KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI.

MICRO-BIOLOGICAL AND PHYSICO-CHEMICAL QUALITY OF WELL WATER: A CASE STUDY OF KASSEH IN THE DANGME EAST DISTRICT, GHANA.

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MASTER OF SCIENCE

In

Environmental Science

BY

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DECALARATION

I hereby declare that this thesis is my own work towards the Master of Science (MSc) degree in EnvironmentalScience and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

I dedicate this work to my children, Arnold and Ellen Kubi and my wife for the assistant given to me whilst I pursue this course. God be with them.

ABSTRACT

Access to good quality drinking water has been a challenge to the people in Kasseh who have for years depended on water from hand dug wells as the main source of drinking water. Unfortunately, water from these sources was not treated before consumption. The research sought to determine the levels of physico-chemical parameters such as pH, temperature, conductivity, turbidity, nitrate, iron and calcium. Levels of total coliforms, faecal coliforms and E-coli were determined as a means of checking bacteriological contamination. Water samples were collected from ten (10) different well with an average depth of eight metres (8m) from the study area. The samples were stored in an ice box and transported to the microbiological laboratory at Ghana Atomic Energy Commission for analysis for both physico-chemical parameters and microbial contamination. The data showed variation of the investigated parameters in samples as follows: pH, 6.6–7.1;phosphate 31.4mg/L-46.7mg/L; conductivity (EC), 467–699µS/cm; TDS, 364-439 mg/L; F^-, 0.4–0.60 mg/L; NO_3^-, 21–42 mg/L; TH 45-92 mg/L; Fe, 0.06–0.3 mg/L; Mn, <0.OOO2 mg/L. All the mean figures recorded falls within the permissible limit of the World Health Organisation except the values for total coliform , faecl coliforms and *Escherichia coli* that were above the minimum detection limit (MDL) of 20 MP per 100 ml in all the samples. The concentrations of most of the investigated parameters in the drinking water samples from Kasseh in the Dangme East Municipality were within the permissible limits of the Environmental Protection Agency drinking water quality guidelines. This simply means that the wells were biologically contaminated and should not be use as a source of drinking water unless is been treated.

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ABBREVIATIONS

NTU:	Nephelometric Turbidity Unit
CFU:	Colony Forming Unit
TDS:	Total Dissolved Solids
TH:	Total Hardness
EDTA:	Ethylene Diamine Tetra Acetic Acid
APHA:	American Public Health Association
AWWA:	American Water Works Association
WHO:	World Health Organisaton
WVI:	World Vision International
WATSAN:	Water and Sanitation
VIP:	Ventilated Improved Pit
KVIP:	Kumasi Ventilated Improved Pit
MPN:	Most Probable Number
TV:	Titre Value
FC:	Feacal Coliform
TC:	Total Coliform
DO:	Dissolved Oxygen
TDS:	Total Dissolved Solids

CHAPTER ONE

1.0 Introduction

Accessibility and availability of fresh clean water is key to sustainable development in food production and poverty reduction. However, safe drinking water remains inaccessible to about 1.1 billion people in the world and the hourly toll from biological contamination of drinking water is 400 deaths of children below age five (Gadgil, 1998).In view of this development, people living in most peri-urban and rural areas who happen to be the victims of this condition look for alternative sources of water which includes well water one (Nkansah *etal.*, 2010).

Maintaining secure water supplies for drinking, industry and agriculture would be impossible without groundwater, the largest and most reliable of all fresh water sources. Unlike other natural resources or raw materials, groundwater is present throughout the world. Possibilities for its abstraction vary greatly from place to place, owing to rainfall conditions and distribution of acquifiers (rocks, sand layers and so on in whose pore spaces the groundwater sits). Generally, groundwater is renewed only during a part of the year, but can be abstracted all year round provided that there is adequate replenishment and also the source is protected from pollution (UNESCO, 2001).

Groundwater constitute the underground part of the water cycle and therefore it is closely related to the atmospheric or climatic processes to the surface water regimes of the rivers, lakes and other surface water bodies. Groundwater involved in present day water cycle is comparatively small compared to the volume of groundwater in stock in porous or fractured strata down to a few thousand metres below the surface.

The earth's total resources of fresh water were estimated at about 10,000,000 cubic kilometers-more than two hundred times the global annual renewable water provided by the rain. This was because most groundwater resources have accumulated over centuries or even over millennia (UNESCO 2003). In some places they bear witness to wetter climates in the past. These unique freshwater resources can be found even in present day desert areas. Groundwater is naturally replenished by surface water from precipitation, streams and rivers when this recharge reaches the water table. Groundwater can be a long-term reservoir of the natural water cycle as opposed to short term water reservoirs like the atmosphere and fresh surface water. As citizens we should be aware of potential threats to our groundwater supplies and help to protect these supplies from contamination. There are many different sources of groundwater contamination. Groundwater becomes contaminated when anthropogenic, or people-created, substances are dissolved or mixed in waters recharging the aquifer. Examples of these are road salt, petroleum products leaking from underground storage tanks, nitrates from the overuse of chemical fertilizers or manure on farmland, excessive applications of chemical pesticides, leaching of fluids from landfills and dumpsites, and accidental spills.Contamination also results from an overabundance of naturally occurring iron, sulphides, manganese, and substances such as arsenic. Excess iron and manganese are the most common natural contaminants. Another form of contamination results from the radioactive decay of uranium in bedrock, which creates the radioactive gas radon. Methane and other gases sometimes cause problems. Seawater can also seep into groundwater and is a common problem in coastal areas. It is referred to as "saltwater intrusion"(Cherry *et al.*, 1987).

These contaminants can originate from a “point source” or “non-point source” – meaning they can come from a single source (or point) or, that they don’t have one specific source and come instead from the cumulative effect of any number of factors or activities.In addition, coliform enters water supplies from the direct disposal of waste into streams or lakes or from runoff from wooded areas, pastures, feedlots, septic tanks, and sewage plants into streams or groundwater. Coliform can also enter an individual house via backflow of water from a contaminated source, carbon filters, or leaking well caps that allow dirt and dead organisms to fall into the water (Nkansah*et al.*, 2010).

1.1 Problem statement

Access and affordability to potable drinking water is a major concern of the people in Dangme East District of the Greater Accra Region. Though numerous efforts were made by the District Assembly in providing potable water for the people in the area, it is still not adequate as not all parts of the district were covered during this process.

To alleviate this problem, individuals began to provide hand dug wells at homes to mitigate the problem of water scarcity. These initiatives have resulted in hand dug wells in almost all homes in Kasseh leading to well water as the major source of water for domestic uses in the area.

Unfortunately, some of these wells were constructed close to pollution sources such as septic tanks, dumpsites, latrines. According to Craun (1985), septic tanks represent a significant threat to potability of groundwater, but also to human health and many cases of groundwater contamination have been found in areas of high septic density.

Most of the wells have no casing caps above the ground level and even some of those with casing caps were made of rusted aluminium sheet, old lorry tyres and wood. Domestic animals defecate around these wells and even drink from buckets used to fetch water from the well. Fetching buckets are mainly plastics and often not kept clean as they are normally left on the ground together with the fetching rope.

Animals roam the community in search of food and water and in the process indiscriminately contaminate the water with their feaces since there are no enclosures to restrict them from having access to them.

Unfortunately, water fetched from the wells are not subjected to treatment before being used for domestic purposes especially for drinking.

Unfortunately, there is no documentation on hand dug well water quality in Kasseh as no research so far has been conducted into the major source of drinking water (wells) in the study area . Considering what was happening in the area it was very important to undertake this research which aims at determining the quality of the well waters in Kasseh my area of study.

1.2Broad Objective.

This research is to assess quality of drinking water at Kassehand see if it meets the standard of drinking water in Ghana in terms of microbiological contamination and physic-chemical parameters.

1.3 Specific Objectives

The Research objectives were to determine;

- The levels of total faecal coliforms in well water
- The levels of somephysico-chemical parameters such as pH, conductivity, total dissolved solids, turbidity, total hardness, fluoride, nitrate, iron, phosphate, manganese and magnesium.

CHAPTER TWO

2.0 Literature Review

2.1 Groundwater Pollution

Water pollution (surface and ground) may be considered as a naturally induced change in water quality or conditions induced directly by man's numerous activities which render it unsuitable for food, food, human health, industry, agriculture or leisure suit. Toxic chemical in water pose the greatest threat to the safety of drinking water and their effects are enormous of which can cause damage to human health, crops and aquatic organism(Essumang*et al.,* 2011).

Any addition of undesirable substances to groundwater caused by human activities is considered to be contamination. It has often been assumed that contaminants left on or under the ground will stay there. This has been shown to be wishful thinking (Cherry *et al*, 1987).

2.1.1 Sources of Groundwater Pollution

Both human activities and natural sources have been found to contaminate groundwater (Wright, 1982). Human activities are recognized as having long term, negative effects on groundwater (WeigmanandKroehler, 1990). In dealing with potential pollution sources, there are numerous uncertainties (Glanville *et al.*, 1997) and pinpointing the contamination source and removing contaminants from groundwater is difficult and, therefore, makes clean up very expensive (WeigmanandKroehler, 1990). Regardless of the distance, a potential pollution source should not be located uphill from a well (Spellman, 2003). It should be remembered that well construction and well placement may allow nitrate contamination to occur, but are not the cause of contamination (Hallberg, 1989).

2.1.2 Septic Systems

The United States Environmental Protection Agency reports that septic systems are the major source of groundwater contamination with the potential to release nitrates and bacteria into the groundwater (WeigmanandKroehler, 1990). The average nitrogen concentration of domestic sewage is 35 mg/L (Horsley, 1995) and has been found to be as high as 70 mg/L (Madison and Brunett, 1985). It is estimated that 60% of the 23 million residential septic tanks in the US are operating improperly. One-third of US households dispose of their almost trillion gallons of wastes using septic systems. The potential problem with septic systems is magnified because those who use them often rely on nearby wells for drinking water (WeigmanandKroehler, 1990). The soil in which a septic system is located should absorb the effluent and provide a high level of treatment. Sand allows the wastewater to pass through too quickly while heavy clay inhibits wastewater movement. Like sandy, permeable soils, areas with fractures or solution channels allow for septic tanks to release nitrates directly into shallow groundwater. Difficulties also occur when septic systems are densely located because they may exceed the soil's capacity to filter impurities. Septic systems must be properly sited (at least 100 ft downhill from wells or Springs), designed, and constructed in order to prevent contamination of groundwater (Weigman andKroehler, 1990).

2.1.3 Fertilizer

The largest nonpoint source of nitrate is agricultural activity (Madison andBrunett, 1985).

More specifically, the high concentration of nitrogen in fertilizer and high application rates of fertilizer, make commercial fertilizers likely to have the greatest impact on groundwater (WeigmanandKroehler, 1990). Synthetic chemicals such as herbicides and insecticides as well as fertilizer runoffs from agricultural farmlands and industrial discharge have the potential to impact on negatively on human health since they block vital metabolic processes in the human body (Essumang*et al.*, 2011).Typically, only when fertilizers are applied in excess of the plant's requirements do they have the potential to contaminate groundwater (Madison &Brunett, 1985; Spalding andExner, 1993). Evidence of this comes from studies conducted in North Carolina and the Southeast where properly fertilized fields did not affect nitrate levels even en in wells down gradient from the fields (Spalding and Exner, 1993). According toChandio(1999), applications of nitrogen-phosphorous-potassium(NPK) fertilizers have been increasing in Pakistan over the last few decades, with applications of nitrogen fertilizers reaching an excess of 2 million tonnes by the late 1990s. As a result, the concentration of chemical compounds has become common in groundwater in the world.

2.2 Physico-chemical Parametersof Water

2.2.1 Mangenese(Mn_2)

Manganese is a vital micronutrient for both plants and animals but when taken in very large doses can cause some diseases and liver damage (Kortasi, 2010). Manganese is abundant in the earth's crust. Upper crustal abundance is around 0.05-1.0% MnO (Taylor and McLennan, 1985). Manganese resembles iron in its chemical behaviour and it's occurrence in groundwater is less abundant than iron. It is found to be lower than iron although in deep wells manganese may reach concentrations as high as 2 to 3 milligram per liter. Solid waste when dissolved usually contains abundant manganese

(DHMT,2006). Manganese at excessive concentrations can be detrimental to human health. Evidence from occupational exposure indicates that manganese can affect neurological function. Miners and welders exposed through airborne contamination for long periods have developed neurological disorders such as parkinson's disease (Esrey*et al.*,1991). Some links have been made between exposure to manganese and a form of motor neuron disease found in the Pacific region, known as Guamian amyotrophic lateral sclerosis (Essumang*et al., 2011*). Pelig-Ba(1989) found correlations between the concentrations of manganese in food and the prevalence of motor neuron disease in the Kii Peninsula of Japan. Cawte*et al.,* (1992) also reported neurological symptoms in manganese ore miners from Australia. Occupational exposure to manganese has also been linked with liver, kidney and lung damage.

2.2.2 Nitrate

Nitrate is easily taken up by plants but also easily leached through the soil because it is very

soluble and very mobile (Hallberg, 1989). The leaching of nitrate is greatest in sandy soils (Hubbard and Sheridan, 1989). Nitrate leaching must be controlled in order to protect or improve water quality (Schepers*et al.*, 1991). At high concentrations, nitrate is a hazardous pollutant in drinking water (Madison andBrunett, 1985). Nitrate is the most common contaminant in numerous aquifers (ClawgesandVowinkel, 1996; Madison andBrunett, 1985) and is a worldwide concern (Schepers*et al.*, 1991). Within the world's aquifers, the levels of nitrate are increasing (Spalding andExner, 1993; Madison andBrunett, 1985). The increase in nitrate levels are likely linked to rapid population growth (Madison andBrunett, 1985).

Natural nitrate concentrations in groundwater range from 0.1 to 10 mg/l (Adeyemo*et al.*, 2002). Nitrate in concentration greater than 45mg/l is undesirable in domestic water supplies because of the potential toxic effect on young infants. Methemoglobinemia is a disease caused by nitrate, which is converted to nitrite in the intestines (Darko*et al*., 2000). The safe nitrate limit for domestic water is set at 45mg/l by WHO (1984). Nitrate cannot be removed from water by boiling but must be treated by distillation. Nitrate was absent in most of the wells in Benin metropolis (Omofonmman*et al.*, 2009).

2.2.3 Iron

Most groundwater supplies contain some iron because iron is common in many aquifers and is found in trace amounts in practically all sediments and rock formations (Schafer, 2008). The iron content of groundwater is important because small amounts seriously affect water's usefulness for some domestic and industrial purposes (Smedley, 1996). The World Health organization recommends that the iron content of drinking water should not be greater than 0.3mg/L because iron in water stains plumbing fixtures, stains cloths during laundering, incrusts well screens and clogs pipes (Quist, 2004). In Benin metropolis, the Urban Water Board recommends 0.3mg/l of iron as the maximum expected limit. All the wells analysed in Benin metropolis falls within the range except that of Edo College which is . 25mg/l (Omofonmman*et al.*, 2009).The common form of iron in the pH range for the groundwaters in the District is the soluble ferrous ion ($Fe2^{+}$). When exposed to the atmosphere, $Fe2^{+}$is oxidized to $Fe3^{+}$. In this state it hydrolyses and precipitates as ferric hydroxide, causing a brown discolouration of the water and the characteristic brown stains in sinks and laundered textiles(Kortasi, 2007). According to Schafer, 2008, iron was also found in elevated concentrations in waters in Ghana. Iron in itself is not a health concern issue, however elevated levels affect the taste and quality of drinking water, leading to colouration of cooking utensils and food.

2.2.4 Magnesium

Magnesium (Mg) isabundant in soil and rocks and essential to human health. The most common source of magnesium is through the erosion of rocks such as limestone and dolomite, and minerals, such as calcite and magnesite (UNESCO-WWAP 2003).

Magnesium controls muscle contraction, protein metabolism, blood coagulation, and energy production, among other vital tasks. Failure to take in enough magnesium over time leads to high blood pressure and osteoporosis (Deborah Chapman, 1996).

That said, not only does this mineral aid in body functions, it can also help prevent disease. Studies show that magnesium in drinking water protects against the deaths of patients with diabetes mellitus, and prevents the development of cerebrovascular disease. Magnesium also lowers the risk of fatality from acute myocardial infarction (heart disease), particularly in females. In high-risk patients, magnesium is recommended to protect against gastric cancer. At high concentrations, magnesium salts have a laxative effect particularly when present as magnesium sulphate (Smedley*et al.*, 1992). Magnesium content in the investigated water samples was varied from 31.19 mg/L to 87.71 mg/L and found above prescribed limit (Awuah *et al.*, 1996).

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2.2.5 Calcium

Calcium (Ca) is abundant in soil and rocks. It is essential to human health (Awuah *et al.*, 1996).
Adults should consume 1000-1200 mg of calcium per day. The human body needs calcium to develop strong teeth and bones. With that, calcium can combat osteoporosis and other bone disorders. It also helps in regulating nerve transmission, blood coagulation, and muscle contraction. Water with high

calcium content is undesirable for household uses such as washing, bathingand laundering because of consumption of more soap and other cleaning agents. In the presentinvestigation, calcium concentration ranged from 58.52 mg/L to 152.3 mg/L and found higherthan prescribed ISI 10500-91 limits. (Quist, 2004).

2.2.6**Total Dissolved Solids (TDS)**

Total Dissolved Solids (TDS) are solids in water that can pass through a filter. TDS is a measure of the amount of material dissolved in water. These materials include; carbonate, bicarbonate, chloride, sulphate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions.

The effects of TDS are; reduction in water clarity, combine with toxic compounds and heavy metals, and lead to an increase in water temperature, high TDS water often has a bad taste and/or high water hardness, and could result in a laxative effects. TDS is used to estimate the quality of drinking water, because it represents the amount of ions in the water.

The source of TDS are; Geology and soils which release ions very easily, urban and fertilizer run- off and decaying organisms. Permissible limits by WHO for TDS in drinking water is 1000 mg/l.

Olobaniyi (2007) reported TDS levels of 21.90 to 300.50 in well water.

2.2.7 Fluoride

Fluoride (F) offers protection against dental caries at low concentrations but at higher levels causes serious problems such as dental and skeletal fluorosis (Schafer 2008). The dominant controls on fluoride occurrence in groundwater are climate and geology. The regionsof Ghana most vulnerable to high fluoride concentrations (and associated dental fluorosis) arethe arid zones of the north and areas where bedrock geology is dominated by granite (Adzaku, 1989). The UpperRegions of Ghana are therefore considered to be the most likely areas to experience potentialproblems. Concentrations of fluoride in excess of 1.5 mg/l (up to 3.8 mg/l) have been observed inBolgatanga and Sekoti in close association with granitic rocktypes (Smedley*et al.*, 1995). Occurrence of dental fluorosis is common in these areas. Groundwatersin granitic rocks of the south-west plateau are considered to be less at risk because of higherrainfall and its diluting effect on groundwatercompositions (Pelig-Ba,1999).Special care should be taken when fluoride is ingested by children—levels over 2 mg/L can damage developing adult teeth before they break through the gums (Cawte*et al.*, 1992).

Most water systems add fluoride to their water supplies, but not all; check with your local provider for additive levels in your area(*Roger*, 1982).

According to recent news and reports, most tap and well water in the U.S. are not safe for drinking due to heavy industrial and environmental pollution. Toxic bacteria, chemicals and heavy metals routinely penetrate and pollute our natural water sources making people sick while exposing them to long term health consequences such as liver damage, cancer and other serious conditions (Dethier, 1988).

2.2.8 Phosphate

The phosphate ion is a polyatomic ion with the empirical formula (PO_4^{2-}). It consists of one central phosphorus atom surrounded by four oxygen atoms in a tetrahedral arrangement.

Phosphorus is the body's source of phosphate, which helps create and manage energy, synthesize protein, fat and carbohydrates, contract muscles, maintain the body's fluid and electrolyte balance, stimulating hormone production and helping the body utilize the B vitamins, speeds up healing, helps treat bone diseases such as rickets and prevents stunted growth in children. Depletion of phosphorus results in health problems such as: anxiety, bone problems, fatigue, irregular breathing, irritability, skin sensitivity, stress, teeth weakness, tremors, weight changes, malaise, stiff joints, bone pain, irregular heartbeat twitching, jerking, and convulsions (http://www.vitamins-nutrition.org/mineral/index.html).WHO guideline level in drinking water is 400 mg/l.

Salvato*et al.* (2003) has it that, phosphorus is usually associated with plant remains, animal wastes or fertilizer. Tjandraatmadja*et al.* (2010) stated other potential sources as; cleaning products, cosmetics, medicated shampoos, food products, faeces and urine.

2.2.9 pH

The indicator for acidity or alkalinity, or basic, is known as the pH value. A pH value of 7 means a substance is neutral (Dethier, 1988). The lower value indicates acidity, and a higher value is a sign of alkalinity. (Awuah andAbrokwah 2008). Basically, the pH value determines whether water is hard or soft. The pH of pure water is 7. In general, water with a pH lower than 7 is considered acidic, and with a pH greater than 7, basic. The normal range for pH in surface water systems is 6.5 to 8.5 and for groundwater systems 6 to 8.5 (Asomaning, G. 1993). Alkalinity is a measure of the capacity of the water to resist a change in pH that would tend to make the water more acidic. The measurement of alkalinity and pH is needed to determine the corrosiveness of the water (Pelig-Ba, 1989).

In general, water with a low pH (< 6.5) could be acidic, soft, and corrosive. Therefore, the water could contain metal ions such as iron, manganese, copper, lead, and zinc...or, on other words, elevated levels of toxic metals. This can cause premature damage to metal piping, and have associated aesthetic problems such as a metallic or sour taste, staining of laundry, and the characteristic "blue-green" staining of sinks and drains(Kesse, G. O. 1985). More importantly, there are health risks associated with toxic metals in groundwater(Asomaning, G. 1993). The primary way to treat the problem of low pH water is with the use of a neutralizer. The neutralizer feeds a solution into the water to prevent the water from reacting with the household plumbing or contributing to electrolytic corrosion. A typical neutralizing chemical is soda ash. Neutralizing with soda ash, however, increases the sodium content of the water (Faure, 1998).Although some bacteria are known to grow at pH 3.0 or perhaps in even more acid media, most species have an optimum range between pH 6.0 and 8.5. A few bacteria are known which prefer alkaline media of pH 8.5 (Esrey*et al.*, 1991). Levels of pH greater than 9 are effective in pathogen removal (Quist, 2004). Moreover, optimum pH for the growth of nitrifying bacteria is in the 8 to 9 range, with pH levels below 7 causing a substantial reduction in nitrification activity (Quist, 2004).

2.2.10 Turbidity

Turbidity is a measure of light transmitting properties of water. It is another test used to indicate water quality of waste discharges and natural waters with respect to colloidal and residual suspended matter. The measurement of turbidity is based on comparison of intensity of light scattered by a reference suspension under the same conditions (Glanville *et al.*, 1997). Turbidity measurements are reported as Nephelometric turbidity units (NTU). Colloidal matter would scatter or absorb light and thus prevent its transmission (Awuah *et al.*, 1996).Turbidity makes water unfit for domestic purposes, food and beverage industries and manyother industrial uses. In the present analysis, turbidity values varied between 0.1 to 3.1 NTUand found within the limits prescribed by WHO and ISI 10500-91.Turbidity range of 2.5 to 7.0NTU.was reported by Shittu*et al.* (2008) in dug well water samples in Abeokuta, Nigeriawhilst the World Health Organization (WHO) guideline value of turbidity for drinking water is 0 - 5NTU.

2.2.12 Alkalinity

Alkalinity is a total measure of substance in water that has “acid-neutralizing” ability (Asomaning, G. 1993). Themain sources of natural alkalinity are rocks which contain carbonate, bicarbonate and hydroxide compounds; borates, silicates and phosphates may also contribute to alkalinity (Kesse, G. O. 1985). High salinity levels of groundwater appear to be responsible for poor quality of water in the Accra plains(Kortatsi*et al.*, 2001). The alkalinity of water is defined as its capacity to neutralize acids. The main ions that contribute to the alkalinity of natural waters are hydroxides (OH^-), carbonate (CO_3^{2-}) and bicarbonate(HCO_3^-) UNDP (1994).

The Akatsi District recorded alkalinity values varying from 24 to 620mg/l with a mean value of 220.4mg/l whilst boreholes in the Ketu District recorded alkalinity values varying from 16 to 764mg/l with a mean value of 262.5mg/l(Tay, C.K, 2002).

2.2.13 Total hardness (TH)

Total hardness is defined as the concentration of calcium and magnesium and is expressed in the in milligram calcium carbonate ($CaCO_3$) per litre (UNDP, 1994).

Hardness in water is due to the natural accumulation of salts from contact with soil andgeological formations or it may enter from direct pollution by industrial effluents (Annang, 2000). Water with a pH > 8.5 could indicate that the water is hard. Hard water does not pose a health risk, but can cause aesthetic problems (Awuah *et al.*, 1996). These problems include an alkali taste to the water (making that morning coffee taste bitter!), formation of a deposit on dishes, utensils, and laundry basins, difficulty in getting soaps and detergents to lather, and formation of insoluble precipitates on clothing(Esrey*et al.*,1991).According to a Wilkes University study, because of the association of pH with atmospheric gases and temperature, it is strongly recommended that water samples be tested as soon as possible. The study says that the pH value of the water is not a measure of the strength of the acidic or basic solution, and alone cannot provide a full picture of the characteristics or limitations with the water supply (Cawte*et al*., 1992).Shittu*et al.* (2008) and Adefemi and Awokumi (2009) reported TH levels of 72 to 108mg/l and 130 to 298mg/l respectively in hand dug wells in Abeokuta, Nigeria. Fasunwon*et al.* (2008) observed TH range values of 25 to 61mg/l in dug wells of Ago – Iwoye State, Nigeria. WHO standard for Total hardness in drinking water is 500mg/l.

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2.2.13 Electrical conductivity (EC)

Electrical conductivity is a measure of water capacity to convey electric current (Quist, 2004). It signifiesthe amount of total dissolved salts (Awuah *et al.*, 1996). Conductivity is the ability of water to conduct electrical current. Conductivity increases as the concentration of ions increases, since electrical current is transported by ions in solution (Smedley, 1996). Abrupt changes in conductivity might indicate that water or wastes are being diverted into the stream from a new source. Conductivity could be used as a measure of total dissolved solids (Faure, 1998). Conductivity is also a good measure of salinity in water (Kesse, G. O. 1985).

2.2.14 Bacteriological Indicators for Water Quality

The greatest risk from microbes in water is associated with consumption of water that is contaminated with human and animal excreta, although other sources and routes of exposure may also be significant.

Groundwater from a shallow origin is particularly susceptible to contamination from a combination of point and non-point sources (Asomaning, G. 1993).

Faecal indicator bacteria including E. Coli are important parameters for the verification of microbial quality of groundwater. Analysis for feacal indicator bacteria provides a sensitive although not the most rapid indication of pollution of drinking water supplies (Quist, 2004).

Total coliforms are generally measured in 100 ml samples of water. A variety of relatively simple procedures are available based on the production of acid from lactose or the production of enzyme ß-galactosidase. The procedure include membrane filtration followed by incubation of the membrane on a sensitive media at 35^0C-$37^0C$and counting colony forming units after 24 hours (Awuah and Abrokwah 2008).According to WHO (2004), E. *coli* is present in very high numbers in human and animal faeces.

Mean *E. coli* value of 2.7×10^3 was observed by Wright (1982) in dug well water samples in Sierra – Leone.

CHAPTER THREE

3.0 Material and Methods

3.1 Study area

Kasseh is found in the Dangme East Municipality which is located in the Eastern part of the Greater Accra Region within Latitudes 5°45' south and 6°00' north and from Longitude 0°20' west to 0°35' East. The district shares common boundaries with North Tongu District at the North, South Tongu and Dangme West Districts at the East and West respectively. At the south is the Gulf of Guinea, which stretches over 45 kilometres (27.9 miles).The Municipal covers a total land area of about 909 sq km (350 sq miles) about 28% of the total area of the Greater Accra Region.Ada Foah, the District Capital is located at the south-eastern part, about 20km off the Accra-Aflao road, along the coast and about 2km from the Volta River Estuary. Other major settlements are Big Ada, Kasseh, Got, Anyamam, Lolonya, Akplabanya, Wokumagbe and Koluedor.

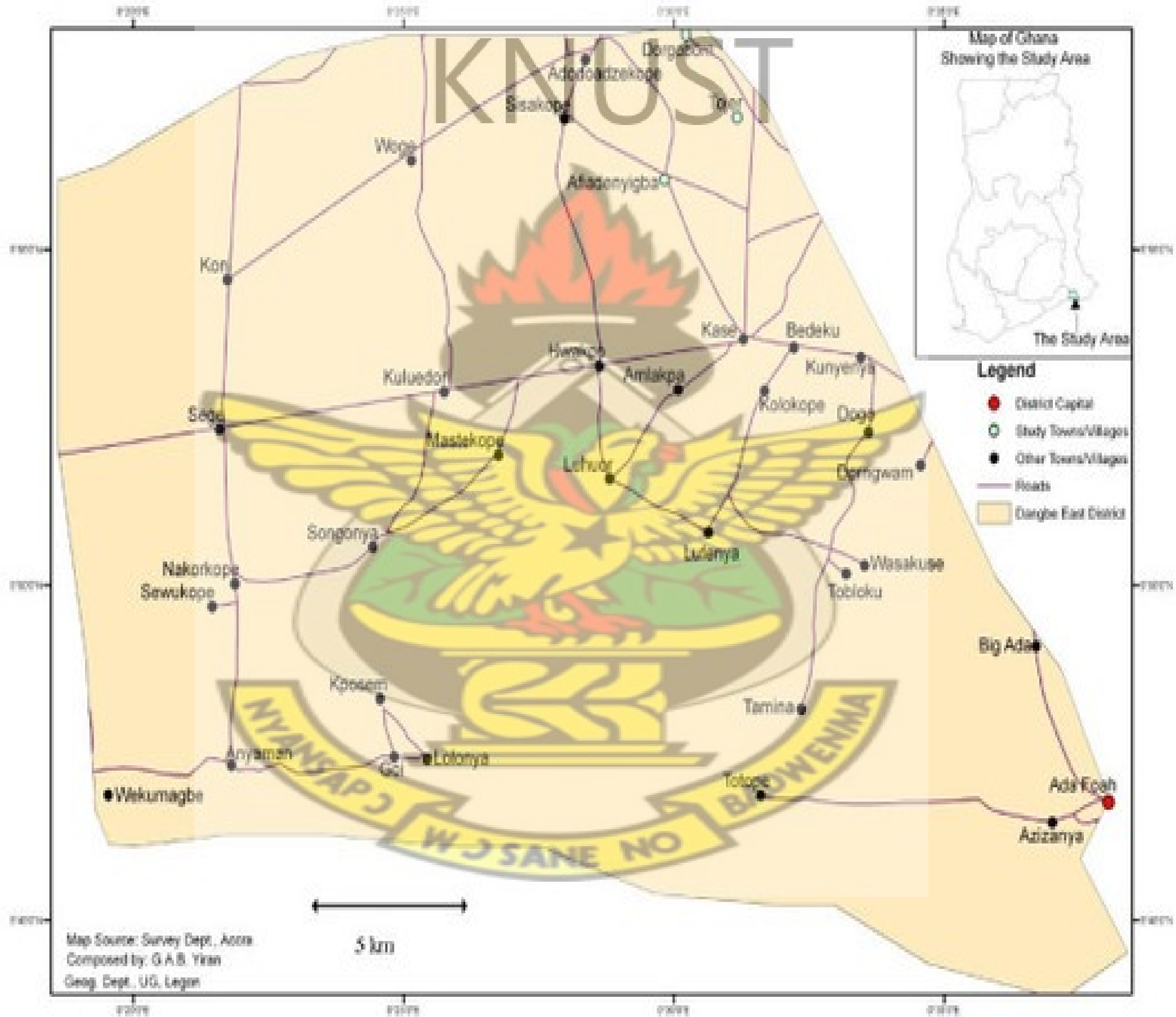

Figure 3.1: map of Dangme East District.

Source: Town Planning Department: Dangme East Municipal Assembly.

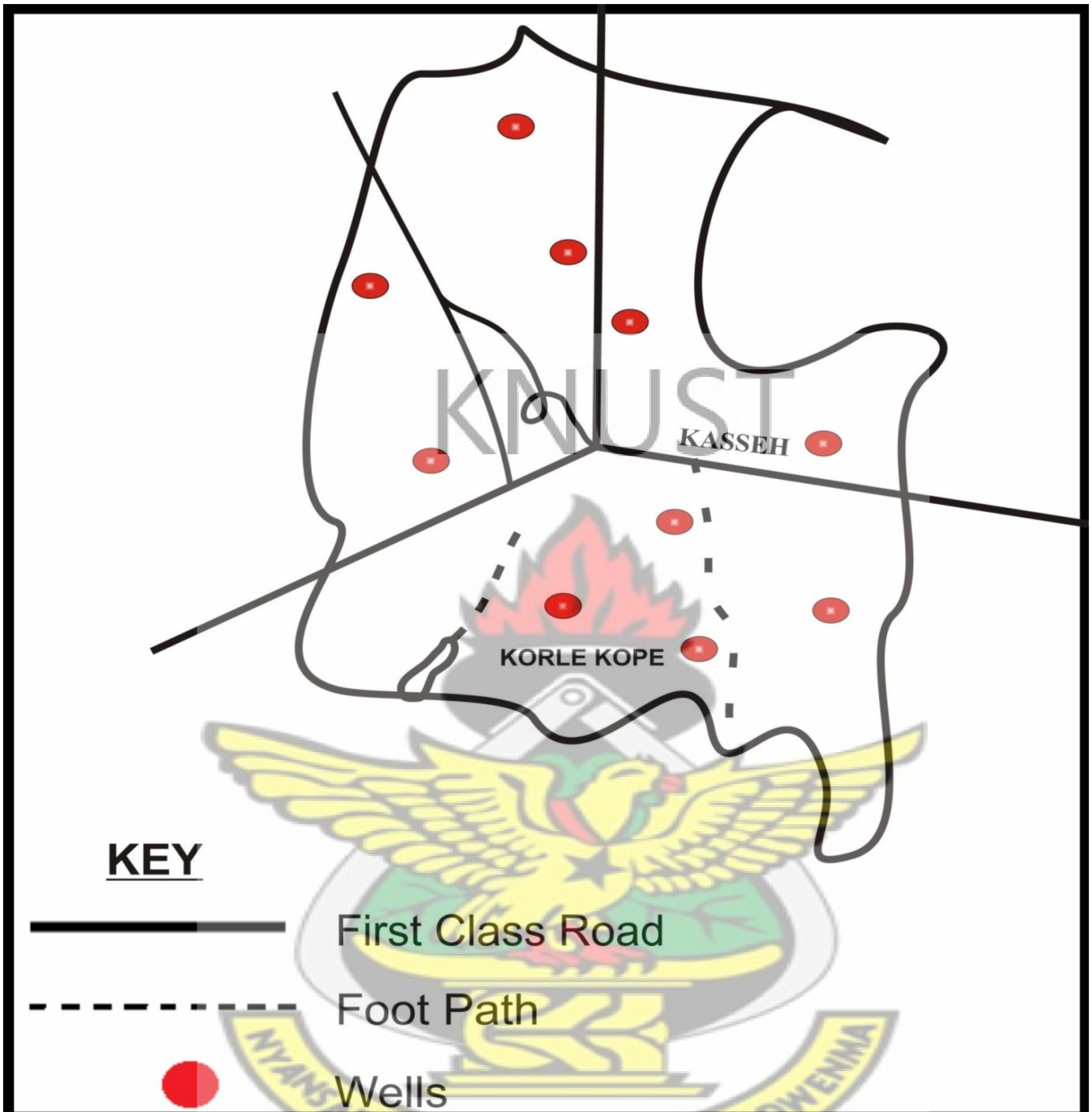

Fig 3.2: A sketch showing the sampling points used during the research.

Well A1

The depth of the well is 6.5m and it is located 9.2m from a latrine on a low lying ground. The fetching bucket is a plastic type. The well has a concrete case and a wooden slab but the inside is not lined with concrete. Animals easily have access to the well as they roam in the community.

Fig. 3.2.: Picture of Well A1

Well A2

The well is 7m deep and surrounded by two septic tanks. One septic tank is located inside the house 8m from the well and the other about 12m behind the house. The well lies on a lower ground than the two septic tanks. The well has a concrete case above the ground level but the inside is not lined with concrete. The well has no cover as in the case of some other wells in the community. Fetching bucket is an old plastic type which is not often kept clean and always exposed.

Fig. 3..2: Picture of Well A2

Well A3

This well is 7.8m from a septic tank and 8.5m deep. It has a concrete case above the ground and a wooden slab. The fetching bucket is usually exposed and sometimes put on the ground together with the rope which normally becomes dirty before use.

Fig. 3.2.: Picture of Well A3

Well A4

The well is 6.6m deep and 17.3m away from a latrine. The well has a concrete case above the ground and wooden slab. It has an old fetching bucket. The rope use for fetching the water is always kept on the concrete case. The well is close to a main street. Animals roaming sometimes defecate around the well.

Fig. 3.2.: Picture of Well A4

Fig. 3.2.: Picture of Well A5

Well A6

This well is 6m deep and inside is lined almost to the bottom. The well is provided with a concrete case above the ground. Boththe fetching bucket and the ropeare usually kept the ground. The well was not close to either a septic tank or a latrine.

Fig.3.2. : Picture of Well A6

Well A7

The well is 5m deep and located under a mango tree. It has a concrete caseabove ground and a wooden slab as its cover. Fetching bucket is a plastic type and most of the time kept on the well. The well is located in the house. The inside is not lined with concrete.

Fig. 3.2.: Picture of Well A7

Well A8

It is 7.5m deep. It has no concrete case but a disjointed wooden slab. The well is located near untarred road. It has an old cracked concrete case above the ground. There is no cover for the well. Animals easily have access to the well. A plastic type of fetching bucket is used and the rope use for fetching are usually left on the ground.

Fig. 3.2.: Picture of Well A8

Well A9

It is 6m deep with a concrete case above the ground level. Fetching bucket is a plastic type. Only the upper portion of the well is provided with concrete.

Fig. 3.2.: Picture of Well A9

Well A10

It is 7.4m deep. It is concreted above the ground with a well covered slab. It is located higher than the ground. Animals do not have easy access to it. Fetching bucket is mainly a plastic type. Good sanitation practice was maintained around this well.

Fig. 3.2.: Picture of Well A10

3.1.1 Climate

The area experiences bimodal rainfall periods. The major one occurring between April/May-July and the minor occurs between September-November every year. The mean annual rainfall is 900mm. Mean annual temperature is about 27^{0}c with day maximum reaching 33ºC at the peak of the hottest months of February and March. During the harmattan period, between December and January, the lowest temperature of about 22ºc is experienced because of the North-East trade winds.

3.1.2Vegetation and Soil

The predominant vegetation is the coastal savannah with woody grassland. A sparse population of neem (Azadiractaindica). Different soil types are found in the Municipal. The various soil types in the district, their characteristics, distribution and agricultural activities.Red Earth with Redish brown Loamy in texture, well-drained, porous permit better vast development, mechanical cultivation located in Tojeh, Caesarkope, and Asigbekope communities is suitable for the cultivation of maize, cassava and vegetables.The soil is basically clayey with few portions of the land being sandy.The greater part of the Municipal is underlaid by tertiary and recent deposits. A small section in the northern and eastern parts (between Afiadenyigba and Sege fall under the Dahomeyan complex rocks of precambrian age.The recent unconsolidated sand, clay and gravel occur in the deltaic areas of the volta , river as well as in the areas surrounding the songor lagoon.The rock of the basement is the dahomeyan, similar to that cropping out to the north of the basin. The Dahomeyan rocks consist predominantly of gneisses, schists and migmatities. These rock whether into dark grey calcareous clay and silt which are only slightly permeable.

3.1.2 Data Collection

Data was taken from November 2010 toApril 2011 and on each visit samples of water was drawn from tens wells from the study area into ten sterilized bottles of capacity of 1.5 litres. The study area was divided into ten zones from which one well was selected at random for sampling. The wells have an average depth of eight (8) metres. The bottles containing the water were stored in ice box with ice in it to regulate the temperature in order that the suspected organisms were not destroyed by excessive temperature. The samples were sent to the chemistry laboratory at Ghana Atomic Energy Commission for analysis within six hours from the time of collection.

3.1.3 Procedures for Laboratory Analysis

3.3.1Total Hardness Determination

Total hardness was determined using the EDTA Titration Method. Fifty (50) ml of the samples was measured into a conical flask and 1ml of buffer solution was added. This was followed by the addition of few grams of Eriochrome Black T. indicator. Titration was done using 0.01 M EDTA solutions, mixing gently until the colour changes from red to blue. The titre value (Tv) was read and concentration computed as;

Total Hardness (mg/L) =Tv x 20.

3.3.2 Conductivity and Total Dissolved Solids (TDS) Determination

A multifunctional conductivity meter (HANNA model HI 9032) was used to determine the conductivity and TDS of water samples in the laboratory. It was calibrated by using sodium chloride standard solution of 12880µS/cm. The conductivity meter was then returned to the operation mode to facilitate measurement. About 50ml of the water sample was poured into a clean glass beaker and the conductivity meter electrode was then inserted into the water sample. The value was read and recorded after five (5) minutes, in µS/cm.

TDS was determined by pouring about 50ml of water sample into a clean glass beaker. The electrode was then immersed into the sample and stirred to ensure uniformity. After the reading stabilized, the value was read and recorded in mg/L. The same procedure was repeated for all other water samples.

3.3.3 Turbidity Determination

Turbidity of water samples was determined with HACH turbidimeter (model number CO 150). The turbidity meter was first calibrated with Formazin standard solutions of 0.2 NTU, 10 NTU, 100 NTU and 1000 NTU by filling consecutively a clean dry cuvette with the well mixed standard solutions. It was then returned to the measurement mode and used.

A clean dry cuvette was rinsed three times with the water sample to be tested. The cuvette was filled with 10ml water sample to be analysed.The light shield cap was replaced. The outer surface of the cuvette was wiped dry with a clean tissue paper. It was then pushed firmly into the optical well and the lid closed. The NTU values were measured by pressing and releasing the arrow and about five minutes, the value was recorded after the display has stopped flashing.

3.3.4 pH Determination

In the laboratory, pH meter (HANNA model 209) was used to determine the pH of water samples. Buffer solutions of pH 4.0, 7.0 and 9.0 prepared from tablets of BDH buffer were used to calibrate the pH meter.

Fifty (50) ml of water sample was poured into a clean glass beaker and the electrode inserted into it. The button selector of the pH meter was turned and the pH was read and recorded. This was repeated for all other water samples.

3.3.5 Conductivity and Total Dissolved Solids (TDS) Determination

A multifunctional conductivity meter (HANNA model HI 9032) was used to determine the conductivity and TDS of water samples in the laboratory. It was calibrated by using sodium chloride standard solution of 12880µS/cm. The conductivity meter was then returned to the operation mode to facilitate measurement. About 50ml of the water sample was poured into a clean glass beaker and the conductivity meter electrode was then inserted into the water sample. The value was read and recorded after five (5) minutes, in µS/cm.

TDS was determined by pouring about 50ml of water sample into a clean glass beaker. The electrode was then immersed into the sample and stirred to ensure uniformity. After the reading stabilized, the value was read and recorded in mg/L. The same procedure was repeated for all other water samples.

3.3.6 Calcium Determination (Photometer Method)

Test tubes were filled with sample to 10ml mark. One calcicol No.1 tablet was added, crushed and mixed to dissolve followed by addition of calcicol No.2 tablet. Sample was allowed for five minutes for full colour development. Wavelength of 570 nm was selected on the photometer. Photometer reading was taken and calcium calibration chart was used to determine calcium concentration in mg/L.

3.3.7 Magnesium determination (Photometer Method)

Test tubes were filled with sample to 10ml mark. One Magnecol tablet was added, crushed and mixed to dissolve and allowing five minutes for full colour development. Wavelength of 520 nm on the photometer was selected for photometer reading followed by the application of Magnecol calibration chart for magnesium concentration in mg/L.

3.3.8 Total iron Determination (Photometer Method)

Test tubes were filled with sample to 10ml mark. One iron tablet was added, crushed and mixed to dissolve. One minute was allowed for full colour development. Wavelength of 520nm on the photometer was selected for photometer reading after which iron calibration chart was used to determine iron concentration in mg/L.

3.3.9Bacteriological Analysis

The membrane filtration method was used in the determination of three parameters namely; total coliform, E-Coli and faecal coliform.

i) **Total coliform determination**

One hundred millitre portion of the groundwater sample was filtered through fourtyseven(47) mm membrane filters of 0.45 pores size. The membrane filter was incubated on M-Endo agar and alternatively one Mac Conkey Agar at 37^0 C for 24 hours. Total coliform was detected as dark-red colonies with metallic sheen on the M-Endo agar and also as all bacteria appearing were counted for each plate.

ii) **Faecal coliform determination**

100 ml portion of the groundwater samples were filtered through 47 mm membrane filters of 0.45 pore size. The membrane filter was incubated on M-FC agar at 44^0 C for 24 hours. The total number of feacal coliform was detected as blue colonies on the M-FC agar. The total number of colonies appearing were counted for each plate.

iii) ***Escherichia coli*** (Thermotolerant coliform)

One millimetre from each of the faecal positive tubes was identified, transferred into 5ml trypton water and incubated for 24 hours at 44^0c. A Kovac reagent was added to each tube of the trypton water. All tubes showing a red ring colour development after gentle agitation denoted the presence of indole and recorded as presumptive for thermotolerant coliforms (*E. coli*). Counts per 100ml were calculated from the Most Probable Number (MPN) tables.

iv) **Procedure for bacteriological analysis**

The samples were removed from storage and allowed to cool to room temperature and the incubation chamber for the analyses was cleaned with ethanol to prevent contamination. The porous unit and the membrane filter forcepts were sterilized by being applied with 98% alcohol which was burnt used to transfer the sterile membrane filter onto the porous plate of the membrane filtration unit with the gride side up and a sterile meshed funnel placed over the receptacle and locked in place. The required volume of groundwater sample (100ml) was added to the membrane filtrations unit using the funnel measure.

The flame from the Bunsen burner was kept on throughout the whole analyses and the forcepts were flamed intermittently to keep it sterile. The samples were filtered through the membrane filter under partial pressure created by a syringe fitted to the filtration unit.
The filtrate were discarded and the funnel unlocked and removed. The sterile forcepts were then used to transfer the membrane filter onto a sterile labeled petri-dish containing the appropriate growth medium (M.F.C agar for feacal coliform and M-Endo agar for total coliform). The membrane filter were placed on the medium by rolling action to prevent air bubbles from forming at the membrane-medium interface. The petri-dishes were incubated upside down at the appropriate temperatures (37^0C for total coliforms and 44^0C for faecal coliform) for 24 hours. After incubation, typical colonies were identified and counted. The colonies were counted three times with the aid of colony counter and the means were recorded.

v) Statistical Analysis

Statistical analysis was carried out using MS Excel 2007 edition for mean values and graphs for parameters.

4.0 CHAPTER FOUR

Below are the graphs representing the various parameters study during the research period

pH – Hydrogen ion Concentration

The pH values for the period of research ranges between 6.6 to 7.1 with a mean of 6.9. The pH of the various wells were relatively constant as minute differences exist in the values obtain during the period of study.

Phosphate

Mean phosphate for all the wells in the study area was35.2mg/l. Phosphate concentration in wells ranges between 34.3mg/l to 46.7mg/l. The lowest phosphate level recorded were in wells 2 and 6 and well 5 recording the highest point.

EPA VALUES

Figure 4.2 Mean Concentration of Phosphate of the wells in study area.

EPA VALUES

Conductivity

The mean vales of conductivity in all the ten wells used were used to plot the graph below.The overall mean value was 649µS/cm. the mean conductivity ranges between 467µS/cm-699µS/cm

The lowest conductibyty was recorded in well 5 and well 7 recording the highest mean value for the area.

Figure 4.3 conductivity level of the wells in study area.

Total Dissolved Solids (TDS)

Mean values recorded for all the ten wells was not so huge. It ranged from 364mg/l -439.5mg/l with the mean value for all the well was 399.8mg/l.

EPA VALUES

Figure 4.4 Total dissolve solids concentration of the wells in study area.

Turbidity

The turbidity readings of the ten wells ranges between 4.3-5.6 NTU with average recording of 5.7 NTU. Though difference exist in the mean values recorded, the difference between the wells.

EPA VALUES

EPA VALUES

Figure 4.5 Turbidity level of the wells in study area.

Salinity

Mean values read over the period in all the ten were all less than 1. The mean value for the wells is 0.5. The range for the values falls between 0.4 – 0.6.

Figure 4.6 Salinity of the wells in study area.

EPA VALUES

Nitrate

The mean values for wells recorded shows wider difference as compared to the other parameters measured. The value recorded ranged between 21mg/l and 42mg/l with the overall mean value as 31mg/l . the readings saw a highest value as 42mg/l and lowest as 21mg/l.

Figure 4.7 Nitrate concentration of the wells in study area.

EPA VALUES

Iron

The reading recorded for iron concentration in the wells have some mean values less than 0.5mg/l .

The readings reange between 0.06mg/l – 0.3mg/l. With an overall mean 0.077mg/l.

Figure 4.8 Iron concentration of the wells in study area.

EPA VALUES

Magnesium

The mean values recorded for the wells have value ranging from 40.5mg/l – 68.3mg/l, with an average mean for the wells as 68.3mg/l. The values were higher than iron and fluoride concentration in the wells.

Figure 4.9 Magnesium concentration of the wells in study area.

EPA VALUES

Calcium

Just as the magnesium concenration, the mean values for calcium were high with the range between 41.7mg/l – 71.5mg/l. The overall mean for the period and all the wells is 71.5mg/l.

EPA VALUES

Figure 4.10 Calcium concentration of the wells in study area.

Total Hardness

The mean values recorded for total hardness in the wells ranges from 45mg/l – 92mg/l. There is not much significant changes in the values observed in all the wells. The mean values for all the ten wells was 72mg/l.

Figure 4.11 level of total hardness in wells

EPA VALUES

Total Coliform

Reading recorded for total coliform concentration ranges between MPN 616/100ml –MPN 762/100ml. The difference between the wells when it comes to coliform concentration was not much as depicted in the curve below.

Figure 4.13 Total coliform concentration of the wells in study area.

EPA VALUES

Faecal Coliform

The range for the values recorded for the faecal coliform concentration was between MPN 392/100ml –MPN 499/100ml. The mean value for all the wells was MPN 418.6 per 100ml.

Figure 4.14Faecal coliform concentrations of the wells in study area.

Escherichia-Coli

E-Coli concentration in the wells falls between MPN151/100ml –MPN 216/100ml. Apart from well 3 which has high level of concentration, the rest have slight difference in the values recorded. The overall mear value for all the wells was MPN175/100ml.

Figure 4.14 *Escherichia coli* concentration of the wells in study area.

CHAPTER FIVE

5.0 Discussions

Both physical and chemical parameters used to assess the quality of the well in study area are discussed below;

5.1. Physical Properties

5.1.1 Hydrogen Ion Concentration (pH)

The pH of the sources of water studied area ranged between 6.6 to 7.1. Out of the ten (10) sampling points used, six of them have their mean pH less than 7 which is an indication of the water being slightly acidic in nature. The rest of the four sampling points have their pH either 7 or 7.1. This implies that majority of the wells in the study area are slightly acidic.The level of the pH of the wells falls within the Ghana Standard Board guideline for safe drinking water. This means that the water in the area meets the standard when it comes to pH level. Groundwater with a pH <7 is widespread in the WestAfrican sub region, primarily due to the geological situation (Kesse, G. O. 1985).The pH of majority of the water sources is acidicwith values below the minimum recommended guideline value of 6.50. The results in this study were typical of similar studies that have been carried in mineralized aquifer waters.The pH values of this research were in conformity with those observed by other authors (Shittu*et al.*, 2008 and Nkansah*et al.*, 2010).

5.1.3 Electrical Conductivity

Generally conductivity of water is determined to obtain the ability of the waters to conduct electrical current. The mean water conductivity values ranged between 699 μS/cm to 744 μS/cm. This may be attributed to the high concentration of dissolved ions present in the wells in the study area. Electrical conductivity is a measure of water capacity to convey electric current. It signifies the amount of total dissolved salts. The mean values obtained for the various well were relatively constant with little variations occurring in the values. The values for electrical conductivity were a lower than what Ansa-Asare*et al*,(2010)at Akatsi, Adidome and Ho where mean values of 970µS/cm, 870µS/cm and 650µS/cm were recorded respectively for the three districts. This means that there was a considerable amount mineral dissolved in the soil in ionized forms. The mean values obtained were less than the guidelines for Ghana Standard Authority in terms of drinkable water which implies that the source of water was good for drinking.

5.1.4 Turbidity

Turbidity is a measure of light transmitting properties of water. It is another test used to indicate water quality of well waters with respect to colloidal and residual suspended matter. The measurement of turbidity is based on comparison of intensity of light scattered by a reference suspension under the same conditions (Pelig-Ba 1989).The values recorded in this particular were lower than some other works done in some parts of the country. This may be due to depth of the wells as the water table of the area is low therefore one has to dig deeper before getting to water. In general, the turbidity of the wells was predominantly below the recommended guideline value of 5.0NTU by EPA. Levels of turbidity recorded in this research were similar to the reported level by Shittu*et al.* (2008) in dug well water samples in Abeokuta, Nigeria. This could attributed to the conditions of the wells being the same in terms of the depth and how the wells have been covered.

5.1.5 Total Dissolve Solids

Total dissolve solids here is about the quantity of both organic and inorganic compounds dissolve in the water source. The various wells used for this research indicate that there exist dissolve solids in the water sources. The mean readings recorded within the period of studies ranges from 364mg/l to 432mg/l. this values actually falls below the Ghana Standard Authority guideline. This therefore confirms the trend of low readings recorded for the parameters discussed earlier in this work. Considering the graph above it was clear that all the wells have similar characteristics when it comes to total dissolved solids. The figures observed in this research was similar to that reported by Olobaniyi (2007) where TDS levels ranges from 21.90 to 300.50 in well water.

5.2 Chemical Properties

5.2.1 Nitrate (NO_3)

Nitrogen enters the ground from several sources. Certain plants such as legumes fix atmospheric nitrogen and transfer it to the soil where it is used by plants. Some of the surplus nitrogen is removed in solution by downward percolating soil water. Nitrate in concentration greater than 45mg/l is undesirable in domestic water supplies because of the potential toxic effect on young infants (DHMT, 2006). The mean values recorded for research work within the period falls within the range of 21mg/l to 41mg/l. Out the ten sampling points, six of them have their values more than 30mg/l whilst the rest four have their values between 20mg/l to 28mg/l. This generally falls below the guidelines set byGhana Standard Authority. The locations of the various sampling points may possibly be the factor accounting for the low nitrate levels as they were not located in any industrial area or places close to farming areas where fertilizers are used for high productivity or the sites being located near dumping sites.

5.2.2 Iron (Fe)

Most groundwater supplies contain some iron because iron is common in many aquifers and isfound in trace amounts in practically all sediments and rock formations. The iron content ofgroundwater is important because small amounts seriously affect water's usefulness for somedomestic and industrial purposes. TheGhana Standard Board recommends that the ironcontent of drinking water should not be greater than 0.3mg/L because iron in water stainsplumbing fixtures, stains cloths during laundering, incrusts well screens and clogs pipes (Hallberg, 1989). The mean values observed for the sampling points falls between a range of 0.06 mg/l to 0.3 mg/l. This means that the wells in the study area have their iron concentration falling below the accepted Ghana Standard Authority guideline of 0.3mg/l. This parameter has also followed the pattern of those discussed earlier.

5.2.3Magnesium (Mg) and Calcium (Ca)

The concentration of magnesium and calcium in any water source contribute to the total hardness of the water. Though the concentration levels of both magnesium and calcium falls below the Ghana Standard Authority guideline for total hardness which is 500mg/l, the figures recorded indicates that still there is some quantities of these minerals deposited in the soil. This may be due to the fact that the parent rocks that make up the soil could contain traces of these elements at various concentrations. The guideline of 500mg/l of these mineral elements was for any health reasons but for reason laundry purposes. The mean values of magnesium and calcium recorded in the study area was higher than what was reported by Nkansah*et al*,*(2010)* but similar to the ones reported by Ansa-Asare*et al.*,(2010).

5.2.4 Fluoride

The dominant controls on fluoride occurrence in groundwater are climate and geology. The regionsof Ghana most vulnerable to high fluoride concentrations (and associated dental fluorosis) arethe arid zones of the north and areas where bedrock geology is dominated by granite. The UpperRegions of Ghana are therefore considered to be the most likely areas to experience potentialproblems. Concentrations of fluoride in excess of 1.5 mg/l up to 3.8 mg/l have been observed inBolgatanga and Sekoti (Upper East Region, in close association with granitic rocktypes (Smedley et al., 1995). Occurrence of dental fluorosis is common in these areas. Groundwatersin granitic rocks of the south-west plateau are considered to be less at risk because of higherrainfall and its diluting effect on groundwater compositions.Much variations were not observed in floride levels of all the wells in the study area. The levels of fluoride recorded in all the sampling points were all lower than the permissible level and were similar to what was observed by Nkansah*et al.* (2010). The values range from 0.4mg/l to 0.6mg/l. This means that the water sources in the area of study does not pose any risk of fluoride related disease.The levels of fluoride in the wells obtained in this research are similar to that observed by

5.2.5 Phosphate

PhosphateLiterature (Salvato*et al.*2003) has it that, phosphorus is usually associated with plant remains, animal wastes or fertilizer.Other potential sources of phosphates as stated by Tjandraatmadja*et al.* (2010) include, cleaning products, cosmetics, medicated shampoos, food products, faeces and urine.Thus high levels of phosphate in groundwater could indicate the possible pollution from faecal origin or agro products.

In the sampled wells, levels of phosphates were below 400mg/l the recommended guideline value by WHO. There was not much difference in the figures recorded for all the wells in the study area but the presence of phosphate in each well could be attributed to the use of fertilizer in the area for farming.

Also sources such as plant and animal waste from the vicinity could be the source of phosphate infiltration into the wells. The levels of phosphate observed confirms what was recoeded by Ansa-Asare*et al,* (2010) in the Akatsi, Adidome and Ho districts in the volta region of Ghana.

5.2.6 Total Hardness

Total hardness is defined as the concentration of calcium and magnesium and is expressed in the in milligram calcium carbonate ($CaCO_3$) per litre (UNDP, 1994).

Hardness in water is due to the natural accumulation of salts from contact with soil andgeological formations or it may enter from direct pollution by industrial effluents (Annang, 2000). Water with a pH > 8.5 could indicate that the water is hard. Hard water does not pose a health risk, but can cause aesthetic problems (Awuah *et al.,* 1996). These problems include an alkali taste to the water (making that morning coffee taste bitter!), formation of a deposit on dishes, utensils, and laundry basins, difficulty in getting soaps and detergents to lather, and formation of insoluble precipitates on clothing (Esrey*et al.*,1991). The mean value of total hardness recorded in this research ranges from 45mg/l to 92mg/l. There has not been much difference in the mean values observed in all the ten wells that were studied. The lowest mean was recorded in well ten (10), whilst the highest mean was observed in well five (5). The mean values recorded in the wells imply that, mineral salts such as magnesium and calcium were present in the wells. The effect of this was that much soap have to be used in any cleaning activity in the area to ensure effective cleaning. The mean values observed in this research falls in line with similar work done in Abeokuta, Nigeria by shittu*et al.,(2008).* Meanwhile the mean values recorde were lower than what Adefemi and Awokumi, (2009) reported atAgo – Iwoye State, Nigeria. The mean values of this research were below the Ghana Standards Authority guidelines which means the water source was safe for drinking.

5.3 Biological Properties

5.3.1 Total Coliforms

The microbial analysis of the water quality of wells at Kasseh in the Dangme East District of the Greater Accra region reveals that there was microbial presence in the sources of water for the people. This was made clear as total coliform count for the well recorded mean values ranging from 6.16×10^2 to 7.62×10^2. Although comparable to some other works done in some other parts of Ghana this value seems to be on the low side, there is still a clear evidence of microbial contamination of the water sources. All the wells have their of contamination lower than 7.00×10^2 except for wells five (5) and ten (10) which figures above 7.10×10^2. The sitting of pit latrines in every household in which this wells were located may possibly account for the contamination. This level of contamination is far higher than theGhana Standard Authority guideline which is 00 MPN contamination.

5.3.2Faecal Coliforms

The levels of faecal contamination in the wells which were used as points of studies during the period of research higher compare to the observatioion made by Nkansah*et al., (2010)*. In that work the mean values were below the permissible limit for drinking water. Faecal coliform have mean values for wells ranging from 3.92×10^2 to 4.99×10^2 and that Escherichia-coli ranges from 1.42×10^2 to2.16×10^2. All these levels of contamination are higher than the 00 MPN level permissible of set by Ghana Standard Authority as guideline to drinking water for safe drinking water. This could be attributed to the way the wells in the study area well handled as some wells do not have cover at all with others having broken cover. All the wells have the rope used for drawing the water kept on the ground where feaces of animals were common.

5.3.3*Escherichia-Coli*

According to WHO (2004), *E. coli* is present in very high numbers in human and animal faeces and its presence provides conclusive evidence of recent faecal pollution and should not be found in drinking water. Thus, its presence in the wells poses health risk to consumers. Results from the research showed that E-coli were present in all the wells sampled in the study area. The mean figure observed during the period of research were between 1.51×10^{2} to 1.94×10^{2} MPN/100ml. These were also higher than what was reported by Nkansah*et al, (2010)* in Kumasi Metropolis. This means that the wells were not well protected against dirt which could be the major source of this contamination.

6.0 CHAPTER SIX

6.1 Conclusion And Recommendation

6.1.1 Conclusion

The well water samples from Kasseh in the Dangme East District of the Greater Accra Region were generally acidic as the mean values recorded were between 6.6 to 7.1. All the wells have their pH less than 7 except wells 4,6,9 and 10 and even that they were between 7 and 7.1. This means that acidity of the water was weak and falls within guideline. All the other parameters such as conductivity, temperature, turbidity, nitrate, magnesium manganese, calcium, biochemical oxygen demand, fall within the Ghana Standard Board guidelines except total coliform, faecal coliform and Escherichia coli which did not fall within Ghana Standard Board guidelines .This means that the water from the wells in Kasseh although have physicochemical parameters less than the Ghana Standard Board guidelines there was microhiological contamination as figures were recorded for E-coli and faecal Coliforms.

6.1.2 Recommendations

- All wells must be sited far from pit latrines and on ground higher than the pit latrine.
- The municipal assembly should provide the people with a more safe water.
- There should be public education to aert the people on the health effects of contaminated water and how to prevent it
- The water from the wells should be treated before use since the water can get contaminated during storage.

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APPENDICES

APPENDIX 1: Results of the analyzed data showing mean values for all the parameters for the six month perioddduring the study.

Parameters	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	S.I UNIT
pH	6.6	6.7	6.8	7.1	6.9	7.0	6.7	6.8	7.1	7.0	
Phosphate	40	34.3	35.6	38	46.7	34.3	39	36.1	37	40	mg/L
Conductivity	467	588	480	655	699	501	402	499	430	678	µS/cm
TDS	364	407	377	439	432	372	384	385	388	432	mg/L
Turbidity	5.5	7	5	5	7	5.5	6.7	5.2	4.3	6	NTU
Salinity	0.55	0.55	0.35	0.55	0.5	0.48	0.5	0.5	0.5	0.4	
Fluoride	0.5	0.5	0.5	0.4	0.6	0.6	0.5	0.5	0.5	0.4	mg/L
Nitrate	27	25	32	21	33	27	33	41.5	37.8	34.7	mg/L

Iron	0.06	0.1	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.2	mg/L
Manganese	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	mg/L
Magnesium	51.6	44.5	40.5	48.9	65	68.3	52.4	47.6	48.9	68.3	mg/L
Calcium	53.8	45.7	41.7	45.5	57.8	71.5	49.0	43.5	43.1	71.5	mg/L
TH	67	71	88	55	92	90	55	70	61	45	mg/L
TC	6.56×10^2	6.64×10^2	6.83×10^2	6.38×10^2	7.62×10^2	7.50×10^2	6.71×10^2	6.85×10^2	6.16×10^2	7.50×10^2	MPN/100ml
F.C	4.10×10^2	4.24×10^2	4.99×10^2	4.39×10^2	4.00×10^2	3.92×10^2	4.09×10^2	4.15×10^2	4.04×10^2	3.92×10^2	MPN/100ml
E-coli	1.77×10^2	1.42×10^2	1.57×10^2	1.51×10^2	2.16×10^2	1.94×10^2	1.71×10^2	1.60×10^2	1.82×10^2	1.94×10^2	MPN/100ml

APPENDIX 2: Below was the Environmental Protection Agency and Ghana Water and Sewerage Company Guideline for Drinking Water in Ghana.

PHYSICO – CHEMICAL PARAMETERS	EPA/GWC GUIDELINE VALUES
PH	6.5 – 8.5

Turbidity (NTU)	5
Temperature	<3^0C above ambient
Calcium	200
Magnesium	150
Iron	0.3
Manganese	0.5
Chloride	250
Fluoride	1.5
BOD	50
Nitrate	50.0 Max
Sulphate	400
Phosphate	400
Ammonia	1.5
Total Dissolved solids	1000
Total Hardness	500
Lead	0.01
Bacteriological parameters	
Total coliform	0.0
Faecal coliform	0.0
Escherichia coli	0.0
Salmonella	0.0
Enterococci	0.0

APPENDIX 3: Below is a table on the guidelines on safe water by the World Health Organization.

PHYSICO – CHEMICAL PARAMETERS	WHO GUIDELINE VALUES
PH	6.5 – 8.5
Turbidity (NTU)	0 - 5
Colour (Hz)	0 - 15
Calcium	200
Magnesium	150

Iron	0 – 0.3
Manganese	0.1
Chloride	250
Fluoride	1.5
Nitrite	3.0 Max
Nitrate	50.0 Max
Sulphate	400
Phosphate	400
Ammonia	1.5
Total Dissolved solids	1000
Total Hardness	500
Bacteriological parameters	
Total coliform	0.0
Faecal coliform	0.0
Escherichia coli	0.0
Salmonella	0.0
Enterococci	0.0