AN ASSESSMENT OF THE EFFECTIVENESS OF CHLORINE DOSAGE, ALONG MUNICIPAL WATER WORKS DISTRIBUTION LINES (A CASE STUDY OF KUBWA HOUSING ESTATE).

BY

FIDELIS DAMI

PGD / AGR. ENG / 2003 / 178

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

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BEING A FINAL YEAR PROJECT SUBMITTED TO THE DEPARTMENT OF AGRIC ENGINEERING, SCHOOL OF ENGINEERING, ENGINEERING TEHNOLOGY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF POST GRADUATE DIPLOMA (PGD) IN SOIL & WATER ENGINEERING.

FEDERAL UNIVERSITY OF TECHNOLOGY,

MINNA.

MARCH, 2005.

CERTIFICATION

This is to certify that this project was carried out by **FIDELIS DAMI (PGD / AGR ENG / 2003 / 178)** and approved as being adequate in scope and quality, meeting the requirement for the award of Post Graduate Diploma (PGD) in Soil and Water Engineering, Federal University of Technology, Minna.

SIGN: ....

PROJECT SUPERVISOR

ENGR. BASHIR MOHAMMED

4th April, 2005

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4.07.05

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EXTERNAL EXAMINER

....

DATE

DEDICATION

This project is dedicated to the Glory of the Almighty God for His abundance blessing.

ACKNOWLEDGEMENT

I thank Almighty God for the privilege to under take this project successfully.

My sincere gratitude goes to my project supervisor Engr. Bashir Mohammed for his full co-operation and painstaking interest in this work. His invaluable vigor to ensure the success of this work remain cherished and of most esteem to me, indeed I am indebted to him and may Allah bless him abundantly.

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ABSTRACT

This project was carried out within Kubwa Satellite town, monitoring the effectiveness of chlorine from the treatment plant and along the distribution network for a period of four weeks during the dry season, with the aim of determining the effectiveness of chlorine dosage along the distribution lines of municipal water works. Water samples were collected from the treatment plant, the main line and from the distribution system within the housing estate. Each of the samples was tested for free chlorine and combined chlorine to assess their effectiveness. The raw water, aerated water and the water that was exposed for 24 hours show 0.00 mg/l of free and combined chlorine while the remaining sampling points show free and combined chlorine less than the recommended standard of World Health Organization (WHO) and Federal Environmental Protection Agency (FEPA). Similarly, a question survey was carried out to get the view of the public about the portability of the water entering their houses for consumption and other uses. Results obtained show that 50% of the people living around the sampling point that show 0.00 mg/l level of residual chlorine complain of water related disease.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Kubwa Housing Estate is a densely populated area, and it is called the best Satellite town of the Federal Capital City, Abuja. Water is an essential commodity in the life of the people, as water is used for industrial and domestic purposes. Therefore the quality of water used at the distribution from the treatment plant is of paramount importance. In line with this, it becomes necessary to assess the effectiveness of chlorine dosage at each point after post chlorination and at the distribution, to trace if there is contamination along the rates due to pipe leakages or pipeline passing through soak away or septic tank.

Chlorination is of proven effectiveness, it has low capital and operating costs, and water treatment personnel World Wide had extensive experience with it, American Society of Civil Engineers (ASCE, 1969).

The chlorinating effect depends on the dose of chlorine added to water and the time of contact between water and chlorine. Of the total amount of added chlorine only a relatively small part is spent for the oxidation of micro organisms. Nikoladze (1989)
The dose of chlorine should exceed the chlorine absorptive of water by the amount of residual chlorine in water, which guarantees that the oxidation of bacteria and organic substances in water has been completed. The concentration of residual chlorine in mains water of an inhabited area at a point nearest to the second – lift pump station should be within (0.3 – 0.5) mg/L Nikoladze (1989).

The graphical relationship between the dose of chlorine and the concentration of residual chlorine in water may be either Linear or have a distinct deflection. The relationship becomes non Linear when ammonia is present in chlorinated water. Since cases are possible when the concentration of residual chlorine in water will drop down sharply, the required dose of chlorine should be determined carefully by experimental methods Nikoladge, (1989).

The conditions of chlorination are varied depending on the quality of initial water. Natural waters with relatively low concentrations of organic substances and bacteria are usually subjected to single chlorination with chlorine being added to filtered water upstream of the pure water tank. In such cases, chlorine doses are usually very small, within 0.5 – 2 mg/L. Double chlorination is often employed in clarification of strongly coloured waters and those rich in organic substances and bacteria. In that case, chlorine is first added to water before flocculation tanks or clarifiers and then to filtered water before the pure water tank Nikoladze (1989)

Preliminary chlorination (before settling) is used for oxidation of organic protective colloids which might inhibit the process of coagulation and also for oxidation of humic substances imparting colour to water, which is done in order to save the coagulant employed for decoration. The chlorine dose in preliminary chlorination is substantially higher that that added to filtered water and may be up to 10mg/L if water has an elevated concentration of organic substances and high color index Nikoladze (1989).

1.2 PROBLEM DEFINITION

The break out of water – borne disease due to poor quality of water supply to the consumers is of great concern. There is need to investigate the source of the contamination, which is posing a risk to the population or community, in the study area. Therefore knowing the effectiveness of chlorine dosage at the distribution lines is of paramount importance.

1.3 AIM

This project is aim at determining the effectiveness of chlorine dosage along the distribution lines of municipal water works. The specific objectives are:

- Measure the level of chlorine concentration along distribution lines.
- Getting the view of the public about the portability of the water m entering their houses
- Identify sources of pollution and suggest possible solutions to prevent future occurrence.

1.4 SCOPE OF THE PROJECT

The chlorine dosage will be monitored at the outlet in Usuma dam i.e. water treatment plant and at different sampling points along the distribution network for four weeks. The points include the distribution points in owner occupier, Federal Housing, Phase three, of Kubwa Satellite town of Federal Capital City, Abuja. The results obtained shall be comparing with WHO standard to trace the points of pollution along the pipelines network, due to leakages and suggest possible solution to the problem.

1.5 JUSTIFICATION

Due to the upgrading of water quality standard it is okey to justify the consistent analysis of the quality of water consume by the society. Beside that, the research helps the inhabitant of the study areas to be aware of the quality of water from the treatment plant and the quality of water received at the distribution.

- It creates awareness to the public in their daily neglects of reporting breakages along their pipelines.

1.6 DESCRIPTION OF THE STUDY AREA.

1.6.1 LOCATION

Kubwa is the best Satellite town with all the necessary social amenities in the Federal Capital Territory, Abuja.

It is located along Zuba, Dei – Dei expressway from the main city, and is approximately about 17km from the city entrance along Zuba, Dei – Dei expressway. Kubwa is under Bwari Area Council, the total population of Bwari is 30,928 as recorded figure of 1991, census and with a projected figure of 64,416 in 2002 of which Kubwa constituted about 40% of this entire population, according to National Population Commission, Nov., (1991).

1.6.2 CLIMATE

Rainfall spread over the month of March to October. The amount of average annual rainfall in 1998 to 2002 is 132.30mm, with average monthly speed of wind of 3.7, daily average vapour pressure of 21.0, average relative humidity of 45.0, average minimum temperature of 20^0c being lowest in May, June and December of each year, but the average maximum temperature in January to December is 35.4^0c, 36.8, 36.9, 36.0, 30.7, 31.0, 28.9, 29.4, 30.7, 34.2, 35.2, 34.2^{0}c respectively. In 1998, the lowest minimum temperature was recorded in July and August being 29.5 on the average, this could be attributed to the fact that this period is usually the peak of raining season, on the other hand, January to April recorded an average of 36.2, indicating the period of dry season and the advent of daily rainy season. The last quarterly of the year (Oct.., Nov. and Dec.) witnessed a slight drop from the immediate processing average minimum temperature (32.3) this could be as a result of harmattan, usually prevalent in this quarter, statistical year book (2002).

1.6.3 WATER SUPPLY IN THE STUDY AREA

The Kubwa town water supply is a combined water supply system. Some wards are partly supplied with borehole water while the rest are supplied with water from the treatment plant. The treatment plant is situated in the eastern part of the town along Dutse Bwari Road. The raw water is being pumped from lower usuma dam 20km east of the town.

Water is being distributed through a piping system to the consumers and in which some of the pipe are leaking. The pipes also supply water to reservoirs, where water hawkers fetch water in their jerry cans for selling to the public.

Pipeline are generally under varied stress conditions during the fluid transportation period and when empty. The pressure of water in pipelines exerted tensile forces on the walls of the pipeline while the weight of the overlying and supporting soils and that of the moving load above the pipeline exerted compressive forces on the pipe. All these forces have destructive consequences on the pipe itself. Therefore pipes for water transportation or any other fluid, must be made of materials of sufficient strength and chemical composition to withstand these operational hazards. Alayanda A. W. (1998).

CHAPTER TWO

LITERATURE REVIEW (INTRODUCTION)

In 1881, Koch demonstrated in the Laboratory that chlorine could kill bacteria. By 1890, the first electrolytic chlorine generation plant was built in West Germany; 1n 1905, continuous chlorination was used for the first time in Lincoln, England, to arrest a typhoid epidemic. The first regular use of disinfections in the United States was by G. Johnson at the Bubbley Creek Filtration Plant in Chicago in 1908, about the same time that Dr. Harriette Chick first advanced her famous theory of disinfections. Chlorination has been the dominant method employed, but ozonation has been widely used also, particularly in France, Germany, Canada, and the U.S.S.R. There has been increasing use of chlorine dioxide in European and U. S. disinfections.

2.1 DISINFECTION BY CHLORINE

Chlorine was first used for day – in, day – out disinfection of a municipal water supply in American in 1908, when George A. Johnson and John L. Leal added chlorine of lime to the water supply of Jersey city, N. J.

The element chlorine was discovered by Scheele. It is the second member of the seventh column of the periodic table. Surrounding it's nucleus is an outer shell of 7 electrons. Because this structure had great stability, the atoms have a strong tendency to acquire an extra electron to complete a shell of eight. The tendency manifests itself as oxidizing activity. Correspondingly, elemental chlorine is a powerful oxidizing agent and functions as an oxidizer in most of its chemical reactions. G. M. Fair, etal (1967).

2.2 CHLORINE REACTIONS WITH WATER

The following substances are released when chlorine or it's disinfecting compounds are added to water:

- Hypochlorous acid (Hocl), hypochlorite ion (Ocl^-), and elemental chlorine (Cl_2). Distribution of the three species depends on PH. Elemental chlorine, from chlorine gas, lasts but a fleeting moment within the normal PH zone. The two prevailing species (Hocl and Ocl^-) are referred to in practice as free available chlorine.
- Mono chloramine (NH_2Cl), dichloramine ($NHCl_2$), and nitrogen trichloride (NCl_3). Ammonia, or organic Nitrogen, is essential to the three species is again a function of PH. Nitrogen trichloride is not formed in significant amounts within the normal PH zone except when the breakpoint is approached. The two prevailing species, NH_2Cl and $NHCl_2$, are referred to in practice as combined available chlorine.
- Complex organic chloramines, more especially in sewage. Because the disinfecting power of the different species of chlorine varies widely, the chemistry of chlorination must be fully understood. Otherwise chlorine and its compounds will not be employed intelligently and efficiently in the disinfection of water and waste water G. M. Fair, etal (1967).

Concentrations of free available chlorine and combined available chlorine are generally determined colorimetrically by the O^- tolidine arsenite (OTA) test. The test is based on the favourable difference in rate reaction of free available chlorine with O^- tolidine. Sodium arsenite (a reducing agent) is added to stop the reaction after the free available chlorine has reacted and, at least approximately, before the combined available chlorine has reacted. Gordon, et. al. (1967).

As a strong oxidizing agent, chlorine reacts with reducing substances to produce the chlorine demand. Depending on the nature of the substance present in water, the chlorine atom, by gaining electrons, is changed into chloride ion or organic chloride. Reducing substances may include inorganic Fe^{++}, Mn^{++}, $N0_2$-, and H_2S along with the greater part of the organic material (living and dead). The inorganic substances generally react rapidly and stoichiometrically; the response of the organic material is generally slow, and its extent depends on how much available chlorine is present in excess of requirements. Because the organic material in drinking water supplies is closely related to their natural colour or stain, their probable organic chlorine demand may be estimated from the depth of colour. In analogous fashion, the organic chlorine demand of waste waters bears some relation to their BOD, or more closely to their (COD). Fair, et. al., (1967).

These reactions are complicating factors in water chlorination. Enough chlorine must be added to take care of them as well as the disinfecting reactions. To assure this, chlorine residuals remaining after a specific time of contact, rather than initial chlorine doses, are made standards of accomplishment or comparison. Ten minutes are specified in most testing. Because the chlorine demand is a function of temperature, concentration, and time, its determination must take all three factors into account. The chlorine that actually accomplishes disinfection is part of the demand. Fair, et. al., (1967) .

2.2.1 FREE AVAILABLE CHLORINE

The following equilibrium equations obtain when elemental chlorine is dissolved in water:

Hydrolysis: $Cl_2 + H_2O \rightleftharpoons HOCl + H^+ + Cl^-$

$(HOCl)\ (H^+)(Cl^-)\ /\ (Cl_2) = K_h = 4.5 \times 10^{-4}\ (Mole/L)^2$ at 25^{0}C

Ionization: $HOCl \rightleftharpoons H^+ + OCl^-$

$(H^+)\ (OCl^-)\ /\ (HOCl) = K_i$ or $(Ocl^-)\ /\ (HOCl) = K_i\ /\ CH^+)$

Solutions of hypochlorite, such as chloride of Lime and Calcium hypochlorite, established the same ionization equilibrium in water. Taking calcium hypochlorite as the example, the reactions leading to equilibrium are $Ca(OCl)_2 \longrightarrow Ca^{++} + 2OCl^-$ and

$H^+ + OCl^- \rightleftharpoons HOCl$

The hydrolysis constant K_h is of such magnitude that no measurable concentration of Cl_2 remains in solution when the PH of the chlorinated water is more than about 3.0 and the total chloride concentration is less than 1000mg per L. At ordinary water temperatures the hydrolysis of chlorine is essentially complete within a few seconds, and the ionization of hypochlorous acid produced is in essence an instantaneous, reversible reaction. Gordon et. al., 1967.

2.2.2 COMBINED AVAILABLE CHLORINE

The most important reaction of chlorine with compounds of Nitrogen is the reaction of hypochlorous acid with ammonia. This is a step wise process, for which the successive reactions are the following:

$NH_3 + HOCl \longrightarrow NH_2Cl + H_2O$

$NH_2cl + HOCl \longrightarrow NHCl_2 + H_2O$

and

$NHCl_2 + HOCl \longrightarrow NCl_3 = H_2O$

When the PH is above 6 and the molar ratio of chlorine (or hypochlorite) to ammonia (or ammonium ions) is not more than 1.0, the formation of monochloramine predominates. G. M. Fair etal, 1967.

2.3 CHLORINATION

Chlorine and its derivatives kill bacteria present in water. It also oxidizes the organic substances and for that reason is a good reagent for preventing reproduction of micro organisms in water. For efficient chlorination, water should be intermixed thoroughly with chlorine added and let to stay in contact with the reagent for at least 30 minutes or for 60 minutes when the chlorination is combined with ammonation) before it will be delivered to customers. Chlorine water contact can be ensured in a pure water tank or in the pipeline which supplies water to consumers, provided that this has a sufficient length Nikoladze (1989).

The dose of chlorine is determined by a chlorination test so that the water delivered to the consumer had a residual content of non-reacted chlorine between 0.3 and 0.5mg/L. Under this requirement, the dose of chlorine for chlorination of filtered water is equal to 0.5 – 2.0 mg/L, depending on what is called the chlorine absorptive of water. For chlorination of unfiltered river water, the chlorine dose may be high as 5 – 8 mg/L or even more Nikoladze (1989).

Water is chlorinated by liquid (or gaseous) chlorine. At small capacity water purification complexes (up to 3000m^3 / day). It is permissible to use chlorinated lime for the purpose. At positive temperatures and normal atmospheric pressure, chlorine is a greenish – yellow gas with a stifling smell and a density 1.5 – 2.5 times that of air depending on temperature). At an increase of pressure (at positive temperatures) gaseous chlorine changes to the liquid state. Therefore, it is kept and transported in the liquid state in a special steel flasks at a gauge pressure of 0.6 – 1.0 Mpa. In this country, chlorine is delivered from chlorine – processing plants in flasks of two types : with a capacity of 25 – 30 kg of liquid chlorine and E – 54, which contains up to 100 kg of chlorine Nikoladge (1989).

Large water – purification stations (of a capacity more than 100,000m3/day) are supplied with chlorine transported in special tank cars of a capacity up to 48 t of in barrels containing 700 – 3,000 kg of liquid chlorine. When added to water, chlorine oxidizes the substances in the composition of protoplasm of bacterial cells and thus kills bacteria. Chlorination is a reliable method for preventing epidemics, since most pathogenic bacteria (typhoid and disenteria bacilli, cholera etc.) are rather unstable relative to chlorine. A drawback of the chlorination method is however, that it does not kill spore forming bacteria Nikoladze (1989).

2.4 COMBINED RESIDUAL CHLORINATION

Combined residual chlorination was first used by Race at Ottawa, Onatario, Canada. At the time, it was argued that chloramines had a germicidal action greater than that of the chlorine alone, that their use could ensure that the water produced was free taste and odours, that a much more long lasting residual was produced, and that the overall cost of disinfection could be reduced. The sum total of many subsequent studies have shown that:

- The germicidal action of combined chlorine may be substantially less than that of the chlorine.
- Combined chlorine is sometimes better from the taste and odour stand point when the taste and odour of concern are the results of chlorine by products.

- The combined chlorine residual is indeed longer lasting than a free chlorine residual. American Society of Civil Engineers (1969).

2.4.1 CHLORINE DIOXIDE

In certain circumstances, chlorine dioxide is an excellent choice among disinfectants. Chlorine dioxide is effective in destroying phenols, yet it does not form trihalomethanes in significant amounts. Chlorine dioxide disinfectant properties are not adversely affected by a higher PH, as those of free chlorine residual are. Consequently, chlorine dioxide is a much quicker disinfectant at higher PHs. In Western Europe, use of chlorine dioxide is increasing, particularly in Holland, Germany, France, and Switzerland in regions where there is an attempt to produce potable water from polluted rivers. In these locations, chlorine dioxide is used for disinfection, often as an adjunct to ozonation. American Society of Civil Engineers (ASCE) 1969

2.5 CHLORINE RESIDUAL ANALYSIS

Two methods for continuous chlorine residual analysis are currently available: the automatic amperometric titrator, and the ion selective probe. In an automatic amperometric titrator, the cell has an indicating electrode made of copper concentrically mounted around a platinum reference electrode. Water flows into the space between the two, and a potential is imposed between the electrodes, resulting in a current flow which is proportional to the amount of chlorine in the sample. Ordinarily, a PH 4 buffer is used, and the free chlorine is measured. The use of a buffer with excess potassium iodide will cause the unit to titrate the total chlorine residual, while an excess of combined chlorine will interfere with attempts to measure the residual. American Society of Civil Engineers (ASCE) 1969.

2.6 TECHNOLOGY OF WATER CHLORINATION

Liquid chlorine, ammonia, and sulfur dioxide are generally added to water in control amounts through orifice flow meters or dosimeters called chlorinators, ammoniators, and sulfonators, respectively. For given dosages, pressure drops across the orifice are kept constant. In dosimeters operated under pressure this is done by a pressure – reducing, pressure compensating valve which keeps influent pressure constant regardless of pressure changes in the container from which the gas is drawn. In dosimeters operated under vacuum, the pressure drop across the orifice is regulated by control vacuum on the inlet and outlet sides of the orifice. The purpose of vacuum feed is to lessen gas leakage. Some simplify pressure devices regulate the volumetric displacement of the gas (bubblers) rather than its rate of flow. G. M. Fair, etal (1967).

2.7 OTHER USES OF CHLORINE

Among uses of chlorine other than disinfections are the following:

- Destruction or control of undesirable growths of algae and related organisms in water and waste water.
- Destruction and prevention of growth of iron fixing and slime forming bacteria in pipelines and other water conduits and of slime – forming bacteria in sewers and waste water treatment works. Free chlorine (via break point chlorination) may control the growth of fresh water mussels and clams in conduits.
- Destruction of filter flies (psychoda) and ponding slime growth on trickling filters.
- Improvement of the coagulation of water and waste water.
- Control of odours in waters and waste waters.

- Stabilization of settling – tank sludges in water purification works. Control of odours associated with sludge treatment, including its drying.
- Prevention of anaerobic conditions in sewerage system and waste water treatment works, by delaying or reducing decomposition.
- Conversion of cyanides to cyanates, such as N_aOCN, in alkaline industrial wastes.
- Destruction of hydrogen sulphide in water and waste waters, and the protection of concrete, mortar, and paint against the corrosive action of this gas.
- Reduction of the immediate oxygen requirements of returned activated sludge and of digester liquor within treatments plants.
- Reduction or decay of the BOD of waste waters discharged into receiving water.
- Preparation at the plant of chlorinated copperas, a useful coagulant. G. M. Fair, etal (1967).

CHAPTER THREE

MATERIALS AND METHODS

Water samples should be collected in a sterile bottle according to the standard procedures (APHA, 1975). They should be collected from all water supplies, both improved and unimproved, used in the detail survey villages. In addition, it is useful to test samples from a wide range of representative supplies and sources from throughout the study area.

However, a single test of a water source may tell us little about that source, because very marked variations of pollutions occur from hour to hour, from day to day, from week to week, and from season to season. A series of samples may be taken from a source before and after the morning water collections, and before and sometimes after heavy rainfall, to see how these factors affect the level of pollution. In addition, samples should be collected once a day at the transition from the dry season to wet season. This is a time when violent fluctuations from the dry season to the wet season. This is a time when violet fluctuations in the pollution of surface waters are to be expected.

If a water is chlorinated, free residuals should be recorded on every occasion that bacteria are enumerated in order to investigate the effect of chlorination on water quality. In addition, when testing chlorinated samples, care must be taken to de-chlorinate the samples before testing and to allow preliminary incubation at 22^0c to promote the resuscitation of damaged bacteria.

Both the level of chlorine and the number of bacteria in a sample of water decreases with time, so that samples must be analyzed within a few hours of sampling. Sunlight and warmth accelerate this decrease, so water samples should be kept shaded and as cool as possible until they are tested. An ideal arrangement is to transport the samples on dry ice in insulated containers to maintain a water temperature of around 50c. This will prevent excessive growth or die off of bacteria. Samples should reached the Laboratory as quickly as possible and in any case within eight hours of collection. If delays are unavoidable, water samples may be filtered while awaiting the journey to the Laboratory. On arrival at the Laboratory, samples should be processed immediately. Since samples will often arrive in the laboratory in the afternoon, immediate processing may necessitate the Laboratory staff working in the evenings. Feachem, R, Sandy Caurncross etal, 1981.

3.1 GENERAL INFORMATION ON DISTRIBUTION NETWORK BY F.C.T WATER BOARD.

Pipelines are essential part of a water supply system, facilitating the transport of water, in varied quantities, from headwork through the treatment facilities to the service reservoir and eventually to the consumers. Water supply pipelines are in two categories namely the trunk main and the distribution mains form part of the distribution network and the service pipe.

Connections are made on the distribution main. There are several advantages of pipeline transport of water compare with other methods such as roads, rail, waterways, air etc.

- Being hidden beneath the ground, a pipeline will not Mar the natural environment.
- A buried pipeline is reasonably secured against sabotage.
- A pipeline is independent of external influences such as traffic congestion and other services.

- It is relatively to increase the capacity of pipeline by installing a booster pump.
- A pipeline cans cross-rugged terrain difficult for vehicle to cross.

There are also disadvantages associated with the water transport by pipeline system.

- The initial capital cost is often large.
- There is often a high cost involve in filling a pipeline.
- Pipeline cannot be used for More than one material at a time (although there is Multi-product pipeline operating in batches).
- There are operating problems associated with the pumping of solids, such as blockages on stoppage.
- It is often difficult to locate leaks or blockage.

Alayande A. W, (1998).

3.2 PREPARATION OF A QUESTIONAIRE.

A questionnaire was prepared to carry out a survey to know the health problem encountered through the consumption of water from Kubwa Water Works.

- Visit to health centers around the sampling point and interviewing health offices about the trace of water borne disease.
- Filling of the questionnaire form by the inhabitant around the sampling point's area.

3.3 RECONNAISANCE TO LOWER USUMA WATER WORKS

The supply of water to city of Abuja is from Usuma Dam water works situated in Northern part of the country which is also the highest level in the territory.

The maximum height of the dam is 45 meters. The raw water intake from the dam reservoir is through pipe openings at different levels in the circular concrete intake tower located within the reservoir. The Usuma Dam Reservoir usually experience the turn over effect during December and the problem persists for up to three weeks. During this period, the turbidity of the water (measure of how clear water is) rises to 7.4 NTU. The iron and manganese content of the water which is usually 0.1ppm rise to 0.8ppm.

The operations of the treatment plant are organized into six section namely operations, Maintenance, Dam Safety, Quality control, Administration and Stone.

Water production from the treatment plant commenced in March 1987, with a production of about 7,000 M^3/day this has now reached 90,000m^3/day.

Treated water capacity of the treatment plant is 118,000m^3/day. When water supply commenced in 1987, production to the city was done jointly with Jabi Dam. Water works but with the completion of the various storage tanks and pumping stations, water is now supplied to the city and the life camp solely by the Usuma Dam Waterworks.

3.4 CHLORINATION AND CHEMICAL DOSING UNITS IN LOWER USUMAN WATERWORKS.

The aeration stage handle the dissolved gas and small quantities of iron and manganese in the raw water a small oxidant is required to handle higher concentrations of iron and manganese. Oxidizing agents used at this state include chorine in the exceptional case when this is not sufficient potassium permanganate is also used. The chlorine also serves to inhibit the growth of Algae in the down stream structure. Iron and manganese poise particular problems in water treatment. Iron as a ferrous compound is usually colourless white its oxidised ferric compound is brown. Manganese salt in water is usually dissolved and colourless when the water is subjected to heat the manganese will neat with oxygen in the air to form black precipitate of Manganese dio-oxide (MnO_2). Therefore it is important to monitor closely the levels of iron and manganese in the water as their presence is not ordinary noted in treated water.

In the Usuma Dam Water Works the coagulant used for neutralizing the charges in the particles is Alumium sulphate (ALUM) AL2 (SO_4 $)_{3}$.$18H_2o$. This neutralization is only effective when carried out rapidly. The Alum is dosed in the raw water just before the distribution Weirs. The Aluminum hydioxide forms a white precipitate at a ph 5.8 <PH<7.2 with an optium PH of 6.2. Abuja water News (1995).

3.5 SELECTION OF SAMPLYING SITES

Visits were made to distribution points around the housing Estate, the mainline and to Usuma Water works to select sampling Sites. The sampling sites selected was Usuma treatment plant, mainline and Kubwa Housing Estate distribution points.

3.5.1 SAMPLYING EQUIPMENTS.

Introduction: a variety of equipment has been devised for collection of water samples. The type of apparatus used will to a certain extent be determined by the sampling location and by the information sought for. In general, the collecting apparatus should meet the following requirement.

a) It should be capable of being sterilized, this is most importantly essential for testing chlorine effectiveness.

b) It should be capable of collecting a sufficient volume of water for analysis.

c) It should be strong and robust enough to withstand any form of rough handling which it may be subjected to.

d) It should be constructed with such materials that it is considered insert. i.e. it should not alter the P.H of the water sample of contains.

3.5.2 SAMPLYING PROCEDURE

The bottles should be sterilized to make sure it is free from any external contamination. The outlet of the tap was also carefully cleaned by using a clean cloth. The tap was then turned on and was allow to run to waste for a minute or two. This flushed the outlet of the tap and discharged water, which had stop for a period in the service pipe, with the use of matchstick, the outlet was sterilized with a flame, and this was possible when the outlet was unbearable to touch.

After this the tap was allow to run for another one minute. The sample bottle was removed and was carefully opened. The bottle was filled until it almost full, the neck was flamed and the screw replaced with aluminum foil. At no time was the finger allow coming in contact with the mouth and neck of the bottle, this was to avoid any contamination. Each sample collected was numbered, with date and time. Finally the samples were ready and dispatched at once to the laboratory.

3.6 MATERIALS FOR LABOURATORY ANALYSIS.

The following instruments was used in the laboratory.

i. Conical Flask
ii. Laboratory thermometer
iii. Ph. Test kit
iv. Sampling bottle 100ml(I litres)
v. O – tolidine arsenite for (OTA) test
vi. 25ml test tube
vii. sodium arsenite
viii. Refrigerator.

3.6.1 TEMPERATURE

The temperature of the body could be defined as the degree of coldness or hotness of the body. Temperature affects the proportion of water as viscosity, density and surface tension. The temperature also affects the taste and odour and the solubility of chemicals and bacteriological activities

3.6.2 TEST PROCEDURE FOR TEMPERATURE

i. Wash a clean 100ml beaker with water.
ii. Rinse twice with the sample to be tested.
iii. Wash the meter probe also with the sample to be tested.
iv. Press the power key on the temperature key.
v. immerse the probe completely into the sample inside the beaker.
vi. The value of the temperature was read in ^{o}C.
vii. The procedure was repeated for rest of the samples.

3.6.3 P.H VALUE

P.H is the measurement of the degree of acidic or basic nature of the water. Samples and is defined as the logarithm of the reciprocal of the hydrogen ion concentration in moles per litre. The P.H value of water is of great importance. In the control of coagulation process (particles removal), removal of iron (Fe) and manganese (Mn) and corrosion are directly related to P.H.

Most bacteriological activities occur with a P.H range of 6 –8, the killing of disease causing organism in water is called disinfections. Chlorine is used and it is sensitive in its efficiency according to P.H.

3.6.4 TEST PROCEDURES FOR P.H

i. Rinse the measuring vessel with the water to be tested and fill to the 5ml mark.

ii. Add fine drops of universal indicator solution and shake gently.

iii. Place the measuring vessel on the white middle strip of the P.H colour of the solution matches a color scale and slides it along until the colour of the solution matches a color. Comparison value or in between two colour comparison value.

iv. Read off the PH value

v. The same procedure was repeated for the rest of the samples.

3.6.5 FREE AVAILABLE CHLORINE

The killing disease causing organism in water is called disinfections. In this country chlorine is used mainly for disinfection's. An amount of free chlorine is allowed in the treated water to destroy foreign contaminations.ΣCL_2, HOCL, OCL are referred to as free available chlorine.

3.6.6 TEST PROCEDURES FOR FREE AVAILABLE CHLORINE.

i. 6ml of water sample was measured in a test tube.

ii. Ten drop of O- tolidine solution was added and shakes for few seconds.

iii. Comparator was used to measure the concentration of free available chlorine after ten minutes.

iv. The same procedure was repeated for the rest of the samples.

3.6.7 COMBINED AVAILABLE CHLORINE

Monochloramine (NH_2CL), dichloramine ($NHCL_2$), and Nitrogen tricholride (NCL_3), Ammonia, or organic Nitrogen, is essential to the production of these compounds. The distribution of the three species is again a function of PH. Nitrogen trichloride is not formed in significant amounts within the normal PH zone except when the break-point is approached. The prevailing two species, NH_2CL and $NHCL_2$, are referred to in practice as combined available chlorine.

3.6.8TEST PROCEDURES FOR COMBINED AVAILABLE CHLORINE

i. 6ml of water samples was measured in a test tube

ii. Ten drop of O- tolidine solution was added and later shake for few seconds.

iii. Sodium arsenite (a reducing agent) was added to stop the reaction, after the free available chlorine has reacted, at least approximately, before the combined available chlorine has reacted.

vi. Comparator was used to measure the concentration of combined chlorine after sixty minutes.

v. Same procedure was repeated for the nest of the samples.

4. RESULTS AND DISCUSSION

Nine sample were tested at a time for free chlorine and combined chlorine, six of the samples are from the treatment plant which comprises of Raw Water, Aerated Water, Clarified Water, Filtered Water, Clear Water Tank, and at the Main Line, while the other three samples were collected from the distribution lines of Kubwa Housing Estate. One of the samples was immediate collection from the tap, the other sample was exposed for twenty four hours before analysis, finally, the 3rd sample was freeze before the analysis. Careful monitoring of the effectiveness of chlorine dosage was observed along the distribution lines.

The result obtained from the laboratory analysis (free available and combined chlorine) was presented in chronological order in this chapter. These result obtained from the laboratory will also to be compared with World Health Organization Standard (WHO) for drinking water to a certain their effectiveness.

TABLE 4.1 RESULTS

28TH JAN. 2005

P.H	7.2	7.0	6.6	6.8	6.4	7.5	6.6	7.0	6.8
Temp^{0}C	24	25	25	26	25	25	42	25	10
							Flat	1	
Water Sample	Raw Wat er	Aerated Water	Clarified Water	Filter water	Clear Water Tank	Main Line	Immediate collection	Open For 24 Hrs.	Freeze Water
Free Available Chlorine Mg/L (10M)	0.00	0.00	0.3	0.2	2.0	0,5	0.1	0.00	0.1
Combined Cl_2 Mg/l 60 Minutes	0.00	0.00	1.5	1.0	1.5	1.8	0.1	0.00	0.1

Based on the experimental result above in table 4.1, raw water and aerated water have no residual chlorine; but the concentration of chlorine and combined chlorine at the main line before going to the distribution is within the guide line value of World Health Organization standard. The exposed water for twenty four hours has no chlorine residual due to the exposure that make the chlorine to escape to the atmosphere. The immediate collection and the freeze water has the same residual, this implies that residual of chlorine can be maintain at a low temperature.

TABLE 4.1.2 RESULT

31ST JAN. 2005.

P.H	7.2	7.4	6.2	6.2	6.2	7.5	7.0	6.6	6.8
Temp^{0}C	25	25	25	24	25	26	28	27	9
							Flat	2	
Water Sample	Raw Water	Aerated Water	Clarified Water	Filter water	Clear Water Tank	Main Line	Immediate collection	Open For 24 Hrs.	Freeze Water
Free Available Chlorine Mg/L (10M)	0.00	0.00	0.6	0.4	2.0	1.0	0.2	0.00	0.2
Combined Cl_2 Mg/l 60 Minutes	0.00	0.00	1.0	1.0	1.5	1.5	0.2	0.00	0.2

From the above table Raw water and Aerated water has no chlorine residual, but the residual chlorine concentration at the main line before going to the distribution and at the distribution is within the guide line value of World Health Organization standard, but the exposed sample has no residual chlorine either in free form or combined form, probably is due to the exposed to the surrounding.

TABLE 4.1.3 RESULT

4TH FEB. 2005.

P.H	6.8	6.8	6.0	6.2	6.0	6.8	7.0	7.1	7.0
Temp^{0}C	24	25	26	24	25	25	27	26	10
							Flat	3	
Water Sample	Raw Water	Aerated Water	Clarified Water	Filter water	Clear Water Tank	Main Line	Immediate collection	Open For 24 Hrs.	Freeze Water
Free Available Chlorine Mg/L (10M)	0.00	0.00	0.5	0.3	1.5	1.0	0.00	0.00	0.00
Combined Cl_2 Mg/l 60 Minutes	0.00	0.00	1.5	1.0	1.5	1.5	0.00	0.00	0.00

Considering the above experimental result, the chlorine residual at the main line is mineral due to inadequate dosage of chlorine pre-chlorination and post-chlorination chambers, the water sample collected at the distribution has no any residual at all, this may be as a result of the pipe leakages that was observed around such area during sample collection. Therefore the immediate collection, exposed sample and freeze sample has no evidence of free available chlorine or combined chlorine.

4.1.4 Mean

P.H	7.1	7.1	6.3	6.4	6.5	.8	6.9	6.9	6.9
Temp^{0}C	24.3	25	25.3	24.7	25	25.3	26.3	26	9.7
							Flat	1,2 &3	
Water Sample	Raw Water	Aerated Water	Clarified Water	Filter water	Clear Water Tank	Main Line	Immediate collection	Open For 24 Hrs.	Freeze Water
Free Available Chlorine Mg/L (10M)	0.00	0.00	0.5	0.3	1.8	0.8	0.1	0.00	0.1
Combined Cl_2 Mg/l 60 Minutes	0.00	0.00	1.3	1.0	1.5	1.6	0.1	0.00	0.1

4.1.5 STANDARD DEVIATION

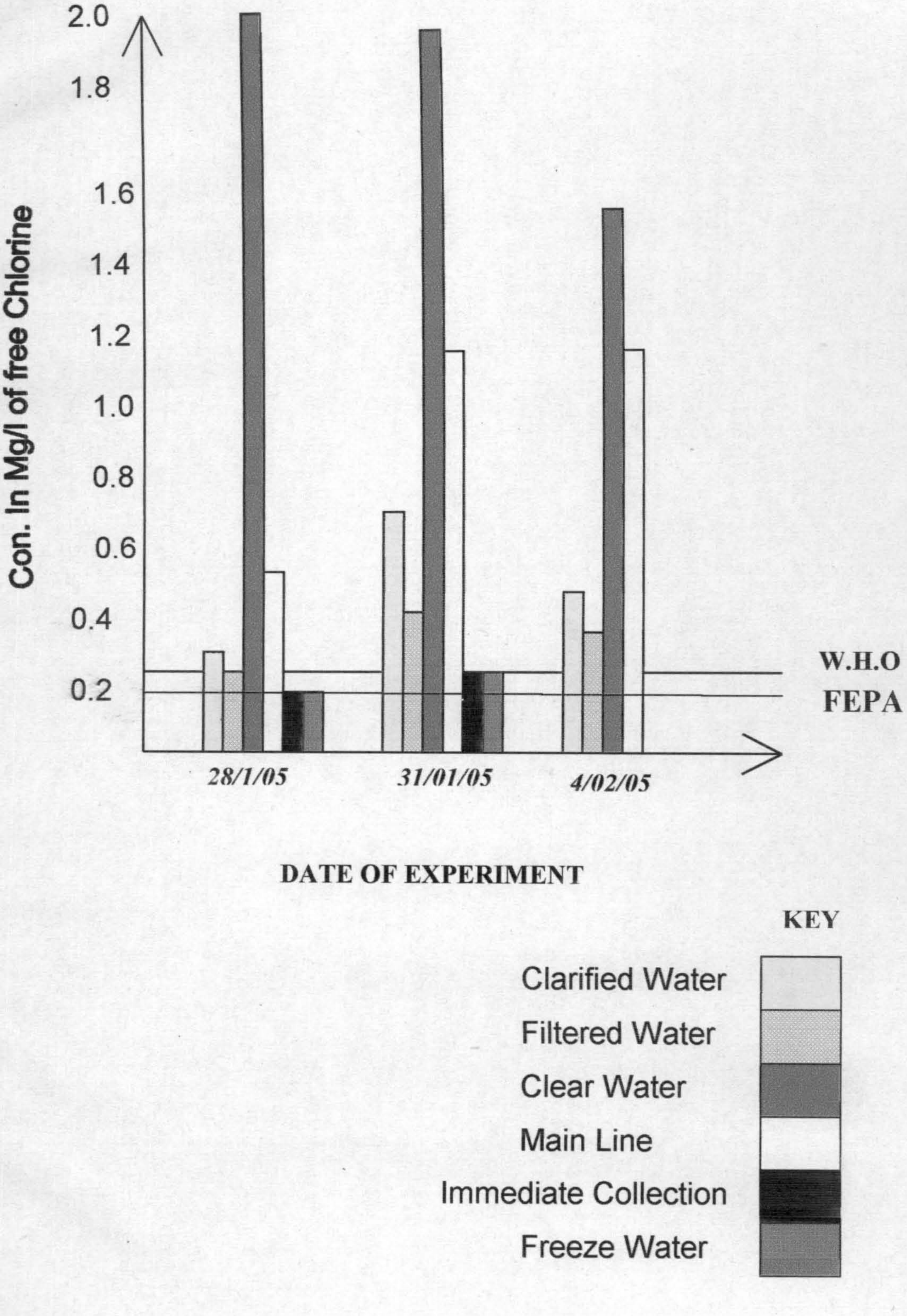
P.H	0.1	0.1	0.2	0.1	0.1	0.0	0.03	0.03	0.03
Temp^{0}C	0.1	0.3	0.4	0.2	0.3	0.4	0.8	0.6	4.8
							Flat	1,2 &3	
Water Sample	Raw Water	Aerated Water	Clarified Water	Filter water	Clear Water Tank	Main Line	Immediate collection	Open For 24 Hrs.	Freeze Water
Free Available Chlorine Mg/L (10M)	0.1	0.1	0.03	0.03	0.5	0.1	0.1	0.1	0.1
Combined Cl_2 Mg/l 60 Minutes	0.2	0.2	0.2	0.1	0.3	0.3	0.2	0.2	0.2

4.1.1 ANALYSIS OF QUESTIONAIRE SURVEY

From the survey carried our around the Municipal town, it was observed that 90% of the people leaving around the sampling points consumed just tap water, 6% consume both tap water and Mairuwa (Water Vendors). The remaining 4% occasionally go for package water along side with the tap water. 10% of the people consuming Mairuwa water complains of being recently affected by water borne or water related disease regardless of the fact that the highest percentage of the public confirming that the tap water is generally clean. The remaining 70% of the people consuming just tap water can not remember when last they had any water related disease.

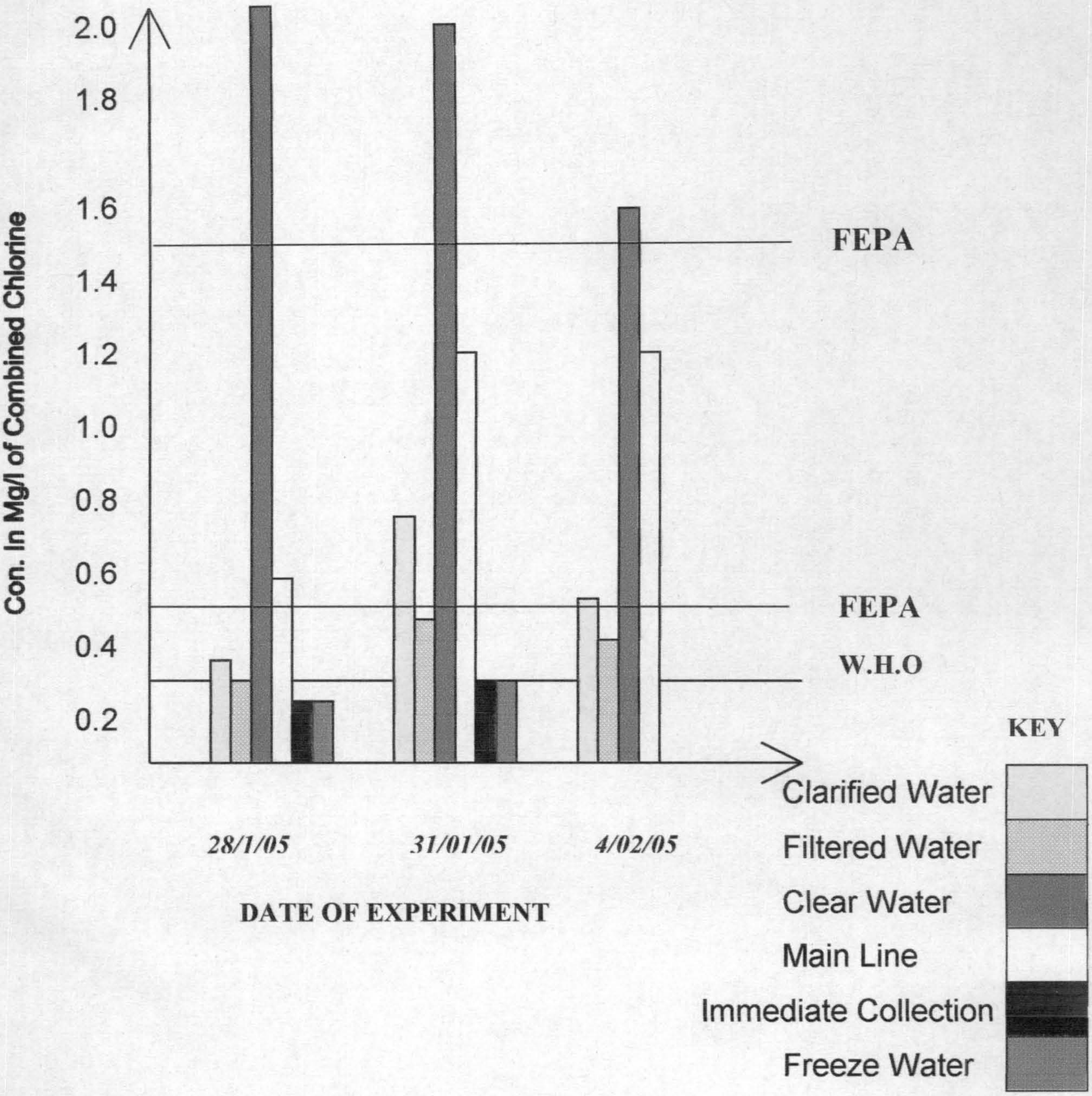
4.1.2 FREE CHLORINE CONCENTRATION

Chlorine is used as a disinfectant for the treatment of drinking water and in special cases wastewater. Chlorine in the form dissolve elemental chlorine, hypochlorous acid and hypochlorite ion is known as free chlorine. Chlorine compound which are formed by reaction of hypochlorite ions with ammonium and organic compounds containing amino groups are known as bond chlorine; both together are known as active chlorine, free chlorine being the stronger oxidizing agent. Free chlorine should be determined at the distribution to guarantee the effectiveness of the dosed chlorine. (0.2 to 0.5)Mg/L of free chlorine should be present in drinking water along distribution points and not less than 0.5Mg/L from the treatment plant outlet chamber.


2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Con. In Mg/l of free Chlorine
W.H.O
FEPA
28/1/05
31/01/05
4/02/05
DATE OF EXPERIMENT
KEY
Clarified Water
Filtered Water
Clear Water
Main Line
Immediate Collection
Freeze Water

4.1.3 CONCENTRATION OF COMBINED AVAILABLE CHLORINE

Concentration of combined available chlorine are generally determined calorimetrically by the O-Tolidine arsenite (OTA) test. The test is based on the favourable difference in rate of reaction of free available chlorine with O-Tolidine.

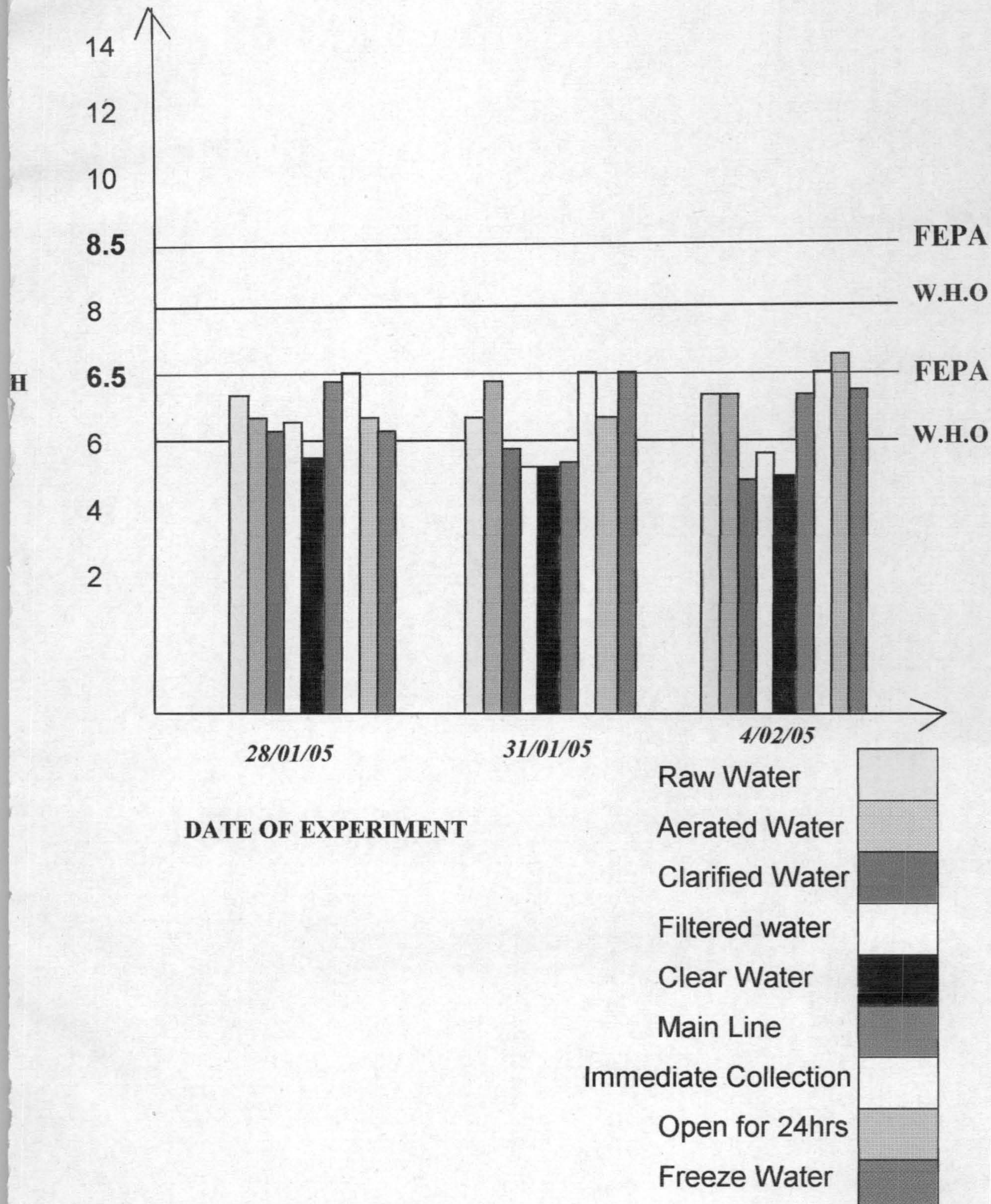


4.1.4 HYDROGEN ION CONCENTRATION P.H

P.H gives intensity of acidity or alkalinity of water.

P.H of pure water (distilled water is 7.0) but P.H may be 4.5 or 8.2 depending on alkalinity and acidity. This kind of situation arises when water contained dissolved impurities. Very acidic or alkaline water P.H is undesirable, because of possible treatment difficulties and corrosive hazards.

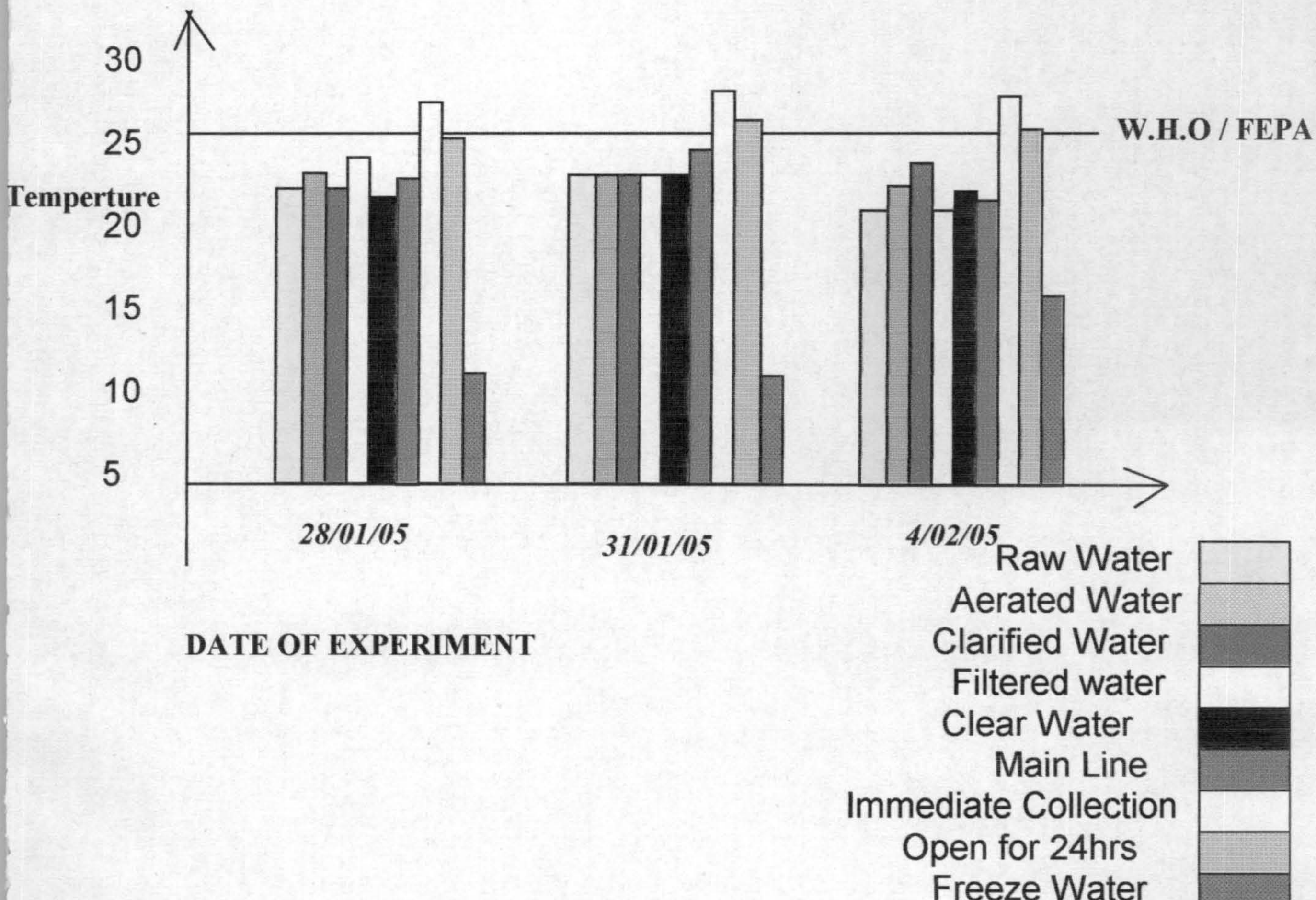
P.H measurement of water suitable for operation and efficiency in coagulation, disinfection, water softening and corrosion control. The guide line value for P.H according to World Health Organization standard is between 6.5 to 8.5, and the undesirable effects is corrosivity or aggresivity and the sources are acid and alkali bearing materials (Ahmed, 1999).


14
12
10
8.5
8
H
6.5
6
4
2
FEPA
W.H.O
FEPA
W.H.O
28/01/05
31/01/05
4/02/05
DATE OF EXPERIMENT
Raw Water
Aerated Water
Clarified Water
Filtered water
Clear Water
Main Line
Immediate Collection
Open for 24hrs
Freeze Water

4.1.5 TEMPERATURE

The temperature of the sample depends greatly on the temperature of the source pumped from the treatment plant and the temperature of the soil through which the pipe passes. Very cold or hot water is not desirable. The solubility of the chemicals and bacteriological activities is influenced by temperature. Temperature also increases the taste and odour. It also decreases the solubility of gases.

On examination the temperature of the sample was found to be between (9-26)^{0}C. The World Health Organization standard temperature of drinking water is 25^{0}C.



CHAPTER FIVE

5. CONCLUSION & RECOMMENDATIONS

5.1 CONCLUSIONS

The necessity of the effectiveness of chlorine dosage to meet the requirement of World Health Organization standards is something that is very essential for portable water. the effectiveness of chlorine from the treatment plant and along distribution network the housing estate was monitored. In order to do this effectively, water samples were collected from the treatment plant for: Raw water, Aerated water, Clarified water, Filtered water, clear water tank along the main line and three different samples within the Housing Estate. Three samples were collected for immediate collection i.e. from the tap at the distribution, three other sample were collected and exposed for twenty four hours before test and the other three sample were freeze before taken to the laboratory for analysis. Each of the samples was tested for free chlorine and combined chlorine to assess their effectiveness, similarly a question survey was also carried out to get the view of the public about the portability of the water entering their houses for consumption and other uses. Results obtained show that the treatment plant is operating below requirement with water bacteriological not fit for drinking because of the low concentration of chlorine residual.

These findings also reveal that pollution increases with the increasing numbers of burst pipes which causes linkages at the distribution.

5.2 RECOMMENDATIONS

Based on these findings of this project, the following recommendations are put forward.

1) More samples should be considered in monitoring the effectiveness of chlorine dosage for better results.
2) The length of the study should cover both raining season and dry season for better representation.
3) Sample should be tested for free chlorine or combine chlorine insitu instead of taking the sample to the laboratory.

REFERENCES

1. **Alayanda A.W (1998)** Pipeline Installation Maintenance & Repairs.
2. **American Society of Civil Engineers (1969)** American Water Works Association Mc- Graw Hill publishing company New York, Page 197 – 233.
3. **Ahmed S.H (1999):** Water Quality for fresh Engineers & Scientists of state &sanitation Agencies.
4. **Abuja Water News (April 1997)** Vol. 2 No.3.
5. **Cain cross S. Caruthers I Curtids D. Feachem R. Bradley D. and Baldwin G (August 1981)** Evaluation for village water Supply & Planning Page 68 – 69.
6. **Gordon M. Fair and John C Geyer (November 1967)** water & waste water Engineering Vol. 2 water purification & waste water treatment & Disposal Page 31-8-31-29.
7. **Hach Company (c) (1983),** Standard method for the Examination of Water & Waste Water.
8. **Mbwette T.S.A (October 1983)** Horrizontal flow roughing filters for Rural Water treatment in Tanzania M. Sc dissertation, University of Dar es Salaam.
9. **Nikoladze G. Mints D and Kastalsky (1989)** Water Treatment for Public & Industrial Supply. Page 213 – 220.
10. **Philip M (1992):** Advance Chemistry, Cambridge Edition.

APPENDIX

QUESTIONAIRE ON QUALITY OF KUBWA WATER BOARD.

1. What is your occupation?

   ☐ Civil Servant ☐ Business Man ☐ Teacher.

2. What type of water do you consume?

   ☐ Tap ☐ Well ☐ Water Hawker (Mairuwa) ☐ Package

3. Do you treat your water before Drinking?.

   ☐ Yes. ☐ No.

4. What type of illness did you experienced?.

   ☐ Typhoid ☐ Diarrhea ☐ Cholera ☐ Dysentery.

5. What is the condition of tap water entering your house?

   ☐ Good ☐ Not Very Good ☐ Bad.

6. Water is the quality of water consumed daily.

   ☐ 25 Litres ☐ 50 Litres ☐ Not Recorded ☐ Less than 25 Litres.

7. How many of you in your flat?.

   ☐ Two ☐ Five ☐ Eight ☐ Above Eight.

8. Do you get water regularly?.

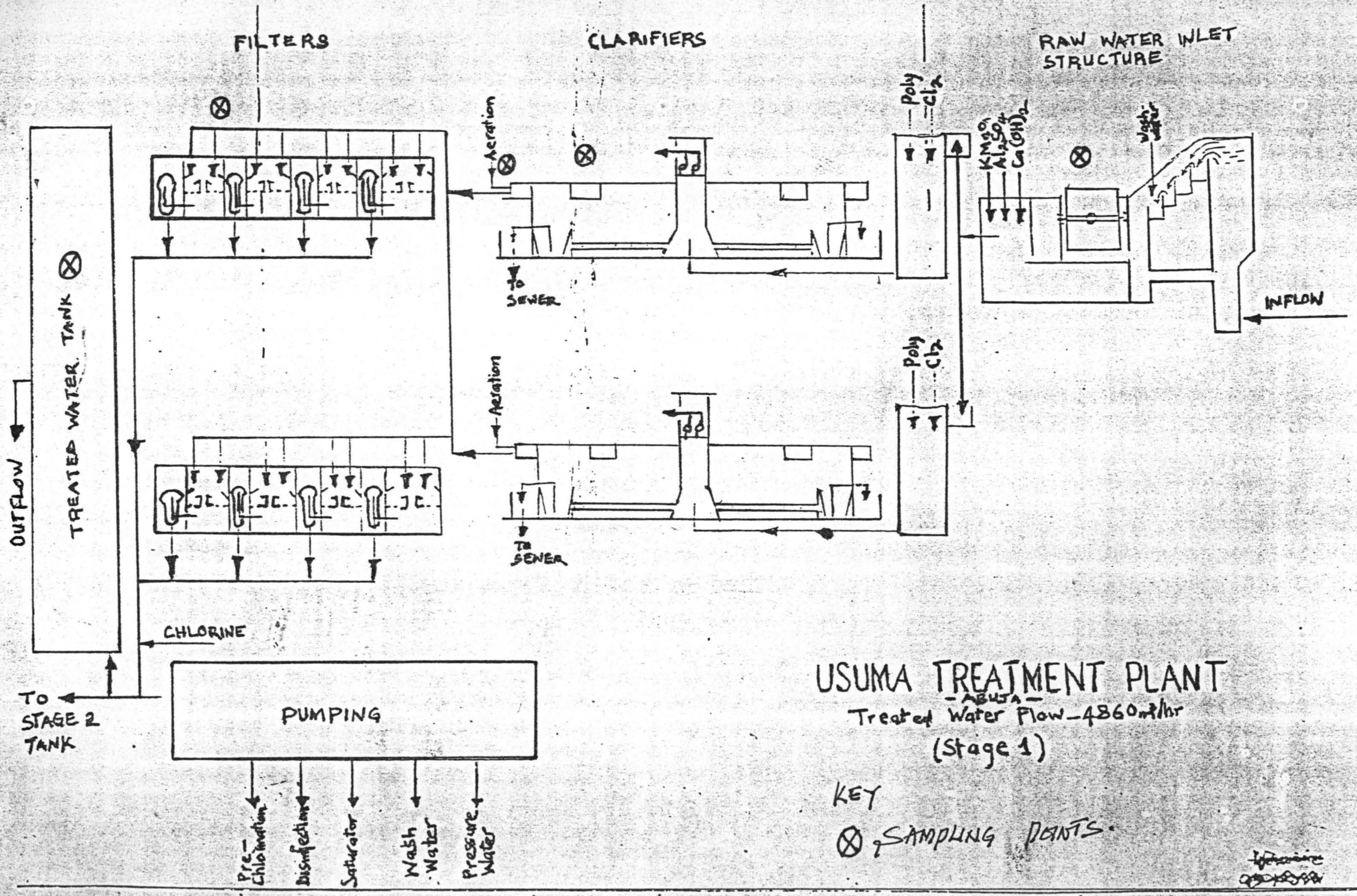
   ☐ Yes ☐ No.

9. What is the colour of the water you drink?.

   ☐ Colourless ☐ Brown ☐ White

10. Have you any pipe leakage around your compound?

    ☐ Yes ☐ No.


FILTERS
CLARIFIERS
RAW WATER INLET STRUCTURE
Poly
Cl_2
$KMnO_4$
Al_2SO_4
$Ca(OH)_2$
Wash water
INFLOW
Aeration
TO SEWER
TREATED WATER TANK
OUTFLOW
CHLORINE
TO STAGE 2 TANK
PUMPING
Pre-Chlorination
Disinfection
Saturator
Wash Water
Pressure Water
USUMA TREATMENT PLANT
-ABUJA-
Treated Water Flow - 4860m³/hr
(Stage 1)
KEY
SAMPLING POINTS.

1.4.1. Flow chart

A synoptical overview is given below :