EFFECTS OF SOLID WASTE DUMPSITES ON GROUNDWATER QUALITY IN SAMARU, ZARIA KADUNA STATE, NIGERIA

BY

OKPANACHI, Adakole Sunday
(B.Sc ABU, 2009)
MSC/SCI/06435/2011 – 2012
(MSc. ENVIRONMENTAL MANAGEMENT)

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NIGERIA

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DECLARATION

I declare that the work in this thesis entitled “Effects of Solid Waste Dumpsite on Groundwater Quality in Samaru, Zaria, Kaduna State Nigeria” has been carried out by me in the Department of Geography under the supervision of Dr. B.A. Sawa and Dr. Yusuf Y. Obadaki.

The information derived from the literature has been duly acknowledged in the text and list of references provided. No part of this thesis was previously presented for another degree at this or any other institution.

OKPANACHI Adakole Sunday	____________	_____________
Name of Student	***Signature***	***Date***

CERTIFICATION

This thesis entitled “Effects of Solid Waste Dumpsite on Groundwater Quality in Samaru Zaria, Kaduna State, Nigeria” by OKPANACHI, ADAKOLE SUNDAY meets the regulations governing the award of the degree of Masters of Science (Environmental Management) of Ahmadu Bello University, Zaria and is approved for contribution to knowledge and literary presentation.

Dr. B.A. Sawa ______________________ __________________
Chairman Supervisory Committee Signature Date

Dr. Y.Y. Obadaki ______________________ __________________
Member Supervisory Committee, Signature Date

Dr. I. J. Musa ______________________ __________________
Head of Department Signature Date

Prof. H.A. Zoaka ___________________ ___________________
Dean of Postgraduate School Signature Date

DEDICATION

This work is dedicated to the most high God, in whom I get my inspiration I say thank you, and also to my Father, you are a great Man, keep resting in the bosom of the Lord.

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To the Almighty God who has given me so much to be thankful for my words are not enough to express my love. I say thank you.

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ABSTRACT

This study looked at the effects of solid waste dumpsites on groundwater quality of Samaru-Zaria, Kaduna State, Nigeria. Water samples were collected from twenty four (24) different wells from three (3) strategic areas that have major dumpsites in Samaru. Twelve of these samples were taken during the dry season (April) and another twelve taken during the rainy season (August) from both bore holes and hand dug wells. Of the twelve samples, six were taken within (0-50 meters) to dumpsites and another six far away (50-150 meters) from the dumpsite. In carrying out the research, physico-chemical properties of well water was tested in the laboratory, while heavy metal properties was tested for soils in the dumpsite and well water. The pollutants assessed include, Biological Oxygen Demand, Total Dissolved Solid, Dissolved Oxygen, Chemical Oxygen Demand, Chloride, Total Hardness, Colour, pH, Magnesium, Zinc, Iron, Chromium and Lead. Test-test was used to test for significant difference between parameters while Chi-square was used to test for the relationship between quality of water in wells close to and those far away from solid waste dumpsite in dry and rainy season and relationship between heavy metal concentration in the soils of dumpsites and shallow and deep well water. From the findings of the research it was discovered that many wells in the study area located close to the dumpsite (0-50 meters) have levels of concentration of pollutants of both physico- chemical and heavy metal to be high (in wells close to dumpsites) compared to wells far from dumpsites < 50m. It was also discovered that the concentration of pollutants during the wet season is higher than that during the dry season. From laboratory analysis conducted it was discovered that COD had the highest physico-chemical concentration of 648.50Mg/L and BOD a concentration of 0.20Mg/L. The heavy metal with the highest concentration is Magnesium with a concentration of 960Mg/L and the least heavy metal concentration recorded was Chromium with a value of 0.0006Mg/L. In general, it was discovered that shallow wells had a higher percentage of contamination for both close to and far away from dumpsites than the deep wells in the study area. It was also discovered that deep and shallow wells close to dumpsites have a higher total contamination rate than deep and shallow wells far from dumpsites but there was no significant difference between them as revealed by the t-test. The results obtained from the chi-square revealed that there is a significant difference between the World Health Organization (WHO) and Nigeria Standard for Drinking Water Quality (NSDWQ) standard for potable water and the obtained values with an implicative result that the water from Samaru shallow and deep wells is not safe for direct consumption. Thus, such water should be treated by employing some measures such as the use of disinfectants or boiling before use which will help reduce the pollutants, but majorly an improved water supply to the study area will go along way to correct the unhealthy conditions.

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CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Human activities on earth give rise to residual materials which are not of immediate use where they arise. These residual materials may be recycled, reclaimed, or reused; otherwise they constitute waste which will ultimately be released to the environment in mobile form or insitu (USEPA, 2008). The biosphere has the capacity to transform many wastes over time, either into harmless products or into nutrients which can be used again. However, the natural assimilative capacity of the environment can easily be exceeded if waste particularly from man's activities is not controlled.

Waste is generated universally and is a direct consequence of all human activities. The disposal of solid waste into the land has been recognized as the major source of groundwater contamination. Waste disposal by land fill has led to pollution of groundwater resources under a wide range of conditions around the globe (Afzal and Elahe, 2008).

Waste is defined as unwanted or undesired materials accumulating after the completion of a process (Cointreau, 2001). Waste was also characterized as items that are no longer used for any significant function. They are classified as items with hazardous properties. Such hazardous wastes include household dump items, sewage, sludge, waste from manufacturing industries etc. (Obeka, 2005). The United Nations Environmental Programme (UNEP Yearbook, 2006) defines waste as those materials which the initial user has no further use for either purposes of production, transformation or consumption and of which can be disposed off.

Wastes generally exist as solid, liquid and gas. Liquid waste are wastes that are free flowing such as fluids, waste water, fats, oil, or grease. They are usually generated from industrial activities like refineries, textile industries, waste water treatment plants etc. These wastes are usually emitted and disposed off on land thereby causing land pollution and also at times in water bodies causing water pollution.

Gaseous waste on the other hand comprises gases and small particles emitted from open fires, incinerators, and vehicles, or produced by agricultural and industrial processes. Once released, the effects of these gases and particles are hard to control. These wastes include gases like carbon dioxide, carbon monoxide, sulphur, chlorofluorocarbon etc.

Solid waste is defined as nuisance, unwanted or discarded material with insufficient liquid content or gas for free movement (Vision 20:20). Cointreau (1982) defined solid waste as non-air and sewage emission created within and disposed off by a municipality, including household garbage, commercial refuse, construction and demolition debris, dead animals and abandoned vehicles. Solid waste is a major health hazard in most urban areas in Nigeria.

Adebibu (1985) grouped solid wastes into eight classes, namely domestic, municipal, industrial, agricultural, pesticides, residential and hazardous wastes. However, solid waste can be classified as biodegradable, or non-biodegradable, soluble or insoluble, organic or inorganic, toxic or non-toxic (Kostawa, 2006; Ajadike, 2007). Irrespective of the classification of solid wastes, most of the urban wastes are degradable which aid the rate of leachate formation and migration compared to non-biodegradable that can last for many years without any sign of decomposition. There is therefore a possibility of leacheate generation, plume extension and migration at the base of urban land fill owing to the decomposition of discarded materials and frequent surface water ingression from urban precipitation. According to Irina (2006), concentration (mg/L) of leacheate constituent are in phases namely; transition (0-5 years), acid formation (10-20 years) and finally maturity (>20 years). Groundwater may not be contaminated at the inception of waste deposition in the landfill. The age of the landfill significantly affects the quality of leachate formed.

The ageing of a landfill is accompanied by increased quantity of leachate. Leachate generated at the initial period of waste deposition (up to five years) in refuse dumpsite has a pH value range of 3.5-6.5 indicating the presence of carboxylic acids and bicarbonate ions. With time, pH of leachate becomes neutral or weakly alkaline ranging between 7.0 and 7.6. Landfills exploited for long period of time gives rise to alkaline leacheate with pH range of 8.0 to 8.55 (Slomczynska and Slomczynski, 2004; Longe and Balogun, 2010). Waste placed in landfills or open dumpsites are subjected to either underflow or infiltration from precipitation. Areas near landfills have great possibility of groundwater contamination because of potential pollution source of leachate originating from the natural environment. Naturally depth from surface, soil type, bed rock, geology, permeability of sediments and climatic variation affect groundwater quality.

Solid waste disposal or dumping creates environmental problems in two main ways. First, much of it is not disposed off and collected on time. In essence the rate of waste dumping is faster than the rate at which it is disposed or cleared. Much of it is burnt or dumped along the streets or haphazardly in illegal land fills. This creates health hazards, blocking drainages, initiate flooding and contamination of ground water quality.

Secondly, because of the inability to sort waste at source, household waste and industrial wastes including toxic waste are often handled together leading to soil and underground water pollution (Osibanjo, 2008).

Water is a common chemical substance that is essential for the survival of all known life forms. Water normally exists in three forms which are Solid, Liquid and Gas (Robert, 1969). Next to air, water is the most essential element for all form of biological activities, comprising over 70% of the earth surface (Longe and Enekwechi, 2007). Annan (2003) described potable water as precious, we cannot live with out it, and human activities have a profound impact on the quality and quantity of water available. Water is of great importance for domestic industrial, agricultural, religious and recreational uses. Water is classified under two main categories based on its location and these are surface and groundwater (Appelo and Posma, 2005).

Groundwater refers to any subsurface water that occurs beneath the water table in soil and other geologic forms (Rail, 2000). Scientists estimate that groundwater makes up to 95% of all fresh water available for drinking. Groundwater is a significant source of water for many municipal water systems, and residents withdrawing their waters from wells, also rely upon groundwater. Surface water refers to water occurring in lakes, rivers, streams ponds and sea and they are found over the surface of the earth. Surface water occupies a vast part of the earth surface (about 70%). Surface water is naturally replenished by precipitation and naturally lost through discharge to evaporation and sub surface seepage.

Contrary to the widely held theoretical view of groundwater being the “safest” water for consumption, some wells are found to be polluted in terms of temperature, mineral contents, particles solute, organic matter and bacterial concentration (Appelo, 2005). These contaminations are mainly gotten from municipal land fill leachate which are highly concentrated complex effluents that contain dissolved organic matters; inorganic compounds such as ammonium, calcium, magnesium sodium, potassium, iron, sulphates, chlorides, copper, lead, nickel, zinc and xenobiotic organic substances (Lee and Jones-Lee, 1993; Christensen, 2001; Tengrui, Al-Harbawi, Lin, Jun and Long, 2007; Ogundiran and Afolabi, 2008).

Therefore, supply of adequate fresh water in large quantity to meet man's demand and maintaining the quality is now a thing of concern (Elinge, Itodo, Birn, Yauri and Mobongo, 2011). Hence contamination of groundwater through the infiltration of leachates via the soil and rocks need to be avoided. The contamination normally takes many years and takes place within a particular distance from the dumpsite. It is very important to avoid the contamination since pipe borne water is not readily available in many parts of Nigeria both in urban and rural areas (Adelekan, 2010). With this problem, there is need for alternative source of water supplies which is groundwater, but due to lack of proper waste management the groundwater is usually affected by refuse dumpsite (Mohammed, 2011). Water is said to be polluted when the water body is adversely affected by organic and inorganic contaminants (Oliver and Ismaila, 2011).

1.2 STATEMENT OF THE RESEARCH PROBLEM

Inadequate solid waste management is a major environmental problem in Nigeria in general and in Samaru-Zaria in particular. The contributing factors range from technical problems, to financial and institutional constraints. There is an absence of any properly designed solid waste disposal facility in Zaria, therefore posing contamination risk to both ground and surface water. The pollutant species in the dumpsites will continue to migrate and attenuate through the soil strata and after certain period of time might contaminate the groundwater system if there is no action taken to prevent the phenomenon (Gandhimath and Kanami, 2013). Groundwater is known as the major source of water supply in Samaru, Zaria and its contamination is a major environmental and health concern.

Past studies have shown impairments of groundwater quality through leachates outflow and infiltration from solid waste dumpsites. These include Akinbile and Mohammed (2011), who worked on environmental impact of leachate pollution on groundwater supplies in Akure, Nigeria. From their result, out of three samples collected from boreholes located near a landfill at Akure, only one of the boreholes was strongly polluted and requires treatment before use. Mohammed (2011), in his research on effects of refuse dumps on groundwater quality in Minna, Niger State, water samples were obtained during dry and wet seasons from hand dug wells. The wells were selected close to the dumpsite. pH and conductivity were determined using standard methods. He discovered that all the samples were not in conformity with World Health Organization (WHO) limit for bacteriological values which make the water to be unsafe for drinking, he then concluded that hand dug well water around the refuse dump sites are not safe for human consumption.

Afolayan, Ogundele and Odewumi, (2012) also conducted a study on hydrological implication of solid waste disposal on groundwater quality in urbanized area of Lagos State, Nigeria. From their study of empirical and experimental examination of the concentration of contaminants in groundwater of fifteen (15) wells, the results they got were analyzed with standard statistical package and compared with World Health Organization (WHO), 2004 and Nigeria Standard for Drinking Water Quality (NSDWQ), 2007 standard limit. They discovered that pH, chloride, iron, and lead are higher around the operational landfills than the non-existing landfill. It was concluded that groundwater contamination is the function of types of waste, season, topography, soil, underlying geology, surface water ingression and direction of groundwater flow.

Yaya and Okafor (2010) also analyzed the microbial status of groundwater and surface water in the federal capital city of Nigeria (Abuja) taking samples during the dry season and rainy season. Result of the research revealed that coliform count in most of the water samples from borehole satisfy the permissible level prescribed for drinking water in the two seasons in line with the WHO and NSDWQ. This was not so for samples from rivers and streams in the same area.

Bello (2011) conducted a similar research on effects of dumpsites on groundwater quality in Samaru-Zaria, Kaduna State. A result of the research study revealed that groundwater in Samaru is not totally pure. He then went further to conclude that the groundwater of the study area especially from wells, is not good enough for direct consumption following evidence of high coliform count in most wells in Samaru.

All the studies conducted on groundwater quality from the review done where conducted outside Zaria, except that of Bello (2011), which was conducted in Samaru-Zaria, Kadauna State. Though the research of Bello (2011) was conducted in Samaru-Zaria, same study area as the present research work at hand, there are some gaps in Bello’s work that this present research seeks to address.

The research conducted by Bello (2011), was conducted to only assess the biopysico- chemical properties of shallow and deep well water in the study area, while the present research assessed both the physico-chemical properties and also level of heavy metal concentration in both shallow and deep well water in the study area. The work of Bello (2011) was conducted using two dumpsites, while the three major dumpsites in Samaru were used for the present study. Finally in the study carried out by Bello (2011), the dumpsite characteristics were not conducted, but the present study carried out a test for heavy metals in soil samples gotten from the dumpsites so as to relate it with the results gotten from groundwater samples in the study area. Finally in the present research the analysis for physico-chemical characteristics and heavy metals was conducted both during the dry and wet season, but that of Bello (2011) was conducted during the rainy season.

Such a study therefore, to the best knowledge of the researcher has not been carried out. It is as a result of this that the present study aimed at assessing the effects of solid waste dumpsite on groundwater quality of Samaru-Zaria, Kaduna State. The specific research questions the study seeks to address are:

i. What is the proximity of the dumpsites to and from wells in the study area?

ii. What are the physico-chemical characteristics of water in shallow and deep wells of the study area?

iii. What is the level of heavy metal concentration from soils at the dumpsites in the study area?

v. What are the levels of heavy metal concentration of water in well from well of the study area?

1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of this study is to access the effect of leachate from solid waste dumpsites on groundwater quality in Samaru, Zaria, Kaduna state, Nigeria. This aim was achieved through the following objectives which are to:

i. identify the proximity of dumpsites to and from wells in the study area.

ii. determine the physico-chemical characteristics (Biological Oxygen Demand (BOD), Total Dissolved Solid (TDS), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), chloride (Cl), total hardness, colour and pH) of water in wells of the study area.

iii. assess the level of heavy metal (magnesium, zinc, iron, chromium, and lead) concentration from the soils at the dumpsites in the study area.

v. assess the levels of heavy metal concentration in water from wells in the study area.

1.4 RESEARCH HYPOTHESES

1. There is no significant difference in physico-chemical properties of well water in the study area.
2. There is no significant difference in heavy metal concentration of well water in the study area.
3. There is no significant difference in the quality of water in wells close to and those far away from solid waste dumpsites in dry and rainy season.
4. There is no significant difference in the level of heavy metal concentration in the soils of dumpsites and shallow and deep well water.

1.5 SCOPE OF THE STUDY

The research work is mainly on groundwater quality of shallow wells (hand dug wells) and deep wells (bore holes) within Samaru. Three major dumpsites were used as reference points for this research work. These are dumpsites in Samaru New Extension, dumpsite in Hayin dogo, and one in Danraka area of Samaru. The study examined the nature and characteristics of solid waste dumpsites in the area and the effects the dumpsite have on wells close to and far away from the dumpsites. Dumpsite in Ahmadu Bello University was intended to be used by the researcher but was not used because the solid waste dumpsite found in ABU is operated based on standard best practices by WHO (2011) where dumpsite is 150 meters away from any residential settlement.

The time frame for carrying out this study was seven months because within this time frame the researcher was able to make assessment of water samples for both the dry and rainy seasons.

1.6 SIGNIFICANCE OF THE STUDY

This study is a very important and relevant study in our society today, because most people in the study area do not have a steady source of pipe borne water supply, therefore they mainly depend on well water as their major source of water supply for their daily domestic use.

The outcome of this study is significant in the following areas. To highlight the relationship between the physical state of an environment and the resultant health implications of mismanaging it. This will help physical planners and health workers coordinate their activities in relation to environmental health policies issues. Guide stakeholders from the environment, health water resource ministries and community based organizations with best options for public campaign towards maintaining a clean environment.

The research is also important because of the fact that groundwater such as well water that is being used to augment the supply of both surface and pipe borne water is now at the shortage due to less recharge of water into the ground water system due to factors limiting the amount of rain fall that infiltrates to recharge the aquifers. In addition, it is also hoped that the research outcome will contribute to the existing body of knowledge on the subject matter.

CHAPTER TWO: CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents the conceptual framework and a review of literature that is related to this research work. In reviewing literature, the subject matter to be considered is the critical literature which is talking about the materials that are directly relevant to the research that the researcher is carrying out. Through this chapter the researcher is able to know the constraint and problems that would be encountered in the course of carrying out this research.

2.2 CONCEPTUAL FRAMEWORK

The physical environment has its waste receiving capacity. That is a threshold, after which hazards occurs. The waste that interferes or defers the waste receiving capacity of the environment creates pollution. The degree of intensity of this interference is growing as our waste load grows (Wesley, 1971). With continuous increase in population, largely due to immigration into Samaru, more and more waste products are released into the environment due to increase in consumption levels. Although solid waste is a nuisance, it is possible to extract useful material from them through recycling.

Refuse collection and disposal in most urban centers was for a long time a function of the government, and only recently some communities have taken into the business of refuse waste management. The need to protect the environment has compelled the Nigerian government to put in place environmental protection related policies over the years. For instance, the third national development plan of 1975-1980 was made to accommodate environmental protection policy as a vital part of the development plan. This was further re-enforced in the fourth National Development Plan of 1981-1985. This particular plan has a proposal to include the Environmental Impact Statement (EIS). In 1988, the Federal Environmental Protection Agency (FEPA) was established and the national guidelines on pollution control was established and signed into law. In 1992 the Urban and Regional Planning decree was promulgated. Sequel to all these, the Kaduna State Environmental Protection Authority (KEPA) amended its environmental protection edict number 9 of 1994 and charged KEPA with legal responsibility to oversee the State's environment. Because of the importance of keeping our environment clean and the great problem solid waste constitute to the environment, the Kaduna State Government under the leadership of Arch. Namadi Sambo, in 2008 introduced a programme called Operation Keep Kaduna Clean, this was aimed at keeping Kaduna state clean, free from the menace of indiscriminate dumping of waste.

Also, in the study area, some refuse dumpsites have been either cleared completely or reduced to a reasonable level. This is evidence in refuse that where cleared in Danraka area, Samaru New Extension, and also refuse dumpsites found along Zaria-Funtua road. These refuse were cleared and the land used for construction purposes, a typical example is one along Sarkin Pawa road in Danraka, and also some are collected to be used on farmland as manure.

However, the campaign on environmental protection is one thing and the level of public awareness and perception of environmental degradation is yet another crucial aspect. The campaign may be well articulated and disseminated, but if the level of public awareness is not well grounded then the utmost aim and objective of this call stands the chance of failing.

2.3 CONCEPT OF WASTE

The problem associated with refuse generation and its impact on dumpsite in urban areas has attracted the attention of many researchers including this present research work. Waste is defined as any gaseous, liquid or solid material that is thrown away because it has no further use by the owner (Thomson, 1974). These unwanted and undesirable materials according to Bery and Horton (1974) originate from industrial and minning project, agriculture and livestock from residential, commercial and municipal activities in urban areas.

2.3.1 Types of Waste

Wastes generally exist in three major forms. These forms are explained below:

2.3.1.1 *Liquid waste*

Liquid waste can be defined as such fluids as waste water, fats, oil or grease used oil and hazardous household liquids etc. They are usually generated from industrial activities like refineries, textile industries, waste water treatment plants etc. These wastes are usually emitted and disposed off on land thereby causing land pollution and also at times in water bodies causing water pollution.

2.3.1.2 *Gaseous waste*

Gaseous waste is defined as uncontrolled airborne emissions and effluents. These emissions consist of gas, mist, smoke, vapour matter, fumes or any combinations. Gaseous waste primarily comes about as a result of human biological process such as manufacturing, processing and consumption of various materials which generate fossil fuels.

2.3.1.3 *Solid waste*

Solid waste is defined as nuisance, unwanted or discarded material with insufficient liquid content or gas for free movement (Vision 20:20). Cointreau (1982) defined solid waste as non-air and sewage emission created within and disposed off by a municipality, including household garbage, commercial refuse, construction and demolition debris, dead animals and abandoned vehicles. Solid waste is a major health hazard in most urban areas in Nigeria, this is the area of the present study.

2.3.2 Types of solid waste

All wastes disposed off to land are competing for the same limited reserves of landfill space, and so any subdivision of waste should be regarded with caution. Wastes may be differentiated by their origin, physical form and detailed composition. Hootweg and Raymond (1999), classified solid waste into four different types depending on their sources.

i. Household waste generally classified as municipal waste.

ii. Industrial waste as hazardous waste.

iii. Biochemical waste or hospital waste.

iv. Agricultural waste

2.3.2.1. *Municipal waste*

Municipal waste consists of household waste, construction and demolition debris, sanitation residue and waste from streets. This cabbage is generated mainly from residential and commercial complexes. With rising urbanization and change in lifestyle and food habits, the amount of municipal refuse waste has been increasing rapidly and its composition changing.

2.3.2.2. *Hazardous waste*

Industrial and hospital waste are considered hazardous as they may contain toxic substances. Hazardous waste could be highly toxic to humans, animals and plants are corrosive, highly inflammable or explosive and react when exposed to certain things e.g. gases. Nigerians consume about 1200 metric tones of hazardous chemicals annually (Ezenwe, 2004). Similarly hospital waste contaminated by chemical used in hospitals is considered hazardous. These chemical includes formal Hyde and phenol, which are used as disinfectants and mercury used in thermometers or equipments that measure blood pressure. In the industrial sector, the mega generators of hazardous waste in Nigeria according to Ezenwe (2004) are:

- Domestic and industrial plastics and rubber (36%)
- Chemical and pharmaceutical (31%)
- Textile wearing apparel and leather (21%)

- Basic metals iron and steel and fabricated metal product (10%)

2.3.2.3. *Hospital waste*

Hospital wastes are generated during the diagnosis, treatment or immunization of human beings and animals or in research activities in production or testing of biological analysis. These wastes are mainly in form of disposable syringe, swabs and bandages, body fluid, human excreta etc. This waste is highly infectious and can be a serious threat to human health.

2.3.2.4. *Agricultural waste*

Agricultural waste, which includes both natural (organic) and non-natural wastes, is a general term used to describe waste produced on a farm through various farming activities. These activities can include but are not limited to dairy farming, horticulture, seed growing, livestock breeding, grazing land, market gardens, nursery plots and even woodlands, examples of waste generated include: spoils from food wastes, pesticides, fertilizers, germicides, etc.

2.3.3 Refuse Waste Generation and Disposal

The issue of refuse waste disposal has transcended individual and local organization to national and even international organization's concern. Aniefok (2004), observed that refuse waste is being accumulated due to large continuous increase in population thereby polluting the environment, if not properly managed. He added that unmanaged refuse dumping is a chief threat to health and sanitary conditions of the Environment.

Agwu (1995) noted that Nigeria produce on the average 1.75 million tonnes of refuse waste per year. He pointed out that 5% of refuse waste in Nigeria are recycled and about 85% is collected and put in open dumps while about 10% is left to lie or decay where it was dumped. This is due to a very poor management of waste which on the long run would lead to associated problems.

Sada (1997) observed that about 146,000 tonnes of refuse were generated in Ibadan in 1975 and 385, 224 tonnes in 1985. Istifanus (1994) also reported the impact of automobile repair shops which generated an overall of 225,000; 321,000, and 90,000 tones for metallic, rubbers and spare parts of automobile wastes respectively in Jos.

Sada (1997) stated that increasing generation and accumulation of refuse waste are beginning to produce social, economic, health and environmental problems of significant proportions. These problems are particularly acute in regions where intensive urban population concentrations have increase refuse waste generation and it is continually decreasing the availability of land suitable for disposal (Istifanus, 1994). These problems can have considerable impact on the environment where adequate environmental policies have not been put in place and implemented to checkmate the growing generation of domestic or municipal refuse waste.

Enebong (1980) confirmed the views that problems of refuse waste control dates back to the time when urbanization started, from that time, there have been an increasing rate of refuse generation as a result of man’s activities. As the character of man’s waste have changed from organic to inorganic corn pound such as plastics, metals scraps, bottles which are resistance to decomposition (non-biodegradable), so also the ability of the environment to sustain life may be impaired. Hootweg and Raymond (1999) lamented that with progress of civilization, the waste generated becomes more complex in nature. Not only did the air get more and more polluted, but the earth itself become more polluted and hazardous with the generation of non-biodegradable solid refuse waste.

In most rural and urban centers within Nigeria the arrangements for refuse disposal have been ineffective or insufficient. These wastes are dumped indiscriminately on open plots of land and particularly along and on streets. Some of the street affected may be rendered impassable for several days or months as a result of this lackadaisical attitude. Adeniyi (1994) then confirmed that every Nigeria is afflicted by this malaise.

2.3.3.1 *Dumping site*

Land fill have serve for many decades as ultimate disposal sites for all types of wastes: residential, commercial and industrial (Farguhar. 1989). Physical, chemical and biological processes interact simultaneously to bring about the overall decomposition of the wastes. One of the by-products of all these mechanism is chemically laden leachates (Schnoor, 1996). The major environmental problem experienced in landfill is the loss of leachate from the site and subsequent contamination of groundwater (Farguhar, 1989).

Modern landfill has liners at the base, which act as a barrier to leachate migration. However it is widely acknowledged that such liners deteriorate over time and ultimately fail to prevent the movement of leachate into an aquifer. It can take years before groundwater pollution reveals itself and chemical in the leachate often reach its peak and often in unanticipated way to affect the ecosystem.

2.3.3.2 *Leachate effects*

Leachate contains a host of toxic and carcinogenic chemicals, which may cause harm to both human and the environment (Lee, 1996). Contaminated groundwater by leachate can adversely affect industrial and agricultural activities that depend on well water. For certain industries, contaminated water may affect product quality, decrease equipment life time, or require pre treatment of the water supply, all of which cause additional financial expenditures. The use of contaminated water for irrigation activities can decrease soil productivity, contaminate crops, and possibly move toxic pollutant up the food chain as animal and human crops grown in an area irrigated with contaminated water (OLeary, 1995).

2.3.4 Water

Water is the world greatest natural resource, yet most people under value its worth. Diamond, gold and emerald are priced because they are so rare, yet none has the value of water, a chemical compound so common that it is found almost everywhere in the world (Coombs and Crabow, 1996).

Approximately 70% of our body (human beings) is composed of water. Water is so vital that most people will die within 48 hours if they cannot replenish their water reserves. By comparison, most people can survive for a week or more without food. No living organism is less than 50 percent in comparison by water, and some 97 percent of water (Coombs and Crabow, 1996).

2.3.4.1 *General definition of water pollution*

Pollution is defined as a condition in which a medium or environment is rendered unfit for its desired purpose. The first implication of this is that pollution is not an absolute condition, but depends on the medium and its desired purpose. For instance, water in a river or lake may be considered clean enough for recreational purposes, such as boat racing and yachting, but would be unsuitable for drinking without further purification (Winkler, 1981). Holdgate (1979), also define pollution as the introduction by man into the environment of substance or energy liable to cause hazard to human health, harm to living organism, damage to structures or amenity, or interference with the legitimate use of the environment.

Dix (1981) defined pollution in various ways, one involves the use of subjective judgment like the deliberate or accidental contamination of the environment with man's waste. Another definition of pollution by Dix (1981) is that he expressed pollution as matter in a wrong place or anything released into the environment which degrade it, or the presence of energy in an unusual or unintended place.

2.3.4.2 *Types / Sources of water pollution*

Types of water pollution could either be surface or ground water pollution. Sources of pollution on the other hand could either be point source or non point source of water pollution. The point source of water pollution is when a harmful substance is emitted directly into a body of water. Oil spillage is said to best illustrate point source of water pollution. A non point source delivers pollutants indirectly through environmental changes. An example of this type of pollution is when fertilizer from a field is carried into a stream by rain in the form of runoff, which in turn affects the aquatic life. Pollution arising from non point source accounts for majority of the contamination in streams and lakes (Krantz and Kifferstein, 2006).

Pollutants are classified according to their chemical and physical natures. They include such unwanted side effect and product as heat, noise, radioactive elements, dust particles, hydrocarbon, carbon dioxide, pesticides, toxic metals and chemical (Detwler, 1971). Domestic sewage and industrial waste water containing large quantities of chemical.

2.3.4.3 *Effects of physico-chemical and heavy metal properties on human health*

Excess amount of physico-chemical properties in drinking water have different effects on human health. A high value of pH causes bitter taste of water, affects mucous membrane, cause corrosion and also affects aquatic life. High amount of hardness in drinking water leads to heart diseases, and kidney stone formation. Exceeding the permissible limit of hardness causes poor lathering with soap, deterioration of the quality of clothes, scale formation and skin irritation (Lalitha and Barani, 2004).

Excessive chloride concentration increases rate of corrosion of metals in distribution systems especially for deep wells. This can lead to increased concentration of metals in the supply, and this can cause laxative effects and gastro-intestinal irritation in humans (WHO, 2002). High amount of DO imparts good taste of water. With regards to solids, high values of TDS in ground water are generally not harmful to human beings, but for persons who are suffering from kidney and heart diseases, continuous consumption of water with high TSS content can cause gastro-intestinal irritation. It also causes undesirable taste and corrosion or incrustation (Shihab, 1993).

In terms of heavy metals concentration, high concentrations of heavy metals can cause various health effects in humans. For example, high intake of chromium can cause, skin rashes, upset stomachs and ulcers, respiratory problems, weakened immune systems, kidney and liver damage, alteration of genetic material, lung cancer and even death (Singh, 2009).

Lead is a naturally occurring element that can be harmful to humans when ingested or inhaled, particularly to children under the age of six. Although the effects of lead exposure are a potential concern for all humans, young children (less than seven years old) are mostly at risk (Reagon and Silberged, 1989). In adults, lead poisoning can cause; poor muscle coordination, damage to the sense organs and nerves controlling the body, increased blood pressure, hearing and vision impairment, reproductive problems (e.g. decreased sperm count). In children, lead can cause damage of the brain and nervous system, behavioral problems, anemia, liver and kidney damage, hearing loss, developmental delays and in extreme cases, death.

Iron and Zinc are essential micronutrients for human health. By micro it means it is needed only in small quantity (Black, 2003). But when intake is high and regular, it can cause some health defects which include liver and kidney diseases, high blood pressures, heart failure and in some extreme cases death (Cardar, 1983). The risks posed by these properties make this study imperative.

2.4 REVIEW OF RELATED LITERATURE

Raman and Narayanan (2011) conducted a research on quality assessment of ground water in Pallavpuram municipal solid waste dumpsite in Chennai. Groundwater samples in and around the dumpsites area were studied to assess the impact of municipal solid waste in groundwater resources in the area. Groundwater samples were collected from the different bore holes in and around the dumpsites. The water samples in all five locations have mild to high iron concentration and mild to high acidity. The researcher therefore concluded that the presence of such dumpsites is a potential source of pollution to the groundwater.

Adekunle, Adetunju, Gbadebo and Banjoko (2007), on Assessment of Groundwater quality in typical rural settlement in Southwest Nigeria, assessed the levels of some physical, chemical, biochemical and microbial water quality parameters in twelve hand-dug wells in Igbara area of south West region of Nigeria. From the results of analysis, it was discovered that most of the pollutants increased in concentration during the rainy season over dry periods. Coliform population, lead, nitrate and cadium in most cases, exceeded the World Health Organization recommended thresholds for potable water. It was therefore concluded that well water in the area is not safe for direct consumption. Regular monitoring of groundwater quality, abolishment of unhealthy waste disposal practices and introduction of modern techniques were recommended.

Longe and Balogun (2010), in their research of groundwater assessment near municipal land fill, Lagos, Nigeria, investigated the extent of groundwater contamination of six sampling points between 10 and 375 meters down-gradient of the landfill site. From results of the analysis, it was discovered that the groundwater samples were generally acidic with a mean pH value of 6.13 which is below the WHO and NSDWQ guidelines for potable water, the study revealed that the quantity of the groundwater resource underlying soils landfill site has been moderately impacted. It was also shown that nitrate, chromium and phosphate concentrations were above the highest permissible limits (WHO, 2004 NSDWQ, 2007). Observations revealed that with time the accumulation of leachate at the base of the sanitary landfill can break through into the groundwater while gas emission also possessed potential environmental and health risk.

Yaya and Okafor (2010) also analyzed the microbial status of groundwater and surface water in the federal capital city of Nigeria (Abuja), taking samples during the dry and rainy season. Result of the research revealed that coliform count in most of the water samples from borehole (deep well) satisfy the permissible level prescribed for drinking water in the two seasons in line with WHO and NSDWQ. This was not so for samples from rivers and streams in the same area.

The research by Lasisi (2011), on leachate and groundwater quality in Olushosun, Abule Egba area of Lagos State, was conducted on eight hand-dug wells. The Water samples were analyzed for some physico-chemical properties and heavy metals. From the research it was discovered that most of the wells except one, are contaminated with high physico-chemical properties and some little level of a heavy metal. This contamination on ground water by leachates from solid waste dumpsites in the area was attributed to the high water table in Lagos state.

Saidu (2011), conducted a research on effects of refuse dumps on groundwater quality in Minna, Niger State, Nigeria, where physico-chemical characteristics of well water samples were analyzed. The pH of the water was within the allowable WHO range of 7.0-8.5. Turbidity (in NTU) ranges from 4.48-13.02, the WHO allowable standard is 5 NTU but from the results of the two season it showed that only one well during dry season fall below the standard and other wells during the dry and wet season were above the allowable standard. The conductivity of the water samples ranges from 344 – 1191 for all the samples in the two seasons, these values exceeded the WHO standard. By implication the wells around the selected site in Minna were not fit for drinking in line with microbial standard. Therefore, the quality of the sample well needs to be improved with adequate treatment.

Afolayan, Ogundele and Odewumi (2012), in a research conducted on hydrological implication of solid waste disposal on groundwater quality in urbanized area of Lagos state Nigeria, discovered from analysis of the water samples that the temperature of the groundwater samples was almost neutral with the exception of three wells. Total suspended solid concentration was found to be greatly high at three wells, not detected in seven and remaining were average and less than standard limit. It was discovered that most of the water samples had high level of heavy metals that are higher than WHO standard limit.

Akinbile (2012), also on environmental Impact of landfill on groundwater quality and agricultural soils in Akure, Nigeria, discovered from the physical, chemical and bacteriological analysis of turbidity, temperature, pH, dissolved oxygen total dissolved solids, total hardness, iron, nitrate, chloride, calcium, copper, zinc and lead, carried out in water samples, that most of the parameters indicated pollution but were below the WHO limits. The results showed that all the boreholes were not strongly polluted but require treatment before use while the soil is absolutely unsuitable for the crop production.

Sunmonu, Adagunodo, Olafisoye and Oladejo (2012), in a research conducted on effect of refuse dumpsite on groundwater quality of Aarada Area, Ogbomoso, South Western Nigeria, revealed that the surrounding soil and groundwater in the research area near the waste disposal site was contaminated to depths exceeding 5 meters, which happens to be within the first aquifer unit in the research area. High level of toxic substances such as lead, nitrate and cadium were observed in the sample wells. It was therefore recommended that the Oyo state government should enforce law against dumping of refuse indiscriminately.

Yusoff (2012), on assessment of groundwater quality near a municipal landfill in Akure Nigeria, discovered from the research of analysis of physico-chemical properties and heavy metal analysis of eight well water samples that all the wells except two have a relatively high concentration of chemical properties, and very low level of heavy metal concentration. The researcher therefore recommended that all the water samples should not be consumed directly but treated before consumption.

Oyelami, Aladejana and Agbade (2013), conducted a research on assessment of the impact of open waste dumpsites on groundwater quality in Onibu-Eja dumpsite, south, western Nigeria. In conducting the research, twenty water samples were collected and analyzed for physico- chemical parameters, major ions and trace metals. All major ions revealed concentrations within the acceptable limits of both WHO and NSDQW standards except chloride and sodium in some of the wells, for most of the trace elements, the concentrations were below detectable limits except for zinc, iron and mnganese.

Akunbo (1990) in his study on the pollution of water in Samaru, Zaria analyzed the water quality criteria including Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), acidity, turbidity, pH, chromium and faecal coli forms. His findings show that water from the well are contaminated by these elements and made the water toxic. This contamination is due to the refuse dumps from the surrounding environment and latrines in such an area. He therefore concluded that the use of these wells in their present condition is hazardous to human health.

Gideon (1999) in his study of some physicochemical and bacteriological qualities of shallow wells in Samaru, Zaria observed that all the wells were polluted with pollution strength varying with locations, land use and well construction design. Gideon (1999) also observed seasonal variation in the pollution which he attributed to high total bacteria count levels in wells.

Folorunsho (2010), in a study on an assessment of the quality of water in shallow wells in Sabon Gari, Zaria Kaduna state, used nine wells as samples to test for some pollutants (magnesium, calcium, alkalinity, BOD, chloride, colour, nitrate, total hardness, turbidity and pH) in the well water. Results from the analysis from the research based on the WHO (2007) standard for safe drinking water, revealed that Sabon-gari wells are in a critical state of pollution and therefore not in any way safe for direct consumption.

Bello (2011) conducted a research on eight sample wells on the effects of dumpsites on groundwater quality in Samaru-Zaria, Kaduna State, within a period of two time frames which were June and August. The study by Bello (2011) revealed that ground water in Samaru is not totally pure and not suitable for direct consumption.

2.4.1 Gap in the Study

All the research conducted from the previous studies discussed about solid waste and groundwater quality in one way or the other, starting from Raman and Narayanan (2011) to Bello (2011), but non of the researches conducted a research same as this present research. Thus, some of the major gaps observed from this present research that are not in the rest include; the present research was conducted for two seasons in dry and rainy season which is not so in the other research conducted, the present research is assessing water quality in both shallow and deep wells using three dumpsites as reference point, a total of twenty four (24) water samples was used to test for both phyisco-chemical and heavy metal properties in the well water, and soils from the three dumpsites were also analyzed for heavy metals. This was not done by any of the previous researches and therefore making this work the first of its kind in Samaru- Zaira, Kaduna State.

CHAPTER THREE: STUDY AREA AND METHODOLOGY

3.1 INTRODUCTION

This chapter critically dealt with the study area, which are Samaru New Extension, Danraka and Hayin Dogo all in Samaru, and also the method that the researcher used to conduct this research.

3.2 THE STUDY AREA

The study area examined features and characteristics of Samaru that include the; location, morphology and evolution, climate, geology, vegetation, soil, drainage, socio-economic setting and population.

3.2.1 Location

Samaru is part of the Zaria urban setting. It lies within latitudes $11^{o}06'$N and $11^{o}12'$N of the equator and longitude $7^{o}39'$E and $7^{o}45'$E of the Greenwich meridian. Samaru is located at the central high plain of Northern Nigeria at the height of about 670 meters above sea level. Samaru is found in Sabon Gari Local government area and it is bounded to the North and North East by Bassawa military cantonment, to the South by Ahmadu Bello University (ABU) main campus, and to the West by Division of Agricultural Collages (Fig. 3.1). Samaru is one of the suburbs of Zaria which is made up of distinct loosely coordinated units (Mortimore, 1970).

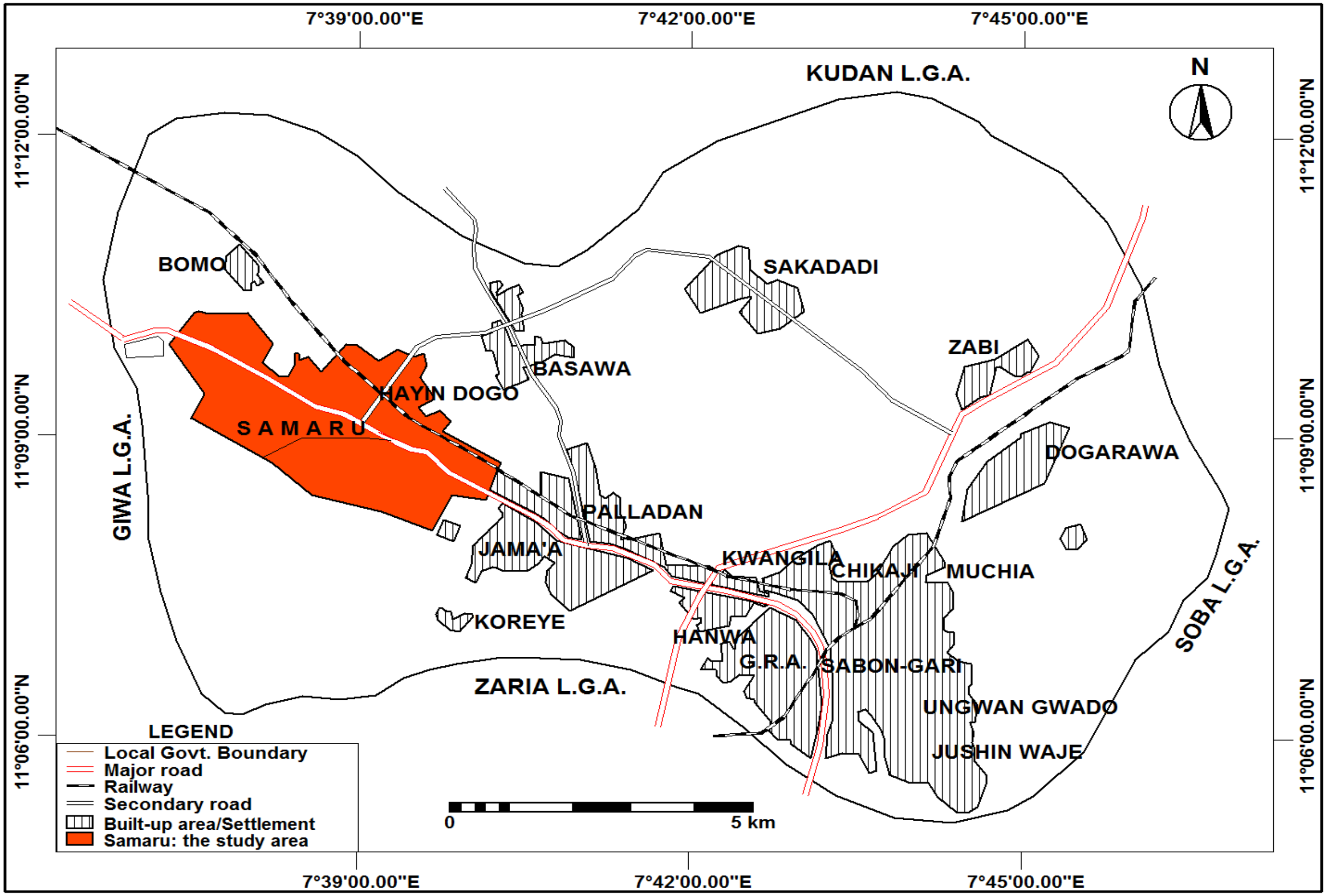

FIG. 3.1: Sabon Gari Local Government Area showing the Study Area

Source: Adapted and modified from Topo Map of Zaria sheet 102 S.W.

3.2.2 Evolution and Morphology of Samaru

Samaru once a village is typical of the unplanned “boom town” which accompanies the rapid expansion of a major employment center which is ABU main campus. Other sources say that Samaru owes it contemporary existence and development to what is now called the Institute for Agricultural Research (IAR), established in 1924. Job seekers as well as laborers came and settled near the site of the department of Agriculture and many people came from as far as Bomo and others from the southern parts of Nigeria. Samaru has grown and is still growing. With the establishment of ABU main campus in 1963, more people have come into Samaru, resulting to more expansion. The university has remained the single and most dominant growth factor in Samaru and has played important role in increasing its importance.

To some extent, proper coordination of residential structures is noted to exist mainly in ABU main campus quarters, Industrial Development Center (I.D.C.) quarters, Silver Jubilee quarters and Aviation site II quarters. Good environmental serene characterize these areas, unlike Samaru settlement where there exist a near squalor in terms of residential structure, pattern and make up (Mortimore, 1970).

3.2.3 Climate

According to the Thornethwaite’s Moisture index, the climate of Samaru is the dry sub-humid type (Ogbaji, 2006).The gross features of rainfall pattern in this region, as in other parts of Nigeria are usually in association with what is often called the Inter-Tropical Discontinuity (ITD) (Oguntoyinbo, 1983; Oladipo, 1993). The ITD itself is the boundary at the ground between the dry tropical continental (cT) air of northern origin and the cool moist tropical maritime (mT) air of southern origin. These two air masses pass through and are responsible for the seasonal changes in Samaru and Zaria as a whole. Sticky hot weather conditions prevail during the northward movement of the ITD because of small diurnal temperature range, high relative humidity with little or scanty showers of rainfall. While the southward movement is associated with dry and cold weather conditions because of great diurnal temperature range and low relative humidity with no rainfall (Ogbaji, 2006).

According to DURP (1979) on the basis of these two air masses and their subsequent weather, the year in Samaru is divided into four seasons;

- Dry season (winter and harmattan) Nov-Feb.
- Hot season (March to April)
- Thunderstorm and rain season (May to June)
- Wet season (July to October)

These are however broadly classified as wet and dry seasons. The wet season lasting from May to September and the dry season lasting from October to April. In April, a light shower occurs once or twice but between May and June considerable thunder storms occurs and the rains begin to get steadier. Between July and September the wet season proper comes on. While May marks the onset of the rain and the end of the hot season, September usually marks the end of the wet season and the beginning of dry season.

With the onset of the wet season, the daily maximum temperature drops and diurnal range of temperature becomes low. July and August in Zaria are months of mildest weather. The diurnal range of temperatures during this period varies from 6.7^{o}C to 9.04^{o}C. The mean daily temperature range in this period is about 26.7^{o}C to 28.9^{o}C cloudiness reaches a maximum in August and consequent the hours of sunshine are at the least. The average duration of sunshine in August varies from 3 to 6 hours. The relative humidity is very high in August between 70-80 percent (Ojo, 1977).

The daily minimum temperature at the beginning of the dry season drops more rapidly than the maximum. Consequently the diurnal range of temperatures increases rapidly. The sky is mostly clear in November which permits longer hours of sunshine. In early November, morning and nights become cooler and pleasant. Dust haze begins to appear and increase in frequency as the harmattan wind is being introduced. In December to January, the haze and dust layer of the harmattan sometimes creates poor visibility (Ojo, 1977).

3.2.4 Geology

The major geologic feature that occurs in Samaru is the basement complex rocks. This consists of metamorphic rock, a product of at least two major cycles. Zaria is underlain by three groups of rocks all of which belong to the pre-Cambrian basement complex of Nigeria. These groups of rocks include:

a. Gneiss of variable composition which include granite rocks, geomantic or schist which have been thoroughly weathered of various depths and are found to form most of the superficial materials which are generally called drift.

b. Quartz, schist or quartzite which form a narrow belt of low rounded hill and valley topography.

c. Porphyritic granite which are characterized by inselbergs of different shapes and sizes. These are often referred to as the old granites. They cover a small area with the largest outcrop forming the Kufena group of hills (Alkali, 2009).

3.2.5 Vegetation

The natural vegetation zone of Samaru is generally known as northern Guinea Savanna, a moist wood land. It is characterized by bushes in form of grasses and interspersed trees, with shrubs located in it. Many of the trees however have been cleared as the need for residential houses arose. There is hardly natural vegetation existing, this is due to anthropogenic activities such as cultivation, bush burning, overgrazing. These activities have changed the vegetation to a derived savannah, which is characterized by shrubs, stems and tress along with some tuft cover and some clusters of trees along river courses (Alkali, 2009).

Among the vegetation in Zaria, there is wood land vegetation characterized by presence of *Isoberlina doka*, *Istomentosa* and *Upaca togeories*, with well developed grass such as *Schizachyrium seroiberbe, Monocymbium ceresiiforme.*. The shrub species include *buttrgspesum spp*, *Piuiostigma spp,* and *Seminalea spp* (Ologe, 1971).

3.2.6 Soil

The soil of Samaru-Zaria belongs to the class of leached ferruginous tropical soil. Some of the soil near inselberg, the largest of which is the Kufena hills which may be classified as weakly developed soil while the fadama soil are hydromorphic soil or vertisols Their origin is mainly due to the accumulation of bulky organic matter and fine alluvial (Ologe, 1971).

The soils are usually sandy in nature, leaching of clay minerals and iron down the profile is the major soil developmental process. Samaru soil is associated with tropical ferruginous soil of guinea savanna. Generally the soil is relatively low in organic matter content and cation Exchange capacity (CEC). The soil profiles of Samaru has an average thickness which is usually less than 150cm in thickness below which occur particularly weathered rock on the parent material (Jayeoba and Leow, 1987).

3.2.7 Drainage

Samaru-Zaria forms one of the watershed that divides the Chad and Sokoto basins. Numerous rivers and streams flow out in a radial pattern. These include river Kubanni, Shika and Saye. The Galma river is the only perennial river in the area, the others are either completely dried up during the dry season or contains only small discontinuous pools along their channels. River Galma, which is also among the major tributaries of river Kaduna is the main drainage system in Zaria, supplied with run-off and seepage from drainage basin about 5.0km^2 in area (Folorunsho and Brinemigha, 2011).

3.2.8 Socio-Economic Setting of Samaru

Samaru-Zaria plays a host to quite a number of educational institutions Mortimore (1970) maintained that education is the major urban industry in Zaria. The influx of people into these institutions has led to the development of other socio-economic and political sectors. Within the last two decades the Zaria region has experienced a rapid urbanization process and also rapid increase in population, which heighten environmental degradation. Samaru is a residential area for workers, students, traders as well as farmers and other workers, directly or indirectly linked to the Ahmadu Bello University and nearly by institutions such as Nigeria Institute of Leather and Science Technology, Industrial Development Center, and Center for Energy Research.

Other socio-economic activities include markets, supermarkets, hospitals and clinics, privately owned primary and secondary schools, Banks such as First Bank, United Bank for Africa (U.B.A), Union Bank, Standbic IBTC Bank and Diamond bank. There are religious institutions like mosques and churches also in Samaru.

3.2.9 Population

Zaria is the second largest city in Kaduna State after the capital Kaduna. During the pre-colonial era, the rate of natural population increase was very low because of the inter tribal wars coupled with high mortality rate which also balanced the high fertility.

Samaru, a town found in Sabon-Gari L.G.A within urban Zaria has been growing rapidly and steadily in recent time. According to demographic census of 1952, Samaru had a total population of about 1,840. In 1963, the population rose to about 4,147 inhabitants. In 1987, the population rose again to about 80,000 and above. For 1996, Samaru has a population of about 37,473 people. In the recent population census of 2006, Samaru has a population of 124,582 people (NPC, 2009).

3.3 METHODOLOGY

3.3.1 Reconnaissance Survey

As a preparation for the study, a reconnaissance survey was undertaken to properly study the area before starting the full research. The objectives were to obtain available relevant information on the environment of the study area, intimate and seek cooperation of residents residing around the dumpsites and to select the wells that water samples were to be collected from for detailed investigation through laboratory analysis.

3.3.2 Types and Sources of Data Required

The types of data that was used for the research work are the physico-chemical and heavy metal properties which are the; Biological Oxygen Demand (BOD), Total Dissolved Solid (TDS), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Magnesium (Mg), Chlorine (Cl), hardness, colour, pH, and heavy metals which are; zinc, iron, chromium and lead.

The sources of data employed in this research work are basically of two types which are; the primary and secondary data sources. The primary data sources were gotten from the field in the form of soil and water samples. While the secondary sources of data were gotten from stored data that have been collected by others such as various levels of government agencies, research institutions etc. It also includes textbooks, journals, magazines, pamphlets, academic thesis, government officials gazette etc.

3.3.3 Sampling Technique

Razaq and Ajayi (2000) define sampling as a systematic process used to select a required portion of a target population or area. In order to achieve a desired output and conduct a thorough study, the researcher used the three major dumpsites in Samaru (Fig. 3.2).

The sampling technique employed for this research is the purposive sampling technique, because sampling site for well water sample collection was purposively chosen. Sample collection was in early April, which is the dry season and August when

Samaru receives the highest amount of rainfall. This is so, in order to observe any temporal variation in the well water quality of the study area. The well water samples were taken from distance that range from less than 10 meters (<10m) to distance of greater than 150 meters (>150m) away from the dumpsites (Peter, Paul and Thomas, 1995). However, in a situation where a borehole or hand dug well is not found within the 10m range the well closest within the range of 10-150 meters were used as wells close to the dumpsite and those 150 meters away were used as wells far away from dumpsite for both the borehole and hand dug wells.

A total of twenty four (24) water samples were collected for the purpose of this research, because twenty four samples would properly cover the study area and also because of the high cost of water analysis in the laboratory. Out of which twelve (12) were for the first month of sample collection (dry season, April) and another twelve (12) samples for the second month of samples collection (wet season, August). Out of each twelve samples, six (6) water samples were collected from shallow wells of depths of between 10-20 meters and the other six (6) samples from deep wells of depths greater than twenty five (25) meters and above. Three of the well samples for both hand dug wells and deep were located close to the dumpsites, while the other three were far away from the dumpsites.

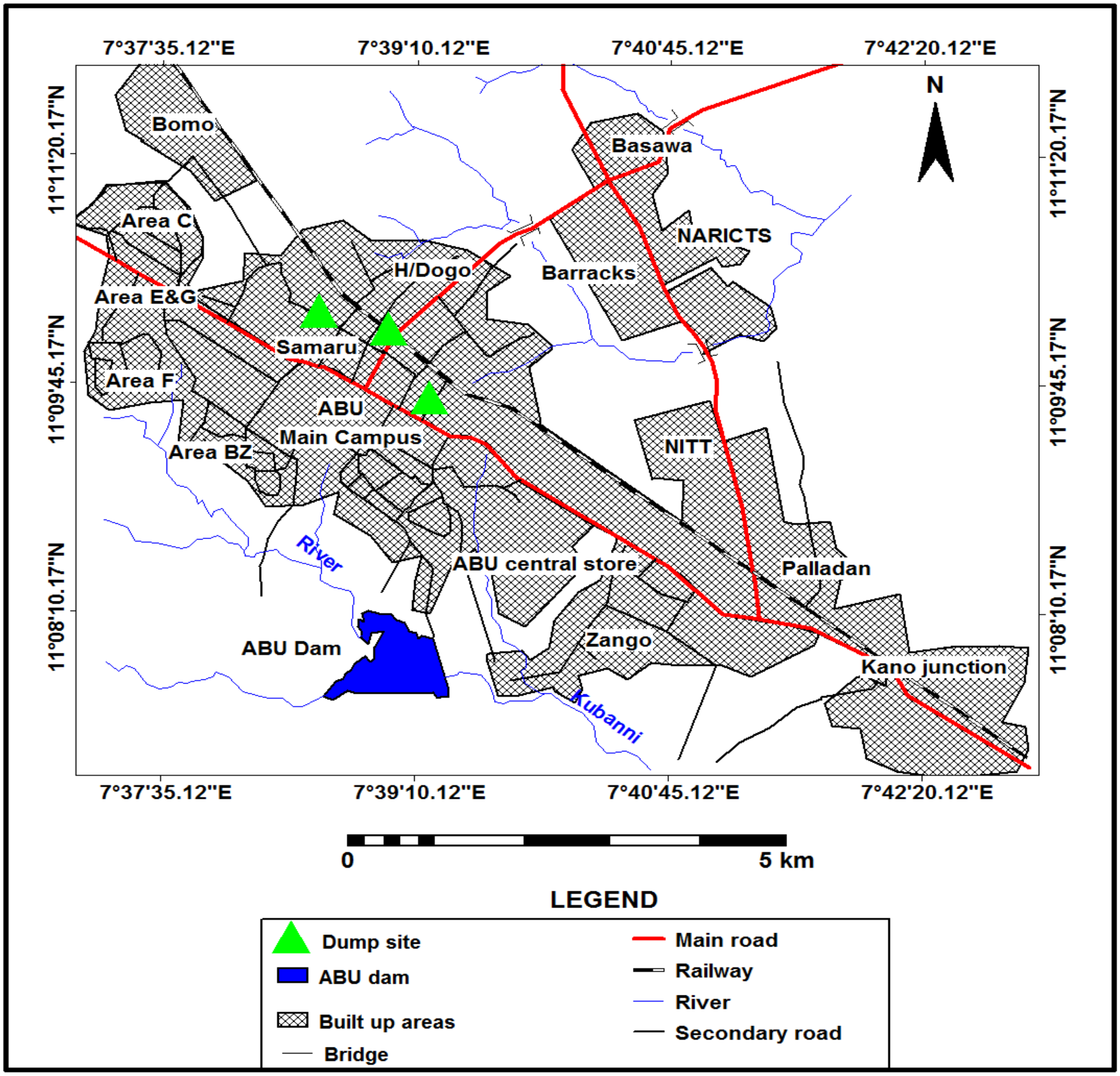

FIG 3. 2: Samaru and its Environs showing the selected Dumpsites

All containers used were deionized with distilled water, rinsed with sample before taking the samples to the laboratory for analysis. The water samples were analyzed within three hours of collection in order to avoid unpredictable change in the samples (WHO, 1971).

3.3.4 Laboratory Analysis of samples

The data analysis for this research work was carried out in the Water Resource Laboratory in Department of Water Resource and Environmental Engineering ABU Zaria, where the physico-chemical properties were tested. The Water and Analytical Laboratory in Chemistry Department ABU Zaria, was also used to test samples for heavy metals. The chemical parameters analyzed are the Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Total Dissolved Solid (TDS), magnesium, chloride and pH. The total hardness and colour are physical parameters considered while zinc, iron, chromium and lead were tested for heavy metals.

3.3.5 Procedure Used For the Chemical Analysis

3.3.5.1 *pH determination*

pH is a measure of the H^+ concentration. It is expressed mathematically as pH= log (H^+). pH value ranges from acidic (1-6.8) through neutral (6.8-7.8) to basic (7.9-14). Therefore pH determines the acidity or alkalinity (basicity) of water.

Method: Electrometrically using glass electrons

Reagent: Buffer solution of pH 4 and 9, and distilled water.

Apparatus: pH meter, beaker, and stirrer

Procedure:

1. A pH meter was warmed for 15-20 minutes. The electrode was then removed from the distilled water and wiped dry.
2. The pH meter was standardized using the buffer solution at a temperature of between 20°C to 25°C.
3. The pH knob was switched off on the electrode from the second buffer, removed and rinsed thoroughly and then wiped with tissue paper.
4. The electrode was inserted into the sample and the power restored, then the reading of the scale was taken.
5. The electrode was finally rinsed and stored, immersed in distilled water.

3.3.5.2 *BOD and DO determination*

The biological oxygen demand is an empirical test in which standardized laboratory procedures are used to determine the relative oxygen requirement of waste water. The test measures the oxygen required for the bio-chemical degradation or biological degradation of organic materials and the oxygen used to oxidized inorganic materials such as sulfide and ferrous iron while the dissolved oxygen (DO), serves as a means of water control. All atmospheric gas even oxygen are soluble in water. The level of DO in water determines the microbiological plant and animal content and also its ability for sustaining the life of fishes and other aquatic organisms. DO have an important effect on water quality and the solubility of atmospheric oxygen in fresh water ranges from 14.6mg/L at 0°C to about 7mg/l at 35°C under atmospheric condition.

Apparatus: These include BOD bottles (300m1), pipette (10ml and 1ml), measuring cylinder, starch solution, conical flask. Others are manganese sulphate solution, sodium thiosulphate, incubator, alkali-iodide reagent and concentrated sulphuric acid.

Procedure:

The dissolved oxygen (DO) of the sample was tested for the day the samples were collected. The samples were initially used to rinse the BOD bottles and were filled up by ensuring no air bubble remained in the bottle. 2ml of alkali-iodide-acid reagent was also added. The bottle was capped and shaken, the sample then formed brownish to whitish precipitate which was also allowed to settle until it made up to 100ml. 2ml sulphuric acid (H_2S0_4) was also added the bottles. 200m1 of the samples were measured into a conical flask and titrated with sodium thiosulphate (0.025N) until a pale yellow colour was formed, titration continued until the sample becomes colourless. The volume of the sodium thiosulphate used for titration was noted.

Therefore DO was estimated as 1ml of sodium thiosulphate = 1mg per liter of DO. After the test of the first day the BOD bottles were rinsed again and filled with the sample. The samples were then incubated for five (5) days in an incubator at 20°C. On the fifth day, the same DO test is carried out as DO_5 and the BOD is calculated as follows:

BOD Difference between DO_1 on the first day, and DO_5 after 5 days.

$$\text{Therefore, BOD} = \frac{(\mathrm{DO}_1 - \mathrm{DO}_5)\text{ x volume of BOD bottle}}{ml\ of\ samples\ used}$$

3.3.5.3 *COD determination*

The Chemical Oxygen Demand (COD) test is widely used in measuring the pollution strength of both domestic and industrial wastes. It allows for measurement of waste in terms of oxygen required to oxidize organic matter to carbon dioxide and water.

Apparatus

Reflux flask, reflux condenser, ferroin indicator, sulphuric (H_2S0_4) acid and standard potassium dicro-mate solution.

Procedure

400mg of sulphuric acid (H_2S0_4) was measured and placed in a reflux flask. 20ml of the sample and 20m1 of distilled water was added and mixed, the 10ml of standard potassium dicro-mate ($K_2Cr_2O_7$) solution and glass beads are already treated to 600°C for an hour. The flask was then attached to the reflux condenser and 300m1 of concentrated H_2S0_4 containing H_2S0_4 was added, mixing thoroughly while adding the acid.

The mixture was refluxed for an hour, cooled and the condenser was washed with distilled water. The mixture was distilled for about 15 minutes with distilled water and cooled to a room temperature. Three (3) drops of ferroin indicator was added and the mixture was titrated with Fe (NH) to a colour change from blue-green to a reddish brown. A blank consisting of 20m1 of distilled water was refluxed in the same manner together with the reagent. Therefore the COD was calculated as:

$$COD = \frac{\text{(a - b) N x 8000}}{\text{ml of samples}}$$

Where

N = Normality of titrate

a = ml titrant for blank

b = ml titrant for sample

3.3.5.4 *T.D.S determination*

The apparatus used include filter membrane, weighing machine or weighing balance, oven, beaker, volumetric flask and desiccators.

Procedure:

250mls of water sample was filtered and then evaporated to dryness in a conical flask using the oven. After the evaporation the residue in the beaker was then measured to get the Total Dissolved Solid (TDS) in ml/L.

This was done by subtracting the difference in the weight of the flask before and after oven drying (Smith and Stopp, 1976).

3.3.5.5 *Chloride determination*

A number of methods are available for the estimation of chlorides in water. The simplest and most widely used method is known as the MOHR method.

This method is based on the titration of a halide such as chloride (Cl) with standard silver nitrate ($Ag\ N0_3$) in the presence of potassium chromate (K_2Cr0_4) as indicator.

Procedure

1. 50ml of the sample was measured into the conical flask.
2. 0.5ml of potassium was then added to the chromate indicator solution.
3. The sample in the flask was then titrated with standard silver nitrate solution.
4. When the titration turns reddish-brown the point was noted Mg of Cl per litre

Calculation: $$\text{mg/l (Cl)} = \frac{Cl}{V_1 * V_2} \times 100$$

Where V_1 is the volume of standard silver nitrate solution used for titration. V_2 is the volume of water sample taken for analysis. Standard Ag $N0_3$ solution provided 1ml = 1mg cl^-.

3.3.6 Methodology Used for Physical Analysis

For the physical analysis of the water samples, colour, total hardness and magnesium were examined.

3.3.6.1 *Colour determination*

Colour is difficult to attain because no form of water is 100% pure. Similarly some people have the ability to detect color property at low concentration, and this is done by physical look or observation of the water.

Method: Platinum – cobalt method

Reagent: Buffer solution

Procedure

1. A nessler tube was filled with distilled water and placed in the left sample position on the comparator.
2. Another tube containing the sample is then placed on the right.
3. The colour discs were placed and rotated to match the colour.
4. The number on the disc was then recorded.

3.3.6.2 *Total hardness and magnesium determination*

Hardness is always expressed in terms of calcium carbonate ($CaCO_3$) and the description may be given as follows:

0-50mg/l	Soft
50-100mg/l	moderately soft
100-150mg/l	slightly hard
150-200mg/l	moderately hard
Over 200mg/l	Hard
Over 300mg/l	very hard

The Method used here is the EDTA Titrimetric method

Procedure

1. The sample was shaken thoroughly
2. 25ml of sample was taken and diluted to 50mls with distilled water.
3. 2ml of buffer solution was then added.
4. After that 2 drops of eriochrome Black indicator was immediately added.
5. Within every 5 minutes interval the solutions was titrated with EDTA.
6. The titer value was then taken after that
7. A blue colouration is the end point.

Calculation

$$\text{Mg/l } CaC0_3 = \frac{A \times B \times 1000}{Ml\ of\ Sample}$$

Where A = ml of Titrant

B = mg $CaC0_3$ eqn. To 1.00ml EDTA titrant.

3.3.7 Methodology for Heavy Metal Determination

To carryout the test and analysis for heavy metals: zinc, iron, magnesium chromium and lead for both the water and soil samples obtained from the dumpsites, the Flame Photometric Detector was used. The detector uses different colours to determine each heavy metal level because they all have different colours.

Procedure

1. 10mls of the sample was weighed based on the specification on the monograph. After that the samples was dissolvent with 25ml of water then the pH of the solution was adjusted to 3-4 with acetic acid (- 60g/l). PbTs, (~100g/l) PbTs, as necessary then diluted to 40ml, with water and then mixed.
2. The quantity of substance specified (2ml) was weighed and dissolved in 30ml solvent which is ethanol (~750g/l) Ts, after which 0.5ml of acetic acid (~300g/l) Ts, was added and diluted to 40ml with ethanol (~750g/l) TS.
3. The quantity of substance as specified (2ml) in the monograph for each heavy metal sample was then measured into a crucible made of silica. It was then carefully ignited at low temperature (50^oC) until the content was thoroughly charred. 2ml of nitric acid (~1000g/l) Ts and 5 drops of sulphuric acid (~1760g/l) Ts, was added to the charred content in the crucible and heated until white fume where evolved, after which heating continued in a muffle furnace at 500^oC until all carbon was burned off.

   After cooling, 2ml of hydrochloric acid was added and allowed to slowly evaporate in a water bath to dryness.

The residue was moistened with 1 drop of hydrochloric acid (~250g/l) Ts, and 10ml of hot water after which digestion was done for 2 minutes. Ammonia (~100g/l) PbTs, was added drop by drop until the pH of solution was found to be between 8 to 8.5, then acetic acid (~60g/l) PbTs, was then added in drops to adjust the pH to between 3 and 4. The substance was then filtered, after which the crucible and the filter were washed with 10ml of water and then diluted with water to 40mls and mixed.

4. The quantity of substance specified (2ml) in the monograph was then placed in another crucible made of silica, it was well mixed with 0.5g of magnesium oxide and incinerated until a homogeneous white mass was obtained. The residue was then dissolved in hydrochloric acid (~ 70g/l) Ts. Drop by drop solution of ammonia (~100g/l) PbTs, was added till the pH of the solution came between 8 and 8.5, then add, drops of acetic acid (~60g/l) PbTs, to adjust the pH to 3-4, the dilute was filtered with water to 40mls and then mixed.

5. Colour development and Measurement

   10mls of freshly prepared hydrogen sulfide was then added to the 40mls of the liquid contained in the comparison tube mixed and allowed to stand for 5 minutes. In another comparison tube a volume of solution of dilute lead PbTs, containing the lead equivalent of the heavy metals limit specified (2ml) in the monograph, dilute with water and the pH adjusted with ammonia (~100g/l) PbTs and acetic acid (~60g/l) PbTs to 3-4. The solution was then diluted with water to 40ml, and then 10mls of freshly prepared hydrogen sulfide Ts, was added mixed and allowed to stand for five minutes.

The colours were then compared by viewing down the vertical axis of the tube in diffused light against a white background, by another suitable method. The colour of the test solution is usually not darker than that of the lead standard.

3.3.8 DATA ANALYSIS

The data obtained were subjected to both descriptive and inferential statistical analysis. Analysis of Variance was used to compare the results of the physico-chemical and heavy metal parameters in the well water with the W.H.O and NSDQW standard limits.

To achieve Objective i, the data was subjected to descriptive analysis, using tables to arrange and show the distances of wells to and from the dumpsites, objectives ii, iii and iv were achieved by analyzing the data using the ANOVA mainly to compare the results of physico-chemical and heavy metal parameters in the well water with the WHO and NSDQW standard limits.

Hypothesis 1 and 2 were tested using the t-test while hypothesis 2 and 3 were tested using the chi-square (χ^2). Statistical test for significance was established at the 0.05 probability level.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents and discusses the findings of the study.

4.2 DISTANCE OF WELLS FROM DUMPSITES

The distance of wells from the dumpsites is presented in this section.

4.2.1 Distance of Wells from Dumpsite in the Study Area in Meters

The distance of wells from dumpsite in the study area for both hand dug and boreholes is presented in Table 4.1.

Table 4.1: Distance of Wells to Dumpsite in the Study Area (in meters)

Location	**Close to Dumpsite**		**Far from Dumpsite**	
	Hand dug well	**Borehole**	**Hand dug well**	**Borehole**
Samaru New Extension	7.40	26.50	152.00	160.00
Hayin Dogo	6.90	30.20	170.00	151.00
Danraka	3.00	8.00	150.00	152.00

Source: Field Survey, 2014

Table 4.1 shows that shallow wells are located closer to dumpsites than the deep wells in Samaru, this is evident from distance of wells close to dumpsites and distances far from dumpsite as seen in Table 4.1.

4.3 PHYSICO-CHEMICAL PROPERTIES OF WELL WATER IN THE STUDY AREA

The water samples collected were twenty four (24) from different wells, and three soil samples collected from the dumpsites in the study area. The twenty four water samples were gotten from different sources of both shallow wells (hand dug) and deep (bore hole) wells, at different time frames i.e. rainy (August) and dry (April) seasons and also from different distances.

4.3.1 Physico-chemical Properties of Well Water Quality in Samaru New Extension During Dry Season.

The physico- chemical properties of water quality for deep and shallow wells close to andfar away from dumpsite at Samaru New Extension during the dry season is presented in table 4.2.

Table 4.2. Physico-chemical Properties of Well Water in Samaru New Extension during Dry season (April)

S/N	Parameter	Borehole		Hand dug well		WHO (2011)	NSDWQ (2007)
	Mg/l	**Close to**	**Far away**	**Close to**	**Far away**	**Standard**	**Standard**
1.	pH (Unit)	6.21	7.30	6.91	7.11	6.5-8.5	6.5-8.0
2.	Colour (Unit)	5.00	5.00	5.00	5.00	5.00	5.00
3.	DO	1.71	1.40	1.50	1.60	3.00	3.00
4.	BOD	0.50	1.30	0.60	0.90	0.8-5.0	0.8-5.0
5.	Chloride	44.30	10.26	66.40	12.49	200.00	200.00
6.	TH	251.40	301.20	646.40	515.10	400.00	400.00
7.	TDS	73.40	96.80	720.00	400.00	500.00	500.00
8.	COD	440.00	630.00	430.00	540.00	10.00	10.00

Source: Laboratory Analysis, 2014.

From Table 4.2, it can be seen that the difference between the water quality of borehole and hand dug wells in New Extension is not much, except for total hardness and Total Dissolved Solid (TDS) which showed a much higher value in shallow wells than the deep wells. It was also observed that all the parameters analyzed fall within the WHO and NSDWQ standard for water quality, except for Total Hardness in shallow wells both close to and far away from dumpsite, TDS of shallow wells close to dumpsite and the Chemical Oxygen Demand (COD) for all the wells in the study area. The high level of TDS is due to the dumpsite, while that of COD and total hardness may be due to natural contamination of groundwater or due to leachate ingress from refuse dumpsite within Samaru New Extension.

From previous studies like that of Longe and Balogun (2010), it was discovered that the pH level of all the groundwater samples are generally acidic and where below the WHO and NSDWQ standard for potable water.

4.3.2 Physico-chemical Properties of Well Water in Samaru New Extension the wet Season

The physico-chemical property of well water close to and far away from dumpsite site in Samaru New Extension during the wet season (August) is presented in Table 4.3

Table 4.3: Physico-chemical Properties of Well Water in Samaru New Extension during Rainy Season (August)

S/N	Parameter	Borehole		Hand dug well		WHO (2011)	NSDWQ (2007)
	Mg/l	Close to	Far away	Close to	Far away	Standard	Standard
1.	pH (Unit)	5.97	5.88	6.72	7.22	6.5-8.5	6.5-8.0
2.	Colour (Unit)	5.00	5.00	5.00	5.00	5.00	5.00
3.	DO	1.32	1.35	1.32	1.41	3.00	3.00
4.	BOD	0.30	1.10	0.40	0.50	0.8-5.0	0.8-5.0
5.	Chloride	51.20	14.31	74.48	15.21	200.00	200.00
6.	TH	253.40	303.90	655.00	520.00	400.00	400.00
7.	TDS	107.40	86.60	710.00	375.00	500.00	500.00
8.	COD	461.00	640.00	450.00	555.00	10.00	10.00

Source: Laboratory Analysis, 2014.

From Table 4.3, it can be observed that the difference between the water quality of borehole and hand dug wells is in total hardness, which shows a high value in hand dug wells both close to and far away from the dumpsites. The hardness of the well water close to the dumpsite is higher, showing that dumpsite have an effect on total hardness of the water. Also TDS of hand dug well close to dumpsite have a higher value that exceeds the WHO permissible limit compared to hand dug well far away from the dumpsite. It was also observed that all the parameters analyzed in both cases fall within the WHO and NSDWQ standard permissible limit for drinking water quality except for total hardness for hand dug well, TDS for hand dug well close to dumpsite and COD for all the wells in New Extension. Previous research by Lasisi (2011) also revealed that most of the hand dug wells tested for physico-chemical properties were contaminated, but Lasisi (2011) did not include boreholes in his research.

4.3.3 Physico-chemical Properties of Well Water in Hayin Dogo During the Dry Season

The physico-chemical properties of well water in Hayin Dogo close to and far away from dumpsite during the dry season (April) is presented in Table 4.4.

Table 4.4: Physico-chemical Properties of Well Water in Hayin Dogo during Dry Season (April)

S/N	Parameter	Borehole		Hand dug well		WHO (2011)	NSDWQ (2007)
	Mg/l	Close to	Further away	Close to	Further away	Standard	Standard
1.	pH (Unit)	6.91	7.54	5.61	6.72	6.5-8.5	6.5-8.0
2.	Colour (Unit)	5.00	5.00	5.00	5.00	5.00	5.00
3.	DO	1.31	5.23	1.70	3.70	3.00	3.00
4.	BOD	1.10	0.60	1.00	0.40	0.8-5.0	0.8-5.0
5.	Chloride	14.20	11.31	12.99	13.40	200.00	200.00
6.	TH	100.00	96.20	200.00	112.00	400.00	400.00
7.	TDS	416.20	104.90	738.99	285.05	500.00	500.00
8.	COD	341.00	253.00	420.00	400.00	10.00	10.00

Source: Laboratory Analysis, 2014.

Table 4.4, indicates that the difference between physico-chemical quality of well water in borehole and hand dug well is not high, except for Dissolved Oxygen (DO) for both borehole and hand dug wells further away from the dumpsite, showing that solid waste dumpsite is not directly responsible for a high DO level of well water in Hayin Dogo. It was also observed that all parameters analyzed fall within the WHO standard for drinking water quality except for DO for both boreholes and hand dug wells far away from dumpsites, TDS for hand dug wells close to dumpsites and COD for all the well water samples which have values above the WHO and NSDQW permissible water quality levels.

4.3.4 Physico-chemical Properties of Well Water for Hayin Dogo during the Wet Season

The physico-chemical property of well water for boreholes and hand dug well close to and far away from dumpsites for Hayin Dogo during the wet season is presented in Table 4.5.

Table 4.5: Physico-chemical Properties of Well Water in Hayin Dogo during Rainy Season (August)

S/N	Parameter	Borehole		Hand dug well		WHO (2011)	NSDWQ (2007)
	Mg/l	Close to	Further away	Close to	Further away	Standard	Standard
1.	pH (Unit)	5.01	5.61	5.86	5.89	6.5-8.5	6.5-8.0
2.	Colour (Unit)	5.00	5.00	5.00	5.00	5.00	5.00
3.	DO	2.40	2.21	1.10	3.15	3.00	3.00
4.	BOD	0.90	0.20	0.80	0.40	0.8-5.0	0.8-5.0
5.	Chloride	43.49	30.49	15.21	13.11	200.00	200.00
6.	TH	224.00	116.00	326.30	115.30	400.00	400.00
7.	TDS	722.10	240.20	529.00	274.00	500.00	500.00
8.	COD	456.00	410.00	300.00	274.00	10.00	10.00

Source: Laboratory Analysis, 2014.

From Table 4.5, it can be observed that there is no much difference between the quality of well water in borehole and hand dug wells at Hayin Dogo except for TDS close to dumpsite for both borehole and hand dug wells, and COD which has a high value for all the wells and this may not just be due to the solid waste dumpsites but also other former land use practice of the area.

4.3.5 Physico-chemical Properties of Well Water in Danraka during the Dry Season

The physico-chemical properties of well water quality for borehole and hand dug wells close to and far away from dumpsites at Danraka during dry season (April) is presented in Table 4.6.

Table 4.6: Physico-chemical Properties of Well Water in Danraka during Dry Season (April)

S/N	Parameter	Borehole		Hand dug Well		WHO (2011)	NSDWQ (2007)
	Mg/l	Close to	Further away	Close to	Further away	Standard	Standard
1.	pH (Unit)	7.19	7.49	5.11	6.21	6.5-8.5	6.5-8.0
2.	Colour (Unit)	5.00	5.00	5.00	5.00	5.00	5.00
3.	DO	5.41	2.20	6.69	3.20	3.00	3.00
4.	BOD	0.90	1.70	1.10	1.50	0.8-5.0	0.8-5.0
5.	Chloride	11.21	9.23	14.10	12.38	200.00	200.00
6.	TH	210.10	6.21	440.00	120.00	400.00	400.00
7.	TDS	113.60	141.80	510.70	210.00	500.00	500.00
8.	COD	450.00	623.00	550.00	660.00	10.00	10.00

Source: Laboratory Analysis, 2014.

From Table 4.6, it can be observed that the difference between the water quality of borehole and hand dug wells in Danraka is not much, except for total hardness and TDS for shallow wells, COD also has very high values. It was also observed that the level of quality of all the parameters observed falls within the WHO (2011) and NSDQW

(2007) limit for permissible drinking water, except for TDS and COD for all well water quality in the area.

4.3.6 Physico-chemical Properties of Well Water in Danaraka during the Rainy Season

Pyhsico- chemical well water quality in Danraka for borehole and hand dug well close to and far away from dumpsites of Danraka during the rainy season (August) is presented in table in Table 4.7.

Table 4.7: Physico-chemical Properties of Well Water in Danraka during the Rainy Season (August)

S/N	Parameter	Bore hole		Hand dug well		WHO (2011)	NSDWQ (2007)
	Mg/l	Close to	Far away	Close to	Far away	Standard	Standard
1.	pH (Unit)	5.73	6.21	5.21	5.31	6.5-8.5	6.5-8.0
2.	Colour (Unit)	5.00	5.00	5.00	5.00	5.00	5.00
3.	DO	4.10	1.11	5.38	2.42	3.00	3.00
4.	BOD	0.70	1.40	1.01	1.30	0.8-5.0	08-5.0
5.	Chloride	17.32	18.16	18.33	19.10	200.00	200.00
6.	TH	121.40	106.80	450.0	123.00	400.00	400.00
7.	TDS	120.00	107.00	500.12	21.01	500.00	500.00
8.	COD	623.00	674.00	570.00	680.00	10.00	10.00

Source: Laboratory Analysis, 2014.

Table 4.7 shows that the quality of water in hand dug and borehole wells in Danraka do not differ much except for dissolved oxygen that shows a high value. It was also observed that the level of all the parameters analyzed, fall within the WHO and NSDWQ permissible limits except for DO for both hand dug and borehole wells close to dumpsite, total hardness for shallow well close to dumpsite and all the parameters in well water for COD.

4.4 TEST FOR SIGNIFICANT DIFFERENCE IN PHYSICO-CHEMICAL PROPERTIES OF WELL WATER IN THE STUDY AREA

The test for significant difference in physico-chemical concentration of well water quality close to and far away from dumpsites in the study area is presented in this section.

4.4.1 Difference in Physico-Chemical Well Water Quality for boreholes in the Study Area during Dry Season (April)

The test for significant difference in physico-chemical well water quality for bore hole in Samaru New Extension during the dry season (April) using t-test is presented in Table 4.8.

Table 4.8: Test for Difference in Physico-Chemical Well Water Quality for Boreholes in Samaru during the Dry (April) and Rainy (August) Season

Location	Season	Calculated t	Tabulated t	Significance
Samaru	Dry Season	0.015	2.365	Not significant
New Extension	Rainy Season	0.46	2.365	Not significant
Hayin Dogo	Dry season	0.46	2.365	Not significant
	Rainy Season	0.49	2.365	Not significant
Danraka	Dry Season	0.003	2.365	Not significant
	Rainy season	0.14	2.365	Not significant

Source: Laboratory Analysis, 2015

From Table 4.8 it was revealed that there is no significant difference in the physico-chemical well water quality for boreholes close to and far away from dumpsite in the study area during the dry (April) and rainy (August) season. This is so because, from the t-test analysis result shown in table 4.8 the result reveals that the tabulated t values are greater than the calculated t values. This is of importance because all the research work reviewed in this study did not test for the significant difference in physico-chemical well water quality. This therefore makes this research work very significant to Samaru and Zaria as a whole.

4.4.2 Difference in Physico-Chemical Well Water Quality for Hand dug Well in Samaru during the Dry (April) and Rainy (August) Season

The test for significant difference in physico-chemical well water quality for hand dug wells in Samaru during the dry and rainy season using the student t-test is presented in table 4.9.

Table 4.9: Test for Difference in Physico-Chemical Well Water Quality for Hand dug Wells in Samaru during Dry (April) and Rainy (August) Season

Location	Season	Calculated T	Tabulated T	Significance
Samaru	Dry Season	0.38	2.365	Not significant
New Extension	Rainy Season	0.40	2.365	Not significant
Hayin Dogo	Dry season	0.44	2.365	Not significant
	Rainy Season	0.23	2.365	Not significant
Danraka	Dry Season	0.41	2.365	Not significant
	Rainy season	0.46	2.365	Not significant

Source: Laboratory Analysis, 2015

Table 4.9 shows that there is no significant difference in the physico-chemical well water quality for hand dug wells close to and far away from solid waste dumpsite in the study area (Samaru). This is so because the student t-test analysis as shown in Table 4.9 shows that all the tabulated t values are greater than the calculated t values. Since calculated t-value is greater than the tabulated t-value is can be concluded that there is no significant difference.

The test for significant, therefore shows that contamination of well water in Samaru for both rainy and dry season is not just all about the dumpsites or the season, but other factors can also be responsible for well water contamination. These factors may include, nature of soil, land use practices, leachate effects etc.

4.5 HEAVY METALS CONCENTRATIONS IN DUMPSITE SOILS

The concentration of heavy metal in soils of dumpsites in the study area is presented in this section.

4.5.1 Heavy Metal Concentration in Soils of Dumpsite for Samaru New Extension

The heavy metal concentration in soils of dumpsite for Samaru New Extension is presented in Table 4.10.

Table 4.10: Heavy Metal Concentration in Dumpsite soil for Samaru New Extension

S/No	Metals	Concentration (mg/g)
1	Magnesium (Mg)	764.930
2	Zinc (Zn)	5.348
3	Iron (Fe)	116.978
3J	Chromium (Cr)	0.220
5	Lead (pb)	0.297

Source: Laboratory Analysis, 2014

Table 4.10 shows the heavy metal concentration in dumpsite soil for Samaru New Extension. From the table it was observed that Magnesium has the highest concentration of metals in the soil while Chromium has the least concentration. It can be noticed from the concentrations that if an urgent step is not taken on the dumpsites the heavy metal will continue to leach into the ground thereby contaminating the groundwater.

4.5.2 Heavy Metal Concentration in Soils of Dumpsite for Hayin Dogo

The heavy metal concentration in soils of Dumpsites for Hayin Dogo is presented in Table 4.11.

Table 4.11: Heavy Metal Concentration in Soils of Dumpsite for Hayin Dogo

S/No	Metals	Concentration (mg/g)
1	Magnesium (Mg)	583.740
2	Zinc (Zn)	3.822
3	Iron (Fe)	123.144
3	Chromium (Cr)	0.176
5	Lead (pb)	0.498

Source: Laboratory Analysis, 2014

Table 4.11 shows the heavy metal concentration in dumpsite soil for Samaru New Extension. From the table it was observed that Magnesium has the highest concentration of metals in the soil while Chromium has the least concentration. It can be noticed from the concentrations that if an urgent step is not taken on the dumpsites the heavy metal will continue to leach into the groundwater thereby contaminating the ground water.

4.5.3 Heavy Metal Concentration in Soil of Dumpsite for Danraka

The heavy metal concentration in dumpsite of soils for Danraka is presented in Table 4.12.

Table 4.12: Heavy Metal Concentration in Soil of Dumpsite for Danraka

S/No	Metals	Concentration (mg/g)
1	Magnesium (Mg)	646.21
2	Zinc (Zn)	4.1432
3	Iron (fe)	103.173
3	Chromium (Cr)	0.121
5	Lead (pb)	0.532

Source: Laboratory Analysis, 2014

From Table 4.12 it was observed that Magnesium has the highest concentration of heavy metals in dumpsite of soils for Danraka, followed by Iron, while Chromium has the least concentration.

4.6 HEAVY METAL CONCENTRATION IN WELL WATER SAMPLES

Heavy metal concentration for well water samples for rainy and dry season in the study area is presented below.

4.6.1 Heavy Metal Concentration for Well Water in Samaru New Extension during Dry Season

Heavy metal concentration of well water for borehole and hand dug wells close to and far away from dumpsites in Samaru New Extension for April is presented in Table 4.13.

Table 4.13: Heavy Metal Concentration of Well Water in Samaru New Extension During Dry Season (April)

S/N	Parameters	Borehole		Hand dug well		WHO (2011)	NSDWQ (2007)
	Mg/L	**Close to**	**Far away**	**Close to**	**Far away**	**Standard**	**Standard**
1.	Magnesium	236.3	145.9	435.90	349.20	50.0	50.0
2.	Zinc	0.0112	0.0063	0.012	0.013	5.00	5.00
3.	Iron	0.10	0.01	0.20	0.14	0.30	0.30
4.	Chromium	0.011	0.003	0.026	0.006	0.05	0.05
5.	Lead	0.012	0.087	0.096	0.028	0.01	0.01

Source: Laboratory Analysis, 2014

From Table 4.13, it can be seen that the difference between the water quality of borehole and hand dug wells in the study area is not much expect for magnesium which showed high values in shallow wells than it did in deep wells. It was also observed that all the parameters fall within the WHO and NSDWQ standards for potable water expect for lead and magnesium in all the wells. The effects of intake of lead are delay in physical or mental development in infants and children, kidney problem and high blood pressure in adults.

4.6.2 Heavy Metal Concentration for Well Water in Samaru New Extension during Wet Season

Heavy metal concentration of well water in Samaru New Extension for borehole and Shallow well close to and far away from dumpsites in Samaru New Extension for August is presented in Table 4.14.

Table 4.14: Heavy Metal Concentration of Well Water in Samaru New Extension During Rainy Season (August)

S/N	Parameters	Borehole		Hand dug well		WHO (2011)	NSDWQ (2007)
	Mg/l	**Close to**	**Far away**	**Close to**	**Far away**	**Standard**	**Standard**
1.	Magnesium	222.40	106.70	464.70	352.10	50.0	50.0
2.	Zinc	0.0123	0.0062	0.014	0.021	5.00	5.00
3.	Iron	0.143	0.131	0.310	0.160	0.30	0.30
4.	Chromium	0.026	0.006	0.030	0.009	0.05	0.05
5.	Lead	0.021	0.093	0.036	0.160	0.01	0.01

Source: Laboratory Analysis, 2014.

Table 4.14 shows little difference between concentration of heavy metals for both borehole and hand dug wells, except for magnesium where wells close to dumpsite have a higher concentration than wells far away from dumpsite, for both the deep and the shallow wells. In the case of concentration with WHO standard Zinc, Iron and Chromium fall within the permissible limits, but Magnesium and Lead are above the WHO recommended limits and this can cause serious health risks and defects.

4.6.3 Heavy Metal Concentration of Well Water in Hayin Dogo During Dry Season

The heavy metal concentration of well water for borehole and hand dug well close to and far away from dumpsites in Hayin Dogo for April is shown in Table 4.15.

Table 4.15: Heavy Metal concentration of Well Water in Hayin Dogo during Dry Season

S/N	Parameters	Borehole		Hand dug well		WHO (2011)	NSDWQ (2007)
	Mg/L	**Close to**	**Far away**	**Close to**	**Far away**	**Standard**	**Standard**
1.	Magnesium	163.40	100.30	242.00	960.00	50.0	50.0
2.	Zinc	0.0131	0.0032	0.006	0.008	5.00	5.00
3.	Iron	0.21	0.01	0.17	0.13	0.30	0.30
4.	Chromium	0.004	N.D	0.006	N.D	0.05	0.05
5.	Lead	N.D	N.D	N.D	N.D	0.01	0.01

Source: Laboratory Analysis, 2014.

*** ND=Not Detected**

From the analysis shown in Table 4.15, there is no much difference between the concentration of heavy metals in the boreholes and hand dug wells for both dry and rainy seasons, except for magnesium which showed a higher value in both deep and shallow wells close to dumpsite and a lower value for wells far away from dumpsite. With regards to the concentration of heavy metals with WHO and NSDWQ standard for potable water, all the heavy metals fall within the permissible limit of WHO standards except for magnesium that have a higher value than the permissible limit of 50mg/l. Lead was not detected in all the water samples for both seasons.

4.6.4 Heavy Metal Concentration of Well Water in Hayin Dogo during the Wet Season

Heavy metal concentration of well water for borehole and hand dug wells close to and far away from dumpsites in Hayin Dogo for August is shown in Table 4.16.

Table 4.16: Heavy Metal Concentration of Well Water in Hayin Dogo during Rainy Season (August)

S/N	Parameters	Borehole		Hand dug well		WHO (2011)	NSDWQ (2007)
	Mg/L	Close to	Far away	Close to	Far away	Standard	Standard
1.	Magnesium	121.30	98.90	300.10	104.20	50.0	50.0
2.	Zinc	0.0062	0.0161	0.013	0.011	5.00	5.00
3.	Iron	0.139	0.158	0.20	0.16	0.30	0.30
4.	Chromium	0.005	N.D.	0.012	N.D.	0.05	0.05
5.	Lead	N.D.	N.D.	N.D	N.D	0.01	0.01

Source: Laboratory Analysis, 2014.

From Table 4.16, it can be observed that the major difference between the water quality for borehole and hand dug wells is in magnesium where the concentration for shallow wells is higher than the concentration for deep wells. The concentration for the rest of the metals does not differ much between the deep and the shallow wells. With regards to the heavy metal concentration and the WHO standard, all the metals fall within the WHO permissible limit for groundwater quality, except for magnesium which has a higher value, while lead was not detected in all the groundwater samples.

4.6.5 Heavy Metal Concentration of Well Water in Danraka During the Dry Season

Heavy metal concentration in groundwater for borehole and hand dug wells close and far away from dumpsites in Danraka for April is presented in Table 4.17.

Table 4.17: Heavy Metal Concentration of Well Water in Danraka during Dry Season (April)

S/N	Parameters	Borehole		Hand dug well		WHO (2011)	NSDWQ (2007)
	Mg/L	Close to	Far away	Close to	Far away	Standard	Standard
1.	Magnesium	446.80	121.40	507.00	160.00	50.0	50.0
2.	Zinc	0.0134	0.0214	0.026	0.026	5.00	5.00
3.	Iron	0.120	0.160	0.140	0.130	0.30	0.30
4.	Chromium	0.021	N.D	0.016	N.D	0.05	0.05
5.	Lead	0.035	N.D.	0.064	N.D.	0.01	0.01

Source: Laboratory Analysis, 2014.

Table 4.17 shows that the difference between the water quality for borehole and hand dug wells is not much except for magnesium that shows difference in quality for borehole and hand dug wells and also for wells close to and far away from dumpsite. In comparing the water quality with WHO and NSDWQ standard for potable water, all the water samples fall within the WHO permissible limit expect for magnesium that have a higher value above 50mg/l. All water samples tested for lead close to dumpsites were above the WHO permissible limit of 0.01mg/l. While chromium and lead far from dumpsite was not detected.

4.6.6 Heavy Metal Concentration of Well Water in Danraka During Rainy Season

Heavy metal concentration of well water for deep and shallow wells close to and far away from dumpsites in Danraka for August is presented in Table 4.18.

Table 4.18: Heavy Metal Concentration of Well Water in Danraka during Rainy Season (August)

S/N	Parameters	Borehole		Hand dug well		WHO (2011)	NSDWQ (2007)
	Mg/L	**Close to**	**Far away**	**Close to**	**Far away**	**Standard**	**Standard**
1.	Magnesium	423.60	107.30	564.00	171.20	50.0	50.0
2.	Zinc	0.0127	0.0031	0.061	0.051	5.00	5.00
3.	Iron	0.1210	0.1330	0.150	0.120	0.30	0.30
4.	Chromium	0.012	N.D	0.021	0.002	0.05	0.05
5.	Lead	0.064	0.001	0.074	N.D	0.01	0.01

Source: Laboratory Analysis, 2014.

From Table 4.18, it was observed that there is no much difference between the samples of borehole and hand dug wells except for magnesium that has a higher value close to dumpsite, and higher values for shallow wells than that of borehole wells. All the heavy metals fall within the WHO and NSDWQ permissible limit for potable water, except for magnesium, and lead in samples close to dumpsite for both borehole and hand dug wells. Chromium was not detected in deep well far from dumpsite and lead was also not detected in shallow well far from dumpsite.

4.7 DIFFERENCE IN HEAVY METAL CONCENTRATION OF WELL WATER IN THE STUDY AREA

The test for significant difference in heavy metal concentration of well water close to and far away from dumpsites in the study area is presented in this section.

4.7.1 Difference in Heavy Metal Concentration for Boreholes in Samaru during the Dry (April) and Rainy (August) Season

The test for significant difference in heavy metal concentration of borehole water close to and far away from dumpsite in Samaru during the dry (April) and Rainy (August) season using the t-test is presented in Table 4.19.

Table 4.19: Difference in Heavy Metal Concentration for Boreholes in Samaru during the Dry (April) and Rainy (August) Season

Location	Season	Calculated t	Tabulated t	Significance
Samaru	Dry Season	0.01	2.776	Not significant
New Extension	Rainy Season	0.45	2.776	Not significant
Hayin Dogo	Dry season	0.45	2.776	Not significant
	Rainy Season	0.45	2.776	Not significant
Danraka	Dry Season	0.45	2.776	Not significant
	Rainy season	0.45	2.776	Not significant

Source: Laboratory Analysis, 2015

Since tabulated t value is greater than calculated t-values, it can therefore be concluded that there is no significant difference in heavy metal concentration of borehole well water close to and far away from solid waste dumpsite in Samaru during the dry and rainy season.

From the previous researches conducted, the researchers only focused on physico-chemical qualities of well water, except for Lasisi (2011), Afolayan, Ogundele and Odewumi (2012), Akibile (2012) and Yusoff (2012) who analyzed physico-chemical well water properties and heavy metal concentration. The research conducted in previous studies was based only on well water concentration, while this research went further to test for the significant difference of heavy metal concentration of deep well water in the study area close to and far away from the dumpsite during the dry and rainy season.

From the t-test it also reveals that solid waste dumpsite is not the only contributory factor to heavy metal contamination in well water in the study area, other factors can include land use type like farming, mechanic workshop, abattoirs etc. This is so, because the conclusion of all the t-test analyzed showed that there is no significant difference.

Table 4.20 Difference in Heavy Metal Concentration for Hand dug Wells in Samaru During the Dry (April) and Rainy (August) Season

Location	Season	Calculated t	Tabulated t	Significance
Samaru	Dry Season	0.45	2.776	Not significant
New Extension	Rainy Season	0.44	2.776	Not significant
Hayin Dogo	Dry season	0.45	2.776	Not significant
	Rainy Season	0.45	2.776	Not significant
Danraka	Dry Season	0.55	2.776	Not significant
	Rainy season	0.22	2.776	Not significant

Source: Laboratory Analysis, 2015

Table 4.20 reveals that there is no significant difference in heavy metal concentration for hand dug wells close to and far away from solid waste dumpsite in Samaru during the dry and rainy season. This is so because, from the student t-test analysis conducted, it was discovered that the tabulated t-values are greater than the calculated t-values, implying therefore that there is no significant difference.

This also implies that solid waste dumpsite is not the only determinant factor of well water contamination by heavy metal in the study area, other factors listed above may also play a role.

4.8 COMPARING QUALITY OF WATER IN WELLS WITH WHO STANDARDS

Comparing quality of water in wells with WHO standards is presented in this section.

4.8.1 Comparison of Quality of Water in Wells Close to and Far Away from Dumpsites during Dry and Rainy Season

The hypothesis below compares the physico-chemical quality of water in wells, close to and far away from dumpsite during dry and rainy season.

Table 4.21: Mean Physico-Chemical Concentration and the WHO Guidelines for Hand dug Wells Close to Dumpsite during Dry and Rainy Season

	Parameter	Result during dry season	Result during rainy season	WHO Guidelines
1.	pH	5.88	5.90	7.5
2.	Colour	5.00	5.00	5.0
3.	DO	3.30	3.28	3.0
4.	BOD	0.90	0.74	5.0
5.	Chloride	31.16	36.00	200.0
6.	TH	428.80	477.10	400.0
7.	TDS	656.56	579.71	500.0
8.	COD	466.67	440.00	10.0

Source: Laboratory Analysis, 2014

Table 4.22: Relationship between observed and Expected Value of Chemical Concentration in Water Samples

Well type	Season	Calculated χ^2	Tabulated χ^2	Significance
Shallow Well	Dry Season	21,021.37	14.07	Significant
	Rainy Season	18,656.18	14.07	Significant

Source: Laboratory Analysis, 2014

Since the calculated value for hand dug wells close to dumpsite for both dry and rainy season is greater than the tabulated value, the null hypothesis is rejected, and the alternative hypothesis accepted, implying therefore that there is a significant difference between the levels of concentration of hand dug wells close to dumpsites and WHO standards during the dry season. This result simply implies from the chi-square calculation that shallow well water in Samaru Zaria close to dumpsite during the dry and rainy season are not pure, and the impurity as seen from table 4.21 is mainly due to the high level of COD concentration found in the well water. High COD in well water leads to decrease in oxygen in water. This can lead to health risks over time like heart attacks and strokes in adults because it is recommended that a glass of water should be taken before going to sleep at night mainly because of the oxygen found in water because it helps to dilute the contamination and metabolized toxic matter in the blood. Therefore appropriate precautionary measures like boiling of water before use should to taken seriously to avoid this health risks. It therefore means that well water in Samaru Zaria close to dumpsite sites during dry and rainy season are not totally pure mainly because of the high level of COD in the water samples.

Table 4.23: Mean Physico-Chemical Concentration and WHO Guidelines for Hand dug wells far from Dumpsite during the Dry and Rainy season

	Parameter (Mg/L)	Result during dry season	Result during rainy season	WHO Guidelines (2011)
1.	pH (Units)	7.44	6.13	7.5
2.	Colour (Units)	5.00	5.00	5.0
3.	DO	2.83	2.33	3.0
4.	BOD	0.93	0.73	5.0
5.	Chloride	12.76	15.81	200.0
6.	TH	249.03	252.77	400.0
7.	TDS	298.35	286.67	500.0
8.	COD	533.33	503.00	10.0

Source: Laboratory Analysis, 2014

Table 4.24: Relationship between Observed and Expected Value of Physico-Chemical Concentration in Well Water Sample

Well type	Distance	Season	Calculated χ^2	Tabulated χ^2	Significance
Shallow	Far from	Dry Season	19,094.50	14.07	Significant
Well	Dumpsite	Rainy Season	24,618.79	14.07	Significant

Source: Laboratory Analysis, 2014

From Table 4.24, it can be seen that the calculated X^2 value for hand dug well water far away from dumpsite in Samaru Zaria, during the dry and rainy season is greater than the tabulated value. This simply implies that there is a significant difference between the levels of physico-chemical concentration of hand dug wells far from dumpsite and the WHO guidelines for potable water during the rainy and dry season. It therefore means that hand dug well water in Samaru far from dumpsite is not suitable for direct consumption based on the Chi-square calculation because of the high level of COD contamination. Looking critically at other physico-chemical parameters in Table 4.23 it can be seen that they all fall within the WHO standards for potable water except for COD. It therefore means that with a little treatment like boiling the water will be suitable for consumption. This further gives credence to the fact stated earlier in the study that solid waste dumpsite alone is not the only pollutant of well water in Samaru, other factors also contribute, but it can be said to be a major source due to effects of leaching.

This research is very important and unique on its own mainly because all other previous research reviewed in this study, did not go into details of comparing the relationship of contaminants based on distance of well close to and far away from solid waste dumpsites.

Table 4.25: Mean Physico-Chemical Concentration and WHO Guidelines for Boreholes close to Dumpsite during the Dry and Rainy Season

	Parameter (Mg/L)	**Result during dry season**	**Result during rainy season**	**WHO Guidelines (2011)**
1.	pH (Units)	6.77	5.57	7.5
2.	Colour (Units)	5.00	5.00	5.0
3.	DO	2.81	2.60	3.0
4.	BOD	0.83	0.63	5.0
5.	Chloride	23.24	37.34	200.0
6.	TH	187.17	199.60	400.0
7.	TDS	201.07	316.60	500.0
8.	COD	410.33	513.33	10.0

Source: Laboratory Analysis, 2014

Table 4.26: Relationship between Observed and Expected value of Phyisco-Chemical Concentration in Well Water Samples

Well type	**Distance**	**Season**	**Calculated X^2**	**Tabulated X^2**	**Significance**
Deep	Close to	Dry Season	16,478.15	14.07	Significant
Well	Dumpsite	Rainy Season	25,638.51	14.07	Significant

Source: Laboratory Analysis, 2014

Since the calculated χ^2 value is greater than the tabulated X^2 value for boreholes close to dumpsite in Samaru-Zaria during the dry and rainy season, the null hypothesis is rejected and the alternate hypothesis is accepted, implying that there is a significant difference between the levels of physico-chemical concentration of boreholes close to dumpsite during the dry and rainy season. This also goes to show that deep wells (boreholes) in Samaru Zaria are not safe for direct consumption mainly because of the high concentration of COD present in the water samples.

From previous research reviewed in this study, the researchers only restricted their research to hand dug (shallow) wells, and did not assess the quality of deep wells. The assessment of water quality on deep wells in this present research makes it different from other researches conducted in Samaru and even beyond and that gives this present research more significance, because many people believe that deep well water is safe for direct consumption, but in the real sense it is not always so.

Table 4.27: Mean Physico-Chemical Concentration and WHO Guidelines for Boreholes far from Dumpsite during the Dry and Rainy Season

	Parameter (Mg/L)	Result during dry season	Result during rainy season	WHO Guidelines (2011)
1.	pH (Units)	7.23	6.90	7.5
2.	Colour (Units)	5.00	5.00	5.0
3.	DO	2.94	1.55	3.0
4.	BOD	1.20	0.90	5.0
5.	Chloride	10.27	20.99	200.0
6.	TH	134.54	175.57	400.0
7.	TDS	144.50	144.60	500.0
8.	COD	502.00	574.67	10.0

Source: Laboratory Analysis, 2014

Table 4.28: Relationship between observed and Expected Value of Physico-chemical Concentration in Well Water Samples

Well type	Distance	Season	Calculated χ^2	Tabulated χ^2	Significance
Deep Well	Far from Dumpsite	Dry Season	32,428.38	14.07	Significant
		Rainy Season	24,818.32	14.07	Significant

Source: Laboratory Analysis, 2014

Since the calculated value is greater than the tabulated value, for borehole far from dumpsite during the dry and rainy season the null hypothesis is rejected, and the alternate hypothesis is accepted, implying that there is a significant difference between the levels of physico-chemical concentration of borehole far from dumpsite.

From Table 4.27 and the chi-square analysis in Table 4.28, it reveals that borehole in the study area far from dump site are also not totally safe and suitable for direct consumption mainly because of the presence of high COD concentration in the water samples.

From the comparison between results and the WHO guidelines using the chi square (X^2), hypothesis one (1) which states that there is no significant difference in the quality of water in wells close to and far away from solid waste dumpsite in dry and rainy season is rejected.

4.8.2 Comparison of Heavy Metal Concentration of Water in Wells Close to and Far Away from Dumpsites during Dry and Rainy Season

The hypothesis below compares the Heavy metal concentration of water in wells, close to and far away from dumpsite during dry and rainy season.

Table 4.29: Mean Heavy Metal Concentration and the WHO Guidelines for Hand dug Wells Close to Dumpsite during the Dry and Rainy Season

	Parameter	Result during dry season (Mg/L)	Result during rainy season (Mg/L)	WHO Guidelines (2011)
1.	Magnesium	282.17	255.77	50.00
2.	Zinc	0.0126	0.0104	5.50
3.	Iron	0.1433	0.1343	0.30
4.	Chromium	0.0120	0.0143	0.05
5.	Lead	0.0157	0.0283	0.01

Source: Laboratory Analysis, 2014

Table 4.30: Relationship between Observed and Expected Heavy Metal Concentration in Well Water Samples

Well type	Distance	Season	Calculated χ^2	Tabulated χ^2	Significance
Shallow Well	Close to Dumpsite	Dry Season	1,083.14	9.49	Significant
		Rainy Season	1,083.14	9.49	Significant

Source: Laboratory Analysis, 2014

From Table 4.30, it can be seen that the calculated χ^2 value is greater than the tabulated χ^2 value, meaning that the null hypothesis is rejected and the alternate hypothesis accepted, implying therefore that there is a significant difference between the values of concentration of heavy metal for shallow wells close to dumpsites and WHO standards during the dry and rainy season.

This results simply implies that hand dug well water for both rainy and dry season in Samaru is not fit for direct consumption, because of the presence of heavy metals mainly magnesium and lead as seen in Table 4.29. The presence of this heavy metal in water when consumed can cause great health risks to humans.

Table 4.31: Mean Heavy Metal Concentration and WHO Guidelines for Hand dug Well far from Dumpsite during the Dry and Rainy Season

	Parameter	Result during dry season (Mg/L)	Result during rainy season (Mg/L)	WHO Guidelines (2011)
1.	Magnesium	252.03	209.17	50.00
2.	Zinc	0.0052	0.028	5.50
3.	Iron	0.0600	0.207	0.30
4.	Chromium	0.001	0.004	0.05
5.	Lead	0.029	0.053	0.01

Source: Laboratory Analysis, 2014

Table 4.32: Relationship between Observed and Expected Heavy Metal Concentration in Well Water Samples

Well type	Distance	Season	Calculated χ^2	Tabulated χ^2	Significance
Shallow Well	Far from Dumpsite	Dry Season	821.59	9.49	Significant
		Rainy Season	511.89	9.49	Significant

Source: Laboratory Analysis, 2014

Since the calculated values are greater than the tabulated values for hand dug wells far from dumpsites during the dry and rainy season as seen in Table 4.32, the null hypothesis is rejected, implying that there is a significant difference between the levels of heavy metal concentration of hand dug wells far from dumpsite and WHO during the dry and rainy season.

This result simply implies that hand dug well water far from dumpsite is not potable mainly because of presence of heavy metals like magnesium and lead which have higher values than the WHO guidelines values as seen in Table 4.31. These heavy metals when consumed have health risks like kidney diseases, high blood pressure, heart conditions and can even lead to death when it accumulates over a long period of time in the human body.

Table 4.33: Mean Heavy Metal Concentration and WHO Guidelines for Boreholes Close to Dumpsite during the Dry and Rainy Season

	Parameter	Result during dry season (Mg/l)	Result during rainy season (Mg/L)	WHO Guidelines (2011)
1.	Magnesium	282.17	255.77	50.00
2.	Zinc	0.0126	0.0104	5.50
3.	Iron	0.1433	0.4030	0.30
4.	Chromium	0.0120	0.0143	0.05
5.	Lead	0.0157	0.0283	0.01

Source: Laboratory Analysis, 2014

Table 4.34: Relationship between Observed and Expected Heavy Metal Concentration in Well Water Samples

Well type	Distance	Season	Calculated χ^2	Tabulated χ^2	Significance
Deep	Close to	Dry Season	1,083.14	9.49	Significant
Wells	Dumpsite	Rainy Season	851.90	9.49	Significant

Source: Laboratory Analysis, 2014

Table 4.34 reveals that there is no significant difference between levels of concentration of heavy metal for deep wells close to dumpsite and the WHO standards during the dry and rainy season. This is very significant because most previous studies only looked at the physico-chemical properties in well water without considering the heavy metal characteristics, and for those that looked at the heavy metal properties they did not go to details to check for the significance of well water close to and far away from dumpsite and also for their significance during the rainy and dry season.

Table 4.35: Mean Heavy Metal Concentration and WHO Guidelines for Boreholes Far from dumpsite during dry and rainy Season

	Parameter	Result during dry season	Result during rainy season	WHO Guidelines
1.	Magnesium	122.53	312.90	50.00
2.	Zinc	0.0103	0.0084	5.50
3.	Iron	0.06	0.1447	0.30
4.	Chromium	0.001	0.0020	0.05
5.	Lead	0.029	0.0313	0.01

Source: Laboratory Analysis, 2014

Table 4.36: Relationship between Observed and Expected Heavy Metal Concentration in Well Water Samples

Well type	Distance	Season	Calculated χ^2	Tabulated χ^2	Significance
Deep	Far from	Dry Season	110.47	9.47	Significant
Well	Dumpsite	Rainy Season	1,387.94	9.47	Significant

Source: Laboratory Analysis, 2014

Since the calculated value is greater than the tabulated value for boreholes far from dumpsite during the dry and rainy season as seen in Table 4.36 the null hypothesis is rejected and the alternative hypothesis accepted implying that there is a significant difference between heavy metal concentration for boreholes far from dumpsites with the WHO guidelines, during the dry and rainy season.

From Table 4.35 and the chi-square analysis in Table 4.36, it reveals that boreholes far from dumpsite in Samaru is not suitable for direct consumptions, this is evidence from the high amount of magnesium and lead that was dictected in the deep well water found in the study area.

4.8.3 Comparison of Heavy Metal Concentration between Soil of Dumpsites and Well Water in the Study Area

The comparison of heavy metal concentration between soil of dumpsites and well water in study are presented in the table below.

Table 4.37: Relationship between Observed Value of Heavy Metals in Soils of Dumpsites and Expected Value of Heavy Metal Concentration in Water Samples for Samaru – Zaria

Location	Calculated^2	Tabulated χ^2	Significance
Samaru New Extension	46,410.54	0.49	Significant
Hayin Dogo	6,131.46	9.49	Significant
Danraka	42,413.43	9.49	Significant

Source: Laboratory Analysis, 2014

Since all the calculated values are greater than the tabulated values as seen from Table 4.37, the null hypothesis in is rejected and the alternate hypothesis accepted implying therefore that there is a significant difference between the level of heavy metal concentration in the soils of dumpsites in Samaru-Zaria and the WHO standards for potable water for both deep and shallow wells in Samaru, the results seen from the high difference between the calculated and tabulated χ^2 shows that the soils in the dumpsites have a very high amount of heavy metal deposits and if something urgent is not done about the dumpsites, the heavy metals will eventually all leach into the ground water and that will pose a great health risk to the inhabitants of Samaru who depend on well water, both deep and shallow for their daily domestic needs.

From previous studies reviewed in this research, no researcher looked at the relationship that exists between observed value of heavy metal concentration and expected value of heavy metal concentration in soil samples for Samaru-Zaria, thereby making this research unique and different from all other research conducted on this case study.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This research work tried to reveal the effects of solid waste dumpsites on ground water Quality in Samaru-Zaria, Kaduna State, and how the problem can be best solved. This chapter is meant to present the summary of findings, the conclusion of the study and to make recommendations.

5.2 SUMMARY

The effect of solid waste dumpsite on groundwater quality is the concern of a good environmental geographer. Apart from groundwater quality, the society and the environment as a whole is facing a threat of being deteriorated because of improper solid waste management, and therefore creating a threat to human health.

The aim of this study is to assess the effect of solid waste dumpsites on groundwater quality in Samaru, Zaria, Kaduna State, Nigeria. While the objectives of the study are to; identify the proximity of dumpsites to and from wells in the study area, assess the level of heavy metal concentration from the soils at the dumpsites in the study area, determine the physico-chemical characteristics of wells in the study area and assess the level of heavy metal concentration in water from wells in the study area.

The sampling period was from April 2014 (dry season) and August 2014 (peak of rainy season). Twenty four (24) water samples and three (3) soil samples where collected altogether. Twelve (12) from each month in both areas close to dumpsite and far away from dumpsites. The parameters being analyzed were BOD, TDS, DO, COD, Chloride, total hardness, colour, pH, for water samples and magnesium, zinc, iron, chromium and lead for both water and soil samples. Standard laboratory procedures and methods were used to analyze all the parameter as described in chapter three (3). The findings from the analysis reveal that some of the physico-chemical and heavy metal parameters fall within the WHO standards for potable water, while others like COD, Magnesium and Lead where found to be higher than the WHO standards.

From the data analysis of the physico-chemical and heavy metal characteristics of the groundwater, it was discovered that some of the parameters analyzed satisfy the WHO and NSDQW standard for water quality, while some had values above the WHO and NSDQW limits for either rainy or dry seasons, shallow and deep wells and wells close to and far from dumpsites as seen in chapter four (4). The pH, colour, DO, BOD, Chloride, TH, TDS, Zinc, iron and chromium all have values that fall within the WHO Standards for potable water, while COD, Magnesium and Lead have values that are higher than the WHO Standards.

T-test and Chi-square (X^2) were used to test the hypotheses. Hypothesis 1 using the t-test states that there is no significant difference in physico-chemical properties of well water in the study area was accepted, meaning that there is no significant difference. Hypothesis 2 also using the t-test which states that there is no significant difference in heavy metal concentration of well water in the study area is also accepted, because from the analysis there was no significant difference. Hypothesis 3 using the chi-square, which states that there is no significant difference between the quality of water in wells close to and those far away from solid waste dumpsite during dry and rainy season, was not accepted implying that there is a significant difference between qualities of well water close to and those far away from dumpsite. Also hypothesis 4 using the chi-square which stated that there is no significant difference in the level of heavy metal concentration in soils of dumpsites with shallow and deep well water was not accepted implying that there is a significant difference in the level of heavy metal concentration in the soils of dumpsites and shallow and deep well water.

5.3 CONCLUSION

The result obtained from this study shows that the groundwater of Samaru is not totally pure. A high level of contamination was recorded for some of the parameters that were analyzed. It can therefore be concluded that the groundwater of the study area especially wells close to dumpsites is not good enough for direct consumption following evidence of high, magnesium, lead and COD in most of the wells.

From the result obtained in the analysis, it can also be said that dumpsites alone is not responsible for groundwater contamination of the study area, but geology of the study area, and some previous land use practices such as mechanic shop, abattoir soil type and geologic factors can also be responsible for groundwater contamination.

From the test and results obtained from the research it was discovered that the physico-chemical properties of well water for both shallow and deep wells in the study area fall within the acceptable limits of the WHO standards except for COD which has a very high value ranging between 400-600 Mg/L while the WHO standard is 10Mg/L. With regards to the Heavy metal concentration the results obtained from the analysis reveal that the heavy metal parameters all fall within the permissible limit of the WHO standards except for magnesium which have an exceptional high value, zinc, iron and lead in some of the well water samples.

5.4 RECOMMENDATIONS

Based on the results obtained from this study, the following recommendations become necessary:

1. Public enlightenment on health hazard associated with contaminated groundwater should be given to the populace by health workers.
2. Wells and boreholes should be properly cased as this will help to reduce surface runoff or any form of contamination entering into the well.
3. There is need for adequate funding of the nation's environment programmes for water quality.
4. There should be provision of adequate disposal facilities by government authorities and agencies to each residential area/household to aid proper refuse collection and effective disposal.
5. Solid waste dumpsite sites should be created by relevant authorities, and these sites should be far from residential areas. By doing this, strict environmental laws and regulations should be put in place for any one who breaks the law, by this, people would be careful in the way and manner the dumpsite their waste.
6. There is need for development of research and analytical capability for an effective information system on the environment which should include a monitoring network to measure the result of government efforts to improve the quality of the environment and a public environmental information system to sensitize the public on risks and opportunities of solid waste dumpsites.

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APPENDICES

SUMMARY OF ANALYTICAL RESULTS FOR PHYSICO-CHEMICAL AND HEAVY METAL PROPERTIES OF WATER SAMPLES

Appendix 1: Summary of Physico-Chemical Water Analysis (shallow well) for Dry Season (April)

S/N	Sample	pH	Colour (unit)	DO (mg/l)	BOD (mg/l)	CL (mg/l)	TH (mg/l)	TDS (mg/l)	COD (mg/l)
1.	W_1 *	6.91	5.0	1.50	0.6	66.40	646.4	720.00	430
2.	W_2 +	7.11	5.0	1.60	0.9	12.49	515.1	400.00	540
3.	W_3 *	5.61	5.0	1.79	1.0	12.99	200.0	738.99	420
4.	W_4 +	6.72	5.0	3.70	0.4	13.40	112.0	285.05	400
5.	W_5 *	5.11	5.0	6.69	1.1	14.10	440.0	510.70	550
6.	W_6 *	6.21	5.0	3.20	1.5	12.38	120.0	210.00	660

Source: Laboratory Analysis, 2014.

Appendix 2: Summary of Physico-Chemical Water Analysis (shallow wells) for Rainy Season (August)

S/N	Sample	pH	Colour (unit)	DO (mg/l)	BOD (mg/l)	CL (mg/l)	TH (mg/l)	TDS (mg/l)	COD (mg/l)
1.	W_7*	6.72	5.0	1.32	0.40	74.48	655.0	710.00	450
2.	W_8+	7.22	5.0	1.41	0.50	15.21	520.0	375.00	555
3.	W_9*	5.01	5.0	2.10	0.90	43.49	224.0	722.10	456
4.	W_{10}+	5.61	5.0	2.21	0.20	30.49	116.0	240.20	410
5.	W_{11}*	5.21	5.0	5.38	1.01	18.33	450.0	500.12	570
6.	W_{12}*	5.31	5.0	2.42	1.30	19.10	123.0	211.01	680

Source: Laboratory Analysis, 2014.

Appendix 3: Summary of Physico-Chemical Water Analysis (deep well) for Dry Season (April)

S/N	Sample	pH	Colour (unit)	DO (mg/l)	BOD (mg/l)	CL (mg/l)	TH (mg/l)	TDS (mg/l)	COD (mg/l)
1.	W_1*	6.21	5.00	1.71	0.5	44.3	251.4	73.4	440
2.	W_2+	7.30	5.00	1.40	1.3	10.26	301.2	96.8	630
3.	W_3*	6.91	5.00	1.31	1.1	14.20	100.0	416.2	341
4.	W_4+	7.54	5.00	5.23	0.6	11.31	96.2	104.9	253
5.	W_5*	7.19	5.00	5.41	0.9	11.21	210.1	113.6	450
6.	W_6*	7.49	5.00	2.20	1.7	9.23	6.21	141.8	623

Source: Laboratory Analysis, 2014.

Appendix 4: Summary of Physico-Chemical Water Analysis (deep well) for Rainy season (August)

S/N	Sample	pH	Colour (unit)	DO (mg/l)	BOD (mg/l)	CL (mg/l)	TH (mg/l)	TDS (mg/l)	COD (mg/l)
1.	W_7*	5.97	5.00	1.32	0.3	51.20	253.4	107.4	461
2.	W_8+	5.88	5.00	1.35	1.1	14.31	303.9	86.6	640
3.	W_9*	5.86	5.00	1.10	0.8	15.21	326.3	529.0	300
4.	W_{10}+	5.87	5.00	3.15	0.4	13.11	115.3	274.0	274
5.	W_{11}*	5.73	5.00	4.10	0.7	17.32	121.4	120.0	480
6.	W_{12}*	6.21	5.00	1.11	1.4	18.16	106.8	107.1	674

Source: Laboratory Analysis, 2014.

NB: *** = Well close to dumpsite**
+ - well far away from dumpsite

Appendix 5: Summary of Heavy Metal Water Analysis (deep well) for Dry Season (April)

S/N	Sample	Mg	Zn	Fe	Cr	Pb
1.	W_1 *	236.3	0.0112	0.10	0.011	0.012
2.	W_2 +	145.9	0.0063	0.01	0.003	0.087
3.	W_3 *	163.4	0.0131	0.21	0.004	N.D
4.	W_4 +	100.3	0.0032	0.01	N.D	N.D.
5.	W_5 *	446.8	0.0134	0.12	0.021	0.035
5.	W_4	121.4	0.0214	0.16	N.D.	N.D.

Source: Laboratory Analysis, 2014.

Appendix 6: Summary of Heavy Metal Water Analysis (deep well) for Rainy Season (August)

S/N	Sample	Mg	Zn	Fe	Cr	Pb
1.	W_7 *	222.4	0.0123	0.143	0.026	0.021
2.	W_8 +	106.7	0.0062	0.131	0.006	0.093
3.	W_9 *	121.3	0.0062	0.139	0.005	N.D.
4.	W_{10} +	98.9	0.0161	0.158	N.D	N.D
5.	W_{11} *	423.6	0.0127	0.121	0.012	0.064
5.	W_{12}+	107.3	0.0031	0.133	N.D.	0.001

Source: Laboratory Analysis, 2014.

Appendix 7: Summary of Heavy Metal Water Analysis (Shallow well) for Dry Season (April)

S/N	Sample	Mg(mg/l)	Zn (mg/l)	Fe (mg/l)	Cr (mg/l)	Pb (mg/l)
1.	W_1 *	425.0	0.012	0.20	0.026	0.096
2.	W_2 +	349.2	0.013	0.14	0.006	0.028
3.	W_3 *	242.0	0.006	0.17	0.006	N.D.
4.	W_4 +	96.0	0.008	0.13	N.D	N.D
5.	W_5 *	507.0	0.026	0.14	0.016	0.064
5.	W_6+	160.0	0.026	0.13	N.D.	N.D

Source: Laboratory Analysis, 2014.

Appendix 8: Summary of Heavy Metal Water Analysis (Shallow well) for Rainy Season (August)

S/N	Sample	Mg(mg/l)	Zn (mg/l)	Fe (mg/l)	Cr (mg/l)	Pb (mg/l)
1.	W_7 *	464.7	0.014	0.31	0.030	0.036
2.	W_8 +	352.1	0.021	0.16	0.009	0.016
3.	W_9 *	300.0	0.013	0.20	0.012	N.D
4.	W_{10} +	104.2	0.011	0.16	N.D.	N.D
5.	W_{11} *	564.0	0.061	0.15	0.021	0.074
5.	W_{12}+	171.2	0.051	0.12	0.002	N.D

Source: Laboratory Analysis, 2014.

N.B

*****	**-**	**Well close to dumpsite**
+	**-**	**Well far from dumpsite**
N.D.	**-**	**Not detected**