister and his colleagues (1968) working in Fresno county, California, USA also, demonstrated the significant increase in shigellosis as a result of the increasing demand for potable water supply which resulted in the growing use of ground water along with other sources (Sandhu, et al, 1979). Polluted waters may also be the cause of non-infectious diseases since they may contain toxic materials from domestic, agricultural and or industrial water (WHO, 1966, WHO, 1968). Gastroenteritis which is spread by faeco-oral route has also been reported as one of the most commonest conditions seen in the children's unit of Ahmadu Bello University Teaching Hospital, Zaria with the highest incidence occurring in the months of May, June and July at the peak of rainy season (Osuhor et al., 1978).

Water related diseases are broadly classified into five epidemiological groups. These includes:

1. Water borne infections such as cholera, typhoid and infective hepatitis.
2. Water shortage or water washed diseases like trachoma and skin infections
3. Water impounding or water-based diseases like schistosomiasis and guinea worm infection
4. Water arthropod or water-related diseases such as malaria, yellow fever and onchocerciasis whose vectors breed in water.
5. Chemical constituents, either in excess or shortage e.g. fluoride causing diseases like dental fluorosis or cares respectively.

2.4 *DRINKING WATER QUALITY AND STANDARDS*

Drinking water must not contain any impurity that would offend sight, taste or smell, microorganisms and substances that would have hazardous effect on health. Maximum contaminant levels are set in drinking water to prevent health problems caused by high concentrations of various contaminants. The presence of microbiological contaminant is used to indicate the possible presence of pollution. In treated water after analysis, none of the samples should have a coliform count index in excess of 2. In the untreated water, none of the samples should have an index greater than 10. For both treated and untreated water, E. coli should be absent and pathogenic organisms such as Salmonella, Shigella, Vibrio and Loptospira should be absent (Sloat and Ziel, 1991).

Improving water quality can markedly reduce the incidence of diseases such as typhoid, dysentery and drancunculiasis (UNDP, 1988). According to WHO, guidelines for drinking water quality, maintaining quality involves care, not only in the selection and protection of the source and where necessary, of treatment methods, but also in ways in which the water is collected at the source and then transported to and stored in the home (WHO, 1987).

2.5 *WATER TESTING AND PURIFICATION*

The objective of bacteriological testing of water is to detect and determine the concentrations of faecal bacteria in water supplies in order to establish the safety of the water before drinking and to assess the level of faecal pollution of water supplies. Contamination control is achieved if the microbial load does not exceed the level established as the lowest acceptable limits. This is because it is quite difficult to achieve a total elimination of all viable microorganisms since the microorganisms population are simultaneously and continuously undergoing the processes of multiplication and death

(Runkle and Phillips, 1969). The most useful indicator organisms for surveillance of bacteriological water quality are members of the faecal coliform group.

All organisms of the coliform group are foreign to water and must be regarded as indicative of pollution. The coliform group includes numerous microorganisms of different biochemical and serological characteristics with the development of indole, methyl red, voges –proskauer and citrate tests as the combination of biochemical reaction that would best separate coliform strains of both faecal and non faecal sources (Ralph 1972).

The presence of few coliforms in a water source has no special significance but the detection of faecal coliform in a number of 1ml sample is an indication that recent sewerage pollution of the water might have occurred. Further testing would therefore determine whether the coliform is of faecal origin or not (Walker, 1978). Members of the faecal coliform group are therefore the most useful indicator organism for surveillance of bacteriological water quality. There are two main methods used to detect and measure indicator bacteria in water. The membrane filtration method and the most probable number multiple tube method (APHA, 1990).

2.6 *MEMBRANE FILTRTION METHOD*

This procedure involves filtering a measured volume of sample (100ml), or an appropriate dilution of it through a membrane filter which has a pore size of 0.45-um. Microorganisms are retained on the surface of the filter which is then placed on an absorbent pad soaked in a suitable selective growth medium (containing lactose) in a glass, plastic or metal petri-dish. It is then incubated at 44°C for faecal coliform detection. Any bacteria able to grow will multiply to form visible colonies on the membrane filter surface. The number of colonies counted is expressed in terms of the number present per 100ml of original undiluted sample.

2.7 *MOST PROBABLE NUMBER MULTIPLE-TUBE METHOD*

This method involves adding measured volume of sample to sets of sterile tubes or bottles containing suitable liquid culture medium. Faecal coliform organisms produce acid and gas when incubated at 44°C. The gas production is detected by its appearance in a small 30mm inverted glass test tube (Durham tube) inserted into the tube or bottle before sterilization. The number of tubes, showing positive reactions is recorded at the end of the incubation period. All estimate of the most probable number (MPN) of organisms present in the original sample is obtained from statistical tables. A range of different dilution is used to ensure that both positive and negative reactions are obtained. (APHA, 1990).

2.8 *PURIFICATION OF WATER*

Purification of water is very important as it removes all injurious substances and microorganisms from water. Purification of water takes place naturally or can occur artificially. Natural purification takes place as water trickles through the earth. During this process, microbes are filtered out as seen in well water especially the concrete ones.

Purification of water can be achieved by a combination of some of the following measures. Protection from human and animal pollution, proper storage, coagulation and sedimentation using alum to remove pollutants more rapidly, and filtration using thick linen cloth, sand filter, candle filter to remove bacteria and protozoa except viruses. Purification can also be achieved by disinfection and boiling, being a simple and reliable method of eliminating pathogens for individual households. Chemical disinfection of water first started with the use of chlorine for the control of odours. This dates back to 1854 when it was used to decolorize the London wastewater (White, 1973). The existence of even a trace of chlorine residual, regardless of the form, drastically reduces or eliminates total coliforms from the distribution system. Chlorine is quite potent and has a

wide range of effectiveness as a germicide. It is easy to handle, apply, measure and control. Most importantly, it can be applied to effect a predictable persisting residual over long distances and extended periods of time (White,1973). Chlorine residual measurements are made to determine the efficiency of disinfection. It has been established that chlorine demand of waters is highly variable. It has also been recognized that satisfactory chlorination could be obtained not by applying a specific dosage but on the basis of the residual maintained (Fabre, 1974).

CHAPTER THREE

3.1 *BACKGROUND INFORMATION TO THE STUDY*

The Institute of Administration, Ahmadu Bello University, Zaria is located in the suburb of Tundunwada in Zaria Local Government area of Kaduna State. Geographically, this is in the guinea Savannah zone of Nigeria. Annual rainfall ranges from 870mm to 110mm spreading over the period of April to September with peak periods of rainfall occurring in July and August. The campus consists of academic and residential areas. The academic area where this study was conducted spans over a space of about 500 square meters. It houses the Faculties of Law and Administration, the administrative block, the clinic and staff school, the old admin quadrangle and six hostels blocks which provide accommodation for the students.

Water supply to the campus has been a problem and it has also remain a scarce commodity generally in Zaria especially during the dry season. This is as a result of population explosion and Government's inability to maintain and upgrade the existing water treatment plants in the water works resulting in frequent break downs. The sources of water supply to Kongo campus community include, rain water and pipe borne water supply from Zaria water works which is about 2 km from the campus. To augment this supply, ten shallow wells of about 5-12 meters deep were dug at strategic points in each of the academic and hostel environment to serve as alternative source of water to the students during scarcity. Each of the hostels has a well and students sometimes drink water from them when the tap stops running especially during power failures. A bore hole was also sunk in April 2000 and connected to the piped system to serve as alternative source of water supply during scarcities. However, high incidence of typhoid fever, gastroenteritis and diarrhoeal diseases are still commonly seen in the student's clinic. The drainage and

waste disposal pattern are also quite poor with frequent flooding of the entire campus during heavy rains. Hence the possibility of contamination of well water sources by sewage or human and animal wastes. This study, therefore, is a cross sectional study of the bacteriological quality of the various water supply sources to the campus. An attempt was also made to compare the findings with the level of health of water consumers in terms of the absence or presence of diarrhoeal diseases among the residents.

3.2 *METHODOLOGY*

3.2.1 *SAMPLE SIZE AND SAMPLING SITES.*

This consists of all water samples from the different sources and at various collection sites. This includes samples from the treatment site at the Zaria water works and at a point midway between the water works and the campus. Tap and well water samples were also taken from each of the five academic areas, the six hostel blocks and the bore hole. They were collected and analyzed for their residual chlorine level and the faecal coliform counts.

3.2.2 *SAMPLING TECHNIQUE*

The samples for bacteriological analysis were collected in 250ml sterile screw –capped bottles containing 0.2ml of 1.8% Solution of Sodium thiosulphate to neutralize the bactericidal effect of any chlorine residue in the water. Samples for chlorine residue measurement were collected in separate bottles.

Prior to collection of the samples, the tap water was allowed to flow for about 3 to 5 minutes to flush the Service line. The pipe flow was then reduced to avoid splashing of the bottle mouth while collecting the water. Samples were transported to the laboratory in

ice packs and analysis was carried out under one hour. Care was taken to avoid contamination. (Yusuf 1983).

To collect well water samples, a string was tied round the neck of the bottle and a weight attached to it. This was then gently lowered till sufficient quantity was collected. Care was taken to avoid touching the walls or collecting samples near the walls of the wells. All samples were accompanied with such data as number of sample, location, and in case of wells, nature, and possible pollution sources. (Umoh, 1976).

3.2.3 *RESIDUAL CHLORINE DETERMINATION*

The residual chlorine measurement was determined by the ortholidine method. Thus, 10ml of water Sample was added to each of the two comparator tubes. In one tube 0.1ml ortholidine was added and mixed thoroughly and this tube was placed on the right hole of the Lovibond comparator, while the other tube and colour development was also compared with standard chlorine colour disk and the reading was recorded.

3.2.4 *BACTERIOLOGICAL ANALYSIS*

All conical flasks, test tubes and pipettes were sterilized in an autoclave at 121°C for 25-30mins before use. Then 0.1ml of sodium thiosulphate was introduced into all the conical flasks and autoclaved together before use so as to neutralize any residue.

All media were prepared strictly according to the manufacturer's instructions. They were prepared, and sterility checked by incubating at 37°C for 24hrs in an incubator and then stored at refrigerator temperature until they were used.

The method adopted for determining the faecal coliform were in accordance with those laid down in Standard Methods (APHA, 1990). The membrane filtration technique was used to determine the faecal bacteria densities. Any microbiological water analysis

consisting of presumptive test, a confirmatory test, and or completed test is regarded as standard by Edberg et al., (1986).

Each bottle was labeled with the sample code number and the sample of water mixed thoroughly by inverting the bottle several times. The pore sizes of the membrane filters used were 0.45-um. Thus, 100mls of each of the water sample were filtered and the membrane filters were aseptically carried and placed on well dried M-Endo agar plates and incubated at 37°C for 24hrs as presumptive test for the presence of coliforms organisms by membrane filtration (MF) method. After the incubation period, typical colonies of coliform organisms (Lactose Fermenting organisms) that appeared red with golden green metallic sheen on the membranes were counted and inoculated into tubes of brilliant green lactose bile broth with durham's tubes and incubated at 37°C for 24 to 48hrs for the confirmatory test. Typical colonies counted were taken as colonies counted per 100mls of sample.

3.2.5 *DATA COLLECTION ON THE INCIDENCE OF DIARRHOEA DISEASES AMONG RESIDENTS*

This consist of two different approaches. First, a secondary data of the incidence of diarrhoea diseases among water consumers in Kongo campus was computed from the medical records of patients attending the school clinic from January to December 1999. All cases of diarrhoeal diseases seen within this period were included in the study using the medical records of the patients to extract relevant information.

The primary data involved the investigation of students and staff by sample survey. Considering the time and resources available for the study, it was virtually impossible to draw a sample frame of all the staff and students resident in the campus for the calculation of the sample size. In commensurate with my resources and capability I decided to select 60 out of 1,196 staff and 240 out of 4,780 students using a stratified sampling scheme.

They were interviewed with the use of a questionnaire to determine the type of water sources in use, the kind of treatment given to it before consumption and whether they had suffered from diarrhoea in the previous three months while in school. The selection procedure was as follows:

The first stratum consisting of staff quarters involved the selection of the head of each household in 60 out of 120 staff quarters using systematic random sampling design. The second stratum consisting of student hostels involved the selection of 60 rooms from each of 10 blocks of hostels containing 48 rooms each using random sampling technique. Thus 60 rooms were selected in all and all the four students residing in each room were enrolled for the study giving a total of 240 students. There were no dropouts recorded. The results were tabulated and analysed

3.3 *DATA ANALYSIS*

The Bacteriological analysis of the water samples were determined by using the membrane filtration method in accordance with those laid down in Standard Methods (APHA, 1990), while the residual chlorine levels were determined by the ortholidine method using the Lovibond comparator (APHA, 1990)

Data analyses was done manually and the quantitation were also determined with the use of a calculator.

3.4 *LIMITATIONS OF THE STUDY*

1. The one month allocated for this research work is grossly inadequate to allow a more comprehensive and detailed analysis of the water sources available to the campus.
2. The material and financial resources required for this type of study has limited the scope of the study to only coliform counts. The membrane filtration apparatus and

the media were not immediately available for the research work. This further delayed the work beyond the allocated time.

3. The erratic power supply interfered with the smooth and timely collection of samples from the water plant and distribution lines including their prompt analysis since almost all the aspect of this study depends on power supply.

4. The medical records kept in the school clinic were in some cases incomplete. Some vital information such as specific diagnosis, detail history, laboratory results and the sources of water available to the patient were not recorded.

CHAPTER FOUR

RESULTS

4.1 BACTERIOLOGICAL ANALYSIS OF WATER SAMPLES

The methods adopted for determining the faecal coliform count were in accordance with those laid down in the Standard Method (APHA, 1990) using membrane filtration method. Table 1 shows the result of the faecal coliform counts for all the well and tap water samples, from the different sampling sites and their corresponding distance from the treatment plant. All the water samples were found to be loaded with high concentrations of faecal coliform well above the accepted level. Site 8 showed the lowest coliform count of $2x10^2$ per 100ml for well water sample, while site 9 revealed the highest faecal coliform load of $90x10^2$/100ml for well sample. The minimum coliform count of $1x10^2$ per 100mls was determined for tap water sample at site 1 (water treatment site), while tap water sample taken at site 10 showed the highest count of $8x10^2$ per 100mls. Generally, the well water samples contain higher coliform counts than the tap water samples. The faecal coliform load appears to be increasing in the tap water samples as water moves away from the treatment plant.

Table 1 – Faecal coliform counts of well and tap water samples from different sampling sites

SITE	DISTANCE IN KM FROM TREATMENT SITE	FAECAL COLIFORM COUNT OF WELL WATER ($X10^2$ PER 100MLS)	FAECAL COLIFORM COUNT OF TAP WATER ($X10^2$ PER 100MLS)
1	0	-	1.0
2	0.8	-	2.0
3	1.5	30	3.2
4	1.7	34	3.0
5	1.8	16	4.0
6	1.8	8	4.0
7	1.9	4	3.4
8	2.0	2	4.0
9	2.1	90	6.0
10	2.2	8	8.0
11	2.3	4	7.0
12	2.5	35	7.0

4.2 RESIDUAL CHLORINE CONCENTRATION

Table 2 – Faecal coliform counts of bore hole and tap water samples and their residual chlorine estimation.

SITE	FAECAL COLIFORM COUNT OF TAP WATER ($X10^2$ PER 100MLS)	RESIDUAL CHLORINE CONCENTRATION IN MG PER LITER
1.	1.0	0.5
2	2.0	0.3
3	3.2	0.2
4	3.0	0.15
5	4.0	0.15
6	4.0	0.10
7	3.4	0.10
8	4.0	0.10
9	6.0	Trace
10	8.0	0.10
11	7.0	Trace
12	7.0	Trace
13 (Bore hole)	2.0	-

Table 2 shows the faecal coliform counts of tap water samples from the different sampling sites along the distribution system with their corresponding residual chlorine

concentrations. Generally, the results revealed that the treated water still contain faecal coliforms in excess of the acceptable standard of less than one coliform per 100mls of water. The faecal coliform load appears to be increasing as one moves further away from the treatment plant, while their corresponding residual chlorine tend to fall rapidly with distance. However, the highest concentration of residual chlorine was determine from site one (treatment plant), while site 9, 11 and 12 shows only a trace of residual chlorine concentration. No chlorine estimation was done for the bore hole and well water samples since they are not treated. The result also showed that the faecal coliform count of the bore hole water sample was 2.0x102 per 100mls of sample.

4.3 DIARRHOEAL DISEASES AMONG THE RESIDENTS.

Table 3 – Incidence of diarrhoeal diseases among residents of Kongo Campus Ahmadu Bello University, Zaria.

MONTH	NO. OF CASES SEEN	INCIDENCE RATE PER 1000
JAN.	166	28
FEB.	172	29
MARCH	186	31
APRIL	174	29
MAY	169	28
JUNE	192	32
JULY	212	35
AUGUST	223	37
SEPT.	148	25
OCT.	108	18
NOV.	92	15
DEC.	88	14
TOTAL	**1930**	**32**

Table 3 shows the incidence of diarrhoeal diseases among residents of Kongo Campus Ahmadu Bello University, Zaria in 1999. In all, there are 5,976 residents. 4,285 (71.7%) of them are full time students while 1017 (17%) are part time students and 674 (11.3%) of them represent the staff population. The result showed that 1,930 diarrhoeal

cases were seen in the school clinic between January and December 1999. The result revealed that there were more cases of diarrhoea diseases in the months of July and August at the peak of rainy season. The least number of cases reported was in December 1999.

Table 4 – Age and Sex Distribution of diarrhoeal diseases among residents of Kongo Campus

AGE	NO. OF MALE CASES (%)	NO. OF FEMALE CASES (%)	TOTAL	PERCENTAGE TOTAL
< 1	381	402	983	40.6
1 – 3	214	188	402	20.8
4 – 20	152	145	297	15.4
11 – 20	135	110	245	12.7
21 – 30	44	57	101	5.2
31 – 40	28	24	52	2.7
41 – 50	9	14	23	1.2
> 50	15	12	27	1.4
TOTAL	**978**	**952**	**1,930**	**100**

Table four shows the age and sex distribution of diarrhoeal cases among residents of Kongo Campus. In all, 1,930 cases were seen between, January and December 1999. The result shows that there were more cases of diarrhoeal diseases among infants (40.6%), than the other age groups, while more cases occur generally in children than in adults. 1,185 or 61.4% reported cases were in the under 3 age group with the majority occurring in infants.

Table 5 – Type of treatment given to the water sources before consumption

TYPE OF TREATMENT GIVEN TO WATER	NO. OF RESPONDENTS	PERCENTAGE
BOILING	12	4
FILTERING	3	1
ADDITION OF ALLUM	-	-
OTHERS	-	-
NONE	285	95
TOTAL	**300**	**100**

Table 5 shows the type of treatment each of the respondents gave to their water sources before consumption. Of the 300 respondents, only 12 or 4% of them boiled water before consumption while only 3 or 1% of the respondents filtered their water before drinking. A total of 285 or 95% of the respondents did not border to treat their water before consumption.

Table 6-- 2X2 contingency table showing the relationship between sources of drinking water and incidence of diarrhoeal diseases

	DIARRHOEA	NO DIARRHOEA	TOTAL
Both Tap and well water	24	34	58
Tap water only	8	234	242
TOTAL	**32**	**268**	**300**

Table 6 is a 2 by 2 contingency table showing the relationship between the sources of drinking water and the incidence of diarrhoeal diseases among the respondents. The result revealed that 24 of the 58 or 41% of the respondents who drank water from both well and tap water sources suffered diarrhoeal disease in the previous three months, while only 8 of the 234 respondents or 4% of the respondents who drank only tap water suffered diarrhoeal diseases in the previous three months. To test if there is any significant relationship between the cases of diarrhoeal diseases and type of water consumed by the respondents, a X2 test of significance was done. This gave a value of $X2=71.12$ $p<0.05$ with degree of freedom = 1. Hence the X2 indicates a significant relationship between the number of cases of diarrhoeal diseases and the source of water being consumed by the respondents.

CHAPTER FIVE

5.1 DISCUSSION

The presence or absence of coliform organisms and faecal coliform such as Eschericha coli in water is used to assess the degree of contamination and hence danger to health. The presence of E. coli in water always indicate a potentially dangerous contamination of either human or animal origin. High count of E. coli indicates heavy or recent contamination, while low count indicates slight pollution and / or contamination (Sloat and Ziel, 1991).

In this study, all the well water samples indicate heavy pollution, while the tap and bore hole water samples generally indicate slight pollution. None of the water samples, therefore, meets the standard set by World Health Organisation(WHO) for drinking water which states that "Drinking water must be free from microbial contamination and the coliform count must be zero or less than 1 per 100ml of treated water" (WHO, 1972).

It is evident therefore, that all the water samples analysed are generally not safe for human consumption and they may be the possible source of diarrhoeal diseases prevalent in the community. The high incidence of diarrhoeal diseases among children who are more vulnerable group may likely be a result of the widespread faecal contamination.

The high faecal coliform counts of the tap water sample might be due to inadequate treatment of water at the treatment plant. This observation was confirmed by the officer in charge at the water treatment plant who admitted to inadequate supply of chemicals which often leads to rationing. Quantitative measurements of the amount of chlorine added is lacking rather it was observed that chlorination dosage in relation to the pollution load of the raw water was based on subjective assessment instead of measurement of turbidity, coliform count and volume of water used. It is, therefore, not surprising that the residual chlorine level in the distribution system persistently failed to

meet the standard requirement of 1.0mg/l at the treatment plant and a minimum of 0.2mg/l in the distribution system (Freedman, 1977). The chlorine dosage has, therefore, failed to achieve the objective of reducing or maintaining the faecal coliform count within the acceptable standards stated by the WHO guidelines (WHO, 1972). It was also observed from the result that the faecal coliform count increases as one moves away from the treatment plant with the corresponding decrease in the residual chlorine concentration (Tables 1 and 2).

This finding agrees with the study carried out by Bueolow and Walton in 1970. They found that the loss in residual chlorine level indicates pollution of water while in the distribution system. Yusuf (1983) also found that the chlorine level diminishes as water flows away from the treatment plant and higher incidence of faecal coliform correspond to a considerable reduction in residual chlorine level. He stated that exposure of storage reservoirs leads to reduced residual chlorine concentrations. White (1975), also noted that the presence of nitrogenous compounds in chlorinated water leads to chloramine formation which effectively reduces the available chlorine in water. He noted that the observed increase in bacteria density as the water flows away from the treatment plant could also be due to the fact that they were recovering from injuries encountered from the disinfectant action of the chlorine.

An attempt to trace the likely sources of contamination of the well water supply sources revealed that all the wells were neither properly constructed nor protected from contamination. It was also observed that the unhygienic condition of the environment of these wells and the indiscriminate refuse and excreta disposal including spillage from damage soak away systems could have contributed to the heavy contamination observed. This may also explain the high incidence of diarrhoeal diseases reported during the months of July and August at the peak of rainy season in this part of the country. The finding may

also explain the high incidence of diarrhoea diseases among children (61.4%) who are more vulnerable to polluted water. The result of the X^2 test done to determine whether there is a significant relationship between the incidence of diarrhoeal diseases among respondents and the type of water sources used for drinking purposes revealed a strong relationship between diarrhoeal diseases and water pollution. This result is similar to the study done in Malawi by Young and Brisco in 1988. They reported that children living in families who used good quality water supplies and latrines experienced 20% less diarrhoea as reported to the health clinic during rainy season. The finding also agree with those of Stanton and Clemens (1987) who observed that socio-demographic factors are associated with increase incidence of diarrhoeal diseases in developing countries

5.2 RECOMMENDATION AND HEALTH EDUCATION MESSAGES

1. Efforts being made to check indiscriminate dumping of refuse within and around the campus should be strengthened and maintained. This will, no doubt, assist in reducing the possibility of ground water contamination from unsanitary waste disposal system.
2. The drainage system of the campus should be checked and adequately maintained to prevent stagnant water and flooding of the campus.
3. Water consumers should at least boil and filter their water before consumption. In addition, high standard of personal hygiene and proper storage of drinking water should always be maintained.
4. All the existing wells should be properly constructed to meet the acceptable standards preferably with concrete walls. They should be at least 60cm (2 feet) high above ground level and at least 30 meters away from latrines, soak-away pits or waste disposal site. They should also be well covered with tight fitting covers. Surface water in the immediate vicinity of the wells should slope away and drained

properly, while permanent containers should be attached for fetching the water to minimize contamination.

5. Water treatment standards should be maintained at the treatment plant. This is to ensure that the minimum residual chlorine level of 0.2mg / L in the distribution system is maintained. Booster stations for additional chlorination can be established in the distribution system to maintain this level along the service lines.

6. The government of Kaduna State and A.B.U. authorities should provide personnel and facilities for periodic monitoring of water treatment standards, the distribution lines and residual chlorine level to ensure adequate chlorination and maintenance of the service lines to take care of leakages and other possible sources of recontamination.

7. Public health education campaigns to enlighten water consumers, water engineers and water handlers on the health hazards associated with contaminated water should be done on regular basis.

REFERENCES

1. Agbu A. A; Alariba H. C. Singh K.A; Adesujun (1988). Bacteriologic studies and chemical Analysis of public well water in Samaru and Zaria city Northern Nigeria. Nigerian journal of microbiology 8(1-2) 88-98

2. Akintola F.O; Acho-chi C; and mark S; (1979) perception of water quality in some villages of the Savannah Zone of Nigeria – Journal of water supply and management 4(4) :243 – 252.

3. Aliyu Y. B. (2000) water and sanitation implication for Health. Unpublished MPH seminar paper April 2000. Dept of Comm medication ABU Zaria.

4. Ann Arbor.(1972) Environmental impact of water chlorination Edited by Robert L. Jolley PP 37-41

5. APHA . (1989) American public Health Association, American water works Association and water pollution control federation (1989) standard methods for the examination of water and waste water 18th edition, New York.

6. APHA (1990)American public Health Association. Standard methods for the examination of water and waste water 19th ed. Amnion public Health Association, Washington D.C.

7. Buelow R. W. and Walton Graham (1971); Bacteriological quality versus Residual Chlorine. Journal of American Water Works Association. vol. 63, No. 1, 28 – 35.

8. Essien. (2000) Water and sanitation MPH class notes. Dept of Comm. Medicine

9. Essien. (1980) Quantitative significance of bacterial index indicative of faecal pollution of water in Malunfashi area. Northern Nigeria. PhD Thesis. Dept. of Community Medicine. A.B.U. Zaria.

10. Feachem. R.G. (1980) Bacterial standards for drinking water quality in developing countries. Lancet 2, 255-256.

11. Feachem . R.G. et al, (1981) Health aspects of excreta and Sullage management, world Bank report.

12. Green.B.L. Elizabeth clausen and warren L (1975) comparison of the new millipore with conventional membrane filtration for the enumeration of faecal coliforms. Journal of Applied microbiology Vol30 PP 697-699.

13. Helmer.R (1975) controlling water pollution. WHO chronicle. WHO Geneva 29:428-434

14. Ibrahim Habiba (1998) Bacteriological quality of commercially packed water available in Samaru Zaria. Bsc Thesis Dept of microbiology, A.B.U. Zaria

15. Mara. D, (1983) Sewage treatment in hot climates; John Wiley and Sons Publications.

16. Mara. D. (1986) Bacterial analysis of drinking water in small water supplies. Russ Institute Bulletin No 10.

17. Runkle. R. S. (1969) Microbial contamination control facilities. American Association for contamination control.

18. Seidler. R. J; Evan T.m; kayman L. E. and Warweck L.E (1981) limitations of standard coliform techniques Journal of American water works Association 73:538-542.

19. Sloat. S and Ziel E (1991). The use of indicator organisms to assess public water safety. Journal of Applied Analytical chemistry technical in formation series 13 : 1-25.

20. Smith.A. L (1969) principles of microbiology 6th edition coy Morby company saint Louis. USA

21. Stanton. B. F. and Clemens J.D. (1987), Socio-economic variables and rates of diarrhoeal diseases in Urban Bangladesh. Transaction of the Royal society of Tropical Medicine and Hygiene. Vol. 81, No. 2, 278 – 282.

22. Umoh. V.O. (1976) Sanitary quality of well water from Samaru village. An unpublished B.Sc. Thesis Dept of Microbiology, Ahmadu Bello University, Zaria.

23. Wagner. E. G. and Lanoix J.N (1959) water supply for rural Areas and small communities, WHO monograph No 39 Geneva 205-220.

24. Walker. R. (1978). Water supply, treatment and distribution, 3rd edition PP 305-420. prentice hall Inc; Englewood cliffs, New Jersey USA.

25. Watt J., Holister A. C., Beck M. D. and Hemphill E. C. (1953), Diarrhoeal Diseases in Fresno County California. American Journal of Public Health vol. 43, 728 - 741

26. Water lines. (1988) Water purification vol. 7 No 1.

27. White .G.C (1975) Disinfection, the last line of defense for portable water-Journal of American water works association. Vol678:410-413.

28. WHO. (1965) WHO technical report series No 297.

29. WHO. (1966) Water pollution control. WHO tech report series No, 318

30. WHO. (1968) – water pollution control in developing countries. WHO technical report series No 404

31. WHO.(1969) – community water supply WHO technical report series No420

32. WHO. (1971) international standards for Drinking water, Geneva

33. WHO.(1972) Health Hazards of the Human Environment, WHO, Geneva.

34. WHO. (1975). Water borne pathogens in water pollution microbiology pp. 207-239 proceedings of the conference on the environmental impact of water chlorination

35. WHO. (1976) surveillance of Drinking water quality. WHO monograph series No 63, Geneva

36. WHO. (1977) WHO chronicle 31, 318

37. WHO. (1984) Guidelines for Drinking water quality Vol. I WHO, Geneva.

38. WHO. (1985) Guidelines for Drinking water quality Vol. 3. Drinking water quality control in small community supplies, Geneva.

39. WHO. (1986) safe water supply and sanitation; pre-requisites for health for all. World Health statistics 39:10

40. WHO. (1987) food safety, world Health Magazine, march 1987

41. WHO. (1994) 47th world Health Assembly. Describing existing drinking water supply and sanitation conditions in sub Saharan Africa as the most deplorable in the world. Journal of health development WHO (Geneva 15pp 228 – 305

42. WHO. (1995) The world Health report 1995. Bridging the gaps P-14

43. WHO. (1996) World Health Statistics 29; 10.

44. Young. D. and Briscoe J. A. (1988). A case control study of the effect of environmental sanitation on diarrhoeal morbidity in Malawi. Journal of Epidemiology and Community Health. Vol 42. No. 1. 83-88

45. Yusuf. Z.I. (1983). The relationship between residual chlorine of tap water in the water distribution system of Zaria. Unpublished B.sc. Thesis A.B.U. Zaria.

APPENDIX I :

SAMPLING SITES AND THEIR DISTANCE IN KM FROM THE WATER TREATMENT PLANT

	SITE	DISTANCE IN KM FROM TREATMENT SITE
1.	Treatment Plant	**0.**
2.	WTC Junction	0.8
3.	Faculty of Law	1.5
4.	President Kennedy Library	1.7
5.	Hostel I & II	1.8
6.	Business School	1.8
7.	Accounting Department	1.9
8.	Administrative Block	2.0
9.	Clinic/Hostel III	2.1
10.	Sardauna/Bedde Hostel	2.2
11.	Hostel IV	2.3
12.	Ali Akilu Hostel	2.5

APPENDIX II

QUESTIONNAIRE ON DRINKING WATER SUPPLY SOURCES AND DIARRHOEAL DISEASES

Age: ☐ Sex: ☐

Class / Level: ☐ Address: ----------

Drinking Water Sources

1. Which of the following water sources do you use for drinking purposes:

   (a) Well Water ☐ Tap Water ☐

   (c) Both Tap and Well Water. ☐

   (d) Others (specify): ----------

2. Do you normally treat your water before drinking? (a) Yes ☐ b) No ☐

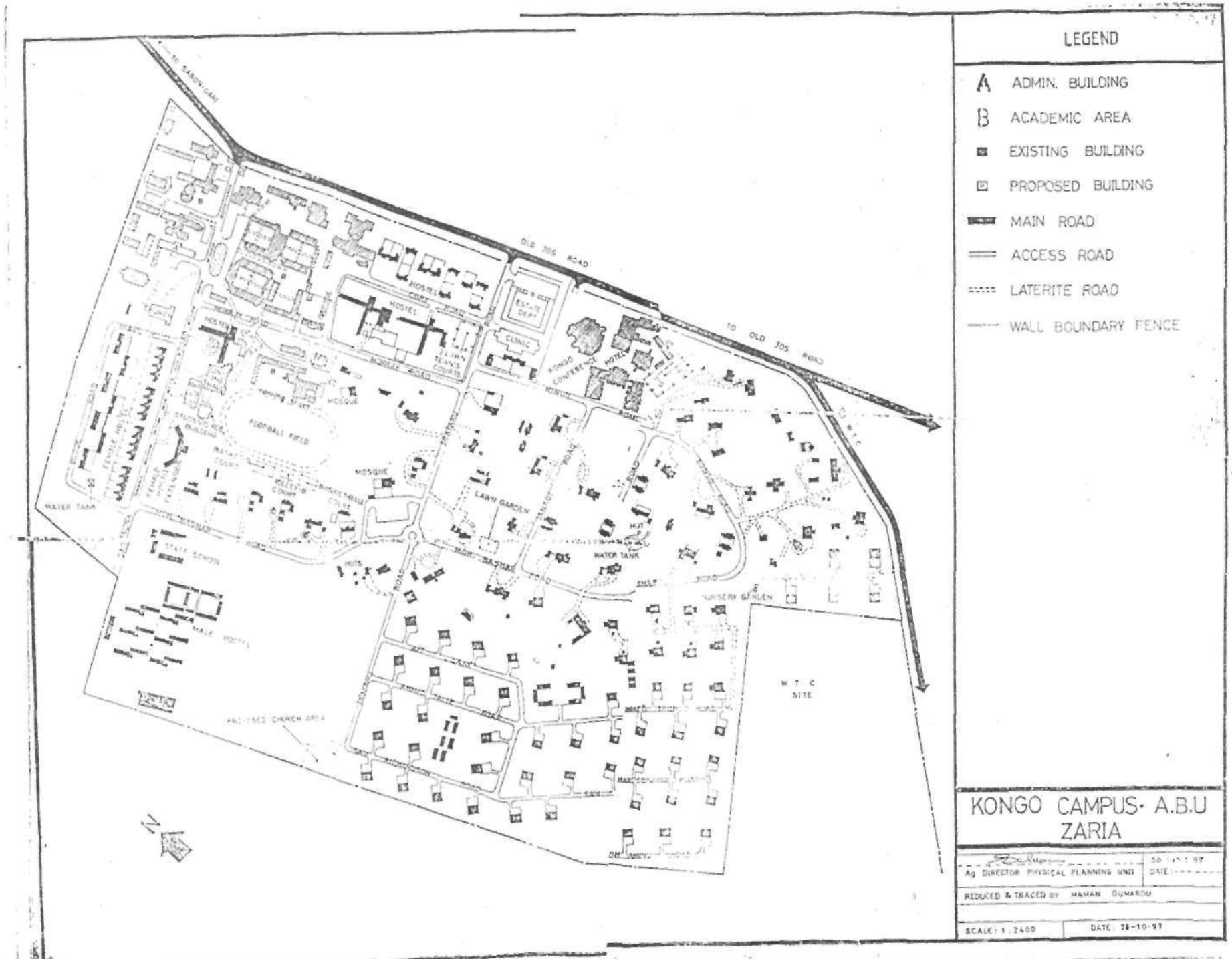
3. If yes which of the following treatment do you give to your water before drinking?

   (a) Boiling ☐ Filtering (c) A☐n of Alum ☐

   (e) None ☐

INCIDENCE OF DIARRHOEAL DISEASES

4. Have you suffered from diarrhoeal diseases in the last 3 months. Yes ☐ ☐


LEGEND
A ADMIN. BUILDING
B ACADEMIC AREA
EXISTING BUILDING
PROPOSED BUILDING
MAIN ROAD
ACCESS ROAD
LATERITE ROAD
WALL BOUNDARY FENCE
TO OLD ZOS ROAD
TO KABON-GARI
HOSTEL
CLINIC
MOSQUE
FOOTBALL FIELD
LAWN GARDEN
WATER TANK
NURSERY GARDEN
W T C SITE
KONGO CAMPUS- A.B.U ZARIA
Ag DIRECTOR PHYSICAL PLANNING UNIT
DATE
REDUCED & TRACED BY HAMAN DUMARDU
SCALE: 1 : 2400
DATE: 28-10-97