UNIVERSITY OF CAPE COAST

GROUNDWATER QUALITY AND SEPTIC TANK INTERACTION: AN ASSESSMENT OF HEALTH IMPLICATIONS IN AMAMOMA, CAPE COAST.

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BY

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Thesis submitted to the Department of Geography and Regional Planning of the Faculty of Social Science, College of Humanities and Legal Studies, University of Cape Coast, in partial fulfillment of the requirements for the award of Master of Philosophy degree in Geography and Regional Planning

DECEMBER 2022

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own research work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature...................................... Date……………………..

Name……………………………………………………..

Supervisor's Declaration

I hereby declare that the preparation and presentation of thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast

Supervisor's Signature................................. Date……………………….

Name…………………………………………………………………

ABSTRACT

Groundwater is the globe's largest and greatest vital source of potable fresh water. It provides drinking water to billions of people and is used to irrigate the majority of the global food supply. In spite of its importance and availability, groundwater is mostly polluted globally. Despite the fact that water from boreholes can be contaminated through different means, the most widely recognized reason for contamination is owing to its closeness of septic tanks. The central purpose main for this research is to assess groundwater interaction with septic tank and its health implications on residents of Amamoma community who is a resident of the community understudy. Structured questionnaire, laboratory test and in-depth interview guide were used to obtain data from residents and assembly man for the community. Forty-two water samples (42) were collected from seven selected groundwater sites in Amamoma. Sample of water was tested six-times period to examine quality using standard analytical procedure. Questionnaires were also administered to residents of Amamoma who use groundwater. The Assemblyman of the community was interviewed his views on the groundwater quality and water related diseases. The results showed that all the seven well contained high levels of total coliform, faecal coliform and E-coli, beyond the WHO recommended levels. It was further revealed that the shorter the distance between septic tank and groundwater sources, the higher the microbial load. As a result, the two most prevalent sanitation-related diseases in the community are diarrhoea and typhoid fever, with children being more vulnerable to suffer from such diseases. It is recommended that Community Water and Sanitation Agency should periodically track and offer remediation to improve the quality of water sources.

KEY WORDS

Contamination

Groundwater

Sanitation

Sanitation-related diseases

Septic tank

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DEDICATION

To my mother Mrs. Cecilia Awortwe Mensah & Ms. Joanna Wilhelmina Mensah

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CHAPTER ONE

INTRODUCTION

Background to the Study

Water is amongst the most vital resources for all living creature's survival. Water is an essential element that sustains human life, and without adequate water, the body cannot survive or continue to be in existence. Water covers about seventy percent of the earth's surface (United Nations 2003). However, only 2.5% is fresh water, and less than 1 % of this fresh water can be harvested in river channels, underground reserves, lakes and streams (UN Food and Agriculture Organization, 2003; World Resources Council, 2005).

Nearly 50% of the global urban population is believed today to be supplied from groundwater sources (Foster et al., 2020). In the case of the EU and USA, groundwater provides the public water supply for 310 and 105 million people, respectively. Over two-thirds of all the abstracted groundwater are used for food production. Groundwater offers close to 17% of water consumed in Australia, 65% of public water requirements in Europe, and 23% of agricultural water in Europe (EASAC 2010).

Globally, about 38% of irrigated lands are done so with groundwater. It supplies about sixty-five % of public water requirements and it is used for household needs and animal rearing (Adelana and MacDonald, 2008). Groundwater is relevant to the agricultural sector due to its all-year-round availability of water for farm irrigation, industrial and other important services, man depend on groundwater for its development. For example, in South Africa, where the main source of water is surface water yet, groundwater is extensively utilized, especially in the rural areas. It is estimated that some hundred million people in Sub Sahara Africa depend on groundwater for domestic purposes as well as for livestock rearing (Pavelic et al, 2012).

The need to ensure that people get access to quality (clean) water of high quality is very vital and this is at the center of Sustainable Development Goals 6, 14 and 11 (United Nation, 2015). Sustainable development Goal six aims at "ensuring the availability and Sustainable management of water and sanitation for all". In the same vein, Sustainable Goal 14 aims at "Conserving and sustaining the oceans, seas and marine resources for sustainable development". Sustainable development goal 14 focuses on the proper distribution of portable water when towns and cities are being planned or developed. Thus, water availability, quality, occurrence, movements on the earth surface and beneath have a role to play in achieving sustainable development in every country.

In spite of its importance and availability, groundwater is the most polluted globally (Brawlower, 2016). There are two main sources of pollution namely the point source and distributed source of pollution. In a time-discrete or continuous manner, the point source might extend into the surrounding environment.

Sewage dumped into lagoons (solid, gaseous, and liquid), industrial wastes, landfills/garbage dumps/barnyards, and liquid/gaseous spills are all examples of point source pollutants while the distributed source is spread through a large area of hydro geologic environment and in which they extend over the entire source area. A distributed source spreads faster and the pollutants may be introduced from various sources and directions. Spreading is enhanced by wind, rain, and snow fall activities through atmospheric circulation and precipitation (Egboka, Nwankwor, Orajaka, & Ejiofo, 1988).

Though groundwater is considered potable, insanitary environment can easily expose it to high risk of contamination (Morris et al., 2017). In spite of the fact that water from boreholes can be contaminated through different means (Onunkwo and Uzoiji, 2015), the most widely recognized reason for contamination is associated to nearness of septic tanks to groundwater location particularly where the connecting land arrangement is fissured and once groundwater is dirtied, is extremely difficult to clean (Sincero et al., 2006). Facilities like, septic frameworks, cesspools, seepage wells for storm water overflow, groundwater re-energize wells are of extraordinary and pivotal worry to groundwater quality assuming that they are firmly found closer to drinking water wells (US EPA 2014).

Septic tanks are the key source of effluents generated to the soil subsurface, and they are strongly linked to the spread of waterborne disease ssource. The impact of a given process by which the pollutant is discharged from its supply can be traced back to the source of contamination of groundwater, which moves through the unsaturated zone, and eventually reaches the aquifer, causing damage to the groundwater ecosystem (Huan et al. 2012). As a result, assessing the risk of groundwater contamination should take into account not just how the contaminant is released, but also where pollution sources are located, the duration of pollutant releases, as well as a number of other considerations (Shrestha et al.2016). Pollution sources in groundwater source protection areas do have the potential to pollute groundwater to various levels; as a result, the location of the source of pollution should be taken into account when assessing the risks of groundwater pollution (Zhong 2005).

Previously, septic tanks were not regarded a significant source of water pollution in many parts of the United States and Europe (EPA 2002; Weiss et al. 2008; Diaz-Valbuena et al. 2011). Yet, presently, there is a developing assortment of proof connecting septic tank framework releases to water-quality disability (Carraraet al. 2008; Katz et al. 2011; Macintosh et al. 2011; Withers et al. 2011; Mallin and McIver 2012). In the United States, almost 3000 cases of waterborne disease are documented each year due to the intake of unclean or improperly treated groundwater (Craun, 1992). For instance, in the year 2000, the pollution of a drinking water framework by Escherichia coli microorganisms in Walkerton, Canada, prompted the passings of seven individuals and made in excess of 2300 others wiped out (O'Connor 2002).

Along the US/Mexican border, rates of waterborne infections like Cholera, Diahorrea, Hepatitis and Giardiasis have happened on account of insufficient strong waste treatment prompting tainted groundwater (Kidd 2002). Groundwater is also regarded as Africa's most dependable source of drinking water (Lapworth et al., 2107). Groundwater is very essential since it supplies 88 percent of drinking water considered safe to the health of man (Kumar, 2004). In 2010, groundwater supplied 35% of drinking water, 80% of remote homes with water for domestic use, 40% of irrigation water, and 6% of self-supplied industrial water in the United States (AIPG, 1984).

In Nigeria and other African countries such as Cote d’Ivoire, Niger, Cameroon has lots of people rely on groundwater which is used for domestic, industrial, drinking and even agricultural purposes. Meanwhile, the challenge for human beings too get access to water have arisen in many cities throughout Sub-Saharan Africa as a result of the overwhelming expansion of impoverished communities arising from the flood of migrants from the countryside to the city in search of a better life of better revenues and living standards (O'Brien et al, 2017). Groundwater is also polluted by various sources for example, homegrown sewage, modern effluents, radioactive waste materials, horticultural spillover water containing synthetic pesticides and manure deposits, perilous and biomedical garbage removal, leachates permeating from landfills, oil slicks, and incidental spillage of oil because of the adverse consequence of human exercises (Khatri and Tyagi, 2015). Over 40% of the population in Africa has access to better sanitation, with septic tanks much more prevalent than improved latrines; less than 10% of city dwellers defecate in the open (Elvira et al 2008). In middle-income nations like Namibia and South Africa, these utilities provide a high level of wastewater coverage.

Human activities such as the search for land or space for septic tank constructions to dispose of solid and liquid wastes release pollutants that have an impact on groundwater quality. This is a leading cause of death and illness among children, it also contributes to poverty, and has harmed the financial loads of young people (WHO 2016; Boschi-Pinto et al. 2008; Pruss et al. 2002). For example, diarrhoea, typhoid fever, eye itching, dysentery and diseases are caused from poor water quality, sanitation, and cleanliness killed 842,000 individuals in low-income generated nations every year, with children under age of five bearing more of the ailment (WHO, 2016). This is particularly important because in most developing countries, residents use on site sanitation facilities with septic tank. According to Ashbolt (2004), poor water quality, sanitation, and hygiene induce 1.7 million deaths per year, properly accounted for 3.7% of the annual health burden, mainly due to infectious diarrhea, with nine out of ten of these deaths occurring in children and nearly all occurring in developing countries.

Despite the challenges confronting the quality of groundwater around the globe and Africa, in Ghana, the extraction of groundwater for home consumption is becoming widely used (Grönwall et al 2018). For example, in the Ga West Municipality, Northern Ghana, Bono East and West Regions, Ashanti and Shama Ahanta West Districts in the area of Jomoro, Ellembelle and Nzema are now using water obtained by boreholes and hand-dug wells (Nkansah et al. 2010). Over 95% of groundwater use in Ghana is for domestic water supply, mostly in rural areas and small towns. Overall, around 41% of households in Ghana depend on groundwater for their water supply – this is generally much higher in rural areas (59%) than urban areas (16%). However, there are some urban areas, in the Upper East and Upper West regions, where 80% of the urban population depend on groundwater for their primary water supply. (UPGro – African Groundwater 2020). Water supplies in rural areas, however, are obtained almost exclusively from groundwater sources. The various groundwater development programmes have resulted in the establishment of more than 10,000 boreholes countrywide (WRC, 2020). Because of the critical line borne water stream in towns and metropolitan regions (almost 80%), the metropolitan populace in Ghana dependent on groundwater is a lot of lower (around 11%) than that in provincial regions (approximately 47%). Some majority of Ghana's population in towns and cities rely on groundwater sources since they live in low- to middle-income communities without accessibility to piped water. Due to inconsistent pipe water supplies and severe surface water pollution, even people in moderate and top level salary metropolitan regions are progressively turning to groundwater. Of the two principle groundwater sources, hand-burrowed wells are by a long shot less expensive to build than boreholes and are subsequently found in poor or far off networks. The issue is that most of these hand-tunneled wells are unlined and their surfaces are the vast majority of the hand-burrowed wells. Some of them are additionally situated to refuse dumps or even pit lavatories, which could be in every way imaginable well springs of pollution to groundwater because of space limits. Boreholes are really only affordable to the very economic stable individuals who use it in their various houses for domestic purposes hence the majority of people (average income earners) resort to hand-dug wells (Liddle et al., 2016).

In Ghana, poorly developed communities are evident with very poor sanitation. Despite the fact that groundwater sources are generally considered safe, contaminated surroundings raise problems with water quality and the health challenges that come with it taking in contaminated groundwater increases the likelihood of diarrheal disorder morbidity and mortality, which can facilitate the outbreaks (Pedley and Howard 1997, Abu Amr and Yassin 2008).

In the world today, diarrhea deaths amounted to 1.5 million children year after year, substantially higher in number than the consolidated cost of AIDS, jungle fever, as well as measles (Black et al., 2010), and "water contamination, unhygienic conditions, and unsanitary conditions are the major reasons" (Overseas Development Institute) (ODI, 2006).

To mitigate the potential risk to human health, as a result of using contaminated water, methods of water treatment that are easy to use, effective, affordable, functional and sustainable need to be used (Sosbey, 2002).

Problem Statement

The rapid increase of student numbers enrolling in the University of Cape Coast has caused a huge deficit in the provision of basic needs of students including accommodation and utilities. Amamoma is a community which hosts students migrating from all parts of Ghana who find themselves in the University of Cape Coast. This community has a high population estimated to be seven thousand six hundred and eighty-nine (PHC, 2010). Due to the in - out system of accommodation policy of the University where second, third- and fourth-year students join the community for accommodation yet, is an example of a community constrained by inadequate supply of pipe borne water and therefore use groundwater as a primary or supplementary water source.

This has caused private home owners to provide different facilities to satisfy this important need. Whilst some of these have appreciable volumes of quality water and waste management facilities, others are unable to do so, with some willing and even striving to provide but constrained by lack of adequate space. The critical need to provide water from this otherwise important source has resulted in the siting of groundwater sources anywhere within the community disregarding sanitation and hygienic standards. A cursory look at the community shows that, when constructing an accommodation facility, house owners and hostel owners do not take into consideration an appropriate interval (minimum 50 ft apart) between the location of groundwater and septic tanks due to limited space they have been given for the purpose of accommodation facility (USEPA,2020). Water and septic tank are two vital units of every accommodation facility which cannot be overlooked by occupants of such facility. Usually, when the space is limited, house owners' site septic tank in close proximity (less than 50 ft) to groundwater.

Residents or house owners in the Amamoma community compete for space for building residential facilities to absorb the students coming into the community because it is a lucrative business on campus. This is due to the high demand for accommodation by students and workers of the University of Cape Coast every year and even when school is on vacation, sandwich students seek accommodation in the community. In this community, preliminary studies show that almost every house or hostel uses groundwater as the main or supplementary water source. This can be observed in many residential facilities (households and hostels) in Amamoma community. This renders groundwater highly vulnerable to cross-contamination (Zume et al., 2021).

Contaminated groundwater used for drinking, cooking, bathing and other domestic purpose has some indicators that renders it unhealthy for consumption and has led to increase report of sanitation diseases such as typhoid, diahorrea, skin rushes among others and the very vulnerable group of this diseases reported are children. Within a month, and average of eighteen reports are received in the CHPS compound whiles skin rashes records about fifteen (15) cases on the average monthly. This is alarming since the health workers believe most of these cases are not even reported at the health center but they go round and offer medications to such who are reluctant to visit the health facility. The impact of poor sanitation on health is highest in communities that rely on boreholes or hand – dug wells located in close proximity to on-site sanitation facilities (Pal et al., 2018a). It is against this backdrop that this research seeks to assess the quality of the water from boreholes and wells in Amamoma community.

Main Objective

The prime focus of this academic studies is to assess groundwater interaction with septic tank and its health implications on residents of Amamoma community.

Specific Objectives

The specific objectives are to;

1. Assess the quality of water from boreholes and hand dug wells in the community
2. Examine the relationship between water quality and location of septic tanks in the community
3. Assess sanitation -related diseases in the community

Research Questions

The study is underpinned by the following research questions

1. What is the quality of Amamoma's groundwater (boreholes, hand dug wells) in the community?
2. What is the relationship between water quality and location of septic tanks in the community?
3. What are the sanitation -related diseases in the community?

Hypothesis of the Study

1. Ho: There exist no relationship between distance of septic tank and the quality of water in wells and boreholes.

Ha: There exists a relationship between distance of septic tank and the quality of water in wells and boreholes.

Significance of the Study

It is normal that this exploration will become helpful and relevant to students and researchers as a working document. It is also expected that the outcome of this research will be useful to all the various stakeholders and policy makers to find a lasting solution to the problems of groundwater contamination. In addition, the study will add to existing literature.

The national development of Ghana is linked to access to safe drinking-water for its population which is a basic human right and is very essential to protect public health of the citizens of this country. Therefore, this study will draw governments attention to the current state of water quality and appropriate measures which needs to be focused on to improve it and the role of stakeholders such as Community water and Sanitation, Environmental Protection Agency, Water Resource Commission. The findings from this research will also serve as a base information on groundwater quality in terms of some selected physico-chemical parameters.

Organization of the Study

This study is organized into five chapters. Chapter one presents the introduction of the study. It covers the background to the study, problem statement, the objectives of the study, the research questions, hypothesis, significance of the study and organization of the study.

The second chapter reviewed literature on the concepts pertaining to groundwater uses, contamination, septic tank and well siting, septic tank and groundwater pollution, groundwater quality and health, water related diseases, methods used to study groundwater quality and sewage interaction.

Chapter three presents the methodology adopted for this study. It describes the study area, the data and source, sample size and sampling procedures used in this research.

The fourth chapter captures the results and discussion, while the fifth chapter concentrates on the study's summary, conclusions, and suggestions.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter examines the pertinent literature. It focused on defining key concepts, uses of groundwater, groundwater contamination, groundwater and well siting, groundwater and septic tank pollution, health impacts of groundwater and water related diseases.

Definition of Key Concepts

Groundwater

Groundwater is the world's biggest liquid fresh water resource, located in aquifers, permeable rock, and silt with water in between (Earle et al, 2015). Capillary movement, which describes how water moves through a porous media and transports water from wet to dry places, moistens soil particles earth science (Water Resources, 2018).

Water found underground in crack formation and spaces in soil and rock is referred to as groundwater. Water is stored underground in a rock body and may be extracted for human use. (Environmental science)

Well

A hole dug in the earth to create access to aquifers in order to acquire water for usage. Wells can be dug or drilled (primarily old wells just under 50 feet deep). Drilled water wells in solid rock can reach depths of up to 300 feet (Minnesota Department of Health,2014). Wells in alluvial and glacial deposits often reach depths of 100 feet and permeate underground water aquifers. Water will increase in the well, causing the aquifer's pressure to rise (Water Resources, Water Availability and Use Science Program, Maryland-Delaware-D.C. Water Science Center,2018)

Septic tank

A tank (generally made of concrete) used to hold domestic sewage to enable solids to settle before being distributed to a leeching field for soil uptake. The majority of particles contained by septic tanks are destroyed by anaerobic bacterial action **(**Department of Social and Health Services,2010.)

Water Quality

A term used to portray the substance, physical, and organic qualities of water as for its appropriateness for a specific purpose. There are some recognized institutions that have a standard measure of parameters that makes water potable such as World Health Organization, Environmental Protection Agency, Standard Authority. Example, threshold for drinking water is zero presence of microbial present in water (total coliform, fecal coliform and Escherichia coli).

Wastewater

Water used in households, industries, and companies that cannot be reused as a drinkable water except when it is treated. Wastewater is always of poor quality because the original clean water had been used for a purpose (Public Health, 2010). It is generated from not only homes but also form companies or manufacturing or production sites.

Seepage

Ground water circulation towards the surface is frequently slower and less concentrated than in springs (USGS, 2020). According to certain interpretations, seepage is the mechanism and springs are the outcome of the gradual transfer of ground water into surface water through minute cracks, pores, interstices, and so on, or even water loss by absorption into soils from fields (Europa.2010).

Sanitation

This refers to general ailments connected with clean drinking water and satisfactory treatment and removal of human excreta and sewage. Disinfection by and large alludes to the arrangement of offices and administrations for the protected removal of human pee and feaces (WHO, 2015). Accessibility to the use of bodily waste and sewage services and amenities that promote privacy and dignity, as well as a safe and wholesome living environment for everybody, is referred to as sanitation. To the degree required by the specific environmental circumstances, "Facilities and Services" must include "collecting, transportation, processing, and disposing of human fecal matter, household sewage, and solid wastes, as well as associated hygiene advocacy."(MOH, 2016).

On-site sanitation

These systems are options which help treat the waste at source, rather than dealing with it several miles away in a centralized manner. On-site sanitation is synonymous with 'household latrine,' but it can also refer to facilities shared by multiple households living on the same property.

The more commonly known on-site sanitation includes septic tanks and pit latrines. On-site sanitation entails dealing with excrement where it is deposited (Franceys, et al., 2012). It is also a sanitation system in which the collection, storage, and treatment (if applicable) facilities are all contained inside the dwelling's plot and near surroundings.

Sanitation Related Diseases

Sanitation related disease often look at the problems, challenges or ill health faced by humans who suffer from poor environmental (sanitation) conditions. Examples of poor sanitation indicators in the environment are wastewater which seeps into the streets of the residential quarters, emitting unpleasant smell (Strauss et al., 2000), poor disposal of human and animal faeces, poor disposal of waste generated from various homes and companies. In effect, poor sanitation practices can pose serious health hazards, and environmental pathologies (OMS, 2014). These are greatly the cause of diseases such as Typhoid fever, Cholerae, Diarrhoea (Carr, 2001). Some other diseases resulting from poor sanitation include skin rashes, gastro intestinal problems, malaria. The impact of these diseases often affects children. This is because, they have weak immune system and old aged persons who have underlined health conditions.

Unimproved Sanitation Facilities

Facilities that do not separate biodegradable waste from human interaction in a sanitary manner. Pit lavatories without slabs, hanging cesspit, and container latrines are examples of poorly maintained facilities (CDC,2022). These unimproved facilities are dominating in developing countries.

Water contamination

Anything physical, chemical, biological, or radioactive material or matter in water is considered a water contamination. Groundwater pollution is a predetermined process of soil contamination caused by the persistent seepage of dirty water from polluted locations (Bioremediation of Pollutants, 2020). The impacts of dumps and spills are often carried far beyond the original pollution location through groundwater. Contamination of groundwater is extremely difficult, to remove.

Water pollution

The presence of hazardous compounds and bio agents in excess of what is naturally present in water, which may jeopardize the health of people and their environment (Vhahangwele,2017). Water pollution may also include substances injected into bodies of water because of numerous human activities. Any amount of such substances causes water pollution, regardless of the risk to human health or the environment (NRDC, 2020).

Septic systems

Some sludge is decomposed inside the tanks and the surrounding sand and subsoil absorb some of it in septic systems (EPA-USA 2019). Bacteria, viruses, detergents, and home cleansers are examples of contaminants that may infiltrate groundwater from septic systems. These can lead to major pollution issues.

Theory of point source

Water has many characteristics that distinguish it. Water has the ability to dissolve more substances in greater amounts than any other liquid. However, it has the inherent capacity to break up and convey materials which easily gets contaminated. Groundwater pollutants ordinarily enter the framework from the surface, not at focuses profound inside the spring. Human activities at or close to the land surface can dissolve groundwater by presenting contaminations that travel through the unsaturated zone to the water table. Pollution can keep on moving inside the soaked zone, and release any place groundwater rises to the top. Examples of human activities which may contaminate groundwater include over-fertilization, misuse of pesticides, oil spills, leaky landfills, leaky septic systems, and leaky underground storage tanks.

As of late, some point-source contamination has been of concern, i.e., the unloaded fields of plants that once delivered pesticides or related synthetics have turned into the issues. The factories can be polluted as the synthetics spill, release, or enter around the facilities and distribution centers (Pass on et al., 2015), and the general climate can be debased by the industrial facility effluents. Point Source contamination has incredibly worked on the nature of getting water bodies all over the planet. Most created countries presently have regulations and allowing frameworks, for example, the Perfect Water Demonstration of 1972 in the US to oversee Point Source contamination. Albeit the consequences of carrying out such a regulation and controlling Point Source contamination are self-evident, its turn of events and implementation require the accessibility of assets and a framework to manage effluents.

Theory of Hydraulic lift

Hydraulic lift is the passive movement of water from roots into soil layers with lower water potential. Also, it is the process which entails the moving of water from relatively moist to dry soil layers using plant root systems as a conduit. Here, water moves in the fluid stage and the bearing of development is normally vertically. At this point when transpiration permits xylem water potential to transcend in drier soil layers. the potential for invert stream has been recognized for quite a while. A part of liquid is mislaid to vanishing and adjoining plants (Dawson 1993, 1996), yet the information shows the potential for pressure driven lift to expand the accessible soil water in upper soil layers for plant use; mature maple trees which lead pressure driven lift truly do come to pass more than little trees which do not, recommending that maple trees build an advantage from the pressure driven lift process (Dawson 1996). Pressure driven lift can work with moving water in the soil plant-environment framework.

The root dissemination joined with some immediate dissipation from the surface soil outcomes in making the soil profile dry from the surface descending. or long drying cycles, moisture is available right at the surface. Hydraulic lift gives a system to the impermanent stockpiling every evening of aqueous or moisture for the use of the plants located in the upper soil layers. The internal water capacitance of most plants is limited; in this manner, the outer stockpiling permits the profound roots to proceed with water retention short-term when happening is decreased (Caldwell and Richards 1989). This briefly put away water, which is quickly extricated during the next morning due to the fact that, it was kept in a locale of high root length thickness.

Uses of Groundwater

Groundwater is critical as a source of safe drinking water., but it is also an ecological concern, and a geological agent (MDPI,2019). Groundwater is not only important for economic growth and societal wellbeing, but it is also critical for health. Groundwater is very essential since it provides approximately 88 percent of man's clean drinking water (Kumar, 2004). Because replenishment is not directly related to rainfall and run-off occurrences, groundwater has the ability to mitigate severe hydrological occurrences. Groundwater storage provides several ways to expand retention and improve overall supply of water. It supplies billions of people with drinking water and is used to irrigate the majority of global food production (UNESCODOC 2004). All through the dry seasons and scarcity of surface water supplies, groundwater typically acts as a stable supply source. During droughts, groundwater can be drawn at volumes larger than replenishment on a short or sporadic period and controlled in ways that enable groundwater storage to replenish.

About two billion people globally rely on groundwater resources, which also include 273 transboundary aquifer networks (ISARM, 2009). Groundwater is one of the world's most plentiful and vulnerable natural resources Groundwater is used in several ways such as the watering of livestock, industry and for irrigation. Aside groundwater's importance, its widespread availability and use is sparse. Groundwater has significant economic possibilities in agriculture, recreation, irrigation, transportation, and industry. (Nsubuga et al. 2014). Groundwater assets assume significant part in homegrown water supply, watering domesticated animals, modern activities, agribusiness, fisheries, the travel industry, and natural preservation (Daniel P. Locuks and Eelco van Beek, 2017).

Empirical studies from water resource commission of Ghana says, in northern Ghana, groundwater dependency is highest due to low seasonal availability of surface water. Approximately, 41 percent of the population depend on groundwater for household use, although this rate is much higher in rural areas (59 percent) than in urban areas (16 percent).

Groundwater Contamination

As indicated by the Texas Groundwater Protection Committee (2012), groundwater contamination is regarded; the adverse change of groundwater's naturally existing chemical, thermal, biotic and morphological quality. This contamination is caused by a difference in origin, including present day and historical oil as well as gas creation and related rehearses, rural practices, creation and business tasks, exchange and modern endeavors, family utilizations, and normal bases that may be affected or result from everyday human exercises. (Public Exploration Committee, 1999). The processes involved in the mechanization and urban development, as a causative element to groundwater contamination, has evolved through period with little concern for ecological implications (Longe and Balogun, 2014), resulting to the degradation of physical, synthetic, as well as organic parts of springs (Isikwu et al., 2011).

Well over 100 million people in affluent nations rely on ground water for drinking purposes (Tuthill et al, 2018), while one of the rural and water-front populations does as well (25 to 30 percent of the households) use septic systems for wastewater disposal (Robertson et al 2011). A vast percentage of shallow sand-dug wells provide drinking water to private households in Nebraska, for example, regardless of the fact that their development for consumptive purposes has been prohibited since 1987. (Nebraska Department of Health and Human neutrons, 2020). Any substance that is infused or deposited in the land has the tendency to contaminate groundwater. (USEPA 2001). Because of the chemicals they use on a regular basis, cleaners, photographers, and beauty salons are all instances of various harmful land users (Essilfie, 2013). If these enterprises are situated close to groundwater sources and septic tanks, the hazard of groundwater contamination from accidental spills or improper treatment will be very high. These enterprises also consume a significant amount of water, contributing in brief "drawdowns" of the water table (WHO, 2006). Pouring these chemicals directly into the earth creates an ongoing risk of groundwater contamination.

Contaminated groundwater can cost government millions of dollars to clean up or perhaps damage the community's principal water source (Hongqui et al 2012). The combined effects of pollution of a regional groundwater by non - point sources (those without a well-defined specific starting spot), such as those caused by excessive utilization fertilizers, herbicides, and pesticides, is a developing worry (WHO, 2016). Minor point sources, such as a significant variety of household septic tanks or minor leaks from agro - industrial sources, also pose a threat to regional aquifer quality (Meybeck et al 2012 (European Commission, 2003).

Groundwater could very well be the only source of potable water for many populations. Conversely, groundwater pollution treatment is costly and time-consuming, causing a slew of issues for affected individuals. As a result, groundwater conservation will become progressively challenging as population density increases in regions not serviced by governmental services. In a watershed, polluted groundwater makes possibly wrecking difference. The path through which groundwater takes determines the chemical constituents. This explains why groundwater contains a wide range of inorganic materials (Freeze et al. 2015. Concentrated plumes of dissolved constituents from septic systems can form in the shallow part of the aquifer, affecting the quality of drinking water derived from domestic wells in sand

and gravel aquifers with massive porous structures that allow for relatively easy and rapid transport of water and contaminants (Verstraeten et al, 2004). The farther a septic tank is from a well, the fewer the contaminants. The quality of groundwater can therefore be attributed to both internal and external factors, and also to the soils ability to change the contaminants (Kinniburgh and Edmunds, 2016). This zone determines the amount of material (contaminants) that should enter the groundwater from the soil surface (Freeze et al. 2015). Some of the contaminants enter the ground in dry state, but requires dissolution by moisture in the soil before further percolation from infiltration can take place (Alley et al 1999). The time taken for contaminants to migrate into groundwater therefore depends on the contaminant type, namely: groundwater soluble contaminants, those lighter than water molecules or heavier but insoluble (Freeze et al. 1985). The majority of inorganic and organic chemical ingredients are soluble. After dissolving in groundwater, they create a chain of plumes of contaminant, which moves out in the path of flow of the groundwater.

Empirical studies from water resource commission Ghana have studies which shows that, Shallow groundwater is progressively defenseless to contamination from deficient sterilization frameworks in urban areas, what's more, from ocean level ascent and over siphoning in seaside springs. Only 33% of wastewater is securely arranged of in Accra, while sewerage frameworks just get 10 percent of all wastewater. Starting around 2014, unfortunate upkeep restricted Accra's wastewater treatment plants to one-fifth their plan capacity. Shallow groundwater is broadly polluted by sources like bathhouses, landfills, restrooms and septic tanks, and creature squander from pig.

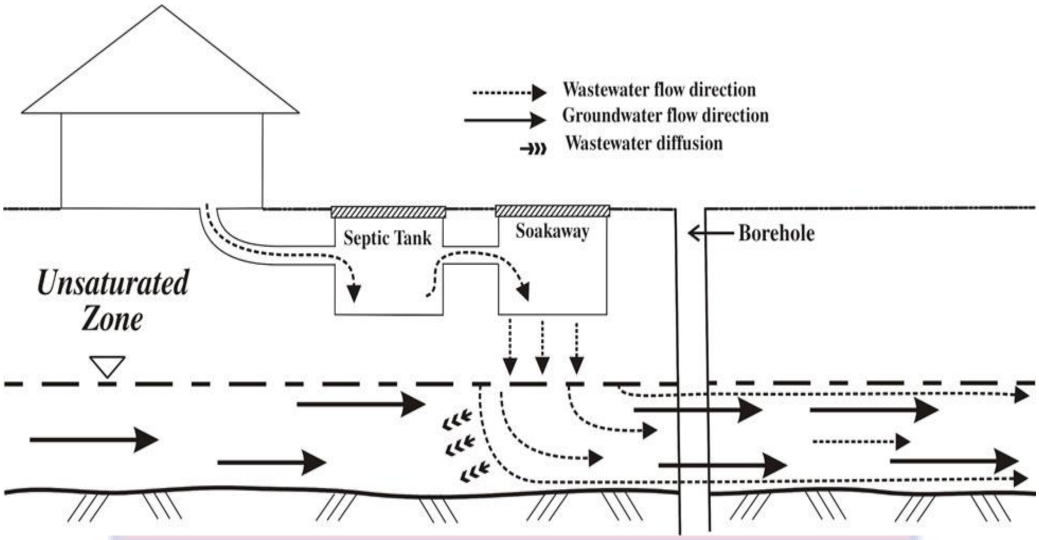

Figure 1: Wastewater Flow in a Typical Septic System

A septic tank and a soakaway pit are two components of a typical domestic septic system (Figure 1). A rectangular cement lined septic pit is common. Wastewater enters the septic tank and is put away for a while to permit suspended solids to settle prior to being released into the soakaway pit. Effluent drains from the soakaway pit into the surrounding soil, passing over the gravel. Chemical and biological processes eliminate some toxins from wastewater effluent as it percolates down through the soil, preventing them from reaching groundwater. Ultimately septic framework emanating comes to groundwater, where it influences water quality. When septic sewage is dumped into poorly graded soils, it travels downward via the unsaturated region and into groundwater.

Dependent on the amount of waste and the proximity to groundwater, the time it takes for septic seepage to flow within the unsaturated zone to reach groundwater ranges from a not many hours to a couple of days (Robertson et al.2015). The pace of relocation likewise relies upon the lithology, porosity and penetrability of the basic soil arrangement. Profluent movement has been checked, both in an upward direction and horizontally, involving varieties in convergences of these constituents (Waller et al., 2017).

Septic tank and well siting

When siting septic tank and wells, onsite systems should provide good treatment, provide good disposal, minimal exposure of the general public to the harmful components and long-term performance, all at a reasonable cost. Contaminants may be discharged into the environment because of an incorrectly sited and designed septic tank system (Obropta et al, 2005). Septic systems can pollute groundwater for a number of reasons, such as unsuitable placement, bad design, defective installation, and improper management and maintenance. Several localities have enacted minimum horizontal setback lengths from objects such as buildings and drinking water wells, as well as minimal vertical buffer distances between impervious soil layers and the water table, for septic systems (EPA-USA, 2001). As a direct consequence, septic tanks must be kept a reasonable distance away from water sources to avoid pollution (EPA, 2001a). Areas of high water shed and thin impervious strata must be avoided for borehole or well construction because the unsaturated soil thickness is inadequate to ensure appropriate treatment (EPA, 2001b).

No septic tank will be introduced under fifty feet (50') from existing or proposed wells/springs, sink openings, or attractions water lines, and tanks will be found downsize from wells or springs if truly conceivable; under 25 feet (O.C.G.A,2016). When deciding where to put the tank, take into account the numerous site constraints such as slope, grade, and stability. A septic tank must be installed on a level of secured foundation (US EPA, 2012). To avoid stormwater inundation, a septic tank on a sloping location may require a stormwater diversion drain. A well may be required to transport sewage from the tank to an upslope effluent management location.

Only 40% of Africa's urban population has private access to piped water networks, putting a cap on the potential for water-borne sewerage. For instance, in Sub-Saharan Africa, the utilization of water-borne sewage frameworks is incredibly uncommon. About 50% of the utilities providing the biggest urban areas say they have a sewage organization. These utilities give a significant degree of sewage inclusion in center pay countries like Namibia and South Africa, as well as in the intriguing illustration of Senegal. In countries like Côte d'Ivoire, Kenya, Madagascar, Malawi, Lesotho, and Uganda, notwithstanding, even where sewer networks exist, just around 10% of the populace in the assistance region approaches them (JIC, 2017). Fewer than half of individuals who have piped water also have flush toilets, which are usually connected to septic tanks rather than sewers. Africa has the second-largest number of individuals defecating in the open, behind Southern Asia, with 221 million people doing same open defecation.

Empirical studies from Centre for Scientific and Industrial and Water Resource Institute Research revealed that any borehole constructed in a home, office or community less than 30 to 50 metres away from a septic tank is likely to be polluted with human excreta and other pathogens, the Water Research Institute of the Council for Scientific and Industrial Research (CSIR-WRI), has said (Graphic Online, 2021).

Septic tanks and Groundwater Pollution

The biggest wellsprings of wastewater to the ground are subsurface sewage removal frameworks, and these are the most often revealed reasons for groundwater defilement (Miller, 2020). Nonetheless, on location frameworks add to defilement of drinking water sources. The USEPA gauges that 168,000 viral diseases and 34,000 bacterial ailments happen every year because of utilization of drinking water from frameworks that depend on inappropriately treated groundwater. Malfunctioning septic systems have been identified as one potential source of ground water contamination (USEPA, 2010). As a result, septic tanks are the largest source of waste released directly into groundwater systems. As such to protect the good health of the public and well water quality, the valuation of groundwater has become exceptionally urgent (Lin et al., 2010).

The table below gives acceptable standard by world health organization (WHO,2006), environmental protection agency (EPA,2001), Ghana standard authority, (GSA,2015) of some parameters of drinking water.

Table 1: Indicators of the quality of drinking water

PARAMETER	WORLD HEALTH ORGANISATION (2006)	ENVIRONMENTAL PROTECTION AGENCY (2001)	GHANA STANDARD AUTHORITY (2015)
Protons of Hydrogen(pH)	6.5-8	6.5-8	6.5-8
Total dissolved solutes	500	500	500
Phosphate	-	-	-
Nitrate	10	10	10
Nitrite	Less than 0.1	Less than 0.1	Less than 0.1
Salinity	1500	1500	1500
Conductivity	2500	2500	2500
Temperature	30	30	30
E coli	0	0	0
Total coliform	0	0	0
Feceal coliform	0	0	0

Source: World Health Organization (WHO, 2006), Environmental Protection Agency (EPA, 2001), Ghana Standard Authority, (GSA, 2015).

Drinkable water is water which does not possess chemicals or bacteria in sufficient quantities likely to pose a health risk (Alonge, 2005). According to Hancher 2021, the probability that, groundwater pollution by microorganisms is most noteworthy where septic tanks are firmly dispersed as in rural regions and other regions, where the by basically no soil (Boehm, 2009). Although groundwater is potable, studies across the globe indicate that, there is some extent of pollution of this potable groundwater. For example, in Florida, coliform bacteria count, nitrate and phosphate focuses were higher in homegrown wells nearer to septic tanks (Arnade, 2009), and in Wisconsin, diarrheal illness in youngsters was related with thickness of adjacent septic frameworks (Borchardt et al.,2003). Arwenyo and colleagues (2017) investigated the effects of the density of septic system for measuring groundwater quality in Uganda and found that the pollution load in groundwater rose in direct proportion to the number of septic systems. Studies in the Nigerian country (Ikem et al., 2012; Adetunji & Odetokun, 2011), Zimbabwe (Dzwairo et al., 2006; Misi et al., 2018), and Uganda (Bakyayita et al., 2019; Nyenje et al., 2014) reported similar results that municipal areas underground water contamination was associated with hygienic practices such as septic systems and open refuse dumping. Aboagye and Zume (2018) discovered peri-urban groundwater contamination in Kumasi, Ghana, because of the extensive usage of pit outhouses and open garbage disposal.

Impact of groundwater contamination on health

Infectious disorders disseminated predominantly by polluted water are known as water-borne diseases. Though these diseases caused by polluted water can be conveyed directly or indirectly by flies or dirty water is the primary vehicle through which they spread, therefore they are referred to as water-borne diseases (WHO, 2011). One of the most significant health-related infrastructure initiatives in the world is assisting people in gaining access to clean drinking water. In 2007, over 1.1 billion people were still drinking contaminated water (WHO World Health Report, 2007). Water containing any amount of fecal coliform bacteria ought not be ingested, according to the World Health Organization (WHO, 2013). Living organism wastes in water producing cramps, nausea, diarrhea, and headaches are Enterococci or coliforms, according to fecal markers. Sometimes bacterial contamination of water produces hemolytic uremic syndrome, a devastating kidney illness with potentially life-long effects. (Mahendra Pal et al, 2018). Septic systems are the major source of wastewater released to the subsurface and are significantly associated to the prevalence of waterborne illness. Untreated drinking water or improperly treated groundwater is responsible for over 3,000-recorded instances of waterborne illness in the United States each year. (Craun, 2020). Many waterborne outbreaks have been linked to fecal and chemical pollution from industry and farms, as well as to effectively clean water (CDC, 2013; Bridgman et al., 2015).

In 2014, 1450 individuals were ill because of a bacterium near well waters in Lake Erie, Ohio, USA, demonstrating the risk of polluted water for humans (Fong et al., 2007). Diarrheal diseases, such as Escherichia. coli infection, giardiasis, and typhoid fever, are among the most common diseases caused by contaminated water (Al Dufour et al 2012). People with poor immunity are more vulnerable to watery diarrheal illnesses (WHO, 2017). Children and newborns, for example, become sick because of an underdeveloped immune system, and thus are more prone to bacteria water-borne illnesses and other hazardous pollutants. Pathogenic microorganisms in drinking water, the main sources of diarrhea. A large portion of the diarrheal illnesses generally happen through oral-waste or hand-to-mouth transmission, and can be aided by water (Bellido-Blasco et 2019). It has been observed that there is a direct link between access to potable water and the reduction in epidemic diseases as well as infant survival rates (Omwenga, et al., 2009); as a result, many programs for sustainable development have laid emphasis on improving water quality and its accessibility to people. According to studies conducted by WHO (2003a), over 75% of preventable diseases in Ghana are related to poor hygiene and sanitation hence, substance pollutions are developing dangers in many emerging nations. The prosperity takes a risk with that are achieved by compound contamination of drinking water integrate skin wounds, vascular, and cardiovascular issues, and dangerous development of the bladder, lungs, or skin, liver, and kidney hurt, tangible framework, covering of the invulnerable structure, and birth forsakes (Rao, 2017). The majority of intestinal (enteric) disorders are contagious and spread by feaces. Viruses, bacteria, protozoa, and parasitic worms that cause sickness and can be discovered in the feaces of affected people (Pepper et al, 2014). These diseases are more common in locations where sanitation is poor. The more prevalent water-borne diseases that impact large populations in tropical areas are hepatitis, cholera, dysentery, and typhoid (WHO, 2010). A huge number of chemicals that are either naturally present on the land or are introduced as a result of human activities dissolve in water, polluting it and causing numerous ailments to man and his environment.

An empirical study on groundwater at Tano North of Ghana revealed that, values for fecal and *E. coli* coliform bacteria are none detectable per 100 mL and total count not exceeding 500 CFU/100 mL (WHO 2004). The levels of fecal and total coliforms in the water sample were well above the WHO recommended limit. With this high amount of fecal and total coliforms, consumers are likely to be infected with waterborne diseases like cholera and diarrheal diseases (Monney *et al.* 2001). The high levels of fecal and total coliforms could indicate that the water tends to be more exposed to more dangerous disease-causing organisms such as protozoa, bacteria and viruses.

Conceptual Framework

A fundamental conceptual framework based on the notion of soil water movement and dispersion was used in this research. Here, atoms move from a locale of higher fixation to a lower focus. A liquid stage is, generally, made out of various compound species (soil and water) each comprised of particles, iotas that are in consistent arbitrary movement (Brownian movement). Likewise do microorganisms move from septic tank which has much concentration of micro-organisms such as fecal coliform, total coliform, E. coli, nitrite, nitrate, phosphate and other elements found in human excreta. These micro-organisms move along with water through soils especially when there is a difference in gradient and seepage along septic tanks.

The rate of concentration/diffusion is observed differently during different seasons (Dry and Wet). During the dry season, soil moisture is low because of low or no rainfall so soil is very dry with little or no moisture in it. This leads to the level of water in the well/ boreholes being low, therefore more infiltration rate of molecules (nutrients- E. coli, coliforms) concentration builds up hence concentration of these molecules found in water is high. This is because, soil moisture is at not at filled capacity, hence nutrient or effluent can easily move from tanks to well depicted by increase in concentration whiles in the wet season, there is full capacity of soil moisture. This makes it difficult or slow movement of nutrient hence low concentration of nutrients when the level of water in wells are low.

In water soil movement, water in soils has a natural propensity to flow from a potentially high-energy state to a region of lower level of energy. A unit volume or mass of water tends to move from an area of higher potential energy to one of lower potential energy. The force of gravity gives a difference in the potential energy of a unit of water could occur in a soil. Due to gravity, water at a higher elevation or slope on a street tends to run down to a lower elevation, whereas water in a soil tends to flow downward. Likewise, when septic tank is sited on a higher elevation or slope, the water from septic tank tends to move from a higher elevation to a lower elevation due to the force of gravity. The flow of water is easy through soil as it does through an open pipe, and the ease through which water flows is referred to as the soil's hydraulic conductivity. Soils with huge pores, such as sandy soils, have a better ability to conduct water than soils with fewer pores, such as clayey soils. Sand, on the other hand, has a higher saturation level of permeability than clays. When soil dries up, the water in the biggest pores evaporates first. In order to travel, water must flow via small pores and in films surrounding soil particles. The soil's positive external pressures and differences in elevation accounts for attraction and in unsaturated soils, the attraction of the soil surfaces for water is often a major component to the driving force. Driving forces are commonly much larger in unsaturated soils than in saturated soils. The driving force commonly changes in magnitude with changing soil properties and wetness.

Conceptual Framework relating to soil water movement between septic tank and well/borehole

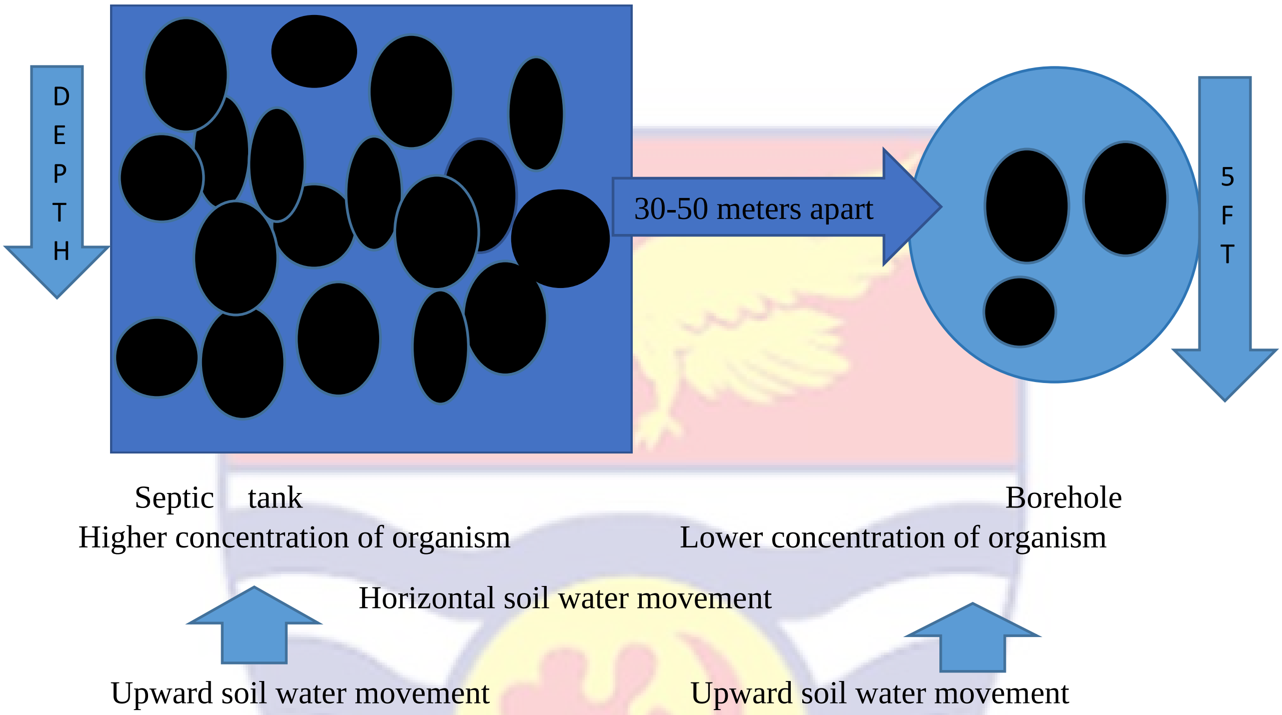

Figure 2: A conceptual framework on interaction between groundwater and septic tanks

Source: (Adapted from Shread,1992)

This conforms to the adapted conceptual framework that there is soil water movement from septic to well water sited in close proximity, less than 30 meters. This is evident as some particles(microbial) in septic tank has some moved from septic tank into well water. There is some form of exchange of microbial load from septic tank in a higher concentration to well with lower concentration. Groundwater contamination depends on its physical, chemical, and biological properties, a contaminant that has been released into the environment may move within an aquifer in the same manner that ground water moves. (Some contaminants, because of their physical or chemical properties, do not always follow ground water flow.) It is possible to predict, to some degree, the transport within an aquifer of those substances that move along with groundwater flow. For example, both water and certain contaminants flow in the direction of the topography from recharge areas to discharge areas. Soils that are porous and permeable tend to transmit water and certain types of contaminants with relative ease to an aquifer below. Illegal mining exposes some elements into surface water such as heavy metals, iron, copper, cyanide and inappropriate use of agrochemicals such as phosphate, have exacerbated surface water pollution in Ghana. The quality of water has changed, and knowledge of their current condition is important for formulating policies to conserve the country's water bodies affecting borehole water quality.

Septic systems can contaminate drinking water from wells when the chemical, biological and physical properties are above the recommended standard from WHO and other regulatory bodies. Contaminated water drank without boiling, addition of chlorine or alum can infect people with diahorrea and typhoid.

This fits the central focus of the study which is the interaction between septic tank and groundwater: an assessment of health implications in Amamoma, Cape Coast. The interaction between these two variables; septic tank and well/boreholes exchange some microbial due to soil water movement from a high potential in close proximity to a lower potential.

CHAPTER THREE
RESEARCH METHODOLOGY

Introduction

According to Stenbacka (2001), technique connects researchers to distinct fields, people, classes, organizations, and quantities of relevant interpretative resources, such as papers and archives. This section presents an overview of the research methods and procedures applied in the study. It describes the processes that were employed in the research such as study area, justification of study area, research philosophy, research designs, procedures involved in sampling, data collection instruments, procedures involved in data collection, data processing and analysis.

Study Area

The its exact place on Earth, often given in terms of latitude and longitude (absolute location) of Cape Coast is 5° 11′ 0″ N, 1° 19′ 0″ W. The Cape Coast Metropolitan Assembly is one of the seventeen (17) Metropolitan, Municipals, District Assemblies (MMDAS) of the Central Region of Ghana and Cape Coast the capital of the Central Region. Cape Coast Metropolis is bordered by the Gulf of Guinea to the south, to the west, Abura/Asebu/Kwamankese District to the east and Heman/Lower Denkyira_District to the north (Ghana Statistical Service,2010).

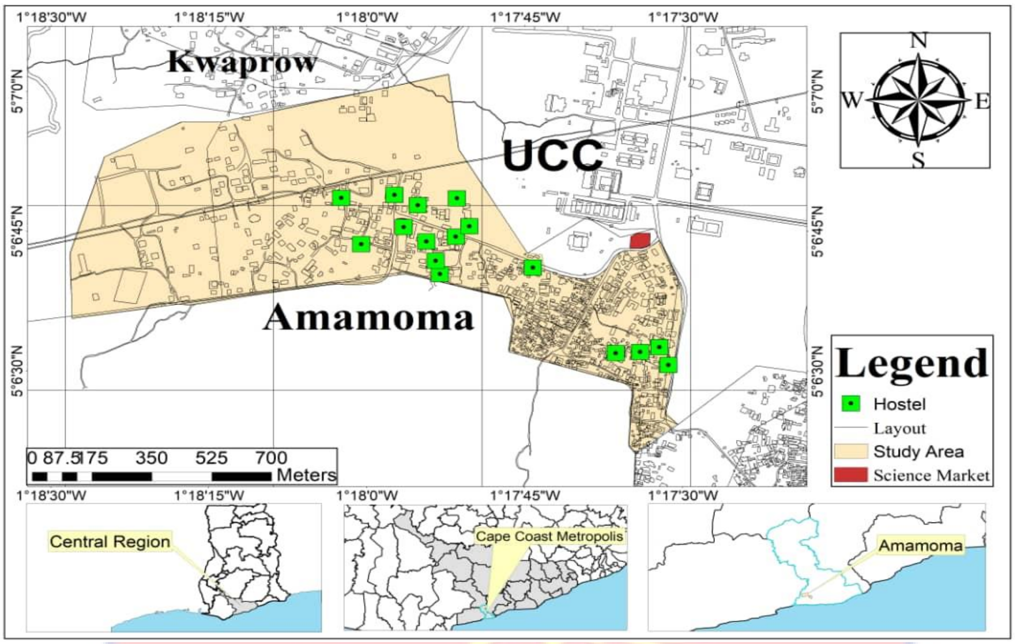

Figure 3: Map of Amamoma Community

Source: GIS and Remote Sensing Unit, Department of Geography and Regional Planning, University of Cape Coast.

Justification of Study Area

The rapid increase of student numbers enrolling in the University of Cape Coast has caused a huge deficit in the provision of basic needs of students including accommodation and utilities. Amamoma was viewed as a useful study area because it is one of the surrounding communities of the University of Cape Coast, which houses several of University students, indigenes of the community and University workers which include teaching staff, administrative staff, sanitary, conservancy staff and other business men and women. Yet, is an example of a community constrained by inadequate supply of pipe borne water and therefore use groundwater as a primary or supplementary water source.

This has caused private home owners to provide different facilities to satisfy this important need. Whilst some of these have appreciable volumes of quality water and waste management facilities, others are unable to do so, with some willing and even striving to provide but constrained by lack of adequate space. The critical need to provide water from this otherwise important source has resulted in the siting of groundwater sources anywhere within the community disregarding sanitation and hygienic standards and has led to the recording of diahorrea cases and skin rashes at the Amamoma Chip compound monthly an average of eight (18) cases with diahorrea and six (16) with skin rashes. Some years back, Cape Coast metropolis experienced some level of water shortage (Ghana web, March 24, 2022) for a long period. Some residents had to resort to the construction of wells or boreholes in several houses to provide constant water supply. Looking at the dense population of Amamoma, the provision of accommodation facility has become a boom venture that every person (indigenes and non-indigenes) of the community wants to partake, because as the years roll by, students' enrollment in the University increases hence very large number of students seek private hostel accommodation in Amamoma community. This makes landlords, family heads or hostel owners compete for space to build hostel facilities to absorb the large number of students seeking accommodation facility in the community. There is no properly calculated space or distance considered between septic tanks and location of wells therefore, failure to carefully consider distance between wells and septic tank location can affect the water quality and its health implication on residents who use groundwater.

Population of Amamoma Community

The population for the research consisted of the number of people in the Amamoma community. It consists of both indigenes and non-indigenes of the town especially student population. According to 2010 population and housing census, Amamoma has two hundred and sixty (260) houses, four hundred and thirty-six (436) households, and a population of seven thousand, six hundred and eighty-nine (7689) (Population and Housing Census, 2010). Most of the residents are Fantes, Ewes and Northerners and the main economic activity is trading (Ghana Statistical Service, 2014). Presently, there are many other tribes residing in Amamoma due to migration and students occupying the community even after completion of school.

Geology and Hydrogeology

The review region is underlain by the Cape Coast Granitoid Complex (CCGC) which is post-Tarkwaian. The Birrimian formation is the rock type of the district and consists of schist which has brought about pegmatite and granites (Ghana Districts, 2013). The granitoids are intrinsically impervious, however optional permeability and penetrability will be created because of breaking and enduring. Their pressure driven potential in this way relies upon the level of breaking and enduring just as potential re-energize of the spring, which is straightforwardly identified with the yearly precipitation and water streaming (Anon, 2004).

Climate

Amamoma is located at the north of Cape Coast Municipality which lies in the littoral anomalous zone of Ghana. The most sizzling months of the year are February and March, not long before the blustery season starts, while the coolest months are namely in the month of June and August. Rainfall has a greater influence on climate inconsistency in the municipality than temperature.

The yearly precipitation of the study area is in the reach 1,000–1,600 mm and this improves the advancement of optional penetrability in the granitoids (Anon, 2004). The precipitation system is twofold maxima. The principal stormy season for the most part happens among May and July, with the top in June, while the subsequent spell is from September to October. The district has a twofold maximal precipitation, with yearly precipitation complete between 750 mm and 1,000 mm (CCMA, 2006). This rainfall regime is great with water supply yet the high temperatures and intensity of sunshine makes water levels in reservoirs go down and the moles or concentration of micro-organisms is high hence, getting access to all year-round water is unattainable.

Vegetation

Initially, Amamoma community was a mangrove vegetation but over time, Amamoma's vegetation is a less dense marshy vegetation. Change in land use for residential purposes has distorted the natural make up of vegetation of Amamoma community. Amamoma is a low-lying area which is inclined to flooding during the period of rains. Marshy areas are being drained for building mostly because there is high demand for hostel facility in Amamoma by students. Regular vegetation comprises of bushes, grasses and a couple of dissipated trees (CCMA, 2006). The first thick vegetation has been dislodged, because of clearance for cultivation, charcoal consuming, shrubbery fires and other human exercises. Since there is less vegetation cover, drainage or surface water in the area easily dries up.

Soil

The dominant soils of the Amamoma are laterite, derived from endured stone as well as schist. Along the inclines the soil profiles have top soils with profundities of around 0.33 m, thick sandy soil of around 2.36 m inside and out as often as possible happen. In the valleys and marshy regions, fine sandy stores happen broadly (Ghana Districts, 2013). Sandy-clay type of soil is found in Amamoma community. The soil is made up of 70% sandy and 30% clay (Department of Soil Science, UCC). Sandy clay soils have large pores and rapid permeability. This means that cross contamination can easily happen due to free movement of micro-organisms due to large pores and contaminated water move through sandy clay soils in the community making groundwater easily susceptible to contamination. This soil type absorbs water rapidly and the area gets very muddy at the least downpour of rain.

Research Philosophy

The study is underpinned by the pragmatism approach. The pragmatism approach makes use of mixed methods (quantitative and qualitative); an approach of getting data for the study. As a philosophical supporting for blended techniques studies, Tashakkori and Teddlie (1998) and Patton (1990) convey the significance for zeroing in consideration on the exploration issue in sociology examination and afterward utilizing pluralistic ways to deal with determine information about the issue. Dissimilar to positivism and interpretivism research ways of thinking, logic exploration can coordinate more than one examination approaches and exploration techniques inside a similar report. Also, studies with sober mindedness research theory can incorporate the utilization of various examination strategies, for example, subjective, quantitative and activity research techniques. For mixed methods research, this choice of pragmatism as a paradigm point to an inquiry process that is built around combining the different strengths of qualitative and quantitative methods. Practicality likewise permits the potential and probability to work this way and that between subjective information and quantitative information, which are regularly considered contrary. It offers analysts the valuable chance to look for helpful marks of association between these two kinds of information. In this research, questionnaires were administered to residents who use well water in order to get the reaction they face upon the use of groundwater. Water samples from wells were taken to the Ghana Water Company Laboratory in Cape Coast to assess the microbial load and general water quality parameters. The assembly man of the area was also interviewed to get his opinion on the issue of water quality and sanitation of the community.

Data and Source

In this study, primary data was used by the researcher. The primary data used was in three phases. First, laboratory analysis on groundwater samples were done at the Laboratory of Ghana Water Company in Cape Coast. The researcher considered some parameters to be tested namely, the PH, Color, salinity, conductivity, total dissolved solutes for the Physical parameters. The chemical parameters consisted of phosphate, nitrite and nitrate and the biological parameters were total coliform, fecal coliform and Escherichia coli.

Research Design

Creswell (2009) defines research designs as "plans and processes that range from broad assumptions to particular data collecting and analysis approaches." Within research, the mixed method technique incorporates both quantitative and qualitative data (Creswell & Plano,2011). Explanatory sequential design was employed in the study. This has distinct phases: quantitative data, followed by qualitative data (Creswell et al. 2003). This design allows for the employment of two or more data gathering equipment (Andew & Halcomb, 2009). The qualitative phase builds on the quantitative one, and the two phases are connected in the intermediate stage in the study. The rationale for this approach is that the quantitative data and their analysis refine and explain those statistical results by exploring participants' views in more depth (Rossman and Wilson 1985; Tashakkori and Teddlie 1998; Creswell 2003). After the laboratory results, the researcher sought to get views of the Assembly Man of the community for his assessment on the topic being studied. The senior nurse at the Amamoma CHPS compound who is also a resident of the community was interviewed on the research being investigated.

Target Population

In this study, the target being focused on to get information from, are the residents in the Amamoma community who have both septic tank and groundwater (wells or boreholes or hand dug out) built in their houses. The focus is on household heads or residents who make use of groundwater. The Assembly Man of the community and the senior nurse at the Amamoma CHPS compound who is also a resident of the community was interviewed on the research being investigated.

Sampling Procedures

According to Valentine et al. (2010), sampling is the process of gathering data from a moderately little subset of a bigger gathering or populace to make inferential affirmations about a bigger populace. There were (235) two thirty -five total number of households with wells and septic tank in Amamoma community. The researcher performed stratified sampling. This made Amamoma community be portioned into subpopulations. So, using the benchmark of the Amamomma Palace, KVIP, Sterner Street, Maplins hostel, White hostel, round palace and after science market roundabout were the subpopulation of Amamoma.

Out of these seven sub populations were five sites purposively selected from each of the seven taking into consideration any residential facilities which had septic tank and borehole/well. These were the two variables considered and were given codes A1W1 to A5W5 representing area of septic tank and well water of first to fifth area in each subpopulation. After doing same for the six remaining sites, the researcher grouped them and randomly selected one from each subgroup to represent the sampling frame for the study. So, in all were seven septic tanks from each subgroup with its corresponding well water in the same group to make a clear and fair representation of Ammamoma community. This water sample for the study was picked once a week for every one month for microbial analysis in Ghana

Water Company Quality Assurance Laboratory. This practice was done repeatedly for six times amounting to 42 samples being understudied.

The second phase was the use of questionnaires for residents in Amamoma who make use of groundwater. Out of the seven sites, selected for the study, ten (10) people being residents or neighbor who are users of groundwater were selected conveniently to respond to questionnaires from the researcher. So, in all, seventy questionnaires were administered to seventy residents around the wells where samples were examined in the laboratory to share their ideas or feel towards groundwater quality and health implications. In the final phase, the Assembly man of the community was interviewed to get his view on the nature of septic tank and well situation in the community. The senior nurse at the Amamoma CHPS compound who is also a resident of the community was interviewed on the research being investigated.

Data Collection Instruments

Questionnaire, laboratory work and in-depth interview where the data gathering devices used were interviews. The questionnaires contained a set of questions or remarks pertaining to the groundwater quality and health impacts on residents of Amamoma community. The questionnaire had four sections, namely; background characteristics of the participant, quality of underground water of the area, standard measure between underground situation and septic tank and health implications of residents who use under groundwater with eighteen (18) items on the questionnaire to aid users of well water tell their experience or reactions using the water. The questionnaires had open ended and close ended questions. This instrument is excellent as it really allows participants adequate time to provide well-thought-out responses.

It was also found acceptable by the researcher since the researcher specified the study topic in such a way that each participant was covered, as well as to allow participants to bring up concerns that were significant to them. Interviews are the most popular technique of data collecting employed in qualitative research, according to Silverman (2000). Interviews are used to investigate individual participants' perspectives, experiences, attitudes, and motives. There are several methods for undertaking qualitative interviews (Patton, 2002). The structured interview guide was used in this study used to obtain information from the Assembly man of Amamoma community. The senior nurse at the Amamoma CHPS compound who is also a resident of the community was interviewed on the research being investigated.

This is useful since it allowed the researcher to delve further into the study's purpose. The advantage of this instrument was that it was a low-cost method of rapidly gathering data with a large quantity of information. In qualitative research, the properly organized method is typically employed to acquire socio demographic data, whereas less structured interviews with more open-ended questions are preferable (Merriam & Tisdell, 2015).

Data Collection Procedure

It was entirely proper to adhere to the ethical guidelines outlined while gathering information from responders by the University of Cape Coast Institutional Review Board (UCC IRB). Ethical clearance is required in order to gain authorization from the target groups and it was sought from the (UCC IRB) and a letter of introduction from the Geography and Regional Planning Department of the University of Cape Coast. The different periods for collecting groundwater sample and running of laboratory tests took a period of six months. It commenced from February 7th, 2020 to July 7th, 2020. The fieldwork of administering questionnaire was done from July to August 2020. The questionnaires were administered to individuals in their respective homes (around a groundwater source). The present researcher facilitating the research introduced herself to the respondents, told them of the aim and objectives of the study and how their response was going to be beneficial to the study. She assured them of confidentiality and anonymity. The researcher assisted the respondents who could not read or write by filling the questionnaires for them with the answers coming from the respondents.

Procedure for collecting water samples

The bottles used for the sampled microbial, chemical and physical analysis for the study were 750 ml unused Bel Acqua bottles whose items were purged before the loading up with test water. The bottles for sample collection had a volume of 750 ml and they were completely flushed with distilled water. After arriving at the inspecting site, each container was flushed with water from the particular well, threefold, before real example assortment was finished.

Sampling at the various sampling sites was collected every first week of the month from February (2020) to July (2020), taking into consideration seasonal variability, that is dry season from February to April and wet season from May to July. The researcher made use of a sampler to fetch water (sample) from the groundwater (borehole, hand dug, well) in a systematic manner. This was done to avoid external contamination from onsite or researcher. It was held in reserve in ice chest with ice pack for transportation to the laboratory for analysis of the water samples. This was done to get accurate temperature for microbial activities to be continually active so that a real analysis can be made at the laboratory.

Data Processing and Analysis

The data acquired were processed for quantitative and qualitative analysis because the study design was a sequential mixed-method.

To ensure accuracy and clarity, the quantitative data from the questionnaire was edited, coded, and scored.

There was a construction for coding manual for the open-ended questions before entry was done with the statistical package for social science version 22. The descriptive statistics were used to analyze the quantitative data, and that frequencies, and percentages were used to represent the results.

With regards to the water quality data, rod like instruments were used in the field to measure some parameters of water in situ. Water level temperature (WLT) had a calibrated tape in feet which measures the depth of water. This instrument has a probe with a sensor that sets stuck upon hitting the tip of groundwater. The sensor is able to record the temperature of the water in situ. pH meter was used to measure the acidity or alkalinity of water sample while turbidimeter was used to measure the turbidity or cloudiness of water sample. Spectrophotometer is used to measure the concentration of certain elements example nitrate, nitrite and phosphate in a sample using the beer lamberts law.

The Beer-Lambert law states that there is a linear relationship between the concentration and the absorbance of the solution, which enables the concentration of a solution to be calculated by measuring its absorbance. For the microbial analysis of total coliform or Escherichia coli presence in water sample, the membrane filter procedure was employed.

Microbial Analysis Procedure

In this process, the researcher, with the help of the laboratory technician, I performed membrane filtration for the microbial analysis of total coliform, fecal coliform and Escherichia coli. First, I placed a sterile membrane -filter over porous plate of receptacle and placed matched funnel unit over receptacle and lock in place. With filter still in place, the researcher rinsed the interior surface of the funnel by filtering 20-30ml portions of sterile dilution water. She then filled the sterile funnel with 100ml of sample under partial vacuum. Using sterile forceps, the researcher gently removed and placed the prepared filter directly on the agar, inverted and incubated for 24 hours. After which we remove them from the incubator and count the microbial present on the filter membrane.

For qualitative data, thematic analysis was used in analyzing data in the form of interview. It is a method for identifying, analyzing, organizing, describing, and reporting themes found within a data set (Braun et al, 2006). Topical investigation gives a profoundly adaptable methodology that can be adjusted for the necessities of many examinations, giving a rich and nitty gritty, yet complex record of information (Braun et al, 2006). The meeting was translated and physically investigated in view of the arising topics.

Reasons for selecting total coliform, fecal coliform and Escherichia coli as parameters for the study.

Total coliforms include bacteria that are found in the soil, in water that has been influenced by surface water, and in human or animal waste. The total coliform group is a large collection of different kinds of bacteria that are generally harmless. The presence of coliform bacteria in water does not guarantee that drinking the water will cause an illness. Rather, their presence indicates that a contamination pathway exists between a source of bacteria (surface water, septic system, animal waste, etc.) and the water supply. Disease-causing bacteria may use this pathway to enter the water supply.

Fecal coliforms are the group of the total coliforms that are considered to be present specifically in the gut and feces of warm-blooded animals. Fecal coliform bacteria indicate the presence of sewage contamination of a waterway and the possible presence of other pathogenic organisms. Individual home septic tanks can become overloaded during the rainy season and allow untreated human wastes to flow into drainage ditches and nearby waters. Diseases and illnesses that can be contracted in water with high fecal coliform counts include typhoid fever, hepatitis, gastroenteritis, dysentery, and ear infections.

Escherichia coli (E. coli) is the major species in the fecal coliform group which can cause serious food poisoning. Shiga toxin-producing E. coli (STEC) is a bacterium that can cause severe foodborne disease. In most cases, the illness is self-limiting, but it may lead to a life-threatening disease including hemolytic uremic syndrome (HUS), especially in young children and the elderly. (WHO, 2018)

Quality Control Measures

GHANA WATER COMPANY LIMITED – CENTRAL REGION WATER QUALITY ASSURANCE SECTION

CERTIFICATE OF ANALYSIS
MICROBIOLOGICAL ANALYSIS

NAME OF CLIENT	GOD FIRST	E E & E CONSTRUCT LIMITED
SAMPLE DESCRIPTION	BOREHOLE	BOREHOLE
LOCATION	KWAPRO-NEAR UNIVERSITY OF CAPE COAST	ASUANSI NYAMEDOM
SAMPLE RECEIPT DATE	17-02-2022	28-11-2019
ANALYSIS COMPLETION DATE	18-02-2022	29-11-2019

PARAMETER	**TEST METHOD**	**UNIT**	**GS-175 GHANA STANDARDS**	**RESULTS**
Total Coliforms	Membrane Filtration	cfu/100mL	0	471
Faecal Coliform	Membrane Filtration	cfu/100mL	0	296
E. coli	Membrane Filtration	cfu/100mL	0	16

Remarks: It was bacteriologically unsafe as it contains Total coliforms count of 471 cfu/mL, Faecal coliform count of 296 cfu/mL and *E.coli* count of 16cfu/mL.

Recommendation

Disinfection of source, Installation of Manganese Removal Facility and filtration by Reverse Osmosis (R.O) followed by installation of Water Softener are recommended to improve on bacteriological and aesthetic qualities, reduce chloride and hardness to acceptable limits before its intended use.

MANUEL TETTEH

Regional Manager (WQA)

Temperature of sites for the study over the six-time period of analysis

Sample	Temp1	Temp2	Temp3	Temp4	Temp5	Temp6
P1	29.4	29.7	29.2	28.4	27.2	27.4
P2	29.7	29.8	29.7	28.8	28.4	27.4
P3	29.7	30.1	29.2	29.5	29.2	27.2
P4	29.9	30.2	29.7	29.4	29	27.8
P5	29.8	29.9	28.8	27.4	29.4	29
P6	29.6	30.4	29.3	28.6	27.4	29.5
P7	29.6	30.4	28.4	28	28.7	29.4

Temperature of water measures the coldness or hotness of water. This is done with a thermometer. For drinking water, World Health Organization (2020). The acceptable standard for temperature of drinking water is between 25 degree celsius to 50 degree celsius. From the data above, all the sites had its temperature range between 28 C to 30.4 C which falls within WHO the acceptable standard.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The purpose of this chapter is to present and discuss the findings from the field data. This chapter is organized into four sections that correspond to the study's specific goals**;** the first section presents the description of socio-demographic characteristics of Amamoma, section two presents the results of water quality analysis from boreholes and hand-dug wells in the community. The third section analyses the relationship between water quality and the location of septic tanks in the community while the final section analyses the sanitation-related diseases in the community.

Socio-Demographic Characteristics of Respondents

This section presents the demographic characteristics of household heads who participated in this research. These indicators were sex, age, marital status, educational level and economic activity of the respondents. Researchers routinely collect demographic data to describe the sample of people or organizations in their studies.

Table 2 shows that males dominate the sampled population (54.3%), with 45.7% females These results do not correspond to the Ghana population and housing census (2010) data, which proved that there are more females than males in Ghana.

From the table, residents between age 18 years to 39 years (61.5%) are in the majority, which affirms the population and housing census (2010) data that Ghana has a youthful population. Ages between 51 – 60 years represent 28.5% of the study population.

On the educational level, table 1 demonstrate that most of the respondents (67.3%) had some formal education (from basic to tertiary) and this is attributable to the fact that there are University students living in the community. Meanwhile, 32.7% of the respondents had no formal education in Amamoma. This also affirms the district analytical report of the 2010 population and housing census.

From the table, we further observe that most of the people living in Amamoma are students (37%) because the community accommodates most of the level two hundred to four hundred students of the university as well as graduate students. More than half (53%) are either civil servants or business people who engage in the selling of consumables like cooked food, provisions or work in the University (Sanitary, Conservancy labourer, Hall administrators).

Table 2: Socio-demographic characteristics of respondents

Sex	**Frequency**	**Percentage**
Male	38	54.3
Female	32	45.7
Total	**70**	**100**
Age		
18-28	23	32.9
29-39	20	28.6
40-50	7	10.0
51-60	13	18.6
61+	7	10.0
Total	**70**	**100**
Marital Status		
Single	36	51.4
Married	27	38.6

Table 2 continued

Widow	6	8.6
Divorced	1	1.4
Total	**70**	**100**
Education		
No formal education	15	21.4
Basic	18	25.7
Secondary	10	14.3
Tertiary	27	38.6
Total	**70**	**100**
Economic Activity		
Business	26	36
Civil servant	12	17
Farms	5	7
Students	36	37
Others	2	3
Total	**70**	**100**

Source: Fieldwork, (2020).

An assessment of the quality of water in the community

In this section, the quality of groundwater is presented and discussed. The section is presented under the following subheadings: sources and uses of water, quality of groundwater in Amamoma, laboratory results on bacteria in water, and indicators of poor water quality.

Sources and uses of water in the community

Corresponding to the first objective the study seeks to achieve, respondents in the study community identified two predominant sources of water used namely, groundwater and pipe borne. The investigation discovered that there are exceptionally restricted wells of water accessible for utilization.

The study found that more than half (41 out of 70) of the respondents make use of pipe borne water for their domestic activities while about two-thirds (65 out of 70) respondents also make utilization of groundwater for their homegrown requirements. However, few of the respondents mentioned stream as a source of water. This finding is in accordance with the perspectives of Karikari (2000) who observed that most of water for families are pipe-borne water supply (treated sources) and untreated water from boreholes (ground water sources), shallow boreholes, wells, waterways and streams. In identifying available source of water to respondents, the assembly member of the community said:

> *The source of water available in Amamoma community is pipe borne water and boreholes. Residents use both boreholes and pipe borne water for domestic activities. There is only one public pipe stand in the community and the pressure on it is quite high*

In Amamoma, most houses resort to pipe borne water and boreholes for their daily survival in terms of the need for adequate water supply requirements. People fetch water from boreholes for bathing, washing and cleaning purposes more in the morning and evening than going to the public pipe stand due to long queues. Also, people fetch drinking water from pipe irrespective of the queue in the morning and evenings. Those who visit the private owned pipe and sell on commercial basis, pay more money because prices per bucket are relatively high than in the public pipe stand.

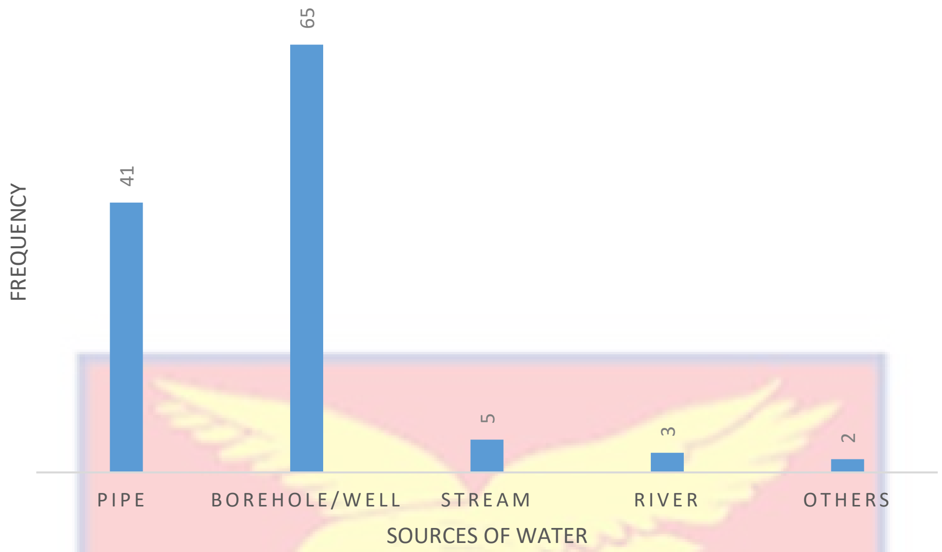

Figure 4: Sources of water

Note: Respondents were asked to treat each source as a separate item
Source: Fieldwork, 2020

Uses of water

Water is a necessity for everyday life; hence humans cannot survive without it. Water is used in our communities for a variation of functions such as domestic use, industrial/commercial use; but the use of water in Amamoma is predominantly for domestic purposes. From Figure 4, there were multiple responses on uses of water. The study recorded 19% for bathing and 18% each for cooking and washing purposes. In addition, 12% of the respondents make use of water through drinking while 16% use it for cleaning. From the respondents, they have the idea or mind that, groundwater is best and much healthier than the chemically induced water from the treatment sector (GWCL) and so, they sometimes rely upon groundwater as their principal point of drinking water.

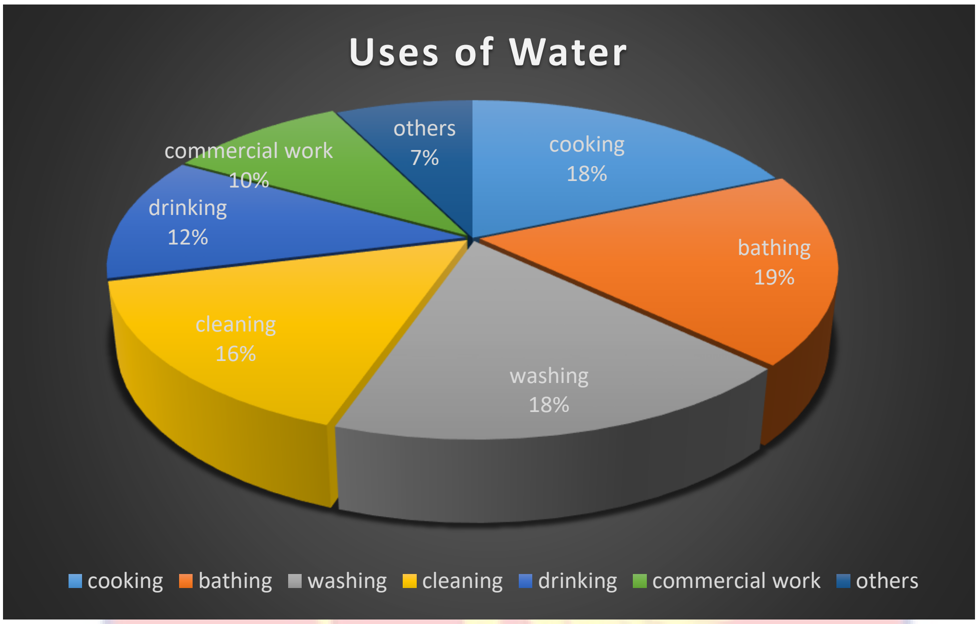

Figure 5: Uses of water

Source: Fieldwork, (2020)

Quality of groundwater

To examine the quality of the groundwater in the community, respondents were asked to indicate their perceptions about the quality of the water they use. The findings in Table 3 shows that, water sources are perceived to be of good quality by 42.9% of the respondents while 20% saw it as very good, with 37.1 % indicating that it is of poor standard. This observation is in affirmation with the work of Morris et al., (2004) who found that, though groundwater is considered potable, insanitary environment can easily expose it to high risk of contamination. Particles were present in water upon drawing it from the ground, poor color, saltiness of water which tends to rust iron filled items when washed and there were some live bacteria in the water such as earthworm, ringworm.

Table 3: Perceived quality of groundwater

State of groundwater	Frequency	Percentage
Poor	26	37.1
Good	30	42.9
Very Good	14	20.0
Total	70	100

Source: Fieldwork, (2020)

Indicators of water quality

The perceptions of the respondents about the quality of the water were borne out of certain indicators of water quality. It was clear that the respondents focused more on the physical quality indicators of water quality including presence of particles in the groundwater, colour, taste, smell, and hardness of groundwater. There were multiple responses on the indicators of poor water quality. From respondents, colour was the most notable indicator that groundwater was of poor quality. This is because colour as an indicator recorded 41 out of 70 respondents. Meanwhile, 24 out of 70 respondents indicated that smell of groundwater can be an indicator of poor water quality (Figure 5). The qualitative response on the state of water in the community revealed that,

> *The water from boreholes or wells sometimes tastes very salty and makes it difficult to use especially for washing since the saltiness does not make it easily lather with soap. Hence, residents' resort to buying more soap to wash or either decide to join the long queues at public stand pipe at a cost.*

(Assemblyman of the community)

Respondents have a poor feeling to the quality of groundwater they depend on especially about its saltiness. For other poor quality indicators, they can find a local remedy for it such as sieving particles filled water, allowing it to settle before use and boiling but for saltiness they have no remedy and this disturbs them a lot.

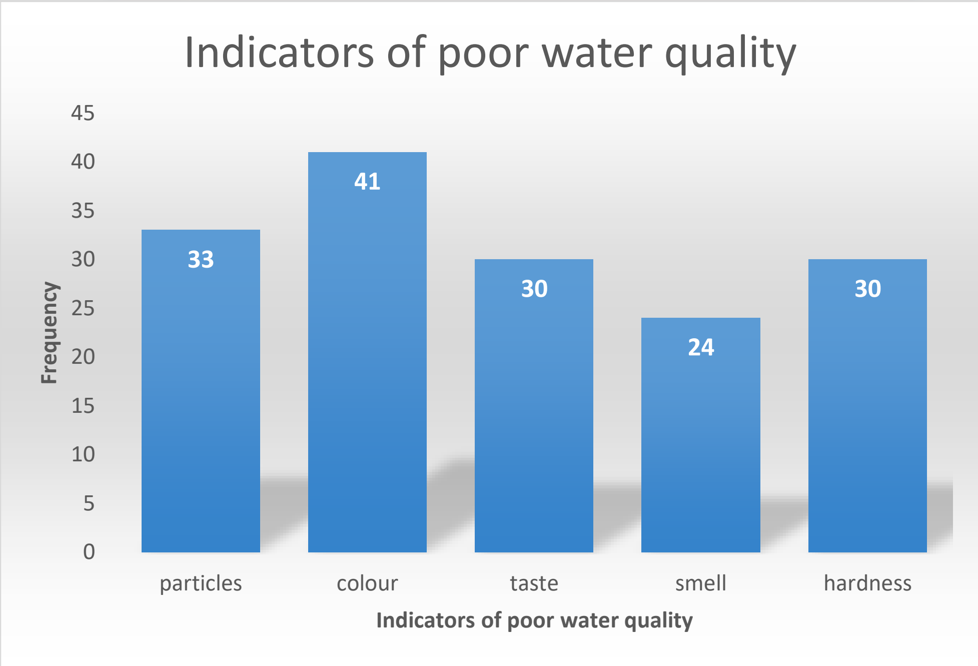

Figure 6: Indicator s of water quality

Note: Respondents were asked to treat each source as a separate item
Source: Fieldwork, 2020

Laboratory microbiological test results

To ascertain the quality of groundwater in the community, a laboratory test of the water was conducted to test or examine the quality of water. This analysis was done with reference to the standard measure (WHO) and Ghana Standard Authority. The results of the test revealed that, domestic groundwater had water filled with faecal bacteria in the research study area. Table 4 shows the average number of 42 samples during the six-time periods that the samples were collected for laboratory analysis on total coliform (TC), faecal coliform

(FC), and Escherichia coli (E.coli), in each community. Out of the 7 wells studied in Amamoma community, all of them (100%) recorded significant counts of TC, FC and Escherichia coli. The conceptual framework adopted for the study shows that water moves from a region of high concentration to a lower concentration. This is evident in the movement of faecal microbial loads from septic tanks closer to location of groundwater (caldwell,1988), hence laboratory results show that microbial loads in septic tanks are now found in well water for consumption. Literature has proved that the massive contamination of groundwater with waste microscopic organisms is because of the great incidence of on-site sanitation facilities that are poorly managed due to high influx of people in the study area (Zume et al., 2021; Aboagye et al., 2018). In Sub Saharan Africa, there has been various evidence which suggests that faecal squander is the predominant wellspring of groundwater defilement (Dzwairo et al., 2006).

Table 4: Mean of the microbiological test results (Counts)

Sample ID	TC (*counts*)	FC (*counts*)	E. coli (*counts*)
P1	3176	130	28
P2	2526	61	12
P3	1966	42	9
P4	1263	74	3
P5	130	40	18
P6	141	40	6
P7	459	44	17

Source: Fieldwork, (2020)
Note: See appendix C for the detailed results on all parameters

World Health Organization (WHO) thresholds for all bacteria = 0 cfu/100 ML

Ghana Standard Authority (GSA) threshold for all bacteria = 0 cfu/100ML

TC=total coliform =0 cfu/100ML

FC=fecal coliform =0 cfu/100ML

E=ecoli =0 cfu/100ML

From the table above (Table 4), is the cumulative counts of total coliform, fecal coliform and Escherichia coli examined over a six-time period. checking the column of total coliform, no sample (from 1 to 7) had zero number of total coliform (minimum count was 130 counts) yet the WHO standard for drinking water is zero. This means the water is not safe for drinking. Also, fecal coliform had no site being zero counts, at all sites, there were some counts of fecal coliform present in water (minimum 40 counts) sample tested and lastly, the organism Escherichia coli had minimum count of 6 present in sample debuting the WHO standard for drinking water.

Groundwater contamination

The quality of groundwater resources in Ghana is generally good except for some cases of localized pollution and areas with high levels of iron, fluoride and other minerals. Salinity in certain groundwater occurrences is also found especially in some coastal aquifers. Large numbers of the toxins in groundwater are of geogenic beginning because of disintegration of the regular mineral stores inside the earth's outside layer (Basu et al. 2014; Pandey et al. 2016; Subba Rao et al. 2020; He et al. 2020a). In any case, because of fast development of the worldwide populace, urbanization, industrialization, horticultural creation, and the economy, we presently are confronted with the test of the adverse consequences of impurities of anthropogenic beginning like the utilization of cyanide for mining. Any substance that is infused or deposited in the land has the tendency to contaminate groundwater. (USEPA 2001). Because of the chemicals they use on a regular basis, cleaners, photographers, and beauty salons are all instances of various harmful land users (Essilfie, 2013). If these enterprises are situated close to groundwater sources and septic tanks, the risk of groundwater contamination from accidental spills or improper treatment will be very high. These enterprises also consume a significant amount of water, contributing in brief "drawdowns" of the water table (WHO, 2006). he nations most impacted by these worldwide changes are those that are going through quick monetary turn of events, with a considerable lot of them situated in the eastern side of the equator (Clement and Meunie 2010; Hayashi et al. 2013; Lam et al. 2015) such as Ghana, Nigeria, China.

The relationship between water quality and location of septic tanks in the community

This section focuses on the impact of location of septic tank on groundwater quality. It has been established from the conceptual framework (Shread 1992) and other related works (Zume et al, 2021; USEPA, 2000) that nearness of septic tanks affects quality of water in boreholes. For example, USEPA (2000) established a potential source of ground water contamination has been identified as faulty septic systems. This makes septic tanks the main contributing factor to groundwater contamination. As such, septic systems should be located minimum 30 meters apart from drinking water sources to avoid a potential contamination (EPA, 2001a). When a septic tank system is improperly sited and constructed, it releases pollutants into the environment (Obropta et al, 2005). Therefore, this section seeks to ascertain whether distance of septic tank to groundwater location is a contributory factor to groundwater pollution. The section covers issues such as distance between water sources and septic and depth of well, persons who decide the distance between water sources and septic tanks, as well as the knowledge of respondents on appropriate distance between septic tank and location of water sources.

Distance between septic tank and groundwater and depth of borehole/wells

Nearness of sampled sites (hand dug wells and boreholes) were estimated in connection (30 meters apart) to nearness to septic tank was assessed. Here, all seven sites were considered and the depth of borehole was also measured. From Table 5, the farthest distance was 26.7meters from a septic tank to a well while the closest was 5.5 meters apart. This variation in distance has an impact or influence on the quality of groundwater sited closer to septic tank, hence it is possible that the sites with shorter distances are more susceptible to groundwater contamination from septic tank than those farther apart from septic tank. The results from Obropta et al (2005) reveal that the arrival of contaminations into the groundwater may results from a septic tank framework being inappropriately sited and developed. Also, O.C.G.A (2016) advised that no septic tank shall be installed less than 30.48 meters from existing or proposed wells/springs, sink holes, or suction water lines, and that septic tanks shall be located downgrade from wells or springs if physically possible.

Table 5: Distance between septic tank and groundwater and depth of borehole/wells

Sample ID	Distance from borehole to septic tank(meters)	Depth of borehole/well(meters)
P1	5.5	14.8
P2	9.4	13.5
P3	13.2	15.4
P4	17.1	27.4
P5	21.3	11.5
P6	25.5	14.8
P7	26.7	10.8

Source: Fieldwork, (2020)

Persons who decide the distance between water sources and septic tank

Efforts at siting wells at appropriate locations generally proves futile, because of hierarchical, governmentally ordered siting plans, made over the complaints of nearby specialists (Freeze et al, 2014). In any event, when public cooperation components, for example, formal reviews and public remark processes were laid out after the declaration of public resistance, those endeavors didn't result in fruitful siting endeavors (David et al, 2014). Table 6 indicates that 71.4% of the respondents mentioned that house owners decided the distance between the location of septic tank and water sources while 24.2% indicated that drilling companies are responsible for the distance between septic tank and water sources. This means that majority of respondents do not resort to any recognized institutions of the state or private enterprises to provide them with guidelines when drilling boreholes or wells but instead they depend on their own ideas especially the house owners, because of the right of owing the asset(land) and right or privilege to make use of it using their own discretion. This is not in line with the assertion of RWSN

2010, that the siting of borehole process should be led by local government with external agents providing support and inputs.

In an interview with the assemblyman of the community, it was further revealed that most households construct wells and toilet facilities without any professional knowledge on proper construction. He therefore appealed for sensitization of community members on how to construct wells and septic tanks. The following excerpts are illustrative of his concerns:

> *It will be prudent to get some state institutions who find themselves in the Central Region to educate and guide house owners who construct wells and septic tanks in their various homes. Unfortunately, engaging these state institutions comes with a high cost and the procedures involved cause much delay. This makes house owners take their own decisions on construction and after some time, there is (infiltration) seepage which later tends to affect the quality of groundwater.*

Table 6: Persons who decide the distance between water sources and septic tank

Decider of measure	Frequency	Percentage
House owner	50	71.4
Drilling company	17	24.2
Others	3	4.2
Total	**70**	**100**

Source: Fieldwork, (2020)

Respondents' knowledge on whether the distance between water sources and septic tanks affects water quality

A couple of studies, have stated that metropolitan groundwater contamination is identified with sanitation works including, septic frameworks, open decline unloading, and open human excreta. Therefore, this section of the study assesses respondents' knowledge on whether the distance between water sources and septic tanks affects water quality. From Table 7, 72.9% of the respondents said they had no idea about whether the distance between water sources and septic tanks affects water quality. This finding is worrying because a study by Arwenyo and others (2017) in Uganda, on the effects of septic framework thickness on quality of groundwater, reported that groundwater foreign substance capacity expanded with respect to the thickness of septic frameworks. In Ghana, Aboagye and Zume (2018), discovered proof of peri-metropolitan groundwater contamination because of the predominant utilization of pit lavatories and open decline unloading in the city of Kumasi.

Table 7: Knowledge on the relationship between distance of septic tanks and water quality.

Knowledge on the relationship	Frequency	Percentage
Yes	19	27.1
No	51	72.9
Total	**70**	**100**

Source: Fieldwork, (2020)

The researcher sought to find the knowledge level of the respondents on the topic being investigated. The respondents were to inform the researcher on the knowledge they have on the impact of distance affecting water quality that is, the shorter or longer distance between a septic tank and location of septic tank. Who decides the distance between these two variables; septic tank and groundwater? Is it the houseowner or an agency? Is there any relationship or precautions that needs to be adhered to when considering the construction of these variables (well/boreholes and septic tank) and its adverse effects?

Knowledge on the relationship between distance of septic tanks and water quality

From the earlier discussion, it has been proved by literature that distance between septic tank and water sources affects water quality. As a result, distance between the seven (7) sampled wells and septic tanks were measured and the distance ranged from 5.5 meters to 26.7 meters apart. Laboratory test was also conducted for presence of Total coliform, Faecal coliform and E.coli present in groundwater samples used for the study six time periods.

Table 8 shows the distance between septic tank and groundwater with its correspondent association microbial load. P1 which has the shortest distance (5.5m) recorded 3176 counts of total coliform, 130 counts of faceal coliform and 28 counts of E.coli. Sample ID P2, with a distance of 9.4m also recorded 2526 counts of total coliform, 61 counts of faecal coliform and 12 counts of ecoli. However, P6 and P7 which have distances of 25.5m and 26.5m respectively had lower counts of total coliform and faecal coliform. Surprisingly, P5 and P7 with distance 21.3 and 26.7 recorded high counts of ecoli counts in water samples (18 and 17) respectively. Cleaners, photographic artists and beauty parlors are for the most part organizations that fill in as instances of possibly dangerous land clients because of the kinds of synthetic substances they regularly use (Essilfie, 2013).

Table 8: Distance between septic tank and groundwater location versus laboratory test

Sample ID	Distance between well and septic tank (in meters)	TC counts	FC counts	E.coli counts
P1	5.5	3176	130	28
P2	9.4	2526	61	12
P3	13.2	1966	42	9
P4	17.1	1263	74	3
P5	21.3	130	40	18
P6	25.5	141	40	6
P7	26.7	459	44	17

Source: Fieldwork, (2020)

World Health Organization (WHO) thresholds for all bacteria = 0 cfu/100 ML

Ghana Standard Authority (GSA) threshold for all bacteria = 0 cfu/100ML

TC=total coliform =0 cfu/100ML

FC=fecal coliform =0 cfu/100ML

E=ecoli =0 cfu/100ML

Correlation Pearson
Number of rows 7 *ρ: pairwise Pearson correlation*

	Distance between well and septic tank	Total Coliform	Fecal Coliform
Total Coliform	-0.962		
Fecal Coliform	-0.727	0.750	
Ecoli	-0.366	0.378	0.571

Pairwise Pearson Correlations

Sample 1	Sample 2	N	Correlation	95% CI for ρ	P-Value
Total Coliform	Distance between well and septic tank	7	-0.962	(-0.995, 0.759)	- 0.001
Fecal Coliform	Distance between well and septic tank	7	-0.727	(-0.957, 0.057)	0.064
Ecoli	Distance between well and septic tank	7	-0.366	(-0.877, 0.535)	0.420
Fecal Coliform	Total Coliform	7	0.750	(-0.007, 0.961)	0.052
Ecoli	Total Coliform	7	0.378	(-0.524, 0.880)	0.403
Ecoli	Fecal Coliform	7	0.571	(-0.319, 0.926)	0.180

There exists a strong negative correlation of -0.962 between total coliform and distance. Hence, as distance decrease, total coliform in septic tank tends to increase and the other way is when distance between septic tank and well increases, the load of total coliform reduces. The P value of 0.001 which is less than alpha value of 0.05, indicates that, this test is statistically significant. Therefore, there is 95% sure of the strong negative correlation.

There exists a moderate negative correlation of 0.727 between fecal coliform and distance which means as one variable(distance) increases, fecal coliform reduces. There exists a weak correlation of -0.366 between E. coli and distance. So, we can conclude from the Pearson paired correlation that; the lesser the distance between the location of septic tank, the higher chance of load of E. coli.

Possibility of seepage from septic tanks into groundwater

The researcher sought to know from the respondents if they were aware of the possibility of seepage occurring from septic tanks into groundwater. From Figure 4, 77% of respondents affirmed that there is the possibility of seepage from septic tanks that can contribute to groundwater contamination while the rest of them 23% of respondents had no idea of the possibility of seepage affecting groundwater quality. This implies that respondents know that seepage causes contamination of water.

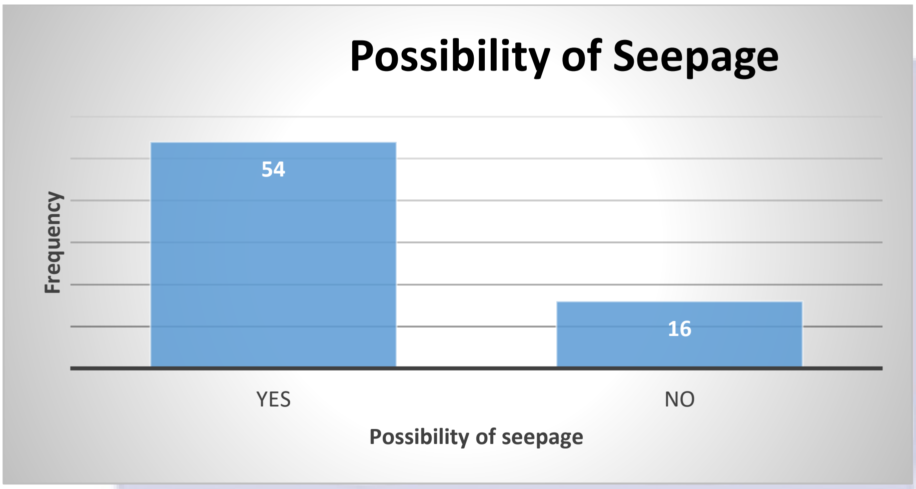

Figure 7: Possibility of seepage
Source: Fieldwork, 2020

The study further sought the view of respondents on the reason for possible seepage or how seepage contaminates groundwater. Table 9 shows that 74.3% of the respondents believe that particles move underground from septic tanks into groundwater through cracks.

Table 9: Reasons for seepage around a septic tank

Reasons for seepage	Frequency	Percentage
Movement of particles	35	50
Underground leakage	17	24.3
Contamination of water	5	7.1
Others	13	18.6
Total	**70**	**100**

Source: Fieldwork, (2020)

The third and final objective of the research was to assess the prevalence of sanitation-related diseases in Amamoma Community. This section focuses on the state of sanitation, sanitation-related diseases, how residents can make groundwater safer for consumption and measures taken to improve sanitation in the community.

State of sanitation in Amamoma community

Before exploring the sanitation-related diseases in the community, the researcher first sought to examine the state of sanitation in the community. From Table 10, respondents' view on the state of sanitation in the community were as follows; 64.3% of the respondents agree that the community has very poor sanitation. They attributed this to how poorly waste is managed in their community; high generation of waste, delay in picking refuse from the dumping site and how careless some people are with waste disposal. Also, 35.7% affirmed that the sanitation was poor while no respondent agreed or saw the sanitation state of the community as good. This confirms a study by Onunkwo and Uzoije (2011) which affirms that appropriate removal of clean sewer squanders are basic variables in guaranteeing the sufficiency and nature of home water sources. The ejection of water in pits, abandoned boreholes or even stream channels and landfills may moreover cause groundwater contamination which is also evident in my work at the Amamoma community. The problem is worse in areas where there are no proper sanitary and waste disposal facilities (Nsiah et al, 2015).

Table 10: State of sanitation in the community

State of sanitation	Frequency	Percentage
Very Poor	45	64.3
Poor	25	35.7
Good	0	0
Total	**7**	**100**

Source: Fieldwork (2020).

The poor sanitation in the community was corroborated by the Assemblyman of the community in the following excerpts:

> *The sanitation problem is worse in my community because over 80% of the students live in my community and the waste generation is extremely high meanwhile, there is no land for refuse disposal. This has caused indigenes to engage in "takeaway" (parceling of the human faeces into polythene bags) in the night. Instead of building household toilets or using the public toilet (KVIP), they practice open defecation due to financial constraints.*

Amamoma community is noted for on-site sanitation practice. This involves an open refuse site where every house dumps its rubbish. The rubbish is gathered over days before finally transported by car or younger children to the refuse site. The student population covers a significant number in the community hence its corresponding waste generation; relatively high. Amamoma has only one public toilet facility and the distance some residents need to cover before reaching the facility is quiet long hence the short cut is to do 'take away' and dump it in the dustbin or carelessly dump it in the bush or weedy environs.

Sanitation-related diseases in the community

With high contamination of water from the poor sanitation conditions in Amamoma community, the review looked to investigate the prevalence of sanitation-related diseases in the community. From Figure 8, diarrhea, typhoid, dysentery accounted for 62% of total diseases resulting from using contaminated water that is polluted by poor sanitation. This finding affirms existing literature that typhoid, hepatitis, cholera, looseness of the bowels, and are the most widely recognized water-borne infections that influence enormous populaces in the tropical districts (Al Dufour et al 2022; WHO, 2020). WHO 2010, further expresses that such sicknesses are more predominant in regions with poor sterile conditions. Of course, various gatherings of people with low resistance are more powerless to waterborne diarrheal infections. For instance, youngsters and babies get infected because of the improperly developed immune system which makes them more vulnerable to microorganisms associated with water-borne illnesses and other harmful pollutants (WHO, 2010).

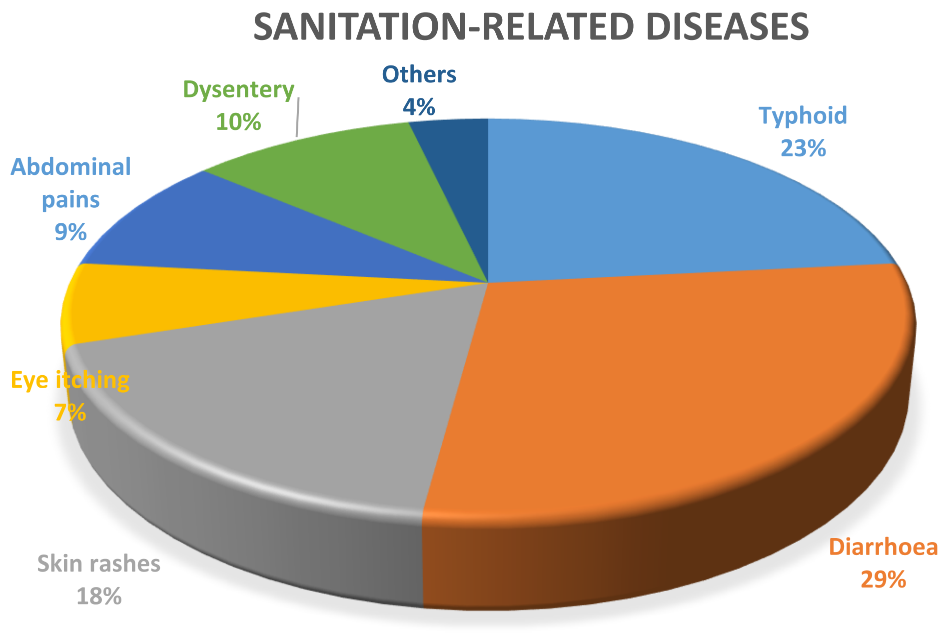

Figure 8: Sanitation-related diseases in the community

Source: Fieldwork, 2020

The interview with the assembly member in the community affirms the response from the users of groundwater in the community. The following narrative from the assemblyman is illustrative:

> *Most often, water and sanitation related diseases such as typhoid, diarrhoea occur in the community. All categories of people suffer from water related diseases but children suffer the most and they feel very weak and helpless when they take contaminated water. I had to pay for the hospital bill for a friend's son because they refuse to renew their health insurance card and this particular health issues drain me because it often happens and needs urgent attention before someone loses the life.*

The community has a health center which provides health assistance or first aid to residents who feel sick. In some serious cases these people are referred to the district or regional hospitals depending on the severity of the ailments.

The senior nurse in the CHPS compound was interviewed on the research being studied and her view on the sanitation related diseases is presented as follows:

> *The residents often report of diahorrea and skin rashes to the facility and they are hesitant to adhere to medical advice when offered by the health workers especially when infected with sanitation related disease such as diahorrea and skin rashes. we urge them to cultivate the habit of washing hands with soap under running water but they seem not to see it as a cause of their sickness.*
>
> *Senior Nurse-Amamoma CHPS*

The senior nurse in the CHPS compound was interviewed on her view about the sanitation situation and her response is presented as follows:

> *The general sanitation of the community is nothing to talk about and I give the blame to nobody but the local authorities in the Assembly and the residents themselves to live and sell food along chocked gutters filled with rats and flies hovering around all the time.*
>
> *Senior Nurse- Amamoma CHPS*

Making groundwater safe

From literature, there are numerous ways of making water safe for domestic uses. The mechanisms of making groundwater safe can be chemical, mechanical or organic. In groundwater, chemicals can be added to water to kill harmful microbes, such as bacteria, viruses, and protozoa, through the addition of disinfectant. Also, mechanical ways of separating particles and contaminants from water. From Figure 8, we realize that in order to make water appropriate for consumption or use, 25.7% of the respondents suggested boiling water before use while 24.2% suggested the periodic addition of chemicals like alum and chlorine.

Alum is one of the most ancient ways to ensure that drinking water is clean. A pinch of alum added to water removes the solid impurities. Once the sediment is thrown away, the water is boiled to kill bacteria. Alum is used as a flocculant to remove unwanted color and turbidity from water supplies. Chlorination is the process of adding chlorine to drinking water to kill parasites, bacteria, and viruses. Different processes can be used to achieve safe levels of chlorine in drinking water. Using or drinking water with small amounts of chlorine does not cause harmful health effects and provides protection against waterborne disease outbreaks.

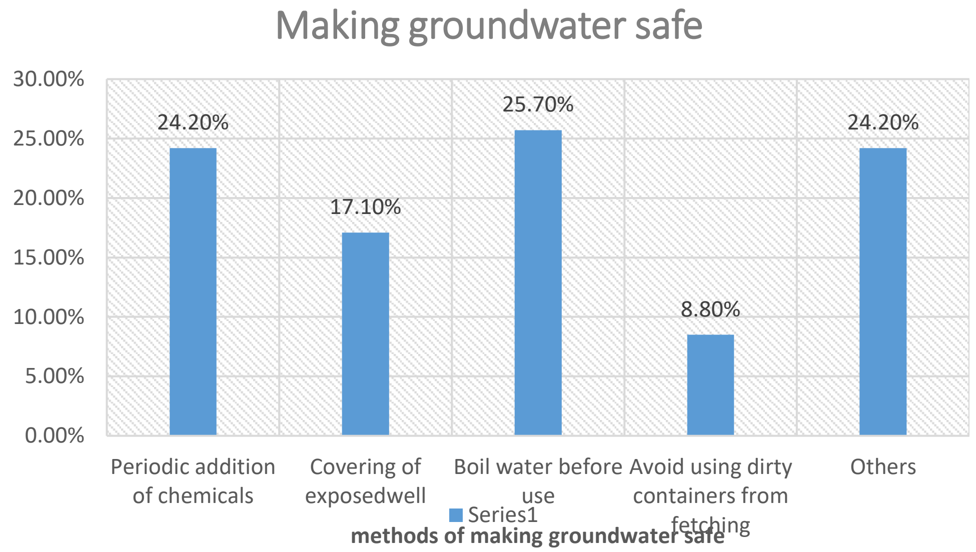

Figure 9: Making groundwater safe

Source: Fieldwork, 2020

Measures taken to improve sanitation in the community

To improve sanitation in the community, respondents made some suggestions as presented in Table 11. About 32.8% suggested that paying fines or charging sanitation offences will be a better approach in solving the sanitation problems, while others suggested communal labour (21.4%) and free waste bins (11.4%). Surprisingly, the responses did not capture anything on behavioral change being worked on by the respondents, instead they believe fines in monetary terms can make people put a stop to poor sanitation practices.

Table 11: Measures taken to improve sanitation in the community

Gap	Frequency	Percentage
Communal labour	15	21.5
Fines	23	32.8
Free waste disposal	8	11.5
Create more refuse sites	10	14.2
Others	14	20
Total	**70**	**100**

Source: Fieldwork, (2020)

The qualitative data from the field on the measures the community is taking to address the sanitation problems and for that matter prevent sanitation-related diseases is presented below:

About 21.5% of respondents envisaged that, regular communal labor can solve the sanitation problem while they need to engage the right authorities like environmental protection agency, environmental health office and planning office from the Metro Assembly to check the distance between a septic tank and groundwater location whiles 32.8% of respondents said that, punishing the perpetrators or sanitary offenders with fines will deter others from doing same because if somebody is caught and taken to the palace or court for disciplinary action, others will learn from it and do the right thing.

The main objective of this research is the assessment of groundwater and septic tank interaction; its health implications in Amamoma community of Cape Coast. In all, after gathering information from the respondents who use groundwater, for this research work and analyzing water samples at the laboratory taking some selected parameters into consideration, getting response from questionnaires issued to residents from which the objective of assessing the interaction of groundwater and septic tank was established. This affirms the fact that, distance has an influence on water quality. That is to say, the nearness of septic tank to groundwater has an impact negatively on the health of individuals especially young children between 0 to six years old and that Amamoma community has a poor sanitation which aids in the sanitation diseases residents face.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

The objective of this study was to assess the quality of underground water in relation to distance from septic tanks and its health implications in Amamoma community. This section sums up the significant discoveries of this review. Ends are drawn in light of the discoveries, and a few proposals made to draw the consideration of policymakers and water related organizations on key considerations when siting septic tank and groundwater (borehole, well and hand dug out well).

Summary of the Study

Groundwater represents the globe's most significant and largest source of fresh potable water. This fresh water which provides billions of individuals with drinking water and is utilized for water system of the biggest portion of the world's food supply. The need to ensure that people get access to quality (clean) water is very vital and this is at the center of Sustainable Development Goals six, fourteen and eleven (United Nation, 2015). In spite of its importance and availability, groundwater is mostly polluted globally. Though groundwater is considered potable, insanitary environmental conditions can easily expose it to high risk of contamination. In spite of the fact that water from boreholes can be polluted through different means, the most well-known reason for contamination is owing to the nearness of septic tanks to boreholes. The fundamental target of the review is to evaluate groundwater communication with septic tank and its health implications on residents of Amamoma community. Specifically, the research sought to:

- Examine the relationship between water quality and location of septic tanks in the community
- Examine the relationship between water quality and location of septic tanks in the community
- Assess sanitation -related diseases in the community

The review used a combination of strategies and a research method to retrieve and analyze quantitative and qualitative data.

Organization of research questionnaires were to guide residents and the researcher to gather information from inhabitants and legislative official for the study area. A sample size of seven wells were purposively selected in the community and water quality parameters were sampled and tested in the laboratory six times within six months. The Statistical package for Service Solution (SPSS) version 22 quantitative data was used for analysis while the manual thematic analysis was used for the qualitative data. Results were presented in tables, diagrams and narratives.

Summary of Findings

Objective 1: An assessment of the quality of water in the community

- Two water sources that were widely used by residents are pipe borne water and groundwater hand dug wells or boreholes.
- In terms of uses, 65 out of 70 respondents make use of groundwater for their domestic purposes, including bathing, cleaning and washing.

- While 42.9% and 20% saw the quality of the water to be good and very good respectively, more than a third (37.1 %) demonstrated that the nature of the water was poor.
- Generally, respondents used the colour, taste, smell, hardness and presence of particles in water to judge the quality of water in the community.
- From the laboratory test, it was found that most wells in the community had an element of fecal composition (Total coliform, Fecal coliform and E. coli). All the sampled wells had the values of total coliform, fecal coliform and E. coli far above the WHO and Ghana Standards Authority minimum values of zero.

Objective 2: The relationship between water quality and location of septic tanks in the community.

- Generally, the distance between septic tanks and most water sources was below the recommended distance.
- About seven out of ten (71.4%) of the respondents mentioned that house owners decided the distance between the location of septic tank and water sources.
- Almost 73% of the respondents said they had no idea about whether the distance between water sources and septic tanks affects water quality.
- Meanwhile, 54 out of the 70 respondents agreed that there is a possible of seepage from septic tanks to groundwater (wells).
- The results show that the shorter the distance between septic tank and groundwater sources, the higher the microbial load. For example, P1

which has the shortest distance (5.5m) recorded 3176 of total coliform, 130 counts of faceal coliform and 28 counts of ecoli. Sample ID P2, with a distance of 9.4m also recorded 2526 counts of total coliform, 61 counts of faecal coliform and 12 counts of ecoli. However, P6 and P7 which have distances of 25.5m and 26.5m respectively had lower counts of total coliform and faecal coliform.

Objective 3: Sanitation-related diseases in the community

- Before assessing sanitation-related diseases in the community, an assessment of residents' perceptions of the state of sanitation in the community was carried out. About 64.2% of the respondents agree that the community has very poor sanitation while 35.7% affirmed that the sanitation was poor. No respondent agreed or saw the sanitation state of the community as good.
- Subsequently, according to the respondents, noted that, diarrhoea, typhoid, dysentery is responsible for 62% of total diseases resulting from using contaminated water that is polluted by poor sanitation. Others included skin rashes, abdominal pains and itching eyes
- To improve the state of sanitation in the community 32.8% suggested that giving fines or charging sanitation offences will be a better approach, while others suggested communal labour (21.4%) and free waste bins (11.4%).

Conclusions

Based on the findings of the study, the following conclusions have been drawn:

- Groundwater in the community has been contaminated with fecal matter hence unsafe for human consumption. Poor sanitation conditions have contributed to the poor quality of water. The study revealed that house owners decide the distance between septic location and groundwater but they barely have an idea of the required or standardized measurements. Meanwhile, they do not seek any advice from professionals as a result of cost and bureaucracy involved in getting the professionals.
- With regards to the relationship between groundwater quality and the location of septic tank, findings revealed that, the nearer the groundwater is located to septic tank, the higher it is susceptible to poor quality in terms of fecal contamination. None of the sites used for the study had the accredited standard of a minimum of 50 ft apart from septic tank by US EPA and CWS in Ghana. Seepage from septic tanks running towards the location of wells which has cracks aid the easy flow of effluents to groundwater.
- On the issue of sanitation related diseases, findings showed that, Amamoma community has very poor sanitation conditions. The refuse site is far away (15km) from northern part of the community and due to high number of students living there, refuse generated is higher the capacity of the community to manage it. The two prevalent sanitation-diseases revealed in the community are diarrhoea and

typhoid fever. Children being more vulnerable to suffer from such diseases. The issue of high-cost burden on family heads when children get sick. Most residents who get infected with water borne related diseases have an expired NHIS card and this makes cost of medical attention increase.

Recommendations

Based on the findings and conclusions of this study, the following recommendations have been made:

- Residents who use groundwater should take samples to credible laboratory for quality checks to be made on it.
- Assembly man should be given the needed support from the Assembly in terms of making themselves available to educate the residents on constructing well/boreholes and septic tank in their facilities especially precautions like distance, slope, nearness to tank or refuse site.
- Residents should make water pure by practicing some traditional methods of making water safe by boiling water before use whiles some recommended chemicals be added periodically to well water to neutralize it and make it safe for drinking.
- The CHPS nurses should do house to house engagements for children below age six and give them immunized to make them resistible to water borne diseases.

REFERENCES

Agudelo-Vera, C., Avvedimento, S., Boxall, J., Creaco, E., de Kater, H., Nardo, A. di, Djukic, A., Douterelo, I., Fish, K. E., Rey, P. L. G., Jacimovic, N., Jacobs, H. E., Kapelan, Z., Solano, J. M., Pachongo, C. M., Piller, O., Quintiliani, C., Ručka, J., Tuhovčák, L., & Blokker, M. (2020). Drinking water temperature around the globe: Understanding, policies, challenges and opportunities. In *Water (Switzerland)* (Vol. 12, Issue 4). MDPI AG. https://doi.org/10.3390/W12041049

Akple, M., Keraita, B., Konradsen, F., & Agbenowu, E. (2011). Microbiological quality of water from hand-dug wells used for domestic purposes in urban communities in Kumasi, Ghana. *Urban Water Journal*, *8*(1), 57–64. https://doi.org/10.1080/1573062X.2010.528436

Alhaji, N., & Baiwa, M. (1970). Factors affecting workers' delivery of good hygienic and sanitary operations in slaughterhouses in north-central Nigeria. *Sokoto Journal of Veterinary Sciences*, *13*(1), 29–37. https://doi.org /10.4314/sokjvs.v13i1.5

Annapoorna, H., & Janardhana, M. R. (2015). Assessment of Groundwater Quality for Drinking Purpose in Rural Areas Surrounding a Defunct Copper Mine. *Aquatic Procedia*, *4*, 685–692. https://doi.org/10.1016/j.aqpro.2015.02.088.

Ashbolt, N. J. (2004). Microbial contamination of drinking water and disease outcomes in developing regions. *Toxicology*, *198*(1-3), 229-238.

Arwenyo B. Wasswa J. Nyeko M. (2017). The impact of septic systems density and nearness to spring water points, on water quality. *African Journal of Environmental Science and Technology*, *11*(1), 11–18. https://doi.org/10.5897/ajest2016.2216

Black, R. E., Cousens, S., Johnson, H. L., Lawn, J. E., Rudan, I., Bassani, D. G., Jha, P., Campbell, H., Walker, C. F., Cibulskis, R., Eisele, T., Liu, L., & Mathers, C. (2010). Global, regional, and national causes of child mortality in 2008: a systematic analysis. *The Lancet*, *375*(9730), 1969–1987. https://doi.org/10.1016/S0140-6736(10)60549-1

Bolger Melita Stevens, P., Knight Merz Sinclair Knight Merz, -Sinclair, Dillon Michael Williams, P., & Otto CSIRO Land, C. (2012). *Contamination of Australian Groundwater Systems with Nitrate*. www.lwrrdc.gov.au

Bralower, T. J. (2002). Evidence of surface water oligotrophy during the Paleocene-Eocene thermal maximum: Nanno fossil assemblage data from Ocean Drilling Program Site 690, Maud Rise, Weddell Sea. *Paleoceanography*, *17*(2), 13-1-13–12. https://doi.org/10.1029/2001pa000662

Butler, D. K. (2000). Groundwater resource assessments. *International Journal of Sustainable Development and World Ecology*, *7*(3), 173–188. https://doi.org/10.1080/13504500009470039

Butler Jumbo, R. (2014). The effect of septic tank locations on borehole water quality in Port Harcourt, Nigeria. The Effect of Septic Tank Locations on Borehole Water Quality in Port Harcourt, Nigeria. *International Journal of Engineering and Technology*, *4*(5). https://www.researchgate.net/publication/269874652

Carmon, N., Shamir, U., & Meiron-Pistiner, S. (1997). Water-sensitive urban planning: Protecting groundwater. *Journal of Environmental Planning and Management*, *40*(4), 413–434. https://doi.org/10.1080/09640569712010

Creswell, J. W. (2009). Research design: Qualitative and mixed methods approaches. *London and Thousand Oaks: Sage Publications*.

Daniel, D., Diener, A., van de Vossenberg, J., Bhatta, M., & Marks, S. J. (2020). Assessing Drinking Water Quality at the Point of Collection and within Household Storage Containers in the Hilly Rural Areas of Mid and Far-Western Nepal. *International journal of environmental research and public health*, *17*(7), 2172. https://doi.org/10.3390/ijerph17072172

Daley, K. (2013). *A Qualitative Case Study Of Relationships Between Public Health And Municipal Drinking Water And Wastewater In Coral Harbour, Nunavut*.

Dillon, P. (n.d.). *Groundwater pollution by sanitation on tropical islands; Technical documents in hydrology; Vol.:6; 1996*.

Edberg, S. C. L., Rice, E. W., Karlin, R. J., & Allen, M. J. (2000). Escherichia coli: the best biological drinking water indicator for public health protection. *Journal of applied microbiology*, *88*(S1), 106S-116S.

Essumang, D. K. (2011a). Groundwater Quality Assessment: A physicochemical properties of drinking water in a rural setting of developing countries. In *Canadian Journal on Scientific & Industrial Research* (Vol. 2, Issue 3).

Essumang, D. K. (2011b). Groundwater Quality Assessment: A physicochemical properties of drinking water in a rural setting of developing countries. In *Canadian Journal on Scientific & Industrial Research* (Vol. 2, Issue 3).

Essumang, D. K. (2011c). Groundwater Quality Assessment: A physicochemical properties of drinking water in a rural setting of developing countries. In *Canadian Journal on Scientific & Industrial Research* (Vol. 2, Issue 3).

Essumang, D. K. (2011d). Groundwater Quality Assessment: A physicochemical properties of drinking water in a rural setting of developing countries. In *Canadian Journal on Scientific & Industrial Research* (Vol. 2, Issue 3).

European Commission. Directorate-General for Economic. (2008). *EMU@ 10: successes and challenges after 10 years of Economic and Monetary Union* (No. 2). European Communities.

Evans & William et al (2019): *drilling of boreholes to ensure sustainable water supply in the Cape Coast municipality using the vertical electrical sounding (VES) technique*

Executive Report on the State of Groundwater Resources of the Northern Regions of Ghana Water Resources Commission of Ghana Canadian International Development Agency Executive Report on the State of Groundwater Resources of the Northern Regions of Ghana. (2011).

Fazal-Ur-Rehman, M. (n.d.). *Nanotechnology; A Great Innovation in Scientific Research and Technology Extraction of Nicotine (3-(1-methyl-2-pyrrolidinyl) pyridine) from Tobacco Leaves separated from Gold Live Classic Brand Cigarettes by Solvent Extraction Approach and Characterization via IR*

Spectra View project Polluted Water Borne Diseases: Symptoms, Causes, Treatment and Prevention. https://doi.org/10.26655/jmchemsci.2019.6.4

Fubara-Manuel, I., & Butler Jumbo, R. (2014a). The effect of septic tank locations on borehole water quality in Port Harcourt, Nigeria. The Effect of Septic Tank Locations on Borehole Water Quality in Port Harcourt, Nigeria. *International Journal of Engineering and Technology*, *4*(5). https://www.researchgate.net/publication/269874652

Fubara-Manuel, I., & Butler Jumbo, R. (2014b). The effect of septic tank locations on borehole water quality in Port Harcourt, Nigeria. The Effect of Septic Tank Locations on Borehole Water Quality in Port Harcourt, Nigeria. *International Journal of Engineering and Technology*, *4*(5). https://www.researchgate.net/publication/269874652

Getso, B. U., Mustapha, A., Abubakar, M. M., & Tijjani, A. (2018). Assessment of Borehole Water Quality for Domestic Use in Three Selected Wards in Wudil Local Government Area, Kano State. *Journal of Environmental Science Studies*, *1*(1), 1. https://doi.org/10.20849/jess.v1i1.394

Halder, J., & Islam, N. (2015). Water Pollution and its Impact on the Human Health.*Journal of Environment and Human*, *2*(1), 36 46. https://doi.org/10.15764/EH.2015.01005

Ian McKenzie, D. (1990). Planning for groundwater source heat pumps. *Canadian Water Resources Journal*, *15*(2), 142–153. https://doi.org/10.4296/cwrj1502142

Joarder *et al*., (2008) Physicochemical Characteristics of groundwater quality from Yola Area, Northeastern Nigeria

Keesari, T., Ramakumar, K. L., Prasad, M. B. K., Chidambaram, S., Perumal, P., Prakash, D., & Nawani, N. (2015). Microbial Evaluation of Groundwater and its Implications on Redox Condition of a Multi-Layer Sedimentary Aquifer System. *Environmental Processes*, *2*(2), 331–346. https://doi.org/10.1007/s40710-015-0067-5

Kochary, S., Byl, T., & Noori, B. (2017a). Modeling the movement of septic water chloride through a soil profile. *Sustainability (Switzerland)*, *9*(4). https://doi.org/10.3390/su9040501

Kochary, S., Byl, T., & Noori, B. (2017b). Modeling the movement of septic water chloride through a soil profile. *Sustainability (Switzerland)*, *9*(4). https://doi.org/10.3390/su9040501

Kochary, S., Byl, T., & Noori, B. (2017c). Modeling the movement of septic water chloride through a soil profile. *Sustainability (Switzerland)*, *9*(4). https://doi.org/10.3390/su9040501

Kölbel-Boelke, J., Anders, E. M., & Nehrkorn, A. (1988). Microbial communities in the saturated groundwater environment II: diversity of bacterial communities in a Pleistocene sand aquifer and their in vitro activities. *Microbial ecology*, *16*(1), 31-48.

König, L. F., & Weiss, J. L. (2009). *Groundwater: modelling, management and contamination*. Nova Science Publishers.

Kortatsi, B. K. (2017) *Groundwater Quality in the Wassa West District of the Western Region of Ghana*.

Kulinkina, A. v, Shinee, E., Rafael, B., Herrador, G., Nygård, K., & Schmoll, O. (2016). *the situation of water-related infectious diseases in The Pan-European region*. http://www.euro.who.int/pubrequest

Kwame, M. M. (2017). *Assessment of Drinking Water Quality in Ehi Community in The Ketu-North District Of The Volta Region Of Ghana*.

Joarder *et al*., 2008 Physicochemical Characteristics of groundwater quality from Yola Area, Northeastern Nigeria

Lavoie, R., Joerin, F., & Rodriguez, M. J. (2014). Incorporating groundwater issues into regional planning in the Province of Quebec. *Journal of Environmental Planning and Management*, *57*(4), 516–537. https://doi.org/10.1080/09640568.2012.751019

Leusink, A. (1992). The planning process for groundwater resources management. *International Journal of Water Resources Development*, *8*(2), 98–102. https://doi.org/10.1080/07900629208722539

Li, M., Liang, X., Xiao, C., & Cao, Y. (2020). Quantitative evaluation of groundwater-surface water interactions: Application of cumulative exchange fluxes method. *Water (Switzerland)*, *12*(1). https://doi.org/10.3390/w12010259

Licciardello, F., Antoci, M. L., Brugaletta, L., & Cirelli, G. L. (2011). Evaluation of groundwater contamination in a coastal area of south-eastern sicily. *Journal of Environmental Science and Health - Part B Pesticides, Food Contaminants, and Agricultural Wastes*, *46*(6), 498–508. https://doi.org/10.1080/03601234.2011.583870

Lutterodt, G., van de Vossenberg, J., Hoiting, Y., Kamara, A. K., Oduro-Kwarteng, S., & Foppen, J. W. A. (2018a). Microbial groundwater quality status of hand-dug wells and boreholes in the Dodowa area of Ghana. *International Journal of Environmental Research and Public Health*, *15*(4). https://doi.org/10.3390/ijerph15040730

Lutterodt, G., van de Vossenberg, J., Hoiting, Y., Kamara, A. K., Oduro-Kwarteng, S., & Foppen, J. W. A. (2018b). Microbial groundwater quality status of hand-dug wells and boreholes in the Dodowa area of Ghana. *International Journal of Environmental Research and Public Health*, *15*(4). https://doi.org/10.3390/ijerph15040730

MacDonald, A. M., Bonsor, H. C., Dochartaigh, B. É. Ó., & Taylor, R. G. (2012). Quantitative maps of groundwater resources in Africa. In *Environmental Research Letters* (Vol. 7, Issue 2). Institute of Physics Publishing. https://doi.org/10.1088/1748-9326/7/2/024009

Margaret Scott, B., & Alcenat, W. (2008). Revisiting the Pivot: The Influence of Heartland Theory in Great Power Politics. In *Comparative Strategy* (Vol. 22).

Mariwah, S. (2018a). Sanitation: the neglected Siamese twin of water in achieving the millennium development goals (MDGs) in Ghana. In *GeoJournal* (Vol. 83, Issue 2, pp. 223–236). Springer Netherlands. https://doi.org/10.1007/s10708-016-9765-4

Mariwah, S. (2018b). Sanitation: the neglected Siamese twin of water in achieving the millennium development goals (MDGs) in Ghana. In *GeoJournal* (Vol. 83, Issue 2, pp. 223–236). Springer Netherlands. https://doi.org/10.1007/s10708-016-9765-4

Mariwah, S., Amo-Adjei, J., & Anima, P. (2017). What has poverty got to do with it? Analysis of household access to improved sanitation in Ghana. *Journal of Water Sanitation and Hygiene for Development*, *7*(1), 129–139. https://doi.org/10.2166/washdev.2017.101

Mariwah, S., Hampshire, K., & Owusu-Antwi, C. (2017). Getting a foot on the sanitation ladder: User satisfaction and willingness to pay for improved public toilets in Accra, Ghana. *Journal of Water Sanitation and Hygiene for Development*, *7*(3), 528–534. https://doi.org/10.2166/washdev.2017.007

Mbugua, H. (2016). *University Of Nairobi The Effect Of Septic Tanks Sewage Disposal System Distances On Borehole Water Quality In Ongata Rongai, Kajiado County, Kenya*.

Mechlem, K. (2016). Groundwater governance: The role of legal frameworks at the local and national level-established practice and emerging trends. *Water (Switzerland)*, *8*(8). https://doi.org/10.3390/w8080347

Mendis, M. D. V. S., & Weerakkody, W. A. S. (2018). The impact of work life balance on employee performance with reference to telecommunication industry in Sri Lanka: a mediation model. *Kelaniya Journal of Human Resource Management*, *12*(1), 72. https://doi.org/10.4038/kjhrm.v12i1.42

Mlipano, C. L., Richard, M., & Lawrence, C. (2017). Effect of Depth and Distance of the Borehole from the Septic Tank on the Physico-Chemical Quality of Water. *Journal of Food Studies*, *7*(1), 41. https://doi.org/10.5296/jfs.v7i1.12187

National Drinking Water Quality Management Framework for Ghana "Prevention is better than cure" Ministry of Water Resources, Works and Housing Government of Ghana. (2015).

Ngwira D.,& Naomi .A. (2014) Gender and poverty reduction in Malawi

Nsubuga, F. N., Namutebi, E. N., & Nsubuga-Ssenfuma, M. (2014). Water resources of Uganda: an assessment and review. *Journal of Water Resource and Protection*, *6*(14), 1297.

Obiefuna;, G. I., & Orazulike, D. M. (2011). *Physicochemical Characteristics of groundwater quality from Yola Area, Northeastern Nigeria*. www.bioline. org.br/ja

Obiri-Danso, K., Adjei, B., Stanley, K. N., & Jones, K. (2009a). Microbiological quality and metal levels in wells and boreholes water in some peri-urban communities in Kumasi, Ghana. In *African Journal of Environmental Science and Technology* (Vol. 3, Issue 1). http://www.academicjournals.org/AJEST

Obiri-Danso, K., Adjei, B., Stanley, K. N., & Jones, K. (2009b). Microbiological quality and metal levels in wells and boreholes water in some peri-urban communities in Kumasi, Ghana. In *African Journal of Environmental Science and Technology* (Vol. 3, Issue 1). http://www.academicjournals.org/AJEST

Obropta, C. C., & Del Monaco, N. (2018). Reducing directly connected impervious areas with green stormwater infrastructure. *Journal of Sustainable Water in the Built Environment*, *4*(1), 05017004.

Oke, S. A., & Fourie, F. (2017). Guidelines to groundwater vulnerability mapping for Sub-Saharan Africa. *Groundwater for Sustainable Development*, *5*, 168–177. https://doi.org/10.1016/j.gsd.2017.06.007

Pal, M., Ayele, Y., Hadush, A., Panigrahi, S., & Jadhav, V. J. (2018a). *Public Health Hazards Due to Unsafe Drinking Water*. https://doi.org/10.4172/2167-7719.1000138

Pal, M., Ayele, Y., Hadush, A., Panigrahi, S., & Jadhav, V. J. (2018b). *Public Health Hazards Due to Unsafe Drinking Water*. https://doi.org/10.4172/2167-7719.1000138

Palamuleni, L., & Akoth, M. (2015). Physico-chemical and microbial analysis of selected borehole water in Mahikeng, South Africa. *International Journal of Environmental Research and Public Health*, *12*(8), 8619–8630. https://doi.org/10.3390/ijerph120808619

Polidori, L. (2011). *Potential and limitations of remote sensing for cadastre and land management Potentiel et limites de la télédétection pour les applications foncières*.

Quagraine, E. K., & Adokoh, C. K. (2010). Assessment of dry season surface, ground, and treated water quality in the Cape Coast municipality of Ghana. *Environmental Monitoring and Assessment*, *160*(1–4), 521–539. https://doi.org/10.1007/s10661-008-0716-5

Reay, W. G. (2004). Septic tank impacts on ground water quality and nearshore sediment nutrient flux. *Ground Water*, *42*(7), 1079–1089. https://doi.org/10.1111/j.1745-6584.2004.tb02645.x

Roldin, M., Locatelli, L., Mark, O., Mikkelsen, P. S., & Binning, P. J. (2013). A simplified model of soakaway infiltration interaction with a shallow groundwater table. *Journal of Hydrology*, *497*, 165–175. https://doi.org/10.1016/j.jhydrol.2013.06.005

Sangodoyin, A. Y. (1993). Considerations on contamination of groundwater by waste disposal systems in Nigeria. *Environmental Technology (United Kingdom)*, *14*(10), 957–964. https://doi.org/10.1080/09593339309385370

Schaider, L. A., Ackerman, J. M., & Rudel, R. A. (2016a). Septic systems as sources of organic wastewater compounds in domestic drinking water wells in a shallow sand and gravel aquifer. *Science of the Total Environment*, *547*, 470–481. https://doi.org/10.1016/j.scitotenv.2015.12.081

Schaider, L. A., Ackerman, J. M., & Rudel, R. A. (2016b). Septic systems as sources of organic wastewater compounds in domestic drinking water wells in a shallow sand and gravel aquifer. *Science of the Total Environment*, *547*, 470–481. https://doi.org/10.1016/j.scitotenv.2015.12.081

Shomaker, J. W. (2003). Evolution of Water Planning in New Mexico and Implications for Transboundary Groundwater Allocation. *Water International*, *28*(2), 181–184. https://doi.org/10.1080/02508060308691683

Subramaniam Sivakumar, S. (2016) Management Plan to Reduce the Adverse Effects of Proximity of Dug Wells and Septic Tanks in Urban Area to Diminish Coliform Contamination. *International Journal of Scientific & Engineering Research*, *7*(3). http://www.ijser.org

Takal, J. K., & Quaye-Ballard, J. A. (2018). Bacteriological contamination of groundwater in relation to septic tanks location in Ashanti Region, Ghana. *Cogent Environmental Science*, *4*(1). https://doi.org/10.1080/23311843.2018.1556197

Tallon, P., Magajna, B., Lofranco, C., & Kam, T. L. (2005). Microbial indicators of faecal contamination in water: A current perspective In *Water, Air, and Soil Pollution* (Vol. 166, Issues 1–4, pp. 139–166). https://doi.org/10.1007/s11270-005-7905-4

Toussaint Wolfgang, Y., Veronique, M., Ossey Bernard, Y., Arsène, bassiguié, & Pascal Valentin, H. (2013). Effects of poor sanitation on public health: Case of Yopougon town (Abidjan). *African Journal of Environmental Science and Technology*, *7*(3), 87–92. https://doi.org/10.5897/AJEST12.058

Valenzuela, M., Lagos, B., Claret, M., Mondaca, M. A., Pérez, C., & Parra, O. (n.d.). fecal contamination of groundwater in a small rural dryland watershed in central chile. in *chilean journal of agricultural research* (vol. 69, issue 2).

Vázquez Suñé, E. Urban Groundwater. Barcelona City Case Study. Tesi doctoral, UPC, Departament d'Enginyeria del Terreny, Cartogràfica i Geofísica, 2003. ISBN 8468892858.

Verrot, L., Geris, J., Gao, L., Peng, X., Oyesiku-Blakemore, J., Smith, J. U., Hodson, M. E., Zhang, G., & Hallett, P. D. (2019). A simple modelling framework for shallow subsurface water storage and flow. *Water (Switzerland)*, *11*(8). https://doi.org/10.3390/w11081725

Watson, J. (1998). *Drinking Water Standards Analysis of four antibiotics and antibiotic resistance in soil and groundwater impacted by wastewater reuse (spray irrigation*). University of Arizona • College of Agriculture • Tucson, Arizona 85721 Revised 5/

Withers, P. J. A., Jordan, P., May, L., Jarvie, H. P., & Deal, N. E. (2014). Do septic tank systems pose a hidden threat to water quality? In *Frontiers in Ecology and the Environment* (Vol. 12, Issue 2, pp. 123–130). Ecological Society of America. https://doi.org/10.1890/130131

Yisa, J., Yisa, J., Oladejo JIMOH, T., & Michael OYIBO, O. (2016). *Underground Water Assessment using Water Quality Index*. http://ljs.academicdirect.org/

Zekt͡ser, I. S. (Igor′ S., Everett, L. G., & International Hydrological Programme. (2004). *Groundwater resources of the world and their use*. UNESCO.

Zhao, Y., Zhang, J., Chen, Z., & Zhang, W. (2019). Groundwater contamination risk assessment based on intrinsic vulnerability, pollution source assessment, and groundwater function zoning. *Human and Ecological Risk Assessment*, *25*(7), 1907–1923. https://doi.org/10.1080/10807039.2018.1476965

Zume, J. T., Mariwah, S., & Boateng, E. N. K. (2021). Evaluating the impacts of on-site sanitation facilities and saltwater intrusion on shallow groundwater quality in peri-urban communities of Cape Coast, Ghana. *Environmental Monitoring and Assessment*, *193*(5). https://doi.org/10.1007/s10661-021-09059-1

APPENDICES

UNIVERSITY OF CAPE COAST

FACULTY OF HUMANITIES AND LEGAL STUDIES

DEPARTMENT OF GEOGRAPHY AND REGIONAL PLANNING

Interview guide for data collection

The purpose of this study is to assess the quality of groundwater and its health implication: a case study in Amamoma. Proper ethical procedure would be used in soliciting for participant's responses. Thank you.

Section A: Background characteristics of participant

1. Sex

   a. Male [ ] b. female [ ]

2. Age

a.18-28 [ ] b.29– 39 [ ] c.40 – 50 [ ] d. 60 and above [ ]

3. Marital status

a. single [ ] b. married [ ] c. widow [ ] d. divorce [ ]

4. Economic activity engaged

………………………………………………

5. What is your educational background?

a. basic [ ] b. secondary[ ] c. tertiary[ ] d. none [ ]

6. Are you a student

A. Yes [ ] B. No [ ]

7. Do you live in this place as

a. House owner b. family member c. rented place d. other

8. Do you sell the water?

A. Yes[ ] B. No[ ]

Research Question 1. What is the quality of groundwater in your area?

9.what is the source of your water?

Source of water of participants in	✓ Tick applicable
Amamoma	
Pipe borne water	
Well/borehole	
Stream	
River	
Others………..	

10. why do you use this source of water? Tick as many as applicable? Explain your answer

Reason for the source of water	✓ Tick applicable
Cheap	
Reliable	

Nearness	
Clean	
Easy accessibility	
others	

11. What is the state of groundwater in this area? Good, better, best.

12. What makes groundwater inappropriate?

-Probe for further explanation to answer.

Feature	✓ Tick the ones applicable
Filters	
Color	
Taste	
Smell	
Hardness	

13. How will you describe the sanitation of your area?

State of sanitation frequency percentage

Good

Better

Best

Reason for answer

Research Question 2. What is the relationship between water quality and location of septic tanks in the community?

14.Who decide the measure between groundwater situation and sceptic tank?

a. Owner of the house b. Drilling agency c. other

15. Do you know the gap here between groundwater situation and sceptic tank?

a. Yes [ ] b. No [ ]

16. Does the distance between septic tank and groundwater affect the quality of water?

a. Yes [ ] b. No [ ]

-explain your answer

17. Do you think there is a possibility of seepage from septic tank to groundwater?

-explain your answer

Research Question 3. What are the sanitation related diseases in the community?

18. Are you aware of some health complications of using untreated water or poor sanitation?

-explain your answer

19. Have you or relative faced such health problem?

a. Yes [ ] b. No [ ]

20. What were some of the symptoms? Tick as many as applicable.

Symptoms	✓ Tick
Typhoid	
Dysentery	
Diarrhoea	
Skin disease	
Eyes itching	
gastric ulcers	
respiratory illnesses (common cold, asthma)	
Acute abdomen	
other	

21.What do you think can be done to improve the current state of groundwater?

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

22. what can be done to improve our sanitation?

UNIVERSITY OF CAPE COAST

FACULTY OF HUMANITIES AND LEGAL STUDIES

DEPARTMENT OF GEOGRAPHY AND REGIONAL PLANNING

Interview schedule for data collection

The purpose of this study is to assess groundwater quality and septic tank interaction: an assessment of health implication in Amamoma Cape Coast. Proper ethical procedure would be used in soliciting for responds from my key respondents. Thank you.

1. How will you describe the water situation in this community?
    a. Probe for different sources of water and the reasons for the choices.
    b. If dug-out wells don't come out, ask whether and why households use water from well.
    c. Probe for challenges in access to water in the community and periods of the year where the challenge is more pronounced.
2. How will you describe the general sanitation situation in this community?
    a. Probe for the main types of sanitation facilities in the community (KVIP, Pit Latrines etc)
    b. Probe for reasons for using such facilities in the community
3. Please, can you describe the siting of wells and toilets (Septic Tanks in this community?
    a. Probe for proximity of wells to septic tanks

b. Probe for whether the proximity affects water quality and how (seepage, etc).

c. Ask for whether Metropolitan Authorities are consulted before the construction of wells and septic tanks in the community

d. What measures are being taken to reduce contamination of wells by septic tanks in this community?

4. How will you describe the prevalence of sanitation-related diseases (diarrhoea, typhoid, cholera etc) in this community?

 a. Who are more likely to suffer from sanitation-related diseases in the community? (Children, elderly, women, etc)

 b. What are the main causes of sanitation-related diseases in this community?

 c. What measures is the community taking to deal with sanitation-related diseases in the community?

2/7/2020	SAMPLE NAME	Nitrite	Nitrate	Phosphate	pH	Temp	colour	Turbidity	TDS	Conductivity	Dissolved Solids	Total Coliform	Faecal Coliform	E. Coli
	p1	0.055	12.8	0.03	6.24	29.4	44	3.9	700	986	704	871	107	12
	p2	0.042	19.9	0.06	5.94	29.7	2	0.6	553	780	554	746	59	14
	p3	0.042	15	0.03	5.89	29.7	6	1.5	565	797	568	260	50	0
	p4	0.032	8.7	0.04	6.53	29.9	5	0.65	1040	1469	1040	40	2	0
	p5	0.097	16.4	0.04	6.91	29.8	109	27	1170	1646	1186	197	136	92
	p6	0.016	21.7	0.1	6.88	29.6	7	1.2	1020	1435	1021	160	0	0
	p7	0.289	71	0.21	6.47	29.6	2	0.55	1780	2510	1781	960	0	0
3/5/2020	SAMPLE NAME	Nitrite	Nitrate	Phosphate	pH	Temp	colour	Turbidity	TDS	Conductivity	Dissolved Solids	Total Coliform	Faecal Coliform	E. Coli
	p1	0.15	18.1	0.04	6.5	29.7	55	5.8	938	1317	947	404	80	0
	p2	0.06	26.1	0.05	5.89	29.8	19	1.9	543	765	543	276	24	0
	p3	0.04	23.9	0.04	5.78	30.1	4	0.65	563	793	564	40	0	4
	p4	0.02	4.9	0.04	6.29	30.2	23	3.2	1070	1513	1071	396	30	1
	p5	0.19	13.3	0.02	6.54	29.9	109	15	1250	1753	1262	0	0	0
	p6	0.04	6.6	0.04	6.71	30.4	20	1.7	1000	1411	1001	124	40	0
	p7	0.1	67.8	0.08	6.2	30.4	3	0.85	1960	2780	1961	54	10	1
4/6/2020	SAMPLE NAME	Nitrite	Nitrate	Phosphate	pH	Temp	colour	Turbidity	TDS	Conductivity	Dissolved Solids	Total Coliform	Faecal Coliform	E. Coli
	p1	0.053	23.5	0.02	6.23	29.2	7	0.6	860	1210	860	404	125	4
	p2	0.036	22.6	0.06	6.07	29.7	27	1	552	777	553	276	88	1
	p3	0.039	23.9	0.01	5.96	29.8	19	1.2	580	816	581	40	26	0
	p4	0.036	4.4	0.02	6.43	29.9	44	3.3	1060	1499	1063	396	242	0
	p5	0.019	2.2	0.04	6.69	29.8	106	9.4	157	222	166	0	0	0
	p6	0.033	5.3	0.03	6.83	29.9	14	0.4	974	1372	976	124	40	0

	p7	0.095	65.5	0.06	6.31	29.8	11	0.65	2040	2870	2041	64	22	1
5/7/2020	SAMPLE NAME	Nitrite	Nitrate	Phosphate	pH	Temp	colour	Turbidity	TDS	Conductivity	Dissolved Solids	Total Coliform	Faecal Coliform	E. Coli
	p1	0.023	26.1	0.05	6.1	29.7	4	0.8	919	1295	919	915	86	16
	p2	0.02	16.4	0.03	6.03	29.7	5	1.1	652	918	654	791	81	11
	p3	0.026	22.1	0.03	5.92	29.7	5	1.3	632	891	633	567	53	15
	p4	0.06	12.8	0.11	6.5	30.1	2	0.4	1090	1531	1090	201	79	9
	p5	0.039	6.2	0.09	6.87	30.1	30	8.4	188	265	192	181	43	16
	p6	0.023	15.1	0.18	6.89	30.1	1	0.4	877	1238	877	87	7	0
	p7	0.066	81.5	0.13	6.2	30.1	4	0.55	1960	2780	1960	710	0	0
6/4/2020	SAMPLE NAME	Nitrite	Nitrate	Phosphate	pH	Temp	colour	Turbidity	TDS	Conductivity	Dissolved Solids	Total Coliform	Faecal Coliform	E. Coli
	p1	0.016	18.2	0.02	6.18	29	2	0.6	786	1107	786	782	261	131
	p2	0.1	18.2	0.0003	6.1	29.2	6	1.4	698	983	698	407	67	44
	p3	0.01	14.6	0.0098	5.97	29.1	36	12	673	944	685	143	72	0
	p4	0.19	15.5	0.016	6.51	29.1	5	0.7	1090	1534	1090	163	57	10
	p5	0.023	13.3	0.02	6.78	29	5	0.75	1050	1487	1051	203	33	0
	p6	0.019	8	0.084	7.01	29.1	3	0.6	802	1128	803	310	83	37
	p7	0.591	23	0.16	6.85	28.4	3	0.8	2030	2860	2031	316	109	0