KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

COLLEGE OF SCIENCE

DEPARTMENT OF THEORETICAL AND APPLIED BIOLOGY

DRINKING WATER SUITABILITY FROM THE KARAGA DAM IN THE NORTHERN REGION, GHANA

BY

AMANTOGE ACHENGO TIMOTHY

NOVEMBER, 2012

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(BSc. AGRICULTURE TECHNOLOGY)

A THESIS SUBMITTED TO THE DEPARTMENT OF THEORETICAL AND APPLIED BIOLOGY, COLLEGE OF SCIENCE, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN ENVIRONMENTAL SCIENCE

NOVEMBER, 2012

DECLARATION

I, Amantoge Achengo Timothy hereby declare that, this is the result of my own work and that no previous submission of this work for a degree has been made here or elsewhere. Works done by others that served as source of information have been duly acknowledged by reference to the authors.

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DEDICATION

To my wife, Lucina Anome and son, Fidelis Amantoge for their love, support, patience and understanding.

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My first and foremost gratitude goes to the Almighty God who protected and guided me throughout my study period.

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ABSTRACT

The study was conducted on physico-chemical parameters and microbial quality of water from the Karaga dam in Northern region of Ghana from July, 2011 to August, 2012. The study was aimed at assessing its suitability and safety for drinking purposes. Two stations were selected for the study based on where the community fetches water and the type of containers used for fetching the water. Two samples were collected per month from both stations from March, 2012 to June, 2012. The parameters analyzed included pH, temperature, Total Dissolved Solids (TDS) and electrical conductivity (EC) were determined using Jenway 4520 conductivity meter. Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) were determined by the Winkler method. Nutrients measured included nitrate-nitrogen (NO_3^-N), sulphate (SO_4^{2-}) and Sodium (Na^+) which were determined spectrophotometrically. The microbial quality (total coliform and faecal coliform) parameters were determined using membrane filtration method. The results obtained included mean total coliforms ranged between 320 and 4110 CFU/100 ml, faecal coliform 128 and 1540 CFU/100 ml were above the Ghana Standards Board and World Health Organisation guidelines for drinking water. This could be due to direct defaecation and urination by wild and domestic animals that come to drink water, the donkeys used to fetch water and human excreta washed from the surrounding by rain into the dam. However, the microbial numbers were not significantly different ($P>0.05$) from station one and two. In general, pH values fell within the stipulated range of Ghana Standards Board and World Health Organisation for drinking water except in June which recorded values of 8.8 and 9.0 at both stations. All other values of the physic-chemical parameters fell below the stipulated range of Ghana Standards Board and World Health Organisation for drinking water. Due to the high numbers of total and faecal coliform counts of the water, some form of treatment like boiling could be done before drinking.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND

Access to a regular supply of safe water is widely viewed by the international development community as a basic human right. According to Kofi Annan, former United Nations Secretary-General:

"Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity."

Quality drinking water is essential for life. Unfortunately, in many countries around the world, including Ghana, water has become a scarce commodity as only a small proportion of the populace has access to treated water. Alternative sources of water such as rainwater, river water and dam water have become major sources of drinking water for people living in rural areas, new settlements and some residents who do not have access to treated water in Ghana and this challenge is magnified in Northern Ghana, particularly the rural communities, where 50% lack access to safe water Community water solutions (CWS, 2009).

These sources are often been polluted by waste- domestic waste, agricultural refuse, demolition waste, industrial waste, mining residues, municipal garbage, sewage sludge and waste from open dumped sites.

Solid waste disposal sites are potentially serious sources of pollution to the environment, especially when located very close to water sources and operated haphazardly. The high pollution potential of these sites is due to the fact that they usually contain almost all types of pollutants from the source community. The contaminants can leach out through the soil, contaminating ground water and runoff polluting surface water.

While agricultural practices vary very much throughout the world (due to variations in population density, economics, climate, soil types and methods of cultivation), there are a number of common activities that are significant sources of pollution- use of chemical fertilizers, use of insecticides and herbicides. Human excrement (night soil), animal manures, fertilizers and biosolids (sewage sludge) used for agricultural purposes may be a source of excess nutrients, which can contribute significantly to algal blooms in slow flowing or still bodies of water.

1.2 PROBLEM STATEMENT AND JUSTIFICATION

Water quality is defined in terms of the chemical, physical and biological contents of water. The water quality of rivers, dams and lakes changes with the seasons and geographic areas, even when there is no pollution present. Water quality guidelines provide basic scientific information about water quality parameters and ecologically relevant toxicological threshold values to protect specific water uses.

Important physical and chemical parameters influencing the aquatic environment are temperature, rainfall, pH, salinity, dissolved oxygen, carbon dioxide, total suspended and dissolved solids, total alkalinity and acidity. These parameters are the limiting factors for the survival of aquatic organisms (flora and fauna) (Lawson, 2011).

Poor water qualities may be caused by low water flow, municipal effluents and industrial discharges. Temperature is a limiting factor in the aquatic environment (Chitmanat and Traichaiyaporn, 2010 and Odum, 1971). Water temperature is probably the most important environmental variable. It affects metabolic activities, growth, feeding, reproduction, distribution and migratory behaviours of aquatic organisms (Largler *et al.*, 1977; Crillet and Quetin, 2006). It affects solubility of gasses in water, gas solubility decreases with increased temperature (Lawson, 2011).

Microbiological pollution in drinking water includes bacteria, virus and fungi. They can be responsible of serious diseases as typhoid, cholera, hepatitis etc. and their presence can be easily detected. Bacterial re-growth is encouraged by the lack of a residual disinfectant and by the possibly great variability of nutrients in aggressive water, such as the low-mineral water, particularly if it has a high temperature (Botzenhart and Kufferath, 1976 and Legnani *et al.*, 1999).

Agriculture activities also contribute significantly to water pollution especially surface water. The highest concentrations of agricultural chemicals in water supplies generally result from the percolation of contaminated runoff into natural and human-made pathways through the soils, although over spraying of water courses and poor disposal practices. These agricultural chemicals-insecticides, herbicides, and fungicides are used to kill agricultural pests.

These chemicals can enter and contaminate water through direct application, runoff, and atmospheric deposition. They can poison fish and wildlife, contaminate food sources, and destroy the habitat that animals use for protective cover.

Farmers apply nutrients such as phosphorus, nitrogen, and potassium in the form of chemical fertilizers and manure.

When these sources exceed plant needs, or are applied just before it rains, nutrients can be washed into aquatic ecosystems which can cause algae blooms, which create foul odour and taste in drinking water, and can kill fish by removing oxygen from the water. High concentrations of nitrate in drinking water can cause methemoglobinemia, a potentially fatal disease in infants, also known as blue baby syndrome.

One of the great advances in the history of public health has been the recognition that a community's fecal matter carries all the diseases in that population. If it's not properly treated even one sick person's wastes can spread the disease epidemically.

Hepatitis A (formerly known as *infectious hepatitis*) is an acute infectious disease of the liver caused by the hepatitis A virus (Hep A), an RNA virus, usually spread the fecal-oral route; transmitted person-to-person by ingestion of contaminated food or water or through direct contact with an infectious person. Tens of millions of individuals worldwide are estimated to become infected with Hepatitis A each year Ryan and Ray, (2004).

Ghana faces significant challenges in meeting the basic water and sanitation needs of its 22 million people. This challenge is magnified in Northern Ghana, particularly the rural communities, where 50% lack access to safe water (CWS, 2009).

The World Health Organization (WHO) estimates that 1.8 million people die each year from diarrhea diseases, 88% of which can be attributed to unsafe water, sanitation and hygiene (WHO, 2004).

Diarrhea remains in the second leading cause of death among children under five globally. Nearly one in five child deaths – about 1.5 million each year – is due to diarrhea. It kills more young children than AIDS, malaria and measles combined.

In 1998, diarrhoea was estimated to have killed 2.2 million people, most of whom were under 5 years of age (WHO/UNICEF, 2000).

Globally, diarrheal deaths account for only 3.2% of total deaths; however, the relative disease burden is twice as high in Africa with 6.6% of deaths attributable to diarrheal disease (Nath *et al.*, 2006). In addition, the waterborne disease burden is even higher than the diarrheal mortality rate suggests, as this statistic excludes the impact of diseases such as guinea worm as well as the detrimental secondary effects of frequent diarrheal episodes in terms of malnutrition and impaired growth.

Besides all this in the known, sources of water such as river water, lakes and dam water are still been used as an alternative sources of drinking water for people living in rural areas, new settlements and some residents who do not have access to treated water in Ghana which the Karaga district is no exception.

The knowledge of the quantity and composition of leachates or levels of contamination of water usually gives an insight into appropriate, effective and sustainable treatment approach and the risk a population is exposed to.

It has therefore, become imperative to assess the drinking water suitability from some of these alternative sources (the Karaga dam) because they have a direct effect on the health of individuals.

1.3 MAIN OBJECTIVE

The main objective of the study was to assess the drinking water suitability from the Karaga Dam which is used as a major source of drinking water.

The specific objectives of the study were:

1. To determine the microbial quality (Total coli form and Faecal coli form).
2. Analyse the Physico-chemical parameters (DO, BOD, pH, EC, Tem. and TDS) of the karaga dam.
3. To determine the levels of nutrients Sodium (Na^+), Nitrate ($NO_{3-}N$) and Sulphate (SO_4^{2-})

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 SOURCES OF DRINKING WATER IN GHANA

Traditionally, the people in rural areas obtain water from unprotected ponds, tanks, wells, dams, streams and rivers. These water sources are frequented daily for collecting drinking and cooking water, washing clothes, bathing, livestock washing, etc. Mostly, these waters are unsafe for consumption due to contamination by fecal matters as well as by their heavy use.

Drinking water is the basic need of human life and in fact an essential component of primary health care and poverty alleviation. A former UN Secretary General, Kofi Annan noted that *"No single measure would do more to reduce disease and save lives in the developing world than bringing safe water... to all*" (as cited in Nketiah-Amponsah *et al.*,2009). The Ghana Water and Sewerage Corporation (GWSC), now Ghana Water Company Limited (GWCL) is responsible for the provision, distribution and supply of water for public domestic and industrial purposes. In line with the decentralization structures, the Community Water and Sanitation Agency (CWSA) an offshoot of the then GWSC was set up in 1998 to facilitate the provision of safe drinking water in rural communities and small towns. In Ghana, approximately 94% of the population has access to water, where access is defined for households with a water source less than 30 minutes away. However, only 74% of the population has access to improved water source. Contrastingly, the WHO (2006), put the proportion of the population with improved water source at 64%, a 10 percentage points lower (as cited in Nketiah-Amponsah *et al.*, 2009).

Below is a figure showing the organizations of the rural sector in Ghana.

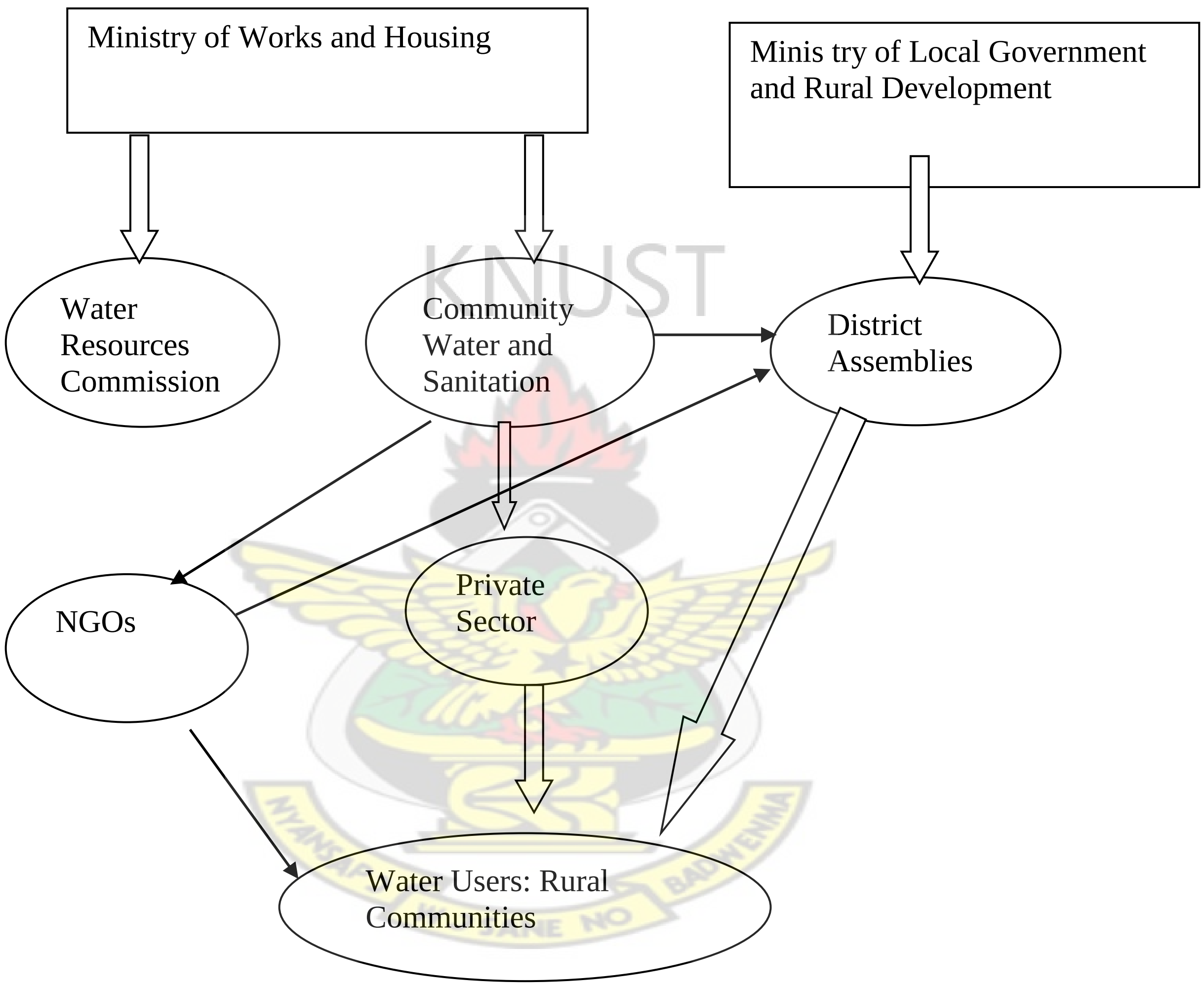

Figure 1: Organizations of rural water sector in Ghana

Source: Baur and Woodhouse (2004).
Note: NGO refers to *nongovernmental organization.*

2.2 AGRICULTURE AND SURFACE WATER POLLUTION

The primary agricultural nonpoint source pollutants are nutrients (particularly nitrogen and phosphorus), sediment, animal wastes, pesticides, and salts. Agricultural nonpoint sources enter surface water through direct surface runoff or through seepage to ground water that discharges to surface water (USEPA, 2011). Despite the fact that surface water and ground water have often been studied and managed as separate resources, they are interrelated.

Various farming activities result in the erosion of soil particles. The sediment produced by erosion can damage fish habitat and wetlands and, in addition, often transports excess agricultural chemicals resulting in contaminated runoff. This runoff in turn affects changes to aquatic habitat such as increase in temperature and decreased oxygen (USEPA, 2011).

The most common sources of excess nutrients in surface water from nonpoint sources are chemical fertilizers and animal manure causing eutrophication in surface water (USEPA, 2005).

Farmers apply nutrients such as phosphorus, nitrogen, and potassium in the form of chemical fertilizers, manure, and sludge. When these sources exceed plant needs, or are applied just before it rains, nutrients can be washed into aquatic ecosystems. There, they can create foul taste and odor in drinking water, cause algae blooms and kill fish by removing oxygen from the water. High concentrations of nitrate in drinking water can cause methemoglobinemia, a potentially fatal disease in infants, also known as blue baby syndrome (USEPA, 2005).

Pesticides used for pest control in agricultural operations can also contaminate surface water as well as ground-water resources. Return flows, runoff, and leachate from farm lands may transport sediment, nutrients, salts, and other materials.

Insecticides, herbicides, and fungicides that are used to kill agricultural pests, can enter and contaminate water through direct application, runoff, and atmospheric deposition. They can poison fish and wildlife, contaminate food sources, and destroy the habitat that animals use for protective cover (USEPA, 2005).

Improper grazing practices in riparian, as well as upland areas can also cause water quality degradation.

2.3 OPEN DEFECATION SITUATION IN GHANA

Open defecation – the riskiest sanitation practice of all – is on the decline worldwide, with a global decrease from 25% in 1990 to 17% in 2008, representing a decrease of 168 million people practicing open defecation since 1990 (WHO), (2010).

However, this practice is still widely spread in Ghana. According to the Ghana Statistical Service Multiple Indicator Cluster Survey (MICS) Report for 2006, open defecation is prevalent in all the ten regions. While the national average, according to the report, is 24%, the practice is most widespread in the Upper East Region with about 82% of the people without any form of latrine, followed by the Upper West Region with about 79% and then the Northern Region with about 73% (as cited in WSMP Ghana, 2011).

Rains also wash away most human faeces left in the open into rivers, ponds, open wells, lagoons and beaches. According to the Ghana Statistical Service (MICS 2006 report), about 19% of the populations (nearly 4.2 million people) still rely on untreated water from streams, dams, ponds, rivers and open wells for drinking and cooking (as cited in WSMP Ghana, 2011). They may therefore have been drinking their own or other people's faeces and injecting themselves with germs and diseases (WSMP Ghana, 2008).

Several factors contribute to this negative practice and these include absence of clean household latrines, public latrines and ignorance of the harmful effects of open defecation. It is also a fact in Ghana, that some people especial those in the rural areas simply prefer the bush or any open field for the simple reason that those places are more airy and convenient. Non enforcement of environmental laws is also a major factor.

2.4. INFECTIOUS DISEASES

It is said that,' we are what we eat, what we drink, and what we breathe.

Safe water is critical to maintaining the good health of a population. However, water and sanitation remains a significant problem throughout much of the developing world.

Under the Mellinnium Development Goals (MDG) program, the UN aims to decrease by 50% the proportion of people without sustainable access to safe drinking water by

2015. It is estimated that 1.1 billion people globally still lack access to an "improved" water supply (Nath *et al.*, 2006).

Provision of safe drinking water is one of the key outputs expected to significantly contribute to public health protection, improvements in the livelihoods of communities and poverty reduction.

It is against this background that the Community Water and Sanitation Agency was established by an Act of parliament of the Republic of Ghana, Act 564, 1998, which is mandated to facilitate the provision of safe water and related sanitation services to rural communities and small towns.

The World Health Organization (WHO) estimates that 1.8 million people die each year from diarrheal diseases, 88% of which can be attributed to unsafe water, sanitation and hygiene (WHO, 2004). Globally, diarrheal deaths account for only 3.2% of total deaths; however, the relative disease burden is twice as high in Africa with 6.6% of deaths attributable to diarrheal disease (Nath *et al.*, 2006). In addition, the waterborne disease burden is even higher than the diarrheal mortality rate suggests, as this statistic excludes the impact of diseases such as guinea worm as well as the detrimental secondary effects of frequent diarrheal episodes in terms of malnutrition and impaired growth.

2.4.1 Water- Related Infections

A water-related disease is one which is in some way related to water or impurities in water. There are four distinct types of water-related route by which diseases may be transmitted from one person to another; water-borne route, water-washed route, water-based route and insect-vector route (Cairncross and Feachem, 1993).

Classification of transmission mechanisms

1. *Water-borne route*

Water-borne transmission occurs when the pathogen is water which is drunk by a person or animal which may then become infected. Potentially, water borne diseases include the classical infections, notably cholera and typhoid, but also include a wide range of other diseases such as infectious hepatitis, diarrhoeas, and dysenteries (Cairncross and Feachem, 1993).

All water borne diseases can also be transmitted by any route which permits faecal material to in to the mouth ('feacal-oral' rout). Water-borne transmission is merely the special case of drinking faecal material in water, and any other faecal rout (Cairncross and Feachem, 1993).

2. *Water-based route*

A water- based disease is one whose pathogen spends part of its life cycle a water snail or other aquatic animal. All these diseases are due to infection by parasitic worms (helminthes) which depend on aquatic intermediate hosts to complete their life cycles. The degree of sickness depends upon the number of adult worms which are infecting the patient and so the importance of the disease must be measured in terms of the intensity of infection as well as the number of people infected. Schistosomiasis also known as bilharzia, is an important disease whose vector is not an anthropod, but an aquatic snail (Cairncross and Feachem, 1993).

3. *Water -washed route*

There are many infections of the intestinal tract and of the skin which, especially in the tropic, may be significantly reduced following improvements in domestic and personal hygiene. These improvements in hygiene often hinge upon increased availability of water and the use for hygienic purposes of increased volumes of water. Their transmission can be described as' water- washed'. The relevance of water to these diseases is that it is an aid to hygiene and cleanliness. A water-washed disease may be formally defined as one whose transmission will be reduced following an increase in the volume of water used for hygienic purposes, irrespective of the quality of that water.

There are three main type types of water-washed diseases. Firstly, there are infections of the intestinal tract, such as diarrhoeal diseases, which are important causes of serious illness and death especially among young children in poor countries. These include cholera, bacillary dysentery, and other diseases. The second type of water-washed infections is that of the skin or eyes. Bacteria skin sepsis, scabies, and fungal infections of the skin are extremely prevalent in many hot climates, while eye infections such as trachoma are also common and may lead to blindness. These infections are related to poor hygiene and it is to be anticipated that they will be reduced by increasing the volume of water used for personal hygiene (Cairncross and Feachem, 1993). The third type of water-washed infections is also not faecal-oral and therefore can never be water-borne. These are infection carried by lice which may be reduced by improving personal hygiene and therefore reducing the probability of infections of the body and cloths with these arthropods (Cairncross and Feachem, 1993).The table below shows the environmental classification of water- related infection by (Cairncross and Feachem, 1993).

Table 1: Environmental classification of water- related infections

Category	Infection	Pathogenic agent
1.Feacal-oral (water-borne or water-washed)	Diarrhoeas and dysenteries	
	Amoebic dysentery	Protozoa
	Balantidiasis	Protozoa
	Campylobacter enteritis	Bacteria
	Cholera	Bacteria
	Cryptospoporidiosis	Protozoa
	E. *coli* diarrhea	Bacteria
	Giardiasis	Protozoa
	Rotavirus diarrhoea	Virus
	Salmonellosis	Bacteria
	Shigellosis (bacillary dysentery)	Bacteria
	Yersiniosis	Bacteria
	Enteric fever	
	Typhoid	Bacteria
	Paratyphoid	Bacteria
	Poliomyelitis	Virus
	Hepatitis A	Virus
	Leptospirosis	Spirochaete
2.Water-washed:		
(a) skin and eye infections	Infectious skin diseases	Miscellaneous
	Infectious eye diseases	Miscellaneous
(b) Others	Louse-borne typhus	Rickettsia
	Louse-borne relapsing fever	Spirochaete
3. Water-based:		
(a) penetrating skin	Schistosomiasis	Helminth
(b) ingestion	Guinea worm	Helminth
	Clonorchiasis	Helminth
	Diphyllobothriasis	Helminth
	Fasciolopsiasis	Helminth
	Paragonimiasis	Helminth
	Others	Helminth

Source: Cairncross and Feachem (1993).

2.4.2 Excreta-Related Infections

1. *Faecal- oral diseases (bacterial)*

Faecal-oral diseases caused by bacteria, person-to-person transmission route are important but so are other routes with longer transmission cycles, such as the contamination of food, crops or water sources with faecal materials. Some of the pathogens in this category, notably *Campylobacter*, *Cryptosporidium, Salmonella*, and *Yersinia*\are also passed in the faeces of animals and birds. This suggests that they will not be greatly influenced by improvements in human excreta disposal unless animals' excreta are also removed (Cairncross and Feachem, 1993).

2. *Soil-transmitted helminthes*

This category contains several species of parasitic worm whose eggs are passed in faeces. They are not immediately infective, but first require a period of development in favourable conditions, usually in moist soil. They then reach their next human host by being ingested, for instance on vegetables, or by penetrating the soles of the feet of animals.

Since the eggs are not immediately infective, personal cleanliness has little effect on their transmission, but any kind of latrine which helps to avoid faecal contamination of the floor, yard, or fields will limit transmission (Cairncross and Feachem, 1993).The eggs of these worms can survive for months between hosts, so the avoidance of free defecation and treatment of excreta is vital if they are to be re-used on the land.

3. *Beef and pork tapeworms*

These tapeworms of the genus *Taenia* require a period in the body of an animal host before re-infecting man when the animal's meat is eaten without sufficient cooking.

Table 2: Environmental classification of excreta-related infection

Category	Infection	Pathogenic agent	Dominant transmission mechanisms	Major control measures (engineering measures in italics)
1.Feacal-oral(non-bacterial) Non-latent low infection dose	Poliomyelitis	Virus	person to person contact Domestic contamination	*Domestic water suppy* *Improved housing* *Provision of toilets* *Health education*
	Hepatitis A	Virus		
	Rotavirus diarrhea	Virus		
	Amoeba dysentery	Protozoon		
	Giardiasis	Protozoon		
	Balantidiasis	Protozoon		
	Enterobiasis	Helminth		
	Hymenolepiasis	Helminth		
2. Faecal-oral (bacterial) Non-latent, medium or high infectious dose, moderately persistent and able to multiply	Diarrhoeas and dysenteries		person to person contact Domestic contamination Water contamination Crop contamination	*Domestic water suppy* *Improved housing* *Provision of toilets* *Excreta treatment prior to re-use or discharge* Health education
	Campylobacter enteritis	Bacterium		
	Cholera	Bacterium		
	E.coli diarrhea	Bacterium		
	Salmonellosis	Bacterium		
	Yersinniosis	Bacterium		
	Enteric fevers	Bacterium		
	Typhoid	Bacterium		
	Paratyphoid	Bacterium		
3. Soil-transmitted helminths Latent and persistent with no intermediate host	Ascariasis (roundworm)	Helminth	Yard contamination Ground contamination in communal defaecation area Crop contamination	*Provision of toilets with clean floors* *Excreta treatment prior to land application*
	Trichuriasis (whipworm)	Helminth		
	Hookworm	Helminth		
	Strongyloidiasis	Helminth		

Category	**Infection**	**Pathogenic agent**	**Dominant transmission mechanisms**	**Major control measures (engineering measures in italics)**
4. Beef and pork tape worms Latent and persistent with cow or pig intermediate host(s)	Taeniasis	Helminth	Yard dcontamination Fodder contamination Field contamination	*Provision of toilets* *Excreta treatment prior to land application* Cooking of and meat inspection
5. Water-based helminths Latent and persistent with aquatic intermediate host(s)	Schistosomiasis	Helminth	Water contamination	*Provision of toilets* *Excreta treatment prior to discharge* *Control of animal harbouring infection* Cooking
	Clonorchiasis	Helminth		
	Diphyllobothriasis	Helminth		
	Fasciolopsiasis	Helminth		
	Paragonimiasis	Helminth		
6. Excreta-related insect vectors	Filariasis (transmitted by *Culex pipiens* mosqitoes)	Helminth	Insect breed in various faecally contaminated sites	*Identification of and elimination of potential breding sites* Uses of mosquito netting
	Infection in Categories I-V, especially I and II which may be transmitted by flies and cockroaches	Miscellaneous		

Source: Cairncross and Feachem (1993).

2.5. PHYSICO-CHEMICAL PARAMETERS

Poor water qualities may be caused by low water flow, municipal effluents, industrial discharges and runoff from agriculture fields.

2.5.1 Temperature

Temperature is a limiting factor in the aquatic environment. Water temperature is probably the most important environmental variable. It affects metabolic activities, growth, feeding, reproduction, distribution and migratory behaviours of aquatic organisms (Largler *et al.*, 1977). It affects solubility of gasses in water, gas solubility decreases with increased temperature (Lawson, 2011*)*.

Temperature is affected by time of the day. High temperatures may be recorded in daytime and become low at night.

2.5.2 pH

Hydrogen ion concentration or pH as one of the vital environmental characteristics decides the survival, metabolism, physiology and growth of aquatic organisms. pH is influenced by acidity of the bottom sediment and biological activities. High pH may result from high rate of photosynthesis by dense phytoplankton blooms. pH higher than 7 but lower than 8.5 is ideal for biological productivity, but pH at <4 is detrimental to aquatic life. pH may be affected by total alkalinity and acidity, run off from surrounding rocks and water discharges (Abowei, 2010).

2.5.3 Dissolved Oxygen

Dissolved oxygen (DO) affects the solubility of and availability of nutrients. Its low levels can result in damages to oxidation state of substances from the oxidized to the reduced form thereby increasing the levels of toxic metabolites.

Dissolved carbon dioxide in aquatic environment increases with decreased dissolved oxygen (Lawson, 2011). It is an important parameter in primary production and phytoplankton biomass.

Water Acidity increases with increased dissolved carbon dioxide. High rate of dissolved carbon dioxide is detrimental to survival, physiology and metabolic activities of aquatic animals including fish.

2.5.4 Total dissolved solids (TDS)

Total suspended and dissolved solids affect metabolism and physiology of fish and other aquatic organisms (Lawson, 2011). They are products of run offs. They increase with increased rainfall and have adverse effects on dissolved oxygen and carbon dioxide.

Suspended solids in water are directly proportional to dissolved solids. Dissolved solids could directly influence water conductivity, the higher the dissolved solids the higher the conductivity.

Urban runoff worsens the water quality in rivers, dams and lakes by increasing the concentrations of such substances as nutrients (phosphorus and nitrogen), sediments, animal wastes (feacal coliform and pathogens).

2.5.5 Nitrate (NO_3-N)

Nitrate in groundwater originates primarily from fertilizers, septic systems, and manure storage or spreading operations. Fertilizer nitrogen that is not taken up by plants, volatilized, or carried away by surface runoff leaches to the groundwater in the form of nitrate. This not only makes the nitrogen unavailable to crops, but also can elevate the concentration in groundwater above the levels acceptable for drinking water quality. Nitrogen from manure similarly can be lost from fields, barnyards, or storage locations. Nitrates are very soluble and do not bind to soils, nitrates have a high potential to migrate to ground water. This is because they do not evaporate; nitrates/nitrites are likely to remain in water until consumed by plants or other organisms.

Most nitrogenous materials in natural waters tend to be converted to nitrate, so all sources of combined nitrogen, particularly organic nitrogen and ammonia, should be considered as potential nitrate sources. Primary sources of organic nitrates include human sewage and livestock manure, especially from feedlots. The primary inorganic nitrates which may contaminate drinking water are potassium nitrate and ammonium nitrate both of which are widely used as fertilizers. Nitrate concentrations over 45 mg/l in drinking water are potentially hazardous to in two ways. The nitrates are reduced in the body to nitrites and can cause a serious blood condition in infants known as methaemoglobinaemia (infantile cyanosis), particularly if their diet is not rich in vitamin C (Cairncross and Feachem, 1993).

2.5.6 Sodium (Na+)

The recommended daily intake of Sodium (Na^+) is 20 mg. Numerous studies have shown that a high Na+ intake is associated with hypertension (McGregor, 1985; McDowell, 1992) and that dietary Na+ restriction, achieved by not adding salt and avoiding Na+ rich foods, may effectively reduce blood pressure (Garzon and Eisenberg, 1998).

However, drinking certain waters may unnecessarily increase Na+ intake to a level may be detrimental for health, especially for individuals on a Na+ restricted diet (Pomeranz *et al*., 2002 and Iannaccone *et al*., 1980).

2.5.7 Sulphate (SO^{-}_{4})

The sulphate (SO^{-}_{4}) content of water should be lower than 200 mg/l.

Sulfates and sulfuric acid products are used in the production of fertilizers, chemicals, dyes, glass, paper, soaps, textiles, fungicides, insecticides, astringents and emetics. They are also used in the mining, wood pulp, metal and plating industries, in sewage treatment and in leather processing (Greenwood and Earnshaw, 1984). It is therefore obvious that higher concentration of SO_4 could be harmful to human when taken in large dose.

Cattle grazing on rangeland often drink water that is contaminated with sulfate (SO_4) salts. Water consumption by cattle begins to decrease at SO_4 levels of 2,500 to 3,000 mg/l (Weeth and Hunter, 1971) and declines further at greater concentrations (Embry *et al.*, 1959). Over periods of > 7 d, high-SO_4 water has also resulted in reduced feed consumption, lowered BW gains (Embry *et al.*, 1959; Weeth and Hunter, 1971), scours (Embry *et al.*, 1959), diuresis (Weeth and Hunter, 1971), and suboptimal production (Loneragan *et al.*, 2001).

High levels of dietary S, which can result from water containing SO_4, have been implicated in reducing net energy values (Zinn *et al.*, 1997), interference with mineral status (Smart *et al.,* 1986; Ivancic and Weiss, 2001), and development of polioencephalomalacia (Olkowski, 1997).

2.6 HARMFUL EFFECTS OF OPEN DEFECATION

Human faeces and animal left in the open fields, bushes or drains generate a lot of viruses, bacteria and parasites. Houseflies usually fly and settle on these faeces and the food we eat and when we eat these contaminated food, we have inadvertently eaten our own or other people's faeces. By this, we open ourselves up for illnesses that can even lead to deaths.

Rains also wash away most human faeces left in the open into rivers, ponds, open wells, lagoons and beaches.

According to the Ghana Statistical Service (MICS 2006 report), about 19% of the population (nearly 4.2 m people) still rely on untreated water from streams, dams, ponds, rivers and open wells for drinking and cooking (as cited in WSMP, 2011). They may therefore have been drinking their own or other people's faeces and injecting themselves with germs and diseases (WSMP Ghana, 2008)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 STUDY AREA

The study was carried out at Karaga, the district capital of the Karaga district.

The Karaga District was carved out of the then Gushegu/Karaga District and officially inaugurated in August, 2004.

The District is located in the North-Eastern part of the Northern Region, between; latitudes 9°30' South and 10°30' North and longitudes 0° East and 45'West. It has a total area of 2,958 Kilometers square. It shares boundaries with four districts in the Northern Region (Figure 2), West and East Mamprusi to the North, Savelugu/Nanton to the West and Gushegu (the mother district) to the South and east. Karaga the district capital is 24 km from Gushegu and 94 km from Tamale, the Regional Capital (Medium Term Plan, 1996). Figure 2 below is map showing the location of the Karaga district in the northern region of Ghana.

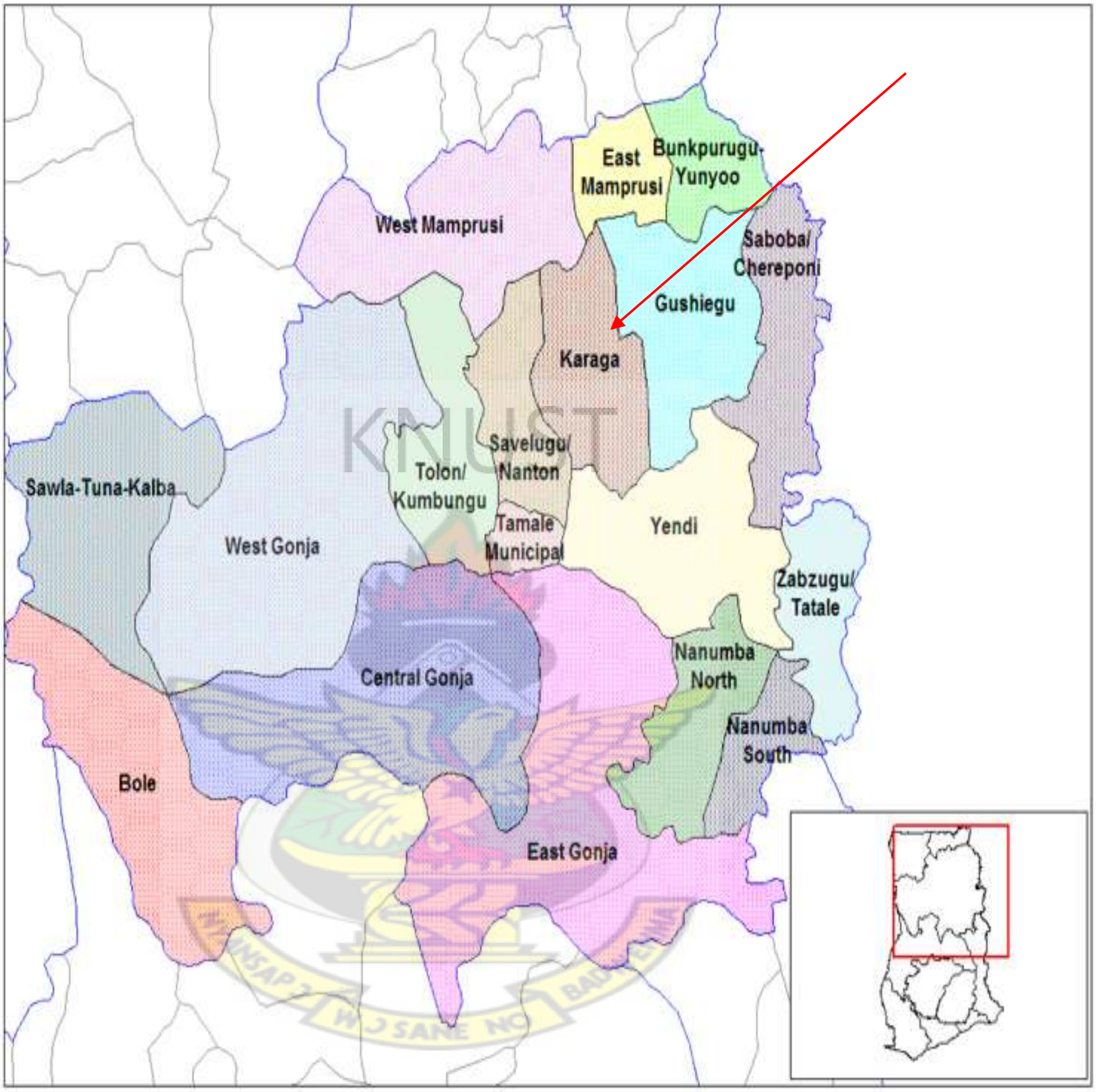

Figure 2: Location of Karaga district (arrowed) in the Northern Region of Ghana

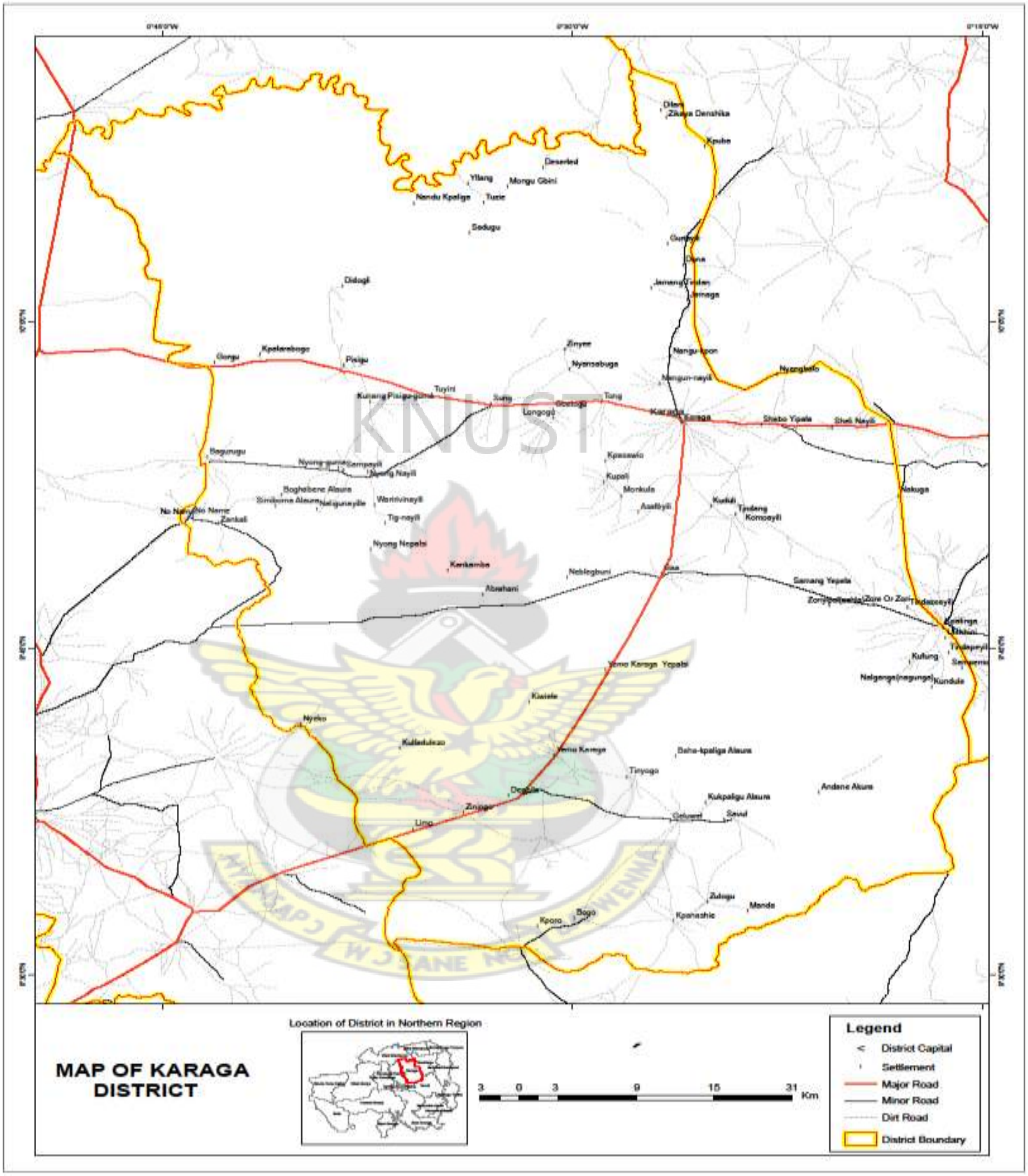

Figure 3: Location of the study dam in the Karaga District

3.2 POPULATION AND SETTLEMENT

The current population of the district as envisage in the I-WASH data (2009) collection report support by UNICEF stands at 89,870 as against the Population and Housing Census (PHC) 2000 figure of 62,719. The sex composition of the district population shows that females constitute 51.7% of the population while males form 48.3%. The population of Karaga constitutes about 20.4% of the district population (DESSAP, 2009).

3.3 CLIMATE

The climate reflects a typical tropical continental climate experienced in northern Ghana. There is a rainy season that lasts from May – October, peaking in August and September. The rest of the year is virtually dry. Rainfall amount is between 900 and 1000 mm per annum. Temperatures are high throughout the year with the highest of 36ºC or above in March and April. Low temperatures are experienced between November and February (the harmattan period).

3.4 VEGETATION

The vegetation is a typical guinea savannah type, characterized by tall grasses interspersed with drought resistant trees such as the Shea (*Vitellaria paradoxa*) and dawadawa (*Parkia biglobosa*). These trees are major economic trees which generate income for the people in the district. The tall grasses are also used in roofing and other art works.

3.5 SOIL

The district lies entirely within the voltaian sand stone basin dominated by sandstones, shales, siltstones and minor lime stones. The northern tip of the district is underlain by lower voltain, which consist of rocks, dominated by shales and sandstones.

The soils are mainly savannah ochrosols, ground water laterites formed over granite and voltain shales. Small areas of savannah ochrosols with some lithosoles and brunosols are very low.

The laterites are similar in acidity and nutrient level to the ochrosols, but are poorer in physical properties, with substantial amounts of concretionary gravel layers near the top horizons and more suited for road and other constructional works than supporting plant roots systems. Despite gentle slopes, the soils are highly vulnerable to sheet erosion and in some areas, gully erosion also occurs. This condition occurs primarily because of the annual burning of the natural vegetation, leaving the soils exposed to the normally high intensity rains (up to 200 mm per hour) at the beginning of the rainy season. The continuous erosion over many years has removed most of the top soils and depleted or destroyed its organic matter content.

This situation does not allow the soil fauna to thrive and keep the top soil layers open and enable healthy plant roots to develop. It results in serious compaction, with considerable reduction in rainfall infiltration rate (Medium Term Plan, 1996).

3.5 PHYSICAL, GEOGRAPHICAL AND ENVIRONMENTAL CONDITIONS

3.5.1 Water and Sanitation

The major sources of water supply in the district are, streams, dams and dugouts, shallow wells, ponds, boreholes and hand dug wells with pumps which are very few. There are no pipe-systems in the district, though Karaga has been earmarked for supply of pipe borne water through the small town water systems. Currently there are three limited mechanization systems in the Karaga Township out of which only two are functioning. Karaga, the district capital with a population of 12,800 (Population and Housing Census 2000 as cited Medium Plan, 1996) with 11 boreholes (two functional) has a coverage of only 19 percent.

3.5.2 Solid waste

Waste generated in the Karaga district range from the materials which are discarded in household dustbins to the by-products of chemical and agricultural activities. Proper solid waste management is one of the biggest environmental problems in the district. For example, types of refuse produced in Karaga town are brought to uncontrolled dumping sites, located in the town which is on a hill sloping to the dam where water is drawn for consumption.

3.5.3 Study site description

The study was carried out on the Karaga dam which is located at the outskirt 800m away from the town at eastern side. It was built in 1952 for the purpose of drinking water and watering of animals. The Global Positioning System (GPS) was used to take the area of the dam and the sampling points. The dam covers an area of 92.5 ha of land. The dam is located on undulating plane, surrounded by highlands from which runoffs feed the dam during raining season. The dam is surrounded on each side by a stretch of farmlands on which cereals and legumes are farmed.

The community also defecates around the dam from which water is drawn for drinking purposes, watering of animals and washing of clothes.

Two stations were selected from the dam based on where the community fetches water from and the containers used in fetching the water. Plate 1 and 2 show people fetching water from the dam from station 1 and station 2 respectively.

Plate 1: People fetching water from the Dam at Station 1.

Plate 2: People fetching water from the Dam at Station 2.

3.6 SAMPLE COLLECTION

Two samples were collected per month from both stations from March, 2012 to June, 2012 for the study of physico-chemical parameters (pH, BOD, DO, EC, TDS and Temperature), microbial quality (Total coli form, faecal coli form) and nutrients (Sodium, Nitrates and Sulphate). Water was collected at 5 meters off shore at the western sides of the dam at two stations, where water is accessed for drinking. About 1.5 l water samples were collected at each sampling station using new voltic plastic bottles. The sealed voltic water bottles were emptied, used to collect the dam water (samples), closed and sent to the laboratory for analysis. The samples were collected against the direction of the water. Samples were labelled at the site with a permanent marker and packed in an ice chase containing ice cubes and transported within 24 hours to the laboratory for the analysis. With the exception of temperature all other parameters were sent to the laboratory for analysis.

The bottles were immersed below the water surface and filled to capacity and properly closed for the physico-chemical parameters (pH, BOD, DO, EC, TDS) and nutrients (Sodium, Nitrates and Sulphate) whereas microbial quality (Total coli form , faecal coli form) parameters bottles were not filled to capacity to allow for respiration.

3.7 SAMPLE ANALYSIS

With the exception of temperature all other parameters were sent to the Council for Scientific and Industrial Research, Water Research Institute laboratory, Tamale for analysis.

The physico-chemical parameters were determined according to procedures outlined in the Standard Methods for the Examination of Water and Wastewater (APHA, 1998).

The parameters analyzed include pH using (Jenway 3510 pH meter), temperature (Celsius thermometer), Total Dissolved Solids (TDS) and electrical conductivity (EC) were determined using Jenway 4520 conductivity meter. Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) were determined by the Winkler method. Nutrients measured include nitrate-nitrogen (NO_{3}-N), sulphate (SO^{-}_{4}) and Sodium (Na^{+})

which were determined spectrophotometrically. The microbial quality (total coliform and faecal coliform) parameters were determined using membrane filtration method.

3.7.1 pH

The pH was determined with Jenway 3510 pH meter. The electrodes were immersed in water samples and the potential difference between them was measured. Standardization was done using buffer solutions of pH values of 4 and 9.

3.7.2 Temperature

The water temperatures were measured at the sampling sites with mercury-in-glass thermometer. The thermometer was immersed in water about 6 cm below the surface of the water and left to stabilize for about five minutes. The values for water temperatures were recorded in degrees centigrade (°C).

3.7.3 Total dissolved solids and Electrical conductivity.

Jenway 4520 conductivity meter was used to determine TDS and Electrical conductivity. Jenway 4520 conductivity meter was calibrated; the tip rinse in container with distilled water, then the meter tip put into water sample and meter was allowed to stabilize before taking reading.

3.7.4 Sulphate

An amount of 100 ml of the water sample was put into a 250 ml Erlenmeyer flask and 5 ml of conditioning reagent added placed on a magnetic stirrer to mix. A spoonful of barium chloride crystals was added and immediately begin timing while stirring for a minute.

Some of solution was poured into the absorption cell of the photometer, and the turbidity measured at 30 second intervals for four minutes and readings taken. The concentration of sulphates in the solution was then determined with the help of calibration curve.

3.7.5 Nitrate

Hydrazine reduction method was used to analysed the samples for the presence of nitrate in water**.** Nine milliliter water sample was added 0.5 ml each of sodium hydroxide and magnesium chloride solutions. All the samples were well shaken, allowed to stand 2-3 minutes following each addition, centrifuged and filtered vide Whatman filter paper No.1. The sample extracts were assayed for NOx. The efficiency of the outlined extraction processes was studied by estimating per cent recovery of the anions from aliquots of water containing nitrate and nitrite, respectively 50 and 2 µg as N.

The values obtained from the samples subjected to the extraction processes were compared with the values obtained from unprocessed aliquots of the same cocktail. The reagent blanks for each process were run simultaneously. The purified charcoal was used at maximum concentration limit, 30 mg ml^{-}1.

Appropriate aliquot of assay extract (0.5 to 2 ml), depending upon nitrite concentration as checked by trial tests, was made 2 ml with distilled water, added 0.1 ml sulfanilamide solution and then 0.3 ml HCl, allowed to stand 2-3 minutes, and added 0.2 ml coupling agent.

The samples were monitored at 540 nm (UV-Visible Spectrophotometer SL-150) after 20 minutes standing against reagent blank. Standard nitrite 0.1 and 0.2 ppm as N in 2 ml volume were simultaneously processed. Extracts containing excessive nitrate were appropriately diluted with water so that nitrate content remained within the linear detection range of acid reduction method (0.5-10 ppm as N).

3.7.6 Microbiological analyses

Water pollution caused by fecal contamination is a serious problem due to the potential for contracting diseases from pathogens. Normally, concentrations of pathogens from faecal contamination are small, and the number of different possible pathogens is large. As a result, it is impracticable to test for pathogens in every water sample collected. Instead, the presence of pathogens is determined with indirect evidence by testing for an indicator organism such as coliform bacteria which come from the same sources as pathogenic organisms.

Coliforms are relatively easy to identify, are usually present in larger numbers than more dangerous pathogens, and respond to the environment, wastewater treatment, and water treatment similarly to many pathogens. Due to this, testing for coliform bacteria can be a reasonable indication of whether other pathogenic bacteria are present in the water or not (Cairncross and Feachem, 1993).

Total and faecal coliforms

The numbers of total and faecal coliforms were determined using membrane filtration technique. A measured volume of water (as guided by WHO, 1993) was filtered through a membrane. Bacteria were retained on the membrane and incubated, after a recover period of one hour, at 33.3^{o}C and 44.3^{o}C for total and faecal coliforms respectively for 24 hours. If present, bacteria grew into visible colonies that were counted manually.

Each test was duplicated for consistency and the results were converted to represent a count per 100ml. To ensure sterile conditions, Petri dishes, medium and forceps were autoclaved. After each sample collection, the filtration unit was flame sterilized using 70% methanol.

The Two-Sample *t* Tests package was to analyze the data. Microsoft office excel 2007 was used in analyzing the results (graphs).

CHAPTER FOUR

4.0 RESULTS

The means of physico-chemical and biological properties of water samples from station one (1) and station two (2) of the dam is presented in figures 4-14 for the period of four months.

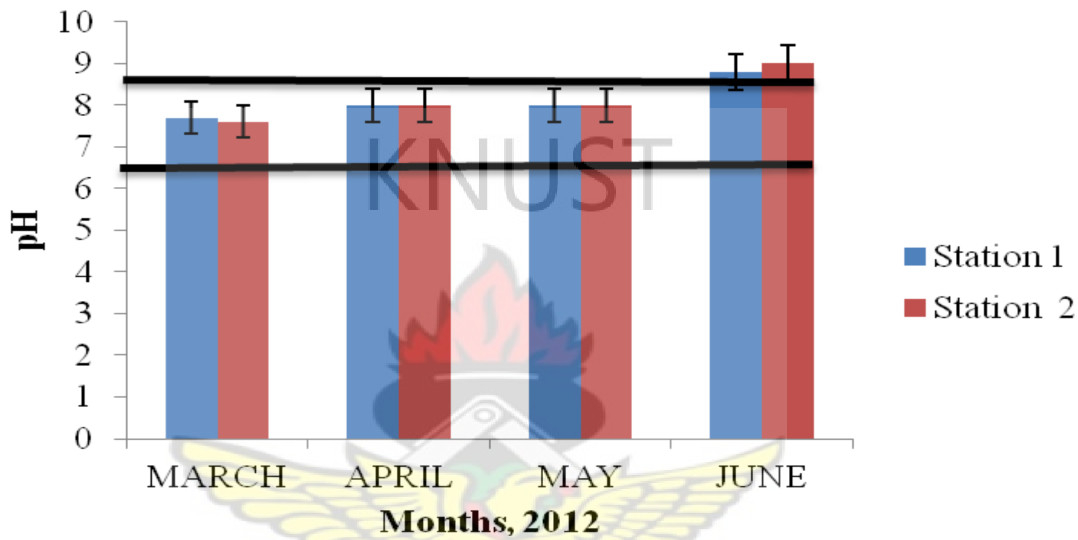

Figure 4: Monthly mean values of pH at station 1 (blue) and 2 (red) in the Karaga dam from March –June, 2012. Bars show SD.

pH

The mean pH values range from 7.6 to 9.0. With the exception of the month of June, mean pH values fell within the stipulated pH values of GSB (6.5-8.5). The month of June recorded the highest pH at both station one and two (8.8 and 9.0 respectively) (Figure 4) which is slightly higher than the stipulated pH values of GSB (6.5-8.5). The month of March recorded the lowest. The variations in pH per station per month were not significantly different (P>0.05).

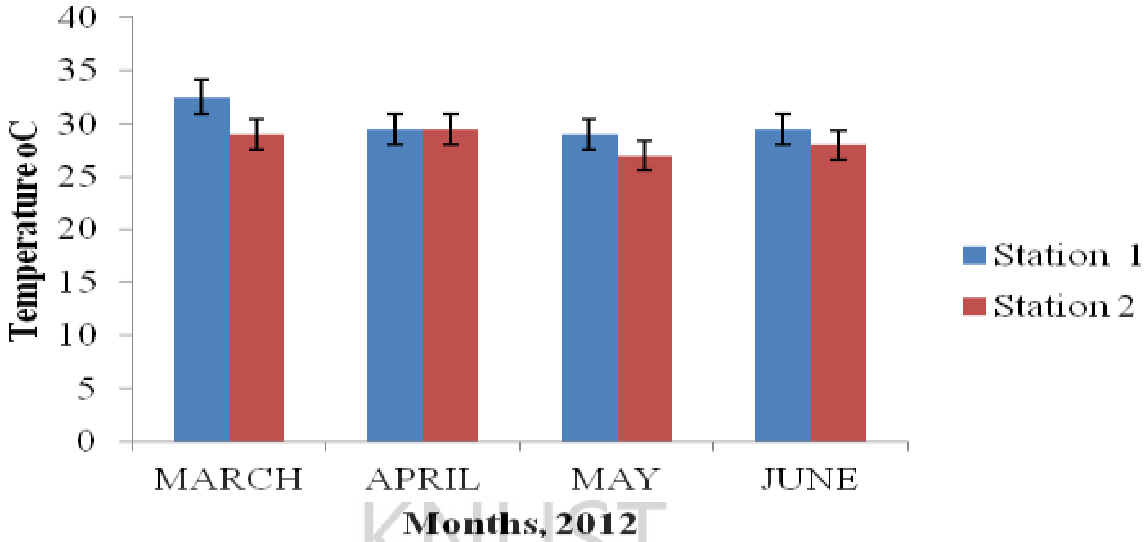

Figure 5: Monthly mean values of Temperature (^{0}C) of water at station 1 (blue) and 2 (red) in the Karaga dam from March –June, 2012. Bars show SD.

Temperature

The mean temperature ranged between 27^{0}C to 33^{0}C. The highest temperature of 33^{0}C was obtained at site one (1) in the month March. The lowest temperature (27^{0}C) was recorded in May at station two (2) (Figure 5). In general, the temperature results are within the guideline values of GSB (25-30^{0}C). There were variations in water temperatures per station per month, however, these variations were not significantly different (P>0.05).

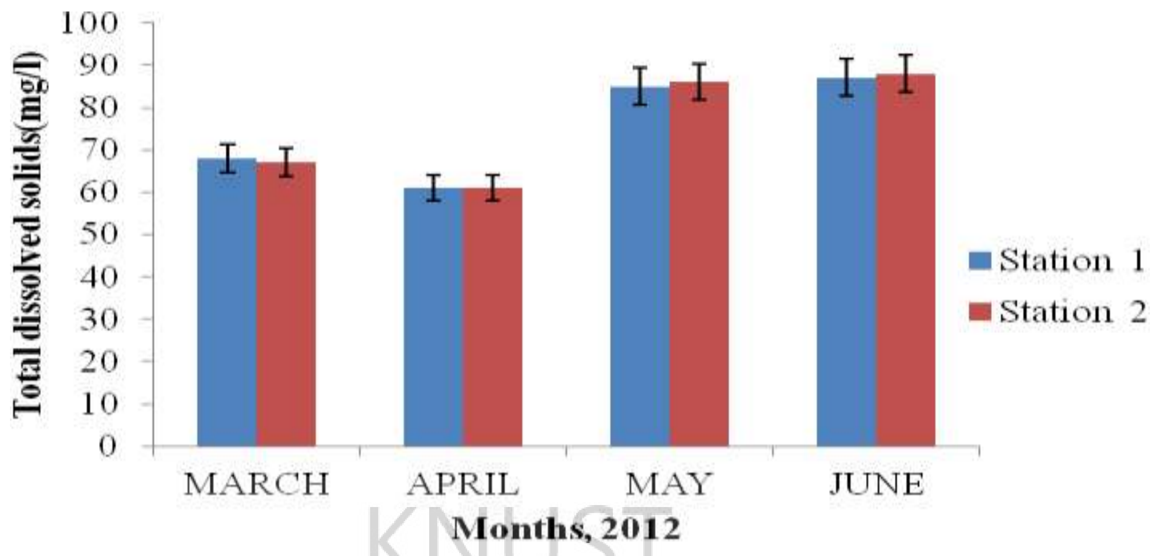

Figure 6: Monthly mean values of Total dissolved solids (mg/l) at station 1 (blue) and 2 (red) in the Karaga dam from March –June, 2012. Bars show SD.

Total Dissolved Solids (TDS)

Monthly mean values of Total dissolved solids values ranged from 61 to 88 mg/l. TDS values were slightly higher in the months of May (85 and 86 mg/l) and June (87 and 88 mg/l) with station two (2) recording the highest TDS in both May and June (86 mg/l in May and 88 mg/l in June). The month of April recorded the lowest TDS (61 mg/l) for both stations (station one and two) (Figure 6). The differences in means were not significant per station per month.

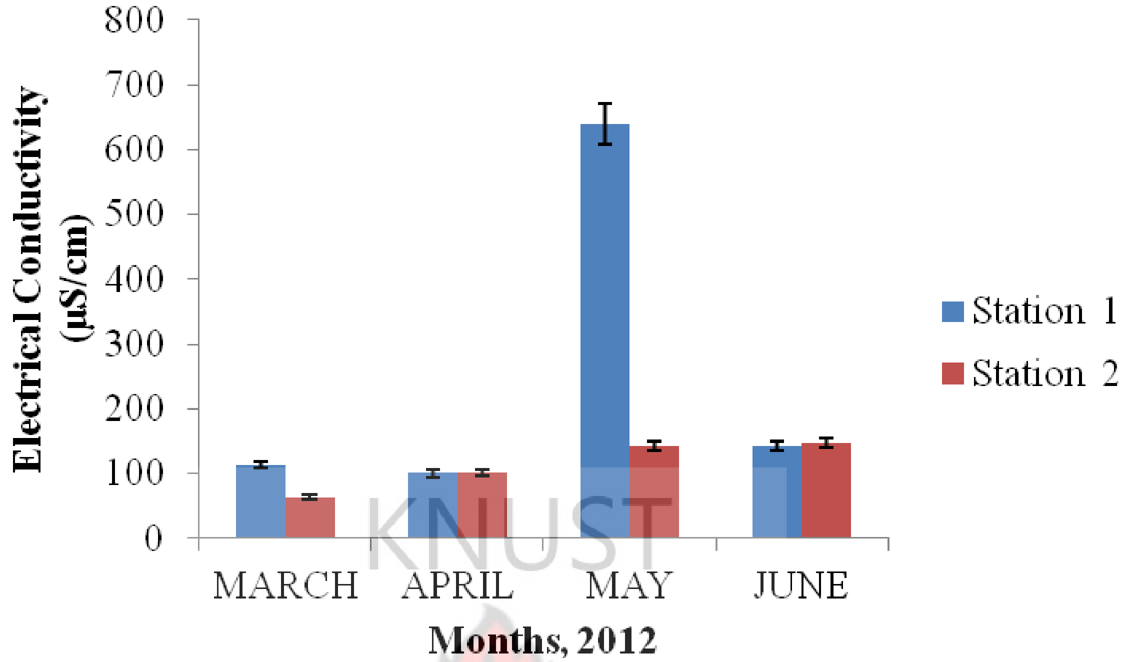

Figure 7: Monthly mean Electrical conductivity (µs/cm) of water at station 1 (blue) and 2 (red) in the Karaga dam from March –June, 2012. Bars show SD.

Electrical conductivity (EC)

Figure 11 indicated that the mean EC varies from 63 to 640 µs/cm.

The highest mean EC (640 µs/cm) was recorded in the month of May at station one (1). The lowest EC (63 µs/cm) was recorded in the month of March at station one (1). The differences in means per station per month were not significantly different (P>0.05).

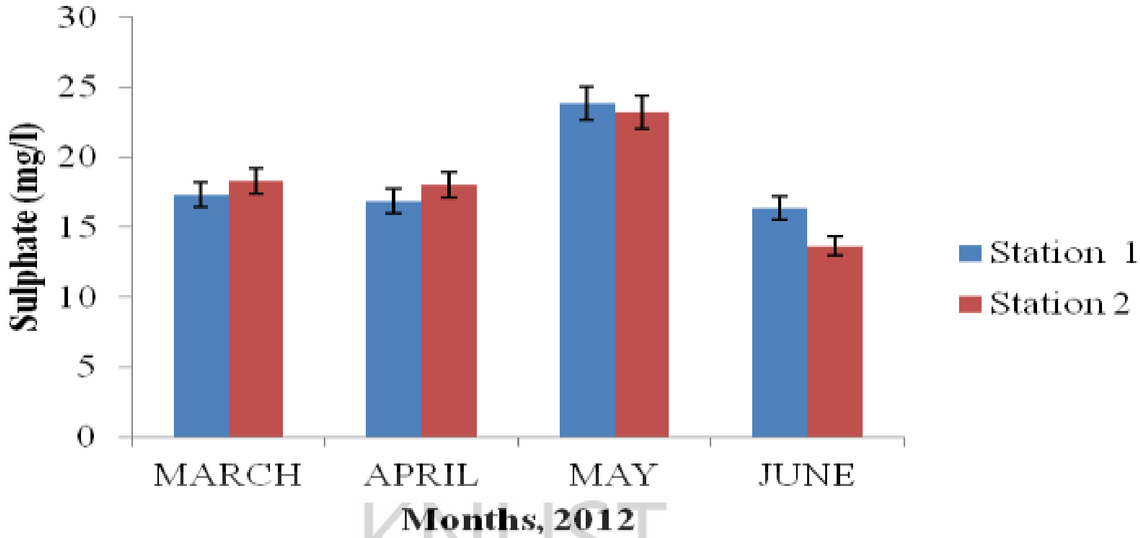

Figure 8: Monthly mean Sulphate concentration (mg/l) of water at station 1 (blue) and 2 (red) in the Karaga dam from March –June, 2012. Bars show SD.

Sulphate

The mean Sulphate concentration (14-24 ml/g) in the dam water was very low as compared to the guideline values of GSB and WHO (400 mg/l). There was maximum record of Sulphate in May (23 and 24 mg/l) and minimum record of Sulphate concentration in June for both stations (14 and 16 mg/l). The variations in sulphate per station per month were not significantly different (P>0.05).

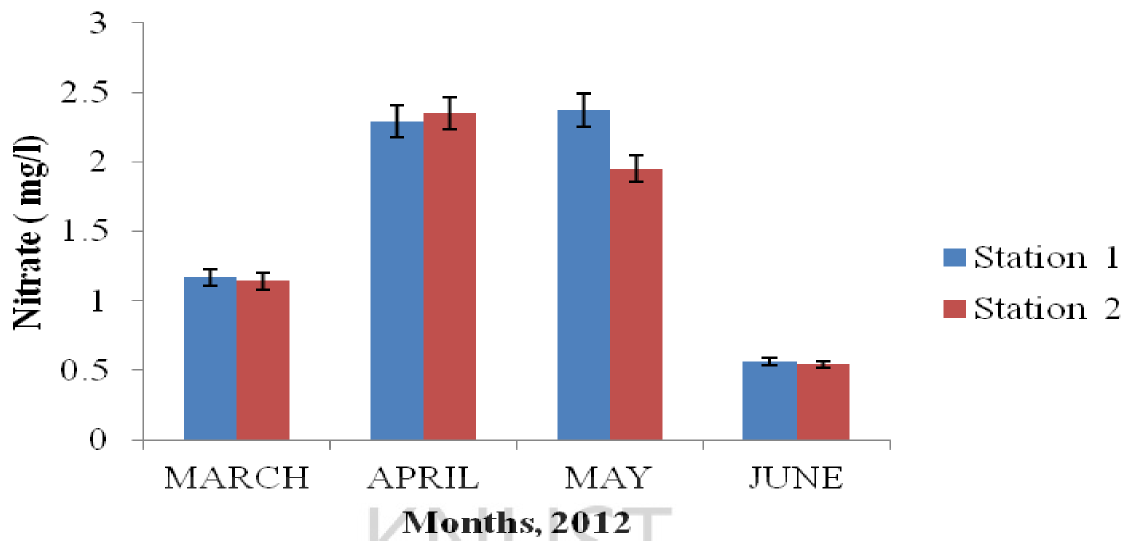

Figure 9: Monthly mean Nitrate concentration (mg/l) of water at station 1 (blue) and 2 (red) in the Karaga dam from March –June, 2012. Bars show SD.

Nitrate

The Monthly mean Nitrate concentration revealed mean lower values record range of between (0.5-2.37 mg/l) which were below the guideline values of GSB and WHO (10 mg/l). The highest value (2.37 mg/l) was recorded at station one (1) in the month of May. June recorded the lowest mean values (0.5 mg/l) at station two and 0.54 mg/l at station one) (Figure 9). The monthly means vary however, the differences in means per station per month were not significantly different ($P>0.05$).

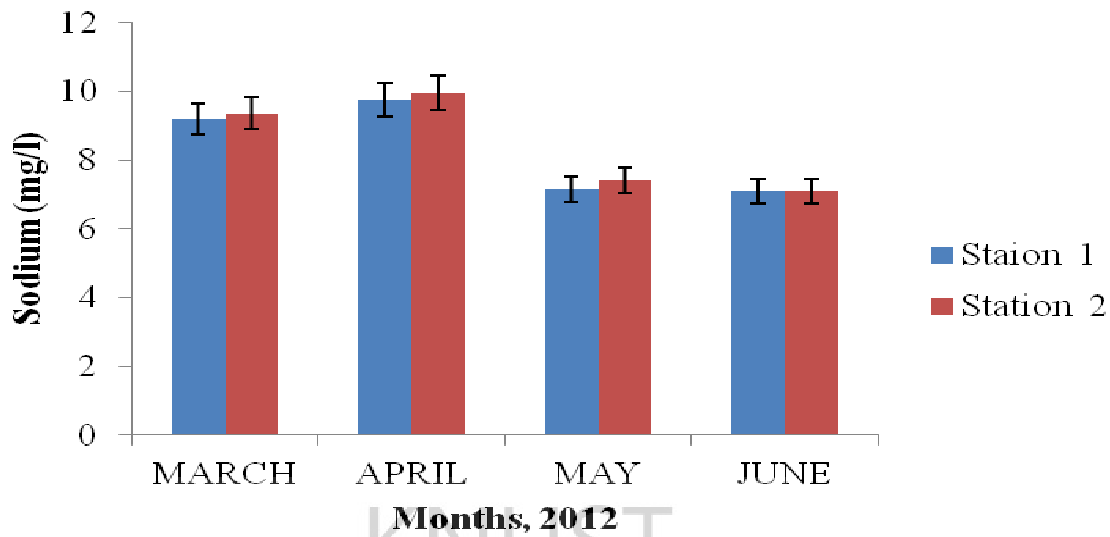

Figure 10: Monthly mean Sodium concentration (mg/l) of water at station 1 (blue) and 2 (red) in the Karaga dam from March –June, 2012. Bars show SD.

Sodium

The mean sodium concentration in the dam water was very low (7.1-10 mg/l) as compared to the WHO and GSB guideline values of 200 mg/l. However, there was high record of sodium in March (9.2-9.4 mg/l) and April (9.8-10 mg/l). April recorded the highest mean Sodium concentration (9.8-10 mg/l). There was a reduction in mean Sodium concentration in May (7.2-7.4 mg/l) and June (7.1 mg/l). There was a progressive reduction in Sodium concentration from April to June (Figure 10). The differences in means per station per month were not significantly different ($P>0.05$).

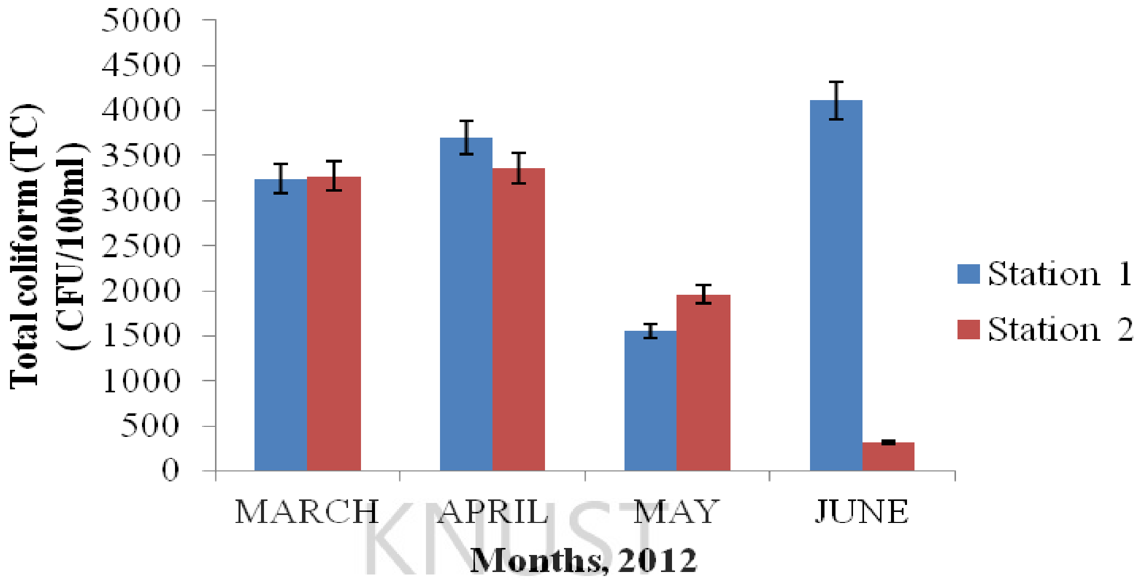

Figure 11: Monthly mean contamination level of total coliform (CFU/100ml) at station 1 (blue) and station 2 (red) in the Karaga dam from March –June, 2012. Bars show SD.

The Monthly mean contamination level of total coliform ranged between 320 and 4110 CFU/100 ml. The month of June recorded highest mean total coliform (4110 CFU/100 ml) at station one and lowest at station two (320 CFU/100 ml) (Figure 11). The results increased in April and decrease in May. The differences in means were not significantly different (P>0.05) per month per station.

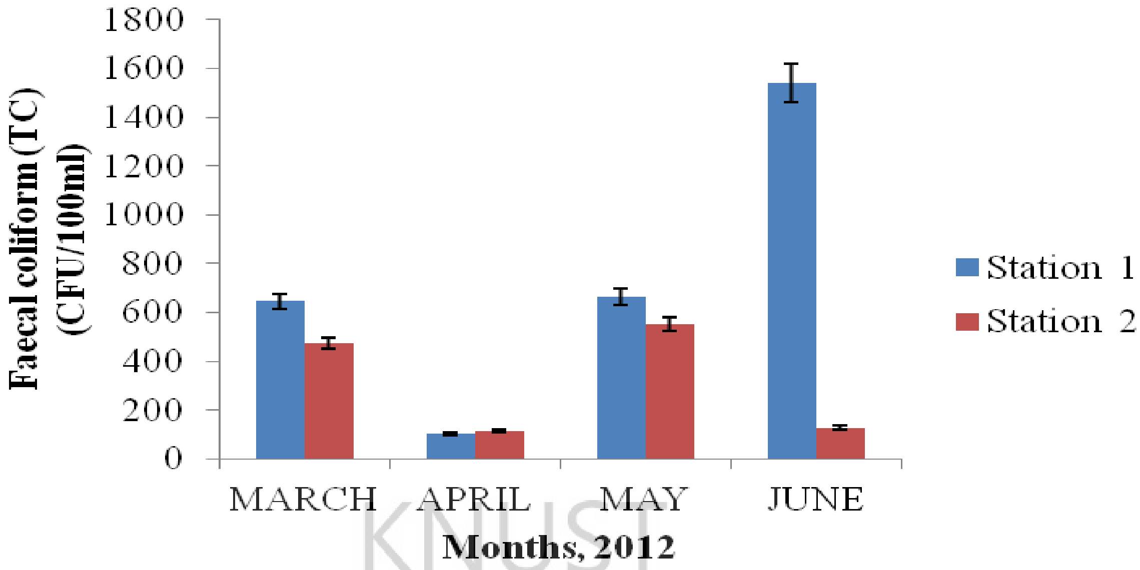

Figure 12: Monthly mean contamination level of Faecal coliform (CFU/100ml) at station 1 (blue) and 2 (red) in the Karaga dam from March –June, 2012. Bars show SD.

Monthly mean contamination level of faecal coliform ranged between 128 and 1540 CFU/100 ml. The month of June recorded highest mean faecal coliform (1540 CFU/100 ml) at station one and lowest at station two (128 CFU/100 ml). There was a decrease in April and a rise in May (Figure 12).

The results suggest that the general sanitary qualities of the water as indicated by total coliforms counts, are unacceptable because for water to be considered as no risk to human health, the faecal coliforms counts/100 ml and total coliform counts/100ml should be zero (WHO, 1987). These results have indicated faecal pollution of the water sources, and imply that these water sources pose a serious health risk to consumers. The variations of faecal coliform per station per month were not significantly different ($P > 0.05$).

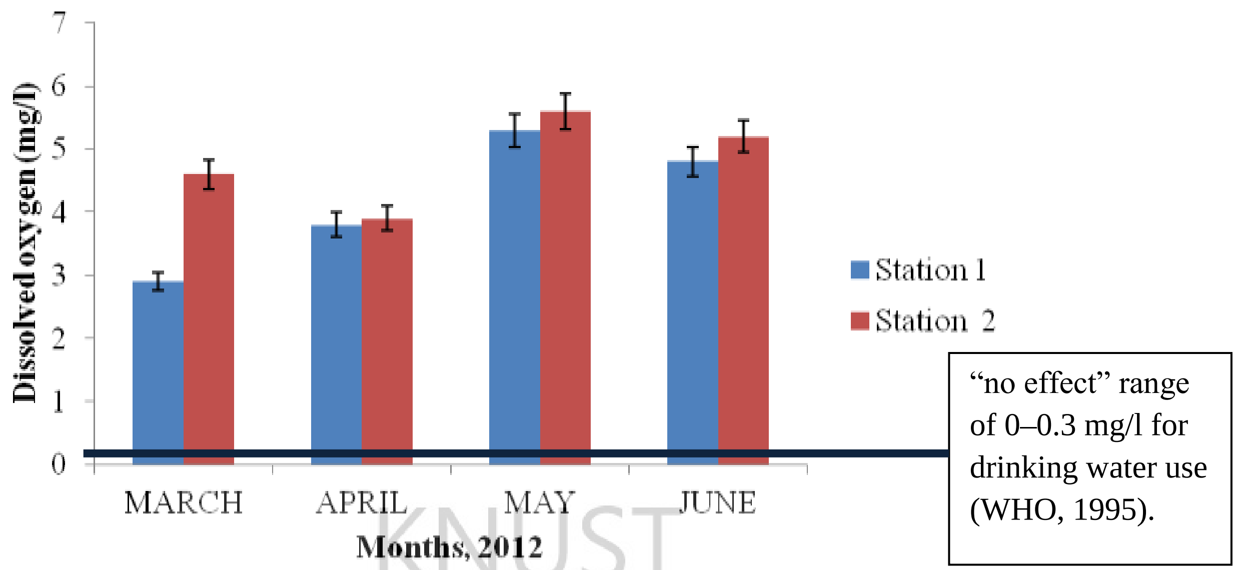

Figure 13: Monthly mean concentration of dissolved oxygen (mg/l) at station 1 (blue) and 2 (red) in the Karaga dam from March –June, 2012. Bars show SD.

Dissolved Oxygen

The Monthly mean concentration of dissolved oxygen values ranged from 2.9 -5.6 mg/l. All the values recorded fell outside the "no effect" range of 0–0.3 mg/l for drinking water use (WHO, 1995).

The month of May recorded the highest (5.3 and 5.6 mg/l). March recorded the lowest (2.9 mg/l) at station one (1). Station two (2) recorded the highest DO in all the months (Figure 13). The variations in DO per station per month were not significantly different (P>0.05).

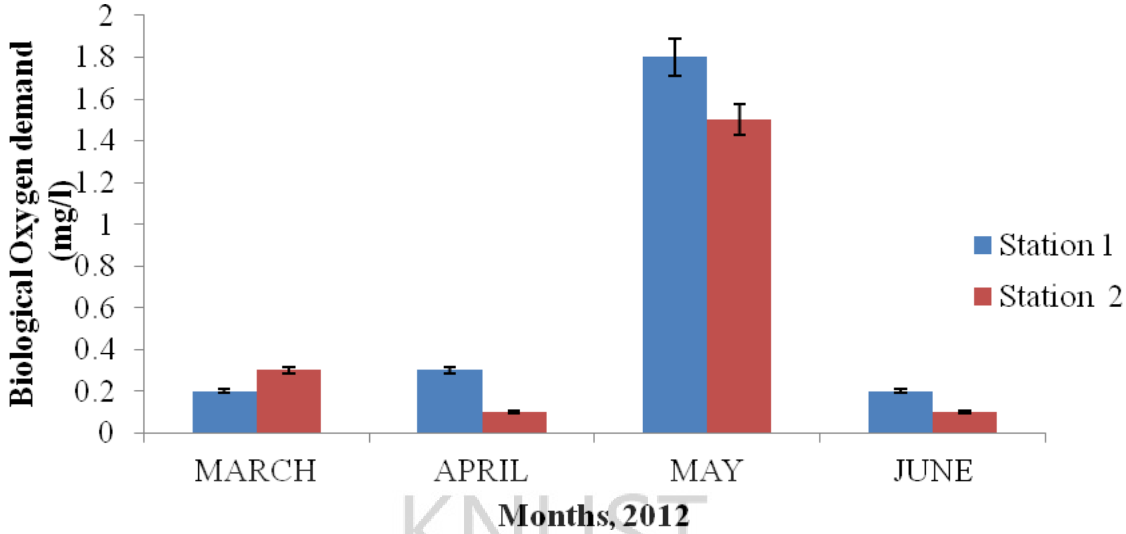

Figure 14: Monthly mean concentration of Biological oxygen demand (mg/l) at station 1 (blue) and 2 (red) in the Karaga dam from March –June, 2012. Bars show SD.

Biological oxygen demand (BOD)

The results of BOD revealed mean values record between 0.1-1.8 mg/l. There was a high level concentrations of BOD in May (1.5 and 1.8 mg/l) at both stations than all the other months (Figure 14). The month of June recorded the lowest (0.1 and 0.2 mg/l) as shown in figure 9. The differences in means of the BOD per station per month were not significant ($P>0.05$).

CHAPTER FIVE

5.0 DISCUSSION

5.1 pH

pH may be affected by runoff from surrounding rocks and water discharges (Lawson, 2011). The highest pH (8.8 and 9.0) recorded in June might be due to the deposition of some organic matters and anthropogenic inputs from the catchments of the dam into the water by run-off.

The lower pH recorded in March might be due to the variation in weather conditions from March to June as also observed by (Lawson, 2011) that pH varied with seasons and variations. As the season progress from March to June with no rains in March there might have been high decomposition which could be responsible for the low pH (7.6) in March as observed by Pidgeon that organic acids resulting from decaying vegetation might be responsible for the low pH in most aquatic ecosystems (Pidgeon and Cains, 1987).

In general, the pH values were within the range of 6.5–8.5 stipulated for drinking and domestic purposes (WHO, 1993) and GSB based on these guidelines, the pH of the dam water would not adversely affect its use for drinking and domestic purposes, and the aquatic ecosystem however, the prevention of people from farming around the dam, will help in the reduction of siltation, deposition of organic matter and chemical fertilizer which can influence the pH of water.

5.2 TEMPERATURE

Temperature is important because of its affects on certain chemical and biological activities in the organisms attributing in aquatic media. The mean temperatures variations are mainly related to the temperature of atmosphere and weather conditions (Adefemi, 2007) and observed that temperature of the water samples during the dry seasons are slightly higher than those obtained for the wet seasons. In general, the temperature results were within the guideline values of GSB (25-30^{0}C) for drinking water.

5.3 TOTAL DISSOLVED SOLIDS (TDS)

TDS are usually the common indicators of polluted waters.

Total suspended and dissolved solids affect metabolism and physiology of fish and other aquatic organisms. They are products of run offs. They increase with increased rainfall and have adverse effects on dissolved oxygen and carbon dioxide (Lawson, 2011).

According to McCutcheon *et al.* (1983), the palatability of water with TDS level less than 600 mgl-1 is generally considered to be good where as water with TDS greater than 1200 mgl-1 becomes increasingly unpalatable.

Some dissolved solids could come from organic sources such as leaves, silt, plankton and industrial waste and sewage. Others include runoff from urban areas, road salts used on street and fertilizers and pesticides used in farms; inorganic materials such as rocks and air that may contain calcium bicarbonate, nitrogen, iron phosphorous, sulfur and other minerals (Lawson, 2011) therefore, the high record in May and June could be attributed to high organic matter eroded from the surrounding farmlands into the dam as the rains start. Also the donkeys that are sent into the water at times defecate into the water during fetching as also indicated by Karikari and Ansa-Asare, (2003).

5.4 ELECTRICAL CONDUCTIVITY (EC)

The average EC value of typical, unpolluted rivers is approximately 350 µS/cm (Koning and Roos, 1999). The highest mean of EC (640 µs/cm) recorded in the month of May at station one (1) which is higher than the recommended value (350 µS/cm) reported by (Koning and Roos, 1999) for drinking water. This could be due to more organic matter and salts accumulation at the station.

Dissolved solids could directly influence water conductivity, the higher the dissolved solids the higher the conductivity. The more salts are dissolved in the water; the higher is the value of the electric conductivity. High purity water that contains no salts or minerals has a very low electrical conductivity. The water temperature affects the electric conductivity, its value increases from 2 up to 3 % per 1 degree Celsius (Lawson, 2011).

In general, this study results were below the 350 µS/cm reported by (Koning and Roos, 1999) as an indication of unpolluted water.

High EC indicates a large quantity of dissolved minerals, salt thereby making it sour and unsuitable for drinking. Similar observation was also reported by (Srivastava and Sinha, 1996).

Therefore, the parameter does not give cause for concern and it makes the water suitable for drinking and other domestic use.

5.5 NUTRIENTS (NITRATE, SULPHATE AND SODIUM)

The monthly mean Nitrate concentration values of water from the Karaga dam were below the guideline values of GSB and WHO (10 mg/l). The lower values recorded (0.5-2.37 mg/l) may be related to the denitrifying bacteria (Merck, 1980). The decrease in concentration level of the nitrate nitrogen in other months may be due to heterotrophic uptake by micro-organisms, sediment adsorption and complete loss of some aquatic macrophytes (Ude *et al.,* 2011). The high record of nitrate in May could be due to erosion of fertilizer from surrounding farmlands in to the dam. This could also be attributed to the oxidation of ammonia by nitrifying bacteria and biological nitrification also observed by (Seike *et al*., 1990).

The high value of Sulphate in May could be due to erosion of fertilizer from surrounding farmlands and mineral rocks in to the dam. It was also indicated by (Mckee and Wolf, 1976) that, source of sulphate could probably be from the mineral rocks anthropogenically added and also enters with rain. The lowest value (14 mg/l) of Sulphate concentration in June could also be attributed to dilution effect as the season progresses and volume of the dam water increases.

The high record of sodium in March and April could be due to evaporation of the water hence reducing the quantity of water in the dam and resulting in its high concentration.

The progressive reduction in Sodium concentration from April to June can be attributed to dilution effect.

The range obtained in the study for the nutrients (Nitrate, sulphate and Sodium) concentration fell below the WHO and GSB guideline values nitrate (10 mg/l), sulphate (200 mg/l,) and sodium (400 mg/l) therefore, the water could be used for domestic and other purposes as far as these parameters are concerned.

5.6 MICROBIAL WATER QUALITY (TOTAL COLIFORMS AND FAECAL COLIFORMS)

The results obtained for the microbial analysis are shown in Fig. 11 and 12. Microbiological water quality results show that the water is contaminated with faecal matter.

The results suggest that the general sanitary qualities of the water as indicated by total coliforms counts are not good because for water to be considered as no risk to human health, the faecal coliforms counts/100 ml and total coliform counts/100 ml should be zero by the GSB and WHO standards.

This high faecal matter contamination could be due to open defecation around the dam from which water is drawn for drinking purposes, watering of animals and washing of clothes. Wild and domestic animals (cattle, sheep, goats, ducks, guinea fowls and domestic fowls) seeking drinking water also contaminate the water through direct defaecation and urination (Karikari and Ansa-Asare, 2003).

5.7 DISSOLVED OXYGEN

DO is one of the important parameter in water quality assessment. It reflects the physical and biological processes prevailing in the water. Non polluted surface water is normally saturated with DO.

All the DO values recorded fell outside the range of 0–0.3 mg/l for drinking water use (WHO, 1995). The DO values, however, fell within the range of 0.1–10 mg/l for which slight adverse health effects can be expected in children and sensitive individuals (WRC, 2003) and Abdul-Razak *et al.*, 2010). High organic content from human faeces, domestic and wild animals, decayed plant materials and domestic wastes that found their ways into the dam may be responsible for low dissolved oxygen. According to (USDA, 1992), the level of oxygen depletion depends primarily on the amount of waste added, the size, velocity, turbulence of the stream and the temperature of the water. Dissolved oxygen in water depends on water temperature, partial pressure of oxygen in atmosphere and salt contents in water (Lawson, 2011). The high record of dissolved oxygen in May could be due to the lower temperatures, turbulence of the water body resulting from the rainstorms as raining season commenced which has been document by Metro 1990 that dissolved oxygen concentrations increase wherever the water flow becomes turbulent, such as in a riffle area, waterfall, or a dam.

5.8 BIOLOGICAL OXYGEN DEMAND (BOD)

BOD is the amount of oxygen required by the bacteria in stabilizing the decomposable organic matter. The aim of BOD test is to determine the amount of bio chemically oxidisable carbonaceous matter (Gupta *et al*., 2003). High values of BOD (1.5 and 1.8mg/l) recorded in May at both stations, could be due to huge load of organic matter eroded from the catchment area of the dam into the water body in May as also observe by (Sangpal *et al.*, 2011).

Biochemical oxygen demand is the amount of oxygen required for microbial metabolism of organic compounds in water. This demand occurs over some variable period of time depending on temperature, nutrient concentrations, and the enzymes available to indigenous microbial populations (Wikipedia, the free encyclopedia). The lower BOD recorded in June could be as a result of lower nutrient concentrations. The low concentration of nutrients could be due to heterotrophic uptake by micro-organisms, sediment adsorption and complete loss of some aquatic macrophytes (Ude *et al.*, 2011).

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

In conclusion, the Microbial water quality results suggest that the general sanitary qualities of the water source, as indicated by mean total coliforms counts range of 320 - 4110 CFU/100 ml and mean faecal coliforms range of 128 -1540 CFU/100 ml, are unacceptable because for water to be considered as no risk to human health, the faecal coliforms counts/100 ml and total coliforms counts/100 ml should be zero.

However, physico-chemical parameters of the water from all the stations compared with WHO and GSB standards indicated that the water samples still fall below the stipulated range of acceptability and hence the water could still be used for domestic and other purposes as far as these parameters are concerned.

6.2 RECOMMENDATION

Since faecal contamination was high, it requires treatment such as boiling or treatment with hypochlorite solution since that will kill most microbial parasites before drinking.

For sustainable management of the water resource, the Karaga district assembly should develop sanitation programmes and propagate these through environmental education to prevent pollution of the water body and consequent transmission of water-related diseases.

Farmers around the dam use chemicals (pesticides, weedicides etc) to control a variety of pests, weeds and diseases, chemical residue analysis should be carried out to ascertain levels of pollution in the water body and also to enhance better management of these agrochemicals.

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APPENDIX

A. Primary water source of households (percentage) Region (%)

Water sources	Upper	Northern	Brong	Western
Improved drinking water				
Boreholes	58	24	35	30
Protected dug wells	18	10	8	16
Public standpipes	0	32	22	11
Subtotal	76	66	65	57
Unimproved water sources				
Surface water (for example, river, lake,	5	24	31	34
Others (vender, tanker, unprotected	19	10	4	9
Subtotal	24	34	35	43
Total	100 (n = 161)	100 (n = 295)	100 (n = 359)	100 (n = 125)

Source: IFPRI Survey, 2005; IFPRI Survey, 2008 cited in (IFPRI), (2010).

B. Physicochemical and biological parameters of health significance

Parameter	Unit of measurement	GSBS	WHO Guidelines
Nitrate (NO_3^-)	mg/l	50	50
Sodium	mg/l	100	200 ^{Dn}
Sulphate	mg/l	200	500^{Dn}
Ph	N/A	6.5-8.5	6.5-8.0^{Dn}
Total Dissolved Solids	mg/l	1000	1000^{Dn}
Temperature	^{O}C	25-30	N/A
Nitrate (NO_3^-)	mg/l	50	50
Sodium	mg/l	100	200 ^{Dn}
Sulphate	mg/l	200	500^{Dn}
Total coliform	No. per 100ml sample	0	0
Faecal coliform	No. per 100ml sample	0	0

Source: Community Water and Sanitation Agency, Water Safety Framework, 2009.

C. Statistical Analysis data

Month	Sample ID	Total coliform (TC) CFU/100ml Method: APHA 9222A	Faecal coliform (TC) CFU/100ml Method: APHA 9222D	ECµ S/cm	TDS mg/l	pH	DO mg/l	BOD mg/l	SO^{-}_{4} mg/l	NO_{3^-}-N mg/l	Na^{+} mg/l	Tem ^{0}C
	S_1	3241	646	113	68	7.7	2.9	0.2	17.3	1.17	9	33
	S_2	3271	473	63	67	7.6	4.6	0.3	18.3	1.14	9	30
March	p-value	0.99	0.75	0.43	0.88	0.6	0.3	0.29	0.32	0.85	0.31	0.48
	S_1	3701	103	100	61	8.0	3.8	0.3	16.9	2.37	10	31
	S2	3363	116	101	61	8.0	3.9	0.1	18	1.95	10	30
April	p-value	0.47	0.45	0.75	0.4	1.00	0.9	0.3	0.32	0.78	0.11	1
	S1	1550	664	640	85	8.0	5.3	1.8	23.9	2.29	7	29
	S2	1960	552	143	86	8.0	5.6	1.5	23.2	2.35	7	27
May	p-value	0.54	0.62	0.43	0.4	1	0.8	0.42	0.85	0.55		0.76
	S1	4110	1540	143	87	8.8	4.6	0.2	16.4	0.56	7	30
	S2	320	128	147	88	8.9	5.2	0.1	13.7	0.54	7	28
June	p-value	0.94	0.26	0.27	0.6	0.59	0.7		0.64	0.64	1.00	0.31

D. Laboratory data

Month	Sample ID	Total coliform (TC) CFU/100ml Method: APHA 9222A	Faecal coliform (TC) CFU/100ml Method: APHA 9222D	EC µS/cm	TDS mg/l	pH	DO mg/l	BODm g/l	SO^-_4 mg/l	NO_{3-}-N mg/l	Na^+ mg/l	Tem ^0C
March	**S_1**	2160	202	107.7	65.1	7.9	3.7	0.2	17.6	1.25	9	33
	S_2	2142	327	11.2	66.9	7.6	5.6	0.3	19	1.25	9	33
March	**S_1**	4322	1090	117.5	70.7	7.6	2	0.1	17	1.09	9	32
	S_2	4400	618	113.9	67.9	7.7	3.6	0.2	17.6	1.03	9	25
April	**S_1**	3277	96	97.8	60.3	8.6	5.1	0.3	17.7	2.14	10	30
	S_2	3625	104	99.4	61	8.6	4.9	0.1	17.9	2.2	10	31
April	**S_1**	4125	110	101.7	61.1	7.5	2.7	0.2	16	2.43	10	29
	S_2	3100	128	101.8	61.7	7.5	2.6	0.1	18.1	2.5	10	28
May	**S_1**	1580	608	138.2	83.8	8.7	4.3	1.6	21.3	2.04	7	33
	S_2	2520	736	142.7	85.3	8.8	4.8	1.3	21.6	1.44	7	31
May	**S_1**	1520	720	1142.2	85.7	7.7	6.2	1.9	26.4	2.7	7	25
	S_2	1400	368	143.4	86.5	7.6	6.3	1.7	24.9	2.45	7	23
June	**S_1**	900	640	142.6	88.2	9.1	5.6	0.2	16.4	0.59	7	29
	S_2	280	140	149.2	89.6	9.2	5.9	0.1	15.4	0.57	7	29
June	**S_1**	7320	2440	143.2	85.7	8.5	4	0.1	16.4	0.53	7	30
	S_2	360	115	144.2	86.8	8.9	4.5	0.1	11.9	0.5	7	27