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EFFECTS OF BEDELE BREWERY FACTORY EFFLUENT ON WATER QUALITY AND MEASURES TAKEN TO ENCOUNTER THE PROBLEMS IN BEDELE DISTRICT, BUNO BEDELE ZONE, OROMIA, ETHIOPIA

MSc THESIS

BY

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June, 2022

Addis Ababa, Ethiopia

EFFECTS OF BEDELE BREWERY FACTORY EFFLUENT ON WATER QUALITY AND MEASURES TAKEN TO ENCOUNTER THE PROBLEMS IN BEDELE DISTRICT, BUNO BEDELE ZONE, OROMIA, ETHIOPIA

A Thesis Submitted to the School of Graduate Studies, Addis Ababa University in Partial Fulfillment of the Requirement for the Degree of Master of Science in

Water Resource Management

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Declaration

This is to certify that this Thesis entitled: ***Effects of Bedele Brewery Factory Effluent on Water Quality and measures taken to encounter the problems in Bedele District, Buno Bedele Zone, Oromia, Ethiopia,*** accepted in partial fulfillment of the requirement for the award of the MSc Degree in **Water Resource Management** by the School of Graduate Studies, Addis Ababa University through the College of Development Studies, done by **Lami Yadata** is a genuine work carried out by him under my guidance. The matter of embodied in Thesis work has not been submitted earlier for the award of any degree or diploma. The assistance and help received during the course of this investigation have been duly acknowledged. Therefore, I recommended that it can be accepted as research Thesis requirements for filling MSc Degree in Water Resource Management

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As members of the board of examination of the final M.Sc thesis open defense, we certify that we have read and evaluated the thesis prepared by **Lami Yadata** under the title ***"****EFFECTS OF BEDELE BREWERY FACTORY EFFLUENT ON WATER QUALITY AND MEASURES TAKEN TO ENCOUNTER THE PROBLEMS IN BEDELE DISTRICT, BUNO BEDELE ZONE, OROMIA, ETHIOPIA****"*** and recommended that the thesis be accepted has fulfilling the thesis requirement for the Degree of Master of Science by Water Resource Management.

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I certify that all the correction and recommendation suggested by the Board of Examiners are incorporated into the final entitled **"***EFFECTS OF BEDELE BREWERY FACTORY EFFLUENT ON WATER QUALITY AND MEASURES TAKEN TO ENCOUNTER THE PROBLEMS IN BEDELE DISTRICT, BUNO BEDELE ZONE, OROMIA, ETHIOPIA"* ***by Lami Yadata.***

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Acronym and Abbreviation

μs/cm	:	Micro Siemens per centimeters
ANOVA	:	Analysis of Variance
APHA	:	American Public Health Association
BDL	:	Below Detection Limit
BOD	:	Biological Oxygen Demand
CES	:	Compulsory Ethiopian Standard
COD	:	Chemical Oxygen Demand
DO	:	Dissolved Oxygen
DS		Downstream
EC	:	Electrical Conductivity
EDP		Effluent Discharge Point
EIP	:	Environmental Integrity Project
EPA	:	Environmental Protector Agency
HRDO	:	High Range Dissolved Oxygen
LSD	:	Least significance differences
NTU	:	Nephelometric Turbidity Unities
pH	:	Power Hydrogen
TDS	:	Total Dissolved Solid
TS	:	Total Solids
TSS	:	Total Suspended Solids
UNICEF	:	United Nations Children's Fund
US		Upstream
WHO	:	World Health Organization
WHO/UNECEF	:	World Health Organization/United Nations Children's Fund

Abstract

Bedele brewery is one of the industries in the Ethiopian town that releasing high amount of effluent wastewater discharge into the surrounding environment and to the water bodies. The aim of this study is to analyze the effects of Bedele Brewery Factory Effluent on Water Quality and measures taken to encounter the problems, in Bedele District, Buno Bedele Zone, Oromia, Ethiopia. Water samples were taken from the upstream part of Dabana stream, from brewery effluent discharge and downstream after 300 m from the point of effluent discharge to determine the pollution level of Dabana stream water quality exposed by Bedele brewery factory effluent. The water samples were analyzed for physicochemical parameters using DR/2400 and DR 3900 Portable Spectrophotometer by following standard methods and laboratory procedures. The analyzed physical and chemical parameters include; electrical conductivity (EC), turbidity, temperature, TDS, TSS, TS, pH, COD, BOD, DO, NO_2^-*-N,* NO_3^-*-N,* NH_3*-N, and* PO_4^{3-} *concentrations were conducted following guidelines of American Public Health Association (APHA, 2017) and (WHO, 2011). Correlations among measured parameters and their significances of water and effluent samples collected were computed using SPSS software (version 22). From the measured values obtained in this study were almost half of the recorded values (turbidity, pH, temperature, TSS, COD, BOD and DO) were above the recommended values and the rest measured parameters were within both the Compulsory Ethiopian standard (CES, 2013) and World health organization (WHO, 2011; WHO, 2017) guidelines. Because of inadequate treatment of the effluent discharge from the factory & infrequent management of treatment plant as recommended standards this studied stream indicates polluted for domestic purposes. It also indicates the effects of discharging of effluent released from the brewery effluent are responsible for the high level of water contamination around the discharge point. Therefore, the waste water released from Bedele Brewery factory to the Dabana River affects the water quality standards and the responsible regulatory bodies (Environmental Protection Authority) should have taken measures in order to protect the river from such pollution problems. Thus, it calls for appropriate intervention, including awareness creation work and improving the existing infrastructure.*

Keywords: Water quality, Bedele brewery, Dabana stream, physicochemical parameters

Table of contents

Declaration i
Statement of the Author ii
Approval Sheet for Submitting Final Thesis iii
Certification of the final Thesis iv
Acknowledgements v
Acronym and Abbreviation vi
Abstract vii
1. INTRODUCTION 1
1.1 Background of the Study 1
1.2 Statements of the Problem 3
1.3 Research questions 5
1.4 Objective of the Study 5
1.4.1 General Objective 5
1.3.2 Specific Objective: 5
1.5 Significance of the Study 6
1.6 Scope and Limitations of the Study 6
2. LITERATURE REVIEW 7
2.1 State of Pollution in Ethiopia 7
2.2 Water Quality 7
2.3 Water Pollution 8
2.3.1 Effect of Water Pollution in Ethiopia 8

2.3.2. Measure of Water Pollution in Ethiopia 11
2.3.3. State of Water Pollution in Ethiopia 12
2.4 The Source of Water Pollution 13
2.4.1 Point Sources of Water Pollution 13
2.4.2 Non-Point Sources of Pollution 14
2.5. Water Quality Parameters or Indicators 15
2.5.1. Physical Parameters 15
2.5.2. Chemical Parameters 18
3. MATERIALS AND METHODS 22
3.1 Description of Study Area 22
3.1.1 Location 22
3.1.2 Climate and Topography 23
3.1.3 Vegetation Cover and Land Use of Bedele Town 24
3.1.4 Demographic Characteristics 25
3.1.5 Economic Characteristics 25
3.1.6 Services and Infrastructure 25
3.2 Research Design 25
3.3. Materials and Reagent Used 26
3.3.1. Apparatus 26
3.3.2. Chemicals and Reagents 26
3.4 Duration and Frequency of Samples Collection 26
3.5 Data Collection 27
3.5.1 Water Samples Collection 27
3.6. Classical Water Sample Analysis Procedures 28
3.6.1. Physical Analysis Procedure 28

3.6.2. Chemical Parameters Analysis 29
3.7. Quality Assurance/Quality Control 31
3.8. Pretest 31
3.9. Quality Assurance and Quality Control 32
3.10. Statistical Data Analysis 32
3.11. Ethical Considerations 32
3.12 Reporting Results and Information Dissemination 33
4. RESULTS AND DISCUSSIONS 34
4.1 Physicochemical Water Quality Analysis 34
4.1.1 Physical Parameters 34
4.2.2 Chemical Parameters 39
4.2 Pearson Correlation of the Present Study 45
4.2 Effects of Brewery Effluents 46
5. CONCLUSIONS AND RECOMMENDATIONS 50
5.1 Conclusions 50
5.2 Recommendations 51
REFERENCES 52

List of figures

Figure 1: Location Map of the Study Area 22
Figure 2: Topography map Bedele Town 23
Figure 3: Mean values of physical parameters 35
Figure 4: Measured values of COD, BOD and DO in the Study Area 41
Figure 5: Mean values of anions and pH 44
Figure 6: Conceptual framework 49
Figure 7: Bedele Brewery Factory effluent discharge point during taking sample from outlet Canal. 70
Figure 8: Bedele Brewery's Sedimentation Tank 71
Figure 9. Bedele Brewery Main Office Block after immediate Main Entrance. 72
Figure 10: Bedele Brewery Fountain & beer processing unit tank..................................... 73
Figure 11: Bedele Brewery beer production & delivering process..................................... 74

List of tables

Table: 1 Water quality parameters used for testing quality of water, their sources and potential health effect (Tadese *et al.,* 2018).. 11
Table 2: Land Use of Bedele Town 24
Table 3: Some Selected Physical parameters of water samples 34
Table 4: One-way ANOVA values of physicochemical parameters 38
Table 5: Some Selected chemical parameters of water samples.. 42
Table 6: Pearson correlations of physicochemical parameters of the study area water samples.. 45

1. INTRODUCTION

1.1 Background of the Study

Water is the most vital and basic need of life. It is a vital requirement for all life processes and supporting activities. Surface water available in ponds, streams, rivers, lakes and dams is used for drinking, irrigation, power production, industrial development and the like. Usually, sources of drinking water are: streams, rivers, wells and boreholes which are not commonly treated. Surface water quality encompasses a wide range of conditions that are part of the aquatic environment. The aquatic environment provides diverse habitat and a clean water supply for aquatic life, wildlife and humans (Etim and Obot, 2014).

The availability and quality of water always plays 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 waters can be contaminated by several sources. In urban areas, the careless disposal of industrial effluents and other wastes may contribute greatly to the poor quality of water (Mathuthu *et al.*, 1997). Most of the water bodies in the areas of the developing world are the end points of effluents discharged from industries.

In many developing countries, water pollution is an ongoing and acute challenge for sustainable development. The transport of pollutants into surface waters has mainly increased because of anthropogenic activities (Hove *et al.,* 2013). As African countries gained political independence in the 1960s, they turned their attention to economic development mainly through industrial production and agricultural intensification. While many of these countries are committed to the 2030 Agenda for Sustainable Development and the Africa Union's Agenda 2063 (African Union, 2018), pressures to attract investors for industrialization and modern agriculturalization may reduce regard to progress with these Agendas (Xu *et al.,* 2014; Sikder *et al.,* 2013).

Industries are the major sources of pollutants in all environments and various levels of the pollutants are discharged into the environment either directly or indirectly. The discharged effluents from industries have been found to be carcinogenic, while other chemicals present are poisonous to humans and toxic to aquatic life (Abdulmumini *et al.*, 2015). Effluents from industries were found to alter the physical, chemical and biological nature of receiving water bodies (Abdulmumini *et al.*, 2015).

A river is polluted when substances degraded the water quality that entered the water way and alters its natural function. Environmental concerns related to health and aquatic ecosystems become global emerging issues. Due to urbanization, industrialization and agricultural activities the function of aquatic systems is disturbed by pollution. Polluted water can harm plants and animals, restrict recreation, spoil scenery, and damage economic uses (Water facts, 1997). The biological status of aquatic environment such as the abundance, biomass and distribution of various indigenous populations which largely depend on their respective physiological condition, dynamics of various life stages, productivity and growth pattern are a reflection of the water quality variables (APHA, 2017).

Worldwide, it is estimated that the industrial sector is responsible for dumping 300-400 million tons of heavy metal, solvents, toxic sludge, and other waste into water each year (Stockholm Water Front, 2010). Close to 70% of untreated industrial wastes in developing countries is discharged into water where they contaminate existing water supplies (UN-Water, 2009). Discharge of industrial waste into water often impacts negatively on water resources and livelihoods. Industrial effluents also contain chemicals and heavy metals that are directly harmful to human health and indirectly affect human productivity (Oluseyi, 2011). Industrial effluents also affects land productivity where crop production suffers from contaminated irrigation water from both surface sources and from ground water aquifers.

In Ethiopia so many Industries are major source of pollution in all environments including water bodies. Among them the Brewery plants have been known to cause pollution by discharging effluent into receiving stream, ground water, and soil (Andargachew and Samuel, 2013). Environmental concern that can be associated with brewery wastewater include biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), pH, nutrients (nitrogen and phosphorus) concentration, and temperature.

Brewery plants have been known to cause pollution by discharging effluent into receiving stream, ground water and soil (Andargachew and Samuel 2013; Olajumoke *et al.*, 2010). It can achieve an effluent discharge of 3-5 m^3/m^3 of sold beer (exclusive of cooling waters). Untreated effluents typically contain suspended solids in the range 10-60 mg/L, biochemical oxygen demand (BOD) in the range 1,000-1,500mg/L, chemical oxygen demand (COD) in the range 1800-3000 mg/L, nitrogen in range 30-100 mg/L and the phosphorus concentrations of the order 10-30 mg/L. Effluents from individual process steps are variable. Effluent pH averages about 7 for the combined effluent but can fluctuate from 3 to 12 depending on the use of acid and alkaline cleaning agents as well the temperatures average becomes about 30℃(Andargachew and Samuel 2013; World Bank Group, 2007).

The major problems of the study area concerning pollution are: lack of environmental management, uncontrolled brewery wastewater effluent discharge that can cause physical, chemical and biological contaminations. Bedele town is one of the few towns in Ethiopia with relative large-scale manufacturing plants like Bedele brewery factory have been discharging its wastes into the surrounding environment, in particular to the nearby river, and there is little acquaintance about the effects of effluent discharge into the receiving water body. Dabana River, as many other rivers serve as a sink for disposal of domestic and industrial wastes. It is located near to Bedele brewery factory and no study has been conducted on the physicochemical quality of the river. There was no study conducted in the area regarding the effects of Bedele Brewery Factory effluent on water quality and measures taken to encounter the problems. Therefore, the current study will aim to characterize some selected physicochemical properties of water quality collected from three sample sites (Upstream, Effluent discharge point and downstream of the river water) in the residents of the Bedele District, Buno Bedele Zone, Oromia, Ethiopia and compared with CES and WHO guidelines for water and waste water. It also aimed at on the assessment of level of pollution and potential source of contaminants of the water quality under the consideration of effluents from Bedele Brewery factory in the area under the study.

1.2 Statements of the Problem

Increase in population from time to time will bring in shortage of water supply and unsafe water supply, which was the major problem of most populations of Ethiopia**.** The increasing world population with growing industrial demands has led to a situation where protection of the environment has become a major issue and a crucial factor for several industrial processes, which will have to meet the requirements of the sustainable development (Amanial, 2016). More than half of the world's rivers are seriously polluted, degrading and poisoning the surrounding ecosystems and threatening the health and livelihood of people who depend on them. In Ethiopia, 90% of the industries are releasing their effluents in to water bodies, streams and land without any treatment mechanisms and are the primary cause of water pollution (Melaku, *et al*, 2004). Among these industries, brewery factories are the major contributors for river pollution by discharging their effluent without appropriate treatment (Kebbede *et al*, 2004).

Some industries do have an effluent treatment plant designed to limit their environmental impact but the efficiency of the treatment plants have never been checked. So, it is not clear, which industry has the highest environmental cost and contributing much in terms of pollution load. Poorly treated waste water heavily impact on the quality of the river water. River/stream in the study area is used for domestic purposes like cooking, washing, bathing and drinking by a certain portion of the population. Also they are used for irrigation, fishery and different uses. However, Bedele Brewery Factor continues to discharge effluent into the river/stream, threatening most of its useful benefits, including irrigation.

Bedele brewery is one of the industries in the Ethiopian town that releasing high amount of effluent wastewater discharge into the surrounding environment and to the water bodies. However, there is little information about the characteristics of brewery effluent wastewater discharge to water bodies for different purposes and its potential effect on water quality in this specific industrial zone in particular and in the country in large. Indeed, generating and understanding this information is very useful to design a strategy for sustainable utilization of brewery wastewater in this industrial zone and beyond, thereby enhancing and maintaining river water quality. Different researches are conducted on Impact of Brewery effluent on water qualities of river water bodies in Ethiopia shows that great impact on water quality (Senthilraja and Jothimani, 2014; Andargachew and Samuel, 2013; Jigar *et al.*, 2019).

The discharge of raw wastes from industries could be affecting water quality and people's livelihoods along the sub catchment. Information on the dynamics between Bedele brewery factory discharges of waste water into Dabana stream is not adequately articulated. On the other hand, there is little known about the types and abundance of pollutants discharged by this industry into the water system and their effects on the livelihoods along the sub catchment. Thus, monitoring and control policies should be put in place. But, monitoring and control policies can be put in place only if a study is conducted to verify and know the types and abundance of pollutants discharged and determine the levels of water quality and its suitability for different uses. So far, there is no research conducted on effects of Bedele Brewery Factory effluent on water quality and measures taken to encounter the problems in the selected site. Therefore, this study is designed to assess the severity and magnitude of the effect of effluents of Bedele brewery factory on the physicochemical water quality parameters of effluent receiving water body and measures taken to reduce the problems in Bedele District, Buno Bedele Zone, Oromia, Ethiopia.

1.3 Research questions

This study was attempted to answer the following basic research questions:-

1. What are the status of physicochemical characteristics, their nature and severity of Bedele brewery effluent discharge?
2. What are the effects of Bedele brewery effluent discharge on the water quality?
3. What are the measures taken to reduce and overcome the problems in the study area?

1.4 Objective of the Study

1.4.1 General Objective

To analyze the severity and magnitude of the brewery factory on the water quality and perception of the people on the effect of the effluents and the actions taken to reduce the problems:

1.3.2 Specific Objective:

- To analyze the nature and severity of the brewery factory
- To assess the effects of the brewery effluent on the water quality
- To assess the measures taken to reduce and overcome the problems.

1.5 Significance of the Study

Provision of safe and adequate water is a global issue and even an ever challenging problem of developing countries like Ethiopia (WHO/UNICEF., 2012). The demands of Bedele town nearby the river water source was satisfied the need and interests of community services as safety quality standard and lack of water quality also solved and reduce the problems that caused by water pollution. Based on this study is expected to give the baseline information about the severity and magnitude of the effects of Bedele Brewery factory effluent on physicochemical properties of the receiving water body or streams in the study area. The study can also be helpful to environmental protection authority and public administrators to be informed, and to take efficient and prompt actions to prevent any possible health outbreaks. Furthermore, the study is also important for providing scientific information for someone intend to further study on this area of study.

1.6 Scope and Limitations of the Study

Industrial growth in the study area of the basin entails the degradation of the water quality of water bodies. Especially, Dabana River experienced waste water contamination in its catchment area, making it prone to pollution. The effects of Bedele brewery factory effluent on the physicochemical properties of the receiving water body were studied. The study is concluded only on the state of the physicochemical properties of the receiving water body within the dry season water quality situation. The perception of the people on the effect of the effluents and the measures taken to overcome the problems was studied. If the rainy season is included it could possibly give different results. Few sampling points are chosen, also due to financial constraints. The study is concluded only on the effects of Bedele brewery factor effluent of physicochemical properties on receiving water body other than the overall impacts of the brewery factory effluent on the receiving water body.

2. LITERATURE REVIEW

2.1 State of Pollution in Ethiopia

According to Ethiopian Public Health Institute, the health risk of the usages of the river water is mostly an issue for the farmers that use it for agriculture. People living on the riverbanks and around might have to use the surface water directly from the river for washing and cleaning purposes (Eriksson, 2019). This applies to those who do not have access to tap water, which is common in the slum areas along the river. Some consider the river water as dead water and it is in general a risk for the population. Many farmers use the river water without any protection for their body, in that way they might be exposed to skin hazards.

Furthermore, the level of awareness about the risks is not well understood in many local communities. Even if there is an understanding, coming from a relatively poor economic background, they have no option (Weldetinae, 2019). As Abel Weldestinae, Associate Researcher at Ethiopian Public Health Institute, said: Farmers that are using the river water for irrigation to their crops daily are exposed to the pollutants either through inhalation, ingestions and/or dermal contact, they are at risk of cancerogenic and non-cancerogenic hazards. The second one is the population in general because these vegetables will accumulate heavy metal, microbiological contaminants. We don't know the level of attention of washing sanitation procedure in the households. This might cause diarrhoea, especially those of the lower economic status (Eriksson, 2019).

2.2 Water Quality

Conceptual Definition

Water quality is defined as that having acceptable quality in terms of its physical, chemical, biological and acceptability parameter so that it can be safely used for drinking and cooking (WHO, 2004). World Health Organization (WHO) define drinking water to be safe as long it does not cause the pollution any significant health risks over a life time of consummation and effort should be made to maintain drinking water quality at the highest possible level.

Freshwater is a scarce resource, essential for agriculture, industry, human and animal life existence. We depend on our streams and rivers to deliver much of these water uses. Without adequate quantity and quality of freshwater sustainable development will not be true for all countries of our globe. In Ethiopia from the increasing human population, uncontrolled urbanization and waste disposal cause serious quality degradation of surface waters. Now a day's water pollution from disposal of industrial wastewater is becoming an environmental concern in Addis Ababa city and its vicinity areas (Abrha *et al.,* 2015).

2.3 Water Pollution

Water pollution is contamination of water by foreign matter that deteriorates the quality of the water. Water pollution covers pollutions in liquid forms like ocean pollution and river pollution. As the term applies, liquid pollution occurs in the oceans, lakes, streams, rivers, underground water and bays, in short liquid-containing areas. It involves the release of toxic substances, pathogenic germs, substances that require much oxygen to decompose, easy-soluble substances, radioactivity, etc. that becomes deposited upon the bottom and their accumulations will interfere with the condition of aquatic ecosystems (Rashmi and Pratima, 2013). *Polluted water* contain significant levels of pollutants usually at levels above who certified drinking water quality standards and are able to cause significant problems when ingested by human(WHO, 2011). Due to the open accessibility of surface water they easily receive foreign materials from various sources which negatively impact on the quality of water.

2.3.1 Effect of Water Pollution in Ethiopia

The main sources of pollution that enters urban surface water bodies are industries, agriculture, wastes from hospitals, municipal solid waste and oily wastes from garages and fuel stations (Gebre & Van, 2009). The effect of water quality impairment, due to anthropogenic activities and limited enforcement capacity, is a rapidly growing threat to water security as well as public health in developing countries. Cumulative effects of deteriorating water quality undoubtedly put pressure on public health and socio-economic developments. For example, most industries in Ethiopia discharge their effluent directly into freshwater systems without any treatment process.

The problem is severe for rivers such as the Awash that pass through major cities (Assegide *et al.*, 2022).

Anthropogenic activities are responsible for the majority of water quality degradation in several rivers, where indiscriminate dumping of domestic and industrial wastes, as well as waste from other sources such as agriculture and health facilities, is common (Igwe*et al.*, 2017; Amoatey and Baawain, 2019) and justified in Ethiopia (Tadesse *et al.*, 2018). Land and water quality degradation in Ethiopia, in general, was not impacted much by anthropogenic activities for the past decades due to the low population density that practice slash and burn agriculture with minimum fertilizer use (Ligdi*et al.*, 2010). However, in the recent past, a wide range of pollutants including organic matter, salts, nutrients, sediments, heavy metals, etc. due to natural processes and anthropogenic sources are posing a serious threat to the land and water qualities of many of the basins in Ethiopia (Moges *et al.*, 2017). The problem is aggravated further due to climate change, rapid population growth, urbanization, industrialization and agricultural practices that put intense pressure on natural resources including the availability and quality of freshwater resources (Berg *et al.*, 2019; Assegide *et al.*, 2022).

The environmental impact on local river water increases as a city gets bigger, especially if the city cannot properly handle solid waste and wastewater. Untreated effluent wastewater from industries and households may be discharged into river water bodies, where solid waste may accumulate along the course of the river water (Dagnachew*et al.*, 2019; Chebet *et al.*, 2020), especially in developing countries where wastewater treatment facilities are not well developed. The discharge of untreated municipal and industrial wastes into water bodies, which resulted in increased heavy metal concentrations in river water, is linked to severe water quality degradation (Islam*et al.*, 2020).

The pollution of surface water with toxic and trace elements has gotten a lot of attention around the world (Islam *et al.*, 2020). Because of their extreme toxicity, abundance, and ease of accumulation by different organisms, heavy metals are regarded one of the most dangerous environmental pollutants that are comes from anthropogenic activities like industries (Islam *et al.*, 2021).

Industries in developing countries generate volumetric wastes which are discharged without treatment into nearby water bodies. For example, almost all of industries in Ethiopia use outdated manufacturing technologies and do not have functional effluent treatment plants and often discharge their wastewater into the freshwater system without any treatment (Tadesse*et al.*, 2018; Girma, 2016).

Therefore, raw and harmful wastes are discharged into the surrounding water bodies. Textile industries are huge industrial consumers of water and producers of wastewaters, with growing demand for textile products leading to an increase in textile wastewater output, making the textile sector one of the most serious sources of pollution globally (Mehari et al., 2015). Dadi *et al.* (2017) investigated the environmental and health impacts of effluents from four different textile and garment plants in Gelan and Dukem areas around Addis Ababa and found that the bacteriological pollutants in the effluent are higher than the permissible limit given by the Federal Environmental Protection Authority (FEPA) (Dadi *et al.*, 2017). Such practices lead to water quality deterioration of many freshwater systems making them unsuitable for irrigation, domestic or industrial purposes (Keraga*et al.*, 2017b).

Table: 1 Water quality parameters used for testing quality of water, their sources and potential health effect (Tadese *et al.*, 2018)

Parameters	Sources	Potential health effects
pH	Due to different dissolved gases and solid	Bitter test, corrosion, affect mucus membrane
Temperature	Due to chemical reaction, hot waste water	Influence chemical, biochemical, biological of aquatic system, effect on solubility of essential gases
EC	Due to different dissolved solid	High conductivity increases corrosive nature of water Turbidity Soil runoff Higher level causing bacteria
TDS	From the presence of all dissolved salt	Undesirable taste, gastro-intestinal irritation, corrosion, or incrustation
Nitrite	NH_3 compounds	Form nitrosamine's - carcinogenic
Nitrate	Runoff, fertilizers septic tank,	Effect on infant symptoms include shortness of breath, blue-baby syndrome
Sulphate	Due to dissolved Ca/Mg/Fe sulphate	Taste affect; gastro-intestinal irritation; calcium sulphate scale, laxative effect
phosphate	Waste water from detergent effluent, rocks	Stimulate microbial growth; rancidity mould growth; algal growth, eutrophication

2.3.2. Measure of Water Pollution in Ethiopia

Point and non-point source pollutions from towns and cities contribute nutrient-rich effluents that are conducive for eutrophication where an upsurge of algae growth in the lakes will happen, and thereby depletes the oxygen needed by fish and other ecosystems (Girma, 2016). Addis Ababa, which is part of the Akaki catchment, has a rapidly growing population, unregulated urbanization and industrialization, poor sanitation, and uncontrolled waste disposal, all of which contribute to a substantial deterioration in surface water quality (Kassegne et al., 2018). Rapid losses of ecosystems and land-use change, in part due to agricultural intensification, have been among themajor drivers for recent increases in water in sedimentation and water quality issues in Ethiopia (Moges et al., 2017).

The costs of water scarcity, misallocation, and water pollution can be difficult to measure and they are not always visible (Mekonnen and Amsalu, 2018). Smallholder farmers grow a variety of vegetables in and around Addis Ababa. Without developed modern irrigation techniques, water scarcity is rampant and these farmers rely on the Akaki River as their primary source of water for irrigation. Due to a scarcity of freshwater, partially treated and untreated wastewater from a variety of industries, as well as gray water from the Addis Ababa city environment, are now used for irrigation (Mengesha *et al.*, 2021). While water quality is a complex issue and involves multiple disciplines, this review focuses on water quality with respect cation, metals and heavy metals in surface water, and their impacts on vegetables, soil, biodiversity, human health, toxic and socioeconomic effects. The river collects untreated and unmanaged domestic, industrial, and agricultural pollutants from the catchment immediately along its course, which could lead to a change in quality of water. As a result, among the major rivers of Ethiopia, the Awash River is the most vulnerable to many types of serious water pollution problem (Keraga*et al.*, 2017b) and similarly the Dabana River is affected by untreated effluent industrial unmeasured wastes from Bedele Brewey factory that discharged to this river course.

2.3.3. State of Water Pollution in Ethiopia

The river basin is convenient for irrigated agriculture and industrial development due to its proximity to major cities such as Addis Ababa, Nazeret, Debre Zeit, Dessie, and Dire Dawa. It has been impaired by pollutants from large-scale irrigation scheme (Keraga *et al.*, 2017b). On top of these, most of the industrial plants and cities do not have wastewater treatment plants (Rooijen and Taddesse, 2009) releasing their effluents directly to the river basin. Therefore, the discharges of these domestic, industrial, and agricultural wastes have been polluting freshwater systems jeopardizing socio-economic and ecological assets in the river basin (Mengistie *et al.*, 2017).

There has been little research on the impact of contaminated water on human and animal health, as well as the socio-economic implications on the riverine community, the downstream river population, the basin, and the country as a whole. Although it is not complete and does not cover the entire basin and sub-basins,this systematic review provides valuable insight into the positiveaspects of several studies that reveal the state of rivers pollution by heavy metals and their sources (Assegide *et al.*, 2022).

2.4 The Source of Water Pollution

Water pollution is caused when water body badly influenced by the addition of bulky amounts of materials to the rivers water. There are two sources of water pollution which are namely as, a point source and a non-point source of water pollution (Gupta *et al.,* 2016).

2.4.1 Point Sources of Water Pollution

This type of pollution takes place when the polluting substance is discharged directly into the water bodies, and includes effluent outfalls from factories, refineries, waste treatment plants etc… that release fluids directly into water supplies. In the developed countries, these practices are regulated even though, completely cannot be avoided. The technology exists for point sources of pollution to be monitored and regulated, due to political factors may be complicate the matters (Carpenter *et al*., 1998).

2.4.1.1 Water Pollution Due to Industrial Activities

Industrial estates are established to fulfill the demand of the growing population in the country. The case of industries on one hand manufactures useful products but at the same time generates waste products in the form of solid, liquid or gas that leads to the creation of hazards, pollution and losses of energy. Most of the solid wastes and wastewaters from industries are discharged into the soil and water bodies and thus ultimately pose a serious threat to human and routine functioning of ecosystem (Andargachew and Samuel, 2013; Tariq et al., 2006). Water pollution is serious problem globally involving the discharge of dissolved or suspended substances into groundwater, streams, rivers and oceans. A major source of pollution in developing countries is industrial activities and this has gradually increased the problem of waste disposal (Andargachew and Samuel, 2013; Olajumoke et al., 2010).

Untreated wastes from processing factories located cities are discharged into inland water bodies resulting to stench, discoloration and a greasy oily nature of such water bodies. These wastes pose a serious threat to associated environment, including human health risks (Andargachew and

Samuel, 2013). Thus, there is need to control the pollution of surface and ground water since the public health and well being of the people have a direct link with the availability of adequate quantity of good quality water (Olajumoke et al., 2010; Ipeaiyeda and Onianwa, 2009).

2.4.1.2 Water Pollution from Slaughterhouses

Untreated wastewater from meat processing typically contains high levels of oxygen demanding substances (like blood, fat, urine, and feces), total suspended solids, ammonia, nitrogen, phosphorus, oil and grease, fecal bacteria, and pathogens. When released into waterways in large quantities and high concentrations, these pollutants can cause extensive damage to waterways (EIP, 2018). They drive excess algae growth, create low oxygen dead zones that suffocate fish and other aquatic life, and turn waterways into bacteria-laden public health hazards. These plants use a large amount of water to wash carcasses and rinse meat, remove hair or feathers, chill meat, and clean, sanitize, and cool processing equipment and facilities. The amount of wastewater generated can vary widely from plant to plant.

Meat processing plants typically dispose of wastewater by releasing it to streams, rivers, and lakes (usually after some treatment), diverting it to municipal wastewater treatment plants, and spraying it on pasture or cropland where it can infiltrate groundwater and runoff into surface waters. Some use a mix of these disposal practices, while others use only one. EPA and state environmental agencies regulate direct discharges to waterways by issuing wastewater discharge permits and by setting water quality standards for “effluent” that are based on available treatment technology (EIP, 2018).

2.4.2 Non-Point Sources of Pollution

Non-point source of pollution of water can be take place when there is runoff of pollutants into a waterway. When fertilizers and pesticides from a field are carried into a stream by rain, in the form of run-off which in turn affects aquatic life is good example of this pollution. Non-point source of pollution add pollutants indirectly through environmental changes. Pollution arising from non-point sources accounts for great percent of the contaminants in streams and lakes. Indirect sources include wastes that enter the water supply from soils/groundwater systems and from the atmosphere in the form of rain water. Soils and ground-waters contain the residue of human agricultural practices (fertilizers, pesticides, herbicides) and inappropriately released of industrial wastes. Atmospheric contaminants are also resulted from human practices: organic, inorganic, radioactive and acid/base the categories of the contaminants (Carpenter *et al*., 1998).

2.5. Water Quality Parameters or Indicators

Water quality parameters are used to describe properties of water that inductive of treatability of quality of water. Those are temperature, pH, Turbidity, hardness, total dissolved solid (TDS), electrical conductivity (EC), dissolved oxygen (DO), chemical oxygen demand (COD), biological oxygen demand (BOD), nitrate-nitrogen (NO_3^-N), nitrite-nitrogen (NO_2^-N), ammonia-nitrogen (NH_3-N), phosphate (PO_4^{3-}) and the like. It is a very essential and important to test the water before it is used for drinking, domestic, agriculture, or industrial purpose. Water most be tested with different physicochemical parameters. Selection of parameters for testing of water is solely depends up on for what purpose we going to use that water and what extent we need its quality and purity (Meride & Ayenew, 2016).

2.5.1. Physical Parameters

The physical characteristics of water and waste water are usually things that we can measure with our own senses, turbidity, temperature, total solids, and EC. The physical contaminates generally do not have direct health affect themselves. However, their presence may relate to a higher risk of micro biological and chemical contamination which may be harm full to human health. For example, increasing turbidity levels are often associated with high level of disease causing of pathogens such as virus, parasites and some bacteria (WHO, 2008).

Temperature

Water temperature is a physical property expressing how to hot or cold water is. Water temperature can be affected by turbid for instance increasing turbidity means increasing water temperature. Since turbidity is the amount of suspended solids in water thus, suspended particle absorb heat from solar radiation more efficiently than water. The heat is then transferred from the particles to water molecules increasing the temperature of the surrounding water. Cool water is generally more palatable than warm water, and temperature will have an impact on the acceptability of a number of other inorganic constituents and chemical contaminants that may affect taste. High water temperature enhances the growth of microorganisms and may increase problems related to taste, odour, colour and corrosion (WHO, 2017).

Turbidity

Turbidity is a measure of relative clarity of a liquid. It is an optical characteristic of water and is an expression of the amount of light that is scattered by material in the water. When a light shone through the water sample material that cause water to be turbid include clay, silt finally divided in organic, organic matter, algae, soluble, colored organic compound and plankton and other microscopic organisms. The WHO (2006) and EPA (2012) standards for turbidity of drinking water is the value of less than 5 nephelometric turbidity unit (NTU). Water is with readings in this range will appear to be clear. Turbidity can provide food and shelter for pathogenic. If no removed turbidity can promote re-growth of pathogen in the distribution system, leading to water born disease outbreaks, which have caused significant cases of gastroenteritis.

Total suspended and Dissolved Solids (TS)

Solids refer to matter suspended or dissolved in water. They have different forms depending on their operation principles. A total solid (TS) refers to the material residue left in the vessel after evaporation of a sample and its subsequent drying in an oven at a defined temperature. They include total suspended solids (TSS) and total dissolved solids (TDS). TSS is the portion of total solids retained by a filter, whereas TDS is the portion that passes through the filter. Total dissolved solids (TDS) are a measure of the amount of particulate solids that are in solution. This is an indicator of non point source pollution problems associated with various land use practices though point sources also contribute. TDS in water supplies originate from natural sources, sewage, urban and agricultural run-off, and industrial waste water (WHO, 2004).

The palatability of water with a TDS level of about 600 mg/L is generally considered to be good. Drinking – water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/L (WHO, 2011). High levels of TDS may cause excessive scaling in water pipes, industrial and household appliances. Also, it can be toxic to aquatic life and can reduce habitat.

Total Dissolved Solid (TDS)

TDS refers to all ion particles in solution that are smaller than two microns. It is the measure of the combined content of all organic and inorganic substance contained in a liquid or molecular ionized. The primary source of Total Dissolved Solid (TDS) are the agricultural and residential run off, leaching of soil contamination and point source water pollution discharged from industrial and sewerage treatment plants. Total dissolved solid majorly constituents the ions sulphates (SO_4^{-2}) chloride (Cl^-), carbonates (CO_3^-), Cations like potassium (K^+), Sodium (Na^+), Magnesium (Mg^{2+}) and Calcium (Ca^{2+}). Total Dissolved Solid (TDS) level of a drinking water supply should be less than 500 mg/L. According to EPA standards evaluated levels of TDS from dissolved ions is not usually considered dangers or harmful and at worst results in being hard or give slightly better or salty test (Heydari and Bidgoli, 2012). The WHO guide lines say that TDS higher than 500 mg/L make the water somewhat undesirable for drinking.

Electrical Conductivity (EC)

Pure water is not a good conductor of electric current rather a good insulator. Increase in ions concentration enhances the electrical conductivity of water. Generally, the amount of dissolved solids in water determines the electrical conductivity. Electrical conductivity (EC) actually measures the ionic process of a solution that enables it to transmit current. According to WHO standards, EC value should not exceeded 400 µS/cm (Meride and Ayenew, 2016). Electrical conductivity (EC) in natural water is the normalized measure of the waters ability to conduct electric current and it is mostly influenced by dissolved solids. The common units for electrical conductivity are micro-Siemens per centimeters (µS/cm). The source of electrical conductivity may be an abundance of dissolved salt due to poor irrigation management, mineral from rain water run of or other discharges. Field measurement of Electrical conductivity (EC) reflect the amount of total dissolved solid (TDS) in natural water. High EC is more associated with waste water discharge from industries, agricultural runoff and acid mine drainage. Most fresh water source the range between 0.001-0.1 µS/cm.

2.5.2. Chemical Parameters

Chemical parameters of water quality give an indication of water acceptability for human consumption which can be domestic use, agricultural use and industrial use. The chemical parameters must be taken in to consideration in the assessment of water quality such as source protection, treatment efficiency and reliability and protection, of the distribution network (WHO, 2006).

pH of Water

The potential of hydrogen (pH) refers to measurement how acidic or basic a water sample is and its values are ranging from 0 to 14 (WHO, 2006). pH of most natural water falls within the range of 4 to 9. The majority of waters are slightly basic (i.e generally over 7.0) because of the presence of carbonate and bicarbonates. The pH increases (acidic) during daytime due to photosynthetic activity because of consumption of CO_2, whereas it declines (alkaline) at night due to respiratory activity (Maiti, 2004). The pH of natural water can provide important information about many chemical and biological processes provides indictors relations to a number of different impairments (WHO, 2006).

Dissolved Oxygen (DO)

Dissolved oxygen is important parameter in water and waste water quality assessment and reflects the physical, chemical, and biological activities live in the water bodies (Maiti, 2004). The dissolved values indicate the degree of pollution in the water bodies. Dissolved oxygen is absolutely essential for survival of all aquatic organisms. Oxygen affects a vast number of other indicators not only biochemical but aesthetic once like the odor, clarity and test. Adequate dissolved oxygen is necessary for good water quality. Dissolved oxygen is vital for aquatic life. The decomposing organic matter, dissolved gases, industrial waste, mineral waste and agricultural run of result to get lower dissolved oxygen (Srivastava *et al.*, 2011; Addo *et al.*, 2013). Concentration levels of dissolved oxygen below 5.0 mg/L adversely affect aquatic life (Ftsum et al., 2015; Sinha & Biswas, 2011).

BOD

Biochemical oxygen demand (BOD) is defined as the amount of oxygen required by bacteria in decomposing organic material in a sample under "aerobic condition at 20^0C over a period of 5 days.

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{Microbes} CO_2 + H_2O + \text{new microbes}$$

Since the test is mainly a bioassay procedure, involving measurement of O_2 consumed by bacteria while stabilizing organic matter under aerobic condition, it is necessary to provide standard conditions of nutrient supply, pH, absence of microbial growth inhibiting substances and temperature. Because of low solubility of O_2 in water, strong wastes are always diluted to ensure that the demand does not increase the available oxygen present in the sample. A mixed group of microorganisms should be present in the sample if not; sample has to be seeded artificially. Temperature is controlled at 20^0C. The test is conducted for 5 days as 70 to 80% of the waste is oxidized during this period. In the waste, there are two major biodegradable compounds; the BOD could be divided into: Decomposition of carbonaceous compounds (CBOD) and Decomposition of nitrogenous compounds (Maiti, 2004).

Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) test determines the oxygen required for chemical oxidation of most organic matter and oxidizable inorganic substances with the help of strong chemical oxidant. The test can be employed for the same purpose as the BOD test taking into accounts its limitations. The intrinsic limitation of the test lies in its inability to differentiate between the biologically oxidisable and biologically insert material. COD determination has an advantage over BOD determination in that the result can be obtained in about 3h, as compared to 5 days required for BOD test. Further the test is relatively easy, gives reproducible results and is not affected by interference's as the BOD test (Maiti, 2004).

Ammonia (NH_3-N)

Ammonia is present naturally in surface waters and wastewater. Its concentration is generally low in groundwater because it is absorbed by soil particles, clays and not leached readily from soils. Ammonia concentration encountered in water varies from less than 10 µg/L ammonia- N in some natural surface and groundwater to more than 30 mg/L in some wastewater (Maiti, 2004).

Nitrate-Nitrogen (NO_3^--N)

Nitrate is one of the most important diseases causing parameters of water quality, particularly blue baby syndrome in infants. The sources of nitrate are nitrogen cycle, industrial waste, nitrogenous fertilizers, etc (Meride and Ayenew, 2016). Surface water contains nitrate due to leaching of nitrate with percolating water. The nitrate itself is not a direct toxicant but is a health hazards because of its conversion to nitrite which react with blood hemoglobin to cause methaemoglobinaemia. Surface water contains nitrate concentration below 1 mg/L polluted by industrial waste water and decaying of organic matter. The EPA standard is 10 mg/L. An increase in concentration above the recommended limit can cause stomach disorders.

Nitrite-Nitrogen (NO_2^--N)

Nitrite-nitrogen (NO_2^--N) is formed in waters by oxidation of ammonia compounds (by aerobic nitrifying bacteria, e.g. Nitrosomonas) or by reduction of nitrate (by facultative anaerobic denitrifying bacteria, e.g. *Pseudomonas).* Such oxidation and reduction may occur in wastewater treatment plants, water distribution system, and natural waters. As an intermediate stage in nitrogen cycle, it is unstable. Very high nitrite levels are usually associated with waters having unsatisfactory microbiological activity (Maiti, 2004).

Phosphate, (PO_4^{3-})

Phosphates in surface waters mostly originated from sewage effluents, which contains phosphate, based synthetic detergents, from industrial effluents, or from land runoff where inorganic fertilizers have been used in farming. Spring water usually contains insignificant concentrations of phosphates, unless they have become polluted. Phosphorous is one of the crucial nutrients for algal growth and can contribute significantly to eutrophication of lakes and reservoirs (Amanial, 2016).

Phosphates enter the water through both point and non-point sources. Nonpoint source (NPS) pollution refers to water pollution from diffuse sources. The non-point sources of phosphates include: natural decomposition of rocks and minerals, storm water runoff, agricultural runoff, erosion and sedimentation, atmospheric deposition, and direct input by animals/wildlife; whereas: point sources may include: wastewater treatment plants and permitted industrial discharges. In general, the non-point source pollution typically is significantly higher than the point sources of pollution. Therefore, the key to sound management is to limit the input from both point and non-point sources of phosphate (WHO, 2011). High concentration of phosphate in water bodies is an indication of pollution and largely responsible for eutrophication. Phosphates are not toxic to people or animals unless they are present in very high levels. Digestive problems could occur from extremely high levels of phosphate.

3. MATERIALS AND METHODS

3.1 Description of Study Area

3.1.1 Location

Bedele town is located in southwestern part of Ethiopia, in the Oromia National Regional State, Buno Bedele zone, at the distance of 483 km from Addis Ababa. The total area of the town is about 2878.1hectare**s.** Bedele is one of the reform towns in the region and has two largest kebeles. Currently the town is categorized into second B level and has Structure Plan, which was prepared in 2012. The town is found at latitude of 8°27′22″- 8°31′08″N and longitude of 36°20′48″-36°22′00″ E and an elevation between 1904 - 2,038 meters above sea level. The town is capital center of Buno Bedele zone (Oromiya Urban Planning Institute, 2011)).

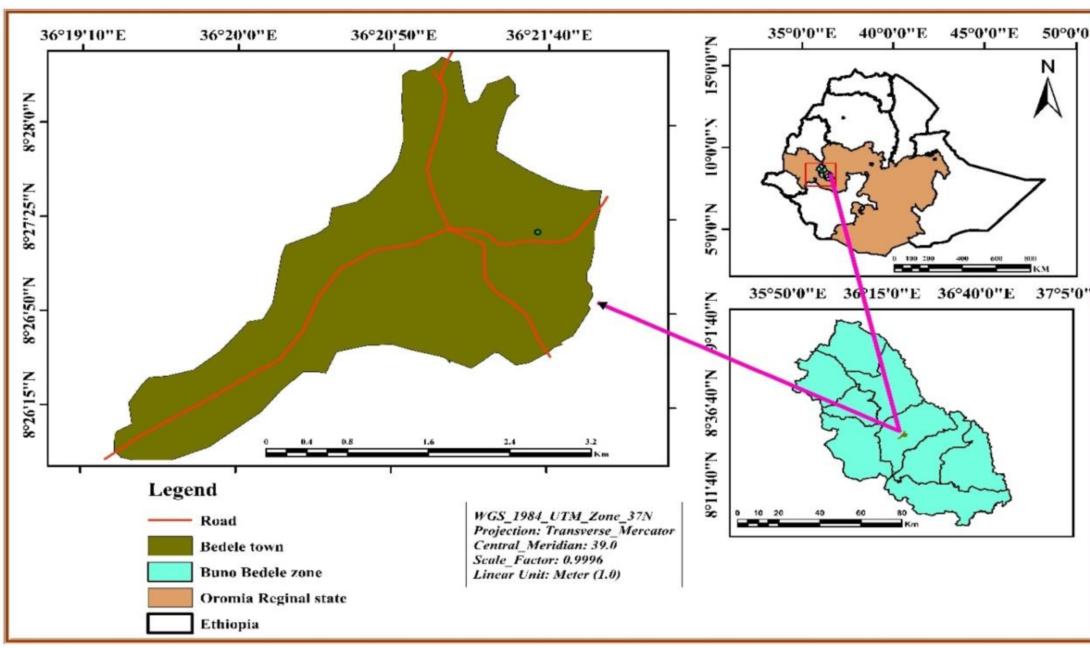

Figure 1: Location Map of the Study Area

3.1.2 Climate and Topography

According to Oromiya Urban Planning Institute (2020), Bedele lies on the Western plateau. The topography of the town is characterized by highly dissected land feature. Based on current boundary delimitation; the peak of the town is Gara Mute Mountain found in the North-West periphery. The highest altitude is found in the suburban areas around the Eastern, Northern and Western; whereas the lowest altitude is areas along with the hills found around in the surrounding outskirt of the town. Regarding to slope of the town, a substantial percentage of the area has between 2-20% slopes. The downtown where commercial activities have been taking place is relatively plain having gentle slope. The altitudinal range of the town is 1904m – 2038m above mean sea level.

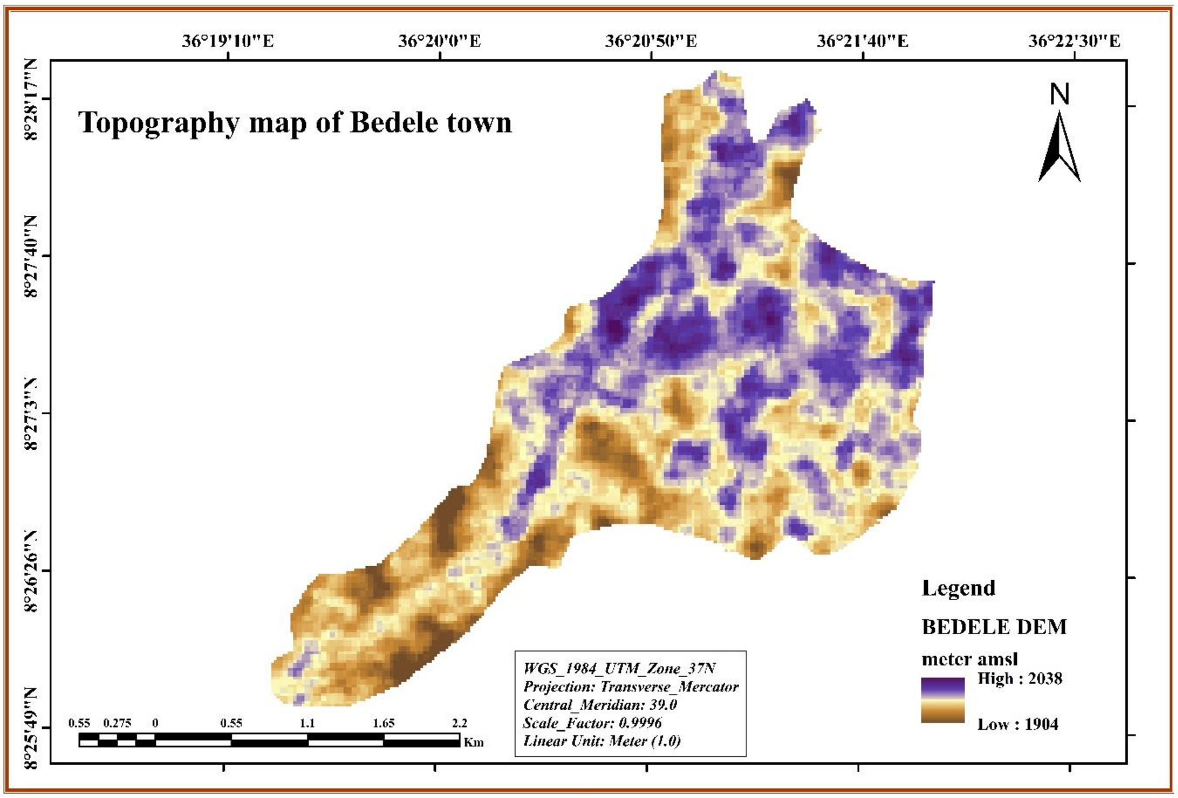

Figure 2: Topography map Bedele Town

The town gets rainfall starting from March to half of December and the annual rainfall ranges from 500-2300mm. As part of south western Ethiopia, the town experiences Tropical climatic condition.The temperature of the town for consecutive 30 years (1987-2016) was average max 25.8 ^{O}C, average min temperature was 12.75 ^{O}C and also average Rainfall was 1902.7mm (Bedele town Metrological station, 2020).

3.1.3 Vegetation Cover and Land Use of Bedele Town

According to the Oromiya Urban Plan Institute (2011), almost less than 20% portion of area covered by exogenic and indigenous trees. These were eucalyptus while the indigenous trees include Oak, coffee bushes, Acacia, Zigba(Birbirsa), junipers procera , eucalypts camandulasis, Cordia Africana and etc.

Table 2: Land Use of Bedele Town

No.	Land Use Function	Existing Total Development Area (Hectare)	Percentage (%)
1	Residence and Administration	1352.7	47
2	Commercial	164.1	5.7
3	Services	212.9	7.4
4	Industry	132.4	4.6
5	Infrastructures, utilities, transportations etc.	339.6	11.8
6	Agricultural land, open space, forest, recreation and special functions	676.4	23.5
	Total Area	2878.1	100

Source: Oromia urban plan institute (2011)

3.1.4 Demographic Characteristics

According to data obtained from CSA 1994 and 2007, the total populations in the town were 11,907 and 19,517 respectively and CSA (2013) projected to reach 31,500 in year of 2017. Out of the projected total population 15,730 were men and 15,770 were females.

Among the total population, the majority of (90%) the residents were ethnic Oromo and 10% were other ethnic group. The majority of the inhabitants practiced Ethiopian Orthodox Christianity, with 52.9% of the population, while 24.98% of the populations were Protestant, and 21.44% were Muslim.

3.1.5 Economic Characteristics

The major economic base of Bedele town were trade (cash crop including coffee), employment (including governmental and non-governmental organization) and daily labor. The rural parts' of surrounding the town performs agricultural activities (Oromiya urban planning institute, 2011).

3.1.6 Services and Infrastructure

According to Oromiya urban planning institute (2011), Bedele is few better town among in south west part of the country by having some infrastructural facilities such as power electricity, telephone, asphalt road, post, different banking, different educational organizations (both government and non-government), health (hospital, station), Factory (Beer) and other facilities.

3.2 Research Design

A cross-sectional study design was employed to assess the effects of Bedele Brewery Factory effluent on water quality and measures taken to encounter the problems in Bedele town, from the upstream of the river water, effluent discharge and downstream of the river water after 300 m from the waste effluent released to the river water sources of the town. The research is both qualitative and quantitative approaches based on structured interviews and laboratory investigation depending on samples taken from the study area respectively.

3.3. Materials and Reagent Used

3.3.1. Apparatus

For this study apparatuses such as DR/2400 Portable Spectrophotometer (HACH Company, Cat., No. 59400-45), HACH DR3900 spectrophotometer (HACH Company, Loveland, CO, USA), pH meter (CT-6021A) water proof, Thermometer, Conductivity meter (wagtech, serial no 2402181), Conductivity/TDS meter model Model-1601, Portable Turbidity Meter (WZS-200), measuring cylinder, beakers (different size), ice cold box and polyethylene bottles were used.

3.3.2. Chemicals and Reagents

All chemicals and reagents used for laboratory analysis were of analytical grade. In all dilutions and cleaning distilled water was used. The containers/bottles were washed up with distilled water before their actual usage. Generally, the chemicals and reagents used in this study were deionized water, Buffer Solutions (pH 4.01±0.02, 7.00±0.02 and 10.01±0.02 at 25 ^{0}C), Potassium Chloride (0.01M KCl), mixture of potassium dichromate (KCr_2O_7), manganese sulfate (MnSO4), alkali iodide azide (NaOH + KI + NaN_3), a High Range Dissolved Oxygen AccuVac, nitraver 5 nitrate reagent, NitriVer 3 Nitrite Reagent Powder Pillow, Ammonia Salicylate Powder Pillow, Ammonia Cyanurate Reagent Powder Pillow and phosver 3 phosphate reagent powder pillows.

3.4 Duration and Frequency of Samples Collection

In order to keep the validity of the data, samples were taken three times in different days from discharge point of effluent waste water, upstream and downstream of the Dabana stream in the intervals of two months consecutively. The samples were taken in December, 2020, February, 2021 and April, 2021; a total of 18 water samples were collected from the selected sites of the study.

3.5 Data Collection

3.5.1 Water Samples Collection

3.5.1.1 Cleaning of Sampling Equipments

Samples were taken at three sampling points along the course of the stream from the upstream to the downstream. These include effluent discharging point (DP), upstream and downstream of the Dabana River. 1L polyethylene bottles were used for samples collection. All polyethylene bottles used for water sampling were thoroughly washed with bottled water and detergent, rinsed with distilled water and then soaked with 10% (v/v) HNO_3. After that, all containers were well-rinsed with distilled water routinely, air dried, and stored with the caps on to prevent contamination. The containers were rinsed with sample water prior to actual sample collection before being used for sampling (APHA, 2005).

3.5.1.2 Water Sampling, Labeling, Preservation and Transportation

A grab sampling technique was employed to take water samples to analysis. In order to have representative samples, a bottle of samples for the analysis of physicochemical parameters were collected from each sampling point at the times of discharging effluent, based on American Public Health Association of guidelines of water and wastewater sampling techniques (APHA, 2005).

A water sample was collected following the standard procedure as described by (APHA, 2017). Water samples from sampling stations were collected with 1 L for physical and chemical, capacity polyethylene bottles. The bottles were previously sterilized by steam sterilize, to avoid any contamination and it was labeled on the field using appropriate coded as upstream (US), effluent discharging point (EDP) and downstream (DS) of water samples of the present study. The water samples were collected and then were temporarily stored in ice-packed cooler and transported to the laboratory and stored in a refrigerator at about 4 ^{0}C prior to analysis. Finally, samples were transported to Wellega University and Nekemte Town Water Supply and Sewerage Service Enterprise Laboratory for physicochemical parameters analysis.

3.6. Classical Water Sample Analysis Procedures

All the analytical procedures used in the physical and chemical parameters of the current study water samples were executed according to standard methods of classical laboratory procedures of water and waste water analysis (APHA, 2017). The water samples were analyzed during December 2020, February and April 2021 and their values were determined in Wollega University Waste water treatment plant and Nekemte town water supply and sewerage enterprise service laboratory.

3.6.1. Physical Analysis Procedure

Some physical parameters studied in this paper are EC, turbidity, temperature, TDS, TSS and TS. Among those parameters temperature, EC and pH were determined in the field at the time of collection because of their instability by standards methods and procedures of water and waste water examination (APHA, 2017) with their representative procedures.

Electric Conductivity (EC): EC was measured using a digital portable conductivity meter. Before measuring the probe was rinsed with distilled water and the purity of distilled water was checked. Then the probe was immersed in a beaker containing a water sample and moved up and down taped on the beaker to be free the electrodes from any bubbles. Then data was recorded for each sample.

Turbidity: The turbidity of water was determined by microprocessor portable turbidity meter instrument by zeroing with deionized water by Turbidity meter Method.

Temperature: The temperature of water samples was determined in the field due to their unstable nature by thermometer. A thermometer was calibrated to 0°C to 100°C was used for temperature measurements. Thermometer was immersed in the water sample until the liquid column in the thermometer stops moving for 3 min and the reading was recorded.

Total Dissolved Solid (TDS), Total Suspended Solid (TSS) and Total Solid (TS): For total suspended solid (TSS), 100 mL of the water sample of each was filtered through a pre weighed filtered paper. The filtered papers were dried at 103 – 105°C in oven and TSS was determined by the following formula.

$$\text{TSS (mg/L)} = \frac{\text{filter post weight} - \text{filter pre weight} \times 1000}{\text{Vsample (mL)}} \text{-- (1)}$$

TDS was measured using combined portable microprocessor based conductivity/TDS meter model Model-1601whereas TS was measured from the two parameters of TDS and TSS given by:

$$\text{TS (mg/L)} = \text{TDS (mg/L)} + \text{TSS (mg/L)} \text{ -- (2)}$$

3.6.2. Chemical Parameters Analysis

The chemical parameters analyzed in this study were determined by an instrument portable DR/2400 Spectrophotometer and portable DR3900 Spectrophotometer based on their respective procedures, chemicals and reagents used as set by water and wastewater analysis (APHA, 2017).

pH of water: The pH water sample was measured by using portable pH meter after calibrating the instrument by buffer solution standards at pH 4, 7 and 10.

Chemical Oxygen Demand (COD): The chemical oxygen demand was measured by closed reflux method using strong chemical oxidant (American Public Health Association (APHA, 2005). The oxidant used for this study was a mixture of potassium dichromate (KCr_2O_7). Finally, COD was determined by a method of colorimetric determination using HACH DR3900 spectrophotometer (HACH Company, Loveland, CO, USA). Results were displayed in mg/L COD by spectrophotometer.

Biochemical Oxygen Demand (BOD): BOD was estimated by preparing the required volume of dilution water with the addition of nutrients namely phosphate buffer, magnesium sulfate, calcium chloride, and ferric chloride. The diluted samples were transferred to BOD bottles. After determining initial DO, final DO was estimated of the bottles kept for the incubation period of five days. The bottles were kept for DO determination and the blank was fixed by adding 2 mL manganese sulfate (MnSO4), 2 mL of alkali iodide azide ($NaOH + KI + NaN_3$) (American Public Health Association (APHA, 2005).

Dissolved Oxygen (DO): A round sample cell was filled with 10 mL of sample (the blank). A blue ampule cap and a High Range Dissolved Oxygen AccuVac Ampul were filled with sample. The tip was kept and immersed while the ampule fills completely. The ampule was held with the tip pointing down and immediately placed the ampule into the ampule cap. The cap prevents contamination from atmospheric oxygen. The ampule was shaked for 30 seconds. A small amount of un-dissolved reagent was not affect results. A two-minute reaction period was begun. This enables the oxygen that was degassed during aspiration to re-dissolved and reacted. When the timer beeps, the ampule was shaked for 30 seconds. The blank placed in the cell holder and touched zero, the display shows: 0.0 mg/L O_2. Then the ampule was placed into the cell holder. Approximately 30 seconds were waited for the air bubbles to disperse from the light path and by touching read results was appeared in mg/L O_2.

Nitrite (NO_2^--N): A content of one NitriVer 5 Nitrate reagent powder pillow was added to 10 mL sample water in the first sample cell and shaken vigorously for one minute, and allowed to stand for 20 minutes for an amber color development. In the second sample cell, about 10 mL of sample water have filled. This has used as a blank to calibrate the instrument to 0.0 mg/L NO_2^--N. Then, the sample prepared in the first sample cell was inserted into the spectrophotometer; a direct reading of the concentration of NO_2^--N has recorded.

Ammonia - Nitrogen (NH_3–N): In the first round sample cell, the 10-mL mark with sample and in another round sample cell to the 10-mL mark with deionized water (this is the blank) were filled. The contents of one Ammonia Salicylate Powder Pillow were added to each cell. After stopper and shaked to dissolve the powder a three-minute reaction period was begun. Then the contents of one Ammonia Cyanurate Reagent Powder Pillow were added to each sample cell. A 15-minute reaction period was begun. When the timer beeps, the blank was placed into the cell holder and was displayed: 0.00 mg/L NH_3–N. Then, the prepared sample in the first sample cell has allowed analyzing and the results were appeared in mg/L NH_3–N.

Nitrate (NO_3^--N): A content of one NitraVer 5 Nitrate reagent powder pillow was added to 10 mL sample water in the first sample cell and shaken vigorously for one minute, and allowed to stand for 5 minutes for an amber color development. In the second sample cell, about 10 mL of sample water have filled. This has used as a blank to calibrate the instrument to 0.0 mg/L NO_3^--N. Then, the sample prepared in the first sample cell was inserted into the spectrophotometer; a direct reading of the concentration of NO_3^--N has recorded.

Phosphate (PO_4^{3-}): In the first sample cell, one PhosVer 3 phosphate Powder Pillow reagent has mixed with 10mL water sample and it was immediately caped and inverted to mix (this is the prepared sample) and allowed to stand for a two-minute reaction period. In the second sample cell, about 10mL of sample water have filled (this is the blank). The blank, in the second sample cell has inserted into the cell holder to make the reading on the instrument zero (0.00 mg/L PO_4^{3-}). Then, the prepared sample in the first sample cell has allowed analyzing and the results were appeared in mg/L PO_4^{3-}.

3.7. Quality Assurance/Quality Control

Prior to the actual data collection time, pretest was done in the laboratory by calibrating laboratory equipment's, checking the expiry date of chemicals , reagents and preparation of new standards for each test using samples to be taken from Nekemte town other than those to be included in the sample to be able to rule out measurement errors due to the measuring instruments and to have a more reliable result. For microbiological analysis more numbers of techniques were under taken to ensure that the data generated are reliable.

3.8. Pretest

Prior to the actual data collection time, pretest is to be done in the laboratory by calibrating laboratory equipments, checking the expiry date of chemicals and reagents and preparation of new standards for each test using water samples taken from other water body or river other than those included in the sample to be able to rule out measurement errors due to the measuring instruments and to have a more reliable result.

3.9. Quality Assurance and Quality Control

Quality Assurance and Quality Control plans were incorporated both in the field and laboratory. As part of the quality assurance and quality control plan, the tools to be used were autoclaved before the analysis started in the laboratory. All sampling bottles were pre-labeled to avoid mixing the samples. Duplicate samples were obtained to verify the accuracy of the results. Measuring equipments were calibrated either in the field or at the laboratory prior to measurements. The final results of parameters were obtained by taking the mean values of all the data sets for each sampling site. Standard analytical methods and references were used while samples are taken to a sound laboratory for analysis.

3.10. Statistical Data Analysis

The primary data collected was first registered to Microsoft Excel spread sheet (version 2010) software application to be able to present descriptive data in frequency table, graphs, and charts. Results were analyzed using Statistical Package for Social Sciences (SPSS version 22) to compute the mean trial values of the physical and chemical properties of their data. The one-way ANOVA was used to identify if there are any significant differences between samples amongst the upstream water sources, the effluent discharge point and downstream of river water samples of the present study. The mean values were compared against the national (CES, 2013) and international (WHO, 2011) standards of water and waste water guidelines values.

3.11. Ethical Considerations

Ethical clearance to conduct this study is obtained from the Addis Ababa University & Permission of manager of Bedele Brewery factory for water sample collection from the selected sites was also another mandates that was convinced for only educational research purposes. Study objectives were clearly explained to the manager of the industry regarding the data to be collected. The industry is to be assured that the information was provided and the result of the laboratory would be confidential and used only for the purpose of the research.

3.12 Reporting Results and Information Dissemination

Following the analysis of the data, a report was submitted to Addis Ababa University. Also the results of the study may be presented to the concerned bodies in order to maximize the environmental sustainability of the industries. Addis Ababa University also can use this scientific paper for further studies.

4. RESULTS AND DISCUSSIONS

4.1 Physicochemical Water Quality Analysis

The results of the physical and chemical parameters analyzed from Bedele Brewery Factory effluent and Dabana stream which receiving the effluent and the upstream of water samples were carried out following the standard method described by (APHA, 2017) and were tabulated in Tables 3, 4, 5, figures 2, 3 and 4.

4.1.1 Physical Parameters

Table 3: Some Selected Physical parameters of water samples

Parameters	Sample Station With Their Results (Mean±SD)			Standards	
	EDP	**US**	**DS**	**CES**	**WHO**
EC (µS/cm)	965.33±1.53	86±1	720±2	1000	1000
Turb. (NTU)	113.1±0.1	23.43±0.06	90.13±0.06	5	5
Temp. ^{0}C	28.3±0.17	23.67±0.06	24.17±0.06	25	40
TDS (mg/L)	689±2	61.33±1.53	514±1	1000	1000
TSS (mg/L)	56.33±0.56	41±1	53±1		50
TS (mg/L)	745.33±1.53	102.33±2.08	567±1.73		

Note: EDP-Effluent Discharge Point, US-Upstream and DS-Downstream

Electrical Conductivity (EC): The EC of water is a measure of the ability of a solution to conduct an electric current. The conductivity depends on the presence of ions, their total concentration, mobility, valence and relative concentration and on the temperature of the water. The measured values of EC were 965.33±1.53 µS/cm (EPS), 86±1 µS/cm (US) and 720±2 µS/cm (DS) water samples (table 3 and figure 2) which were lower than 1000 µS/cm set by CES and WHO guide lines. The highest mean value of EC was recorded at the effluent discharge point; this is due to the fact that brewery effluent contains various anions and cations resulting highest concentration of electrical conductivity and the lowest EC was found at the upstream water sample sites. This is one of the main objectives that are used as an indicator for the requirement of the study. Electrical conductivity indicates the existence of ions in effluent of brewery effluent plant released to carry an electric current. The existence of ions in effluent show the quantity of dissolved materials present in the water bodies. Moreover, the higher EC of the effluent released to the stream was responsible to cause of eutrophication. There was significant difference between the recorded values of EC along sample sites ($P<0.05$) (Table 3).

Turbidity: Turbidity in water is caused by the presence of suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms. The recorded values of turbidity in this study were 113.1±0.1 NTU at effluent discharge point, 23.43±0.06 NTU at Upstream, 90.13±0.06 NTU at Downstream of the water samples (table 3 and figure 2). Those values are higher than 5 NTU of the guideline limits of waste water and water quality set by CES and WHO. The statistical ANOVA values of turbidity among sampling sites are significantly different at ($p<0.05$) confidence level; table 4.

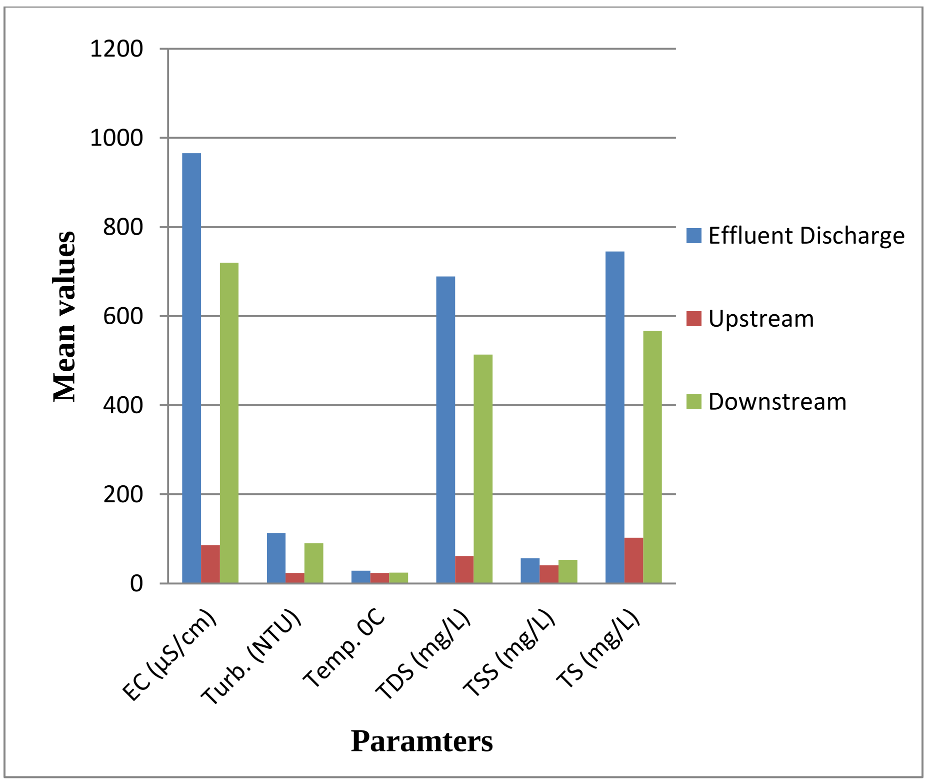

Figure 3: Mean values of physical parameters

Temperature

Temperature is an important controlling factor in the biological processes occurring in the catchment either acting singly or in conjunction with other environmental factors**.** The result showed that, the temperature mean value obtained from the effluent discharge point (28.3±0.17 ^{0}C), upstream (23.67±0.06 ^{0}C), and downstream (24.17±0.06 ^{0}C) as tabulated on table 3 and figure 2. The recorded value of the temperature at the effluent point is higher than 25 ^{0}C set by CES and all the sampling sites are lower than 40 ^{0}C set by WHO guide lines (40 ^{0}C). The recorded values of temperature in the current study are within the ranges of 22.5 to 32 ^{0}C in Gondar, Ethiopia (Jigar et al., 2019) studied on impact of Dashen Brewery Effluent on Irrigation Water Quality of Shinta River water. The temperature of sampling sites were significantly different (P = **0.05**) confidence level among sampling sites.

Total Dissolved Solids (TDS)

The discharge of water with a high TDS level would have adverse impact on aquatic life, make the receiving water unfit for drinking, reduce crop yields if used for irrigation, and exacerbate corrosion in water systems. Highest amount of TDS affects the concentration of dissolved Oxygen in the receiving water body (stream) and influence the Osmo-regulation of aquatic life. Moreover, if TDS exceed the limit standard also affect the utility of water for drinking and irrigation. In the current study, the average values of TDS of the three sampling points were 689±2 mg/L (effluent discharging point), 61.33±1.53 mg/L (upstream) and 514±1 mg/L (downstream) (Table 3 and figure 2). The total dissolved solids value in the effluent discharge is higher than both the upper and downstream of water samples because the brewery effluent discharge released by Bedele brewery factor effluent containing excess amount of colloidal forms and dissolved solid matters. The measured TDS values of the three sampling sites were lower than 1000 mg/L set by both CES and WHO guide lines. The mean total dissolved solids concentration in Gondar town was found to be 13 to 37 mg/L (Jigar *et al.,* 2019) on similar impact of brewery effluent on water quality of Shinta River water samples which is lower than the current study. There is a significant difference ($P<0.05$) of average TDS values among the effluent discharging points, upstream and the downstream of the river (Table 4).

Total Suspended Solids (TSS)

The TSS concentration is a measure of the amount of materials suspended in water which includes a wide range of sizes of materials from silt and plankton to industrial wastes and sewage. The total suspended solids affect the light intensity of water; suspended solids are the cause of suspended particle inside the water body influencing turbidity and transparency. In this study, the analyzed TSS values were 56.33±0.56 mg/L (effluent discharging point), 41±1 mg/L (upstream) and 53±1 mg/L (downstream) of the water samples (Table 3 and figure 2). The values recorded at effluent discharge point and the downstream of water samples were higher than 50 mg/L set by WHO guide line standards. Accordingly, the values recorded at effluent discharge of water sample are higher than the upstream river sample before receiving the brewery factory effluent. The downstream water sample points after receiving the brewery effluent discharged also higher than the upstream of the river samples indicates that high load of TSS values at effluent discharge. The same concentration values of total suspended solids were reported by (Jigar *et al.,* 2019) in Gonder town on impacts of brewery effluent on water quality of Shinta River water samples (10.2 to 38 mg/L). This value is lower than the current study. There is a significant difference ($P<0.05$) of TSS between the three sampling points of this study area (Table 4).

Table 4: One-way ANOVA values of physicochemical parameters

		Sum of Squares	df	Mean Square	F	Sig.
EC	Between Groups	1242891.556	2	621445.778	49937.607	.000
	Within Groups	74.667	6	12.444		
	Total	1242966.222	8			
Turbidity	Between Groups	13016.469	2	6508.234	1171482.200	.000
	Within Groups	.033	6	.006		
	Total	13016.502	8			
pH	Between Groups	2.940	2	1.470	73.500	.000
	Within Groups	.120	6	.020		
	Total	3.060	8			
Temperature	Between Groups	38.802	2	19.401	1587.364	.000
	Within Groups	.073	6	.012		
	Total	38.876	8			
TDS	Between Groups	629497.556	2	314748.778	128760.864	.000
	Within Groups	14.667	6	2.444		
	Total	629512.222	8			
TSS	Between Groups	390.222	2	195.111	250.857	.000
	Within Groups	4.667	6	.778		
	Total	394.889	8			
TS	Between Groups	661166.889	2	330583.444	102594.862	.000
	Within Groups	19.333	6	3.222		
	Total	661186.222	8			
BOD	Between Groups	34424.000	2	17212.000	4303.000	.000
	Within Groups	24.000	6	4.000		
	Total	34448.000	8			
DO	Between Groups	22.996	2	11.498	1478.286	.000
	Within Groups	.047	6	.008		
	Total	23.042	8			

Nitrite	Between Groups	.003	2	.001	56.797	.000
	Within Groups	.000	6	.000		
	Total	.003	8			
Nitrate	Between Groups	39.176	2	19.588	452.026	.000
	Within Groups	.260	6	.043		
	Total	39.436	8			
Phosphate	Between Groups	11.183	2	5.592	2516.195	.000
	Within Groups	.013	6	.002		
	Total	11.196	8			

Total solids (TS): The mean values of TS in the entire study area are: 745.33±1.53 mg/L at effluent discharge point, 102.33±2.08 mg/L at the upstream water sample and 567±1.73 mg/L at downstream water samples as tabulated on table 3 and figure 2**.** Similar to other analyzed parameters, the TS values are higher at effluent discharge point than the upstream and downstream water samples indicate that high loads of organic and inorganic maters that are responsible for the pollution of the water quality at the study area. The statistical results ($p<0.005$, ANOVA) of total solids are significantly different among the sampling sites of water samples (table 4).

4.2.2 Chemical Parameters

Chemical Oxygen Demand (COD): The chemical oxygen demand (CO) is used as a measure of the oxygen equivalent of the organic matter content of the sample that is susceptible to oxidation by strong chemical oxidants. The mean concentrations of COD are 273±12 mg/L at effluent discharge point, 42±2 mg/L at upstream and 81±2 mg/L at downstream water samples table 3 and figure 3. The value recorded at effluent discharge point is higher than 250 mg/L guide line limits set by WHO standards. The measured results of COD in the entire sites is lower than the ranges compared to other studies reported by (Jigar *el al.,* 2019) on impacts of brewery effluent on water quality of Shinta River water samples (800.2 to 872.6 mg/L) at Gondar town, Ehiopia.

COD varied significantly ($p<0.005$, ANOVA) which can be attributed to the different oxidizing agents unique to the different industries and those found naturally in the environment. The high amount of COD at effluent discharge point indicates the presence of chemically oxidisible carbonaceous matter attributed build-up of organic and inorganic pollution loads from the effluent discharges.

Biological Oxygen Demand (BOD): The measured values of Biological Oxygen Demand (BOD) content in this study were 42±2 mg/L at upstream of water, 80±2 mg/L at downstream of water and 188±2 mg/L at the effluent discharge point as tabulated in table 3 and figure 3. From this result, the values recorded at effluent discharge and downstream of water samples are higher than 60 mg/L set by WHO guide line values and lower at the upstream of the water. On an average basis, the demand for oxygen is proportional to the amount of organic waste to be degraded by aerobically. Hence, the low COD content is an indicator of good quality of water, while a high COD indicates polluted water. BOD directly affects the amount of dissolved oxygen (DO) in surface water like rivers and streams. The greater BOD, the more rabidly oxygen is depleted in the water and leads to aquatic organisms become stressed, suffocate and die. The mean BOD concentration in Gondar town was found to be 636 to 745 mg/L (Jigar *et al.*, 2019) on similar impact of brewery effluent on water quality of Shinta River water samples which is higher than the current study. The analysis of variance (ANOVA) result showed that BOD was significantly different ($p<0.05$) among the various stations sampled.

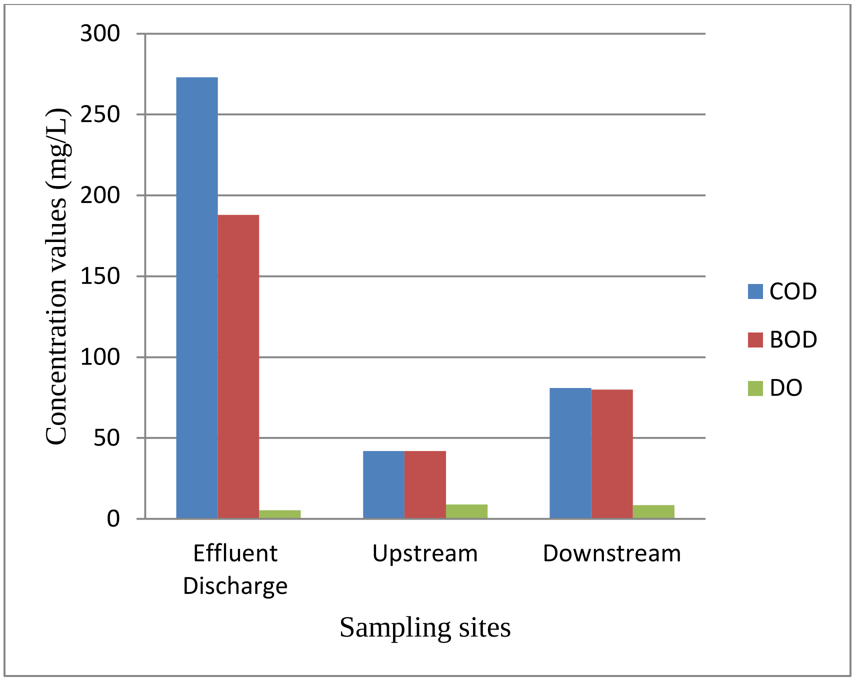

Figure 4: Measured values of COD, BOD and DO in the Study Area

Dissolved Oxygen (DO): Depending upon water temperature and salinity saturation rate, DO varies between 5.0 to 7.0 mg/L set by national and international standards. Oxygen demand for decomposition of materials results in depletion of DO in water and threatens aquatic life and water quality. The recorded values are ranged from 4.4±0.1 (effluent discharge) to 9±0.1 mg/L (upstream of water) (table 3 and figure 3). It is considerably high; these are due to the capacity of water to hold oxygen. The value measured in effluent discharge is lower than and in upstream and downstream thee water are higher when compared with CES and WHO which is 5.0-7.0 mg/L. Similar value was reported by (Jigar *et al.*, 2019) in Gondar, Ethiopia, on impact of brewery effluent on water quality of Shinta River ranged from 2.1 to 3.2 mg/L hich is slighty lower than the current study. The mean DO values in the entire study are significantly different among sample sites from each other at 95% confidence level (table 4). The lowest Average DO value was recorded at the discharging point due to highest organic demand from brewery waste water and the highest average DO value was found at the upstream of water since no brewery effluent discharge exist at this site.

Table 5: Some Selected chemical parameters of water samples

Parameters (mg/L)	Sample Station With Their Results (Mean±SD)			Standards	
	EDP	US	DS	CES, 2013	WHO
COD	273±12	42±2	81±2		250
BOD	188±2	42±2	80±2		60
DO	4.4±0.1	9±0.1	8.53±0.06	5.0-7.0	5.0-7.0
pH units	6.2±0.1	7.6±0.1	6.9±0.2	6.5-8.5	6 to 9
NO_2^- -N	0.77±0.06	0.33±0.06	0.46±0.03	3	3
NO_3^- -N	6.57±0.06	1.47±0.15	3.73±0.32	50	50
NH_3-N	BDL	BDL	BDL	1.5	20
PO_4^{3-}	3.02±0.01	0.45±0.01	2.54±0.08		5

Note: EDP-Effluent Discharge Point, US-Upstream and DS-Downstream

pH: pH is a measure of the acid balance of a solution. The pH of water affects the solubility of many toxic and nutritive chemicals. The mean pH value recorded from discharging point, upstream and downstream was 6.2±0.1, 7.6±0.1 and 6.9±0.2 respectively (Table 5 and figure 4). Since, the mean pH value recorded is in the permissible limit recommended by WHO and CES for different purpose; here it is not negatively affected. There was a significant difference of pH ($p < 0.05$) among the discharging point, the upstream and downstream sampling points (Table 4). All recorded water samples tested for pH values were below the limited standard given by WHO (6 to 9) and CES (6.5 -8.5) for water and waste water quality as well as irrigation purpose. The measured values of the pH at the effluent discharge is lower than the upstream and downstream of water sample. So, repeated and follow-up monitoring is crucial for the released effluent for further uses to the nearby users. The recorded concentrations of pH in this study was higher than the ranges 5.6 to 6.5 units reported by (Jigar *et al.*, 2019) studied in Gondar Ethiopia on impacts of brewery effluent on water quality of Shinta River water samples. The statistical ANOVA values ($p<0.05$) sows there is a significant difference among the three sampling sites.

Nitrite (NO_2^--N) content: The nitrite (NO_2^--N) content of water is an important parameter that indicates the accumulation of nitrite due to leaching from nearby agricultural fields and pollution of water by organic matter due to microbial activity. In this particular study, the nitrite concentration measured was in the range of 0.33±0.06 mg/L (Upstream water sample) to 0.77±0.06 mg/L (Effluent discharge point) which was lower than 3mg/L set by CES and WHO standard limits as tabulated in table 5 and figure 4. From ANOVA results ($P \leq 0.05$) there is significantly different among the water sample sites (table 4). The higher concentration value of nitrate at effluent discharge point indicates due to the presence of nitrate containing organic wastes from the effluent Bedele brewery factory sources.

Nitrate (NO_3^--N): The average concentration of NO_3^--N at effluent discharging point, the upstream and downstream of water samples were 6.57±0.06 mg/L, 1.47±0.15 mg/L and 3.73±0.32 mg/L respectively tabulated in (Table 5 and figure 4). These results are within the ranges between 2.3 to 16 mg/L that studied in Gondar Ethiopia on impacts of brewery effluent on water quality of Shinta River water samples. According to this study laboratory result, the highest average NO_3^--N concentration was recorded at the effluent discharging point and lowest was observed at the upper-stream water sample sites and all the measured values are lower than 50 mg/L set by CES and WHO maximum permissible for water and waste water samples. The recorded result indicates that the average concentration of nitrate in this study is significantly different ($P<0.05$) along the three sample sites (table 4). The main reason that the level of nitrate content is higher at effluent discharge point was as a result of nitrogenous (protein) wastewater released from the brewery waste water. The released waste oxidized to nitrate by the action of microbial activities.

Ammonia-nitrogen (NH_3-N): The amount of ammonia-nitrogen concentration in this study area is not detected by the instrument that we used for the identification of some selected chemical parameters.

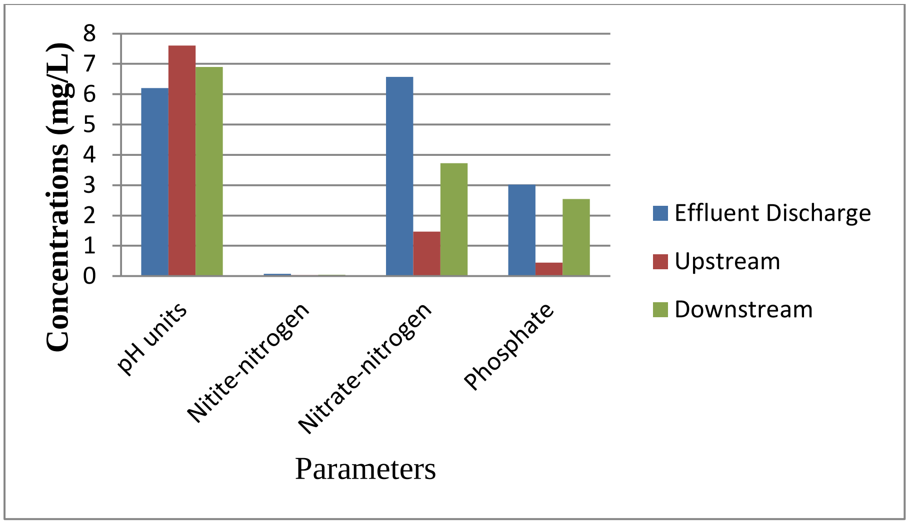

Figure 5: Mean values of anions and pH

Phosphate (PO_4^{3-}): Phosphate beyond prescribed limits (5mg/L) is adversely affected the aquatic life and downstream of river users. Excess phosphate leads to unbalance plant growth which known as eutrophication that causes pollution of water body and it causes the growth of blue green algae which releases toxic substance (cyan toxins) into the river. The average concentration of (PO_4^{3-}) in this study area is 3.02±0.01 mg/L at effluent discharging point, 0.45±0.01 mg/L at upstream and 2.54±0.08 mg/L at downstream of water samples shown as table 5 and figure 4 which was lower than 5mg/L set by WHO maximum permissible concentrations. The higher amount of phosphate at effluent discharge point was due to effluent discharged from Bedele brewery effluent content of phosphate containing compounds and the lowest value was recorded at the upstream water samples before confluence water sampling site due to interruption of the brewery effluent at this station. The measured phosphate concentration in this study was higher than the ranges of 1.2 mg/L to 6 mg/L reported by (Jigar *et. al*., 2019) in Gondar, Ethiopia in similar impacts of brewery effluent discharge on water quality of river water samples. The phosphate content of the current study was significantly different ($P<0.05$ ANOVA results) among sampling sites (Table 4).

4.2 Pearson Correlation of the Present Study

Table 6: Pearson correlations of physicochemical parameters of the study area water samples

	COD	BOD	DO	NO_2^- -N	NO_3^- -N	PO_4^{3-}	EC	Turb.	pH	Temp.	TDS	TSS	TS
COD	1												
BOD	.995**	1											
DO	-.999**	-.991**	1										
NO_2^- -N	.969**	.979**	-.965**	1									
NO_3^- -N	.951**	.974**	-.937**	.948**	1								
PO_4^{3-}	.755*	.814**	-.728*	.810**	.915**	1							
EC	.818**	.869**	-.795*	.864**	.949**	.994**	1						
Turb.	.802**	.855**	-.778*	.851**	.940**	.997**	1.000**	1					
pH	-.914**	-.942**	.894**	-.906**	-.984**	-.924**	-.950**	-.943**	1				
Temp.	.997**	.987**	-.999**	.959**	.932**	.715*	.782*	.764*	-.891**	1			
TDS	.816**	.867**	-.793*	.862**	.948**	.995**	1.000**	1.000**	-.950**	.780*	1		
TSS	.772*	.827**	-.746*	.814**	.927**	.994**	.992**	.993**	-.941**	.734*	.992**	1	
TS	.816**	.867**	-.792*	.862**	.947**	.995**	1.000**	1.000**	-.950**	.779*	1.000**	.992**	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

From Pearson correlation coefficient matrix as shown (Table 6), it is observed that the correlation of EC with turbidity, TDS and TS; turbidity with TDS and TS; TDS with TS had strongly positive correlation (r=1.000), COD with BOD and temperature respectively (r=995 & r=0.997), PO_4^{3-} with EC, turbidity, TDS, TSS and TS respectively (r=0.994, r=0.997, r=0.995, r=0.994 & r=0.995); TSS with EC, turbidity and TDS respectively (r=0.992, r=0.993 & r=0.992) and TS with TSS (r=0.992) are pairs strongly positively correlated and DO with COD, BOD, NO_2^-, NO_3^- & temperature; pH with COD, BOD, NO_2^-, NO_3^-, PO_4^{3-}, EC, turbidity, temperature, TDS, TSS & TS are pairs negatively correlated significantly at 99% confidence level. Whereas COD with PO_4^{3-} & TSS (r=0.755, r=0.772); temperature with PO_4^{3-}, EC, turbidity, TDS, TSS & TS respectively (r=0.715, r=0.782, r=0.764, r=0.780, r=0.734, r=0.779) are pairs positively correlated and DO with PO_4^{3-}, EC, turbidity, TDS, TSS & TS are pairs negatively correlated significantly at 95% confidence level. The recorded values of pH and DO are negatively correlated against all the measured water samples except against each other which are positively correlated at both 99% and 95% confidence level. Likewise, the correlations of BOD, NO_2^-, NO_3^- & pH are strongly correlated at 99% confidence level. Finally, all the rest physicochemical parameters of the present study have high correlation against each other between and within sampling sites at ($r<0.99$ & $r>0.80$). The significant positive correlation 99 % confidence level of the studied water quality parameters could possibly reveal that the water sample comes from the same sources.

4.2 Effects of Brewery Effluents

The Bedele brewery factory is one of the largest factories that discharge high load of effluent wastewater to nearby river water bodies that affects its qualities in Ethiopia. Concerning to this, one of the major environmental issues associated with the disposal of Bedele brewery effluent discharge wastewater is water pollution. The brewery effluent finds its way to the water bodies and due to its organic load, the oxygen budget in the receiving water body is depleted which can lead to decline of aquatic life. The indiscriminate disposal of brewery effluent in the soil may result in accumulation of salts and will lead to groundwater pollution as a result of leaching due to the presence of high concentration of sodium in the effluent (Senthilraja and Jothimani, 2014).

Exposure effects of effluent affect micro and macro fauna, as well as humans and livestock. The major concern here is the diseases caused by the toxic components of contaminated waters where effluents are disposed off. The sources are there as there are no working treatment plants available, so, over 99% improperly treated wastewater which results in the depositing of toxics, usually, nutrients from the large organic waste are being deposited from the brewery effluent into the water bodies. This can lead to eutrophication (caused by excess nutrient load) which also alters the water balance and energy in the structure and function of the biotic community. Sand/debris of the effluents is also deposited in the waters when the turbidity of the effluent is in excess. These multiple exposures cause organisms that can tolerate the changes in the environment to survive while others who cannot eventually die off. When this happens there is likely to be a proliferation of the tolerant organism due to a reduction in competition for resources within the environment. The changes in the dynamics of the environment by toxic effluent are thus critical and require attention by policymakers & regulatory body.

Factors for the effluents

Water may be treated differently in different communities depending on the quality of the water which enters the plant. The treatment plant is designed to allowing operators, technicians or staff operating and maintaining water treatment system, emphasizing safe practices and procedures. Municipal and industrial effluents, such as wastewater, sludge, or wastewater, are treated in effluent treatment plants. The manufacturers of these effluent treatment plants designed the plant to remove harmful pathogens, hazardous chemicals, detergents, and toxins, as well as separate and extract valuable substances from the effluent (Abdelnaser, 2011).

The recommended water treatment chemical is used to efficiently treat water in our country's numerous effluent treatment plants. The effluent quality in one’s treatment plant is critical. The effluent's characteristics determine the important factors that are associated with it. When designing the treatment plant, the biological, chemical, and physical properties that affect effluent quality must be taken into account. Those factors affecting quality of effluent are: seasonal variations, Size of the effluent treatment plant, Estimation of the effluent inflow properly, Usage of equalization tanks and ponds, Solid material, Physical characteristics of effluent, Capability to withstand shock loads and Other factors that easily affect the quality of effluent (Abdelnaser, 2011).

Measures taken to encounter the problems

Based on the present study, the physicochemical analyzed/recorded values make some indication for the measures taken to encounter the problems. This means from the some selected parameters result half of it has higher than the maximum permissible concentration values of national and international guidelines. Accordingly, the Bedele Brewery factory treatment plant is not completely treating the effluents and the effluents are also not properly managed by the factory and it is directly discharged to nearby stream water (Study site).

Challenges in the Implementation of the Measures

There are big challenges in the implementation of the measures taken for the correction of treatment system of the Bedele brewery factory to treat the effluent and control it safely. Once it needs great human mind change to handle the measure problems. This can be taken through teaching peoples around the factory for what purpose they used and not used this stream water and the factory must take the responsibility to control the effluent discharge by making disposable sites rather than discharging their effluent wastewater to nearby stream water sites.

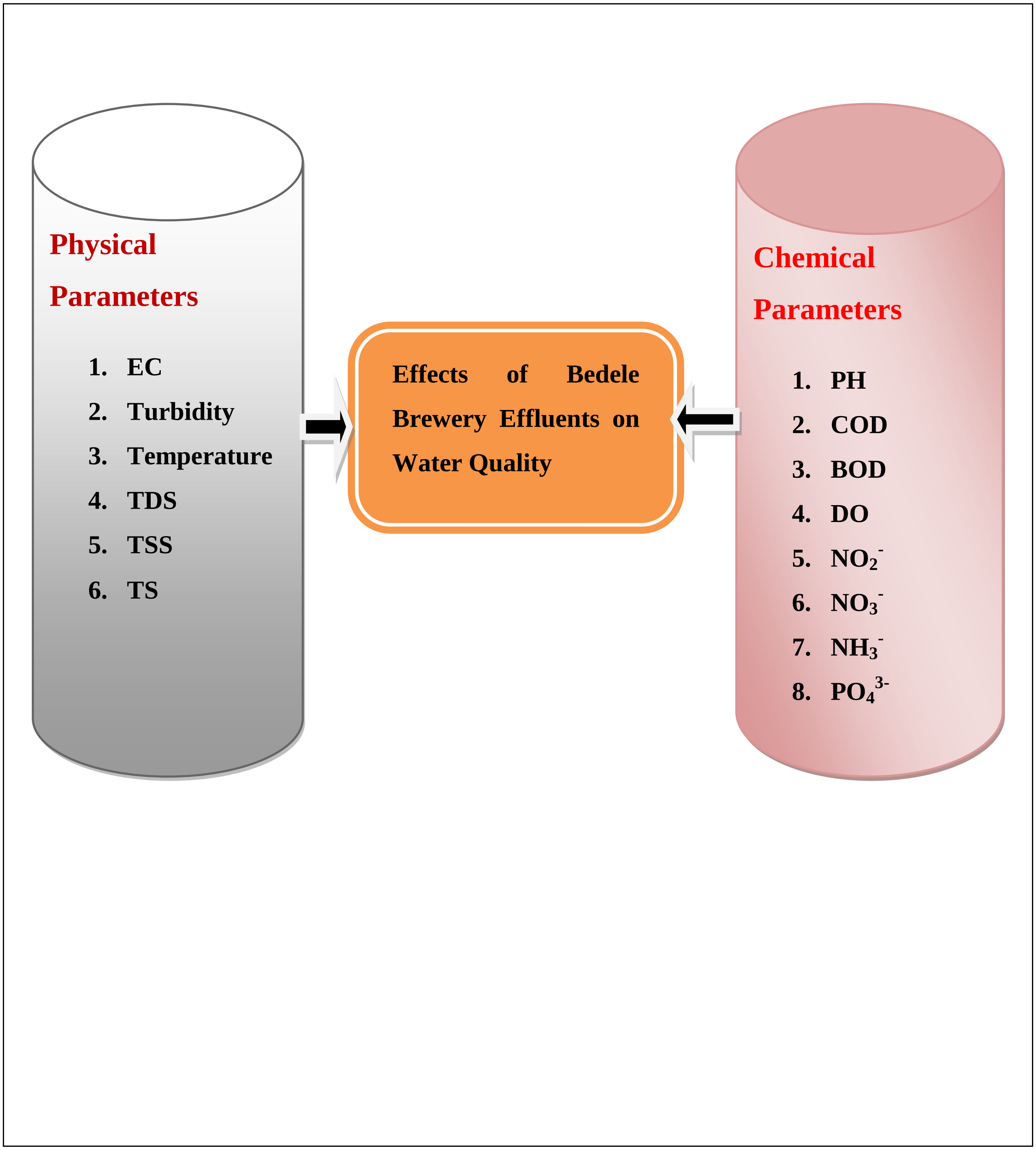

Figure 6: Conceptual framework

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The effects of Bedele brewery factory effluent on water quality assessment on Dabana stream was conducted based on selective physicochemical water quality parameters. Present investigation concludes that about 69.05% of the studied physical and chemical parameters concentrations of the current study of water samples were found to be within the recommended limit of Compulsory Ethiopian standards (CES, 2013) and World health organization (WHO, 2011; WHO, 2017) guide lines except for pH, temperature, COD at effluent discharge point, ***TSS and BOD at both effluent discharge point and downstream of the river*** and turbidity and DO in all selected sites. The high turbidity as observed in the study is often associated with disease causing microorganism such as bacteria and other parasites. The increasing values of other parameters of certain contaminants also indicate that the discharged brewery factory effluent on Dabana stream was unsafe for domestic purposes without some forms of physical, chemical and bacteriological treatments. Thus, the study indicated that the Bedele brewery factory effluent affects Dabana stream water quality nearby the factory which poses unacceptable to aquatic lives, in the river and people using it for domestic purposes and other activities. The Dabana stream which receives the effluent discharge is thus not potable for domestic purposes without some treatments of physicochemical and bacteriological properties while it is useful for agricultural purposes.

5.2 Recommendations

From the results of present study it was recommended that;

- Adequate waste disposal facilities should be provided to inhabitants of the Dabana stream area. The government and other responsible authorities like Bedelle municipality office should prevent indiscriminate dumping of effluent discharge wastewater from the Bedele Brewery Factory into the river and also the public should be educated /awareness is mandatory on the health risks of indiscriminate disposal of these wastes. That will be important for the assessment of the use of the river water for domestic purposes and its health impact on the community.

- It is recommended that the wastewater treatment practiced by Bedele Brewery Factory and other industries including breweries and other factories must use wastewater treatment plant in appropriate system in regular follow-up.

- It is also recommended that monitoring programs for the discharge of Bedele brewery effluent should be implemented to address all activities that have been identified to have potentially significant environmental impact.
- Monitoring frequency should be sufficient to provide representative data for the parameter being monitored and monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken.
- There is also an urgent need for public awareness on the state of the water and apply legal and relevant laws regarding proper treatment of effluent discharge from Bedele Brewery factory before entering to the nearby water bodies.

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APPENDIXES

Appendix 1: Physicochemical analysis procedures of the current study

S/N	**Parameters**	**Instruments/Methods**
1	EC (µS/cm)	Conductivity meter
2	Turbidity (NTU)	Turbidity meter
3	Temperature ^{0}C	Thermometer
4	TDS (mg/L)	Conductivity/TDS meter
5	TSS (mg/L)	Filtration
6	TS (mg/L)	Filtration
7	pH units	pH meter
8	COD (mg/L)	Closed Reflux
9	BOD (mg/L)	Dilution
10	DO (mg/L)	HRDO
11	NO_2^- -N (mg/L)	Diazotization
12	NO_3^- -N (mg/L)	Cadmium Reduction
13	NH_3-N (mg/L)	Salicylate
14	PO_4^{3-} (mg/L)	PhosVer® 3 (Ascorbic Acid)

Appendix 2: Some Selected Physicochemical Analysis of the current study of water samples

S/N	Parameters	Sampling Station With Their Results								
		EDP			US			DS		
		Day-1	Day-2	Day-3	Day-1	Day-2	Day-3	Day-1	Day-2	Day-3
1	EC (µS/cm)	964	967	975	85	86	87	720	718	722
2	Turb. (NTU)	113.2	113.1	113	23.4	23.4	23.5	90.1	90.2	90.1
3	Temp. ^{0}C	28.2	28.2	28.5	23.6	23.7	23.7	24.2	24.2	24.1
4	TDS (mg/L)	689	691	687	61	60	63	514	513	515
5	TSS (mg/L)	56	56	57	42	41	40	54	52	53
6	TS (mg/L)	745	747	744	103	100	104	568	565	568
7	pH units	6.1	6.3	6.2	7.5	7.7	7.6	6.7	7.1	6.9
8	COD (mg/L)	271	273	275	40	42	44	79	81	83
9	BOD (mg/L)	186	188	190	40	42	44	78	80	82
10	DO (mg/L)	4.5	4.4	4.3	9.1	8.9	9	8.6	8.5	8.5
11	NO_2^- -N (mg/L)	0.7	0.8	0.8	0.3	0.3	0.4	0.42	0.48	0.48
12	NO_3^- -N (mg/L)	6.5	6.6	6.6	1.6	1.5	1.3	4.1	3.6	3.5
13	NH_3-N (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
14	PO_4^{3-} (mg/L)	3.02	3.01	3.03	0.45	0.45	0.46	2.63	2.53	2.47

Note: BDL=Below Detection Limit, EDP= Effluent Discharge Point, US = Upper Stream & DS= Downstream

Appendix 3: Maximum Permissible guidelines of analyzed Physicochemical Parameters

S/N	Parameters	Standards	
		CES, 2013	WHO, 2017
1	EC (µS/cm)	1000	1000
2	Turb. (NTU)	5	5
3	Temp. ^{0}C	25	40
4	TDS (mg/L)	1000	1000
5	TSS (mg/L)	-	50
6	TS (mg/L)	-	-
7	pH units	6.5-8.5	6 to 9
8	COD (mg/L)	-	250
9	BOD (mg/L)	-	60
10	DO (mg/L)	5.0-7.0	5.0-7.0
11	NO_2^- -N (mg/L)	3	3
12	NO_3^- -N (mg/L)	50	50
13	NH_3-N (mg/L)	1.5	20
14	PO_4^{3-} (mg/L)	-	5

Note: CES=Compulsory Ethiopian Standards, WHO=World Health Organization

Appendix 4: Post Hoc Tests Multiple comparison by LSD of the present study

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
EC	Effluent Discharge	Upstream	882.666667*	2.880329	.000	875.61876	889.71458
		Downstream	248.666667*	2.880329	.000	241.61876	255.71458
	Upstream	Effluent Discharge	-882.666667*	2.880329	.000	-889.71458	-875.61876
		Downstream	-634.000000*	2.880329	.000	-641.04791	-626.95209
	Downstream	Effluent Discharge	-248.666667*	2.880329	.000	-255.71458	-241.61876
		Upstream	634.000000*	2.880329	.000	626.95209	641.04791
Turbidity	Effluent Discharge	Upstream	89.666667*	.060858	.000	89.51775	89.81558
		Downstream	22.966667*	.060858	.000	22.81775	23.11558
	Upstream	Effluent Discharge	-89.666667*	.060858	.000	-89.81558	-89.51775
		Downstream	-66.700000*	.060858	.000	-66.84891	-66.55109
	Downstream	Effluent Discharge	-22.966667*	.060858	.000	-23.11558	-22.81775
		Upstream	66.700000*	.060858	.000	66.55109	66.84891
pH	Effluent Discharge	Upstream	-1.40000*	.11547	.000	-1.6825	-1.1175
		Downstream	-.70000*	.11547	.001	-.9825	-.4175
	Upstream	Effluent Discharge	1.40000*	.11547	.000	1.1175	1.6825
		Downstream	.70000*	.11547	.001	.4175	.9825
	Downstream	Effluent Discharge	.70000*	.11547	.001	.4175	.9825
		Upstream	-.70000*	.11547	.001	-.9825	-.4175
Temp.	Effluent Discharge	Upstream	4.63333*	.09027	.000	4.4125	4.8542
		Downstream	4.13333*	.09027	.000	3.9125	4.3542

	Upstream	Effluent Discharge	-4.63333*	.09027	.000	-4.8542	-4.4125
		Downstream	-.50000*	.09027	.001	-.7209	-.2791
	Downstream	Effluent Discharge	-4.13333*	.09027	.000	-4.3542	-3.9125
		Upstream	.50000*	.09027	.001	.2791	.7209
TDS	Effluent Discharge	Upstream	627.66667*	1.27657	.000	624.5430	630.7903
		Downstream	175.00000*	1.27657	.000	171.8763	178.1237
	Upstream	Effluent Discharge	-627.66667*	1.27657	.000	-630.7903	-624.5430
		Downstream	-452.66667*	1.27657	.000	-455.7903	-449.5430
	Downstream	Effluent Discharge	-175.00000*	1.27657	.000	-178.1237	-171.8763
		Upstream	452.66667*	1.27657	.000	449.5430	455.7903
TSS	Effluent Discharge	Upstream	15.33333*	.72008	.000	13.5714	17.0953
		Downstream	3.33333*	.72008	.004	1.5714	5.0953
	Upstream	Effluent Discharge	-15.33333*	.72008	.000	-17.0953	-13.5714
		Downstream	-12.00000*	.72008	.000	-13.7620	-10.2380
	Downstream	Effluent Discharge	-3.33333*	.72008	.004	-5.0953	-1.5714
		Upstream	12.00000*	.72008	.000	10.2380	13.7620
TS	Effluent Discharge	Upstream	643.00000*	1.46566	.000	639.4137	646.5863
		Downstream	178.33333*	1.46566	.000	174.7470	181.9197
	Upstream	Effluent Discharge	-643.00000*	1.46566	.000	-646.5863	-639.4137
		Downstream	-464.66667*	1.46566	.000	-468.2530	-461.0803
	Downstream	Effluent Discharge	-178.33333*	1.46566	.000	-181.9197	-174.7470
		Upstream	464.66667*	1.46566	.000	461.0803	468.2530

COD	Effluent Discharge	Upstream	231.000000*	1.632993	.000	227.00421	234.99579
		Downstream	192.000000*	1.632993	.000	188.00421	195.99579
	Upstream	Effluent Discharge	-231.000000*	1.632993	.000	-234.99579	-227.00421
		Downstream	-39.000000*	1.632993	.000	-42.99579	-35.00421
	Downstream	Effluent Discharge	-192.000000*	1.632993	.000	-195.99579	-188.00421
		Upstream	39.000000*	1.632993	.000	35.00421	42.99579
BOD	Effluent Discharge	Upstream	146.000000*	1.632993	.000	142.00421	149.99579
		Downstream	108.000000*	1.632993	.000	104.00421	111.99579
	Upstream	Effluent Discharge	-146.000000*	1.632993	.000	-149.99579	-142.00421
		Downstream	-38.000000*	1.632993	.000	-41.99579	-34.00421
	Downstream	Effluent Discharge	-108.000000*	1.632993	.000	-111.99579	-104.00421
		Upstream	38.000000*	1.632993	.000	34.00421	41.99579
DO	Effluent Discharge	Upstream	-3.600000*	.072008	.000	-3.77620	-3.42380
		Downstream	-3.133333*	.072008	.000	-3.30953	-2.95714
	Upstream	Effluent Discharge	3.600000*	.072008	.000	3.42380	3.77620
		Downstream	.466667*	.072008	.001	.29047	.64286
	Downstream	Effluent Discharge	3.133333*	.072008	.000	2.95714	3.30953
		Upstream	-.466667*	.072008	.001	-.64286	-.29047
Nitrite	Effluent Discharge	Upstream	.043333*	.004181	.000	.03310	.05356
		Downstream	.030667*	.004181	.000	.02044	.04090
	Upstream	Effluent Discharge	-.043333*	.004181	.000	-.05356	-.03310
		Downstream	-.012667*	.004181	.023	-.02290	-.00244
	Downstream	Effluent	-.030667*	.004181	.000	-.04090	-.02044

		Discharge					
		Upstream	.012667*	.004181	.023	.00244	.02290
Nitrate	Effluent Discharge	Upstream	5.100000*	.169967	.000	4.68410	5.51590
		Downstream	2.833333*	.169967	.000	2.41744	3.24923
	Upstream	Effluent Discharge	-5.100000*	.169967	.000	-5.51590	-4.68410
		Downstream	-2.266667*	.169967	.000	-2.68256	-1.85077
	Downstream	Effluent Discharge	-2.833333*	.169967	.000	-3.24923	-2.41744
		Upstream	2.266667*	.169967	.000	1.85077	2.68256
Phosphate	Effluent Discharge	Upstream	2.566667*	.038490	.000	2.47248	2.66085
		Downstream	.476667*	.038490	.000	.38248	.57085
	Upstream	Effluent Discharge	-2.566667*	.038490	.000	-2.66085	-2.47248
		Downstream	-2.090000*	.038490	.000	-2.18418	-1.99582
	Downstream	Effluent Discharge	-.476667*	.038490	.000	-.57085	-.38248
		Upstream	2.090000*	.038490	.000	1.99582	2.18418

*. The mean difference is significant at the 0.05 level.

Appendix 5: Pearson Correlations of physicochemical properties of the present study of water samples

		Sites	EC	Turb.	pH	Temp.	TDS	TSS	TS	COD	BOD	DO	Nitrite	Nirate	Phosphate
Sites	Pearson Correlation	1	-.273	-.247	.490	-.812**	-.270	-.205	-.269	-.776*	-.713*	.799**	-.671*	-.553	-.174
	Sig. (2-tailed)		.477	.522	.180	.008	.482	.596	.485	.014	.031	.010	.048	.123	.653
	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9
EC	Pearson Correlation	-.273	1	1.000**	-.950**	.782*	1.000**	.992**	1.000**	.818**	.869**	-.795*	.864**	.949**	.994**
	Sig. (2-tailed)	.477		.000	.000	.013	.000	.000	.000	.007	.002	.010	.003	.000	.000
	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Turb.	Pearson Correlation	-.247	1.000**	1	-.943**	.764*	1.000**	.993**	1.000**	.802**	.855**	-.778*	.851**	.940**	.997**
	Sig. (2-tailed)	.522	.000		.000	.016	.000	.000	.000	.009	.003	.014	.004	.000	.000
	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9
pH	Pearson Correlation	.490	-.950**	-.943**	1	-.891**	-.950**	-.941**	-.950**	-.914**	-.942**	.894**	-.906**	-.984**	-.924**
	Sig. (2-tailed)	.180	.000	.000		.001	.000	.000	.000	.001	.000	.001	.001	.000	.000

	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Temp.	Pearson Correlation	-.812**	.782*	.764*	-.891**	1	.780*	.734*	.779*	.997**	.987**	-.999**	.959**	.932**	.715*
	Sig. (2-tailed)	.008	.013	.016	.001		.013	.024	.013	.000	.000	.000	.000	.000	.030
	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9
TDS	Pearson Correlation	-.270	1.000**	1.000**	-.950**	.780*	1	.992**	1.000**	.816**	.867**	-.793*	.862**	.948**	.995**
	Sig. (2-tailed)	.482	.000	.000	.000	.013		.000	.000	.007	.002	.011	.003	.000	.000
	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9
TSS	Pearson Correlation	-.205	.992**	.993**	-.941**	.734*	.992**	1	.992**	.772*	.827**	-.746*	.814**	.927**	.994**
	Sig. (2-tailed)	.596	.000	.000	.000	.024	.000		.000	.015	.006	.021	.008	.000	.000
	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9
TS	Pearson Correlation	-.269	1.000**	1.000**	-.950**	.779*	1.000**	.992**	1	.816**	.867**	-.792*	.862**	.947**	.995**
	Sig. (2-tailed)	.485	.000	.000	.000	.013	.000	.000		.007	.002	.011	.003	.000	.000
	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9

COD	Pearson Correlation	-.776*	.818**	.802**	-.914**	.997**	.816**	.772*	.816**	1	.995**	-.999**	.969**	.951**	.755*
	Sig. (2-tailed)	.014	.007	.009	.001	.000	.007	.015	.007		.000	.000	.000	.000	.019
	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9
BOD	Pearson Correlation	-.713*	.869**	.855**	-.942**	.987**	.867**	.827**	.867**	.995**	1	-.991**	.979**	.974**	.814**
	Sig. (2-tailed)	.031	.002	.003	.000	.000	.002	.006	.002	.000		.000	.000	.000	.008
	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9
DO	Pearson Correlation	.799**	-.795*	-.778*	.894**	-.999**	-.793*	-.746*	-.792*	-.999**	-.991**	1	-.965**	-.937**	-.728*
	Sig. (2-tailed)	.010	.010	.014	.001	.000	.011	.021	.011	.000	.000		.000	.000	.026
	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Nitrite	Pearson Correlation	-.671*	.864**	.851**	-.906**	.959**	.862**	.814**	.862**	.969**	.979**	-.965**	1	.948**	.810**
	Sig. (2-tailed)	.048	.003	.004	.001	.000	.003	.008	.003	.000	.000	.000		.000	.008
	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Nitrate	Pearson Correlation	-.553	.949**	.940**	-.984**	.932**	.948**	.927**	.947**	.951**	.974**	-.937**	.948**	1	.915**

	Sig. (2-tailed)	.123	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.001
	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Phosphate	Pearson Correlation	-.174	.994**	.997**	-.924**	.715*	.995**	.994**	.995**	.755*	.814**	-.728*	.810**	.915**	1
	Sig. (2-tailed)	.653	.000	.000	.000	.030	.000	.000	.000	.019	.008	.026	.008	.001	
	N	9	9	9	9	9	9	9	9	9	9	9	9	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 6:

Figure 7: Bedele Brewery Factory effluent discharge point during taking sample from outlet Canal.

Appendix 7:

Figure 8: Bedele Brewery's Sedimentation Tank

Figure 9. Bedele Brewery Main Office Block after immediate Main Entrance.

Figure 10: Bedele Brewery Fountain & beer processing unit tank.

Figure 11: Bedele Brewery beer production & delivering process.