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ASSESSING THE PHYSICO CHEMICAL AND MICRO BIOLOGICAL WATER QUALITY OF SURFACE WATER RESOURCE (THE CASE OF SHINE RIVER, ADDIS ZEMEN TOWN)

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BAHIR DAR UNIVERSITY

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SCHOOL OF RESEARCH AND POSTGRADUATE STUDIES

FACULTY OF CIVIL AND WATER RESOURCES ENGINEERING

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JULY, 2020

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THESIS

Submitted to the faculty of Civil and Water Resources Engineering in Partial Fulfillment of the requirements for the Degree of Master of Science Specialization in Water Supply and Sanitary Engineering Presented to the Faculty of Civil and Water Resources Engineering, Bahir Dar Institute of Technology, Bahir Dar University

ADVISOR: ADUGNAW TADESSE (PhD)

June, 2020

Bihar Dar, Ethiopia

DECLARATION

I, the undersigned, declare that the thesis comprises my own work. In compliance with internationally accepted practices, I have acknowledged and refereed all materials used in this work. I understand that non- adherence to the principles of academic honesty and integrity, misrepresentation/fabrication of any idea/data/fact/source will constitute sufficient ground for disciplinary action by the University and can also evoke penal action from the sources which have not been properly cited or acknowledged.

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This thesis has been submitted for examination with my approval as a university advisor.

Advisor Name: ___________________________________

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ABSTRACT

Surface water quality is a matter of critical concern in developing countries because of ever increasing population and their demand. Shine River is one of the perennial rivers in Tana sub basin that gives multiple purposes for the community living around the river banks of Addis Zemen Town. However, due to very poor liquid and solid waste management practices of the community river water highly vulnerable to pollutions. The objective of this study was to assess the physicochemical and micro biological water quality of Shine River. For the study, five sampling sites of the river reach were selected systematically and samples collected from sampling site both during wet (August and September 2011) and dry (December and February 2012) season using composite sampling techniques. A total of 15 water quality parameters were tested; five parameters tested on situ using multi probe and remain 10 parameters were tested in laboratory. Based on the WHO water quality test procedure, samples transported to laboratory. From the study, TDS, EC, Ammonia, Nitrite, Nitrate, Phosphate, Temperature, pH, Ca^{2+}, K^{+}, Na^{+} and mg^{2+} mean values were almost found within the permissible limits of EPA and WHO in all sampling points during dry and wet seasons. Whereas the mean value of turbidity, BOD_5, DO (SP4 and SP5), fecal and total coliform were above the permissible limit of WHO at all sampling points on both during dry and wet seasons. Irrigation water quality parameters like salinity, SAR, SSP and MAR values below the permissible limits of the FAO guidelines. But MAR at sampling point four was above FAO guidelines in the study area. The water pollution levels in dry and wet season were poor water quality (slightly polluted) and unsuitable (heavily polluted) respectively. From statistically analysis result, water quality parameters (BOD, DO, Po_4, No_2, NH_3) were spatially not significant variation ($p > 0.05$) and other parameters (Temperature, pH, turbidity, TDS,EC, Ca, mg and No_3) were statistically significant and except (Ammonia, Nitrite), all other parameters temporally significant variation ($p < 0.05$). Finally, close monitoring of the river water and develop river water quality management is very important for shine river to sustain development program in the watershed.

Keywords: Addis Zemen, coliforms, MAR, pollution, SAR, Shine River, SSP

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LIST OF ABBREVIATION

ANOVA --Analysis of variance

BOD --Biological oxygen demand (mg/l)

CCME-- Canadian council of minister of the environment

DO--Dissolved oxygen demand (mg/l)

EC---Electrical conductivity (μS/cm)

EEPA--Ethiopian environmental protection authority

FAO--Food agricultural organization

GIS ---Geographical information system

GPS--Geographical positioning system

MAR ---Magnesium adsorption ratio (meq/l)

pH---Hydrogen per Oxide

RSBC---residual sodium Bicarbonate (meq/l)

SAR--Sodium adsorption ratio (meq/l)

SP--Sampling point

SSP--Soluble sodium percentage (meq/l)

T^o---Temperature (°C)

TDS--Total dissolved solids

WAWQI--Weight arithmetic water quality index

WHO--world health organization

WQI---water quality index

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1 INTRODUCTION

1.1 Back ground

Water is the most precious gifts of nature and is absolutely vital for the life to sustain. It becomes one of the most demands in recent years due to the population increase, intense agricultural, urbanization and industrialization activities. Water shortage and pollution become one of the most hazards facing in recent year (PCE, 2002) Humans need water not only for drinking but also for various other purposes like bathing, washing, cooking, industrial, agricultural and recreational activities (Wondim and Mosa, 2015).

Testing water quality is very essential and important before it is used for drinking, domestic, agricultural or industrial purpose. Water must be tested with different physic-chemical parameters. Selection of parameters for testing of water is solely depends upon for what purpose we going to use that water and what extent we need its quality (Singh et al., 2013).

Monitoring the water quality is used to assess the usability of that water for a particular purpose, whether for human consumption, agricultural production, industry or the needs of the environment. During the last decades, there has been an increasing demand for monitoring water quality of many rivers by regular measurements of various water quality variables (Antonopoulos et al., 2001). Water quality can be broadly defined as the physical, chemical, and biological composition of water as related to its intended use for such purposes as drinking, recreation, irrigation, and fisheries (Jahad, 2014).

Surface water quality is a matter of critical concern in developing countries because of growing population, rapid industrialization, urbanization, and agricultural modernization. Of all water bodies, rivers are the most vulnerable to pollution because of their role in carrying agricultural run-off, municipal and industrial wastewater (Huang et al., 2010). The availability and quality of water always have played an important role in determining the quality of life. Water quality is closely linked to water use and to the state of economic development (Chennakrishnan et al., 2008). Ground and surface water can be contaminated by several sources. In urban areas, the careless disposal of wastes may contribute greatly to the poor quality of water (Mathuthu et al., 1997). Surface water is most exposed to pollution due to their easy accessibility for disposal of wastewaters. Water pollution is continuously becoming a serious problem, mainly caused by the disposal of untreated sewage and industrial waste, animal waste and chemical fertilizers (Alobaidy et al., 2010)**.**

Rivers play an important role in the uptake and transport of industrial, municipal effluents and organic loading caused by runoff from agricultural fields, roads, and streets. Leaching and direct effluent discharge are primary sources of water pollution (Shrestha and Kazama, 2007).

Water pollution is commonly defined as any physical, chemical or biological change in water quality which adversely impacts on living organisms in the environment or which makes a water resource unsuitable for one or more of its beneficial uses (WHO, 2010).

Pollution of river bodies has become a major and global problem that is becoming critical in developing nations of the world because of inadequacy or non-existence of surface water quality protection measures and sanitation.

According to the world commission on water for the 21st century, more than half of the world's major rivers are depleted and contaminated (Nyasulu, 2010). As a result, they threaten human health and poison the surrounding ecosystem. Contaminated drinking water can cause various diseases such as typhoid fever, cholera and other intestinal diseases (Danquah, 2010). In developing countries, about 1.8 million people, mostly children, die every year because of water-related diseases (WHO, 2007a). Rivers and streams are sinks for wastes. Wastes are most often discharged into the receiving water bodies with little or unregard to their assimilative capacities. It is erroneous to believe that these bodies of water could serve as a limitless dumping ground for wastes, However, discharges of raw sewage, garbage, as well as oil spills are threats to the diluting capabilities of the oceans, and rivers in major cities while most coastal waters are grossly polluted (World Bank, 2011). The water quality is judged based on evaluating the different classification of water quality index (WQI). Those are Weight Arithmetic water quality index, Canadian Council of minister of the environment and National Sanitation Foundation water quality index methods. The present study is estimation of water quality index using weighted arithmetic water quality index method. In this study the reason for choosing the WAWQI method since it has edge over other methods such as in this method multiple water quality parameters are incorporated in to a mathematical equation that rates health of water body through a number called water quality index as well as it describes the suitability of surface and ground water sources for human consumption. Furthermore, WQI can be used as an indicator of water pollution by providing feedback on the quality of water to the policy makers and environmentalist. Water quality index is important to be measured in order to determine health of the river before consuming or safe to use in other purposes. In order to develop these water quality indexes; several parameters have to be considered. The parameters are physical, chemical and biological. Each of the parameters has significant impact on the water quality (Al-Mamun and Zainuddin, 2013).

Generally, most rivers are being polluted by what is known as anthropogenic activities due to industrial and agricultural development. Specifically, urban rivers are much more prone to pollution due to the concentration of industries and the population in urban settlements. Researches on water quality of urban rivers have to be done continuously, especially where the rivers are being used for domestic and production purpose which is common in most African countries due to poverty and poor planning.

Shine River is one of the perennial and polluted River which is used to variety of purposes like bathing, washing of clothes, cooking food, construction of building, animal drunk and irrigation purpose at downstream. Therefore evaluation of water quality is essential to human life because it is one of the most important factors that influence human health (Melegy et al., 2014).

1.2 Statement of the proplem

Nowadays, increasing of urbanization, agricultural and industrial practice brings on both surface and groundwater pollution and it will rapidly decrease the water quality in term of its physical, chemical and biological characteristics (Aris et al., 2014). Surface water quality is influential and significant importance because of its role to human health, aquatic life, ecological integrity and sustainable economic growth. Indeed, without good quality, water sustainable development and environmentally sound management of water resources will be meaningless (Ifabiyi, 2008). Zinabu Gebre, Mariam and Zerihun Desta (2002) stated that industrial effluents, domestic sewage and nonpoint source pollutants contribute large quantities of nutrients and toxic substances that have a number of adverse effects on the water bodies. At field visit and the report of Addis Zemen Town of Administration Office, the town has a very poor liquid and solid waste management system. Shine River runs through Town of Addis Zemen and has not a good water quality because of the town municipal and domestic wastes directly discharged into the river as result downstream, the water is very colored, cloudy, smell and almost the physical phenomena of the river change from day to day. The river which receives the municipal wastes from the Town is used for multi purposes like domestic and irrigation. In addition to the surrounding communities of the Town are different activities takes place along the river side, like traditional sand mining, intensive agricultural practice, animal husbandry and open defecation As results that can be degraded the river natural channel characteristics, aquatic ecosystem, irrigation lands, crop yield and river water consumption for domestic and irrigation purpose and threatens human health and aquatic life year to year. When the problem becomes worst for the long time, the community around the town may be exposed to different disease and at downstream of irrigated lands highly salinity as a result vegetable plants may be affected and aquatic micro invertebrates will be disappeared.

1.3 Objective of the study

1.3.1 General objective

The main objective of this study was to assess the physico chemical and microbiological water quality of Shine River.

1.3.2 Specific objective

- To evaluate the suitability of Shine River water for domestic and productiveness
- To evaluate the extent of temporal and spatial variability of Shine river water quality parameters in its reach from upstream to down stream
- To evaluate the pollution level of Shine River using water quality index

1.4 Research question

- Does the Shine River water quality suitable to the domestic and irrigation use?
- Do what extent the quality of Shine River varies with respect to space and time?
- What is the pollution level of Shine River?

1.5 Scope of the study

The scope of study for this research is at Shine River which located in Addis Zemen Town and the study was covered round 3 km distance from upstream side of Addis Zemen town up to downstream side at the irrigated farm lands. The purpose of this research is to evaluate the temporal and spatial variability of water quality parameters, the suitability of Shine River water for domestic and productiveness and the pollution level using water quality index. Water quality at Shine River was analyzed based on 15 physic- chemical parameters which are Turbidity, Temperature, pH, EC, TDS, NH_3, NH_2, NO_3^{1-}, BOD_5, DO, PO_4^{3-}, Ca^{2+}, mg^{2+}, Na^+, K^+ and micro biological parameters which are fecal and total coliforms. When analyzing water quality for domestic consumption, it was considered to the quality of the water during rainy (August and September in 2011) and dry season (December and February in 2012). But analyze water quality for production purpose, it was considered for dry season only. Because during the irrigation period which in most cases is the dry season as no farmer will good practice irrigation along the rainy season. The important parameters for determining the suitability of water for irrigation uses are salinity, SAR, SSP and MAR only considered.

1.6 Significance of the study

This study was conducted to assess the physic chemical and micro biological water quality of surface water resource for domestic and production uses. The result of this study will help to improve the water quality of the river, to contribute the knowledge of the pollution level of municipal waste effluent on the river and their effects on surface water resources, to know the quality status of Shine River and it serves as baseline information for researchers who conduct similar researchers. The results of this research also would help to avail a plan of action for the health of the people and aquatic life and the sustainable use of the rivers.

1.7 Organization of the thesis

The thesis consists of five chapters. The introductory part is the one section that deals with background overview of the study, statement of the problem, objectives, the scope of the study, and significance of the study. The Second chapter Review of some relevant literature is presented. The third chapter explains the geographical location of study area, material and methodology adopted for the study including sources of data, sample point location and some important physical, chemical and biological parameters and statistical tools used in data analysis. Then chapter four deals data analysis and discussions. Chapter five is summarized with conclusions and some recommendations

2 REVIEW OF RELATED LITRATURE

2.1 Source of water

Water is one of the main important abiotic components of the environment. Approximately, 97% of the total water is found in oceans, which is not appropriate for drinking, and only 3% is considered as fresh water, out of which 2.97% is found as glaciers and ice caps. Only the remaining little portion, 0.03%, is obtainable as surface and ground water for human use (Muhammad et al., 2013).

It is one of the foundations that supports all forms of plant and animal life and is generally derived from two important natural sources; surface waters such as freshwater (2.76) percent of the total water available on earth, lakes, rivers, streams, ponds etc. and groundwater, such as borehole water, springs and well water (Momodu and Anyakora, 2010). Water has unique chemical properties due to its polarity and hydrogen bonds, which mean that it can dissolve, absorb, adsorb or suspend many different compound (Who, 2007b). Therefore, water is not pure in nature because it absorbs contaminants from its environment and those derived from humans and animals, as well as other biological activities (Gilliard, 2005).There are two types of source of water surface and ground water.

2.1.1 Surface Water

The municipal areas use surface water for their drinking water supply. Precipitation that does not evaporate or penetrate the soil flows as surface water that can accumulate in streams and streams are connected to rivers. The lakes are interior depressions that contain stagnant freshwater. In general, ponds are considered to be small temporary or permanent waters that are shallow enough for rooted plants to grow above and below the ground. While lakes contain almost a hundred times more water than all rivers and streams combined, they are still an important part of the total global water supply. Due to the interconnection of groundwater effect of untreated and partially treated industrial wastewater on surface water resource and surface water, these contaminants can be divided between the two sources. None of the water sources can be completely free of contaminants in the water. Due to the water cycle (hydrology), the two sources of drinking water feed each other and share pollutants.

In sub-Saharan Africa, where there were 748 million people still relying on unsafe drinking water sources in 2012, of which 173 million obtained their drinking water straight from surface water (rivers, streams or ponds). The remaining population relied on ground water (unprotected, open wells or poorly protected Source: natural springs) (MDGR, 2014). The distribution of water on the Earth's surface is extremely uneven. Only 3% of water on the surface is fresh; the remaining 97% resides in the ocean. Of freshwater, 68.7% resides in glaciers, 30.1% underground, and less than 1% is located in lakes, rivers, and swamps. Looked at another way, only one percent of the water on the Earth's surface is usable by humans, and 99% of the usable quantity is situated underground.

Table2. 1 Distribution and proportion of water on earth surface (source (MDGR, 2014))

source of water	From the total water found in (%)
Oceans	97
fresh water	3
Total	100
Ground water	30.1
icecaps and glaciers	68.7
Others	0.9
surface water	0.3
Total	100
Rivers	2
Swamps	11
Lakes	87
Total	100

2.1.2 Ground water

Groundwater is underground or subsurface water. Groundwater comes from surface water that seeps through soils and is found in the pores between soil particles and other geological materials. Formations in which all pores are saturated with water are called saturated zones or aquifers. The top of the aquifer is called the groundwater level. Aquifers usually consist of gravel, sand, and sandstone or crushed rock, such as limestone. These materials are permeable because they have large contiguous spaces where water can flow. The amount of groundwater and the speed with which the groundwater flows depend on the size of the spaces in the ground or the rock, and how well the spaces are connected (USGS, 2009). The groundwater is in an underground and saturated zone, but it can trap surface water.

2.2 Introduction of water pollution

Pollution is defined as the introduction into the environment, of substances or energy liable to cause hazards to human health, to cause harm to living organisms and ecological systems, damage to structures or amenities or interference with legitimate uses of the environment (Harrison, 1992). In most cases, the lack of sanitation and inefficient sewage treatment plants are some of the major causes of pollution of rivers in many cities. The UN World Summit (2002) estimated that roughly 45,000 cubic meters of waste water were discharged into rivers, lakes and streams around the world. Fresh water resources in Southern Africa are under pressure from pollution and water quality is a growing concern, particularly in urban areas and close to industrial centers (Merritt et al., 2007).Water pollution is the pollution of water bodies from contaminants being introduced to the natural environment because of humans' activity. Water pollution is often caused by the discharge of inadequately treated wastewater into the natural bodies of water. This can lead to environmental degradation of aquatic ecosystems. In turn, this can lead to public health problems. For example, people living downstream may use the same polluted river water for drinking or bathing or irrigation. Contaminants leading to water pollution include a wide spectrum of chemicals, pathogens, and physical changes such as elevated temperature (Ogundiran and Fawole, 2014b). Water pollution is a major global problem. It requires ongoing evaluation and revision of water resource policy at all levels (international down to individual aquifers and wells). It has been suggested that water pollution is the leading worldwide cause of death and diseases and that it accounts for the deaths of more than 14,000 people daily. In addition to the acute problems of water pollution in developing countries, developed countries also continue to struggle with pollution problem (WHO, 2016).

2.3 Source of River water pollution

There are several sources from which potential pollutants may enter water courses, but these can be categorized into two groups as: point sources and non-point sources pollution. The pollutants enter waterways through untreated sewage, storm drains, septic tanks and run-off from farms among others (GOK, 2009). In addition, according to GOK (2008), development of water supplies has not been matched by a corresponding increase in facilities of sanitary disposal of wastewater. As a result, wastewater is discharged into rivers, valley depressions and dams leading to high pollution levels. In addition, main sewer systems suffer from constant breakages and/or leakage due to increased discharge to fixed systems.

2.3.1 Point sources of pollution

Point source of water pollution refers to contaminants that enter a waterway from a single, identifiable source, such as industrial or ditch. Examples of sources in this category include discharges from a sewage treatment plant, a factory, or a city storm drain and municipal wastes. Many studies that conducted in different parts of the world and there is considerable, river water quality change due to point sources. Among those studies, some has stated that industrial wastewater effluent pollution over river water quality in Nigeria, Africa (Awomeso et al., 2010). Studies on the pollution of the water body by textile industry effluents and they found that the effluents discharged into the stream such as the textile industry effluent considerable negative effects on the water quality of the streams and human health (Awomeso et al., 2010). In Ethiopia, also the effluents directly discharged into the water body. Elias (2017) have also conducted a study on contamination of rivers and water reservoirs in and around Addis Ababa City and actions to be combat it concludes that Rivers are highly polluted due to increasing human population, uncontrolled urbanization and inadequate sanitation infrastructure and system. The main cause of this pollution is the domestic waste; industrial as well as hospital wastes from a different point (Yohannes and Elias, 2017).

2.3.2 Non point sources of pollution

Nonpoint source pollution refers to diffuse contamination that does not originate from a single discrete source. This type of pollution is often the cumulative effect of small amounts of contaminants gathered from a large area. A common example is the leaching out of nitrogen compounds from fertilized agricultural lands, nutrients runoff in storm water from the agricultural land field or forest are also cited as example of non-point source pollutions.

2.4. Municipal waste water

Wastewater is a complex mixture of natural inorganic and organic material mixed with manmade substances. In its broadest sense, wastewater can be classified as domestic (sanitary) wastewater also known as sewage, including agricultural wastes and municipal wastewater, which is a mixture of the former two (Gray et al., 1999). Domestic wastewater consists of effluent discharges from households, institutions and commercial buildings. Industrial waste water is the effluent discharged by manufacturing units and food processing plants. In addition to domestic wastewater and industrial wastewater, storm water, ground water seepage entering to the municipal sewage network also adds the volume of a municipal wastewater. As it is known that Municipal wastewater is a discharge of a complex mixture of chemicals (both inorganic and organic wastes, from the production processes in a municipality) and its effects can affect the composition of healthy water physic - chemistry over time. This variation can alter other parameters such as the concentrations of suspended solids, biological oxygen demand (BOD), conductivity, temperature, color and odor of the receiving water bodies (UNESCO, 1996).

2.4.1 Composition of Municipal Wastewater

It helps in the choice of treatment methods, deciding the extent of treatment, assessing the beneficial uses of wastes and utilizing the purification capacity of natural bodies of water in planned and controlled manner. For example, temperature is a physical property, which affects both the amounts of gases dissolved in the wastewater and the biological activity in the wastewater (Eddy, 2003) . Other physical parameters include color, odor, solids (residues) and turbidity. Solids can be further classified into suspended and dissolved solids (size and settle ability) as well as organic (Volatile) and inorganic (fixed) fractions. Chemical parameters associated with the organic content of wastewater include the biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon, and total oxygen demand.

2.5 PHYSICO CHEMICAL AND BIOLOGICALWATER QUALITY PARAMETERS AND THEIR IMPACTS ON WATER USE

Having good water quality is important for a healthy river and ecosystem. Several basic conditions must be met for aquatic life to thrive in the water. When these conditions are not optimal, species populations become stressed. When conditions are poor, organisms may die. Thus, various water quality parameters need to be measured in order to determine the health of the river water so that it is safe to use for any purpose. In order to develop a water quality or river index, there are several parameters that need to be considered. These parameters can be divided into three groups, which are physical, chemical, biological parameters.

2.5.1 Physical Parameter

2.5.1.1 Turbidity

Turbidity is the optical property of a water sample that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. In simple terms, turbidity answers the question, "How cloudy is the water?" Light’s ability to pass through water depends on how much suspended material is present. Any substance that makes water cloudy will cause turbidity. Turbidity may be caused when light is blocked by large amounts of silt, microorganisms, plant fibers, sawdust, wood ashes, chemicals and coal dust. When the concentration of ammonia within the river is high, there will be high amount oxygen depletion due to higher amount of nitrogenous oxygen demand (NBOD). At the same time when the amount of ammonia, nitrate, and phosphate is high, the growth of plants also high and it will be floating on top of the water surface and cause eutrophication. The units of measure for turbidity are Nephelometric Turbidity Units or NTUs (Lutz, 2004).

Turbidity affects fish and aquatic life by interfering with sunlight penetration. Water plants need light for photosynthesis. If suspended particles block out light, photosynthesis and the production of oxygen for fish and aquatic life will be reduced. If light levels get too low, photosynthesis may stop altogether and algae will die. It is important to realize that reduced photosynthesis in plants result in lower oxygen concentrations and large carbon dioxide concentrations in a water body. Turbidity will also affect the fish negatively in terms of food identification and positively in terms of not being spotted by predators (Cunningham et al., 2001). Mehari muuz weld Mariam (2013) studied on physico chemical anlysis of surface water resource for domestic and agricultural use (the case of Gud Bahri river, Wukiro, Estern Tigray, Ethiopia), the Turbidity value ranged 0.68 to 65.5 which is above the standard limit of WHO.

2.5.1.2 Temperature

Temperature is a measure of how cold or how hot the water is, expressed in degrees Celsius (^oC).Temperature is the basic important factor for its effect on other properties of waste water (Kuzhali et al., 2012). Water temperature is influenced by substrate composition, turbidity, vegetation cover, run-off, inflows and heat exchange with the air. Water temperature varies with season, elevation, geographic location, and climatic conditions and is influenced by stream flow, streamside vegetation, groundwater inputs and water effluent from industrial activities. Water temperature also increases when warm water is discharged into streams from industries. Discharging industrial effluents with increased temperature will cause remarkable reduction in the self-purification capacity of a water body and cause the growth of undesirable algae (Kuzhali et al., 2012). Temperature can be measured using a thermometer with a range of 0–50°C or a suitable electronic thermometer. The probe (or thermometer) is placed in the water to be measured. Since the solubility of dissolved oxygen decreases with increasing water temperature; high water temperatures limit the availability of dissolved oxygen for aquatic life. In addition, water temperature regulates various biochemical reaction rates that influence water quality. The EPA (2000) permissible standard for temperature in drinking water is 25°C while maximum limits for discharging industrial effluent into receiving water body are 40°C and 20-35°C respectively. Metabolic rate and the reproductive activities of aquatic life are controlled by water temperature. Metabolic activity increases with a rise in temperature, thus increasing aquatic organisms demand for oxygen (Imoobe and Koye, 2011). Depletion of dissolved oxygen could impact metabolic and reproductive activities of the aquatic environment and speed up rates of photosynthesis and decomposition. It could also provide the right environment to enhance faster growth of pathogens, which may increase susceptibility of aquatic organisms to disease (Imoobe and Koye, 2011).

2.5.1.3 Total dissolved solids

Total dissolved solids refer to any minerals, salts, metals, cat ions or anions dissolved in water. This includes anything present in water other than the pure water molecule and suspended solids. (Suspended solids are any particles/substances that are neither dissolved nor settled in the water). In general, the total dissolved solids concentration is the sum of the cat ions (Positively charged) and anions (negatively charged) ions in the water. Parts per million (PPM) is the weight to weight ratio of any ion to water. Conductivity is usually about 100 times the total cat ions or anions expressed as equivalents. Total dissolved solids (TDS) in mg/l usually range from 0.5 to 1.0 times the electrical conductivity. Some dissolved solids come from organic sources such as leaves, silt, plankton, and industrial waste and sewage. Other sources come from runoff from urban areas, and fertilizers and pesticides used on lawns and farms. Dissolved solids also come from inorganic materials such as rocks and air that may contain calcium bicarbonate, nitrogen, iron phosphorous, sulfur, and other minerals. Many of these materials form salts, which are compounds that contain both a metal and a nonmetal. Salts usually dissolve in water forming ions. Ions are particles that have a positive or negative charge**.**

2.5.2 Chemical Parameters

2.5.2.1 pH

pH is a measure of hydrogen ions concentration present in the solution and that used to identify the solution as acidic or alkaline. On the scale from 0 to 14 pH of 7 indicates neutral solution. When pH is less than 7 the water is acidic and if pH is greater than 7 the water is alkaline. It is important to quantify the health of the river since public uses for different uses. Although textile factory is one of the sources of acidity, by measuring the acidity/alkalinity, they added base or acid to neutralize the water (Omole and Longe, 2012). Unless and other wise when the concentration of pH exceeds the limit, this is detrimental to environment because certain aquatic life would not be able to survive outside the normal range pH of water. Prabu et al (2011) studied about the physico chemical water quality of Huluka river in Ambo Ethiopia, the pH value was found below WHO standards.

2.5.2.2 Electrical Conductivity (EC)

Electrical conductivity is a function of total dissolved solids (TDS) known as ions concentration, which determines the quality of water (Tariq et al., 2006). Electric Conductivity or Total Dissolved Solids is a measure of how much total salt (inorganic ions such as sodium, chloride, magnesium, and calcium) is present in the water (Mosley et al., 2005). Conductivity is a measure of current carrying capacity. Thus, as concentration of dissolved salts increases, conductivity increases. The more ions the higher the conductivity. Conductivity itself is not a human or aquatic health concern, but because it is easily measured, it can serve as an indicator of other water quality problems. If the conductivity of a stream suddenly increases, it indicates that there is a source of dissolved ions in the vicinity. Therefore, conductivity measurements can be used as a quick way to locate potential water quality problems. All-natural waters contain some dissolved solids due to the dissolution and weathering of rock and soil. Some but not the entire dissolved solids act as conductors and contribute to conductance. Waters with high TDS are unpalatable and potentially unhealthy. According to Nadia and Mahmood, (2006) discharge of wastewater with a high TDS level would have adverse impact on aquatic life, render the receiving water unfit for drinking and domestic purposes, reduce crop yield if used for irrigation, and exacerbate corrosion in water networks. Mehari muuz weld Mariam (2013) studied on physico chemical anlysis of surface water resource for domestic and agricultural use (the case of Gud Bahri river, Wukiro, Estern Tigray, Ethiopia), the conductivity value ranged 382 to 1090 which is above the standard limit of WHO. Based on conductivity result Gud Bahri river was not fit for domestic use.

2.5.2.3 Dissolved oxygen

Dissolved oxygen is a measure of the quantity of free oxygen molecules in water. The concentration of DO is an important indicator of the health of an aquatic ecosystem because oxygen is essential for almost all forms of life**.** Fish and other aquatic animals depend on dissolved oxygen (the oxygen present in water) to live. The amount of dissolved oxygen in streams is dependent on the water temperature, the quantity of sediment in the stream, the amount of oxygen taken out of the system by respiring and decaying organisms, and the amount of oxygen put back into the system by photosynthesizing plants, stream flow, and aeration. Dissolved oxygen is measured in milligrams per liter (mg/l) or parts per million (ppm). The temperature of stream water influences the amount of dissolved oxygen present; less oxygen dissolves in warm water than cold water. For this reason, there is cause for concern for streams with warm water. Trout need DO levels in excess of 8 mg/liter, striped bass prefer DO levels above 5 mg/l, and most warm water fish need DO in excess of 2 mg/l.

2.5.2.4 Biological oxygen demand (BOD_5)

BOD is a chemical procedure for determining the amount of dissolved oxygen needed by Aerobic biological organisms in a body of water to break down organic material present in given water sample at certain temperature over a specific time period. It is the most important quality indicators; the biochemical oxygen demand is very significant to characterize the status of a water body. BOD is the first indicator of the pollution status of the river, especially concerning the presence of domestic and urban discharges. Therefore, one of the principal goals in water management practice is the determination of a suitable relationship between the BOD detected in the stream and the pollution sources. When BOD content is very low and after some distance it comes to zero indicates that it is free from microorganisms (Satapathy, 2016). In general unpolluted waters typically have BOD values of 2 mg/L or less, and those receiving wastewaters may have values up to 10 mg/L or more (Ugya, 2016). Dessalew, Tarfassa and Getachew (2017) studied Assessment on the Current Water Quality Status of Walgamo River, Addis Ababa, Ethiopia. The maximum BOD value in dry and wet season were 21mg/l and 72mg/l which is found above the WHO standard limit.

The most widely used parameter of organic pollution measurement applied to both Wastewater and surface water is the 5-day biochemical oxygen demand BOD_5. The (five-day) BOD_5 of water is the amount of dissolved oxygen taken up by aerobic bacteria in degrading oxidizable matter in the sample, measured after 5 days' incubation in the dark at 20°C (Vaishali and Punita, 2013). This technique is the basis of BOD_5 analysis for all types of sample even though considerable extensions of procedure are necessary in dealing with wastewaters and polluted surface waters. In this test, microorganisms consume organic compounds for food while consuming oxygen at the same time (EPA, 2000). The biochemical oxygen demand is widely used to determine the pollution due to organic loading and the quality of receiving surface water. High concentration of DO supports a greater number of species of organisms in aquatic ecosystem.

2.5.2.5 Ammonia Nitrogen (NH_3-N)

The high concentration of NH_4^+ causes a problem with taste and odour of water apart from toxicity to aquatic lives (Sina, 2014). Moreover, drinking water containing more than 0.2 mg/L of ammonia significantly decreases the disinfection efficiency. Symptoms of poisoning are restlessness, dullness, weakness, muscle tremors profuse salivation, vocalization, lung edema, tonic- clonic convulsion and finally death by heart failure. The low amount of NH_4^+ enhanced the self-purification activities of surface water, by increasing the rate of nitrification-de-nitrification transformation process in river water. Sources of ammonia include: sewage discharges; industries using ammonia or ammonium salts; industrial discharges and commercial fertilizers. In surface or ground water ammonium generally results from the decomposition of nitrogenous organic matter, and is one of the constituents of the nitrogen cycle (Dallas and Day, 2004). Ammonia is a common pollutant and is one of the nutrients contributing to eutrophication (Holmes, 1995).

2.5.2.6 Nitrate Nitrogen (NO_3-N)

Nitrates are contributes to freshwater through discharge of sewage and industrial wastes and run off from agricultural fields (Solanki, 2012). The highest amount of nitrate concentration was known to support the formation of blooms (Uduma and Uduma, 2014).

Nitrates occur naturally in soil and water, but an excess level (more than 45 mg/l) of nitrate can be considered to be a contaminant to surface and ground water (Yohannes and Elias, 2017). According to Yohannes and Elias (2017), the most causes of excess of nitrate in water are human activities. These sources can be traced to agricultural activities, human wastes and or, industrial pollution. This was observed as the concentration of nitrates at the discharge point being similar to the concentration at the downstream point. Levels of nitrate results in excessive nutrient enrichment in the water body leading to loss of diversity in the aquatic biota and overall ecosystem degradation through algal blooms, excessive plant growth, oxygen depletion and reduced sunlight penetration (Yohannes and Elias, 2017).

2.5.2.7 Phosphate (PO_4^{3-})

According to Mosley et al., (2005), phosphorus is never found in its natural form in pure form, but only as phosphate. Phosphorus is one of the key elements for the growth of plants and animals. Phosphorus in marine and freshwater systems exists either in a particulate phase or in a dissolved phase. The particles include live and dead plankton, phosphorus precipitates, phosphorus adsorbed to particles and amorphous phosphorus. The dissolved phase comprises inorganic phosphorus (generally in the soluble form of orthophosphate), organic phosphorus, which is secreted by organisms and macromolecular colloidal phosphorus. Phosphate has no adverse health effects when a water content of more than 1.0 mg / l affects coagulation in water treatment plants, which generate organic particles that contain microorganisms, which is not completely removed before of the distribution (USEPA, 2007).The discharge of wastewater into the water causes the phosphorus to enter the waters where the wastewater is discharged. Phosphorus is the limiting nutrient in freshwater systems, and any increase generally leads to greater aquatic vegetation leading to eutrophic processes (Yohannes and Elias, 2017).

2.5.2.8 Calcium

Calcium is the greatest significant and abundant in the human body and sufficient consumption is essential for normal growth and health. Around 95 percent calcium in human body stockpiled in bones and teeth. The high deficiency of calcium in humans may cause of; rickets, poor blood clotting, bones fracture etc. The maximum daily requirement is of the order of 1 - 2 grams mostly dairy products. There is certain evidence to indication that the incidence of heart disease is reduced in areas served by a public water supply with a high degree of hardness, the primary constituent of which is calcium, so that the presence of the element in a drinking water supply is advantageous to health (Environmental Protection Agency, 2001). According to (Organization, 1993), its permissible range in drinking water is up to 75 mg/l.

2.5.2.9 Magnesium (Mg)

Magnesium is plentiful and a major nutritional requirement for humans (0.3-0.5 g/day). It is the second major component of hardness and it generally comprises 15-20 per cent of the total hardness expressed as $CaCO_3$ (Environmental Protection Agency, 2001). Human body contains about 25g of magnesium (60% in bones and 40% in muscles and tissues). According to the WHO standards, the allowable range of magnesium in water should be 150 mg/l (Mohsin et al., 2013).

2.5.3 biological parametrs

In order to assess the quality of water, biological parameters should also be considered. Fecal coliform and groups of microorganisms are the examples of biological parameters.

Fecal coliforms that come from fecal matter can tolerate higher temperatures than most environmental coliforms, so those that ferment lactose and produce gas at 44°C are called thermo tolerant coliforms, or fecal coliforms. These are more closely associated with fecal pollution than total coliforms. The most specific indicator of fecal contamination is Escherichia coli (E. coli), which unlike some fecal coliforms never multiplies in the aquatic environment (UNICEF., 2008). When evaluating fecal contamination, it is suggested to measure turbidity along with E. coli (or fecal coliforms), since pathogens can adsorb onto suspended particles, and to some extent be shielded from disinfection. When water has been disinfected, it is also important to measure chlorine residual and pH. These four parameters (E. coli/fecal coliforms, turbidity, disinfectant residual chlorine and pH) are considered the minimum set of “essential parameters” required to assess microbiological quality of drinking water (WHO, 2006). Fecal coliform is a form of bacteria found in human and animal waste. Fecal coliform are bacteria whose presence indicates that the water may have been contaminated with human or animal fecal material. If fecal coliform counts are high in a site, it is very likely that pathogenic organisms are also present, and this site is not recommended for swimming and other contact recreation (Said et al., 2004). The measurement is expressed as the number of organisms per 100 ml sample of water (N/100ml). The main cause of fecal pollution in natural aquatic environments is the discharges of wastewater (Antunes et al., 2007). Domestic wastewaters are the main source of pathogens in receiving natural waters, and indicator microorganisms must be monitored to prevent outbreaks of enteric diseases, rather than to detect the presence of specific pathogens. Residual water contains millions of bacteria per milliliter of water. Protozoan, fungi and virus are also abundant is these waters (Pelczar et al., 1993).

Table 2. 2 bacteria count per 100ml and the associated risk
Source: (Michael, 2006)

No	bacteria count per 100ml and associated risk count per 100ml	Risk category
1	0	inconformity with WHO guideline
2	0-10	low risk
3	11-100	intermediate risk
4	101-1000	high risk (too Numerous count)
5	> 1000	Very high risk

2.6 Same water quality parameters for production uses

Salinity indices such as sodium absorption ratio (SAR), soluble sodium percentage (SSP), residual sodium Bicarbonate (RSBC), Kelly Ratio (KR) and Magnesium adsorption ratio (MAR) are important parameters for determining the suitability of water for agricultural uses (Vasan and Raju, 2007). Electrical conductivity is a good measure of salinity hazard to crops as it reflects the TDS in groundwater and surface water. Salinity is the amount of dissolved salts in water (total soluble salt content) while salinity hazard is the potential of the dissolved hazards inhibiting plant growth (Bauder et al., 2008). Hamza (2012) notes that salinity hazard is the most influential water quality guideline on crop productivity and is measured by electrical conductivity of the water and the total dissolved solids in water. The author further notes that irrigation water with a high EC reduces yield potential. Hamza (2012) notes that toxicity of sodium (sodium hazard or sodality) occurs with the accumulation of sodium in the plant tissues and exceeds the tolerance limit of crop and points out that reduction in water infiltration can occur when irrigation water contains high sodium relative to the calcium and magnesium contents (Tak et al., 2012). The most common measure to assess sodicity (sodium hazard) in water is the Sodium Adsorption Ratio (SAR) which defines sodicity in terms of relative concentration of sodium (Na) to the sum of calcium and magnesium ions in the sample. For this purpose, several criteria, such as SAR, MAR and SSP were used to assess the quality of irrigation waters

According to Hamza (2012), observed that irrigation water with SSP greater that 60% may result in Na accumulation and possibly a deterioration of soil structure, infiltration, aeration and reducing soil permeability. Soluble Sodium Percent (SSP) using the following equation;(2.1)

$$SSP = \frac{Na}{Ca + Mg + Na + K} \times 100$$

.

Where all ionic concentrations are expressed in meq/l

Residual Sodium Carbonate (RSC) represents the amount of sodium carbonate and sodium bicarbonate in water when total carbonate and bicarbonate levels exceed total amount of calcium and magnesium. Waters with RSC of 1.25-2.50 meq/L are within the marginal range, while RSC values of 2.50 meq/L or greater are considered too high making the water unsuitable for irrigation use. RSC and KR is determined by the formula below (Hamza, 2012) equation (2.2)

$$KR = \frac{Na^{+}}{Ca^{2+} + Mg^{2+}} \qquad RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$$

JOHN OMUNGALA (2017), observed on the suitability of Athi River for irrigation purpose Athi river town in Kenya. The Sodium Adsorption Ratio result varies 0.44 meq/l to 1.31 meq/l.

Table 2.3 SAR value

sampling point

SP1	SP2	SP3	SP4	SP5	SP6	SP7

0.44	0.75	0.83	1.31	0.75	0.79	0.98

2.6.1 Impacts of Water Pollution on Irrigated agriculture

Various parameters/ qualities of irrigation water have an impact on the yield and health of crops and soil fertility. Bauder et al. (2008) observed that salinity (the amount of salt dissolved in water) directly affects plant growth and generally has an adverse effect on agricultural crop performance and can adversely affect soil properties thus leading to a long term decrease in irrigated crop productivity. The authors further note that saline conditions restrict or inhibit the ability of plants to take up water and nutrients, regardless of whether the salinity is caused by irrigation water or soil water which has become saline because of additions of salty water, poor drainage, or a shallow water table. Ayers and Ayers and Westcot (1994) observed that plants uptake water through a process of osmo-regulation, wherein elevated salt concentration within plants causes water to move from the soil surrounding root tissue into the plant root. When the soil solution salinity is greater than the internal salinity of the plant, water uptake is restricted. The result is often a smaller plant than one not affected by salinity. Yield reduction may occur even where plant symptoms appear minimal. In situations of elevated salinity plant tissue may die, thereby exhibiting necrosis at the leaf edges. Additionally, saline water may lead to concentrations of some elements which can be toxic to plants (Ayers and Westcot, 1994). The authors also observed that the reduced water uptake by the plant due to salinity can result in slow or reduced growth and may also be shown by symptoms similar in appearance to those of drought such as early wilting. Some plants exhibit a bluish-green color and heavier deposits of wax on the leaves. These effects of salinity may vary with the growth stage and in some cases may go entirely unnoticed due to a uniform reduction in yield or growth across an entire field. Various crops have varying salinity tolerance levels and varying effects on the yield with an increase in soil salinity. As the salinity is increased, the yield reduces. Irrigation water with high salinity will consequently lead to an increase in soil salinity leading to a reduction in the yield.

2.7 Water quality index

WQI is a unit less number varies between 0 and 100. A higher index value represents poor water quality according to Weight arithmetic WQI method. Therefore, a numerical index

is used as a management tool in water quality assessment (Avvannavar and Shrihari, 2007).

Water quality index is also one of the most efficient tools for expressing water quality, which offers a simple, steady unit of measurement to communicate water quality, making it a significant factor in the evaluation and management of surface water. It provides a single number that express over all water quality at a certain location and time, based on several water quality parameters. The objective of water quality index is to turn complex water quality data in to information that is understand able and usable by public. A single number cannot tell the whole story of water quality. There are many other water quality parameters that are not included in the index. However, a water quality index based on some very important parameter can provide a simple indicator of water quality. In general, water quality indices incorporate data from multiple water quality parameters in to a mathematical equation that rates the health of a water body with number. The suitability of water for different uses is assessed by means of various water quality indices (WQIs). These indices reflect the rank of water quality in lakes, streams, rivers, and reservoirs. A comparison of water quality determinants with their respective regulatory standards is the concept behind most WQIs. There are many methods for water quality index quantification these are Weight arithmetic (WAWQI), National Sanitation Foundation (NSFWQI) and Canadian Council of Minister of the Environment (CCME WQI) water quality index methods. According to Sum ayah (2018), when compared the CCME and WA water quality index method for the suitability of Bani–Hassan River for drinking purpose the result showed that CCME WQI method was classified water as (fair) water quality while WAWQI method result was ranked it as (unsuitable for drinking usage). Therefore, WAWQI more advanced than CCCMEWQI method. In this study the Weighted Arithmetic Method were selected.

Table2. 4 the result of CCME WQI method (for drinking purpose)

No. Location	1	2	3	4	5	6
Canadian WQI	75	77	78	79	78	79
Categorization	Fair	Fair	Fair	Fair	Fair	Fair
Class	III	III	III	III	III	III
F1(Scope)	30	30	30	30	30	30
F2(Frequency)	24.4	23	20.8	20	19	20
F3(Amplitude)	17.3	14.4	11.2	1.9	13	6.8

Table 2.3 5 the result of WA WQI method (for drinking purpose)

Location No.	1	2	3	4	5	6
Arithmetic WQI	168	146	131	113	134	101
Categorization	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
Class	E	E	E	E	E	E

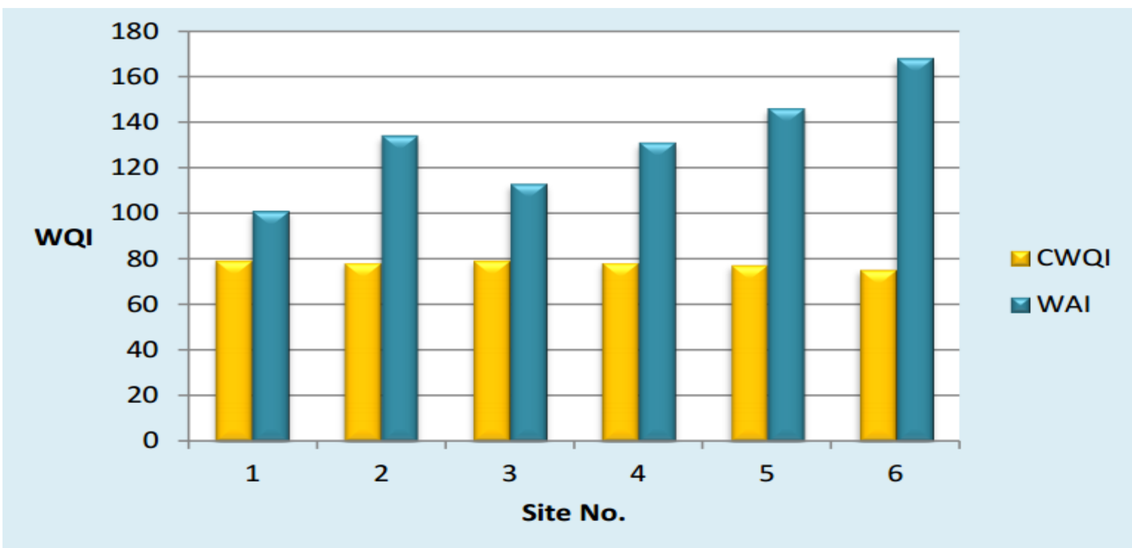

Figure 2.1 the results of Weighted Arithmetic Index and the Canadian WQI for multi locations at Bani-Hassan River.

2.7.1 Weight Arithmetic Water Quality Index Method equation

WQI = ((Σ w n* Q n) / ΣWn) ---2.1

Where, WQI is water quality index

Qn is quality rating

Wn is unit weight

Table 2.4 water quality index range (source (Chatterjee and Raziuddin, 2002)).

Water quality index	Water quality status
0-25	Excellent (very clean)
26-50	Good (clean)
51-75	Poor (Slightly polluted)
76-100	Very poor (moderately polluted)
>100	Unsuitable (heavily polluted)

2.7.2 Merits of weight arithmetic water quality index

- WQIs can be used to show water quality variation both spatially and temporally
- Provide a simple, concise and valid method for expressing the significance of regularly generated laboratory data
- Aid in the assessment of water quality for general uses;
- Allow users to easily interpret data with respect to certain parameters
- Use full for communication of overall water quality information to the concerned citizens and policy makers.
- Describe the suitability of both surface and ground water sources for human consumption.
- Improve communication with the public and increases public awareness of water quality conditions and Assist in establishing priorities for management purposes.
- Reflects the composite influence of different parameters i.e. important for the assessment and management of water quality.

2.7.3 Limitations of weight arithmetic water quality index

- Proved only a summary of the selected parameters
- May not carry enough information about the real quality situation of the water.
- Cannot evaluate all water quality risks.

3 MATERIAL AND METHOD

3.1 Description of study area

The study area was conduct on Shine River which is the largest feeding of Rib River and located in Rib watershed in Addis Zemen Town in South Gondar Zone, Amhara region, on the road connecting Gondar and Bahir Dar. It is situated 747 km north of the capital city, Addis Ababa and 67 km of North West of Debretabor. The town is geographically located an latitude and longitude of 12°07’24.84’’N and 37°46’47.44’’E respectively, and an average elevation of 1975 meters above sea level. It is administrative center of Libo Kemkem woreda and it has a lot of infrastructures like, hospital, commercial buildings, Technical, vocational and educational college and constructing of urban drainage. The highest amount of Rain fall recorded in the area is from June to September, the medium and the smallest amount of rainfall recorded in the area are from October to May months. The maximum mean daily rainfall of the Town is 150mm and the minimum rainfall is 5mm. The maximum and minimum average temperature of the Town is 26°c and 14°c respectively and the total average temperature is 20°c. Based on the 2012 report a total number of urban populations of Addis Zemen town has 37,630 from this 19,348 were men and 18,282 women. Most of the population settlement pattern in the Town was the right and left bank of along the river side due to this, the Town covered by the mountain. So the expansions of the Town were upstream and downstream side rather than right and left side. The natural land use and cover round in the study area has been almost clear which is an agricultural and grazing activity. The waste disposal system of Addis Zemen Town both liquid and solid wastes were unmanaged. The Town has not vacuum tracker to collect the Town’s wastewater. Both storm water and domestic wastewater release to the river by urban drainage. The Shine

River crosses the town that comes from the north and runs to the south directions and to meet Rib River.

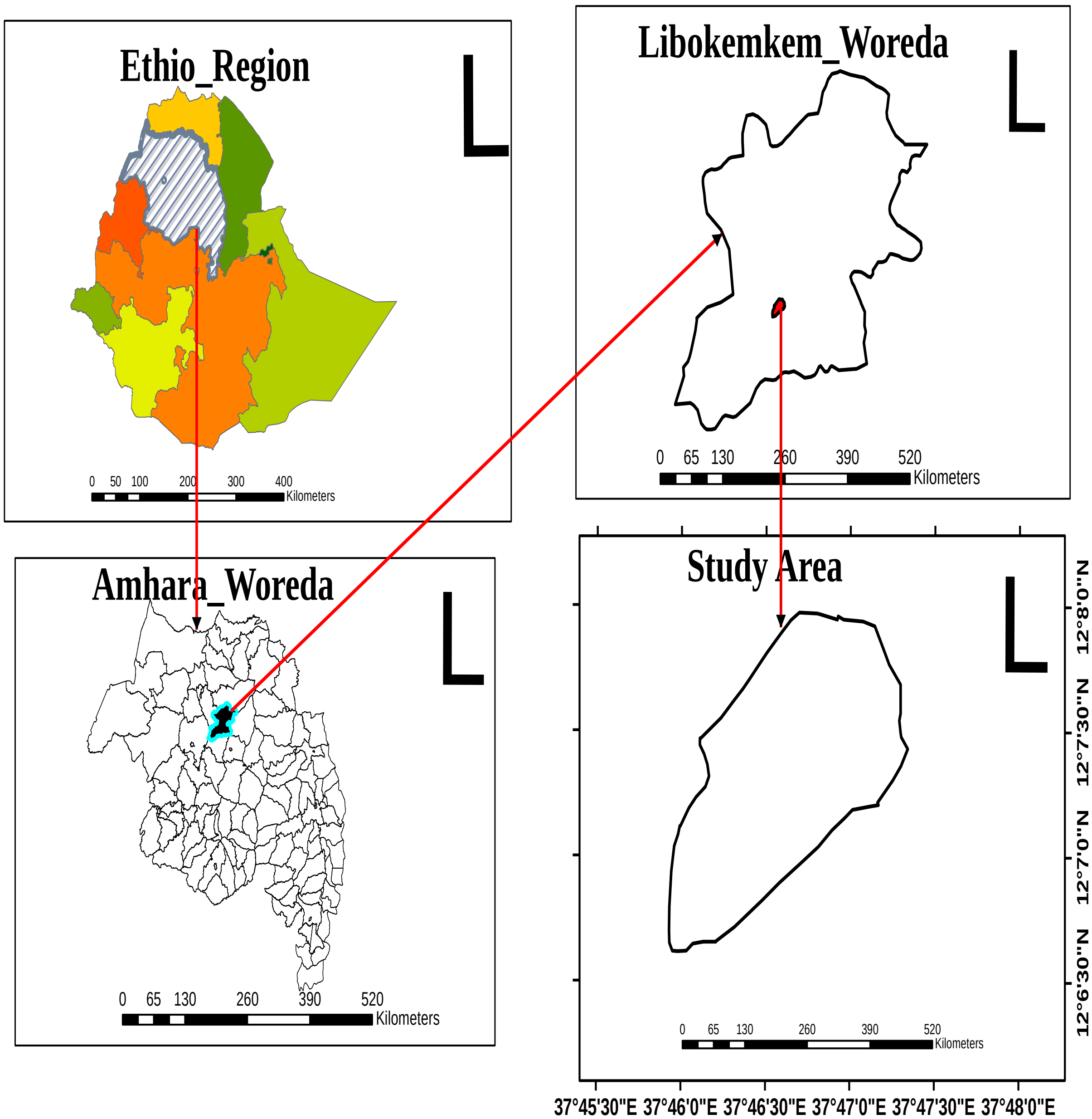

Figure 3.1 Descriptions of study area

3.2 Sampling point selection, Sampling time and frequency

The selection of sampling points is the most important during water quality assessment. A successful sampling program involves the selection of sampling sites according to the objective of the study because several natural and artificial factors are responsible for water pollution. Therefore, there are several rules for sampling site selection. For this study systematic sampling were used. For the purpose of water quality parameter testing, the selection of sampling sites require, on a prior basis, extensive investigation, and field survey of such sources, such as domestic wastewater discharges, natural and man- made pollutants. In addition, those sampling points where the river are being used for domestic purposes. Based on these criteria the sampling was selected at five points along the river (figure 3.2). Three sampling points were within the Town, while the other two points were (downstream and upstream) of the Town. The first sampling point (SP1) was selected upstream side of the Town. At this point the river is not exposed to the domestic waste water but agricultural runoff sources during wet period. The second sampling point two (sp2) was just within the Town 1 km distance from sampling Point one (sp1). At this point detergents, open defecation and Addis Zemen prison waste water mixed with the River. The third sampling point (sp3) was selected within the Town at Bridge (0.5 km distance from sampling Point two (sp2). At this point solid waste dispose, open defecation takes place and. The fourth sampling point (sp4) was also selected within the Town below at Addis Zemen health center (0.5km distance from sp3). At this point slaughter waste discharged, soaps, detergents discharged commercial wastes and open defection takes place. The last sampling point (sp5) was selected below the Town boundaries at weir structure (1km distance from sp4). At this point dead animals and solid wastes disposal site and local people grow different vegetables crops.

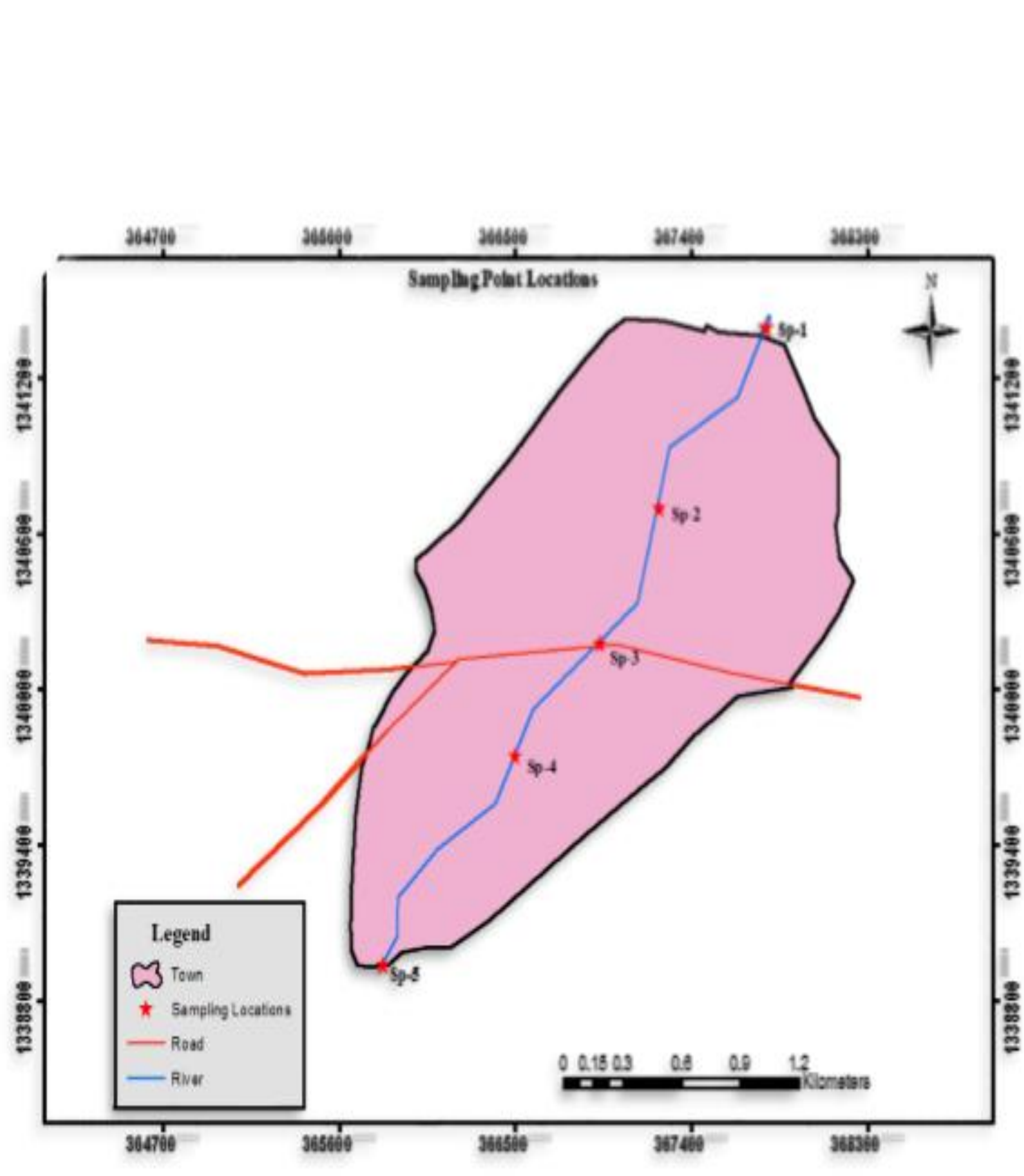

Figure 3.2 Sampling point location

Table 3.1 Descriptions of sampling points

Sampling point	Relative distance (km)	GPS coordinate			Sampling point location
		X	Y	Z	
Sp1	0	367716	1341326	1955	Most upstream site located above the effluent before joined to the river.
Sp2	1 km	367451	1340878	1950	This point mixing of detergents, open defection and prison wastewater join to the river.
Sp3	1.5km	367094	130702	1944	At this point open defection, soaps, detergents and solid waste disposal site to the River (bridge).
Sp4	2 km	367020	1340453	1938	This site slaughter wastes discharged to the river, soaps detergents and open defection takes place.
Sp5	3 km	367008	1340173	1931	This site local people grow different type of vegetables (weir structure). At this point different dead animals and solid wastes dispose.

3.2.1 Sampling time and Sampling frequency

River water quality sampling frequency and time is an important aspect of the river water quality monitoring. A suitable sampling frequency for each location will provide a measure of the real water quality status for the water quality managers as well as the decision makers. Sampling frequency is determined by the level of variation in the quality of water. If large variations occur in short duration of time, sampling needs to be done frequently (Bhushan and Basu, 2017). In this study sampling frequency of surface water was four months per year and twice a month in 15 days interval. Sampling was taken 8 times for each of the parameters and conducted to two seasons, wet season (August and September in 2011) and dry season (December and February in 2012). Samples were transported to Amhara water development Bereu; Amhara design and supervision works Enterprise and BIT laboratory in ice box within 3 hours which was recommended time.

3.3 Material and equipment

Materials during data collection were laboratory equipment's, reagents and tools like Google Earth, and GIS were used.

- GIS- were used to the study area mapping and Google earth was used in my study to have general information about the study area before the actual site visit and also were used the distance of each sampling points were located.
- Laboratory equipment,
- For chemical water quality parameters reagents or tablet were used (example for Ammonia (Ammonia No1&2), Nitrite (Nitricol), Nitrate(Nitricol No1&2, Nitra test and Nitrate powder), phosphate (LR No1 &2), magnesium (magnicol No1&2) and calcium (calcicol No1&2) and potassium (potassium tablet) were used respectively and distle water for washing of bottles were used.

Table 3.2 physic chemical and bacteriological parameters and methods were used for experimental analysis

Parameters	Instruments name and methods was use for experimental analysis
Temperature	YSI 556 multi probe
Electric conductivity	YSI 556 multi probe
Turbidity	Turbid meter
Ph	YSI 556 multi probe
Total dissolved solids(TDS)	YSI 556 multi probe
Dissolved oxygen(DO)	YSI 556 multi probe
Biological oxygen demand(BOD_5)	BOD Incubator
Phosphate(PO_4^{3-})	Spectrophotometric

Ammonia-nitrogen(NH_3-N)	Spectrophotometric
Nitrate nitrogen(NO_3-N)	Spectrophotometric
Fecal and total coliform	Bacteriological test kit
Potassium,	Spectrophotometric
Magnesium	Spectrophotometric
calcium	Spectrophotometric
Sodium	Flame photometer

3.4 Physico chemical water quality parameters

Various physical and chemical water quality parameters were measured in the laboratory and at the field level at Shiny River. Water quality parameters such as temperature, pH, TDS, Dissolved Oxygen, and EC were measured at the field level by multi probe while water quality parameters such as BOD, Turbidity, Na^{+1}, K^{+}, mg^{+2} and Ca^{+2} and nutrients such as (Nitrate, nitrite, phosphate and ammonia) were measured in the laboratory by Spectro photometer. These physic chemical water quality parameters evaluated based on WHO and EPA standards for intended use.

3.5 Sampling methods

In water quality analysis there are two types of sample collection methods those are grab and composite. For this study surface water quality evaluation composite sampling was used. Composite sample is a sample consisting of two or more sub-samples mixed together in known Proportions. There are two basic types of composite samples in water sampling.

Time weighted samples:- are sub samples of equal volume taken at constant intervals during the sampling period.

In flow weighted sampling:- the sub samples are proportional to the effluent flow or volume during the sampling period. A flow-weighted sample can be created by taking samples at constant intervals but with varying sample volumes that are proportional to the flow at the sampling time. The samples were collected in new plastic containers which were pre-cleaned by washing with non-ionic detergents, rinsed in tap water and distilled water before sampling. The containers were rinsed thoroughly with the surface water sample before being filled with the sample water and taken for physicochemical analysis.

3.6 Data collection

Generally data was collected from primary and secondary sources.

Primary data: the data was collecting from 5 sampling sites (SP1 to SP5) along the segment of the study area round 3kms along the river. Primary dates' such as Temperature, PH, EC (Electrical Conductivity), DO and TDS (Total Dissolved Solids) were measure using YSI Multi Probe. BOD (Biological Oxygen Demand), Turbidity, Nitrate, Ammonia, Nitrite, Phosphate, magnesium and calcium were measured at civil and water Resource faculty of Bahir Dar University, Poly Campus, sodium was measured at Amhara design and supervision works enterprise and Total and Fecal coliforms were measured by biological test kit at south Gondar zone water and energy department and live photographs were taken during field observation.

Secondary data – was collected by reading manuals, reports and related research documents and some relevant information's was collected from Addis Zemen Town administration office such as population data, rainfall data and temperature data's of the study area.

3.7 Bictrological test method

Water samples were collected in pre-sterilized plastic bags and were filtered on the spot using membrane filters with a spore size of 45µm. The filters were incubated in an ELE Paqualab 25 field incubator, in sterilized aluminum Petridis with a bacterial medium of m-Coli Blue24 on absorbent pad, at 37C and 44oC for total coli forms and E-coli/fecal coli forms, respectively. The filters were examined for 24 hours to assess bacterial growth. The results were compared with WHO guidelines maximum permissible limit value for drinking water purpose.

3.8 Water pollution level evaluation by water quality index

A water quality index (WQI) helps in understanding the general water quality status of a water source and hence it has been applied for both surface and ground water quality assessment all around the world since the last few decades (Shah and Joshi, 2017). The water health can also examine by using water quality index. Interpretation of complex water quality data is difficult to understand and to communicate during decision-making process. Assembling the various parameters of the water quality data into one single number leads an easy interpretation of data, thus providing an important tool for management and decision making purposes. The purpose of an index is to transform the large quantity of data into information that is easily understandable by the public. Water quality index exhibits the overall water quality at specific location and specific time based on several water quality parameters. WQI is a set of standards used to measure changes in water quality in a particular river reach over time and make comparisons from different reaches of a river. This index allows for a general analysis of water quality on many levels that affect a stream's ability to host life and whether the overall quality of water bodies poses a potential threat to various uses of water (Ogundiran and Fawole, 2014a).

3.8.1 Water quality index calculation

Calculation of water quality index was based on important physic-chemical parameters. WQI was calculated by using the recommended standards by WHO and EPA Water Quality Guidelines. To determine the WQI, the Weighted Arithmetic Index method was used.

3.8.1.1 Steps in calculating water quality index using WAWQI method

Step 1: Collect data of thirteen (13) physic - chemical water quality parameters.

Step 2: Calculate Proportionality constant " K " value using formula

$$K = 1 / \sum_{i=1}^{n} (1/Sn) \quad \text{------} 3.1$$

Where "Sn" is standard permissible for n^{th} parameters recommended by WHO and EPA.

Step 3: calculate quality rating for n^{th} parameter (qn) where there are n parameters. This is calculated using formula

$$Qn = 100\left(\frac{Vn-Vio}{Sn-Vio}\right) \text{------} 3.2$$

Whereas Vn = measured value of the n^{th} parameter of the given sampling location.

Vio = Ideal value of n^{th} parameter in pure water. Vio for pH = 7, Do =14.6 and 0 for all other parameters and Sn = Standard permissible value of the n^{th} parameter.

Step 4: Calculate unit weight for the n^{th} parameters.

$$Wn = (k/s\,n) \text{------} 3.3$$

Step 5: Calculate Quality Index (WQI) using formula,

$$WQI = ((\Sigma\, w\,n * Q\,n) / \Sigma Wn) \text{------} 3.4$$

Table 3.3 Water quality index and status (Chatterjee and Raziuddin, 2002).

Water quality index	Water quality status
0-25	Excellent (very clean)
26-50	Good (clean)
51-75	Poor (Slightly polluted)
76-100	Very poor (moderately polluted)
>100	Unsuitable (heavily polluted)

3.9 Water quality assessmenet for irrigation purpose

Irrigation water quality has always been a major part of agricultural crop yield. To determines the suitability of surface water for irrigation purposes. For this purpose several criteria, such as salinity. SAR, SSP, and MH, were used to assess the quality of irrigation, waters.

SAR was defined by (Wilcox, 1955) The experiments show that the SAR reasonably predicts the degree to which irrigation water tends to enter into a cat ion- exchange reaction in the soil. High values of SAR imply a hazard of sodium replacing adsorbed calcium and magnesium, a situation ultimately damaging to the soil structure (Khan et al., 2013).

SAR was computed according to the relationship shown in Equation 3.5 with concentrations given in meq/l.

$$SAR = \frac{\boldsymbol{Na+}}{\frac{\sqrt{(\boldsymbol{Ca\,2+ + mg2+})}}{\mathbf{2}}} \text{ ---3.5}$$

generally, calcium and magnesium in water are in equilibrium. However, if the amount of magnesium in water increases, it adversely affects soil quality by increasing the alkalinity of the soil, thus, reducing its crop yield (Szabolcs, 1964).

MAR was calculated by the following Equation 3.6 with all the ions are expressed in meq/L.

$$MAR = \frac{mg2+}{Ca2+ + mg2+} \times 100 \text{ ---3.6}$$

The Soluble Sodium Percentage (SSP) was calculated by the following equation (Jha et al., 2007) with all the ions are expressed in meq/L.

$$SSP = \frac{(Na+K)\times 100}{Ca+mg+Na+K} \text{ --3.7}$$

3.10 Statistical data analysis

First all selected parameters were determined in water quality laboratory and in situ measurement. The water qualities of river were analysis depending on spatial and temporal variations, maximum value, minimum value and mean value of the raw data for the whole sampling sites. All selected physical, chemical and biological parameters were measured and analysis by using Microsoft excels, one-way ANOVA, WQI, NAR, SSP and MH. Finally, the result was expressed by graphs and tables.

ANOVA was checking the presence of significant variations of the selected physic-chemical and microbiological parameters of Shiny River water quality among the

Sampling sites and sampling period of each water quality parameter. P-value of less than was 0.05 considered statistically significant

4 RESULTS AND DISCUSSION

4.1 Physical water quality assessment for domestic purpose

4.1.1 Water Temperature

The temperature ranged from a 19.5 °C at upstream to 23.6 °C at downstream in wet season and in dry season the temperature ranges from of 22 °C at upstream to a maximum of 24.8 °C at downstream. The overall mean value of all sampling points both wet and dry season was 21.2 °C and 23.5 °C respectively (Figure 4.1). The highest mean temperature was recorded during dry period and the lowest mean temperature was during the wet period which is high solar radiation, low water level, clear atmosphere and higher atmospheric temperature in dry season. The mean temperature of River shine increase from upstream to downstream as result the water quality of Shine river decreases from upstream to downstream due to this the biological activities increase from upstream to downstream of the river which is organic matter easily breakdown across the river. The temperature of all sampling points both wet and dry season found within the permissible values of both WHO (5-30°C) and EPA (25-40°C) standards for ambient surface water.

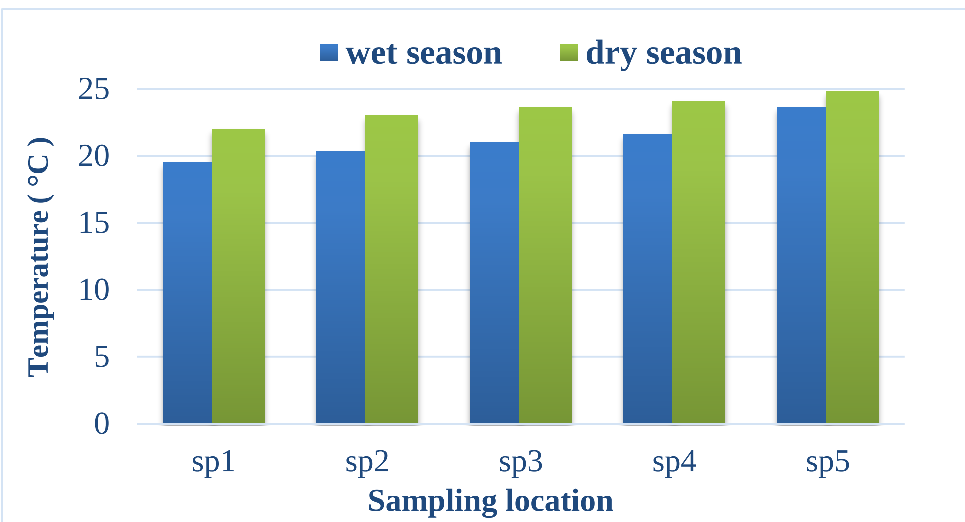

Figure 4.1 water temperature of Shine River

4.1.2 Turbidity

Turbidity refers to the amount of light scattered or absorbed by a fluid and is an optical property of the fluid. Turbidity, also called sedimentation, indicates the clarity of the water. Water can become turbid if there are too many suspended particles such as silt, clay, plankton, decaying organic matter, and from sewage and industrial waste. Clear water has many benefits. It increases the enjoyment of sightseeing, fishing, underwater nature observation, and other recreational uses of the river, and thereby encourages tourism and perhaps a more important reason is that clear water is penetrated by sunlight necessary for photo-synthesis by aquatic plants, and the generation of oxygen. The turbidity value of water varies from a minimum of 39 NTU at upstream (SP1) to 58 NTU at downstream (SP5) in wet season whereas in dry season the turbidity value of water varies from a minimum of 9.5 NTU at upstream to a maximum of 32 NTU at downstream (Figure 4.2). The mean values for all sampling points of both wet and dry season were 48.9 NTU and 17.4 NTU respectively. The minimum values of turbidity both wet and dry period were found above the permissible values of WHO Standards (5NTU) for domestic use. Where as in dry period all sampling points were within the permissible limit of EPA (30 NTU) for ambient surface water standards except sampling point five due to around this point manual sand mining activities takes place. The highest turbidity recorded during wet period and the lowest in dry period due to catchment runoff, soil erosion, and waste discharge from urban areas in wet period. Based on Turbidity, water quality of Shine River decreases from upstream to downstream across the river which might be increase small streams to carry urban and agricultural runoff in to the river. Based on thus, turbidity of Shine River is likely non suitable for direct domestic use. According to WHO standards the turbidity value of drinking water supply should not be exceeded 5 NTU.

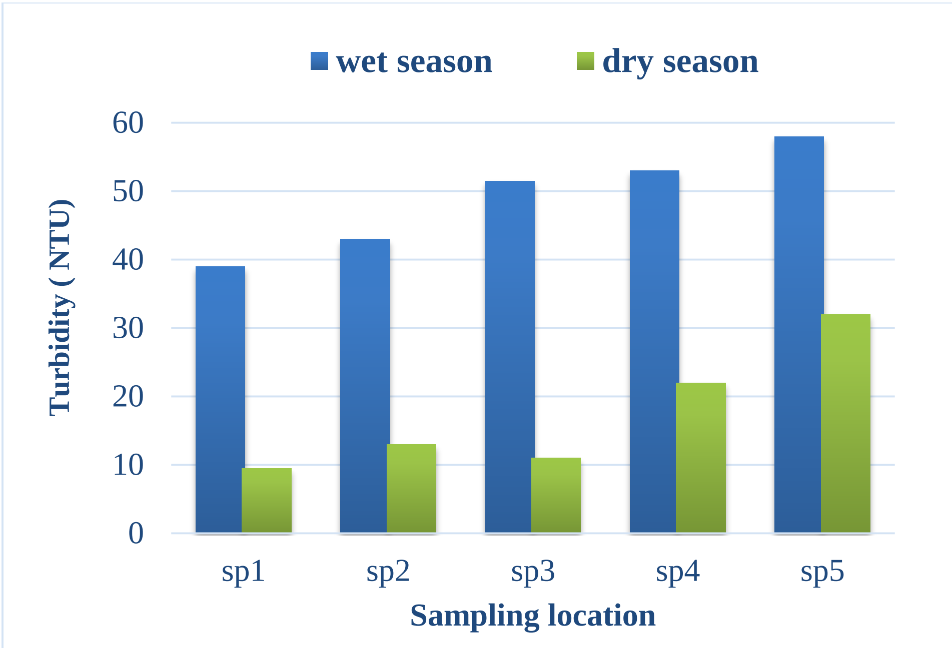

Figure 4.2 Turbidity of Shine River

4.1.3 Total dissolved solids (TDS)

TDS is a measure of solid substances dissolved in water. TDS includes salts, some organic materials, and a wide range of other things from nutrients to toxic materials (Parmar and Parmar, 2010). The quantity of TDS in the Shine River water varied from 128.8 mg/L to 165.8 mg/L during the wet season. On the other hand, the quantity of TDS in the Shine River water varied from 181 mg/l to 258 mg/l (Figure 4.3).The mean value for all sampling points of wet and dry season was 147.5 mg/l and 222.2 mg/l respectively. Higher TDS value recorded during the dry season may be attributed to the lesser volume of the river water mixed with domestic wastes during this season. The maximum value of TDS was recorded at downstream of the river during Dry season from sampling point (SP5) which is 258 mg/L and the minimum was recorded at the upstream of the river from sampling point (SP1) during wet season .The higher values of TDS may be due to higher concentration of dissolved solids in water that causes adverse effect in taste. Generally, the increase of TDS record value from upstream to downstream which might be increase entry of sewage wastewater results enrichment of dissolved ions. TDS value was within the permissible limit of WHO (2008) for domestic use and EEPA (2003) for ambient surface water standards. The maximum permissible limit of river water for dissolved solids is 600mg and 500 mg/L respectively. According to WHO standards for the survival of aquatic ecosystem should not be exceeded 500 mg/l.

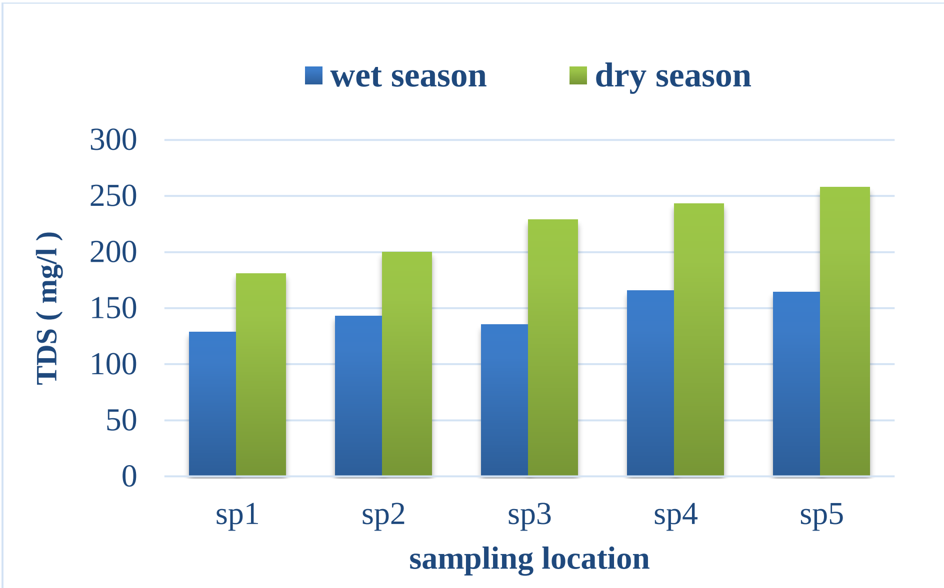

Figure 4.3 TDS of Shine River

4.2 Chemical water quality assessment for domestic purpose

4.2.1 pH

It is a measure of hydrogen ions concentrations present in the solution and identify the solution is acidic or basic. The water quality result showed that Shine River water quality was slightly neutral or slightly alkaline condition. The pH value of water varied from 7.18 at SP4 to 7.3 at SP1 in wet season where as in dry season a minimum of 7.35 at SP4 to a maximum of 7.46 at SP5. The overall mean value all sampling points of both wet and dry season were 7.2 and 7.4 respectively (Figure 4.4). The highest mean pH was recorded during dry period and the lowest pH was during the wet period. When compared with pH values of Huluka River in Ambo, Ethiopia ranged between 7.91 to 8.15 in dry and 7.42 to 8.03 in wet season by Prabu et al., (2011), the pH value of Shine River was found to be lower. Huluka River is almost similar character sticks to Shine River. Both the maximum and the minimum pH record values found within the interval of WHO (2008) standards for drinking (domestic), recreation, agricultural and aquatic life water use and EEP (2003) for ambient surface water. The permissible limit for pH is 6.5-8.5 and 6-9 respectively. This range was important to microorganisms for breakdown of organic matter. The pH values were within the “no effect” range of 6.0–9.0 for domestic water use (WRC, 2003).

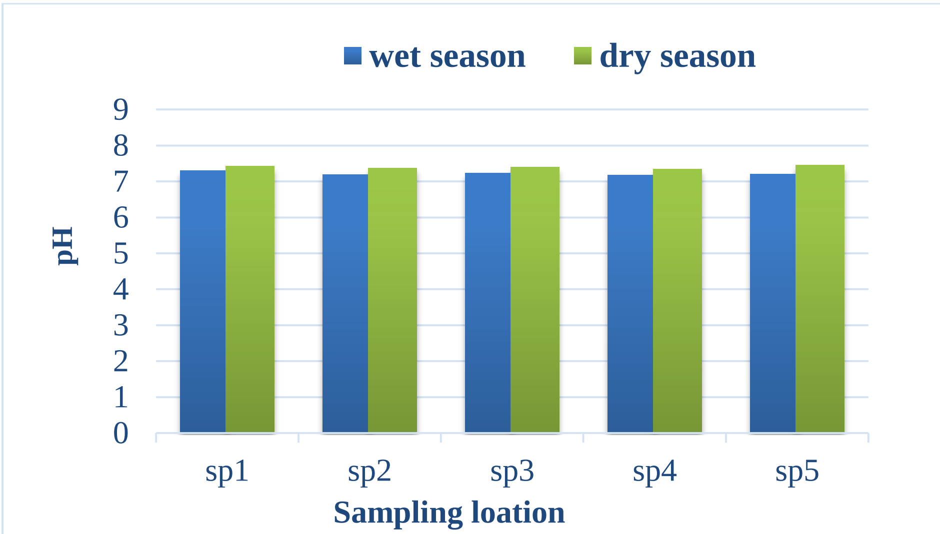

Figure 4.4 pH of Shine River

4.2.2 Electrical conductivity (EC)

Electrical conductivity is important parameter of water quality for indicating salinity or total salt content in water bodies. Electrical conductivity (EC) is the ability of water to carry on electric current, which in ionic strength as conductivity is a measure of total ions. The Electrical conductivity of Shine River varied from 195.9 µS/cm to a 264.5µS/cm during wet season. Whereas the quantity of EC of Shine River varied from 279µS/cm to 383µS/cm (Figure 4.5). The mean values of all sampling points of both wet and dry season were 227.1 µS/cm and 339.6 µS/cm respectively. The maximum value of EC was recorded at downstream of the river during dry season from sampling point (SP5) which is 383 µS/cm and the minimum was recorded at the upstream of the river During rainy season from sampling point (SP1) which is 195.9. The highest EC was recorded during dry period and the lowest EC was during the wet period which might be in dry period entry of domestic wastewater (slaughter wastes and Addis Zemen prison waste water) mixed with less flow of river water and human activities takes place which, might be the sample water becomes concentrated rather than diluted. Generally, the EC value was increase from upstream to downstream due to this, the present study that in the upstream where the population settlement along the river side is low and low human activities whereas in the downstream areas the population settlements along the river side is high, because of high population settlement along the riverside may be the communities dispose more solid and liquid wastes as one goes downstream of the river which might results have increased the concentration of ions from upstream to downstream. The electrical conductivity values recorded all sampling points both wet and dry season were within permissible values of WHO (2008) for domestic use and EEPA (2003) for ambient surface water standards. The maximum permissible limit of electric conductivity is 700 mg/l and 1000mg/l respectively. According to WHO standards the EC value for the survival of aquatic ecosystem should not be exceeded 700 μS/cm.

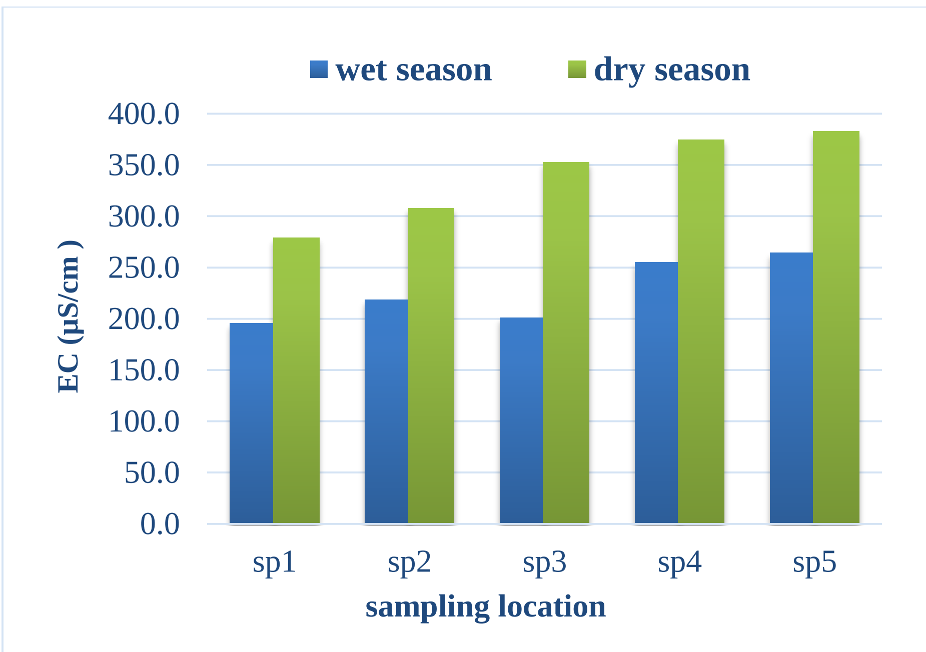

Figure 4.2 The EC value of Shine River

4.2.3 Ammonia concentration

Ammonia (NH3) is a measure for the amount of ammonia, a toxic pollutant often found in landfill leachate and in waste products, such as sewage, liquid manure and other liquid organic waste products. It can also be used as a measure of the health of water in natural bodies such as rivers or lakes, or in man-made water reservoirs (Aziz et al., 2004). Ammonia is produced by the microbial activity of organic nitrogenous matter. The ammonia concentration values ranged from a minimum of 0.06 mg/l at SP1 to a maximum of 0.12 mg/l at SP5 in wet season where as in dry season, it ranged from a minimum of 0.03 mg/l at SP1 to 0.23 mg/l at SP2 (Figure 4.6). The overall mean value of all sampling points of wet and dry season was 0.08 mg/l and 0.17mg/l respectively. The highest ammonia was recorded during dry period and the lowest ammonia was during the wet period. The ammonia concentration values recorded at all sampling points both wet and dry season were found within WHO (2008) for domestic use and EPA (2003) for surface water course permissible limit value 1.5 mg/l and 20mg/l respectively. Based on ammonia findings Shine River was fit for domestic consumption. According to WHO standards the ammonia value of domestic water supply should not be exceeded 1.5mg/l.

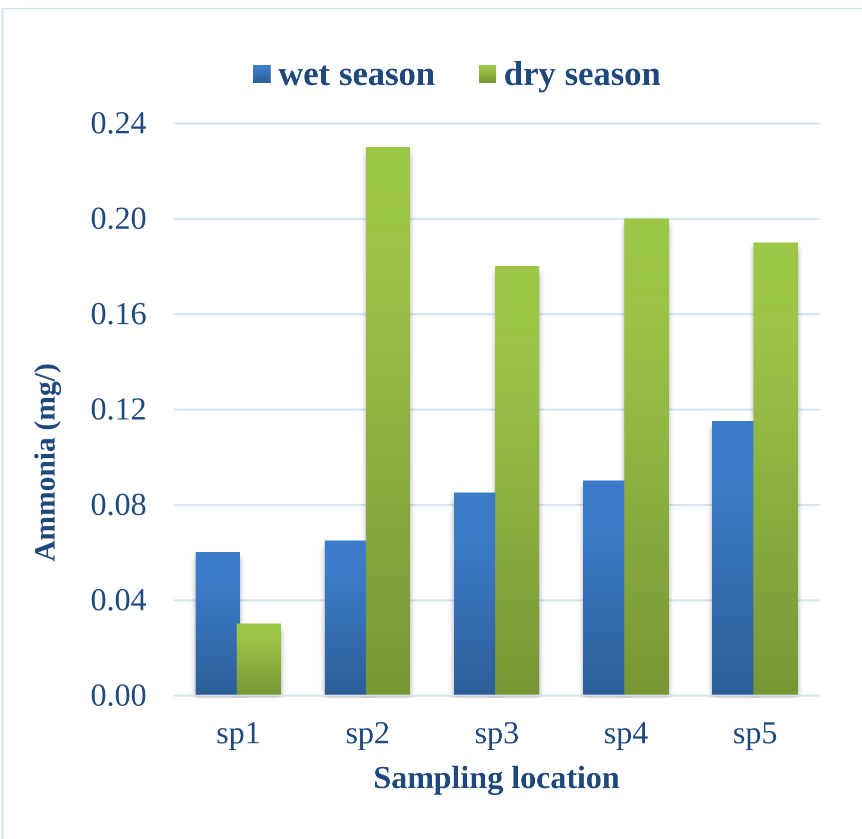

Figure 4.3 Ammonia of Shine River

4.2.4 Nitrite concentration

Under oxidation condition of ammonia and reduction of nitrate is formed nitrite (Kannan and Kannan, 1996). Nitrites are relatively short-lived because they are quickly converted to nitrates by bacteria. The nitrite concentration values ranged from a minimum of 0.04 mg/l at SP2 to a maximum of 0.1 mg/l at SP3 in wet season where as in dry season ranged from a minimum of 0.04 mg/l at SP1 to a maximum of 0.08 mg/l at SP5 (Figure 4.7). The mean value of all sampling points of wet and dry season was 0.07mg/l and 0.06 mg/l respectively. The amount of nitrite concentration value recorded all sampling points both wet and dry season was under the permissible values of WHO (2008) (3mg/l) for drinking water and EEPA (< 0.1mg/l) for surface water.

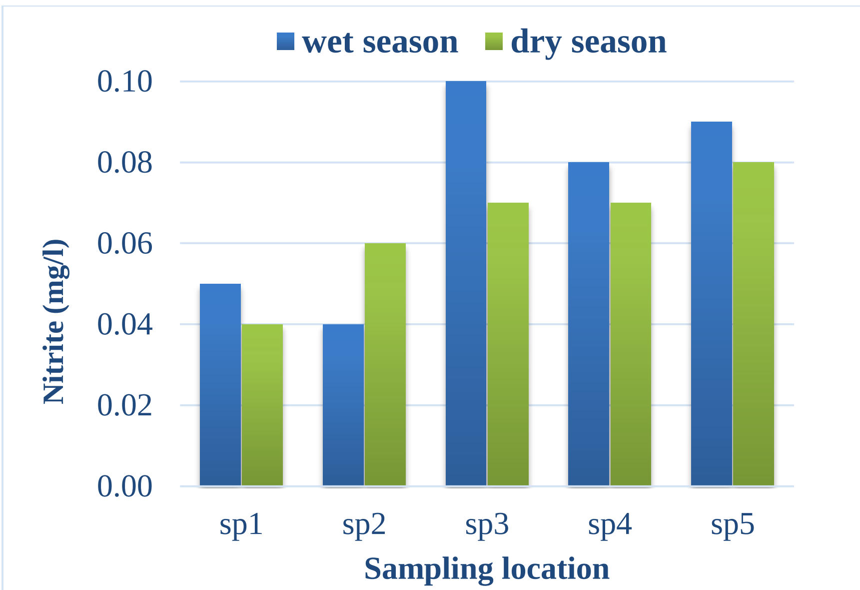

Figure 4.4 Nitrite of Shine River

4.2.5 Nitrate concentration

The concentration of nitrates is used as indication of level of micronutrients in water bodies and has ability to support plant growth. High concentration of nitrate favored growth of phytoplankton. Surface water can be contaminated by sewage and other wastes rich in nitrates. A high concentration of nitrate in drinking water is reported to cause blue baby syndrome (Tufuor et al., 2007). The nitrate content in the study area varied from a minimum of 3.29 mg/l at SP3 to a maximum of 3.81 mg/l at SP2 in wet season and in dry season varied from a minimum of 3.6 mg/l at SP1 to a maximum of

4.5 mg/l at SP3 (Figure 4.8). The mean value of all sampling points of wet and dry season was 3.56 mg/l and 4.2 mg/l respectively. The nitrate concentration value recorded all sampling points both wet and dry season was under the permissible values of WHO (2008) and EEPA (2003) standards for domestic use. The permissible limit of nitrate concentration is 45mg/l and 50mg/l respectively. According to WHO standards the nitrate value of domestic water supply should not be exceeded 45 mg/l.

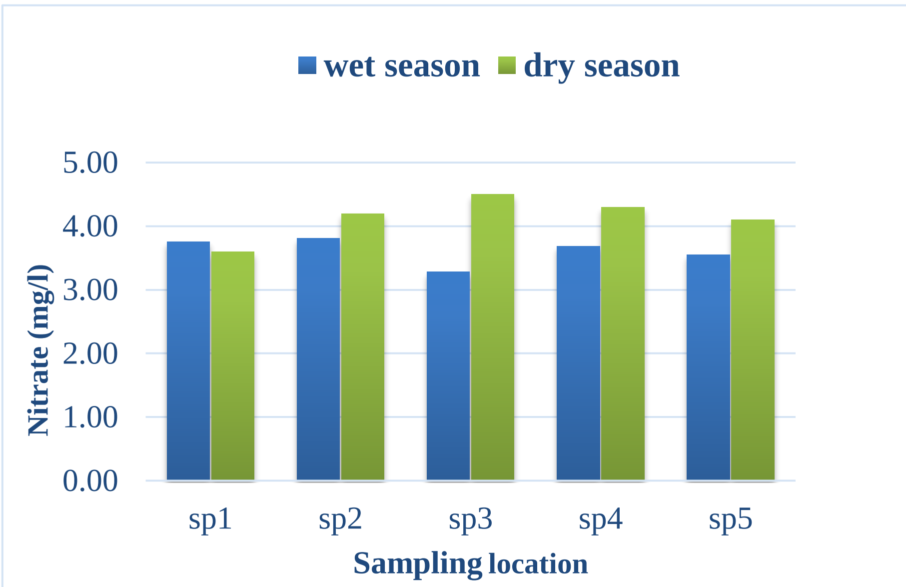

Figure 4.5 nitrate of Shine River

4.2.6 Phosphate concentration

Phosphate may occur in surface water as a result of domestic sewage, detergents, soaps and agricultural effluents with fertilizers. It is a vital nutrient for all living things but, introduction of excessive phosphorus in form of phosphates in aquatic environment can cause eutrophication. The phosphate concentration values ranged from a minimum of 0.63 mg/l at SP1 to a maximum of 0.7 mg/l at SP5 in wet season and in dry season ranged from a minimum of 0.39 mg/l at SP1 to a maximum of 2.3 mg/l at SP5 (Figure 4.9). The mean value of all sampling points of wet and dry season was 0.62 mg/l and 1.2 mg/l respectively. Maximum phosphate values recorded at Sp5 during dry period might be around this site entry of detergents due to washing of clothes, washing of bodies, domestic sewage and disposal of dead animals stockpiled and could have contributed to the inorganic phosphate content in the river. Except sp5, all other sampling points both wet and dry period of the phosphate value was under the permissible limit of WHO (2003) for drinking water standards. The permissible limit of phosphate value is 1mg/l.

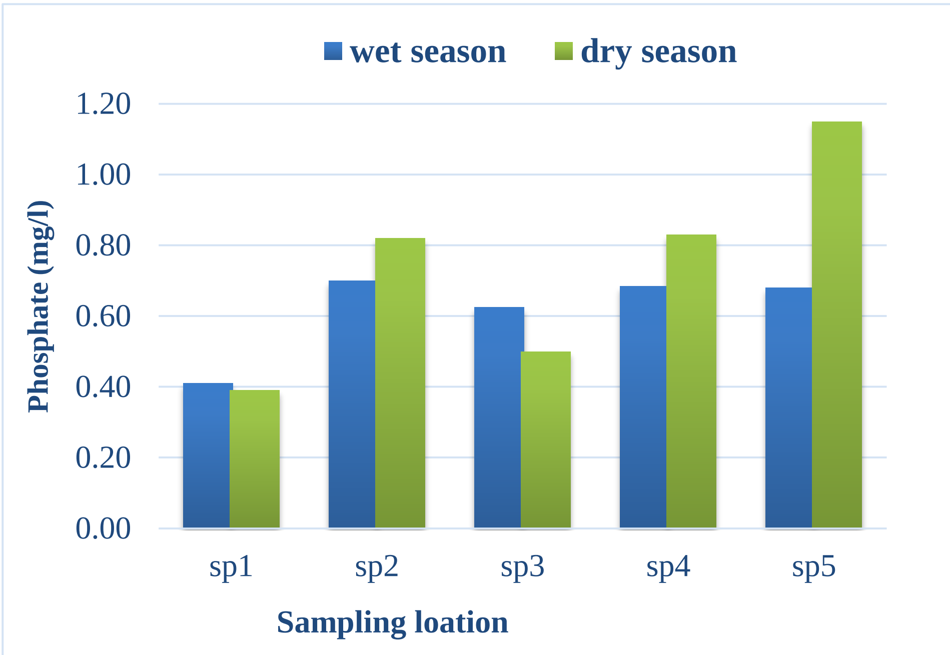

Figure 4.6 phosphate value of Shine River

4.2.7 Biological oxygen demand (BOD_5)

BOD_5 of water is the amount of dissolved oxygen taken up by aerobic bacteria in degrading of oxidizable organic matter in the sample measured after five days incubation in the dark at 20°C. The fifth day BOD values ranged from a minimum of 8 mg/l at SP1 to a maximum of 18 mg/l at SP5 in wet season while in dry season the BOD_5 value ranges from a minimum of 6 mg/l at SP1 to 24mg/l at SP5 (Figure 4.10). The mean value of all sampling points of both wet and dry season was 13 mg/l and 16 mg/l respectively. The fifth day BOD value recorded all sampling points both wet and dry season was above the permissible limit of 2-5 mg/l standard of WHO (2008) and Ethiopian EPA (2008) to the protection of aquatic species. The increase BOD_5 value recorded from upstream to downstream both wet and dry season might be dilution and natural self -purification process effect was insufficient to higher the BOD_5 levels. The highest BOD value recorded in dry season and the lowest value in wet season due to this the increase of organic matter break down in aerobic bacteria in dry period. Based on BOD_5 concentration of Shine River not suitable for domestic purpose without proper treatment. According to WHO standards the BOD value for domestic water supply maximum should not be exceeded 5 mg/l.

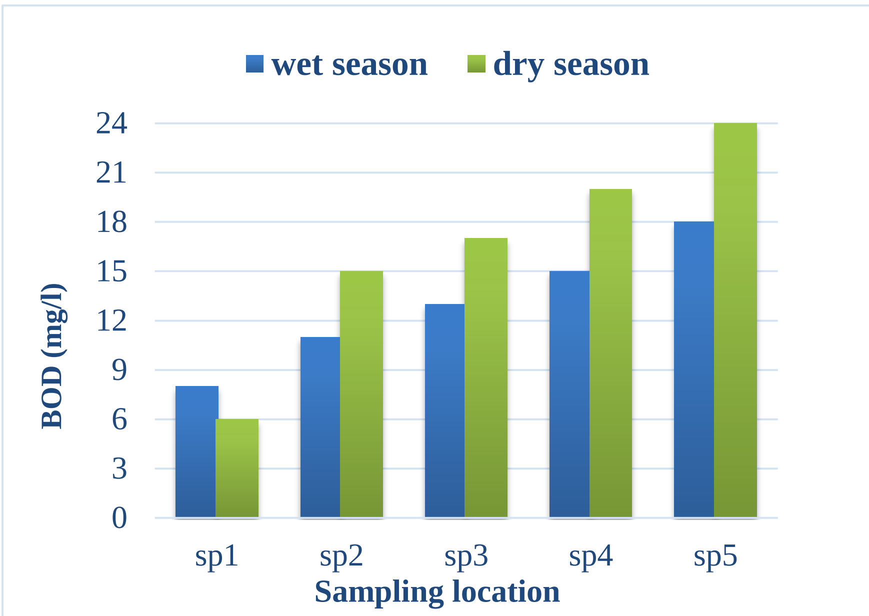

Figure 4.7 BOD value of Shine River

4.2.8 Dissolved oxygen (DO) concentration

Dissolved oxygen (DO) is essential to all forms of aquatic life including the organisms that break down man-made pollutants. The amount of dissolved Oxygen (DO) in water is one of the most commonly used indicators of a river health. DO concentrations are influenced by many factors including water temperature, the rate of photosynthesis, the degree of light penetration (turbidity and water depth), the degree of water turbulence or wave action, and the amount of oxygen used by respiration and decay of organic matter (Volunteers, 2006). In the present investigation DO levels was ranged from a minimum of 4.3 mg/l at SP5 to a maximum of 6.8 mg/l at SP1 in wet season where as in dry season DO values ranged from a minimum of 3.6 mg/l at SP5 to 7.2 mg/l at SP1. The mean value of all sampling points of both wet and dry season was 5.6 mg/l and 5.1 mg/l respectively, which were found above the permissible limit of WHO standards (Figure

4.11). The highest DO was recorded during wet period and the lowest DO was during the dry period which might be in dry period solubility of gas decrease. Solubility of gases are inversely proportional to temperature. Sampling point (SP1, SP2 and SP3) in wet period and (SP1, SP2) in dry period was above the permissible limit of (5 - 8mg/l) per WHO (2008) standards which are satisfactory for survival and growth of aquatic organisms. Whereas sampling point (SP4, SP5) in wet period and (SP3, SP4, SP5) in dry period was the lowest DO value recorded per WHO standards. They were lower than 5 mg/l which is many life forms are put under stress (Boman et al., 2008). The current findings showed that DO value reduced from upstream to downstream due to increasing of pollution loads goes to upstream to downstream of the River. As reported by Saksena et al., (2008), dissolved oxygen is generally reduced in the water due to respiration of biota, decomposition of organic matter (human and animal excreta, soap), oxygen demanding wastes and inorganic reluctant such as ammonia, nitrites etc. resulting in the uptake of oxygen in the oxidative breakdown of these wastes. According to WHO standards the DO value for the survival of aquatic ecosystem should be exceeded 5mg/l.

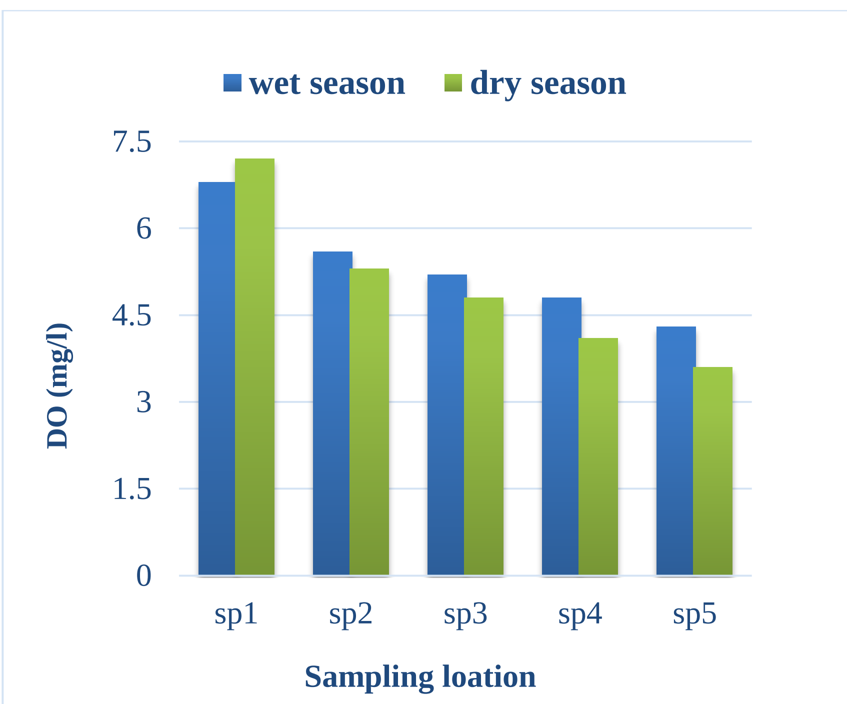

Figure 4.8 DO value of Shiny River

4.2.9 calcium concentration

Calcium is directly related to hardness. The calcium ion values ranged from a minimum of 14.5 mg/l at sp5 to a maximum of 24 mg/l at sp3 in wet season where as in dry season calcium concentration ranges from a minimum of 32 mg/l at sp1 to a maximum of 52 mg/l at sp5 (Figure 4.12). The mean value for all sampling points of wet and dry season was 19.4 mg/l and 41 mg/l respectively. From the result showed the highest value recorded in dry and the lowest value in wet season which might be the surrounding community used detergents and soaps their washing of bodies and clothes more in dry period. All sampling point both wet and dry season calcium concentration was lay under the permissible value of WHO (2008) (75mg/l).

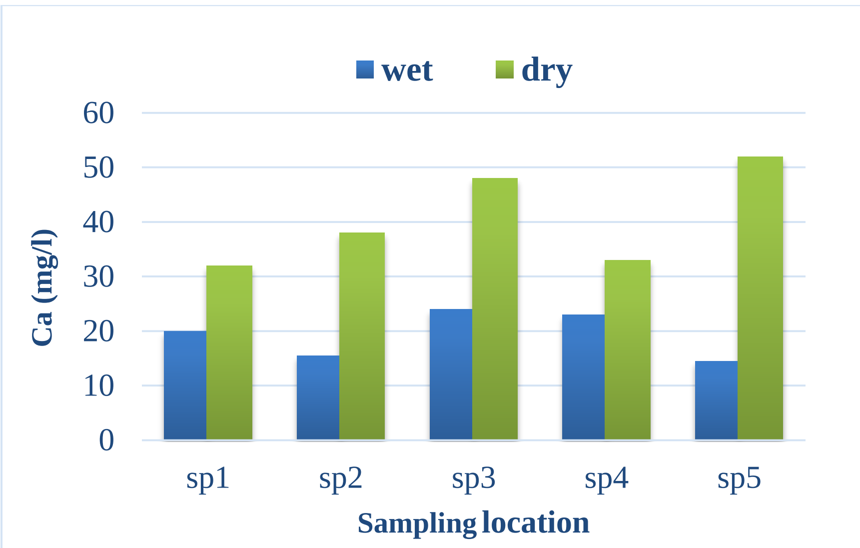

Figure 4.9 calcium ion of Shine River

4.2.10 Magnesium concentration

Magnesium is directly related to hardness. Magnesium content in the investigated water samples was ranging from a minimum of 17 mg/l at sp3 to a maximum of 31.5 mg/l at sp1 in wet season where as in dry season magnesium concentration was ranging from a minimum of 43 at sp1 to a maximum of 64 mg/l at sp5 (Figure 4.13). The mean values for all sampling points of wet and dry season were 24.6 mg/l and 53.6 mg/l respectively. All sampling point in wet season except in dry period magnesium ion was lay under the permissible values of WHO (2008) (50mg/l) for domestic use. But in dry period sp3, sp4 and sp5 were above the limit.

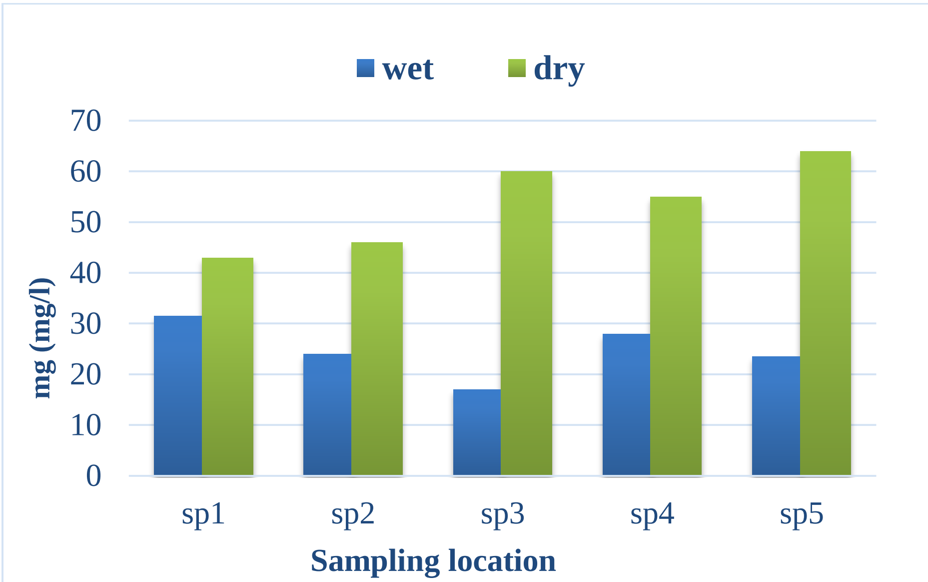

Figure 4.10 magnium ion of Shine River

4.3 Biological water quality assessment for domestic purpose

4.3.1 Fecal coliforms

The fecal coliform counts ranged from a minimum of 67 cfu/100ml at SP1 to a maximum of 292 cfu/100ml at SP4 in wet season where as in dry season ranged from 70 cfu/100ml at SP1 to a maximum of 328 cfu/100ml at SP4 (Figure 4.14). The mean values for all sampling points of wet and dry season were 189 cfu/100ml and 261 cfu/100ml respectively. The highest fecal coliforms were recorded during dry period and the lowest fecal coliforms were during the wet period. The increase fecal coliforms value recorded from upstream to downstream both wet and dry season might be high amount of animal and human wastes as goes to downstream. The fecal coliforms all sampling points both wet and dry season in the study area were show to be above the maximum permissible limit of WHO (0 cfu/100 ml). Based on risk associated category for human health the fecal coliform at SP2, SP4 and SP5 both wet and dry season too numerous count (high risk category) and the rest SP1 and SP3 medium risk category for health. The fecal coliform values were within the "no effect" range of 5.0–6.0 for domestic water use (WRC, 2003). These values indicate significant and increasing risk of infectious disease transmission when the water is used for domestic purposes. Based on this limit all sampling points of Shine River are not fit for domestic use. According to WHO standards the fecal coliform value of domestic water supply should not be exceeded 0cfu/100ml.

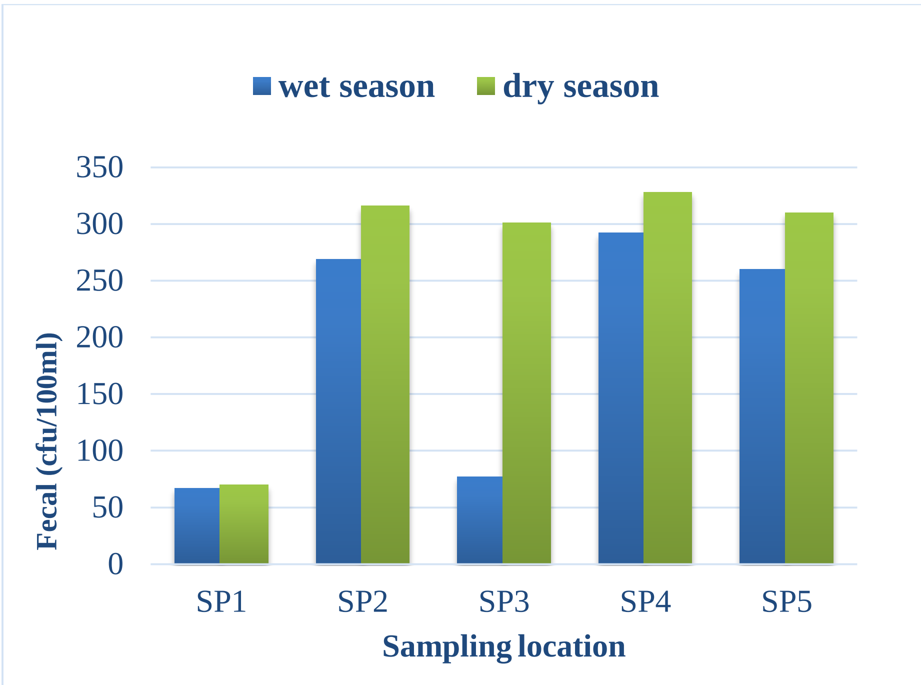

Figure 4.11 fecal coliform of Shine River

4.3.2 Total coliforms

The total coliform counts ranged from a minimum of 69 cfu/100ml at SP1 to a maximum of 102 SP4 cfu/100ml in wet season where as in dry season ranged from 102 cfu/100ml at SP1 to a maximum of 143 cfu/100 ml at SP4 (Figure 4.15). The mean value for all sampling points of wet and dry season was 82 cfu/100ml and 120 cfu/100ml respectively. Based on risk associated category for human health the total coliform at SP1, SP2, SP3 and SP5 in wet season was medium risk human health where as in dry season all sampling points were too numerous count (high risk category) for human health. Based on the result, it concludes that Shine River not fit for domestic consumption. According to WHO standards the total coliform value of domestic water supply should not be exceeded 0cfu/100ml.

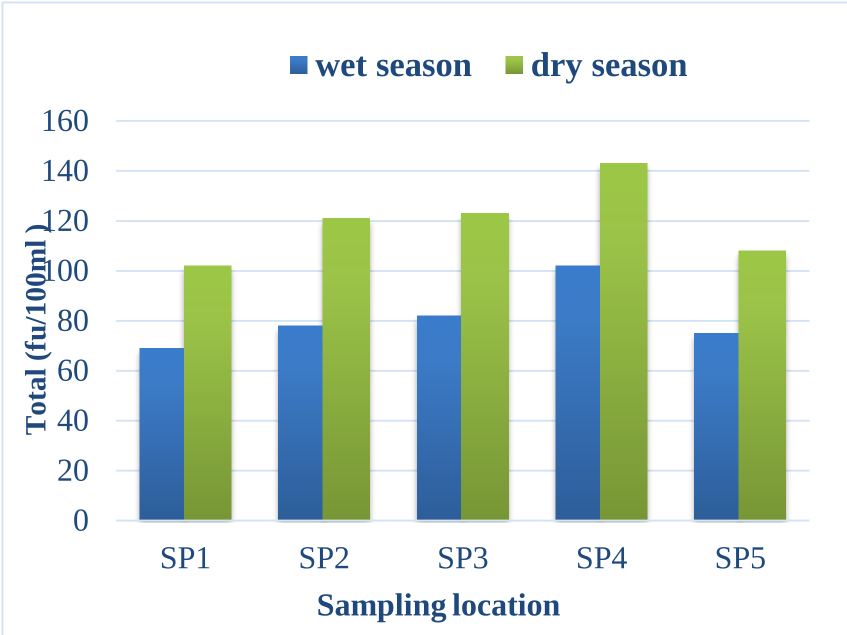

Figure 4.12 total coliform of Shine River

4.4 Water quality assessment for irrigation purpose

Evaluation of Water Quality for Irrigation depends upon many factors, including Salinity, Sodium Absorption Ratio (SAR), Soluble Sodium Percentage (SSP) and Magnesium Hazard (MH). These factors could be a guide for farmers to avoid crop loss due to irrigation, and they could take measures to improve soil productivity and crop yields. Table 4.1 shows the calculated values of these factors for each surface water sample.

Table 4.1 Table Irrigation water quality parameters in the study area

Sampling point	SAR (meq/l)	SSP (meq/l)	MAR (meq/l)
sp1	0.57	16.46	44.61
sp2	0.54	14.93	42.1
sp3	0.49	12.17	42.86
sp4	0.55	15.38	50.1
sp5	0.46	11.48	42.11

4.4.1 Water Salinity

To evaluate salinity of Water, Electric Conductivity has been measured. The build-up of salinity level in water has a negative effect on both the soil structure and crops grown on the soil, where the skyrocket of salinity in the irrigation water increases the osmotic pressure of the soil solution (Suresh and Nagesh, 2015). According to Richards (1954) classified water suitability for irrigation depending upon EC into four classes. The electrical conductivity values ranged from a minimum of 279 to a maximum of 383µS/cm with a mean value of 337.1 µS /cm. All sampling points with EC value between 250 and 750 µS /cm, indicating that all samples were a good (class 2) water quality for irrigation in the table 4.2 below. Based on this limit Shine river was suitable for irrigation purpose.

Table 4.2 surface water suitability for irrigation based on EC (source (Richards, 1954))

EC µs/cm	Class
< 250	Excellent (class 1)
250-750	Good (class 2)
750-2250	permissible (class3)
>2250	Unsuitable (class 4)

4.4.2 Sodium Absorption ratio (SAR)

The sodium adsorption ratio parameter evaluates the sodium hazard in relation to the concentration of Ca^{2+} plus Mg^{2+} in irrigation water (Bauder et al., 2008). In fact, the high SAR leads to deterioration of physical properties of soil; hydraulic conductivity and clay swelling (Sappa et al., 2015). In the study area, the SAR values ranging from a minimum of 0.46 to a maximum of 0.57meq/l with a mean value of 0.52 meq/l indicate that all the samples were an excellent quality for irrigation or low sodium water in the table 4.2 below.

Table4.3 Surface water suitability for irrigation based on SAR (Source (Richards, 1954)**).**

SAR	Quality of water
0-10	low sodium water (Excellent)
10-18	medium sodium water (Good)
18-26	high sodium water (Doubtful)
> 26	very high salinity (un suitable)

4.4.3 Soluble Sodium Percentage (SSP)

Soluble sodium percentage gives a clear idea about sodium content which is important for studying sodium hazard. High SSP probably hinders the growth of plants and reacts with soil to reduce its permeability (Joshi et al., 2009). Soluble sodium percentage ranged from 11.8 to 16.46 with a mean value of 14.1meq/l. All sampling points SSP value less than 20 score indicating an excellent quality for irrigation in table 4.4 below.

Table 4.4 Surface water suitability for irrigation based on SSP (source (Todd, 1980)**).**

SSP	Suitability for irrigation
<20	Excellent
20-40	Good
40-60	Permissible
60-80	Doubtful
>80	Unsuitable

4.4.4 Magnesium Adsorption ratio (MAR)

Magnesium hazard is considered as one of the most important parameter in determining the suitability of water for irrigation purpose; moreover, it is necessary for plant growth; however, the high amounts of Mg^{2+} in water will adversely affect crop yields (Sappa et al., 2014). Water with MAR <50% is suitable for irrigation while any one with MAR >50% is not suitable for irrigation purposes (Paliwal, 1972). In the current study, Magnesium hazard ranges from 42.1 to 50.1 with a mean value of 44.34. Results from this research showed that all the water samples except sampling point four have MAR value <50%. Based on MAR assessment, it concludes that Shine River was suitable for irrigation except sampling point four.

Table4.5 Surface water for irrigation based on MAR (source (Ayers and Westcot, 1985)**).**

MH/MAR	**Water quality**
<50	Suitable
> 50	Unsuitable

4.5 Temporal and Spatial varaibility of water quality parameters

Temperature. The spatial variation showed that aminimum mean value of 20.8 at up stream (sp1) and amaximum mean value of 24.2 at downstream (sp5). The temporal varaition showed that aminimum mean value of 21.2 in wet season and amaximum of mean value of 24.5 in dry season. Due to this the maximum value in dry season,which is high solar radiation,low water level, high atmospheric temperature. The statistical variations of temperature both spaiatally and temporally were significant at the 5% level ($p < 0.05$) (Appendices A and B). Indicating different sources of pollutant from sampling season and space affecting on the quality of Shine River.

pH. The spatial mean values varied between 7.37 at up stream and 7.27 downstream. The temporal mean values varied between 7.18 in wet season and 7.4 in dry season. The variations of pH between the dry and wet season and along the course of the river (between upstream and downstream)were statistically significant at the 5% level ($p < 0.05$) (Appendices A and B). Indicating different sources of pollutant from different sampling season and space affecting on the quality of Shine River.

Turbidity. The spatial distribution showed that aminimum mean value of of 24 NTU at up stream (sp1) and amaximum mean value of 45 NTU at downstream (sp5). The maximum value at Sp5 from upstream and the minimum value at downstream across the river which might be increase small streams to carry urban and agricultural runoff in to the river.

The temporal mean values varied between 17 NTU in dry season and 49 NTU wet season. The highest turbidity value during wet period and the lowest in dry period due to catchment runoff, soil erosion, and waste discharge from urban areas in wet period The statistical variations of turbidity both spatially and temporally were significant at the 5% level ($p < 0.05$) (Appendices A and B). Indicating different sources of pollutant from different sampling season and space affecting on the quality of Shine River.

Total dissolved solids. The spatial distribution showed that aminimum mean value of 155 mg/l at up stream (sp1) and amaximum mean value of 212 mg/l at downstream (sp5). The results showed that lower values in the upstream catchment and increased at downstream. At (upstream), there were less polluting activities to raise the concentration of the dissolved solids. While from the (downstream), there were a lot of commercial activities, market which resulted in a lot of solid and liquid wastes being discharged into the river and increasing the amount of dissolved solids. In this area there was lot of unmanaged solid wastes.

The temporal mean values varied between 147 mg/l at wet season and 222mg/l at dry season. The statistical variations of TDS both sapatially and temporally were significant at the 5% level ($p < 0.05$) (Appendices A and B). Indicating different sources of pollutant from different sampling season and space affecting on the quality of Shine River.

Electric conductivity. The spatial distribution showed aminimum value 237.4 µs/cm at up stream (sp1) and maximum value of 323.7 µs/cm at downstream (sp5). The highest value at (sp5) was attributed to the high concentration of chemical constituents from urban domestic wastes and institutions around this area. The minimum value at Sp1 was as a result of non domestic effluents bcause of this site were found above the Town which could not contribute to chemical pollution of the water. In addition to higher elemental loads that were washed into the upstream from down stream river from the diffuse and point sources prevalent.

The temporal varaition showed aminimum value 227.1 µs/cm in wet season and amaximum value of 340 µs/cm dry season. The statistical variations of conductivity both sapatially and temporally were significant at the 5% level ($p < 0.05$) (Appendices A and B). Indicating different sources of pollutant from different sampling season and space affecting on the quality of Shine River.

Dissolved oxygen. The spatial variation showed that the lowest mean values of 4 mg/l at downstream and the highest mean value of 7 mg/l at upstream. The highest mean value reoreded at upstream dueto this the highest waste loads that were washed into upstream to downstream from diffuse and non point sources pollutants. The temporal mean values varied between 5 mg/l in dry and 5.6 mg/l wet season.The satatistical variations of dissolved oxygen (DO) between the dry and wet season (temporally) were significant at ($p < 0.05$. But the course of the river between upstream and downstream (spatially) were statistically not significant $p>0.05$ (Appendices A and B). Indicating different sources of pollutants from different sampling season affecting the quality of Shine River.

Biochemical oxygen demand. The spatial variation showed that aminimum mean values of 7 mg/l at upstream (Sp1) and amaximum mean value of 21 mg/l at downstream (Sp5). The temporal mean values varied between 13 mg/l in wet and 16.4 mg/l dry season The variations of biochemical oxygen demand (BOD) between the wet and dry season (temporally) were satatically significant ($p < 0.05$). But along the course of the river between upstream and downstream (spatially) were not statistically significant at the 5% level ($p>0.05$) (Appendices A and B). Indicating different sources of pollutants from different sampling season affecting the quality of Shine River.

Nitrate-N. The spatial distribution showed that aminimum mean values of 3.7 mg/l at upstream and the maximum mean value of 4.0 mg/l at downstream. The temporal variation showed that the minimum mean values of 3.6 mg/l in wet and maximum mean values of 4.2 mg/l dry season The statistical variations of nitrate both sapaitally and temporally were significant at the 5% level ($p < 0.05$) (Appendices A and B). Indicating different sources of pollutant from different sampling location and season affecting on the quality of Shine River.

Ammunia. The spatial mean values varied between 0.05 mg/l at upstream and 0.16 mg/l at downstream. The temporal mean values varied between 0.09 mg/l at wet and 0.12 mg/l at dry season The statistical variations of ammonia both sapaitally and temporally were not significant at the 5% level ($p > 0.05$) (Appendices A and B). Indicating different sources of pollutant from different sampling location and season were not affecting on the quality of Shine River.

Nitrite. The spatial mean values varied between 0.05 mg/l at upstream and 0.09 mg/l at downstream. The temporal mean values varied between 0.07 mg/l in wet and 0.06 mg/l dry season. The statistical variations of nitrite both sapaitally and temporally were not significant at the 5% level ($p > 0.05$) (Appendices A and B). Indicating different sources of pollutant from different sampling location and season were not affecting on the quality of Shine River.

Phosphate. The spatial mean values varied between 0.4 mg/l at upstream and 0.9 mg/l at downstream. The temporal mean values varied between 0.62 mg/l in wet and 0.74 mg/l dry season The statistical variations of phosphate between the dry and wet season were significant at the 5% level ($p < 0.05$) and along the course of the river (between upstream and downstream) were statically not significant($p > 0.05$) (Appendices A and B). Indicating different sources of pollutant from different sampling season affecting on the quality of Shine River.

Calcium. The spatial variation showed that the lowest mean values of 26 mg/l at upstream and the highest mean value of 36 mg/l at downstream. The temporal mean values varied between 19.4 mg/l in wet and 40.6 mg/l dry season The statistical variations of calcium both sapaially and temporally were significant at the 5% level ($p < 0.05$) (Appendices A and B). Indicating different sources of pollutant from different sampling season and space affecting on the quality of Shine River.

Magnesium. The spatial variation showed that the minimum mean values of 37.3 mg/l at upstream and the maximum mean value of 43.8 mg/l at downstream. The temporal mean values varied between 24.8 mg/l in wet and 53.8 mg/l dry season The statistical variations of magnesium both sapaially and temporally were significant at the 5% level ($p < 0.05$) (Appendices A and B). Indicating different sources of pollutant from different sampling season and space affecting on the quality of Shine River.

Total coliforms. The spatial distribution showed that the lowest mean values of total coliform counts of 85 cfu/100 ml at upstream and the highest mean value of 123 cfu/100 ml at downstream. The temporal mean values total coliform varied between 69 cfu/100 ml in wet and 143 cfu/100 ml dry season. The variations of total coliforms between the dry and wet season and along the course of the river (between upstream and downstream) were were statistically significant at the 5% level ($p < 0.05$ (Appendices A and B). Indicating different sources of pollutant from different sampling season and space affecting on the quality of Shine River.

Fecal coliforms. The spatial mean values of fecal coliforms count varied from aminimum of 68 cfu/100 ml at upstream to a maximum of 310 cfu/100 ml at downstream. The temporal mean values of fecal coliform varied between 67 cfu/100 ml in wet and 310 cfu/100 ml dry season. The variations of fecal coliforms between the dry and wet season and along the course of the river (between upstream and downstream) were statistically significant at the 5% level ($p< 0.05$) (Appendices A and B). Indicating different sources of pollutant from different sampling season and location affecting on the quality of Shine River.

4.6 Pearson correlation analysis

The correlations among physicochemical and biological parameters of the Shine river were presented in Table 4. 6. Correlation coefficient (r) between parameter with parameter all sampling points were calculated. For parameter such as water temperature, pH, turbidity, electrical conductivity, total dissolved solids, phosphate, ammonia, nitrate, nitrite, biological oxygen demand, Dissolved oxygen, calcium, magnesium, fecal and total coliforms of Shine river. The degree of line association between any two of the water quality parameters as measured by the simple correlation coefficient (r) is presented in table 4-6.

Table 4. 6 Correlation Coefficient (r) among physic-chemical and biological parameters of Shine river

paramete	Temp	pH	Turbi	TDS	EC	BOD5	DO	No3	NH3	PO4	NO2	Ca	Mg	fecal.	Tota
Temp	1														
pH	-0.34	1.00													
Turbi	0.96	-0.21	1.00												
TDS	0.96	-0.42	0.97	1.00											
EC	0.95	-0.43	0.97	1.00	1.00										
BOD5	1.00	-0.42	0.95	0.97	0.97	1.00									
DO	-0.98	0.51	-0.91	-0.96	-0.95	-0.99	1.00								
No3	0.40	-0.97	0.23	0.42	0.42	0.47	-0.56	1.00							
NH3	0.81	-0.76	0.65	0.75	0.75	0.84	-0.89	0.85	1.00						
PO4	0.80	0.09	0.86	0.73	0.72	0.75	-0.68	0.00	0.46	1.00					
NO2	0.81	-0.10	0.77	0.77	0.76	0.80	-0.79	0.13	0.52	0.46	1.00				
Ca	0.61	0.09	0.50	0.47	0.44	0.58	-0.58	0.02	0.40	0.30	0.89	1.00			
Mg	0.80	0.01	0.92	0.87	0.87	0.78	-0.73	-0.07	0.34	0.73	0.77	0.45	1.00		
fecal	0.76	-0.80	0.66	0.76	0.77	0.80	-0.84	0.85	0.95	0.52	0.35	0.14	0.36	1.00	
Total	0.34	-0.84	0.31	0.53	0.54	0.43	-0.51	0.71	0.54	-0.17	0.36	0.06	0.29	0.57	1

***** Correlation rating > 0.9 strong significant posetive correlation * -0.61 between - 0.9 negative significant correlation

* Correlation rating < 0.61 not significant posetive correlation * Correlation rating > -0.9 strong significant negetive correlation

* Correlation rating < -0.61 not significant negative correlation *Correlation rating 0.61-0.9 posetive significant correlation

From the above table showed that temperature has shown the strong significant positive correlation with Turbidity (r = 0.96), TDS (r=0.96),EC (r=0.95 and BOD (r= 1.00) and signinificant correlation with fecal, mg, ca, nitrite, ammonia and phosphate. It also not significant positive correlation with pH (r=0.34),Nitrate (r= 0.4) and total coliform while strong signifiant negative correlation with DO (r= -0.98). The BOD had shown strong negative correlation with DO (r= -0.99) and significant positive correlation with Nitrite, feal,phosphate and ammonia. This indicate that changing in amount of Nitrite, fecal, Phosphate and ammonia have caused significant posetive change in ondutivity value. The electrical conductivity showed strong significant positive correlation BOD (r= 0.97) and strongly negative correlation with DO (r= -0.95) and not significant positive correlation Ca, Nitrate and total oliforms. The nitrate had shown posetive significant correlation is with ammonia (r=0.85), fecal (r=0.85) and total coliforms (r= 0.71) and mg, ca, Nitrite and phosphate not significant correlation. The ammonia showed that strong signifiant posetive orrelation of feal and not significant posetive orrelation with phosphate, nitrite, ca, mg and total oliforms. The phosphate showed not signifiant posetive correlation with nitrite, mg, ca, fecal and not significant negetive correlation with total coliform. This indicate that changing in amount of nitrite, mg, ca, fecal and total coliform have caused not significant posetive change in phosphate value.

4.7 Assessmet of pollution status of Shine River using water quality index based on physio chemical parameters

For water quality index calculation, the water quality parameters are selected based on its direct involvement in deteriorating water quality. The standards for the water quality were used as recommended by WHO standards. Thirteen water quality parameters have been selected for the purpose of calculation of WQI of Shiny River. They were Temperature, pH, Turbidity, Electrical conductivity, Total dissolved solids, Biological oxygen demand, Dissolved oxygen, NO_3, NO_2, PO_4, NH_3, Ca and Mg. The WQI values of Shiny River for wet season and dry season were calculated separately given in table 4.6 and 4.7 respectively.

Table 4.7 Water quality index during wet period

parameter	SP1	SP2	SP3	SP4	SP5	K
Temperature	19.5	20.3	21	21.4	23.6	0.58
pH	7.3	7.2	7.23	7.18	7.21	0.58
Turbidity	39	43	51.5	53	58	0.58
EC	195.9	218.7	201.4	255.2	264.5	0.58
TDS	128.8	143	135.3	165.8	164.5	0.58
BOD	8	11	13	15	18	0.58
DO	6.8	5.6	5.2	4.8	4.3	0.58
NO_3	3.76	3.61	3.3	3.69	3.56	0.58

NO_2	0.05	0.04	0.1	0.08	0.09	0.58
PO_4	0.41	0.7	0.63	0.69	0.68	0.58
NH_3	0.06	0.07	0.09	0.09	0.12	0.58
Ca	20	15.5	24	23	14.5	0.58
Mg	31.5	24	17	28	23.5	0.58
∑Wi	1.27	1.27	1.27	1.27	1.27	
∑QiWi	108.6	131	137.5	150	160.7	
WQI	85.5	103.1	108.2	118.4	126.6	
Extent of pollution	Moderately polluted	Heavily polluted	Heavily polluted	Heavily polluted	Heavily polluted	
Overall mean WQI	**108.4**					

From the above table 4.6 showed that WQI values of the wet season ranging from 85.5 to 126.6 and the overall mean value of sampling points were 108.4 of the sample points of Shine River, which is the sample of the study area in the wet season of the pollution level was heavily polluted in other words the river water quality status was poor to very poor due to that Turbidity, DO and BOD values in the wet and dry season were very high and above the permissible limit which makes the river water quality moderately to heavily polluted and the water require proper treatment before use in the wet season. Generally, based on water quality index River Shine does not fit for domestic purpose.

Table 4.8 water quality index during dry period

parameter	SP1	SP2	SP3	SP4	SP5	K
Temperature	22	23	23.6	24.1	24.8	0.58
Ph	7.43	7.38	7.4	7.35	7.46	0.58
Turbidity	9.5	13	11	22	32	0.58
EC	279	308	353	375	383	0.58
TDS	181	200	229	243	258	0.58
BOD_5	6	15	17	20	24	0.58
DO	7.2	5.3	4.8	4.1	3.6	0.58
NO_3	3.6	4.2	4.5	4.3	4.2	0.58

NO_2	0.04	0.06	0.07	0.07	0.08	0.58
PO_4	0.39	0.82	0.5	0.83	1.15	0.58
NH_3	0.03	0.023	0.18	0.2	0.19	0.58
Ca	32	38	48	33	52	0.58
Mg	43	47	60	55	64	0.58
∑Wi	1.27	1.27	1.27	1.27	1.27	
∑QiWi	43.1	74	74	111.5	164	
WQI	33.9	58.3	58.4	87.8	129.7	
Extent of pollution	Clean	Slightly polluted	Slightly polluted	Moderately polluted	Heavily polluted	
Overall WQI	**74.1**					

From the above table 4.7 showed that WQI values of the dry season ranging from 58.3 to 129.7 and the overall mean values of sampling points were 74.1 of water samples of Shine River which is the sample of the study area in the dry season of the pollution level was slightly polluted or water quality status of Shine River was poor water quality due to that Turbidity, DO and BOD values in the dry season was very high and above the permissible limit which makes the river water quality slightly polluted. When the seasonal values of Turbidity were compared to the wet season is more than the dry season whereas BOD was the reverse. According to water quality index When compare the pollution level of the two seasons, the wet season more polluted than dry season due to this Turbidity values highly affected the level of pollution in the wet season than dry season. Generally, based on water quality index River shine water not suitable for domestic purpose.

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Physicochemical and micro biological water quality assessment on Shine River was conducted based on selective water quality parameters which are relevant to indicate the suitability of water for domestic and irrigation purposes. With the exception of turbidity, BOD, DO, fecal and total coliform, all the other water quality parameters were found below the permissible limits of WHO standards for domestic water use. Depending on bacteriological analysis result showed that most of fecal and total coliform bacteria of River Shine were high risk category (Numerous counts) for human health. It can conclude that the Shine river water is not suitable for direct human consumption at all sampling locations and both dry and wet season. Based on irrigation water quality parameters assessment like salinity, SAR, SSP and MAR values found below the permissible limits of the FAO guidelines in the study area indicated that most of sample points River Shine water was suitable for irrigation. However it imperative that periodic monitoring of river water quality and effluent discharges into the river is done. Based on water quality index value showed that, Shine River in dry and wet season were 74.1 and 108.4 respectively. In other words the water pollution status of Shine River was poor (slightly polluted) and unsuitable (heavily polluted), which indicates that River Shine was not suitable for direct domestic use. Like drinking, cooking and bathing. Due to this Turbidity, DO and BOD values in the wet and dry season were very high and above the permissible limit of WHO standards. From statistically analysis result, water quality parameters (BOD, DO, Po_4, No_2, NH_3) were spatially not significant variation ($p > 0.05$) and other parameters (Temperature, pH, turbidity, TDS,EC, Ca, mg and No_3) were statistically significant and except (Ammonia, Nitrite), all other parameters temporally significant variation ($p < 0.05$) which might be due to the different factors such as rainfall and changes in the human activities which led to loading the river with different pollutants during the period of sampling. The water quality parameters result showed that increase from upstream to downstream resulting that deterioration of the water quality from upstream to downstream of River Shine.

5.2 Recommendation

On the basis of the finding the following are recommended: -

- It is recommended that effective management of the Shine River is required in order to minimize pollution level. There is also an urgent need for public awareness on the state of the water and apply legal and relevant laws regarding to disposal of solid and liquid wastes across the river.
- Before check the physic chemical and biological water quality parameters, the community shouldn't be used for domestic consumption and highly recommended to check the physic chemical and biological water quality continuously.
- Constructing adequate public latrines that help to attain open defecation free areas in the town enhancing the environmental awareness of the population.
- As it was observed that some people use the river water for domestic purpose, drinking for cattle and for irrigation so the Town local community should be

aware of the pollutants to keep the river from being susceptible for chemical, pathogenic organisms and toxic substances gradually.

- The river water quality management is very important for Shine River to sustainable development of agriculture production and river water use for domestic. Therefore, it should be conduct close monitoring program in the watershed.
- In this research only the physic-chemical and biological characteristics of the river water is considered. Finally, it is advisable further study on the heavy metal characteristics of river water.
- SAR, MAR and SSP irrigation water quality parameters only considered for determine of the suitability of water for irrigation purpose. It is highly recommended to have future studies/research should be need on the other irrigation water quality parameters like residual sodium bicarbonate (RSBC), carbonate and Kelly Ratio (KR) as well as the soils quality test at downstream of irrigated lands in detail.

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APPENDIX

Appendix A: one way ANOVA of water quality parameters among the sampling seasons (Temporal variation)

		Sum squares	Df	*Mean square*	*F*	*P-value*
Temperature	Between Groups	0.096	1	0.096	1922.000	0.0005
	Within Groups	0.000	2	0.000		
	Total	0.096	3			
PH	Between Groups	0.042	1	0.042	1672.485	0.0059
	Within Groups	0.000	2	0.000		
	Total	0.042	3			
Turbidity	Between Groups	1056.250	1	1056.250	21125000.000	3.29E-06
	Within Groups	0.000	2	0.000		
	Total	1056.250	3			
EC	Between Groups	11804.823	1	11804.823	46751.772	2.14E-05
	Within Groups	0.505	2	0.252		
	Total	11805.328	3			
TDS	Between Groups	5484.143	1	5484.143	2171937.832	4.6E-07
	Within Groups	0.005	2	0.003		
	Total	5484.148	3			
NO_3	Between Groups	0.250	1	0.250	50.000	
	Within Groups	0.010	2	0.005		
	Total	0.260	3			0.019
NO_2	Between Groups	0.000	1	0.000	0.000	
	Within Groups	0.010	2	0.005		
	Total	0.010	3			1.00
NH_3	Between Groups	0.000	1	0.000	0.000	
	Within Groups	0.010	2	0.005		1.00
	Total	0.010	3			
PO_4	Between Groups	0.160	1	0.160	32.000	
	Within Groups	0.010	2	0.005		0.02
	Total	0.170	3			
BOD_5	Between Groups	9.000	1	9.000	1800.000	
	Within Groups	0.010	2	0.005		0.0005
	Total	9.010	3			
DO	Between Groups	0.087	1	0.087	696.200	
	Within Groups	0.000	2	0.000		
	Total	0.087	3			0.0044
Ca^{+2}	Between Groups	464.618	1	464.618	184007.139	5.4E-06
	Within Groups	0.005	2	0.003		

	Total	464.623	3			
Mg^{+2}	Between Groups	841.000	1	841.000	16820000.000	5.95E-06
	Within Groups	0.000	2	0.000		
	Total	841.000	3			
Fecal coliform	Between Groups	2601.000	1	2601.000	520200.000	1.92E-06
	Within Groups	0.010	2	0.005		
	Total	2601.010	3			
Total coliform	Between Groups	1521.000	1	1521.000	304200.000	3.29E-06
	Within Groups	0.010	2	0.005		
	Total	1521.010	3			

Apendix B: One way ANOVA of water quality parameters among the different sampling locations.

		Sum squares	Df	Mean square	F	P-value
Temperature	Between Groups	13.689	1	13.689	7.77	0.02
	Within Groups	14.092	8	1.76615		
	Total	27.781	9			
PH	Between Groups	0.081	1	0.081	40	0.0002
	Within Groups	0.01584	8	0.00198		
	Total	0.09684	9			
Turbidity	Between Groups	2464.9	1	2464.9	33.07	0.0004
	Within Groups	596.2	8	74.525		
	Total	3061.1	9			
EC	Between Groups	31646.25	1	31646.25	21.3	0.001
	Within Groups	11880.05	8	1485		
	Total	43526.3	9			
TDS	Between Groups	13957.7	1	13957.7	21.9	0.001
	Within Groups	5093.468	8	636.6835		
	Total	19051.16	9			
NO_3	Between Groups	0.676	1	0.676	8.5	
	Within Groups	0.62905	8	0.078631		0.01

	Total	1.30505	9			
NO_2	Between Groups	0.0000625	1	0.0000625	0.16	0.6
	Within Groups	0.00309	8	0.000386		
	Total	0.0031525	9			
NH_3	Between Groups	0.01722	1	0.01722	5.2	0.052
	Within Groups	0.02645	8	0.003306		
	Total	0.04367	9			
PO_4	Between Groups	0.20449	1	0.20449	0.6	0.4
	Within Groups	2.37331	8	0.296664		
	Total	2.5778	9			
BOD_5	Between Groups	28.9	1	28.9	0.9	0.35
	Within Groups	239.2	8	29.9		
	Total	268.1	9			
DO	Between Groups	0.289	1	0.289	0.2	0.6
	Within Groups	11.332	8	1.4165		
	Total	11.621	9			
Ca^{2+}	Between Groups	1123.6	1	1123.6	22	0.001
	Within Groups	396.9	8	49.6125		
	Total	1520.5	9			
Mg	Between Groups	2073.6	1	2073.6	37	0.0002
	Within Groups	439.5	8	54.937		
	Total	2513.1	9			
Fecal coliform	Between Groups	11424.4	1	11424.4	0.8	0.03
	Within Groups	106281.2	8	13285.15		
	Total	117705.6	9			
Total coliform	Between Groups	3960.1	1	3960.1	18	0.002
	Within Groups	1738.4	8	217.3		
	Total	5698.5	9			

Apendix C: physic- chemical data collection during lab and field measurment (four months)

August							September				
Parameter	sp1	sp2	sp3	sp4	sp5		sp1	sp2	sp3	sp4	sp5
Temperature (°C)	19.2	20.1	21	21.2	23		19.8	20.5	21	21.6	24.2
pH	7.33	7.16	7.26	7.14	7.18		7.26	7.24	7.19	7.21	7.23
Turbidity (NTU)	42	48	61	63	64		36	38	42	43	52

EC (µS/cm)	177.7	223	184.7	248.3	276.6		214	214	218	262	252.3
TDS (mg/l)	120.3	146	129.3	161.3	173		137.3	140	141.3	170.3	156
DO (mg/l)	7	5.8	5.6	5	4.5		6.6	5.4	4.8	4.6	4.1
BOD_5 (mg/l)	7.6	10	12	13	15		8.4	12	14	17	21
PO_4 (mg/l)	0.38	0.64	0.47	0.57	0.51		0.43	0.76	0.78	0.8	0.85
NH_3 (mg/l)	0.04	0.06	0.07	0.12	0.15		0.03	0.07	0.1	0.06	0.08
NO_3 (mg/l)	3.6	3.89	2.78	3.63	3.21		3.65	3.73	3.79	3.75	3.9
NO_2 (mg/l)	0.03	0.03	0.09	0.07	0.08		0.03	0.04	0.1	0.08	0.09
Ca^{+2} (mg/l)	20	14	23	23	15		20	17	25	23	14
Mg^{+2} (mg/l)	18	13	11	22	19		45	35	23	34	28

December							February				
Parameter	sp1	sp2	sp3	sp4	sp5		sp1	sp2	sp3	sp4	sp5
Temperature (°C)	21.5	22	23.2	24.5	24.9		22.5	24	24	23.7	24.7
Ph	7.4	7.41	7.38	7.33	7.44		7.46	7.35	7.42	7.37	7.48
Turbidity (NTU)	13	16	14	24	28		6	10	8	20	36
EC (µS/cm)	263	282	324	343	356		295	334	382	407	410
TDS (mg/l)	163	180	200	223	237		198	220	258	263	279
DO (mg/l)	7.6	5.4	5	4.2	3.8		6.8	5.2	4.6	4	3.4
BOD_5 (mg/l)	5.8	14	16	19	22		6.2	16	18	21	26
PO_4 (mg/l)	0.32	0.86	0.48	0.8	1.2		0.46	0.78	0.52	0.86	1.1
NH_3 (mg/l)	0.03	0.19	0.15	0.12	0.13		0.03	0.24	0.21	0.28	0.25
NO_3 (mg/l)	3.4	4.1	4.4	4.2	3.9		3.8	4.3	4.6	4.4	4.5
NO_2 (mg/l)	0.03	0.05	0.05	0.03	0.06		0.04	0.06	0.08	0.1	0.1
Ca^{+2} (mg/l)	28	34	41	32	48		36	42	55	34	56
Mg^{+2} (mg/l)	39	42	54	50	60		47	50	66	60	68
K^{+1} (mg/l)	2.4	2.7	1.8	3.4	2.8		2.8	3.1	2.4	4	3.3
Na^{+1} (mg/l)	20.1	20.3	20.6	20.8	20.3		20.5	20.7	21.2	21.3	20.7

Appendix D : micro biological data collection during lab experiment (four moths)

	August		September	
sampling point	E coli/100ml or fecal coliform	Total coliform/100 ml	E coli/100ml or fecal coliform	Total coliform/100ml
SP1	72	67	62	71
SP2	284	74	254	82
SP3	48	85	106	78
SP4	306	106	278	98
SP5	256	64	264	86

	December		February	
sampling point	E coli/100ml or fecal coliform	Total coliform/100ml	E coli/100ml or fecal coliform	Total coliform/100ml
SP1	71	100	69	104
SP2	302	114	330	128
SP3	290	116	312	130
SP4	320	150	336	136
SP5	302	104	318	112

Apendix E: Photo taken during lab experiment and field observation

Water sample dropped into BOD bottle and after fifth days reading

Chemical parameters reading by photometric   dissolved oxygen again reading in the lab

YSI 556 multi Probe (TDS, EC, pH, DO and Temperature measurements)

Addis Zemen prison wastewater effluent

Biological incubator