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Assessment of Municipal Solid Waste Generation, Composition and Effects of Dumping Site on Water Quality at Mizan-Aman Town

By

Gera Barnabas Woyita

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This is to certify that the thesis prepared by Gera Barnabas, entitled: Assessment of Municipal Solid Waste Generation, Composition and Effects of Dumping Site on Water Quality at Mizan-Aman Town

Submitted in partial fulfillment of the requirements for the degree of Master of water supply and sanitation fulfills with the regulations of the University and meets the accepted standards regarding originality and quality.

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Examiner ___________________________ Signature____________ Date______________

Advisor ____________________________ Signature____________ Date_______________

Advisor ____________________________ Signature____________ Date_______________

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ABSTRACT

In Ethiopia, despite the progress that has been made to advance water supply access and the health status of the population in the last one and half decades, communicable diseases account for about 60-80% of the health problems. The existing burden of diseases is preventable and a considerable proportion is directly related to using unsafe water.

Poor solid waste management systems from urban municipal dumpsites into surface and groundwater sources can be harmful to the urban population who use these water sources. Gradual accumulations of contaminants in the water sources can result in high loads of pollutants that are potentially toxic to the users. In Mizan Aman Town River Gechab, Cosakol, Shonga, Petrous, and Nimbus drain through the town and improved groundwater wells are the main sources of potable water for most residents. This study was conducted from December 2020 to April 2021, intending Assessment of Municipal Solid Waste Generation, Composition and Effects of Dumping Site on Water Quality at Mizan-Aman Town Bench Maji zone, SNNPR, Ethiopia

A random research design was used in the study. The solid waste generation rate, composition, and disposal practices were assessed. The water quality of water resources around dumping sites was assessed. Water samples were collected from wells and the surface water during both the dry and the rainy seasons. The results that were found in the research were used as baseline information for a government institution to provide methods of managing solid waste disposal systems and to plan efficient collection and management of solid waste from the source of generation to disposal site.

The Physic-chemical parameters measured show that other than the pH, total hardness, electrical conductivity, TDS, iron, fluoride odor, and taste, all other concentration values exceeded the Ethiopia minister of water and irrigation guidelines for drinking water and WHO guideline. The presence of a high load of bacteria in both surface and groundwater samples means that leachate is altering the water quality of water in the vicinity of the dumpsite. The bacteriological concentration of water from all sampling sites exceeded the Ethiopian minister of water and irrigation standards. Hence the surface and sub-surface water in the neighborhood of the dumpsite presents a significant threat to public health.

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ABBREVIATIONS AND ACRONYM

BOD	Biological oxygen demand
CSA	Central Statistics Agency
CFU	Coliform Forming Unit
CFU	Colony Forming Unity
COD	Chemical oxygen demand
EC	Electrical Conductivity
EPA:	Environmental protection agency
FC	Fecal Coliform
L/c/d:	Litter per capita per day
MF	Membrane filtration
MSW:	Municipal solid waste
MS EXCEL	Microsoft Excel
ND.	Not detected
NTU	Ne photometric Turbidity Unit
PH	Hydrogen Potential
RSS	Random Simple Sampling
SNNPRS	South nation nationality and people regional state
SWM	solid waste management
TC:	Total Coliforms
TCU	True Color Unit

TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UNEP	United Nations Environmental Program
UNCED	United Nation Conference on Environment and Development
WHO	World Health Organization
WRMA	Water Resource Management Authority
WASH	Water Sanitation and Hygiene
µS	Micro Siemens

CHAPTER 1

1. INTRODUCTION

1.1.Background to the Study

Development in the twentieth century shifted rural inhabitants to cities and towns, resulting in a slew of environmental issues. Environmental challenges are being handled on a global, regional, and local scale (Smith, 2010). Solid waste management from home, commercial, and agricultural sources is one of the most pressing environmental issues today.

The United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992 identified a solid waste management problem, and the focus now is on trash reduction. It was also determined that solid waste should be reused and recycled (UNEP, 2017).

Solid waste management is a problem that authorities in fast-growing cities, particularly in developing countries, are grappling with. According to the World Health Organization, solid waste disposal takes precedence over water quality in Africa (Herblock, 2018). In metropolitan Africa, rapid population increase has been linked to the production of hazardous toxic substances (UNEP, 2018). Regardless of the scenario in Africa, “(Ogwueleka, 2017)” there is a lack of infrastructure donations to address the difficulties associated with massive amounts of solid garbage, and as a result, heaps of solid trash are frequent in urban areas.

Open dumping, composting, and landfilling are the most popular waste disposal methods in Ethiopia. Open dumping is decided on the basis of geography rather than geological or hydrogeological concerns (Widmann, 2019).

“(Ustohalova et al, 2017)”. “Open solid waste dumping is a frequent practice because it is fairly affordable for municipal solid trash.”

1.2.Statement of the Problem

According to the National Population and Housing Census, Mizan Aman has an urban population of 82,861 people and households (CSA, 2017). By creating solid trash every day, this large population was gradually placing a lot of strain on surface and well water contamination. Mizan Aman town was situated above the water supply dam, with trash from the solid waste dumping site being discharged straight into the river and well by runoff from the dumping site.

during rainy seasons the rivers that were once the major sources of water for domestic use are polluted resulting of this person using wells as an alternative source of water.

Low-level pollutant discharges may not be dangerous, but long-term partitioning to the sediments can result in significant toxic accumulations that can affect users. Rivers Gechab, Cosacol, Nimus, Shonga, and Petrous flow through Mizan Aman, and surface water and groundwater wells are the primary sources of drinkable water for the majority of the town's people.

However, it was discovered during the current study that open dumping of garbage is still the most common activity conducted by all institutions, families, and commercial centers when it comes to final disposal, resulting in increased risks of environmental, surface, and sub-surface water pollution. It is also noted that no scientifically acceptable dump site exists for all institutions, households, and commercial areas, as well as the municipality as a whole. Almost all solid wastes are buried or dumped in open areas without being treated at the disposal location. Winds, erosion, and domestic or wild animals distributed the solid wastes as a result of this condition.

During the research, I discovered that uncollected and improperly disposed solid waste pollutes river streams and riverbanks. This Can contaminate food supplies and cause foodborne disease, as well as causing fires, foul odors, smoke, and dust aesthetic issues. Sneezing, coughing, and other symptoms of discomfort it may be the finest medium for microorganism development. During rainy seasons, arthropods such as the common housefly, mosquito, and others, as well as rodents and other animals such as rats, mice, dogs, and cats, are attracted. The goal of this study is to investigate the physic-chemical and microbiological quality of drinking water in Mizan Aman, bench Maji zone SNNPRS, from the source to the home level.

Figure 1-1Solid waste dumping site and improper disposal site

1.3.Research Questions

The research questions for the study are:

i. What are the generation rate and composition of solid waste generated in the study town?

ii. What is the physic-chemical and microbial quality of the well and stream water?

iii. Is there a difference in the physic-chemical and microbial quality of the well and stream among sampling sites?

iv. Is there a seasonal variation in the physic-chemical and microbial quality of the wells, streams, and household level?

1.4. Objectives of the Study

1.4.1. General Objective

The general objective of this study is to evaluate Municipal Solid Waste Generation, Composition and Effects of Dumping Site on Water Quality at Mizan-Aman Town

1.4.2.Specific Objectives

- To determine the generation rate and composition of solid waste generated
- To determine the physic-chemical and microbial quality in the well, stream, and household level
- To determine seasonal variation on the water quality.

1.5. Significance of the Study

The information obtained was helping the Mizan Aman town administration in policy preparation on waste management and location of wells as well as monitoring of the pollution levels of the stream and wells. The results found in this study were for study yielded data and information that was useful in managing the level of pollutants in the wells and stream based on the guidelines provided by the Ethiopia minister of water irrigation and electricity and the world health organization effluent discharge recommended minimum levels. The findings of this study were helping the country's government in decision-making and institutionalization of a framework for waste management. The results that were found in the study could use as baseline information for government institutions and others interested in the quality of the water sources in the study areas. The results that were found in the generation and composition of solid waste were used as input for town administration to plan efficient collection and management of solid waste.

1.6.Scope of the Study

This research mainly targeted on effects of a solid dumping site on surface and sub-surface water quality during the wet and dry seasons and also solid waste generation rate and composition of solid waste generated and their effects

CHAPTER 2

2. LITERATURE REVIEW

2.1. Introduction

This chapter reviews the applicable literature to the study. It reviews the sources and importance of ground and surface water, the composition of MSW, factors affecting surface and groundwater quality. It also discusses the belongings of some pollutants on human health and their associated risks. Lastly, it reviews the effects of the dumpsite and season variations on ground and surface water quality.

We find our drinking water from dissimilar places dependent on where we live in the world “(CAWST, 2020).”

A safe water supply is a precondition for the health and livelihood of the populace. Maintainable Millennium Development Goal line target is formulated in terms of sustainable access to the affordable drinking water supply. The availability of improved and quality water supply and sanitation infrastructures are widely recognized as a vital component of human rights, social and economic growth “(ADF, 2005)”.

To meet basic health needs, safe water must be available throughout the day for domestic use: drinking, cooking, and hygiene. According to the World Health Organization, for population, a quantity of approximately 50 liters per person per day is suggested to minimize the health risks associated with poor hygiene “(WHO, 2018)”. For those using “Improved Sources” other than on-plot piped water, such as endangered wells, springs, public standpipes, or stored rainwater, water collection and storage are typically obligatory. Where on-plot piped water is alternating, storage may still be required. In 2010, over 40% of the world’s population including many users of value-added sources realized water from outside the home “(WHO/UNICEF., 2012)”. The distance to the water source used by a household is a robust self-governing prognosticator of disease risk in that household “(Pickering and Davis, 2012)”.

2.2. Sources of Water

Water can be collected into Surface-water containing oceans, rivers, lakes, reservoirs, streams, and many others, Groundwater which is measured mostly as cleaner than the surface water, and lastly the rainfall which falls as an implication of absorption and rainfall of the clouds “(Stanistski,2010)”.

Surface water ordinarily contains materials that must be removed before it can be used as drinking water while groundwater is that pumped from wells and wells that have been drilled from underground aquifers and is usually free from harmful contaminants.

2.3.Surface water

Surface water is water which is above the surface of the earth which includes oceans, rivers, lakes, reservoirs, ponds, and streams According to the study of sir "(alexander,2005)", the surface water resource for Mizan Aman has identified 11 rivers near and some distance away from the town. Amongst these rivers, the Gacheb Rivers near Mizan Aman with a drainage area of 65km2 was selected as the water supply source for the town.

2.3.1. Groundwater

Groundwater exists in the pore spaces and breakages in rocks and residues beneath the Earth's surface. It initiates as precipitation or snow. It infiltrates through the soil skeleton into the groundwater system. With time the penetrating of wells its way back to surface streams, oceans, or lakes.

Mizan Aman Area is made of the trap of serious volcanic overlying the basement rock at depth. Alluvial deposit fills the larger valleys of the adjacent areas while residential soil occurs throughout the area over the mild to precipitous slopes. The geology of the area is composed dominantly of basaltic rock types. The study was made by sir "(Alexander Gibbs 2015)" penetrating boreholes which have been penetrated to a depth of 200m, revealed that the underground composed the rock of tertiary trap series vacancies (basalt, royalties, ignimbrites).

In the geology of environments like Mizan Aman tertiary volcanic rocks characterize the area groundwater could be expected within secondary porosity. i. e.Existence of adequate fracturing and mothering, where breakage zones intercept watercourse it is believed that deep groundwater recharge could be enhanced. However, the area has numerous watercourses and obtains sufficient rainfall contravention in the area generally poor.

2.3.2. Wells

In Ethiopia, groundwater (Shallow/hand-dug well or Deep Well) is an important source of water and a foremost source for national supply in many areas, especially in the dry ranges where surface waters are scarce and seasonal (e.g. Far north and Somali region in the east). Inadequate data exist for the general state of groundwater distinction across Ethiopia. From those available, the quality is shown to be highly variable, ranging from freshwaters in many of the springs issuing from the crystal-like basement rocks to more saline waters in parts of the Crash and the alluvial formations of the plains "(Aberrant, 2010)".

Table 2-1 Different groundwater source in Mizan Aman town

S.no	Well name	Depth(m)	Drawdown(m)	Yield(l/s)	Remarks
1	Bodega	105	54	2	EC measurement on 24/11/93
2	High school	97	64	1.2	>2 m/s
3	Stadium	120	80	2.2	abandoned due to poor quality
4	Prison HDW	93	42	2.5	
5	Aman wells				5 wells, either dry or insignificant yield, in the vicinity of Aman, one well-utilizing quality

Source: Mizan Aman city water supply and sanitation office 2009 E.C

2.4.Pollution of Surface and Groundwater

The faintness of groundwater to contamination shows groupings of geological and hydrological parameters give risks associated with groundwater pollution than other combinations "(Demetrious, 2018)". Groundwater aquifers are hydraulically connected to the overlying land surface through linked pore borders. The defenselessness of an aquifer to uncleanness is contingent on this. Groundwater that receives water and contamination from land surface is considered more susceptible than groundwater that receives water and contaminants more progressively and in lower quantities.

The quality of groundwater depends on the relative quantity of contaminants that reach the aquifer, the travel time of contaminants, and the geological system contaminant-attenuation capacity. The gradation of decrease occurs be depending on soil and rock category and type of contaminant and the associated activity "(WHO, 2018)".

Any free-for-all to control or prevent surface and groundwater pollution in any area requires an adequate proper understanding of such normal important characteristics of any targeted aquifer in terms of vulnerability to contamination and the background evidence of the happenings in the area in question.

Even though 12 boreholes have been drilled about Mizan Aman areas only one of the wells was reported to be productive with acceptable water quality but currently in this year (2011 E.C) only one borehole to be functional. All the rest 10 (Eight) boreholes found to be with very low yield (<1 l/s) & one is drilled around 302m and it gives more than (5 l/s) but not drinking by the color case & the other is dry hence abandoned and backfilled"(Mizan Aman water supply and sewerage office 20011 E.C)".

2.5.Concept of solid waste

The term "solid waste" incomes any garbage, refuse, or sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded physical, as well as solid, liquid, semisolid, or measured gaseous material resulting from industrial, commercial, mining, and farming actions "(Salam Abdul, 2012)". This is waste that can generate fires below certain conditions, e.g. waste oils and solvents are reactive solid wastes that tending to react to measures and conditions. These are unbalanced; they foundation explosions, noxious fumes when heated. Deadliness: unwanted that is dangerous or fatal when consumed.

2.5.1 Sources and types of solid waste

Toward categorize what exactly community solid waste constitutes; there have been unlike attempts of categorization based on many arrangement criteria. Some of those conditions are the source from which solid waste originates and the nature of solid waste mechanisms. Based on the nature of items that constitute solid wastes, they can be personal into organic or mineral, burnable or non-combustible, and putrescible or non-putrescible "(Edelman, 2017)" cited in "(G/Tankan, 2012)". Concerning the source from which solid waste originates, '(Martin,2014)" characterized municipal solid waste as household (residential) refuse, institutional wastes, street sweepings, commercial areas wastes, as well as building and demolition debris. In developing countries, MSW also contains various amounts of industrial wastes from moderate industries. In these sources, there are varied types of solid wastes. But, some of the characteristic solid wastes of those sources are described by "(Solomon, 2015)".

Domestic solid wastes: wastes fashioned from household activities such as food preparation, cleaning, fuel burning, old clothes, equipment, old-fashioned utensils and equipment, packaging, newsprint, and garden wastes. In developing countries, food waste and ashes dominate families' solid wastes.

Commercial wastes: waste from shops, workplaces, hotels, restaurants, etc. and characteristically consisting of packaging materials, office supplies, and food wastelands. In low-income countries, food markets contribute the largest amount of commercial waste.

Institutional wastes: waste from schools, hospitals, clinics, government offices, military bases, etc., and comprise hospital and clinical wastes including potentially infectious and hazardous materials.

Industrial wastes: composition of industrial waste depends on the kind of industries involved. It consists of food waste from kitchens, and canteens, packaging materials, plastics, papers, and metal items.
Construction and demolition wastes: its composition depends on the type of construction materials used, but it typically includes soil, brick, stone, concrete, ceramic materials, wood, packaging materials, and the like. Therefore classifying wastes by their sources and type is a useful way of determining the relative contributions of different sectors of society to the waste stream and how to strategy for their collection and disposal.

2.6.The physical composition of solid waste

One of the most important differences between the waste generated in developed and developing nations is in terms of its composition. In the unindustrialized country the amount of organic stuffing in waste is almost three times higher than that in developed countries "(Medina, 2016)" and "(Zebras, 2015)". Even though the volume of waste generated in developing countries is much lower as likened to that in industrialized countries, the nature of waste is denser and has a very high humidity content.

Full knowledge of the physical composition of solid wastes is an essential element in:

- The selection of the type of storage and transport most appropriate to a given situation
- The determination of the potential for resource recovery
- The choice of a suitable method of disposal and
- The purpose of the environmentally friendly impact applied by the solid wastes if they are improperly managed "(Sharma, 2016)".

2.7.The solid waste generation rate

Solid waste generation rate refers to the "amount of waste disposed of during a given period and the quantification of it involves different methods: by measurement at the point of generation, through use of automobile survey and by investigation of records at the removal facility" UNEP (2018); cited by "(Sabena, 2013)".
The rate of hard waste generated in an assumed town or institution is strong-minded by demographic growth and it is significant to manage this waste to minimize the effects it has on anthropological health and the environment. It is understood as nowadays waste management, (the collection, transport, recovery, and disposal of waste, counting the management of such operations and after-care of disposal sites) is truly concerned with things that are to be disposed of. However, waste minimization is not only trying to

minimalize the number of things to be disposed of. As stated by "(Pangram 2018)", waste minimization comprises three options, Preventing and/or reducing the generation of waste at source, improving the quality of the waste generated, such as reducing the danger and encouraging re-use, salvaging, and recovery

2.8. Effects of Municipal Solid Waste on the Environment

Most dumpsites are sited within the neighborhood of living communities and wetlands. The dumpsites are often not scientifically suited for the adsorption of toxic substances. Pollute ground and surface water: Community solid waste streams can bleed toxic materials and pathogenic creatures into the leachate of dumps and landfills

The landfill site of Mizan Aman town is at the center of Mizan Aman town in front of Eden hotel there leachates are direct drains to well and water supply dam at the downstream of the towns. The landfill site is selected for more than 30 years but still, now it is used for dumping.

Figure 2-1 Solid waste disposal site ate the center of Mizan Aman town

2.9.Water Quality and Human Health

Access to safe feasting water is important as a wellbeing and enlargement issue at national, regional, and local levels. In some regions, it has been shown that reserves in water supply and cleanliness can yield a net economic benefit, as the reductions in negating health effects and health-care costs outweigh the costs of responsibility for the interventions. This is true for investments ranging from major water supply organizations topwater action in the home. Information has also shown that interventions in humanizing access to safe water favor the poor in particular, whether in rural or urban areas and can be an effective part of poverty qualification strategies "(WHO, 2018)". Safe water is a requirement for health and growth and a basic human right, yet it is still denied to hundreds of loads of people throughout the unindustrialized world. Water-related diseases caused by inadequate safe water supplies attached with poor hygiene and cleanliness cause 3.4 million deaths a year, mostly amongst kids "(UNICEF, 2017)".

2.10. Effects of Agricultural activity

The area is predictable for coffee plantations as well as fruits, cereals, honeybunch, and spices. These products will have a regional market both nationally as well as in the neighboring countries' road network. Construction was an increase due to access to extension facilities, new undeveloped techniques, contributions such as hybrid seeds, nourishment, and pesticides. Most importantly the project road was creating an opportunity for the production of quality cash crops as it facilitates on-time transport of unprocessed crops.

2.11. Livestock Watering and Population

Streams are recognized to be the main sources of livestock watering at Mizan Aman town and its environment. The livestock populace in Mizan Aman town as data collected from the municipality is as followed

Table 2 2 Livestock population in Mizan Aman town

Town Administration	Cattle	Sheep	Goat	Poultry	hours	mules	Donkey	Total
Mizan Aman	17562	3906	1563	100864	588	251	602	125336

(Source: Mizan Aman city water supply and sewerage office 2011 E.C)

2.4.Water Supply and Sanitation

At present, the town doesn't have any system for the safe disposal of wastewater. Each household is in charge of disposing of its' waste and the existing facilities do not cover the need of the town in terms of the sanitary state of affairs. Currently, cleanness in Mizan–Aman town is the responsibility of both the town municipality and the town health center; even though they have insufficient means at their disposal to adequately execute their role. In the town, there is one tractor with a trailer for solid waste collection, transportation, and disposal.

Sanitation

- Accessibility of Latrines 10467
- Pour flush type of toilet 5166
- Dry pit Latrines 5390

As far as sanitation concerned 94.6% of the respondents do have toilet facilities and the toilet facilities institute improved pit latrine and unimproved pit latrine as supported by 69.1% and 24.8% of the respondents respectively (Bench Maji zone water & irrigation Dep't 2019)

2.5.Adverse Impacts on Physical Environment

2.5.1. Soil Erosion and Pollution

The area is susceptible to erosion due to the high rainfall in the highland zone as well as due to the soil type, highly weathered volcanic and Precambrian rocks. The vegetation cover has reduced such an impact in vegetated areas. However, if vegetation is to be removed at construction and material sites the amount of silt produced will be very high. Soil that will be generated during construction can also be vulnerable to erosion since it rains most of the year in part of the highland zone. This can lead to silt generation into water bodies. During operation, erosion can emanate from embankments used as fills, if proper grassing is not applied. The same will be true at material sites and cut faces. Soil compaction can result from the application of heavy machinery such as rollers, dozers trucks, etc. Used in the road construction, in the operation of borrow pits, and at quarries. The structure and texture of the soil will be affected and this will impact agricultural productivity. The sealing of the soil surface by compaction and asphalt spills on the surface (in plant and store sites) leads to the destruction of the soil's physical properties and its various functions. It will also lead to an increased volume of surface water runoff. Runoff of waters intercepted and concentrated by the road as well as runoff waters from the road surface may lead to erosion and gully formation in roadside ditches and diverting drains. Soils can also be affected by improper disposal of waste materials from road cuts and other excavation works, and disposal of wastes from contractor’s camps and used oils and lubricants and spills of oils and fuel from engines of vehicles and diesel operating machinery as well as accidental spillage. Pollution of soils can result from wastewaters, sewage, and cleaning of equipment, storage, and handling of hazardous substances like bitumen, oil, paraffin oil, detergents, fuels, paint, and lubricants. It is needed to carefully store and safely dispose of the waste material away from productive soils and water sources as this affect surface and sun surface water quality.

2.5.2. Impact on water resources

The rivers that have been listed in the baseline section are mostly permanent flowing during all seasons and used for multiple household purposes. But water is not clear due to runoff which is connected by ditches from town. However, Earthworks near such rivers as well as soil gathering and leakage of pollutants will have temporary impacts during structure phases. Any modification of the hydrological factors such as channel width, bank modification, or scouring of the river bed for such purposes as a construction material will lead to permanent impacts. Waste generated at plant and campsites as well as hazardous chemicals can have adverse impacts on surface and ground waters, particularly for groundwater in fractured volcanic areas. Spoils and seepage from machinery at quarry locations can also drain into watercourses and the groundwater due to mistakes in water supply dam site selection and design, planning before opening the sites.

2.6.Pollution of Groundwater and Surface Water

The faintness of groundwater to pollution indicates combinations of environmental and hydrological parameters that give risks associated with groundwater pollution than other combinations (Demetrious, 2008). Groundwater aquifers are hydraulically connected to the overlying land surface through interwoven pore fringes. The faintness of an aquifer to contamination depends on this. Groundwater that receives water and contamination from land external is considered more defenseless than groundwater that receives water and pollutants more slowly and in lower amounts. The quality of groundwater depends on the relative amount of pollutants that reach the aquifer, travel time of pollutants, and the geological system contaminant-attenuation capacity. The gradation of attenuation occurs be dependent on soil and rock type and type of pollutant and the connected activity "(WHO, 2006)".

Any effort to control or prevent surface and groundwater pollution in any area involves an adequate proper understanding of such natural intrinsic characteristics of any targeted aquifer in terms of vulnerability to pollution and the background material of the activities in the part in demand.

2.7.Potential Health Effects of contaminated surface water flow and groundwater

Landfilling is common universally though, it's a controlled method of disposing solid wastes on land to eliminate public health, environmental hazards and minimize nuisances without polluting surface or subsurface water resources.

Despite this, many removal sites are inadequate lining and precautions in the construction leading to seepage of leachate from the decomposition of the organic wastes "(Butt and Gaffer, 2012: Longed and Bologna, 2010)". In such dumping sites, the leachate continues to percolate into the ground and may contaminate groundwater sources "(Mort, Raindrop, Dahlia, and Chandra, 2006)". Gradual contamination of groundwater resources has a potential risk to the natural location and the health of users especially children and elderly people "(Mort et al., 2006)"

Many water-borne diseases such as diarrhea, typhoid, cholera, paratyphoid, hepatitis, enteric fever, dermatitis, the blue baby syndrome can be caused by drinking water that has high nitrates. Benzene, a known component of gasoline, is a human carcinogen “(Butt & Equal, 2007)”.The thoughtful health effect of lead such as learning disabilities in children; kidney, nerve, liver problems; and condition risks. The best way to reduce the health risks associated with poor consumption water excellence is by preventing impurities from attainment the groundwater is “(Butt & Equal, 2007)”.

2.8.Solid Waste Management in Mizan Aman town

There are commercial and industrials enterprises, hotels, residential areas, hostels, guest houses, education organizations, bus parks, hawking, and several other activities that take place within all that area of the town and its environs.

Solid Waste produces an experiment for municipal cleaners as the municipal dumping site may not close. The ultimate disposal of the wastes is at the enforcement Eden community dumping site. Waste management especially at the dumpsite is a major experiment in Mizan Aman

2.9.Waste Composition in Mizan Aman Municipal Dumpsite

Regarding the source from which solid waste emanates, the wastes at the Mizan Aman Municipal Dumpsite can be characterized as household (residential) refuse, institutional wastes, street sweepings, commercial wastes, as well wastelands from construction and demolition debris.

Solid wastes of garden wastes, leftover food waste, rubbish, plastics metals, cardboard, glass, bottles, fruits, crops, and animal residues underwrite to the concentration of pollutants as they contain carbon materials.

Commercial solid waste such as construction wastes, demolition, and debris are other sources of inorganic constituents. Decomposition at the landfills is often hindered by the huge accumulation of solid wastes “(Ahmed & Ian, 2012)”.

2.10. Landfill Age

The duration of time for solid dumping determines waste decomposition in landfills. The leachate forms in layers and becomes toxic with time (Asadi, 2008). Leachate of recent landfills contains high COD and BOD with a gradual subsequent reduction in the lower layers. (Asadi,2008). Carbon-containing compounds decompose faster than inorganic compounds with age. (Chiang, Chang & Chung, 2001). Inorganic compounds are not such toxic as they are removed through infiltration by rainfall (Chiang et al.2001). Sulfate is reduced to sulfide through infiltration precipitates heavy metals (Adhikari, Khanal & Manandhar, 2013). Leachate quality in the landfills becomes toxic as organic matter therein undergoes stabilization (Adhikari et al., 2013).

2.11. Leachate Formation

Municipal solid waste disposal sites have been associated with surface and groundwater pollution. The gradual decomposition of organic substances at the dumping sites needs to be addressed “(Zouboulis, 2012)”. Depositing of solid wastes from any sources forms leachate within the dump and landfills. This is a resultant of the Physical, chemical, and biological processes.”(Kjeldsen et al, 2012)”. Physic-chemical characteristics of leachate depend on the source of the solid waste materials and volume. The geology, compaction, and moisture content play a role in the retention of the contaminants. Water flow and climatic conditions determine leachate toxicity “(WHO, 2011)”. Researchers, such as “(Kjeldsen et al. 2012)” in their research of groundwater uncleanness ascertain that availability of water is crucial in solid waste decomposition.

2.12. Leachate Composition

Municipal leachate is multiple organic and inorganic components. This is a result of the diverse origin of the deposited solid wastes. In most developing countries with low technology for managing the solid waste generation and management the management of solid wastes is still underdeveloped “(Tatsi and Zouboulis, 2012)”. Undersized solid waste organization practices poses threat to the quality and sustainability of soil and water resources. Leachates pollution in the municipality is a major limitation to municipal waste management.

2.13. Physical and aesthetic parameter

The physical appearances of drinking water are usually things that we can measure with our senses: turbidity, color, taste, odor, and temperature. In general, we judge consumption water to have good physical possibilities if it is clear, tastes good, has no smell, and is cool. The attendance, taste, and odor of drinking water should be acceptable to the consumer. The table below shows the WHO Guidelines for Drinking Water Quality for animal parameters

Table 2 -3 WHO guidelines for drinking water quality: physical parameter

s.no	Parameters	WHO guidelines
1	Color	The aesthetic value of < 15 True Color Units (TCU)
2	Odor	Aesthetic only, no health-based value is proposed
3	Temperature	Aesthetic only, no health-based value is proposed
4	Turbidity	< 5 NTU

(WHO, 2018)

Physical contaminants generally don't have direct health effects themselves; however, their presence may relate to a higher risk of microbiological and chemical contamination which may be harmful to human health. For example, increased turbidity levels are often associated with higher levels of disease-causing pathogens such as viruses, parasites, and some bacteria (WHO, 2018). Drinking water samples can be tested for the following physical parameters: color, odor, taste, temperature, and turbidity

2.13.1. Color

Color in drinking water may be due to the presence of colored organic substances and certain metals such as iron, manganese, and copper. In general, the color of a water sample is evaluated by simple visual observation. It can also be measured by visual comparison with a series of standard solutions. Levels of color above 15 TCU can be detected in a glass of water by most people, although it generally does not pose a health threat. Color may occur in drinking water for one or more of several reasons. It may be due to the presence of natural organic matter and vegetation, such as leaves and bark; or metals such as iron, manganese, and copper, which are abundant in nature and are naturally colored or highly colored industrial waste, the most common of which are pulp and paper and textile waste

2.13.2. Taste and odor

Although taste and odor are not parameters of health concern, they are perhaps the most important characteristics of drinking water from the point of view of the user. It is next to impossible to convince people that water is safe to drink if it either tastes or smells bad. Bad taste and odor may cause people to reject the water in favor of another. A common example is a chlorine. People often dislike the taste and smell of over-chlorinated water (in the context of a new water supply or household chlorination initiative) and will prefer to go back to a possibly contaminated drinking water source. Guidance in proper dosage and awareness rising should always accompany the supply of chlorinated water.

Newly drilled boreholes in the ground with a high concentration of iron, or which have not been properly disinfected after drilling can develop a smell and taste over time. The well could eventually be abandoned. A similar scenario can occur with saline (salty) aquifers. Although taste and odor themselves do not pose a health threat, they may indicate chemical or biological contamination, especially when a change happens quickly. Poor taste or odor may suggest the need for more testing.

The attendance of color in water may affect the dimension of turbidity. As well, reasonable color in certain types of water may damage the elimination of turbidity by coagulation and sedimentation (Health

Canada, 1995). Water that is colored with organic matter can also reduce the efficiency of disinfection with chlorine and make it difficult to produce free residual chlorine

2.13.3. Temperature

Temperature does not carry any connotation in terms of pollution. However, we generally prefer cool water over warm water. High water temperature (20-30°C) can also enhance the growth of microbes and may principal to taste, odor, color, and corrosion problems. The most necessary temperature for drinking water is between 4^{o}C to 10^{o}C (3950^{o}F) and temperatures above 25^{o}C (77^{o}F) are usually objectionable.

2.13.4. Turbidity

Raw water turbidity has been reported to variety from less than 1 to more than 1000 NTU whereas it is usually <1 NTU in filtered waters. Turbidity can also harm customer suitability of water as a result of visible cloudiness. The turbidity of water is related to or affects many indicators of drinking water quality. For example, there is a association between high turbidity and the appearance, color, discrimination, and perfume of both raw and filtered drinks of water. It is an important indicator of the conceivable presence of pollutants that would be of health concern.

2.14. Chemical water quality parameters

Water may contain chemicals that can be beneficial or harmful to our health. Many chemicals find their way into our drinking water supply through different natural processes and human activities “(WHO, 2018)”.

Natural chemical contamination rarely changes over time for a particular water source. Hence, testing for chemical contamination is done less frequently or only during the commissioning of a new water source. Household Water Treatment (HWT) technologies may not be able to remove all chemical contaminants from drinking water. Therefore, water quality testing carried out at the water source can help to identify an effective and appropriate HWT technology for a particular area.Many human-made chemicals can contaminate water and affect its usability. Sources of chemical contaminants can be divided into the following five groups

Table 2-4 Sources of chemical contamination

Chemical source	Example	Chemical
Naturally occurring chemicals	Rocks and soils	arsenic, Barium, Boron, Chromium, Fluoride, Manganese, Molybdenum, Selenium, Sodium, Sulfate and Uranium
Chemicals from agricultural Activities	Application of manure, fertilizer, and pesticides; intensive animal production practice	Ammonia, Nitrate, Nitrite
Chemicals from human Settlements	Sewage and water disposal, urban runoff, fuel leakage	Nitrate, ammonia, heavy metals, pesticides, other organic chemical
Chemicals from industrial Activities	Manufacturing, processing, and Mining	Antimony, Cadmium, Cyanide, Lead, Nickel, Mercury
Chemicals from water treatment and distribution	Water treatment chemicals; Corrosion of. And leaching from, storage tanks and pipes	Aluminum, Chlorine, Iodine, Silver, Zinc

"(WHO, 2018)"

The risks associated with chemically contaminated water are identified through the comprehensive testing of water samples. Once a contaminant has been identified, it is possible to establish the effects it will have on human health using previously conducted research. However, most developing countries do not have the resources to acquire this knowledge.

The WHO established a set of drinking water guidelines based on research and experiments to recommend the maximum chemical contaminant concentrations for drinking water "(WHO, 2018)".

2.14.1. Nitrate and Nitrite

The nitrate in drinking water was set at 10 mg/L nitrate-nitrogen (NO3-N) or 45 mg/L nitrates (NO3-) (WHO, 2011a). Nitrate in groundwater and surface water is normally low but can reach high levels if there is leaching or runoff from agricultural fertilizers or contamination from human and animal feces. Nitrite is formed as a consequence of microbial activity and may be intermittent. High nitrate and nitrite levels can cause serious illness by acute exposure. The main health concern is methemoglobinemia, or blue baby syndrome, which occurs in infants that are bottle-fed with formula prepared with drinking water

"(Knobeloch, Salna, Hogan, Postle, & Anderson, 2000)". It causes them to have difficulty breathing and their skin turns blue from a lack of oxygen. It is a serious illness that can sometimes lead to death

Nitrite levels should be less than 3 mg/liter to protect infants from methemoglobinemia (short-term exposure). There is a provisional guideline for long-term nitrite exposure set at less than 0.3 mg/L. The guideline value is considered provisional because of the uncertainty of the chronic health effects and our susceptibility to it. Concentrations greater than 44.3 mg/L nitrate cause 97% of reported illnesses. High nitrate levels are often associated with higher levels of microbiological contamination since the nitrates may have come from manure or sewage.

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2.14.2. pH

There was WHO health-based guideline value for pH. Because of the impression of pH on the effectiveness of decontamination and corrosion effects, it is recommended that pH be comprised at all levels of assessment as a core parameter. Tests should be performed on all samples taken from sources. For basic/initial assessments a pH range of 6.5 to 8.5 is optional "(WHO, 2018)". The pH of the water in a stream, river, lake, or underground flow was vary depending on several conditions: the source of the water; the type of soil, bedrock, and vegetation through which it travels; the types of contaminants the water encounters in its path; and even the amount of mixing and ventilation due to commotion in its flow.

2.14.3. Conductivity

Conductivity, the ability of water to carry an electric charge, testing for EC does not give specific information about the chemicals present in water, but it gives an estimation of TDS. Thus, the EC of water is an indirect measure of dissolved chemicals. TDS (mg/L or ppm) = EC (µS/cm) x 0.67 and, therefore, of its taste and salinity which primarily comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates). There was WHO health-based guideline value for conductivity but it is generally considered that drinking water becomes significantly and increasingly unpalatable at levels greater than 1400 µS/cm (being equivalent to a total dissolved solids value of approximately 1000 mg/l) (WHO, 2011a). Although this parameter does not provide information about specific chemicals in water, it can act as a good indicator of water quality problems, particularly when it changes with time. It is recommended as a parameter in all levels of assessment because of this, together with the ease and cost of the assessment.

2.14.4. Iron and manganese

In surface water, manganese can be dissolved or suspended. If surface water has iron in it, it will be a red-orange color from the iron that is suspended in the water. Water with high levels of suspended manganese usually has a black color or black flakes in it. Drinking water with high concentrations of iron and manganese may be present in water, are likely to affect the acceptability of water for drinking, but have limited direct health significance.

Iron and manganese, however, can change the color of water and it may cause people to not use it and choose another, possibly contaminated, water source instead "(Guy Howard 2003)". People need small amounts of manganese to keep healthy and food is the major source for people. However, too little or too much manganese can cause adverse health effects "(Ljung & Vahter, 2007)"

Most municipal solid waste contains cautions: Ca2+, Mg2+, Na+, K+, Fe2+, Mn2+, and NH4+ and anions: HCO3-, Cl- and SO42 The distribution of ions in leachate toxicity are varied"(Christensen,2001)"

2.15. Bacteriological Aspects of Drinking Water Quality

The WHO Guidelines for Drinking Water Quality recommend that all water intended for drinking should have zero fecal contamination in any 100 ml sample. However, many countries have developed their water quality standards which may differ from the WHO Guidelines. The risk of fecal contamination in drinking water using E. coli as an indicator is shown in the following table. Many relief agencies also use these values to determine when water treatment is required in emergencies "(Frontières, 1994)".

Routine water quality testing techniques are not available for viruses, protozoa, and helminths. The WHO Guidelines recommend the protection of the water source and treatment to remove them from drinking water. The degree of treatment required is a function of the source water (i.e. ground or surface water) and the level of fecal contamination.

Springwater issuing from aquifer areas with prevailing matrix-flow conditions reveals excellent raw water quality "(Wilhartitz 2009)". Microbial water quality at the spring outlet can decrease rapidly "(Stadler 2008"). Concerning the given hydrogeological situation, efficient diagnostic tools for the detection and analysis of fecal pollution are needed to guide microbial system assessment, enable internal microbial water quality monitoring or allow regulatory surveillance activities "(Farnleitner, 2008)".

Selective standard fecal indicator bacteria is still the methodological and regulatory basis for fecal pollution analysis of water resources “(WHO, 2004)”

Table 2- 5 Diseases Associated with Water Contaminated with Pathogens

E.coli level (CFU/100 ml sample)	Risk	Recommended action
0 – 10	Reasonable quality	Water may be consumed as it is
10 – 100	Polluted	Treat is possible but may be consumed
100 – 1000	Dangerous	Must be treated
> 1000	Very dangerous	Rejected or must be treated thoroughly

(WHO, 2011)

2.16. Bacteriological limits of Drinking-water Quality

The coliform group could be the primary indicator of bacteria for the presence of disease-causing organisms in drinking water. It is a primary indicator of the suitability of water for consumption. If a large number of coliforms could be found in water, there is a high probability that other pathogenic bacteria or organisms exist. The WHO and Ethiopian drinking water guidelines require Zero presence of total coliform in public drinking water supplies. The disease caused by water-related micro-organisms is divided into four main classes

- Water-borne diseases: it is caused by water that is contaminated by a human, animal, or chemical wastes. Examples include cholera, typhoid, meningitis, dysentery, hepatitis, and diarrhea. A host of bacterial, viral, causes diarrhea and parasitic organisms most of which can be spread by contaminated water “(WHO, 2018)”. Poor nutrition resulting from frequent attacks of diarrhea is the primary cause for stunted growth for millions of children in the developing world “(Addisie, 2012)”
- Water-related vector diseases: diseases interconnected by vectors, such as parasites that breed or live near water. Examples include malaria, yellow fever, dengue fever, and filarial. Malaria causes over 1 million losses a year alone “(WHO, 2018)”. Stagnant and poorly managed waters provide the breeding grounds for malaria-carrying parasites.
- Water-based diseases: Parasitic aquatic organisms referred to as helminths cause that and to be transmitted via skin penetration or contact. Instances include Guinea worm disease, filarial, paragonimiasis, clonorchiasis, and schistosomiasis.
- Water-Washed diseases: These diseases flourish in conditions where freshwater is scarce and sanitation is poor. Examples include tuberculosis.

CHAPTER 3

3. MATERIALS AND METHODS

3.1.Description

Mizan-Aman town is located in the Southern Nations, Nationalities, and People's Region.The town was one of the zonal cities or capital cities of the zone. It is located at a distance of 561 and 836 kilometers southwest of Addis Ababa and Hawassa respectively. The town is also found at a distance of 50 and 230 km from Tepi and Jimma respectively.

Astronomically, the town is suited 06^{0}59'80'' north latitude and 35^0 35' 60'', east longitude. The city is divided into two sub-city Mizan and Aman sub-city. The total area covers 2925 hectares of land with an average elevation of 1345-1460 meters above sea level. The general population density is the population spreading per density is 1310 people per Km^2 or 13 people per hectare.

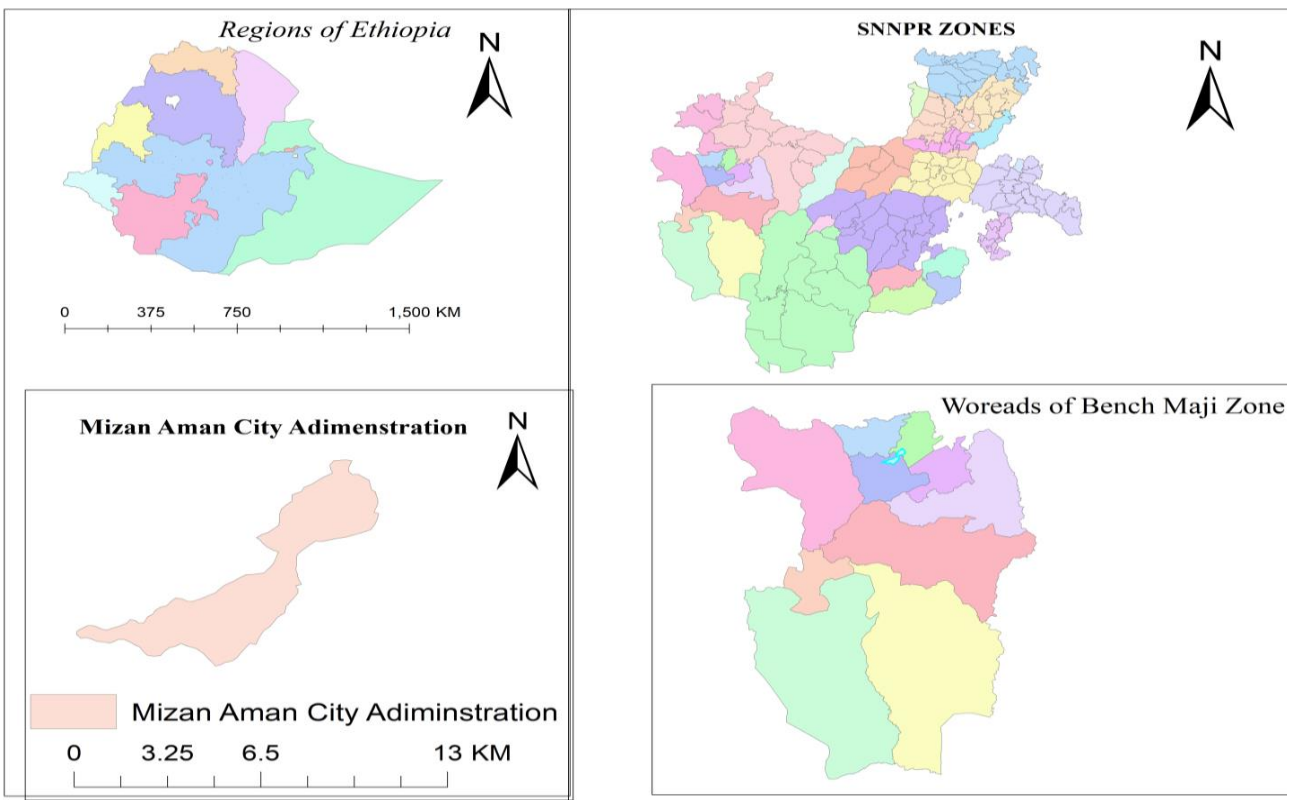

Figure 3-**1**Map showing the study area

3.2.Climatic conditions

Mizan Aman town is located in the western highlands of the country close to the border with Sudan and the Baroakabo basin. The town location is categorized into subtropical(weinadega) climatic zone. The mean annual rainfalls of Mizan Aman is 2072mm and the mean temperature varies from 16°c to 32°c

3.3.Population

According to the recent population and housing census results "(2011 CSA preliminary)", the total population size of the city was 82,861 from those males account for 40,969 and females accounts 41,892. Regarding to age structure, 36 % of the total people of the city falls within the age bracket of 1-14 years. The majority of the inhabitants (62 %) goes to the working-age group (between 15- 64)

Table 3-1 Population projection of Mizan Aman town

Description	2011	2013	2018	2023	2028
Projected Population	82,861	89,795	108,725	130,384	154,855

Source: - Bench Maji zone water and irrigation 2011

Table 3-2 Total numbers of college and school

Types of school	Number of schools	No of students in 2011 E.C
Preprimary school	39	4,785
Primary school	25	18,994
High school	6	7,875
College	5	17,723
TOTAL	75	49,377

Source: - Bench Maji zone water and irrigation 2011E.C

3.4.Socio-economic background of the City

Slow economic recoveries, refreshment of work, rapid population growth were among the factors that exacerbate more the unemployment rate of the people in the city. On the other hand most pertinent factors that reflect the poverty situation were the poor conditions of infrastructures and housing in the city. Deteriorated infrastructure, shortage of housing, and others were visible indicators of poverty in the city. Due to these most of the people got their incomes from working in the informal sector. These activities hindered them to live in slum areas of the city with low facilities of latrine, electricity, water supply, and the like. Now a day it is well known that the city is growing fast and mitigating the aforementioned problems. Moreover; the city planned or developed this CIP document to improve the wellbeing of the community through the provision/ construction of income-generating activities like municipal services, road construction, and public buildings with the help of different fundraising groups.

3.4.1. Economic Activity of the City

Mizan-Aman city is one of the business areas in SNNPR that acts as a commercial center. The city functions mainly as a market and commercial center in all directions. Economic activities are a mix of administrative functions, local trade, and commerce, plus a small amount of agro-processing.

The city is the central commercial site for both agricultural and industrial products. Especially, fruit, spices, and coffee are transshipped to national central markets from Mizan-Aman city. When one looks into the migration status of Mizan-Aman city. According to the economic activities of Mizan-Aman city, with the increasing size of the city, some farming areas are engulfed and changed into built-up areas.

Around the city, there are main coffee production areas and a high supply of coffee to the central market. Commercial activities are highly concentrated along the highway and feeder roads. There is one marketplace; at the center of the city with several shops. And also open market every day as a mini-market. In these markets, various kinds of fruits come from neighbor rural Keble and finished goods from the central market of the Mizan-Aman city (bench Maji zone water and irrigation 2011)

Table 3-3 Numbers of the hotel, pension, bars, restaurants, and traditional teje house

	Item name	Total number	Total bedroom
Mizan Aman Town	Hotel	26	364
	Pensions	40	513
	Bars	45	-
	Restaurants	553	-
	Traditional Teje house	90	-
Total		754	877

Source: - Bench Maji zone water and irrigation 2011 E.C

3.5.Geology and hydrology

Regionally, the geology of the Mizan Aman Area is made of the trap series of volcanic rocks overlying the basement rock underlying. Alluvial deposits fill the larger valleys of the adjacent areas while residual soils occur throughout the area over the gentle to steep slopes. The local geology of the area is composed dominantly of basaltic rock types. This rock is characterized by affinity (fine-grained) with tight joints &sub vertical random fracturing at places. Boreholes, which have penetrated to a depth of 302m during the previous investigation program (Gibbs, 1995) have also revealed that the underground is made of the tertiary trap series volcanic s i.e. (Basalts, rhyolites, ignimbrites). Deposits of alluvial soil feature the

Gacheb & Shonga river valleys. These sandy deposits of very limited thickness over the bedrock are well represented at the banks of this river & especially at the relatively flat bottom of the valley & river meandering sections. The area between Mizan Aman typically indicates the prevalence of sand, gravel & basaltic boulders transported from the ridge in the adjacent southeast of the area.

According to Davidson, 1983 in the area immediately west, south-west & south of Mizan Aman, North, South to North-East, southwest trending fault are reported to be the dominant structural feature in the area.

3.6.Hydrogeology& Groundwater

State of an aquifer in the geological environments like Mizan Aman, where tertiary volcanic rocks characterize the area, groundwater could be expected within secondary porosity i.e. existence of sufficient fracture &weathering. Where fracture zones intercept watercourses, it is believed that deep groundwater recharge could be enhanced. However, though the area has several streams &receives sufficient rainfall, fracturing in the area is poor. The approach previously attempted to locate borehole sites by inferring structural zones & following the saline principle as Gibbs, (1995)

Did not give a satisfactory result the yield from all the wells was less than 1l/s & hence abandoned. The present survey also has revealed that the geomorphologic configuration of the town area dominated by steep slopes &narrow at adjacent valleys, compiled by impermeable volcanic bedrock &overlaying clay-rich soils, do not allow the existence of significant aquifer for the location of possible good field area moreover, few locations .which could probably be indicated as the location for the single well site, at some distance from; the town location. The area was also found to be constrained by the expected low yield &access problem.

The thickness of the unconsolidated deposits & weathered profiles around the area is limited. Therefore, except for bearing very little & insignificant groundwater feeding very small spring & and dug wells, these units are insignificant to be considered as potential aquifers. However, where this is hydraulic continuity with the underlying weathered &locally fractured volcanic rocks intercepted by streams, as well as found in relatively thicker extent at suitable topography, there could be shallow groundwater potential for only small-scale local use

3.7. Conceptual framework

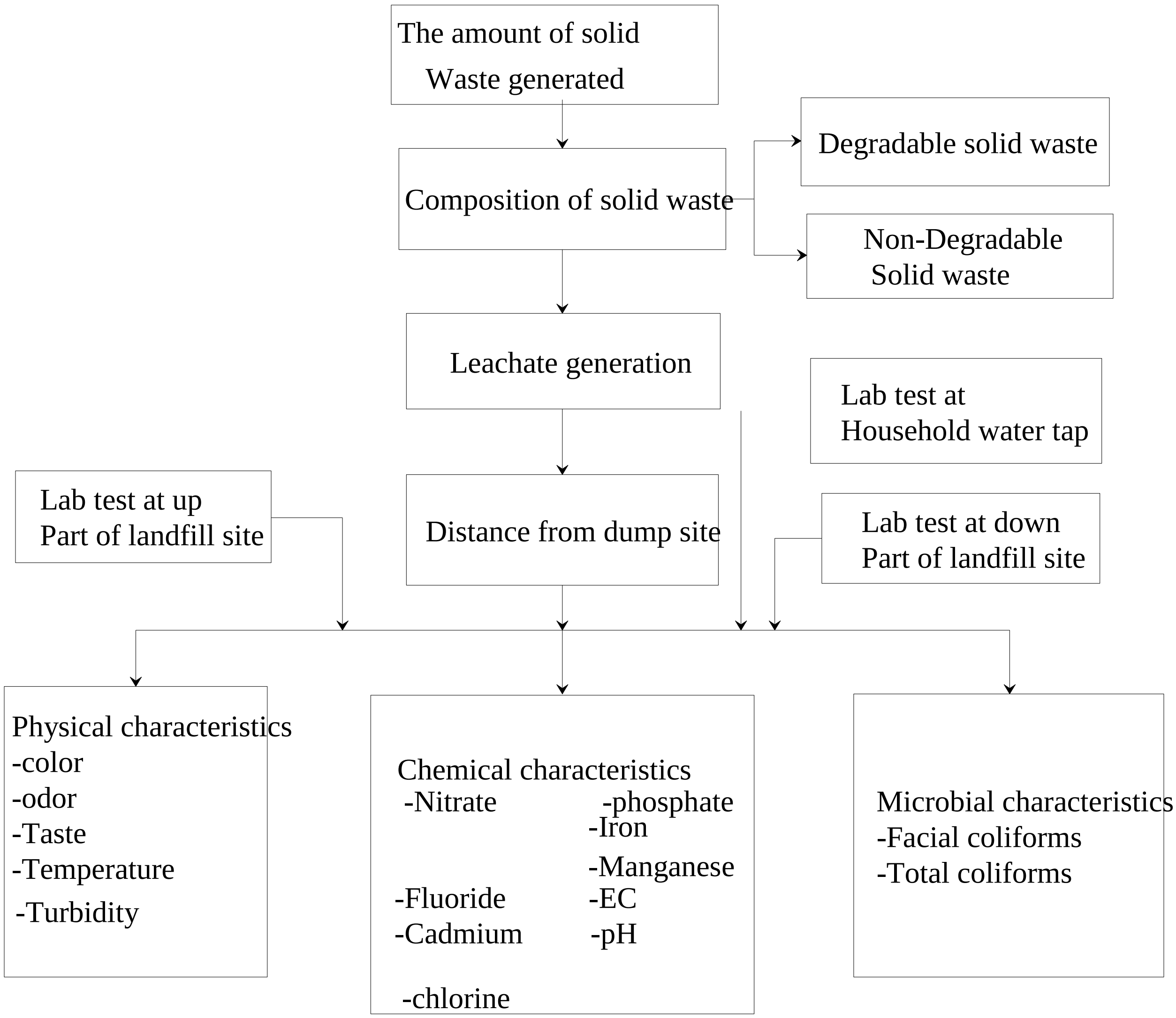

Figure 3-2 Conceptual frameworks

3.8. Research Design

The correctional study was carried out to assess the solid waste generation per capita per day from the household, institution, and commercial area. For solid waste, the sample size was 35 from the household, 10 from the institution, and 13 from commercial respectively with a total of 58 samples were collected and Physic-chemical and microbial quality of the water samples from the source to household use tap, dry season December January and February for wet season march, April and May are from upstream dumping site of the stream (n=2) downstream of the dumping site of streams (n=2), downstream of the dumping site of well (n=2) and also hand-dug from upstream dumping site of well (n=2), household water taps (n=10), the results of Physic-chemical and microbial drinking water quality was compared with the standards set by the WHO (2018) and the Compulsory Ethiopian Standard (CES 58: 2013).

3.9.Sampling Frequency

The maximum number of household respondents in the target district was determined by using a formula developed by Yemane (1969) shown in Equation 1. The marginal error of 5% with a confidence level of 95% was used to determine the required sample size.

$$n\ (i)= \frac{N*Z^2*P*Q}{W^2*(N-1)+Z^2*P*Q} \ldots\ldots \text{Equation 1}$$

Where

n =Sample size of Households

N =Total number of household heads (N=4029)

Z =confidence level (at 95% level z=1.96)

P= proportion 50% (0.5 this maximizes the sample size)

W=errors limits of 5% (0.05)

Q=1-P

From CSA (2011), the targeted district has a household size of 4029 this intends to have a household sample size of 35; which has become the total household population for our household sample collected. Based on this calculation on Equation 1; a total of 35 households were selected. To increase the response rate of the sample I have contacted 35 households and upon data clearing and filtrations exactly 35 household responses were taken for analysis.

Table 3-4 GPS date sample site from Streams

Sample name	Distance from dumping site(M)	X-coordinate	Y-coordinate	Elevation(M)
Dumping site	0.00	6^{O}59”02’N	35^{O}35”91’E	1418
Gachab river	-300	7^{O}01”40’N	35^{O}37”50’E	1429
Cosakol river	-500	6^{O}59”14’N	35^{O}35”53’E	1423
Petrous river	300	6^{O}59”45’N	35^{O}35”15’E	1411
Nimbus river	500	7^{O}00”02’N	35^{O}35”30’E	1345

Table 3-5 GPS data from sample site of wells

Sample name	Distance from dumping site(M)	X-coordinate	Y-coordinate	Elevation(M)
Dumping site	0.00	6^{O}59”02’N	35^{O}35”91’E	1418
Well- 1	-400	6^{O}59”17’N	35^{O}35”24’E	1426
Well- 2	-600	6^{O}59”29’N	35^{O}35”38’E	1423
Well-3	400	6^{O}59”30’N	35^{O}35”23’E	1412
Well-4	600	6^{O}59”18’N	35^{O}35”53’E	1393

3.10. Sampling Procedures and Techniques

The method of sample collection from each sampling location was according to WHO (2018) guidelines for drinking water quality assessment and American public health association guidelines (APHA, 1998). Samples were taken from locations that are representative of the water tap (household), up part of the solid waste dumping site, down part of the dumping site for streams and wells at dry as well as rainy seasons.

Solid waste disposal site down and up part, Systematic random sampling method was used to determine representative sampling points (Daniel, 2015). The selected households for household container water sampling were the ones that use water from the water supply system of the town for drinking and other domestic purposes.

For the bacteriological analysis, water samples were collected from all the selected sampling sites in pre-sterilized plastic bags and immediately taste on the site with portable bacteriological analysis equipment (ELE Paqualab 25). From each sampling point, 200ml samples were taken for analysis. Regarding the physicochemical analysis, samples were collected in 200ml plastic containers which were properly washed and rinsed and immediately analyzed for each sampling site using portable Physic-chemical analysis equipment (HQ440d multi and DR/2400 spectrophotometer) for all the physical and chemical parameters selected to be tested.

3.11. Methods of Sample Analysis

3.11.1. Physic-Chemical Analysis

Water samples were collected in properly splashed and washed plastic bottles. Parameters such as PH, Temperature, Total Dissolved Solids (TDS), and Electrical Conductivity (EC) were measured on the site using HGE HQ47T multi-parameter transferrable meter or PH/Conductivity/TDS/Temperature meter having the different conductors to amount each of the strictures. The meter connects with smart probes that mechanically identify the testing parameter, standardization history, and method locations to minimalize errors and organization time. The pH adjustment of the meter was done using normal safeguards of pH measurement

On behalf of conductivity, the meter is standardized using the optional standard standardization solution range, and the probe is thoroughly rinsed with distilled water from one sample to another following the HGE HQ47T User Manual instructions "(HACH, 2018)". Both examinations were standardized using the recommended standardization solutions to maintain the maximum level of accuracy. The investigations of the instrument were immersed in the sample of the water to be tested and the measured parameters were displayed on the LCD shade of the appliance and carefully recorded. About turbidity, it was analyzed calorimetrically using a portable digital spectrophotometer (DR) following HGE instructions.

3.12. Bacteriological Analysis

In place of bacteriological analysis of the water testers, the samples were collected from all the sample collection situations using pre-sterilized plastic bags of 200ml volume after wearing rubber gloves on hand. The samples were reconnoitered using the membrane filtration method for bacteriological water quality to determine the presence of total Coliforms and Fecal Coliforms and to determine the degree of pollution "(WHO, 2018; EPHA, 2017)".

The percolation tackle was sterilized before use and re-sterilized between testers using methanol when analyzing water samples "(WHO, 2018)". The cellulose membrane filter is transferred from the filtration apparatus to a sterilized aluminum Petri-dish containing absorbent pad soaked with m-Coli Blue24 Broth which will be used as a medium to grow total Coliforms and Fecal Coliform. The Petri-dish was then disappearing using ELE P 25 field incubator by adjustable the infection at 36^0C and 44^0C for the development of total Coliforms and fecal Coliforms/E-Coli respectively for 24 hours. The filters will be examined 24 hours forward-thinking to count the grown colonies to regulate the TC and FC in the samples. At 36^0C TC/E-Coli was grown as blue collections whereas other Coliforms were grown as red congregations and the sum of the two was the effects for total Coliforms.

3.13. Methods of Data Analysis

A computer database was used to examine organized data using Microsoft Excel version 2010 and Expressive measurements like percentage mean and range were used to describe the findings. Pearson's correlation (r) values were determined using Microsoft Excel version 2010 to show the correlation between different Physic-chemical and microbiological limitation in a different season

CHAPTER 4

4. RESULTS AND DISCUSSIONS

4.1.Types and composition solid waste generated in the Household

The door-to-door solid waste congregation of the town is significant both in spatial coverage and productivity. As a result, the only solid waste option of the majority of households is restricted to two choices.

To screen and control existing institutional solid waste administration systems and to make monitoring, financial and institutional decisions, it is necessary to characterize the solid waste by its source, type, and arrangement

As it was observed the total solid waste generating per day from the household was 44.06 kg/day the (figure 4-1)below, shows the percentage of solid wastes generated per day from households are 27%,16%,11%,9%,8%,7%,6%,6%,5% and 5% for food waste, ashes, fruits, Insubstantial, bottles, plastic, metals, paper, wood, and glass, respectively. This improper disposal of solid waste exposed communities to different breathing and water-borne diseases. The study area was high rain full zone from year to year the causes overflow so the inclined of waste have directly adulterated the surface and sub-surface water quality. The Mizan Aman town water supply dam was constructed downstream of the town that means solid waste and its leachate is entered into the water supply dam by runoff during the rainy season this may affect the physical, chemical, and organic quality of water. All most of the householders have a well this well was also posh by surface and sub-surface runoff from the dumping site.

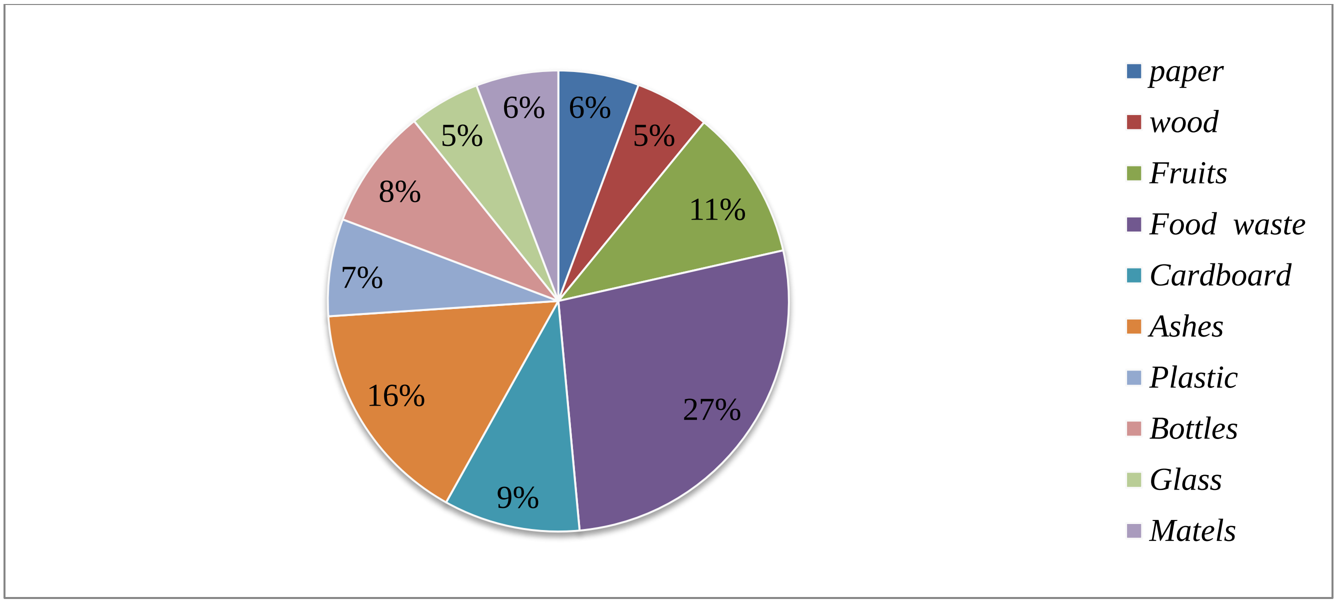

Figure 4-1Solid waste composition in percentage from household

The first and determined quantity of solid waste generation per day was the food waste and followed by ashes wastes. The reason behind the higher quantity of food waste generation in the household was might be related to the preparations and serving of food in the household.

Ash waste (wood ash and charcoal leftover) the second waste from the household. However, according to the informants from each household, ash waste was increasing from time to time due to the increased food cooking materials so ash generation in the households increases from day today.
Fruit waste was the third solid waste generation in the selected household. This is because the study area has huge products of fruits and most of the households are dependent on them. Cardboard was the fourth solid wastes from household solid waste in presents per day bottle waste was fifth solid waste generation selected in households

Plastic waste was the sixth solid waste generated in the household. According to "(Dehghani, K. and Changing, F.2008)", unless correctly managed plastic wastes have negative impacts on health and an aesthetic environment. The researchers also reported that the average operating 'lifespan' of plastic to be approximately 20 minutes but it can last in the landfill of an anaerobic environment for up to 1000 years

Paper waste was the eighth solid waste generation in households. Paper and carton solid wastes were also mainly produced from falsified materials from industry and students exercise books from domestic although paper waste is recyclable or decomposable, comfortable to burn which in turn causing air pollution or ash or dust wastes.

4.1.1. Degradable and Non-Degradable solid wastes from household

The most solid waste generated in the household was degradable solid wastes this included; food waste, paper, ashes, wood, fruits, and cardboard wastes while plastics, glass, bottles, and metal were segregated as none degradable solid wastes during the study.

The solid waste generating from the commercial was 44.06 kg/day from this 33.9 kg/day degradable and 10.13kg/day non-degradable.The total value of degradable solid waste generated from all households was significantly higher than the value for non-degradable solid waste materials. The total value of degradable waste generation from all households was found to be 77% while the value for the non-degradable solid waste was 23% (fig4-2). In line with this finding, solid waste with high organic content has been reported by many authors in many different cities such as Addis Ababa 60% (Tesserae, 2010); Debrebrahan 80% "(Vikrant, T. et al., 2014)"

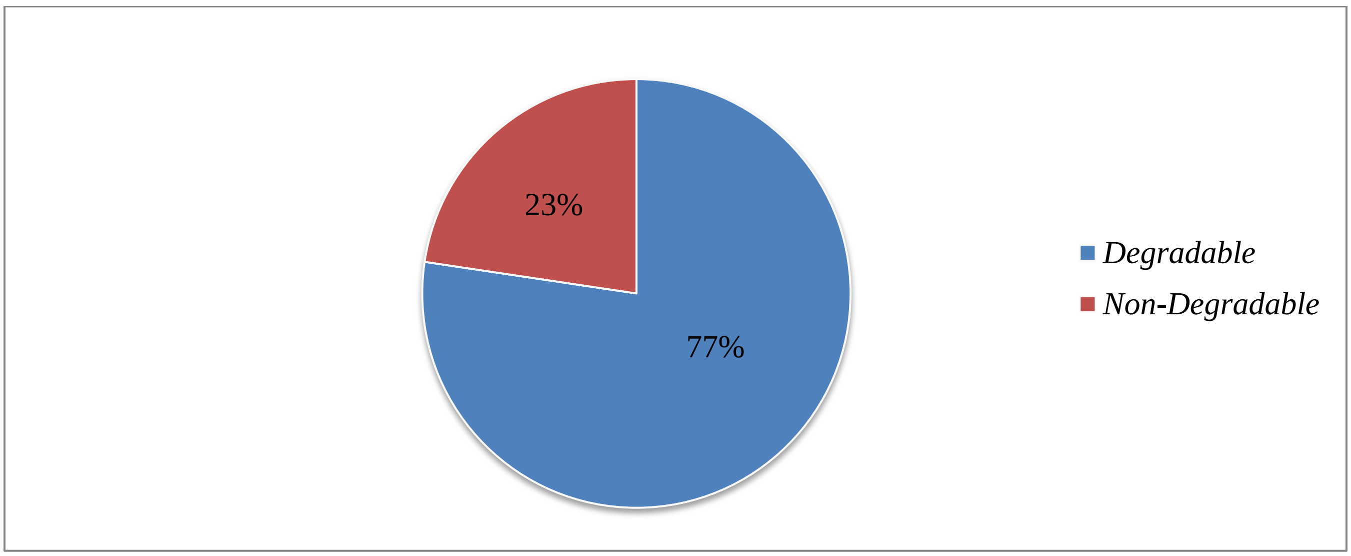

Figure 4-2 proportion of degradable and Non-degradable solid waste from the household

4.2.Solid waste generation and composition from institutions

Solid waste cohort, waste handling and separation, storage and dispensation, gathering and transport, and final discarding are some of the significant practices done for sound solid waste management

To display and control existing institutional solid waste organization systems and to make regulatory, financial, and institutional decisions, it is necessary to characterize the solid waste by its source, type, and composition In my study area only includes schools and colleges other institutions are far from the study area and their wastes are collected to the study area landfill site.

The solid waste generating from the commercial was 202.1 kg/day from this 169.79 kg/day degradable and 32.3kg/day non-degradable

From (figure 4-3) below the proportion of solid wastes generations per day from the institution are 34%,,18%,13%,12%,7%,6%,4%,3% and 3% for food waste, fruits, wood, paper, ashes, plastic, glass, metal, and bottles, correspondingly

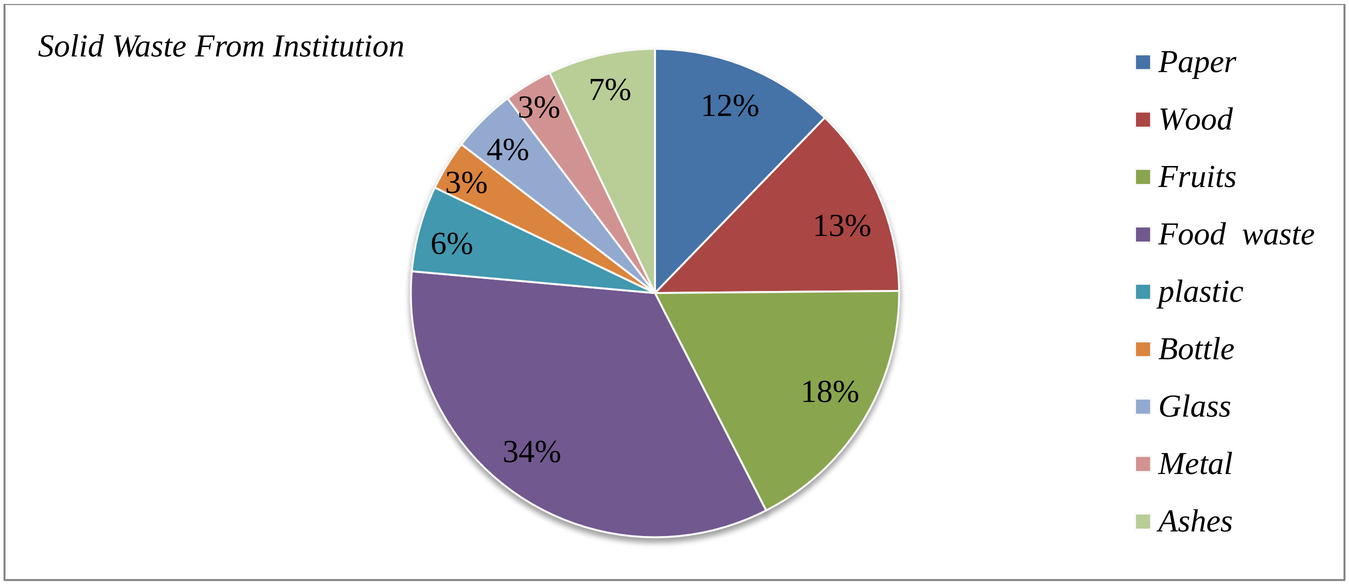

Figure 4-3 Solid waste composition in present from the institution

4.2.1. Degradable and non-degradable solid waste from the institution

The most solid waste generated in the institution was degradable solid wastes this included; food waste, paper, ashes, wood, fruits, and cardboard wastes while plastics, glass, bottles, and metal were segregated as none degradable solid wastes.

The total value of degradable solid waste produced from all institutions was considerably higher than the value for non-degradable solid waste materials. The total value of degradable waste generation from all the institutions was found to be 84 percent while the value for the non-degradable solid waste was 16 percent (fig.4-4). In line with this finding, solid wastes with high organic gratified have been reported by many dramatists in many different cities such as Addis Ababa 60 percent “(Tessa, 2010)”; Debrebrahan 80 percent “(Vikrant, T. 2014)”

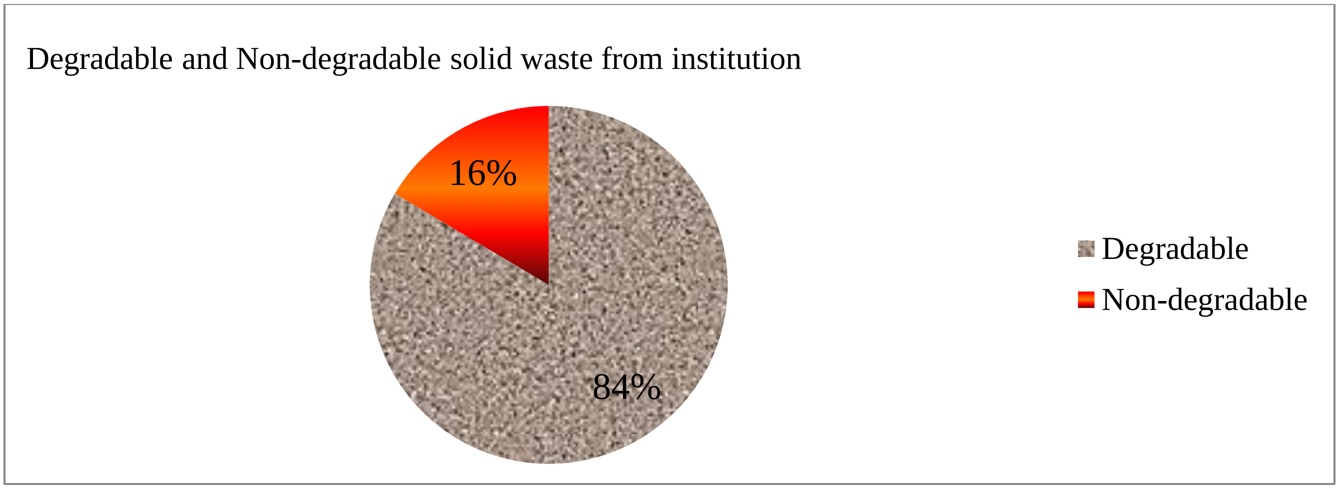

Figure 4-4 Degradable and Non-degradable solid waste from the institution

4.3.Commercial Solid waste generation and composition

Each participating commercial center was provided with five or more plastic bags for their daily solid waste based on the amount of solid waste that they have been producing daily. This was to prevent both the overloading of bags and the handling of excess weight of materials. Waste was placed into clearly manifest large plastic delivery bags to identify the bags as being from an individual property. This was also allowing the waste to be assigned to a particular business category for recording and interpreting data. The solid waste generating from the commercial was 154 kg/day from this 113.53 kg/day degradable and 40.47 kg/day non-degradable From (figure 4-5) below the total commercial solid waste produced the maximum one was food waste which is 29% and the others are 16%, 14%, 10%, 9%, 7%, 5%, 5%, and 5% which are fruits, ashes, metals, wood, bottle, glass, plastic, and paper waste respectively.

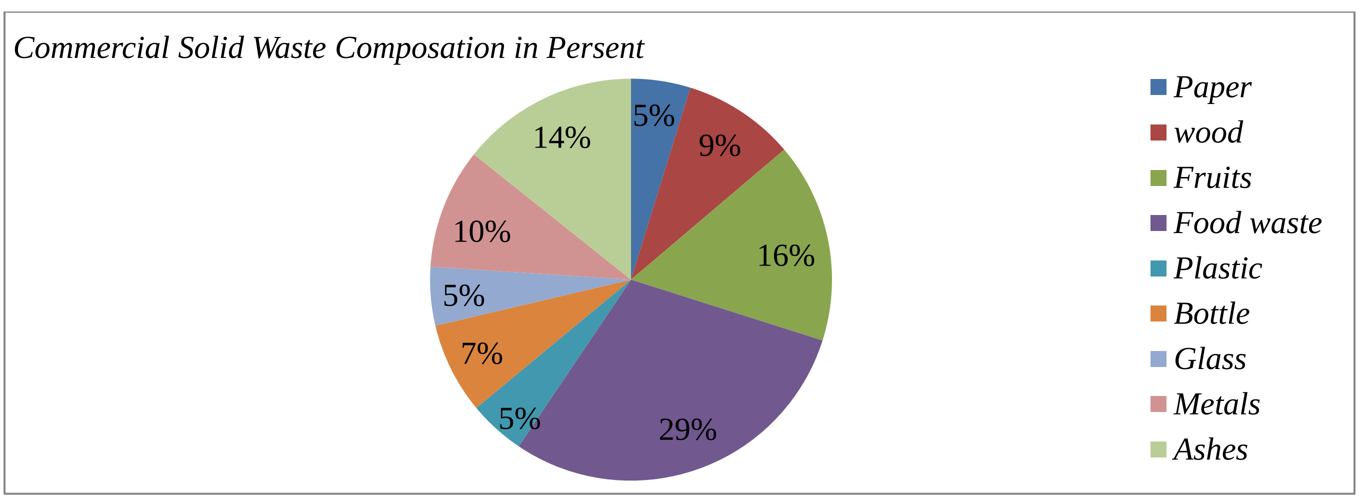

Figure 4-5 Commercial solid waste composition in percent

4.3.1. Degradable and Non-degradable Commercial Solid waste

The most solid waste produced from the commercial centers solid was Degradable solid wastes this included; food waste, paper, ashes, wood, fruits, and cardboard wastes while the second was Non-degradable solid waste such as plastics, glass, bottles, and metal.

The total value of degradable solid waste generated from commercial centers was considerably higher than the value for non-degradable solid waste materials. From (fig.4-6) below the total value of degradable waste generation from commercial centers was found to be (74%) while the value for the non-degradable solid waste was (26%) .

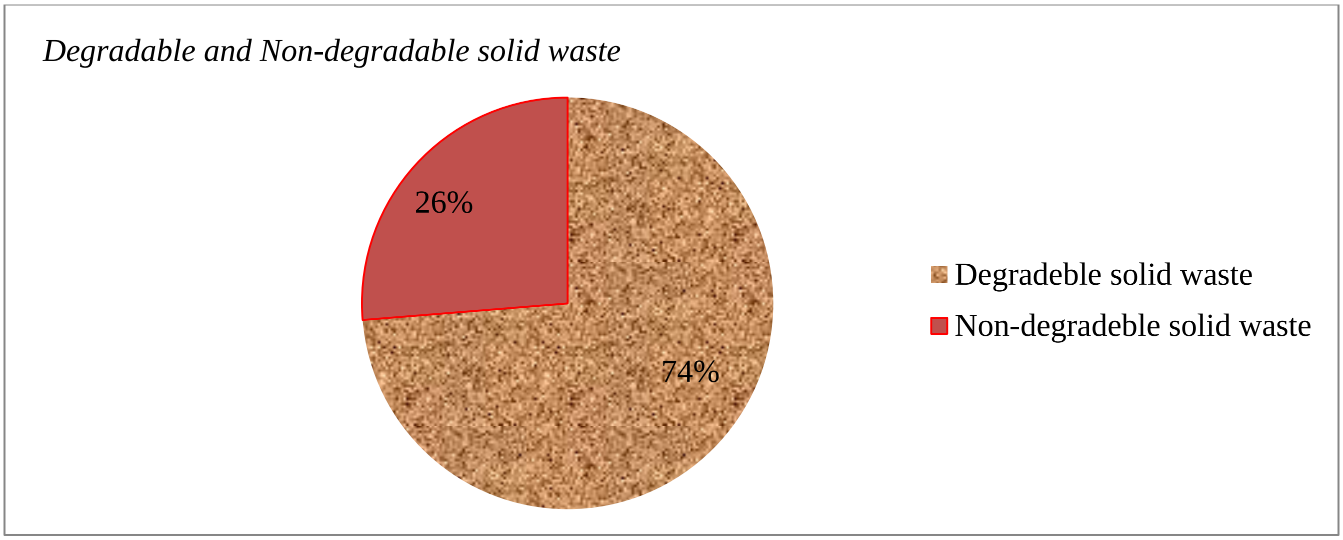

Figure 4-6 Degradable and Non-degradable commercial solid waste composition in percent

4.4.The Total Solid Waste Generated From All Sources

The city town is not in a position to manage the waste completely and properly. The peripheral urban area of the city must also be given due importance by the municipality "(Vikrant H. R. 2014)

From the study area municipality of Mizan Aman city, solid waste generated the maximum was institutional solid waste which is 51% the second one was commercial solid waste which is 38% and the 3rd was household solid waste which is 11%.

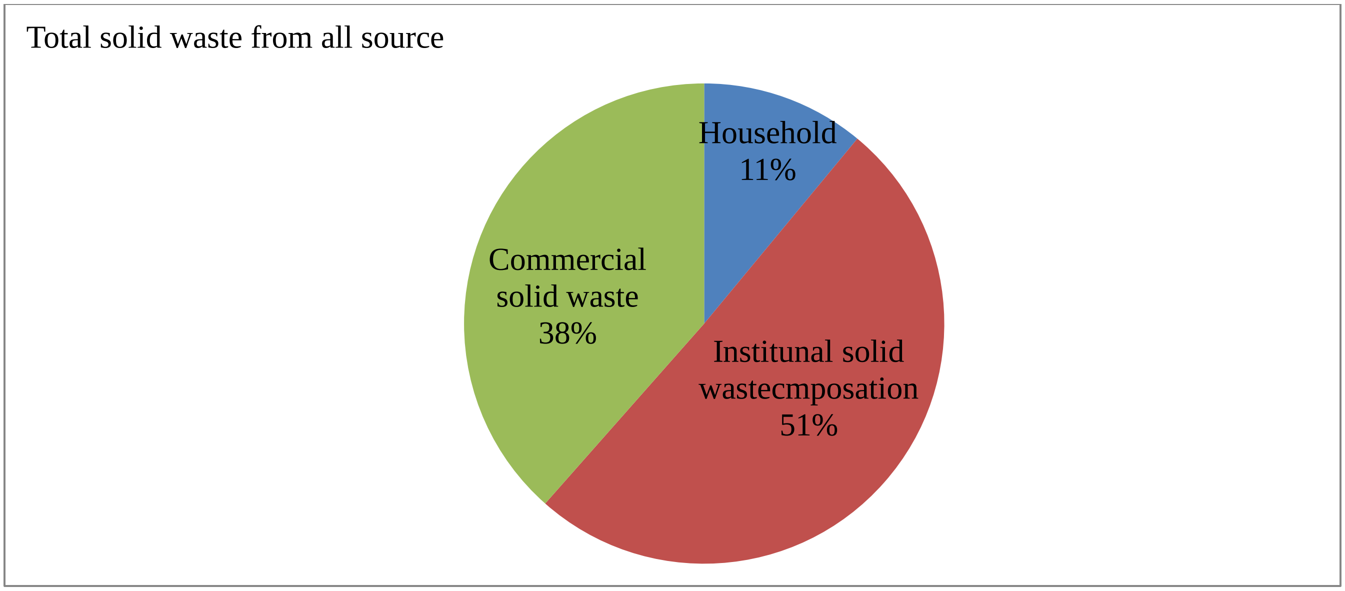

Figure 4-7 Total solid waste generated from all source

4.4.1. Total solid waste composition from all sources

The solid waste composition study is to identify the amount of waste generated in the respective area. In this case, the solid waste composition study was used to identify and quantify the amount of solid waste generated in the municipality .solid Waste collection vehicles are allocated to different streams by both government and private bodies. The solid waste from municipality was collected and transported to the landfill accordingly to the groups like domestic, commercial, and institutional.

The amount of solid waste generated per day from the household, institutional and commercial is 44.06kg/day,202.1kg/day, and 154kg/day respectively and the total amount becomes 400.16 kg/day the percentage of solid wastes generated per day from all sours from (figure5-8) below are 31%,16%,,11%,,10%,,9%,,7%,,6%,,5%,,5%, and 5%, for food waste, fruits, wood, paper, ashes, plastic, glass, metal, and bottles, respectively. The collected data shows that the maximum proportion of refuse caused by food waste second highest was fruit waste and the third-highest was ashes. As the first step to develop an effective SWM strategy for a given region, it is important to know the amount of waste generation, the waste composition, and the waste stream. The per capita waste generation rate is important to predict future waste groups and to evaluate the waste generation trends

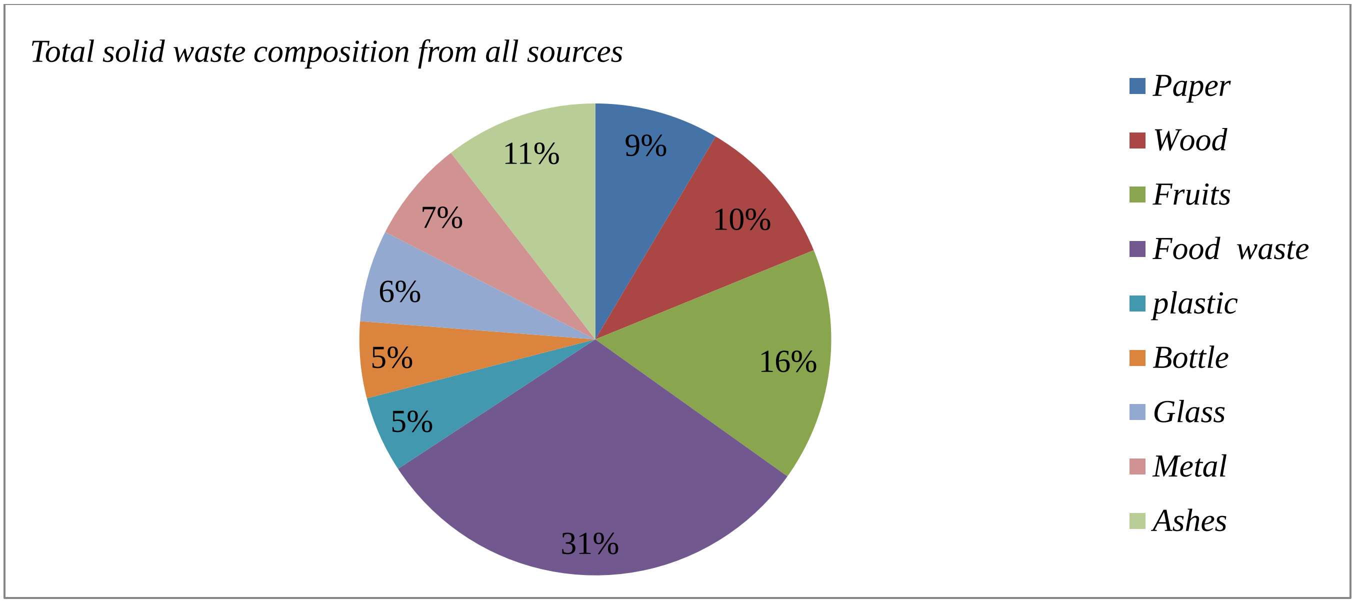

Figure 4-8 Total solid waste composition from all source

4.4.2. Degradable and Non-degradable Solid waste from all source

The municipal solid waste consists of a highly heterogeneous mass of discarded materials from urban residences, commercial establishments, institutions, street sweepings, and light industrial activities. "(SBPDD report (2009)"

As it is indicated in the review of the literature part of this research municipal solid waste is a term usually applied to various mixtures of solid wastes produced in urban areas. But commonly urban wastes can be subdivided into two major components called biodegradable and non-biodegradable. The biodegradable component of urban solid waste constitutes organic wastes such as food waste, garden waste, and agricultural waste which undergo biological degradation under controlled conditions and can be turned into compost or organic fertilizer. While non-biodegradable wastes include inorganic materials which can't be decomposed and degraded. Likewise, from my observations in disposal sites, illegally dumping areas and residential areas, Mizan Aman town's physical composition of municipal solid waste is also composed of both biodegradable and non-degradable components. The dominant types of biodegradable solid wastes are food waste, fruits, vegetable peelings, onion, seed coats, grasses, kitchen and garden wastes, animal wastes, ash, dust, leaves, scarp of chat, papers, wood scraps, bones, straw, dead animals, cardboard, cartons, and paper packaging materials, etc. Whereas non-biodegradable wastes of the town include different types of plastics(like plastic bags or "festivals", broken pieces of plastic materials, bottles plastic packaging materials), cables and useless electronic materials, pieces of ceramics, glass, cans, pieces of metals, textile scraps, discarded old shoes, packaging materials, etc.

The total value of degradable solid waste generated from the municipality was considerably higher than the value for non-degradable solid waste materials. From (fig.4-9) below the total value of degradable waste generation was 66% while the value for the non-degradable solid waste was 34% .this shows waste from Mizan Aman municipal was polluting the environments.

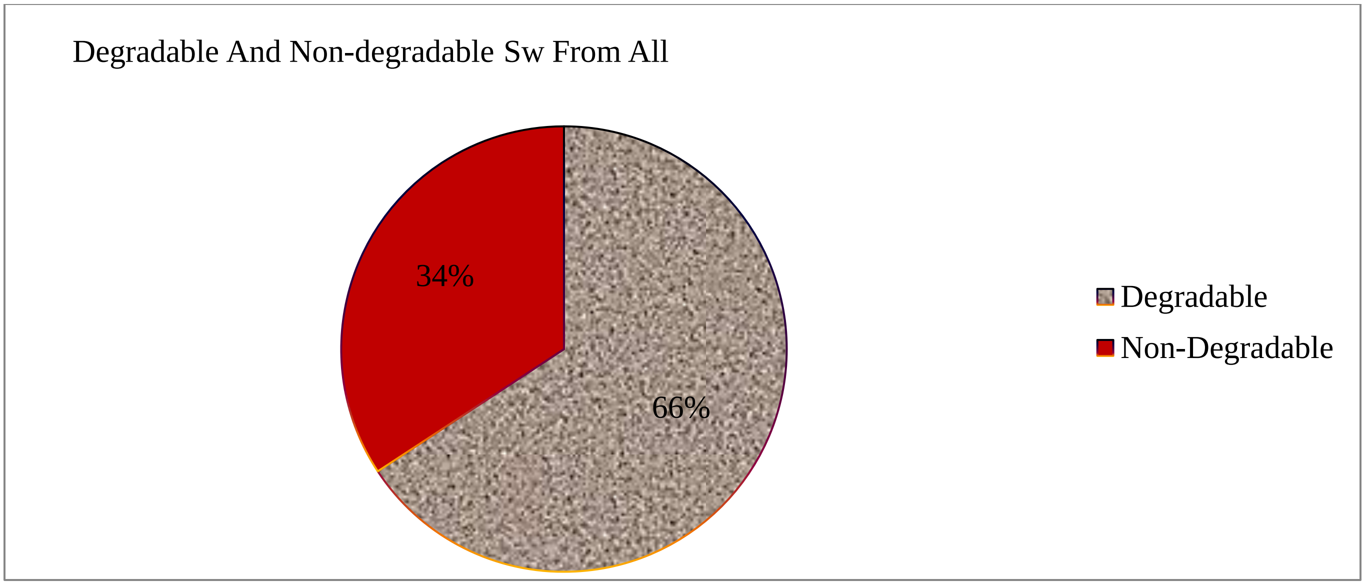

Figure 4-9 Degradable and Non-Degradable solid waste from all sources

4.5.Physic-Chemical Analysis Results of Samples from streams and wells

4.5.1. pH

Table 4-1 pH measured from the stream during the dry and rainy season

Season	Month	Sampling points

		Sample 1	Sample 2	Sample 3	Sample 4
Dry season	December	7.32	7.42	7.42	7.44
	January	7.13	7.13	7.41	7.12
	February	7.32	7.35	7.33	7.23
Mean		7.25	7.3	7.38	7.26
Wet season	March	7.24	7.22	7.23	7.33
	April	7.25	7.0	7.21	7.31
	May	7.12	7.12	7.11	7.32
Mean		7.20	7.11	7.18	7.32

Table 4-2 pH measured from wells during the dry and rainy seasons

Season	Month	Sampling points			
		W-1	W -2	W- 3	W- 4
Dry season	December	7.5	7.2	7.4	7.6
	January	6.8	7.2	7.0	7.2
	February	8.5	7.3	7.4	7.5
Mean		7.6	7.23	7.26	7.43
Wet season	March	7.6	7.2	8.3	7.7
	April	7.2	7.8	7.9	7.4
	May	7.7	8.2	7.5	7.4
Mean		7.5	7.7	7.9	7.5

The groundwater and surface water pH for wet and dry seasons were measured (Table 4-1 and 4-2) above the results in Table 4-1 shows that the mean pH in stream water ranged from 7.25 to 7.38 during the dry season and 7.112 to 7.32 during the rainy season and was slightly alkaline.

Table 4-2 shows that the mean pH in wells during the dry season is from 7.23 to 7.6 and 7.5 to 7.9 in rain seasons did not show an extensive variation. The mean pH during the study was within the guidelines and in an adequate range. The pH value indicates a neutral to alkaline leachate which recommends a methanogen stage. This concurs with the findings of “(Khateeb 2013)” who observed that at this stage significant quantities of pollutants such as ammonia are consistent with such pH value.

The results of the present study were comparable to the average PH record of 7.6 from water sources at Akaki-Kalita sub-city of Addis Ababa “(Mengstayehu, 2007)” and slightly less than the record of 8.3 from water sources at Ziway town (Kassahun,2008) and 8.22 from water sources of Woliso town "(Birhanu, 2016)"

4.5.2. Temperature

The measured temperatures in both surface water and wells during the wet and dry seasons are given in (Table 4-3 and Table 4-4). The average measured temperatures were higher during the dry season as associated to the wet season. This is due to a lot of heat produced naturally from the sun that heats the water bodies during the dry season in Mizan Aman highlands during such period "(MCK, 2013)". From streams in both dry and wet season, the result becomes 21.39 ^{o}c-22.53 ^{o}c and 19.11 ^{o}c-20.53^{o}c respectively and for wells it becomes 21.34^{o}c to 22.53 ^{c}c at the dry season and 18.45-19.96 ^{o}c at wet season. This conclusion agrees with "(Morris 2003)" who noted that water temperature is an important factor in the influence of the number of dissolved chemicals.

Table 4-3 Temperature measured from streams during the dry and rainy seasons

Season	Month	Sampling points from the stream			
		Sample 1	Sample 2	Sample 3	Sample 4
Dry season	December	21.62	21.54	21.41	21.22
	January	21.12	21.15	21.43	23.13
	February	22.37	21.35	21.34	23.24
Mean		21.70	21.34	21.39	22.53
Wet season	March	19.25	20.27	21.23	20.31
	April	18.28	19.22	20.22	18.32
	May	20.11	19.12	20.15	18.72
Mean		19.21	19.57	20.53	19.11

Table 4-4 Temperature values for the four wells measured during dry and rainy seasons

Season	Month	Sampling points			
		W-1	W-2	W-3	W-4
Dry season	December	21.62	22.54	21.41	21.22
	January	21.12	21.15	21.43	23.13
	February	22.37	22.35	21.34	23.24

Mean		21.70	22.34	21.39	22.53
Wet season	March	19.25	20.55	19.23	17.31
	April	21.28	19.45	20.22	18.32
	May	18.21	19.88	20.15	19.72
Mean		19.58	19.96	19.9	18.45

The climatic condition of Mizan Aman town is responsible for the moderate temperature values since the elevation of Mizan Aman town lies within the range of 1130-1250 m a.m. which is approaching the upper elevation limit of the moderate climatic zone of the country.

A similar study accompanied in Bahir Dar town indicated a mean temperature of 21.8 ^{0}C "(Genet, 2008)" and a study conducted in Woliso town indicated a mean temperature of 20.5^{0}C "(Biryani, 2016)". A slightly higher temperature of 27.7 ^{0}C was reported from the examination of water samples from Nigeria "(Oyem et al, 2014)". From these educations, we can control that since the readings were carried out in the tropics where the climate is categorized by high temperature and rainfall, these factors may have generally contributed to the high-temperature records of the water samples that were above the "WHO;2018) limit of <15 ^{0}C.

According to WHO (2018), cool water is normally more palatable than warm water, and temperature will influence the satisfactoriness of several other inorganic constituents and chemical pollutants that may affect the taste. High water temperature enhances the growth of microbes and may increase problems related to taste, odor, color, and corrosion.

4.5.3. Electrical Conductivity of Water

The electrical conductivity (EC) for wet and dry seasons as compared to Ethiopia ministry of water and irrigation (EMWI) and WHO guideline is presented in (Figure 4-10 and 4-11) The location of the wells (W1, W2, W3, W4) and sampling points (S1, S2, S3, S4) The results in Figures 15 and 16 indicate that Well 3 (166us/ml) and sampling point, S3 (193us/ml) which are adjacent and located nearest to the dumpsite downstream had the highest electrical conductivity during the rainy season. All sampling points other than S1 had relatively high electrical conductivity as compared to the Ethiopia ministry of water and irrigation (EMWI) and WHO guidelines.

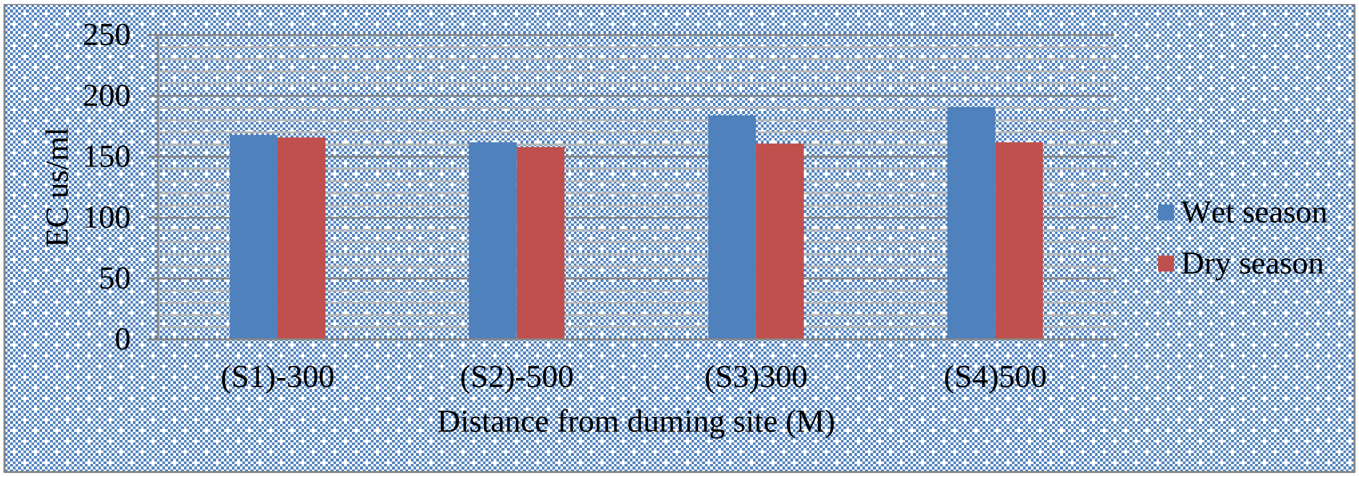

Figure 4-10 EC measured from the stream during dry and rainy seasons

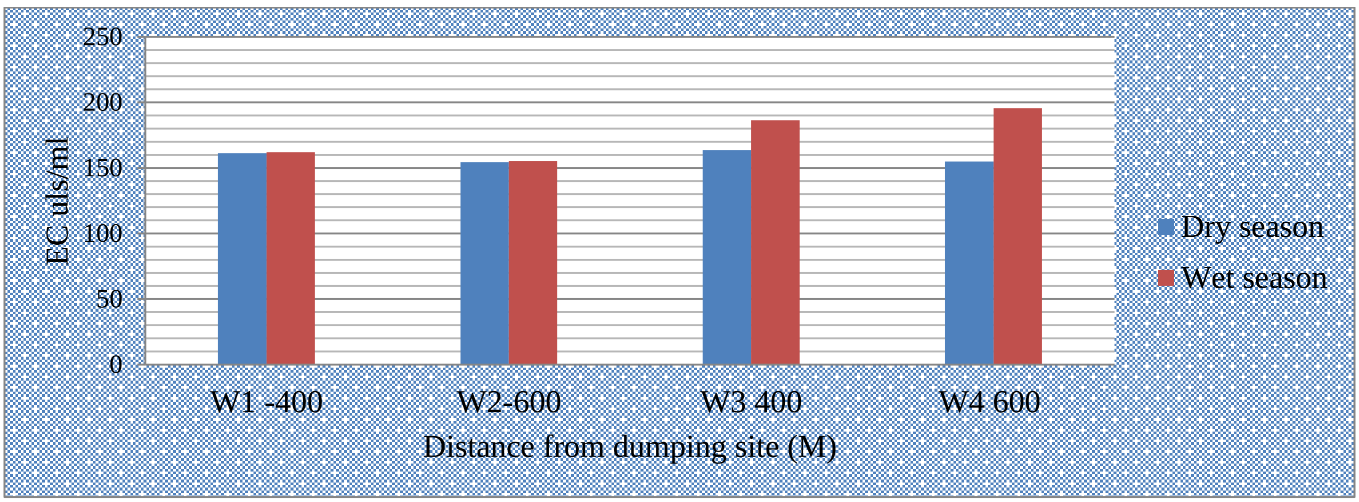

Figure 4-11 EC measured from wells during dry and rainy seasons

4.5.4. Zinc Concentration levels

In this study the mean Zn concentration levels in surface water for all the sampling sites are presented in (Figure 4-12), Measured values were detected only during the wet season in four sampling points; S1, S2, S3, and S4. The zinc consciousness increased from S1 (1.95mg/l), S2 (2.35 mg/l), S3 (2.57mg/l) and S4 (2.81 mg/l) during rainy season and zero from dry season. The concentration of Zn in the downstream sampling points exceeded the recommended limit of 1.5 mg/l levels suggested by the Ethiopia ministry of water and irrigation (EMWI) and WHO guidelines. The attentiveness of Zn increased downstream probably due to gradual accumulation from the municipal wastes and that from the dumping site. When Zn metal is dumped intermittently in the landfills, the resulting leachate infiltrates into the groundwater or is eroded into the streams consequently causing water pollution. This detection concurs with "(Dammed

2013)" who noted that among other sources of Zn into aquatic bio networks include urban runoff and municipal solid waste leachate.

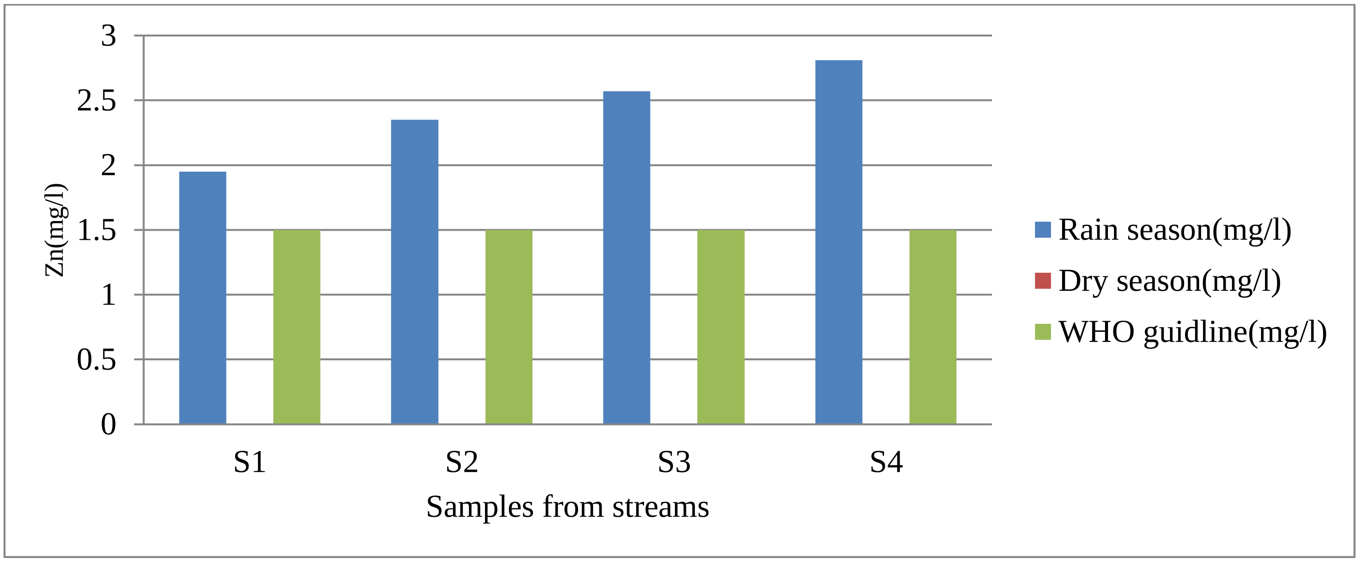

Figure 4-12 Zinc measured from the stream during the dry and rainy season

4.5.5. Manganese Concentration Levels

Slow values were distinguished during the rainy season and dry season in the sampling points; S1, S2, S3, and S4. The results in (Figure 4-13 and 4-14) indicate higher levels of manganese (6.8, 4.08, 9.54, and 5.54) at rain season and 0.45, 0, 0.35, and 0.62 respectively at the dry season for wells w1, w2, w3, and w4 at dry and rainy season are 0.1, 0, 0, 0.25 and 2.08, 1.01, 0.95, 2.1, correspondingly recommended guideline (1.0 mg/l) during the dry season while indicated a similar value to the commended recommendation but rain season it higher.

The high levels observed at sampling point S3 could probably be due to runoff of solid waste dumping site activities in the Ethiopia minister of water and irrigation next to the sampling point. In all the sampling sites the mean Mn attentiveness levels in surface water were found to be higher than that suggested limit of 1.0 mg/l for Mn in drinking water (EMWI, 2017).

Manganese concentration levels over the recommended levels are of concern. At levels exceeding 1.0 mg/l, manganese in water supplies causes an undesirable taste in drinks and pigments sanitary ware, and laundry. The indicator of manganese in drinking water, like that of iron, may lead to the accumulation of deposits in the distribution system. The ill-effects of manganese in human beings via inhalation include neurotoxin causing breathing tract, co-ordination damage, uneasiness, dementia, and uncontrolled undertaking similar to Parkinson's disease and brains damage '(Zwieback, 2019)'.

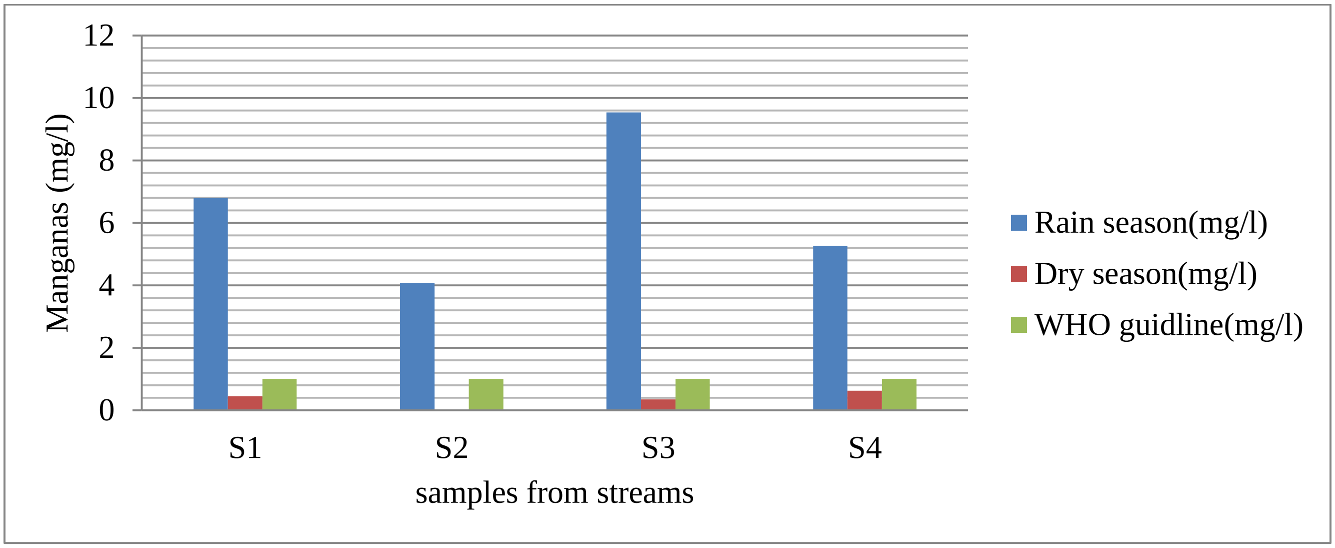

Figure 4-13 Manganese samples from the stream during the dry and rainy season

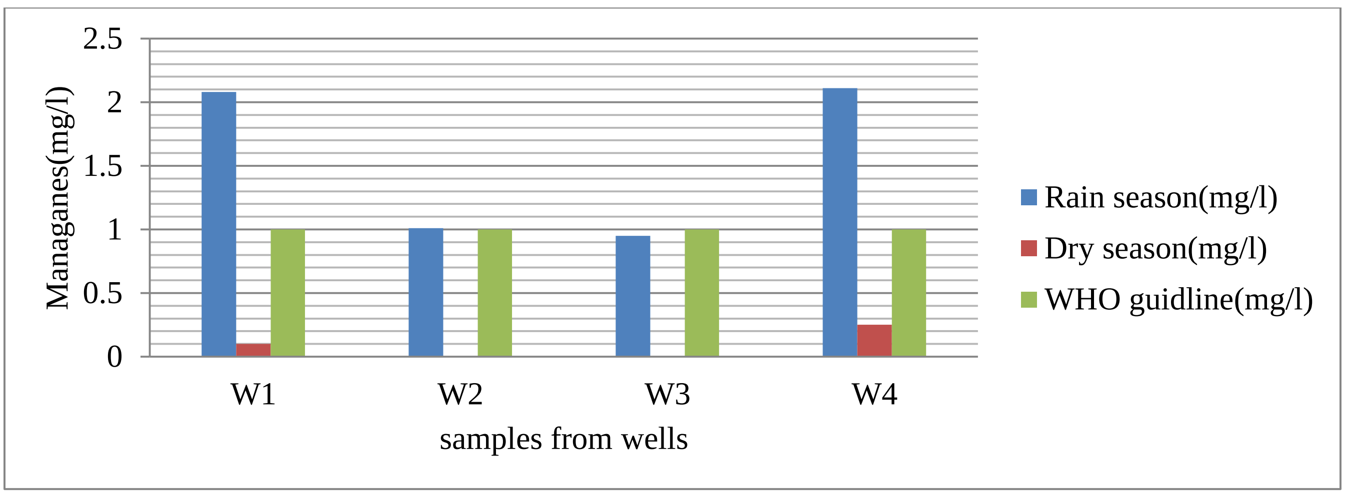

Figure 4-14 Manganese samples from wells measured during the dry and rainy season

4.5.6. Cadmium concentration levels

The measured levels of cadmium in surface water and for wells throughout the rain and dry seasons were not distinguished. This suggests that there is little contamination from municipal waste. Cadmium contamination from sources such as cadmium-containing batteries and plastics, or cadmium-plated steel and electronic wastes is low at the dumpsite. The releases could be accepted and deposited in areas far from the source. Cadmium has contaminated effects on the skeletal system, the breathing system, and the kidney. It can also disrupt the biosynthesis of hemoglobin "(Joisted, 2006)". It is also oncogenic. The results suggest that cadmium is not a life hazard in both the surface and wells in the study area.

4.5.7. Total Suspended Solids (TSS)

The results of measured levels of total suspended solids (TSS) are given in (Figure 4-15 and 4-16) are S1, S2, S3, S4 at dry season are as follows 20,45,53,61mg/l respectively and rain season are 35,110,140,102 mg/l separately There were higher awareness levels recorded during the rainy season both in streams and wells as compared to the dry season. Other than the sampling site that is furthest upstream and downstream sampling point's recorded higher values than the recommended Ethiopia Minster of water and irrigation guidelines of 30 mg/l. The values of TSS during the rainy season increased downstream probably due to gradual growth from the municipal wastes and that from the removal site. Suspended material is a major pollutant carrier. Organic pollutants, toxic heavy metals, nutrients, and pathogens are found in composites of suspended matter. The type of suspended matter determines the turbidity and transparency of water.

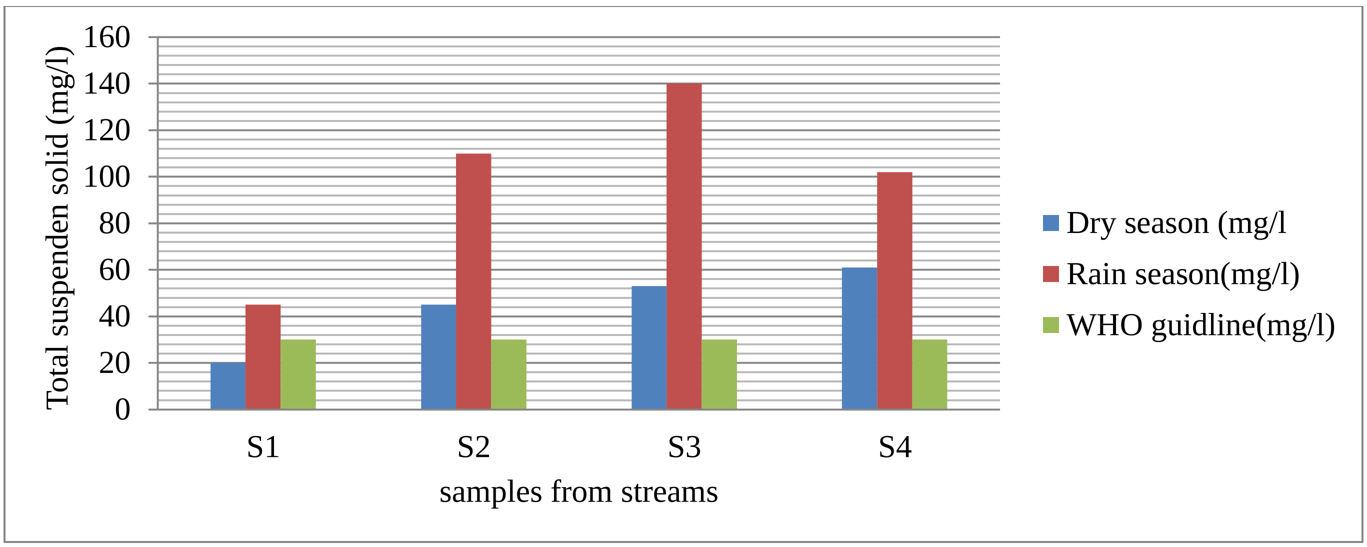

Figure 4-15 TSS from four streams measured during the dry and rainy season

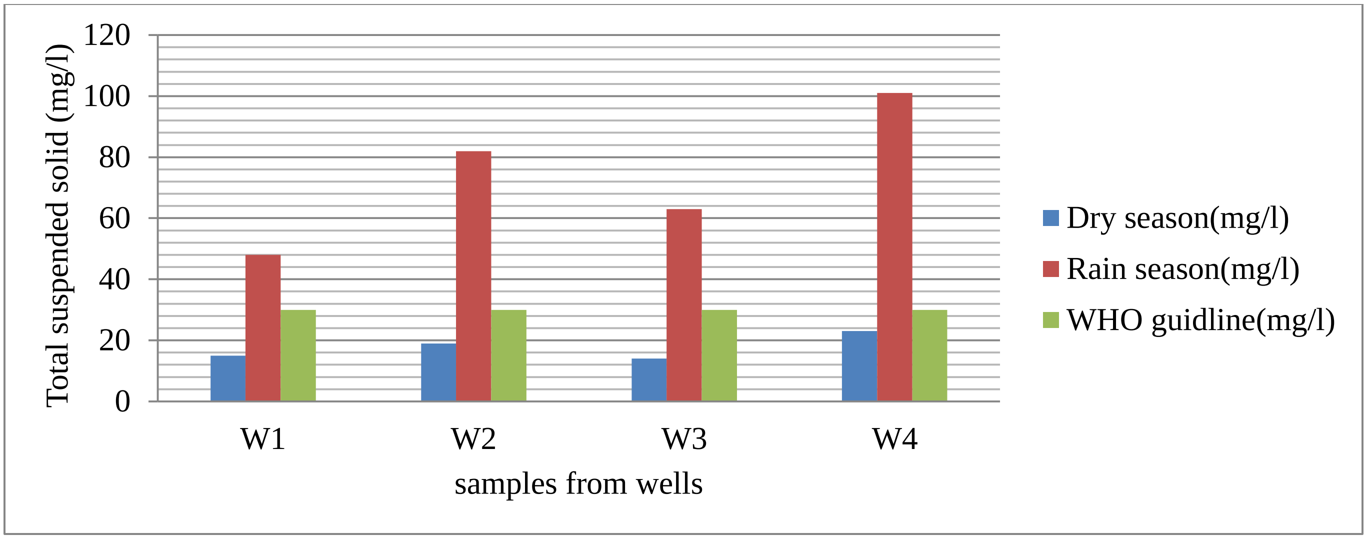

Figure 4-16 TSS from four wells measured during the dry and rainy season

4.5.8. Dissolved Nitrates

The results in Figure 4-17 show that all the sampling points of the stream recorded higher levels (ranging from 4.5-8.5 mg/L) of nitrates than the recommended Ethiopia minister of water and irrigation guidelines of 3.0 mg/l in both the rain and dry season From figure 4-18 wells recorded higher levels (ranging from 2.1 mg/L to 7.8 mg/l) The measured levels of dissolved nitrates for wells during the rain and dry seasons against the recommended Ethiopia minister of water and irrigation advice limit and WHO guideline limit is 5 mg/l. This concurs with “(WHO 2018)” that high concentration of nitrate cause ground and surface water toxic waste by increasing their nutrient levels. When nitrates in domestic water exceed the thresholds, it can result in diseases like methemoglobinemia (blue baby syndrome) in children and nitrosamine in adults. The harmfulness of nitrates comes from the natural reduction of nitrates to nitrites by gastric enzymes in the human system.

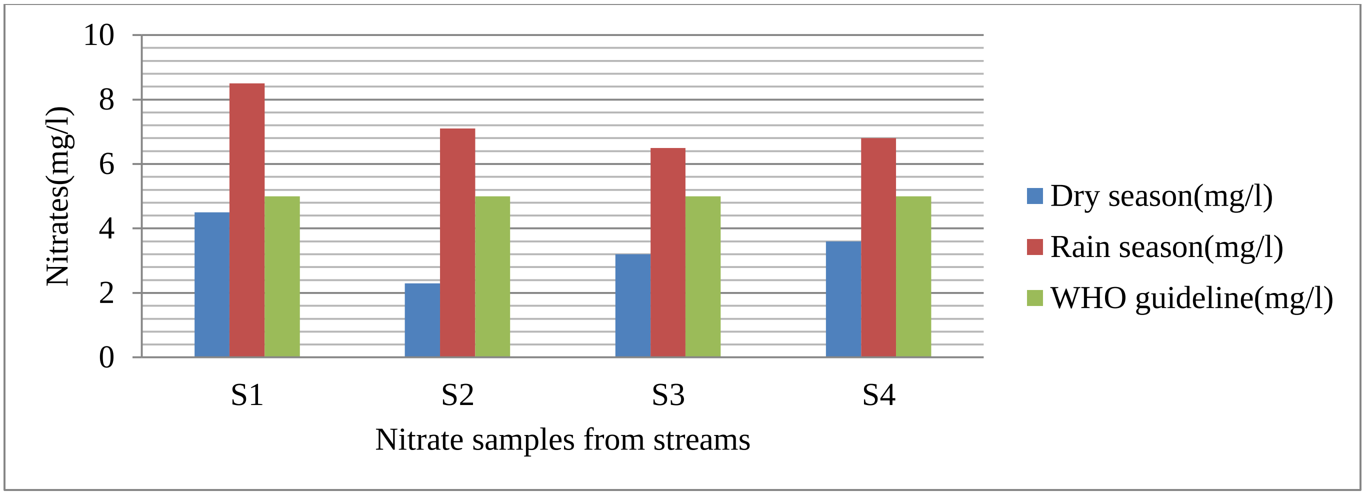

Figure 4-17 Nitrate samples from streams measured during the dry and rainy season

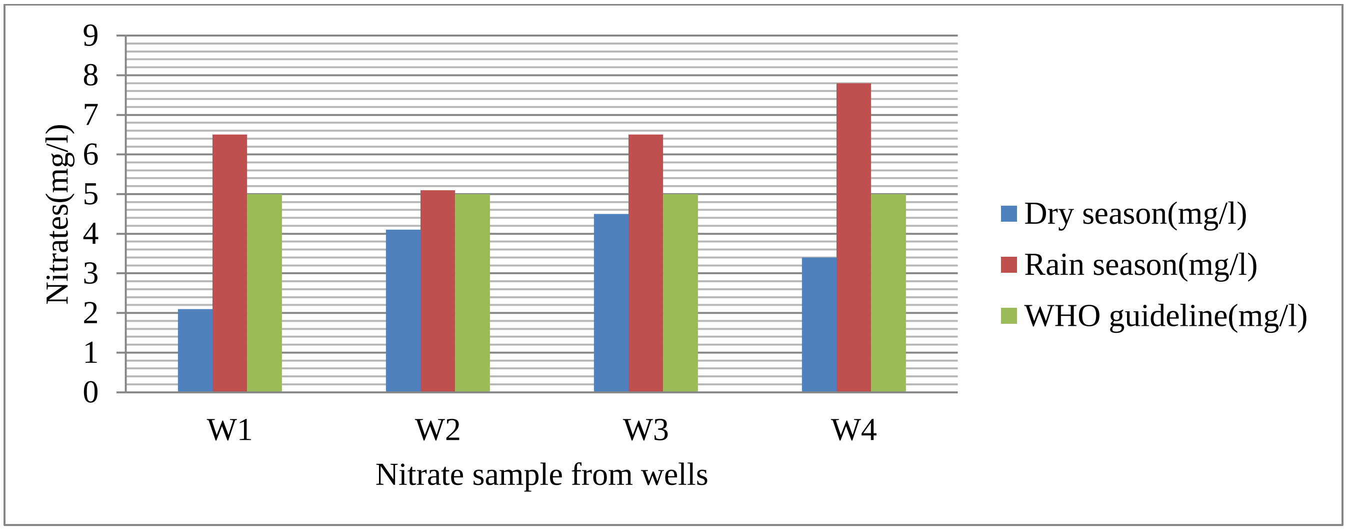

Figure 4-18 Nitrate samples from four wells measured during the dry and rainy season

4.5.9. Total Coliforms

The levels of Total coliforms amounts in-stream and wells were very high both in the rainy seasons and dry seasons in all the samples; all exceeding 600 mg-1 as compared to the Ethiopia minister of water and irrigation guidelines of nil/100ml.The presence of Escherichia coli. Forms in drinking water are reflected through organic indicators like the total coliforms. The Escherichia coliforms originate from the intestinal tract of warm-blooded animals and usually an indicator of the presence of pathogens in water. Their presence in drinking water is of great concern because of the many contaminations they may cause to anthropological beings. This finding is consistent with “(Butt et al. 2007)” that total coliforms may not automatically be injurious to human; though, Conservation Protection Agency (EPA) considers them useful indicators of the presence of pathogens

4.6.Physic-chemical and Bacteriological Analysis of Water Samples from Household

4.6.1. Physic-Chemical Analysis

The water illustrations from domestic containers were physic-chemically and bacteriologically analyzed to determine the water excellence status as it reaches the household container or point of use.

4.6.2. Temperature

The temperature records of the samples from domestic containers were within the range of 21.73^{0}C to 28.74 ^{0}C with the highest record from S5-8 and the lowest form S-8 with the average value of 24.04. The results were comparable to the temperature range of 22.1 ^{0}C to 23.60 ^{0}C records for the samples from household taps. The difference in the temperature records of the water samples from different household containers can be due to the difference in storage styles of the households.

A similar study showed in Bihar Dar town showed a mean temperature of 23.8 ^{0}C "(Genet, 2008)" and a study showed in Woliso town showed a mean temperature of 22.25^{0}C "(Briana, 2016). A somewhat higher temperature of 27.7 ^{0}C was reported from the analysis of water samples from Nigeria "(Odem 2014)". After these studies, we can conclude that since the studies were carried out in the tropics where the climate is categorized by high temperature and precipitation, these elements may have generally contributed to the high-temperature records of the water samples that were above the "(WHO 2018)" limit of <15 ^{0}C.

However, the general extraordinary temperature of the water being supplied to Mizan town is generally attributable to the climatic disorder of the area as deliberated earlier in the segment. In general, the temperature records of the samples from household containers for this study were above the "(WHO 2018)" tolerated limit of <15^{0}C and this harms the palatability of the water. High water temperature enhances the growth of microorganisms and may increase problems related to taste, odor, color, and corrosion (WHO, 2018), and tastelessness decreases as the temperature of the water increases.

Giving to "(WHO (2018)", cool water is in all-purpose more palatable than warm water, and temperature will have an impact on the acceptability of several other organic ingredients and biological contaminants that may affect the taste.

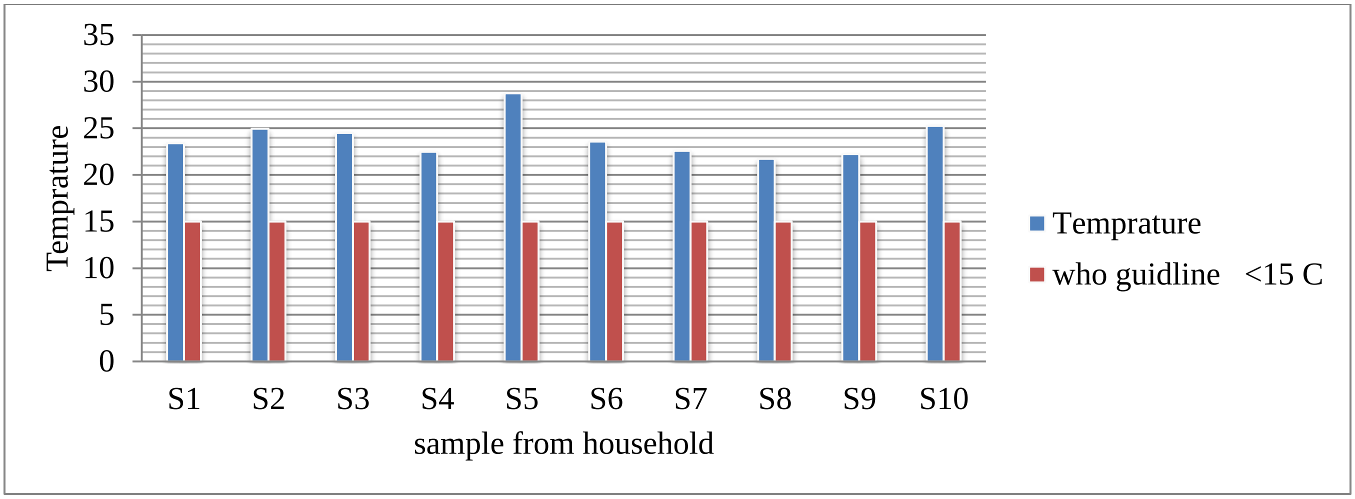

Figure 4-19 Temperature of the water samples collected from household

4.6.3. pH

The pH records from study area household containers were found between 7.24 and 7.84 at the dry season and 6.9-8.1 at the wet season. So the pH records of the samples from household containers were within the WHO and general standard limits of 6.5 to 8.5

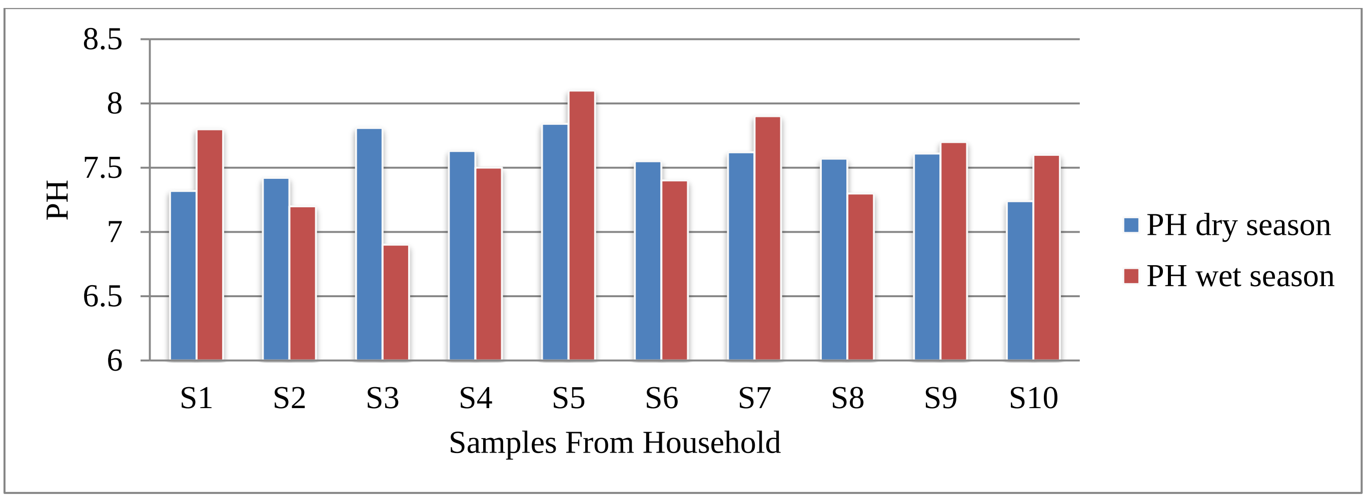

Figure 4-20 pH of household

4.6.4. Total Hardness

Hard water is characterized by high mineral contents that are usually not harmful to humans. It is often measured as calcium carbonate ($CaCO_3$) because it consists mainly of calcium and carbonates the most dissolved ions in hard water. According to World Health Suggestion (WHO, 2018), the hardness of the water should be 500 mg/l. The hardness of the study area ranges from 76.4-200 mg/l which is characterized as soft water according to discussed in the literature review and a similar study was directed in Tameka district of Darussalam, total hardness testified from 30mg/L to 710mg/L (Mengele, 2010). Therefore, according to the literature of the study area improved water supply of Mizan Aman is not harmful to the consumer according to the WHO standards.

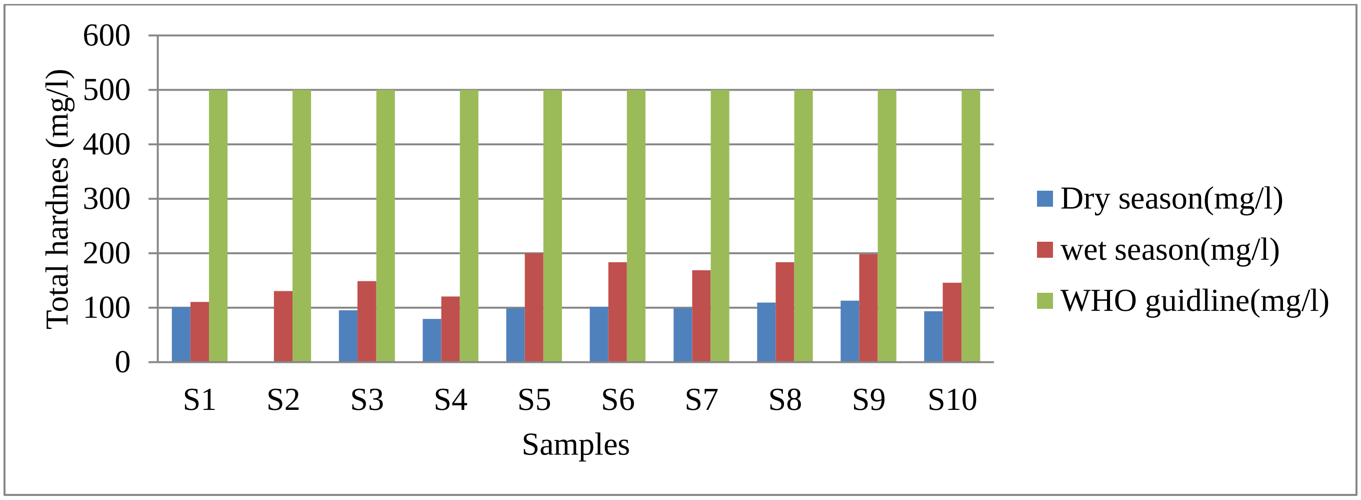

Figure 4-21 Total Hardness from household

4.6.5. Turbidity

Figure 4-22 below shows the results of turbidity of Mizan Aman town water supply during dry and wet season scenarios The turbidity results in the dry season were found to be within the range of 1.00 to 2.3 NTU and were found to lie within the permissible limits of WHO and Ethiopian compulsory limit of <5NTU (ESA, 2013) but for wet seasons it becomes 6.7 to 13.5NTU. The results show that it is much greater than the maximum allowable value recommended by both WHO and Ethiopia recommended values, especially during the wet season.

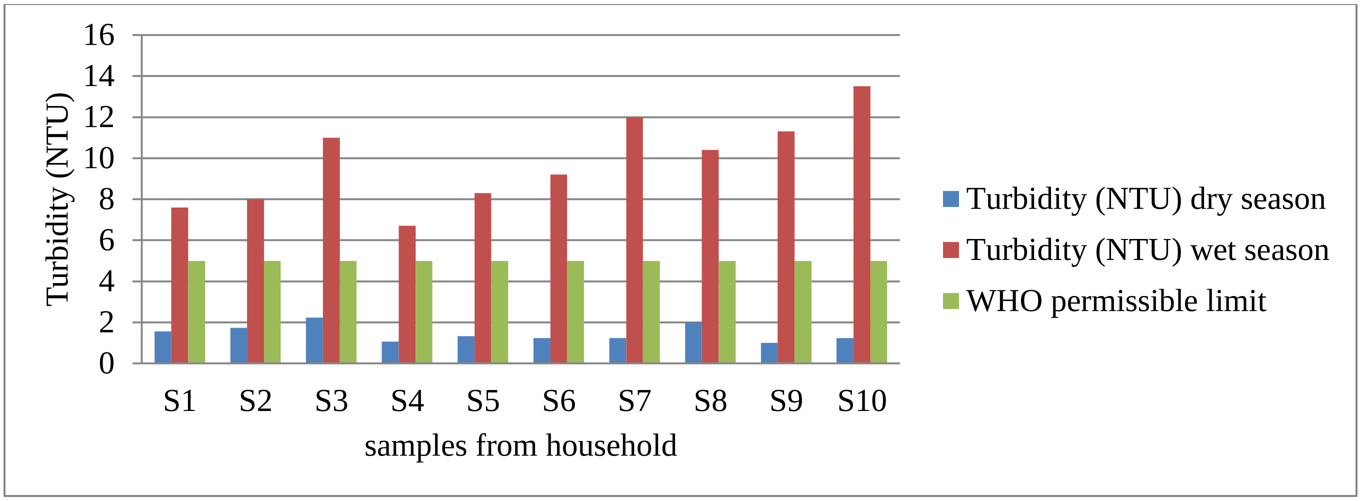

Figure 4-22 Turbidity from households

4.6.6. Color

Generally, color can be classified into two types: true and apparent color. The most common cause of true color is moldy organic material such as dead leaves and grass. This type of color is usually found in surface water. Outward color is produced by inorganic materials, usually iron, copper, or manganese.

When water has a visible color to it, it is usually due to the presence of decaying organic material or inanimate impurities such as iron, copper, or manganese. Limits for color in consumption water are usually set based on artistic concerns. According to the "(WHO 2018)" standard guideline, it should not be more than 15TCU, which is the maximum permissible limit.

Figure 4-23 below illustrations the values of color throughout wet and dry seasons. The result designates that the values are unwarranted than the WHO Maximum Allowable value at wet season.

This is because of the solid wastes landfill from the town drain to the sources of water supply by overflow during rainy season due to lack of proper solid waste disposal site selections

The color in water does not pose any health risks. However, there are some exceptions. If the color is due to a metal pollutant, such as copper, mild intestinal symptoms may result. We can see that the main causes of color in the study area may be due to the decaying of gradual and inorganic material from the landfill site.

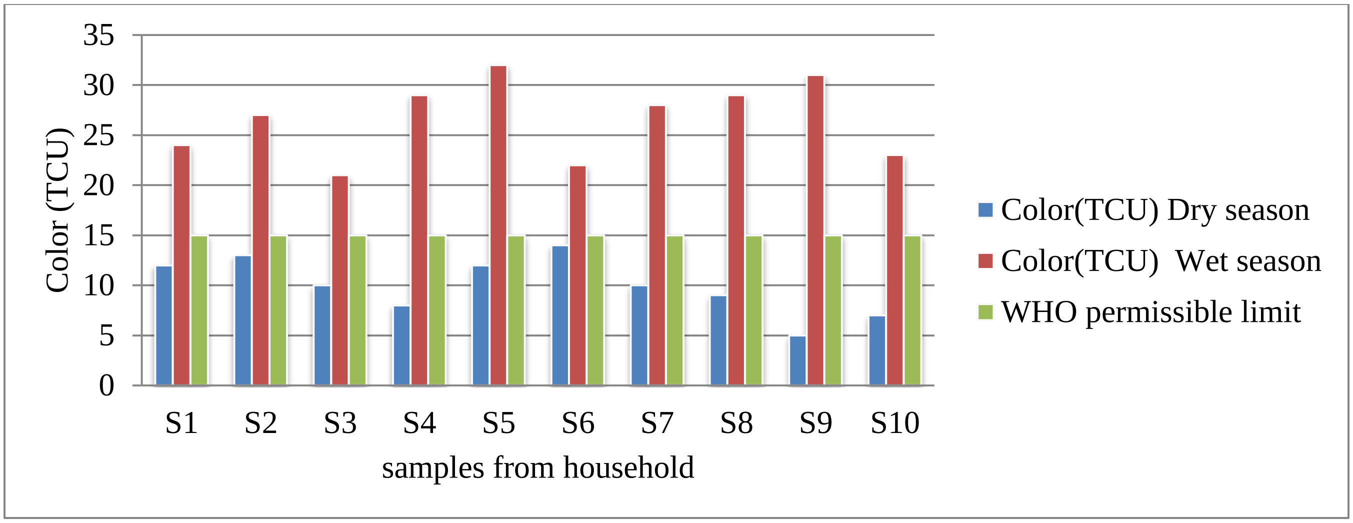

Figure 4-23 color samples results

4.6.7. Total dissolved solids (TDS)

In consumption water, total dissolved solids are principally made up of inorganic salts with small concentrations of organic matter. Contributing ions are mainly carbonate, bicarbonate, chloride, Sulfate, nitrate, potassium, calcium, and magnesium. The major contribution to total dissolved solids in water is due to the ordinary contact with rocks and soil. Minor assistances to TDS are from pollution including urban runoff. In some cases, however, considerable impact occurs from snow and ice control on roads in winter.

The TDS tests are considered to regulate the general quality of water. From fig 4-24 below the TDS values found in water supply systems range from 101 to 131 pm at the dry season and 163-190 ppm at wet seasons. The well-being risks are not significant as the values of TDS is much less than 1000 ppm, which is the WHO standard thoroughgoing acceptable limit

Figure 4-24 TDS Results from household containers

4.6.8. Electrical conductivity (EC)

Electrical Conductivity (EC) was a display of total dissolved salts (TDS). It establishes if the water is drinkable and capable of satisfying thirst. The conductivity of potable waters varies generally from 50 to 1500 µmhos/cm. The conductivity of Municipal Solid waste may be near to that of the potable water. However, the industrial wastewaters may have conductivities above 10000 µ mhos/cm. According to WHO standards, the EC value of consumption water supply should not be exceeded 1000µS/cm.

The result describes that the EC values of Mizan Aman town water supply vary from 229 to 399 µS/cm during the dry season and 424.7 to 476.2 µS/cm during the wet season, which is below the WHO guideline ate dry season and also for the wet season which is shown in figure 30. These results indicate that the water in the classifications are characterized by low ionized and has a low level of ionic awareness movement due to low concentrations of dissolved solids

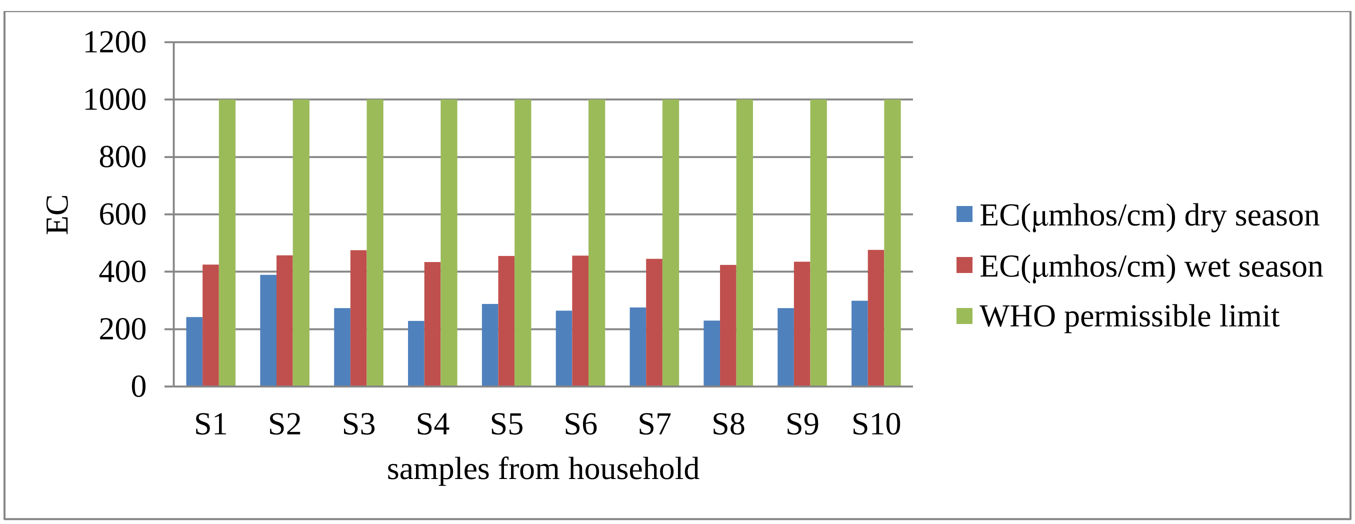

Figure 4-25 Electrical Conductivity samples results

4.6.9. Odor and Taste

The presence of organic compounds in water is the primary cause of odors. Some odors indicate greater biological activity, while others could be the result of industrial contamination. Sanitary inspections should always include a study of potential or current causes of odor, and challenges to rectify an odor problem should always be made. Taste is probably the most common cause of consumer dissatisfaction. In general, inorganic metal compounds such as magnesium, calcium, sodium, copper, iron, and zinc are distinguished by taste buds in the oral cavity. Water should not be offensive to the majority of customers since it should be devoid of objectionable flavor and odor. .

4.6.10. Iron

The iron registers for the samples from household bottles were found to be in the range of 0.20 to 0.31 mg/l, and the chronicles from all of the samples were determined to be within the WHO and domestic standard maximum allowable level of 0.3 mg/l (ESA, 2013). When compared to the iron records from tap water and tasters from wells and streams, the iron records from residential containers indicated a lower iron concentration.

4.6.11. Manganese

Manganese concentrations, for the water sample from household containers at dry seasons, were within the range of 0.01 to 0.12 mg/l and an average of 0.04mg/l which were found to be compliant with the WHO and national health-based guidelines value. Manganese meditations, for the water sample from domestic containers at rain seasons, were within the range of 0.9-2.7mg/l and an average of 1.66mg/l it is not adequate at rain seasons. According to "(WHO 2018)", manganese is used primarily in the manufacture of iron and steel alloys, as an oxidant for cleaning, bleaching, and disinfection (as potassium permanganate), and as an ingredient in various products.

At heights, more than 0.1 mg/l, manganese in water supplies causes an undesirable taste in beverages and stains hygienic ware and laundry. Concentrations below 0.1 mg/l are usually acceptable to consumers. The health-based value of 0.4 mg/l for manganese is higher than this satisfactoriness threshold of 0.1 mg/l "(WHO, 2018)".

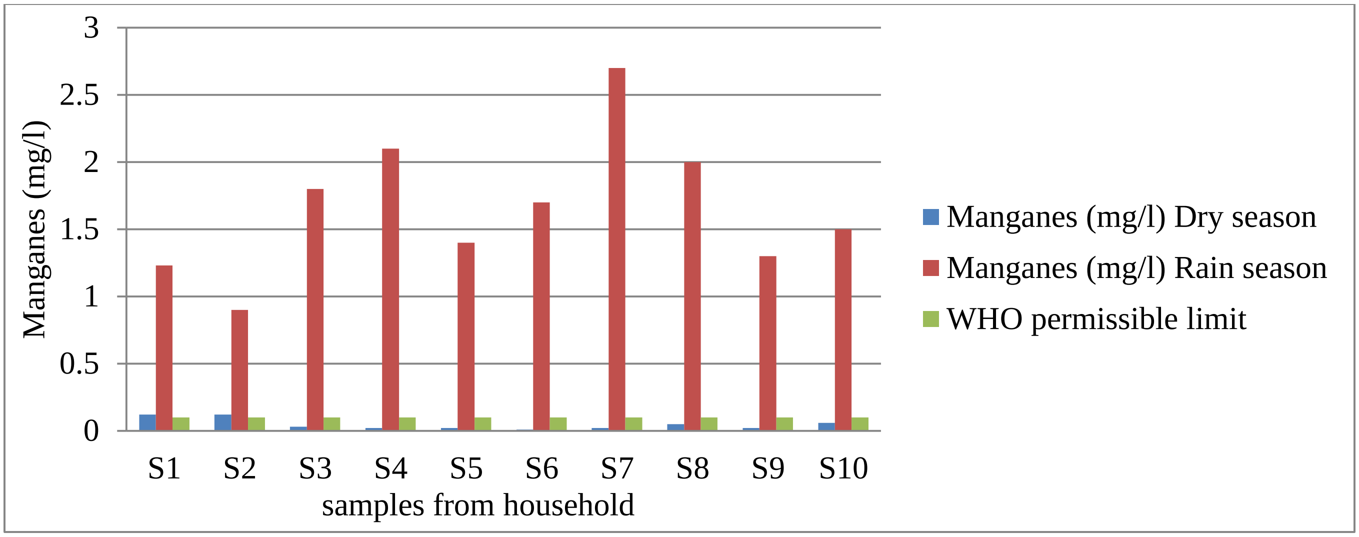

Figure 4-26 comparison of the average values of manganese from household

4.6.12. Nitrate and Nitrite

The nitrate Lab result from the study area lies between 1.00 mg/l-1.33 mg/l at the dry season and 5.5mg/l-8.8mg/l found within the prescribed limit of WHO permissible limit at the dry season and above at wet season

This shows tricking site is directly affects the water supply system during the wet season by runoff which can affect health problems. A similar study reported in window genet district of nitrate range from 0.9 to 1.27 mg/l (Haile Michael and Mages, 2012) which shows that the Nitrate range of study area was 0.06-1.3mg/which Indicates pollution-free, good water quality wise and suitable for drinking purpose at dry season but 5.5mg/l-8.8mg/l at wet season affects human health such as headaches, dizziness, flushing of your face and neck, upset stomach or throwing, low blood pressure, and irregular heart rhythms.

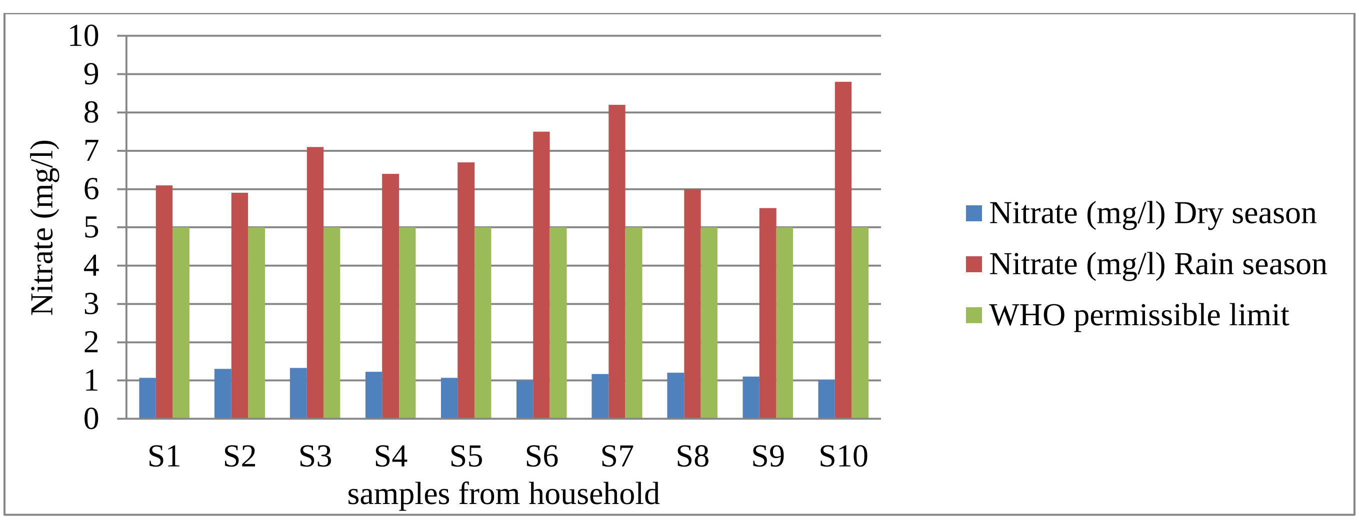

Figure 4-27 Nitrate lab results at the dry and rainy season from household

4.6.13. Phosphate

Phosphates in surface waters mostly originated from sewage effluents, which contains phosphate, based synthetic cleaners, from manufacturing sewages, or from land runoff where inorganic fertilizers have been used in agroindustry. Groundwater usually contains insignificant concentrations of phosphates, unless they have become polluted. Phosphorous one of the crucial nutrients for algal growth and can contribute meaningfully to the eutrophication of lakes and reservoirs "(Alan et al., 2000)".

The implication of phosphorous lies in its capability to cause eutrophication in water in presence of other nutrients, particularly nitrogen. The quality principles of phosphorous in waters in only to check the unwanted algal growth, in the study area range phosphate is 0.09-0.42mg/l at the dry season which means it is acceptable and no health special effects but for the wet season it becomes 2.2-2.9mg/l this show the amount phosphate in consumption water is above the level of limit given by WHO

Figure 4-28 Phosphates lab results at dry and wet season

4.6.14. Fluoride

fluoride may be released by industrial pollution, the majority of fluoride found in drinking-water supplies at levels of health concern is derived from natural sources (e.g. fluoride-containing minerals). Fluoride should always be analyzed during source development, in particular for groundwater sources. Fluoride can be determined by using a spectrophotometer or color comparator; it can be determined by these methods in the laboratory or by the use of ion-specific electrodes. For fluoride, WHO has set a health-based guideline value of 1.5 mg/l "(WHO, 2018)", There are important health effects of long-term exposure to fluoride in water. Higher amounts of fluoride between 1.5–4. Mg/L can cause dental fluorosis. Very high amounts of fluoride greater than 10mg/L can lead to skeletal fluorosis. This is why the WHO proposes that drinking water should not have more than 1.5 mg/L of fluoride.

In study areas, effects show that the concentration of fluoride ranges from 0.02-0.04 mg/l this shows no health difficulty affording to the WHO Guide value.

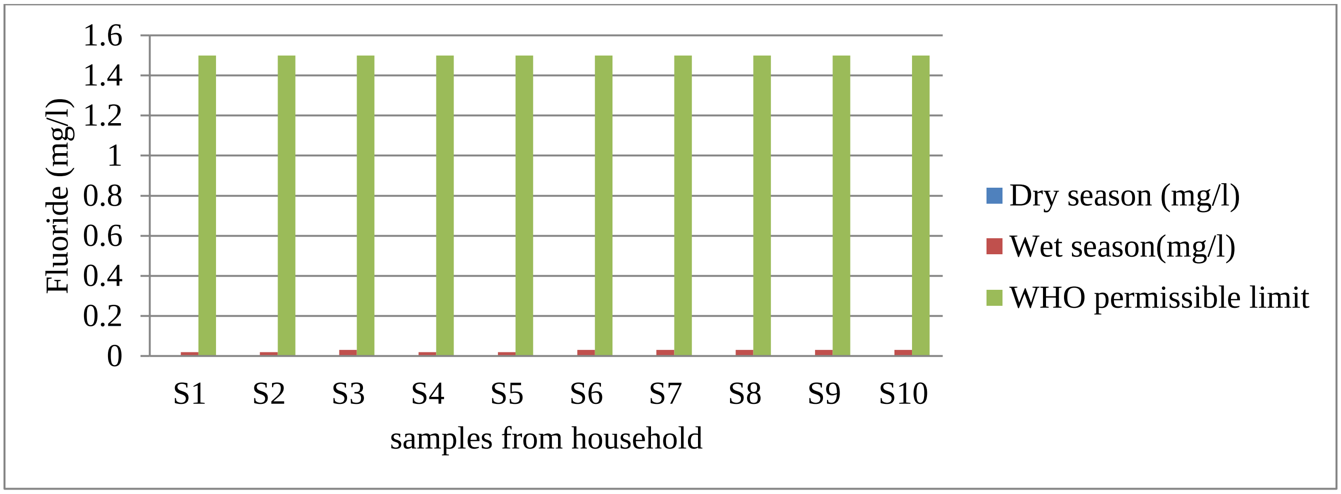

Figure 4-29 Fluoride measured at dry and wet season

4.7.Bacteriological quality of water Samples from Household Containers

Samples from household containers were examined to determine the presence of pointer organisms and to evaluate the microbiological quality of the water at the point of use during dry and wet seasons. All samples from domestic bottles were found to be affirmative for Total Coliform with a TC count zero at dry season but for the wet season it becomes 2-12 TC which is above the WHO and National limit of 0 CFU/100ml this means water was polluted at the wet season by excess because of poor solid waste dumping and management

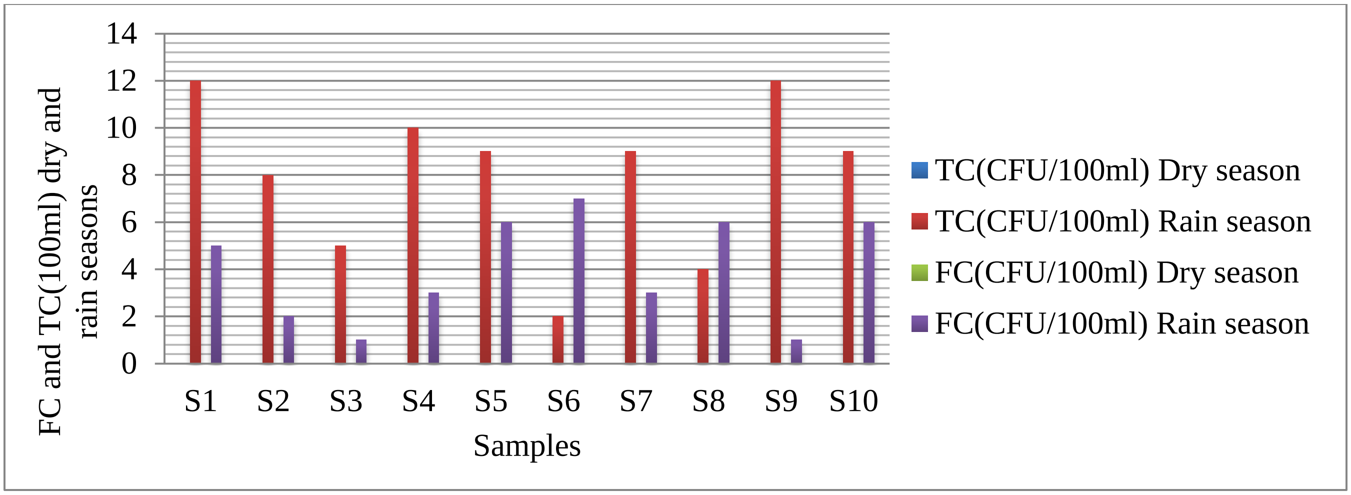

Figure 4-30 Total coliform and fecal coliform samples

The results of bacteriological analysis for samples from household containers showed that the water used for domestic purposes including drinking in the study area was of poor quality micro-biologically during the wet season and the pollution is partially due to poor solid waste administration practices and partly due to lack of disinfection of the water supplied to the town by the Water Supply Office. According to "(UNICEF 2017)", contamination of water often occurs during the transportation of water to the home and in the home himself. Such contamination is linked to cleanliness awareness and practices of water bearers and family members and, in some cases, to the availability of suitable receptacles and utensils (e.g., closed water jars and long-handled ladles).

The generally microbiological examination for the study area indicated there was increasing bacteriological water quality during rain season The water quality deterioration was more serious at the household containers (point of use) and this is an indicator for unfortunate solid waste management and storage practices at the household level in the study area which was further interested by the lack of any poor solid waste management system.

4.8.Correlations between Physic-chemical Parameters in walls and Stream Water and Distance from Dumpsite

From summarizing correlations between the Physic-chemical parameters in the stream water and the distances of the sampling points from the dumpsite and the sign of (r) denotes the nature of association while the value of (r) denotes the strength of association. If r = Zero this means no association or correlation between the two variables. If $0 < r < 0.25$ = weak correlation. If $0.25 \leq r < 0.75$ = intermediate correlation. If 0.75 ≤ r < 1 = strong correlation. If r = l = perfect correlation. The results show that except for Manganese, a positive correlation was observed between the levels of each Physical parameter and the distance from the dumpsite in both the dry and wet seasons.

If 2 variables are of the quantitative type, one variable is called the independent and denoted as (X) variable and the other is called the dependent and denoted as (Y) variables to find the relation between x and y computes the simple correlation coefficient using the following formula:

$$r = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sqrt{\left(\sum x^2 - \frac{(\sum x)^2}{n}\right)\left(\sum y^2 - \frac{(\sum y)^2}{n}\right)}}$$

……….equatio

Where r=correlation coefficient

X= independent variable

Y= dependent variable

n= sample size

4.8.1. Total Dissolved Solids (TDS) in Stream Water and wells

Figure 4-31 shows the correlation of TDS in streams during the dry and wet seasons as a function of distance from the dumpsite. Figure 4-32 the correlation of TDS in wells during the dry and wet seasons as a function of distance from the dumpsite. This shows that a concentration was increasing from upstream to downstream of the dumpsite, therefore, this is a valuable indicator that there are mineralized solids from the dumping site that percolated in stream water with rainwater. The correlation between distance and level of TDS in dry and wet season at the stream is (r=0.00652) which is a weak correlation and from well are (r=0.57735) this result shows direct intermediate correlation. Total Dissolved Solids recorded in the stream water in the range of between121-191 mg/L were much lower than those found by Mohammed (2011) and Ohwoghere-Asuma and Aweto (2013).

Table 4-5 the Regression, t-stat, and p-values of TDS from streams at wet and dry season

Streams	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	210.81	809.73	0.26	0.84	10,499.3	10,077.7	10,499.3	10,077.7
121.00	3.19	6.73	0.47	0.72	82.30	88.68	82.30	88.68
wells								
Intercept	208.33	1,390.94	0.15	0.91	17,465.28	17,881.94	17,465.28	17,881.94
137.00	0.25	10.54	0.02	0.98	134.13	133.63	134.13	133.63

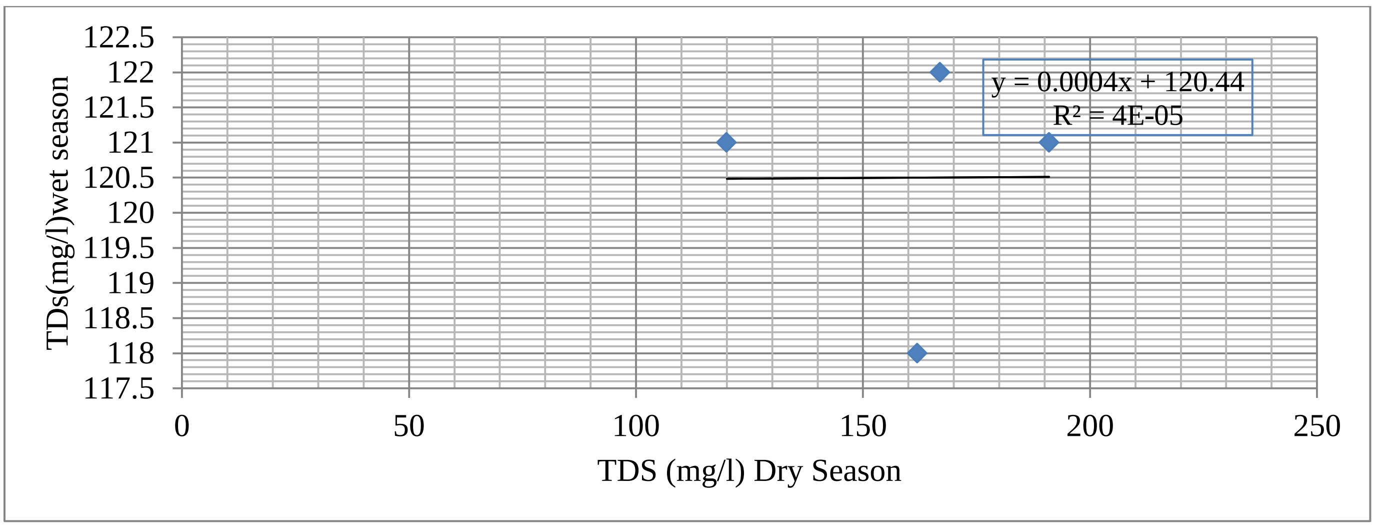

Figure 4-31 correlation of TDS in stream water at dry and wet season

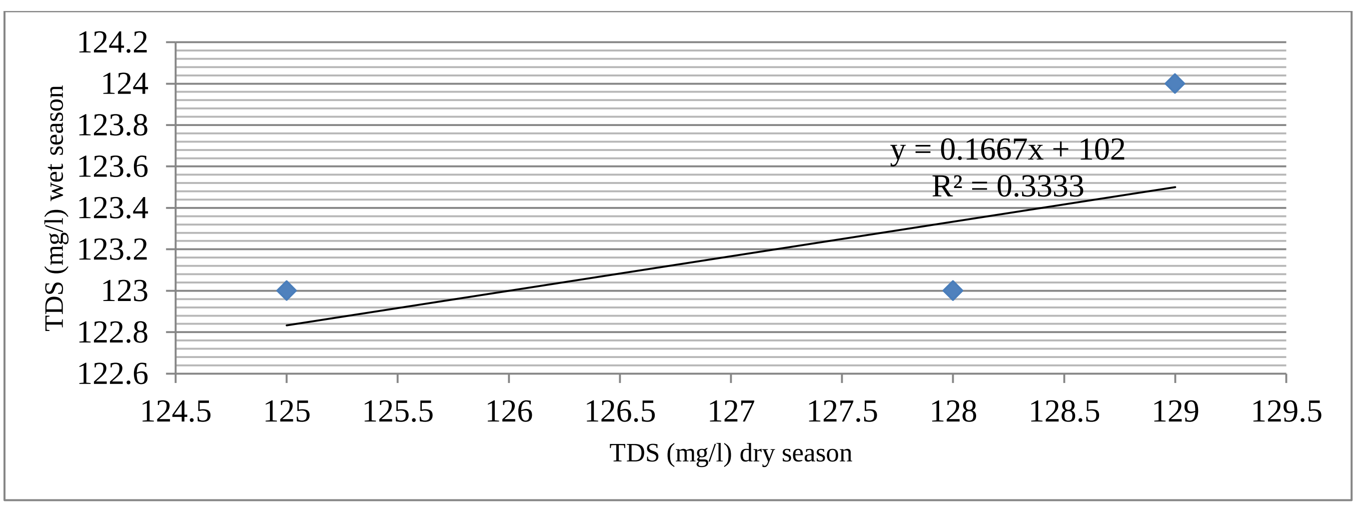

Figure 4-32correlation of TDS in wells at dry and wet season

4.8.2. Electrical Conductivity in Stream Water and wells

Changes in electrical conductivity (EC) in stream water concerning distance from the dumpsite are shown in Figure 4-33 (dry and wet season) The results of Figure4-33 and Figure 4-34 both reveal negative correlations between electrical conductivity and the distance from the dumpsite. Electrical conductivity along with the stream declines as one moves upstream. However, these correlations were not significant (r=-0.0873) indirect intermediate correlation and (r=-0.0151) this result shows strong correlation respectively for both stream water and wells.

Table 4-6 The Regression, t-stat and p-values of EC from streams at wet and dry season

Streams	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	237.3	183.8	1.29	0.41	-2098.2	2572.9	-2098.2	2572.9
161.1	-0.31	1.16	-0.26	0.83	-15.13	14.5	-15.1	14.5
Wells								
Intercept	237.36	183.8	1.29	0.41	-2098.2	2572.9	-2098.2	2572.9
161.1	-0.310	1.16	-0.26	0.83	-15.13	14.5	-15.13	14.51

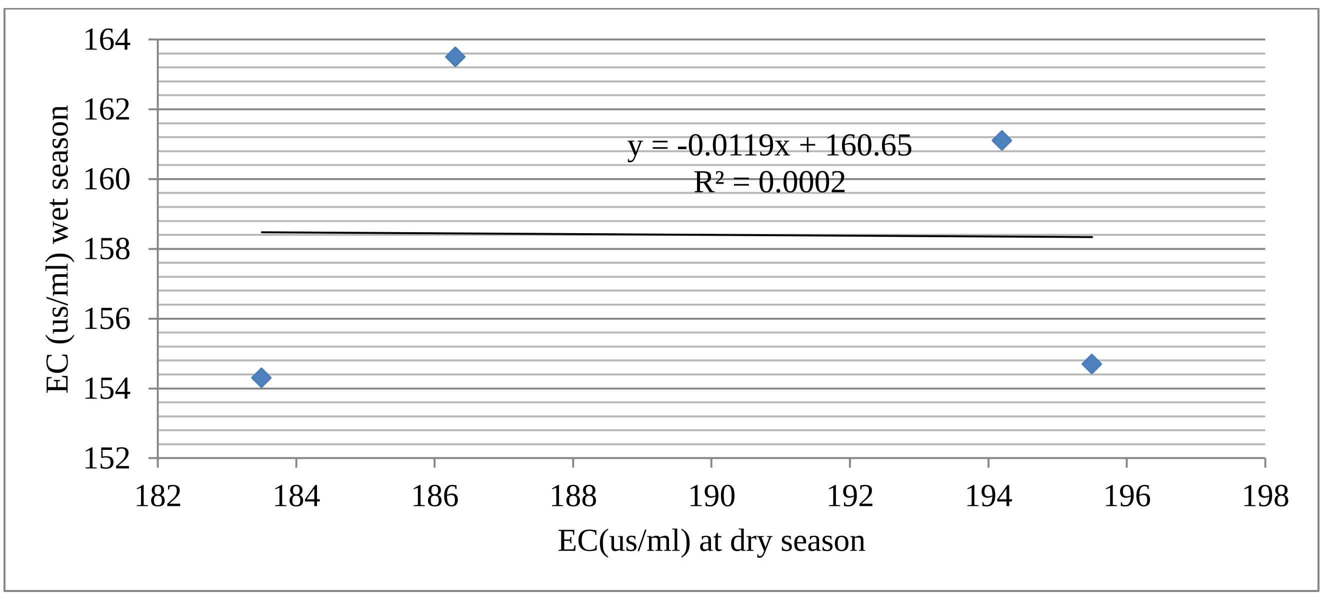

Figure 4-33 correlation of EC in streams water at dry and wet season

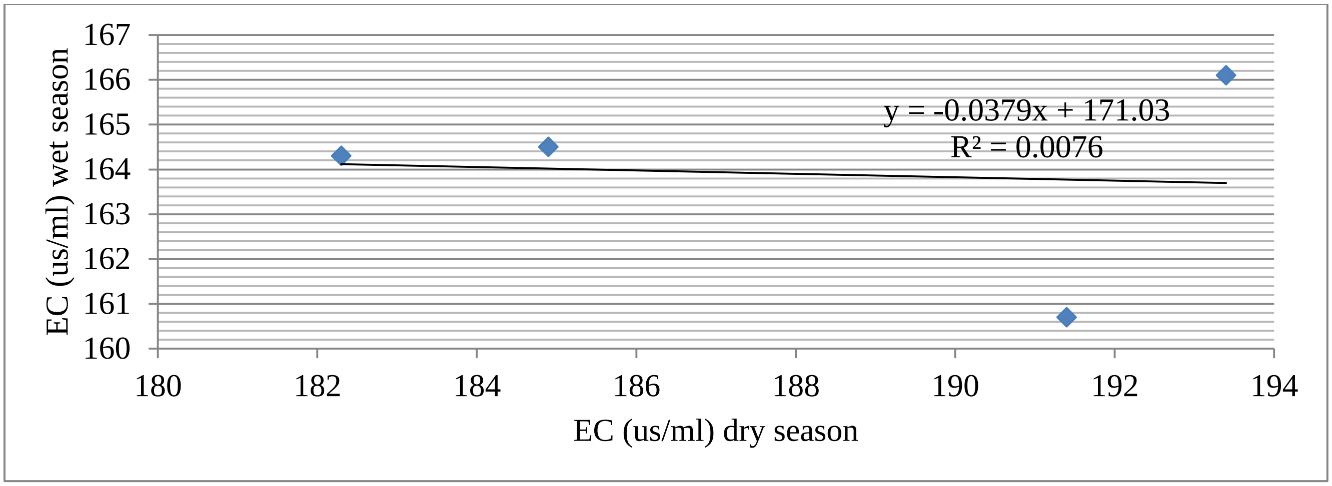

Figure 4-34 correlation of EC in wells dry and wet season

4.8.3. Nitrates in Stream Water and wells

The results of the correlation analysis between levels of nitrates in the stream water and the distance from dumpsite as well as wells water and the distance from dumpsite are presented in Results shows a negative insignificant correlation of nitrate levels for wells and positive for streams. This shows that a concentration was increasing from upstream to downstream of the dumpsite, therefore, this is a valuable indicator that there are mineralized solids wastes from the dumping site that percolated in stream water with rainwater. The correlation between distance and level of Nitrate level in dry and wet season at the stream is (r=0.82) which is a direct strong correlation and from well are (r=-0.204) this result shows indirect weak correlation.

Table 4-7 the Regression, t-stat and p-values of nitrate from streams at wet and dry season

Streams	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	13.18	9.05	1.456	0.383	-101.8	128.23	-101.8	128.23
2.1	-1.65	2.23	-0.74	0.593	-30.03	26.720	-30.036	26.72
Wells								
Intercept	13.18	9.054	1.456	0.383	-101.8	128.2	-101.8	128.23
2.1	-1.65	2.23	-0.742	0.59	-30.03	26.72	-30.03	26.720

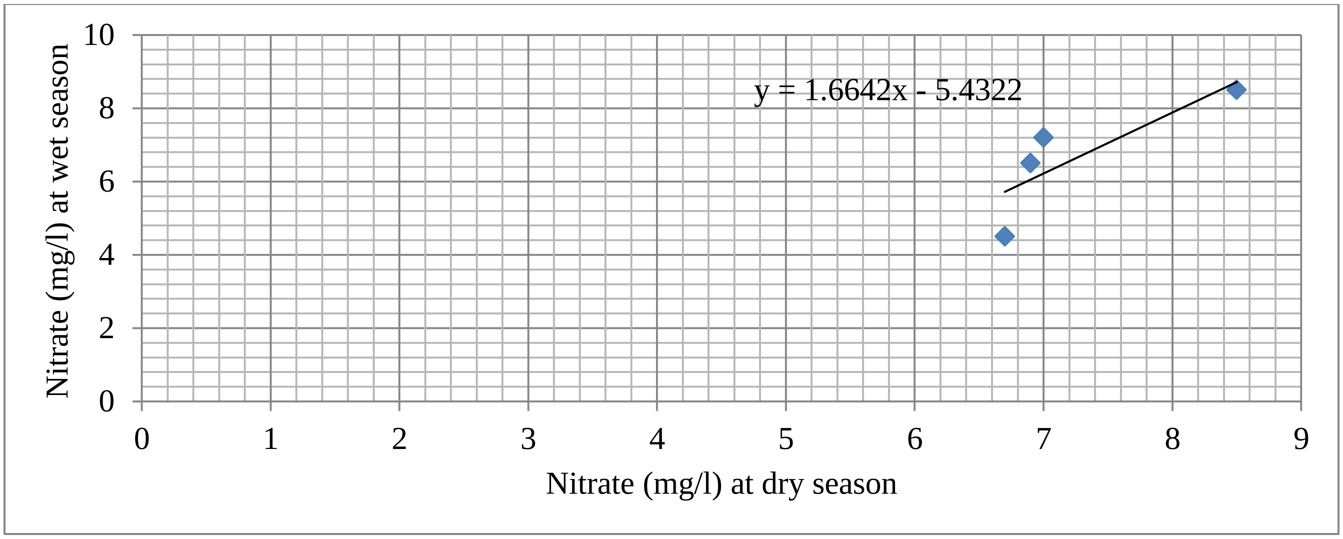

Figure 4-35 Correlation of Nitrate in stream water dry and wet season

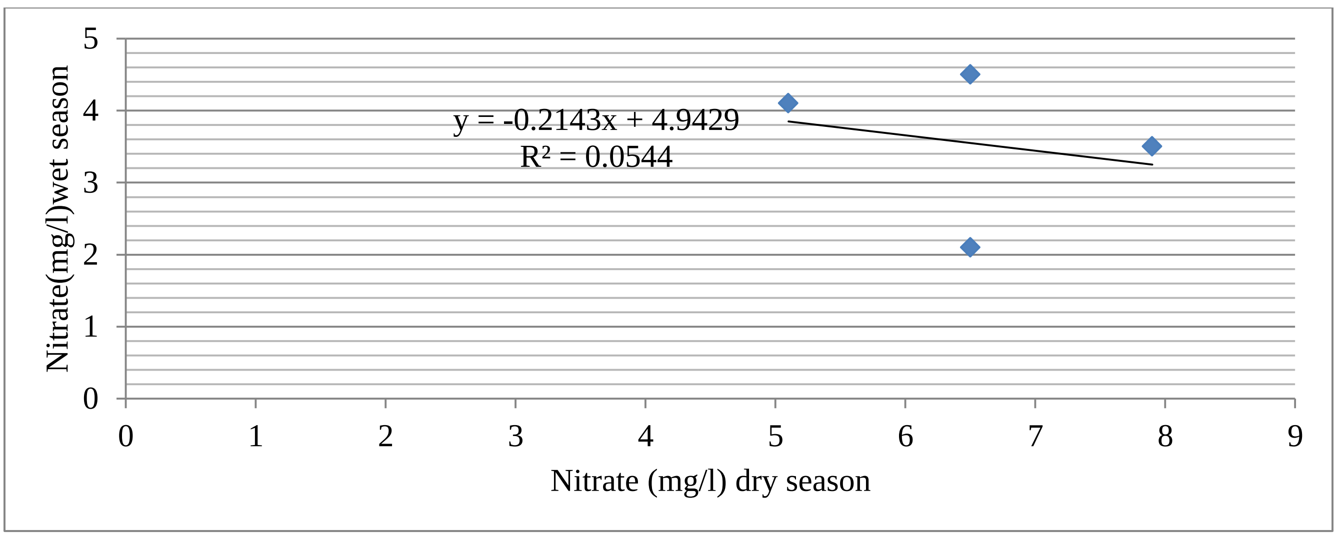

Figure 4-36 Correlation of Nitrate in the wells dry and wet season

4.8.4. Manganese in stream water and Wells

Figure 4-37 and 4-38 shows how the levels of manganese differed in the stream concerning the distance of the stream water and wells from the dumpsite. This shows that there was a positive though significant correlation between the levels of manganese and distance of the streams and wells from the dumpsite with a correlation coefficient of (r= 0.85) direct intermediate correlation and (r= 0.82) direct weak correlation respectively. Manganese levels decreased as one moved from the downstream towards the upstream streams and wells.

Table 4-8 the Regression, t-stat and p-values of Manganese from streams at wet and dry season

Streams	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	5.515275	3.531	1.5615	0.36	-39.36	50.39	-39.36	50.3
0.45	2.614	8.28	0.31547	0.805	-102.67	107.90	-102.6	107.9
Wells								
Intercept	6.207	0.054	113.9	0.005	5.515	6.89	5.515	6.89
8.5	0.108	0.008	12.3	0.051	-0.003	0.220	-0.003	0.220

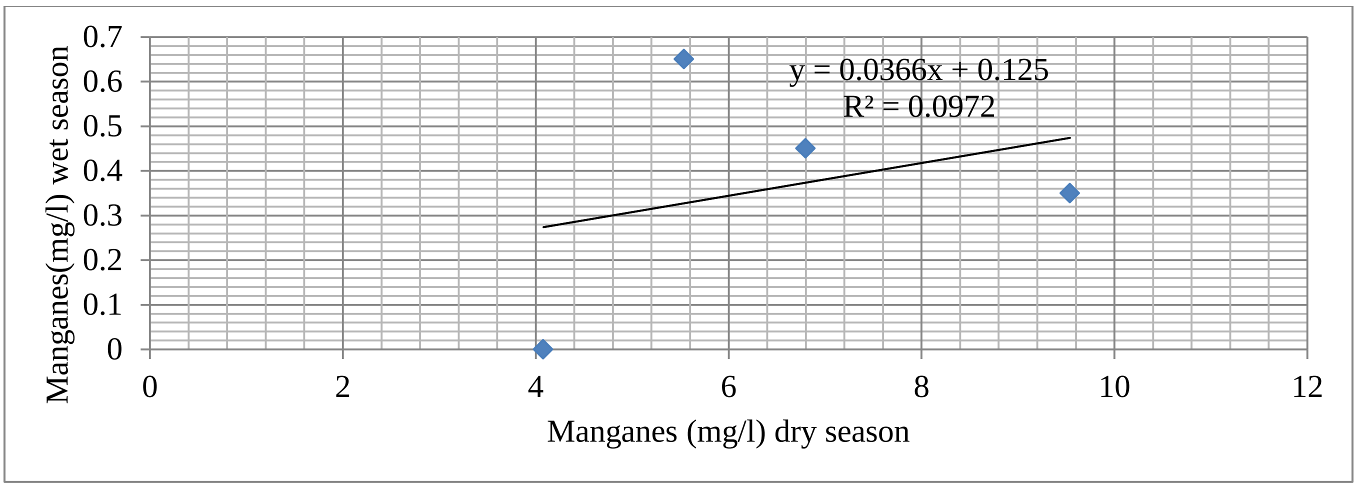

Figure 4-37 Correlation of Manganese in stream water at dry and wet season

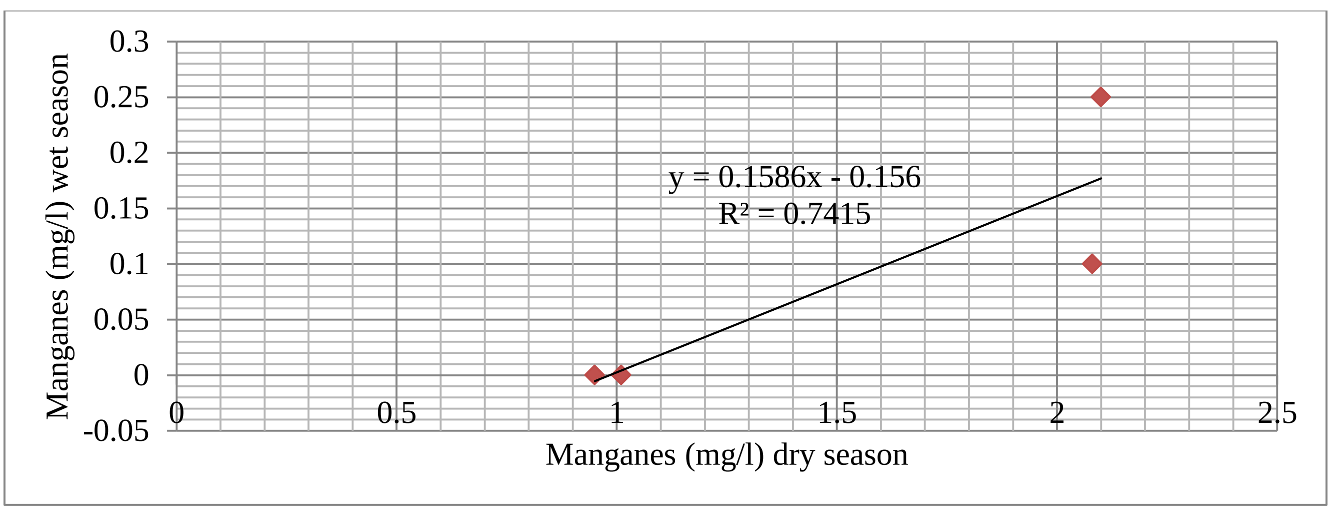

Figure 4-38 Correlation of Manganese in wells at dry and wet season

4.8.5. pH in streams water and Wells

Figure 4-39 shows the trend in pH in the streams during the dry and wet seasons while Figure 44 shows the trend in pH throughout the wet and dry seasons. Results in both Figure 4-40 and Figure 4-41 show that the pH was the same in all the wells during the dry and wet seasons. The pH correlate significantly with the distance of the streams are (r=-0.41) which is an intermediate correlation and for well (r=-0.79) which is also a strong correlation

Table 4-9 The Regression, t-stat and p-values of pH from streams at wet and dry season

streams	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	9.37	3.56	2.62	0.23	-35.9	54.6	-35.92	54.6
7.2	-0.28	0.49	-0.57	0.6	-6.57	6.0	-6.57	6.00
wells								
Intercept	9.37	3.56	2.62	0.23	-35.92	54.66	-35.92	54.6
7.2	-0.28	0.49	-0.57	0.66	-6.57	6.002	-6.57	6.00

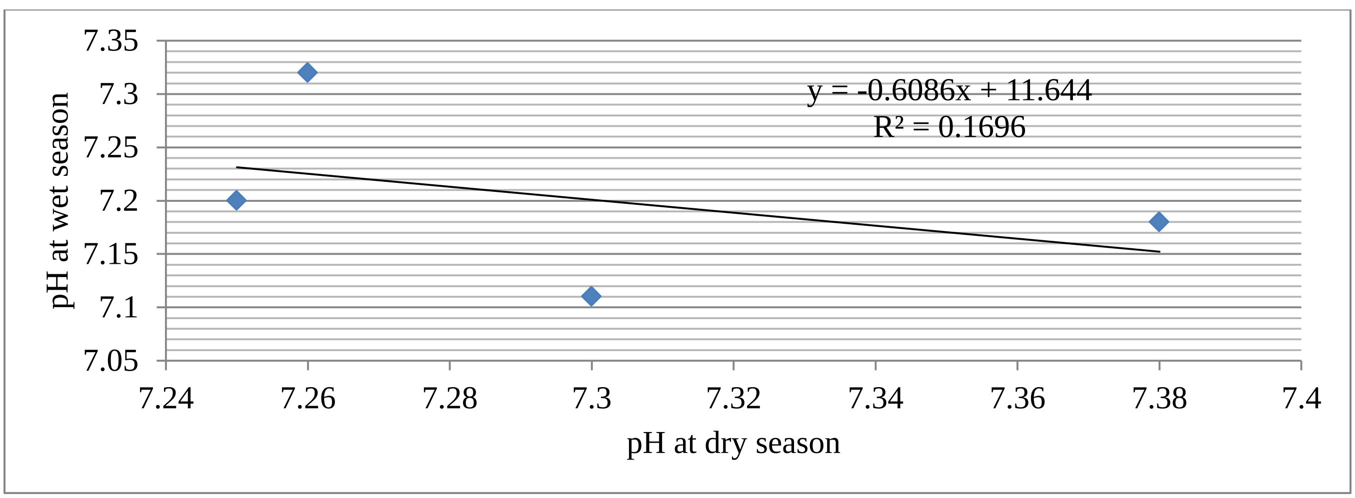

Figure 4-39 correlation of pH in streams at dry and wet season

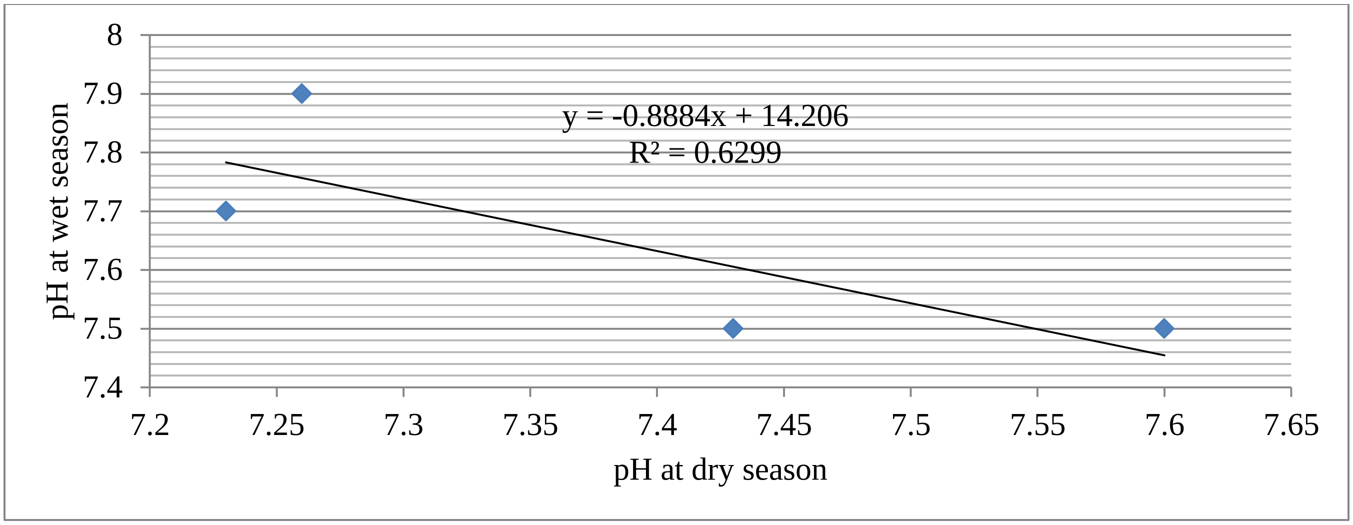

Figure 4-40 Correlation of PH in wells at dry and wet season

4.8.6. The temperature in Well and streams Water

The trends in temperature in stream water and well the distance from the dumpsite in dry and wet seasons are depicted in Figures 4-41 and Figure 4-42 respectively. Both Figures 4-41 and 4-42 shows that during the dry and wet season in both stream water and wells, there was a negative correlation between the temperature of streams and wells water and the distance of the wells from the dumpsite although the correlation was not significant (r=-0.778) indirect intermediate correlation and (r=-0.5943) which is an indirect strong correlation for streams and wells respectively.

Table 4-10 the Regression, t-stat and p-values of pH from streams at wet and dry season

Streams	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	35.02	12.65	2.76	0.22	-125.7	195.8	-125.7	195.8
19.21	-0.67	0.64	-1.04	0.48	-8.81	7.47	-8.81	7.47
wells								
Intercept	674.18	246.9	2.72	0.22	-2464.1	3812.5	-2464.1	3812.5
383.3	-0.49	0.65	-0.75	0.588	-8.76	7.78	-8.76	7.78

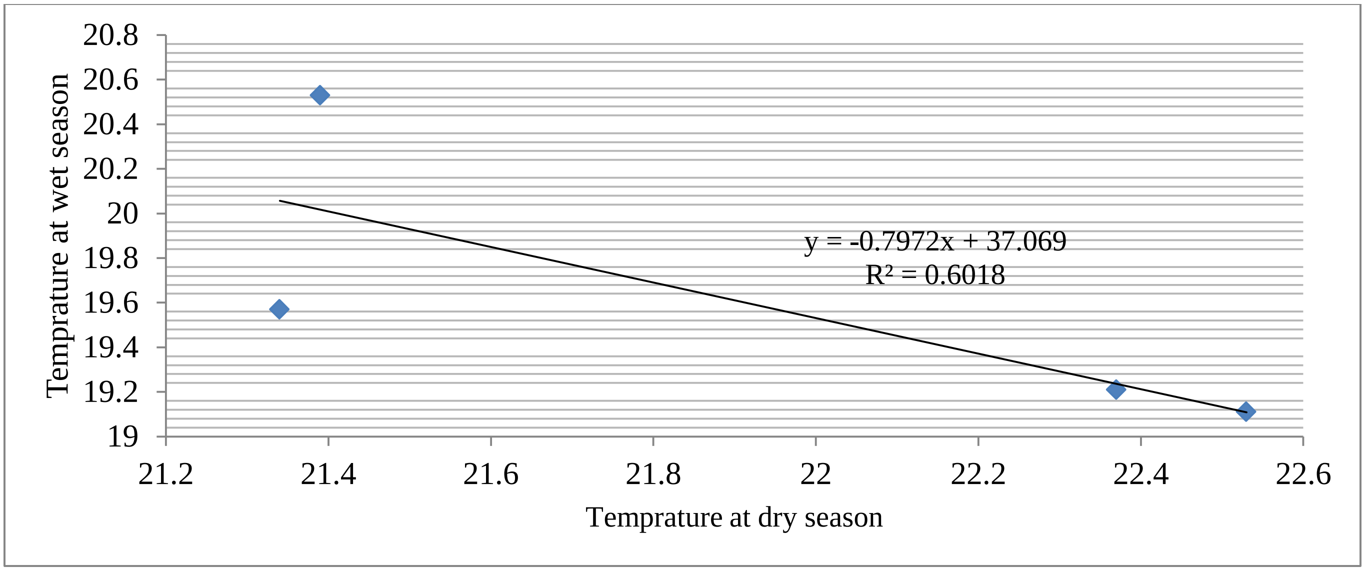

Figure 4-41 Correlation of temperature in streams at dry and wet season

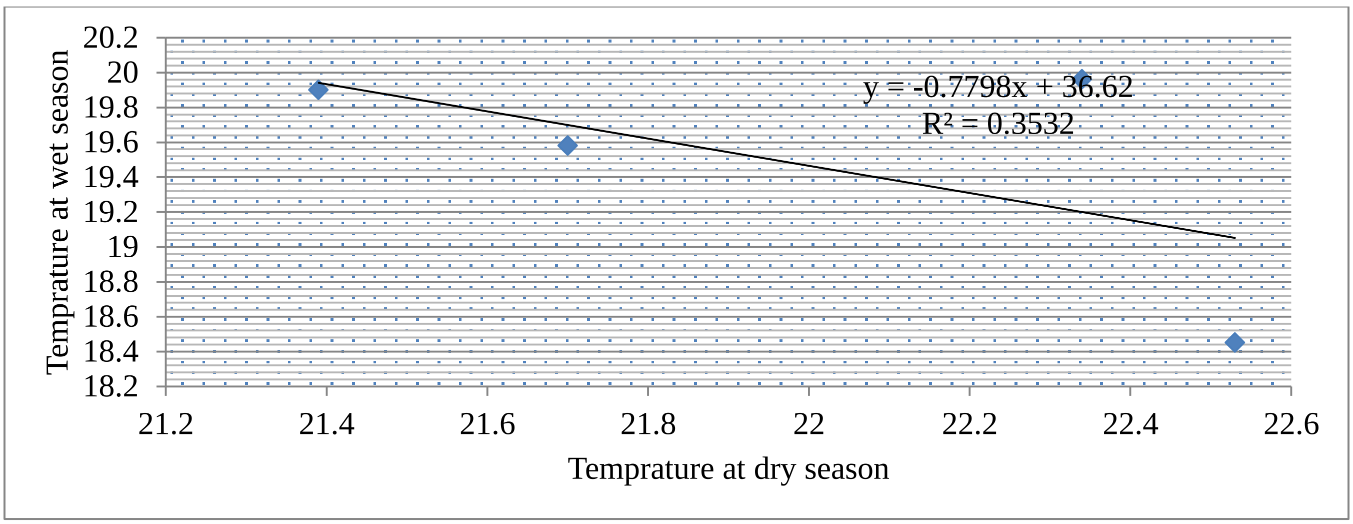

Figure 4-42 Correlation of temperature in wells dry and wet season

CHAPTER 5

5. CONCLUSIONS AND RECOMMENDATIONS

5.1.CONCLUSIONS

It was decided that the Mizan Aman community dumping site, was found prone to groundwater and surface water contamination through leaching action. The Physic-chemical parameters measured show that other than the pH, total hardness, electrical conductivity, TDS, iron, fluoride odor, and taste, all other concentration values exceeded the Ethiopia minister of water and irrigation guidelines for drinking water and WHO guideline. The presence of a high load of bacteria in both surface and groundwater samples means that leachate is altering the water quality of water in the vicinity of the dumpsite. The bacteriological concentration of water from all sampling sites exceeded the Ethiopian minister of water and irrigation standards. Hence the surface and sub-surface water in the neighborhood of the dumpsite presents a significant threat to public health. Any use of this water especially for domestic purposes should be disallowed as its use will lead to waterborne diseases .

There was a considerable amount of heavy metal pollution during the rainy season in the surface water, especially of Mn, and Zn and this suggests that both surface water and groundwater pollution is enhanced by rain seasons. This makes water from the stream and wells unhealthy for human consumption, especially during the rainy season.

Finally, the extent of contamination of groundwater due to leachate percolation depends on the distance of the water source from the dumpsite and the sampling side. Results show that concentrations of contaminants are higher at sampling sites that are downstream from the dumpsite.

Results obtained from bacteriological examination show that there was coliform growth in all the water samples, an indication of the presence of fecal pollution. Domestic drinking water is therefore contaminated bacteriologically. This implies that the water chlorination in the town is disorganized.

5.2.Recommendations

- To be able to maintain portable water which is free from microbial and chemical contaminants there is a need to relook the solid waste disposal site and management of solid waste at source particularly in terms of classification, disposal technique, and citing of disposal site concerning geology and hydrogeology of the area.
- Public awareness campaigns. are crucial in an attempt to waste avoidance, reduction, reuse, and recovery, thereby limiting the amount of waste that gets to the dumpsite subsequently limiting wastes that will interact to form leachate and make the dumpsite manageable.
- A mechanism should be developed for periodic assessments and monitoring of the concentration levels of the pollutants in the surface water and wells to develop a model for predicting pollution status for potable water at different seasons of the year.
- There is a need for further research on the safe distance between the dumping site and the sources of potable water to reduce leachate pollution of this catchment.
- The water source from River Gachab, Nimbus, and Cosakol is a health hazard particularly to pregnant mothers and infants if used for domestic purposes because of the presence of both chemical and biological contaminants.
- Results obtained from bacteriological examination show that there was coliform growth in all the water samples, an indication of the presence of fecal pollution. Domestic drinking water is therefore contaminated bacteriologically. So this town must continue the treatment of the consumption of water by chlorination to avoid bacteria from the drinking water before the distribution for the communities.
- There are a need for the government and other Non- Governmental Organizations to get on education programmers customized to the quality of drinking water.
- consumption of this polluted water can affect human health and economic impacts so the important solution at the household level is treatment by chlorination this improves microbial loads from the drinking water

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APPENDIX I

The solid waste generated from schools and collage at Mizan Aman town

1	Name of school	NO of students	Degradable in kg					Non- degradable in kg					Ashes	Total
	Elementary school (1-4)		Paper	Wood	Fruits	Food waste	Total	Plastic	Bottle	Glass	Metals	Total		
1	Kekar	812	1.5	1.5	2	0	11	1.5	0	4.4	1.4	2.3	0	24
2	Radical	935	2.5	1.5	2	0	14	0	0	0	0	1.3	4.5	15
3	Aman	750	1.2	2.8	0	3.1	7	0.2	0	0	1.5	0.2	0	7.2
4	Zamad ab	931	2.7	2.3	3	3.4	15	0	1.5	0	0	1	3.1	16
Total sum		3428	7.9	8.1	7	6.6	45	1.7	1.5	1.5	2.9	3.95	3.6	49
Elementary school (5-8)														
1	Mizan	1105	2.25	1.2	0	2.1	5.3	1.3	0	0	0	1.3	0	6.5
2	Mizan kutir	1240	1.5	2.3	3	0	16	0.8	1.4	0	0	0.8	6.15	17
3	Aman	1260	2.5	2.5	5	0.9	15	1.3	0	1.7	0	1.3	0	16
4	Mizan kutir 2	979	1.4	1.6	0	0	8	0.4	0	0	0	0.4	2.1	8.4
Total		3594	7.65	7.6	4.2	3	44	3.8	1.4	1.7	0	3.76	4.25	48
High schools														
1	Mian	1569	2.5	1.5	0	5.3	20	1.2	0	5.1	0	1.2	0	21
2	Aman	1748	1	2.3	8	8	23	1	1.3	0	2.2	2.3	2.7	25
	Total sum	3317	3.5	3.8	3.4	13	43	2.2	1.3	2.1	2.2	3.47	2.7	46
Colleges														

1	Agri college	3960		4	6	21	41	3.3	4.5	1	2.6	3.3	3.5	44
2	Abyssinia college	4145		5	0	0	5	0.5	0	2.3	9.3	3.5	4.8	5.4
	Total	3960	3960	5.7	6	21	46	3.8	2.5	3.3	1.4	6.75	3.8	50

APPENDIX II

The mean values of Temperature for dry and rain periods for streams and wells.

Season	Month	Sampling points from streams			
Dry season		S 1	S 2	S 3	S 4
	December	21.62	21.54	21.41	21.22
	January	21.12	21.15	21.43	23.13
	February	22.37	21.35	21.34	23.24
Mean		21.7	21.34	21.39	22.53
Wet season	March	19.25	20.27	21.23	20.31
	April	18.28	19.22	20.22	18.32
	May	20.11	19.12	20.15	18.72
Mean		19.21	19.57	20.53	19.11
Season	Month	Sampling points from wells			
Dry season		W-1	W-2	W-3	W-4
	December	21.62	22.54	21.41	21.22
	January	21.12	21.15	21.43	23.13
	February	22.37	22.35	21.34	23.24
Mean		21.7	22.34	21.39	22.53
	March	19.25	20.55	19.23	17.31

Wet season	April	21.28	19.45	20.22	18.32
	May	18.21	19.88	20.15	19.72
Mean		19.58	19.96	19.9	18.45

Where s1, 12, s3,s4, shows streams samples and w1 w2 w3 w4 represents the four wells

APPENDIX III

Manganese levels for sampling points on the stream measured during the dry and rainy season

Streams	Wet Season	Dry Season	Distance From Dump Site
	6.8	0.45	300
	4.08	0	500
	9.54	0.35	-300
	10.54	0.65	-500
	30.96	1.45	
Wells	Wet Season	Dry Season	Distance From Dump Site
	0.9	0.1	300
	1.01	0	500
	1.2	0	-300
	2.1	0.25	-500

APPENDIX IV

TSS levels for sampling points on the streams and wells measured during the dry and rainy season

Streams	Wet Season	Dry Season	Distance From Dump Site
	35	20	300
	110	45	500
	140	53	-300
	600	61	-500
Wells	Wet Season	Dry Season	Distance From Dump Site
	50	17	300
	85	19	500
	64	16	-300
	101	24	-500

APPENDIX V

Temperature values for the four streams and four wells measured during dry and rainy seasons

Season	Month	Sampling points from streams			
		Sample 1	Sample 2	Sample 3	Sample 4
	December	21.62	21.54	21.41	21.22
Dry season	January	21.12	21.15	21.43	23.13
	February	22.37	21.35	21.34	23.24
Mean		21.7	21.34	21.39	22.53
	March	19.25	20.27	21.23	20.31
Wet season	April	18.28	19.22	20.22	18.32
	May	20.11	19.12	20.15	18.72
Mean		19.21	19.57	20.53	19.11
Season	Month	Sampling points from wells			
		W-1	W-2	W-3	W-4
	December	21.62	22.54	21.41	21.22
Dry season	January	21.12	21.15	21.43	23.13
	February	22.37	22.35	21.34	23.24

Mean		21.7	22.34	21.39	22.53
Wet season	March	19.25	20.55	19.23	17.31
	April	21.28	19.45	20.22	18.32
	May	18.21	19.88	20.15	19.72
Mean		19.58	19.96	19.9	18.45

APPENDIX VI

TDS levels for sampling points on the stream and well-measured during the dry and rainy season and correlation values from dumping site distance

Streams	Wet Season	Dry Season	Distance From Dump Site
	120	121	300
	162	118	500
	167	122	-300
	191	121	-500
Mean	160	120.5	
Wells	Wet Season	Dry Season	Distance From Dump Site
	176	137	300
	151	132	500
	187	134	-300
	188	130	-500
Mean	175.5	133.25	

APPENDIX VII

Levels of pollutants during the study period from November to May 2028, as compared to WHO guidelines for effluent Discharge.

	Dry			Rain			WHO permissible limit
Parameter	Nov	Dec	Janu	march	April	May	
pH	7.4	7.5	7.6	7.8	8.4	7.6	6-5-8.5
TDS	1540	1550	1600	2880	2860	2230	1200 mg/l
EC	2100	2135	2010	2080	3980	3990	0
NO3-	84	83	100	164	281	161	10
Pb	0.59	0.61	0.41	0.91	0.71	0.68	0.01 mg/l
Mn	14.5	14.91	16.81	23.91	38.15	37.45	10 mg/l
Zn	1.09	2.01	2.41	2.91	3.81	3.07	0.5 mg/l
Cd	0.08	0.09	0.05	0.19	0.16	0.06	0.01 mg/l
E. Coli	>1600	>1600	>1600	>1600	>1600	>1600	Nil/100ml

APPENDIX VIII

Mizan Aman Town Water Supply Pump House

APPENDIX IX

Solid waste directly inters into water body by surface runoff from the dumping site

APPENDIX X

Solid waste dumping by donkeys and car   site

APPENDIX XI

The solid waste dumping site

APPENDIX XII

pH meters


HQ440d multi
HACH