Ethiopian Institute of Architecture, Building Construction and City Development
የኢትዮጵያ አርክቴክቸር፣ ህንፃ ግንባታ እና ከተማ ልማት ተቋም
Addis Ababa University
አዲስ አበባ ዩኒቨርሲቲ

THE RELATIONSHIP BETWEEN URBAN LAND USE INTENSITY AND URBAN RIVER QUALITY; THE CASE STUDY OF BULBULA RIVER

A thesis submitted to the school of Graduate Studies of Addis Ababa University, in partial fulfillment of the requirements for the Degree of Master of Science in urban planning

Student: Tizita Gezahegn

MAY 2024

Addis Ababa, Ethiopia

Declaration

I, undersigned, declare that this thesis is my original work and that it has not been submitted partially; or in full, by any other person for an award of degree in any other university/institution.

Name: Tizita Gezahegn

Signature: ________________

Date: ____________________

Approval

As a member of the Examiners board of the final master's thesis, we have read and evaluated the thesis prepared entitled "The relationship between urban land use intensity and urban river quality; the case of Bulbula River" and recommended to the Ethiopian Institute of Architecture, Building Construction and City Development, Addis Ababa University to accept the thesis for the Fulfillment of Requirements for the award of Degree of Master of Science in Urban Planning.

Board of Examiners

Hayal Desta (PhD)		
Advisor:	Signature	Date
Tibebu Assefa (PhD)		
External Examiner:	Signature	Date
Alazar Assefa (PhD)		
Internal examiner:	Signature	Date
Chair Person:	Signature	Date
Dagnachew Adugna (PhD)		
Graduate Program Director:	Signature	Date

Acknowledgement

First and foremost, I want to thank **God** for guiding me from the beginning to where I am now, and for keeping me positive and strong through all of my ups and downs. My greatest gratitude goes to my big brother **Dr. Befekadu Gezahegn**, who has been there for me from crawling to flying, from nothing to where I am today, and from financing **my** education to advising me to go through this research in every aspect.

I'd want to express my heartfelt gratitude to my advisor, **Dr. Hayal Desta**, for his unending assistance in carrying out the research. I am deeply grateful for his willingness to assist me whenever I needed it, even if it meant disrupting his own duties. This paper would not have been possible without him.

I'd like to thank **Mr. Bereket** for being by my side from the beginning of this study and throughout the data collecting and sampling procedure.

I would like to further extend my acknowledgement to **AAEPA** for the partial research cost cover. Special thanks are extended to **my family**.

Table of Contents

List of Figures

List of Tables

Acronyms

AAEPA	Addis Ababa Environmental Protection Authority
AAS	Atomic Absorption Spectrophotometer
AAWSA	Addis Ababa Water and Sewerage Authority
BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
ECA	Economic Commission for Africa
FEPA	Federal Environmental Protection Authority
mg/l	Milligram per liter
POP	Persistent organic pollutants (POPs)
SPSS	Statistical Package for the Social Sciences
SSA	Sub-Saharan African
TSS	Total suspended solid
UWW	Urban waste water
UNEP	United Nations Environmental Program
WHO	World Health Organization
WWTP	Waste water treatment plant

Abstract

Land use is one feature of an urbanization that can have a big impact on the quality of the surface water. Many urban rivers have been replaced by built-up areas as a result of urbanization and other human endeavors. As a result, the structure and storage capacity deteriorate and the river's density and water surface area decrease. The quantity and quality of fresh water have rapidly decreased in recent years as a result of unsustainable urban land use. Rivers and water reservoirs may be impacted by pollution from both point and non-point sources. The study evaluated the land usage within the Bulbula River watershed and the associated inflow of waste into the river. River pollution is caused by pollutants that push into the river stream from both point and non-point sources. Various laboratory analyses were carried out to evaluate the degree of pollution present in the Bulbula River basin. Three sample locations were used for the dry and wet seasons. However, the study found that, when looking at different land use types, the intensity of the land that is being used has higher contribution for the pollution of urban rivers and renovations to river banks could reduce the amount of pollutants that can enter the river through various channels. Due to the massive amount of debris disposed into the Bulbula River, construction areas, gasoline stations, garages, medical facilities, and congested settlements, the water analysis for the Bullbula River indicated that the stream is significantly contaminated by NO_3, PO_4, N, and TSS.

Key words: - Bulbula River, Urbanization, Land use intensity, River pollution, water Quality

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

The phrase "land use" refers to how people use land. It is a representation of the commercial, industrial, mining, residential, and recreational activities that are carried out in a certain location. Land use changes happen often and on a variety of scales. They can have distinct and combined effects on the quality of the air and water, the functioning of watersheds, the production of waste, the quantity and caliber of wildlife habitat, the climate, and the health of people (EPA, 2023). The physical characteristics of these lands are the outcome of long-term interactions between humans and the natural environment. Land use refers to the anthropogenic usage of lands and their resources. Moreover, the processes of urbanization, industrialization, and agriculture can alter land use, resulting in surface features of watersheds that impact runoff quantity and quality. The relationship between indicators of water quality and land use determines how changes in land use affect the quality of the water (Moriken et.al, 2019).

The acceleration of global urbanization since 1850 reflects, in part, a similar acceleration of global population growth; however, urbanization is more than just a rise in an average degree of human habitation. Although there was no obvious pattern in total urban growth in less developed countries due to varying definitions of urban and a lack of quality in their census data, the developing world's urbanization began to accelerate in the late twentieth century. According to the United Nations, urbanization was high throughout the Americas, as well as most of Europe, parts of western Asia, and Australia in 1995. South America was the most urbanized continent, with the exception of one of its countries (Guyana) having a population that was more urban than rural. One in every three people in Sub-Saharan Africa lived in a city. In Ethiopia, Malawi, Uganda, Burkina Faso, Rwanda, and Burundi, the figure was less than 20%. Cities and towns housed an estimated 40% of China's 1.2 billion population and 29% of India's 0.96 billion (Xizhe et al., 2018). The transition from the twentieth to the twenty-first centuries heralded a new and more visible period of global urbanization. In 2008, the world reached the long-awaited demographic tipping point of 50% of the world's population living in cities. Further acceleration of urbanization is likely to raise the share of the world's urban population to 75 percent by 2050, up from just 10 percent in 1900. (Xizhe et al., 2018).

Pollution is defined as the deliberate introduction of pollutants into the natural environment that results in negative change (Narwaria & kush, 2012). Pollution can be in the form of chemicals or energy, such as noise, heat, or light. Pollutants, or pollutants, are either foreign substances/energies or naturally generated toxins.One of the most serious problems confronting mankind along with other life forms on our planet today is pollution. Pollution of the environment is defined as “the contamination of the physical and biological components of the earth/atmosphere system to such an extent that normal environmental processes are adversely affected.” Pollutants can be substances that occur naturally or energies, but when they exceed natural levels, they are considered pollutants. Any use of resources that are natural at a rate faster than nature's ability to replenish them can lead to pollution of the air, water, and land. There are several types of environmental pollution, including air, water, soil, noise, and light-weight pollution. These have a negative impact on the living system. Pollution's interaction with public health, environmental medicine, and the environment has changed dramatically. (Narwaria & kush, 2012)

Most cities throughout the world are experiencing urbanization. Despite the fact that urbanization brings numerous difficulties and obstacles, many city governments are working hard to alleviate and resolve these issues, as well as to make cities more

Pleasant and comfortable places to live. As a result, the environment in urban areas, particularly in large cities, is fast deteriorating. The rate of consumption of natural resources (e.g., water, energy, fossil fuel, forest products, etc.) is relatively high in metropolitan regions due to high population density and expensive lifestyle. There is also mismanagement of natural resources, for which prompt compensation is difficult. A few acute urban concerns include a lack of potable water, a paucity of forest goods, power outages caused by excessive electrical use, and so on.

The Bulbula River poses a serious risk to both human health and the environment due to its high levels of pollution from trace metals and excess nutrients. Hospitals, densely populated areas, fuel stations, garages, municipal trash, construction debris, and other sources are the main sources of pollution in the Bulbula River. The Bulbula River's water is heavily contaminated (Tilahun, 2007).

1.2 statement of the problem

Rapid urbanization, combined with the growth of industries such as manufacturing, and service, transportation, and construction, resulted in an increase in job prospects for migrating untrained rural labor. The rise in affluence in urban areas has also resulted in a shift in the city's way of life. Urbanization which has emerged as a result of population growth and industrialization brings along lots of problems. Along with such socio-economic effects of urbanization as stress, noise and high rentals, urbanization happens to have some adverse effects on environment. Urbanization and industrialization are dealt with together as fundamental factors causing environmental pollution. Land use is one feature of an urban watershed that can have a big impact on the quality of the surface water. Many urban rivers have been replaced by built-up areas as a result of urbanization and other human endeavors. As a result, the structure and storage capacity deteriorate and the river's density and water surface area decrease. The quantity and quality of fresh water have rapidly decreased in recent years because of unsustainable urban land use. The land use within the watershed has a significant impact on the quality of river water. The watershed's patterns of land cover may change as a result of increased human activity, which could lower river water quality. Therefore, unsustainable land use changes brought about by rapid urbanization result in environmental degradation, including pollution of surface waters.

1.3. Objectives of the study

1.3.1. General objective

To identify the main causes of river pollution in Addis Ababa along the Bulbula River.

1.3.2 Specific objectives

1) To assess the land use intensity and effect on surface water quality
2) To assess the quality of surface water

1.4 Research Question

1) What are the impacts of urban land use intensity on urban river pollution?
2) What is the status of surface water Quality?

1.5. Scope of the Study

The study looked at water contaminants that were discharged into the river from several sources. It includes an examination of the findings from a lab experiment on various river water contaminants. The study concentrated on the water pollutants brought on by escalating urbanization, urban land use intensity and their environmental impacts, both direct and indirect, and how they affect the standard of living for people of Addis Ababa and the vicinity of the river. Although there are several rivers in Addis Ababa, the Bulbula River is chosen due to its great sensitivity to contaminants from gasoline stations, hospitals, domestic waste and industrial discharges. Therefore, uncontrolled development opens the door for the rapid expansion of concrete infrastructure, manufacturing industries, and domestic trash, increasing the volume of untreated discharge to the river and resulting in significant water pollution.

1.6. Significance of the Study

This study added to the body of knowledge by assessing the impact of urban land use to water pollution by taking Bulbula River as a case study and clearly affirm the effects of urban land use intensity on the environment of Addis Ababa city. Since Urbanization is ongoing process one cannot stop the evolution of modernization, therefore, the study described urbanization and its related impact on environment due to its effect on the pollution of water. This paper assessed the water pollution that arises because of the existing rapid urbanization and unsustainable urban land use in the city of Addis

Ababa and its effect on the livelihood activities of the residents in the city. Thus, the study can be proposed to identify a better way for both government policy makers and residents so they can reconcile rapid urbanization with sustainable and comfortable environment in the city of Addis Ababa.

1.7. Limitation of the study

The study is focused on the contamination of the Bulbula river stream caused by rapid and unregulated urbanization and the effect of land use intensity along the river. Due to the scarcity and difficulty of laboratory equipment, the study is confined to a more in-depth analysis of metal contaminants discharged into the Bulbula River from various sources. Furthermore, due to the lack of documented data for previous EPA study, comparing pollution levels from the past and present was impossible.

1.8. Organization of the document

The study's documentation is divided into five chapters. The first chapter covers the study's introduction and background. It discussed the study's scope, limitations, and significance. The second chapter is a survey of the documents connected to the study's literature. The third chapter organized the study's methodologies, covering the type of data used and data gathering. The fourth chapter discusses the analytical result based on the acquired data. The final portion contains the drawn conclusion and recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1 Urbanization and land use intensity

The term "urbanization" refers to the overall rise in population and the extent to which a town has been industrialized. It entails a boost in the amount and size of cities. It represents the migration of people from rural to urban places. An increase in the dimensions and population density of urban areas causes urbanization. Urbanization is the movement of people from rural to urban locations, "the gradual increase in the proportion of people living in urban areas," and how each community responds to change—the transition of a society from a country to an urban way of life. By 2050, it is expected that 64% of Africa and Asia and 86% of the developed world will be urbanized (Earth: Urbanization). Notably, the United Nations recently forecast that cities will absorb nearly all global population expansion from 2017 to 2030, absorbing around 1.1 billion more city dwellers during the next 13 years (Sanyaolu, 2018).

Changes in land use, building, and structure all have an effect on the urban environment when it comes to urban public space design. The ecosystem surrounding urban surface water is altered by land utilization in a variety of ways. A few factors in the development of urban public spaces, such as changes in land use, land structure, and construction on land, have a particular impact on the urban environment (Baojie Lei et.al, 2022).

Over the past few decades, there has been a fast increase in urbanization worldwide due to urban land sprawl and rural-urban migration. Cities face enormous challenges as a result of growing populations and such urban spatial changes. The term "urban land use intensity" is frequently used in land use management, landscape analysis, and urban planning and design. It describes the level of land development in metropolitan regions (Chang Xia et.al, 2020).

2.2 Rivers and Urban land use

River water quality is greatly impacted by the land use within the watershed. As human activity increases, the patterns of land cover within the watershed may alter, potentially leading to a decline in the quality of the water in rivers. The main elements impacting the hydrological system's alteration, which in turn affects runoff and water quality, have been identified as changes in land cover and land management techniques (Juan Huang et.al, 2013).

Land use has changed significantly as a result of the rapid urbanization process and the unchecked expansion of metropolitan limits, drawing attention to the effects of natural resources, particularly the amount and quality of water resources. Changes in land use have the tendency to exacerbate non-point source contaminants in the watershed by strengthening soil erosion and having an impact on all the hydrological cycle's connections. The level of water contaminants is positively connected with land usage related to economic conditions and human activities. Natural woods and other undeveloped regions have higher-quality water. Nonetheless, not all land use types have the same effects on water quality (Dechao et.al, 2020).

Historical patterns of urban expansion have tended to undermine the very environmental resources necessary for their establishment, growth, and distinctive character. Some of the numerous ecosystem functions that have been lost or damaged can be recovered through well-planned urban river restoration. According to case studies, this can give tangible benefits to human well-being, such as health, economic worth, quality of life, and helping to regional regeneration. Furthermore, considering potential impacts on ecosystem services when planning river management or urban projects that touch rivers can assist in averting or minimizing and potentially establishing appropriate remedies for damage to critical and socially useful river functions. This is especially true given the growing consensus about the importance of ecosystem services in addressing a wide range of sustainability challenges, including land use planning, agriculture and forestry, carbon and microclimate management, fisheries, watersheds, biodiversity, and tourism management (OECD 2010). Given the present state of resource-degrading practices and their consequences for human well-being, as demonstrated by the Millennium Ecosystem Assessment (2005), ecosystem societal benefits mustn't be restored in existing urban infrastructure and centrally considered in future development planning (Mark & Helen, 2012).

The majority of communities formed on river banks, illustrating their historical significance and utility for human settlements. Over time, rivers functioned not only as a source of water for the population and irrigated farmland, but also as a primary mode of communication between areas, as pathways for people to traverse, and as a means of trade and movement of commodities. Rivers, however, have deteriorated due to urbanization to the point where they no longer provide the socioeconomic benefits that permitted health villages to exist. As a result, urban river restoration has become increasingly popular in recent years River and lake restoration benefits both flood control and ecological services while also increasing recreational value and urban quality of life. However, economic developments, modes of communication and transportation, the direction of urban growth processes, urban policies and planning, and resident behavior all have an impact on river-city interaction (Nicoli, 2022).

Rivers have played an essential role in establishing and growing vernacular towns and cities. Rivers were often overlooked, canalized, or even disappeared under culverts as industrial cities grew. However, as industry has moved out from city centers, rivers have become cleaner, less stinky, and less unattractive. River corridors are now considered as an amenity that provides access to nature and recreational opportunities. They contribute significantly to the provision of vital ecosystem services through potentially rich riverine ecosystems and their amenity qualities (Pattacini, 2021). Rivers are natural geographical restrictions that provide a significant infrastructure for urban development. Alexander emphasizes the significance of treating natural sources of water with care in urban environments, arguing that "always preserve a belt of common land, immediately beside the water." River corridors cannot be studied in isolation; they are inextricably linked to the surrounding urban forms and have an impact on urban development patterns. They are linked to constructing and expanding cities "macroforms,' such as key transportation axes and open space infrastructure. Rivers form sharp lines and have been defined as 'undulating linear bands of public space between sections of streets and building blocks': a barrier between two stages of development. They are sometimes referred to as an edge or urban vacuum type of area since they are the last remaining paths where man can re-establish his right to access and enjoyment (Pattacini, 2021).

2.3 Land use and Environmental Pollution

2.3.1 Environmental pollution

Toxins introduced into the natural systems of the environment cause pollution, which has an adverse effect. Pollutants can be chemical or energy substances, such as sound, heat, or light. Pollutants are the ingredients of pollution that include naturally occurring contaminants and imported substances/energies. Environmental pollution is one of the most severe challenges now harming humans and other living forms on our planet. Environmental pollution is defined as "The contamination of the physical and biological components of the earth/atmosphere system to such an extent that normal environmental processes are adversely affected" (Narwaria & kush, 2012). Pollutants can be substances that occur naturally or energy, but when they exceed natural levels, they are considered pollutants. Any use of natural resources at a rate faster than nature's ability to replenish them can lead to pollution of the air, water, and land.

There are several types of environmental pollution, including air, water, soil, noise, and light-weight pollution. These have a negative impact on the living system. Pollution's interaction with the general public, environmental medicine, and the environment has changed dramatically (Narwaria & kush, 2012).

Most of the twenty-first century's critical environmental concerns will undoubtedly be created by the continuation and escalation of current crises that are currently receiving insufficient political attention. In many countries, the concerns may go unnoticed, or they may be acknowledged, but absolutely nothing is done. The most recent issues are climate change, freshwater scarcity, deforestation, pollution, and population increase. These issues are exceedingly complex, and determining how they interact is difficult. It is critical to examine challenges through the prism of the social, economic, and cultural systems. Even if the connections between environmental challenges are becoming increasingly clear, we still lack a detailed understanding of how the problems are related, how they interact, and what the best remedies are. One difficulty is integrating land- and water-use planning to ensure food and water security.

Currently, there is a paucity of information on ecosystem services in urban areas, and there is a need to expand the knowledge basis for land-use planning. There are significant knowledge gaps about how all services were created. The spatial and temporal scales at which individuals benefit shifts in service production through time and feedback loops between ecosystem service usage and output. We also need to learn more about the synergies and antagonistic interactions between the production and consumption of diverse service benefits, including the effects of different types of recreation on biodiversity. While many of these elements are being investigated in the

UK National Ecosystem Assessment, a number of biophysical, social, and economic issues must yet be addressed (Mark & Helen, 2012).

The escalation of environmental issues is mostly attributed to factors such as rapid population growth, urbanization, metropolitanization, technological advancements, industrialization, and an increase in the number and improvement of automobiles. In both developing and established nations, these behaviors stand out as the root causes. Among the serious environmental issues are pollution of the water, air, and soil, as well as noise pollution and pollution brought on by industrial facilities. Numerous issues are brought about by urbanization, metropolitanization, urbanization that has arisen as a result of pollution increase, and urbanization that has resulted from industrialization. Urbanization has certain negative environmental repercussions in addition to socioeconomic effects like stress, noise, and expensive rent. Together, urbanization and industrialization are discussed as the primary causes of environmental degradation.

Environmental deterioration has been happening quickly in Ethiopia due to unchecked development, leading to several issues, such as land insecurity, declining water quality, excessive air pollution, noise, and issues with garbage management.

2.3.2. Urban Land use intensity and environmental problems

Historically, land use changes due to urbanization was primarily investigated as a potential environmental danger that would result in soil, water, air, and forest deterioration, as well as biodiversity loss. By the beginning of the twenty-first century, the adverse ecological state of metropolitan areas had been observed. Human-modified and often artificial landscapes with significant anthropogenic disruptions (e.g., environmental contamination, soil sealing, trash disposal) characterize metropolitan ecosystems. Cities generally consume far more energy than they produce, resulting in heat, (airborne and waterborne) pollutants, and greenhouse gas emissions (Viacheslav et al., 2018).

The primary causes of this problem are the sheer quantity of the metropolitan population, the haphazard and unregulated growth of urban regions, and a serious lack of infrastructure. Housing, sanitation, transportation, water, power, health, education, and other public amenities are under severe strain as a result of the metropolitan population's fast increase, both naturally and through migration. Among rural immigrants, poverty, unemployment, underemployment, beggary, thievery, dacoits, burglaries, and other social ills are rampant. The valuable agricultural land is being progressively encroached upon by urban sprawl. All of this increase will have a significant negative impact on the environment, quality of life, and available space. The development of the infrastructure needed to support such dense population growth is well behind the rate of urbanization. As a result, the urban environment, especially in big cities, is fast declining. Here are some significant environmental issues.

A. Over Exploitation of Natural Resources The rate of consumption of natural resources (e.g., water, energy, fossil fuel, forest products, etc.) is relatively high in metropolitan regions due to high population density and expensive lifestyle. There is also mismanagement of natural resources, for which prompt compensation is difficult. A few significant challenges of metropolitan regions include a lack of drinking water, particularly ground water, a shortage of forest products, power outages caused by excessive electrical use, and so on.

B. Air Pollution Many anthropogenic activities, such as the transport of a large number of automobiles, industries, and so on, pollute the air in urban areas. These activities emit pollutants such as carbon monoxide, carbon dioxide, oxides of nitrogen, oxides of sulfur, hydrocarbons, vapors of organic compounds, particulates, and toxic metals, among others, which can pose a multitude of health risks.

C. Noise Pollution Noise pollution in metropolitan areas is caused by autos, vehicles, social functions, industries, and other sources of noise, which causes psychological and bodily problems.

D. Unusual Rise in Temperature The uncontrolled development of huge buildings in metropolitan areas absorbs solar energy and emits heat radiations in the afternoon, raising climatic pressure. As a result, 2015 was the hottest year in recent memory. Because dust can cause the condensation of water vapor into rain drops, cities frequently get more rain than the surrounding countryside.

E. Management of Solid Waste A densely populated urban region produces a lot of solid trash while concurrently using a lot of material. Municipal wastes, industrial wastes, hazardous wastes, etc. are all examples of solid wastes. With an increase in population comes a rise in the creation of solid waste, which emits toxic fumes and bad odors and serves as a breeding ground for disease vectors. The gases generated contribute to air pollution, surface runoff from wastes contributes to water contamination, and several diseases are spread by vectors.

F. Development of Slums Slums are sections of cities and towns that lack essential services and public facilities. Due to a lack of housing options and the un-flux of rural residents into urban regions, slum settlements develop. Rusted tins, empty tar barrels, jute sacks, and other materials are used to build their homes. These places tend to be populous but lack basic services including electricity, water, drainage, roads, restrooms, and medical facilities. Slum neighborhoods become the focal points of a lot of environmental issues. The following are a few noteworthy issues: (i) Because there is insufficient access to clean water, these areas dispose of their trash in a haphazard way that pollutes the air and water. (ii) The typhoid, cholera, enteric fever, and other diseases are brought on by contaminated water. (iii) Unplanned waste disposal facilities and open defecation areas generate breeding grounds for a variety of disease-carrying insects like flies and mosquitoes. These provide health risks not only in surrounding slum areas but also in distant locations (Rai, 2017).

2.4. Urban River pollutions

2.4.1 Water pollution

Water pollution is the contamination of any water source, including rivers, ponds, lakes, and other bodies of water, around the world. It is the addition of things to water in an amount as to change its natural character and hence lessen its utility. Pure or natural water lacks any flavors, colors, and odors. Any water that tastes bad, smells bad, or is cloudy is polluted. Thus, the presence of physical, chemical, or biological contaminants that change the quality of water and have the potential to endanger living things is what is meant by "water pollution" (Wambebe & Xiaoli , 2021).

Due to the flow characteristics of river water, river ecology is more susceptible to external pollution. Additionally, pollution has the potential to spread throughout the river basin once it has begun quickly. Due to the rapid growth of the urban economy, the rapid rise in population, the deepening industrialization, the rise in urban consumption of water and river pollution discharge, the river's self-purification, and the ecological compensation of the declining ability, the quality of water has significantly declined in recent years.

Consuming water helps people stay hydrated, nourish themselves, and maintain good hygiene. The result is wastewater. Their occurrence brings up the requirement for their disposal. Typically, the creation of systems acquisition and wastewater collection is anticipated in urban development through urbanistic plans. Their treatment, or an effort to improve their quality so that they can be released into a natural receiver, takes place at the location of the collection. The man uses numerous generating resources from waste products from his work in order to survive. Whether for residential, industrial, or urban usage, the utilization of water resources results in various types of wastewater. All interested parties, including the government, local communities, users, operators, and non-governmental organizations (NGOs), are accountable for the integrated management of water resources, which serves as a practical means of achieving sustainable development in the water sector, including wastewater management. (Iacoba, 2013).

Point and diffuse source pollution include biodegradable organic material, metals and nutrients. These result in changes in physico-chemical characteristics of rivers, in particular temperature, inorganic and organic suspended solids, nutrients, dissolved oxygen, biochemical oxygen demand (BOD), conductivity and ph. Levels of trace metals can increase as a result of pollution. Changes in discharge and water velocity can also be due to human impact (Maryna et.al , 2021).

Due to increasing urbanization, human activities have had a considerable negative impact on the ecological environment. The influence is particularly pronounced in the water quality in these places as a result of the massive discharge of municipal wastewater and urban drainage into river basins. This in turn has an impact on the agriculture and aquatic life in the area, as well as the people that live there. It is difficult for any nation to pursue sustainable growth without harming the environment. For instance, it is difficult to prevent difficulties that might quickly deteriorate and degrade the water quality at the intake locations for water supplies. Additionally, cost-effective techniques are more practical for poorer nations to safeguard their natural resources. Flat areas of many countries frequently see rapid urbanization-related population increase, making the flat river bottoms more vulnerable to damage.

2.4.2 River pollution today

Physical growth of urban areas comes as a result of people moving from rural to urban areas, which eventually leads to urbanization. River basins around the world are changing as a result of anthropogenic pressures such as urbanization, industrialization, and population growth. Any natural system, such as a river basin, is elegant in its own right. The quality of the natural river basin environment is declining due to over-urbanization and poor resource management. Urbanization is connected with changes in land use, deterioration of river water quality, increased flooding, and disruption of the natural river basin ecology (Satyavati et.al, 2013).

River pollution is already a serious problem in North America, South-East Asia, and Europe. We estimate that in these areas, several rivers in 2010 received high inputs of N (>50 kg km-2 year-1), P (>30 kg km-2 year-1), triclosan (>10 g km-2 year-1), microplastics (>5 kg km-2 year-1), and Cryptosporidium (>100 1017 oocysts km-2 year-1). These areas (South-East Asian countries) have major issues with water pollution, which has a negative influence on eutrophication and waterborne infections. Pollution levels in African sub-basins are lower than they are in those areas. However, there are already some indications of the effects of dirty water on children's health. In 2010, triclosan, 0.72 kton, microplastics, 9.5 Tg of nitrogen, 1.6 Tg of phosphorus, 1.6 1017 oocysts of cryptosporidium, and 0.45 Tg of microplastics entered rivers worldwide. These inputs go to South-East Asian rivers in greater than half of the cases. River pollution is primarily caused by sewage systems. The exceptions are a few sub-basins in South-East Asia and Africa where open defecation contributes more than 20% of the N, P, and Cryptosporidium that rivers in those regions receive. Similar worldwide estimates are revealed by existing analyses, albeit at different spatial scales. Our uniform spatial and temporal scales strengthen our comparisons of various contaminants around the globe (Maryna et.al , 2021).

High population density, the creation of toxins in human waste, and the effectiveness of wastewater treatment in various nations all contribute to high pollution levels. High population densities in South-East Asia are the cause of the region's high pollution levels. On 12% of the world's surface, this area houses about half of the world's inhabitants. Comparatively, on 20% of the world's surface, sub-basins of Europe (excluding Russia) and North America house about 10% of the world's population, or

0.8 billion people. In 2010, 20% of the entire population was connected to sewer systems with just 50% or less of the majority of contaminants being removed from the wastewater. The high rates of sewage system connections, particularly in urban areas, are the primary cause of the high pollution levels per km2 of subbasins in Europe and North America. In this country, more than two thirds of the people reside in urban areas and are primarily connected to sewer systems with removal efficiency of more than 50% for the pollutants under study.

2.4.3 River pollution globally

Approximately 80% of the world's population is anticipated to reside in sub-basins with several pollution issues in the future. Over half of the world's surface area is covered by these sub-basins, where pollutant imports will rise by at least 30% between 2010 and 2050 or 2100. All scenarios except $High_{urb}$-$High_{wwt}$ fall under this. Global inputs of the majority of pollutants will less than double between 2010 and 2050 under the Low_{urb}-Low_{wwt} scenario, which assumes low urbanization and low wastewater treatment. According to this scenario, population growth will be rapid between 2010 and 2100, nearly doubling. The world's population will be connected to sewer systems to the tune of one-third. In comparison to other 2100 scenarios, this amount is significantly smaller. In the Low_{urb}-Low_{wwt} scenario, projected inputs of pollutants to rivers from sewage are lower than in the other scenarios as a result of the low sewer connection and low wastewater treatment. In contrast to the other scenarios, more nutrients and Cryptosporidium are anticipated to enter rivers as a result of open defecation, mostly in developing nations.

The scenarios with moderate (Mod_{urb}-Mod_{wwt}) and high urbanization ($High_{urb}$-Low_{wwt}, $High_{urb}$-Mod_{wwt}) are expected to have larger future inputs of the majority of pollutants into waterways. Even while population growth is slower than in the Low_{urb}-Low_{wwt} scenario in the $High_{urb}$-Low_{wwt} and $High_{urb}$-Mod_{wwt} scenarios, respectively, the rate of urbanization is substantially higher. In 2100, it is anticipated that more than two-thirds of the world's population will be connected to sewage systems. Depending on the level of economic growth, wastewater treatment efficiency is slightly enhanced (Mod_{urb}-Mod_{wwt}, $High_{urb}$-Mod_{wwt}). Overall, compared to the Low_{urb}-Low_{wwt} and Mod_{urb}-Mod_{wwt} scenarios, the $High_{urb}$-Low_{wwt} and $High_{urb}$-Mod_{wwt} scenarios estimate larger inputs of the majority of pollutants to rivers (Maryna et.al , 2021).

2.4.4 River pollution in Africa

Africa as a continent looks to have ample amount of water; it has huge wetlands, more than 160 lakes greater than 27 km^2, 17 rivers, each with catchments above 100,000 km2, and limited but widespread groundwater. Africa experiences an abundance of rainfall, with its annual average amount of precipitation being on par with that of Europe and North America.9 Estimates place the yearly withdrawals of water for Africa's three primary uses—agriculture, domestic usage, and industry—at a meager 3.8%. There are areas of the world where coverage has to be improved, especially in Africa. A troubling picture is emerging where water quality is being measured. Numerous significant water bodies, which provide thousands of local residents with water for drinking, washing, and irrigation, are exhibiting unsafe amounts of possibly harmful contaminants. These include biological toxins, persistent organic pollutants (POPs), and heavy metals. Numerous sources, including regional industries and home waste water, are the source of these pollutants. It is obvious that protecting water quality and putting preventative policies and practices in place will be challenging without improved monitoring (WWD, 2010).

The world is also confronting a water quality crisis as a result of severe and increasing water contamination in both developed and developing countries. There is an abundance of water resources in Africa, yet there is a scarcity of high-quality water. This is a major threat to health, food security, biodiversity, and overall well-being. One-third of river sections in Africa, America, and Asia are already affected by severe pathogen and salt pollution. Groundwater supplies 75% of Africa's drinking water, which is frequently used with little or no filtration. While the region's population has more than doubled in recent years, access to safe drinking water has not improved. It has been discovered that environmental variables such as contaminated water and air pollution cause 28% of Africa's illness burden. Cholera, typhoid, ascariasis, and diarrhea are all diseases caused by ingesting dirty water contaminated with protozoa, parasites, bacteria, viruses, fecal matter, and inadequate sanitation. Humans and animals are exposed to heavy metal poisoning through the food chain or drinking metal-contaminated water. Eye pain, nose, and skin irritations, intense headaches, nausea, vomiting, dizziness, organ dysfunction, and gastrointestinal upset are just a few of the many health symptoms of heavy metal toxicity (Wambebe & Xiaoli , 2021).

Early research on water quality in Sub-Saharan African (SSA) cities mostly stems from concern over the availability of urban water supplies. It has also been investigated how many nutrients are present in urban rivers around some SSA cities. The uncontrolled sewage outflow makes it difficult to evaluate the nutrient loading from urban activity in the majority of cases. Because the sewage treatment facilities in megacities are so inadequate and outdated, a significant proportion of sewage is discharged directly without being treated. In Dar es Salaam, for instance, the oxidation ponds constructed in the late 1950s are still in use, and just 15% of the city's citizens have access to the sewage system (Ismael et al., 2022).

2.4.5 River pollution in Ethiopia

One of Africa's fastest-growing populations is in Ethiopia. In 2015, there were 19 million people living in urban areas, with 4 million of them residing in the nation's capital, Addis Abeba. Ethiopia's urban population is projected to grow to 37 million people by 2030 (UN, 2018). The emergence of industry coincides with the growth of population (Malin & Jonathan , 2019). The contamination of Addis Ababa Rivers is caused by both solid and liquid trash created by the above stated sources. Despite being the sole city having sewer networks, Addis Abeba has a very limited sewer network coverage that accounts for 7.5% of the built-up areas. Because only parts of the city's older areas are connected to the central sewer system, both residential and commercial properties use septic tanks. The city authority is currently working to control and treat the river in Addis Abeba, including a recent massive river and waterfront development project and a few private sectors. However, these efforts are limited and do not address the city's overall pollution problem (Yonannes & Elias, 2017).

Unrestrained urbanization and poor sanitary infrastructure in Ethiopia are significant contributors to the substantial degradation of surface water quality. The majority (more than 40%) of large and medium-scale manufacturing businesses are located in Addis Abeba city and its surrounding areas, where water contamination from the dumping of industrial effluent is now a worry for the environment. As a result, numerous rivers and streams that pass through significant cities and towns are highly polluted. Point sources, such as wastewater treatment facilities and single-source industrial discharges, can release pollutants into surface waters. The majority of pollutants, however, come from non-point source polluting activities, such as runoff from cultivated land, urban areas, industrial and construction sites, and malfunctioning septic tanks. Because of this, environmental groups, institutions, the impacted community, and many academics have expressed alarm over the pollution of the Addis Abeba rivers, particularly the Akaki River.

2.4.6 River pollution in Addis Ababa

There are currently more than 2,000 enterprises in Addis Abeba, and almost 90% of them discharge their effluents into the river network untreated (Yonannes & Elias, 2017). For the past 60 years, urban farmers in Addis Abeba have grown vegetables with the Akaki river serving as their primary irrigation water source. Today, river water is used to irrigate almost 60% of the city's vegetable crops. In accordance with Weldetsadik, Drehsel, Keraita, Itanna, and Gebrekidan (2018) The city of Addis Abeba is experiencing severe surface water contamination as a result of rising population, urban farming, growing industries, and a lack of sewage treatment (Yonannes & Elias, 2017). It is crucial to address the pollution issue and launch mitigation procedures in order to create sustainable conditions in the surface water and lower threats to human health. It is vital to build management systems and conduct environmental research (Malin & Jonathan , 2019).

Today's rivers, which are present throughout the majority of Ethiopia, including Addis Abeba city, are extremely contaminated, mostly as a result of a lack of effective industrial waste management systems, increases in the urban human population, growth of urbanization, and a lack of sanitary infrastructure facilities. The water quality of the city's rivers in Addis Abeba was occasionally alarmingly deteriorating, and the major sources of pollution there were waste from people living near the rivers and away from them, industries, hospitals (both point and non-point sources), and macro and micro sectors of the city.

Even though Addis Ababa city, Ethiopia, strives for sustainable development (SD), the city's waterways are severely polluted, which has detrimental effects on the city's ecology and socioeconomic situation. The main causes of the city's waterways being polluted include industrialization, rapid urbanization, population increase, and informal settlements, which helped to generate a significant amount of industrial and domestic effluents. Other anthropogenic activities including farming, the careless and unplanned disposal of municipal, hospital, and garage wastes, inadequate sewage treatment systems, and environmental degradation in both the city and the surrounding countryside all contribute to the pollution of the waterways. All of these elements played a part in the vicious cycle that resulted in river pollution, environmental damage, water-borne illnesses, and poverty. In general, this article examines the major causes of river pollution, its effects, and its main sources. difficulties, and eventually offers a potential fix for reducing them. The essay further contends that in the Addis Ababa City River's sources of water pollution and address some of the effects on the with the goal of increased biodiversity and improved health for the riverine ecosystem and its inhabitants, multi-stakeholder activities are essential. Riverine habitats, enhanced Addis Abeba river basin water quality, and a better environment for locals the town.

2.5. Major Sources of river pollution

Rivers and water reservoirs may be impacted by pollution from both point and non-point sources. For example, a factory, which typically has a pipe or channel coming from it, is an example of a point source a recognized location that discharges directly into a body of surface water. Groundwater is also affected by point sources, which are places where pollutants seep into the soil and rock from a specific source, such as pit latrines, septic systems, or underground fuel tanks. Point sources include, for instance, pipes used for municipal and industrial discharge. Non-point or diffuse sources are those where pollution spreads over a wide area; it is frequently difficult to pinpoint the exact spot of origin as well as difficult to manage and control. For instance, widely used pesticides or fertilizers may seep into nearby groundwater or be washed by rain from a field into a river or stream. Other examples include mining, urban and industrial runoff, and erosion linked to buildings. The harmful sediments, fertilizers, bacteria, organic wastes, chemicals, and metals that result from these operations contaminate surface waters.

Many constituents and contaminants from diffuse and point sources are found in wastewater. Large point sources are easily quantifiable since they are the product of specific activities in the area that are linked to UWW collecting systems. Small point sources, such as homes and small businesses, are much harder to locate and measure than point sources that are frequently managed. Additionally, illegal pollution discharges are common at UWW.

2.5.1 Point sources

Industrial wastes

Water pollution is a major global issue that involves the release of dissolved or suspended pollutants into groundwater, streams, rivers, and oceans. In developing nations, manufacturing processes are a significant contributor to pollution, which has made waste disposal an even bigger issue. Increased industrial activity has led to an increase in surface water contamination from commercial, residential, and agricultural sources. The beverage industries were noted as significant global economic contributors and large water consumers. Despite the fact that beer contains 95% water, much more water is consumed to create a container of beer than is actually in the beer when it is packaged and sent to the consumer. The creation and management of wastewater in the beverage sector now poses a serious threat to freshwater ecosystems, aquatic life, and public health. Continuous emission of effluents into rivers and streams causes levels of dangerous and trace metals to rise, which has a detrimental effect on freshwater bodies. Due to the lack of adequate waste water treatment infrastructure, the beverage industry generates a significant amount of wastewater in the majority of developing countries, particularly in Africa. A similar situation exists in Ethiopia. In Addis Ababa, there are about 2500 businesses, 90% of which lack on-site waste water treatment facilities, according to an AAEPA investigation. These companies empty their rubbish into nearby ditches and stream channels (Abrha & Chen, 2017).

Waste produced by industrial processes like manufacturing, fabrication, construction, chemical plants, and other processes is referred to as industrial waste. They are among the dangerous toxins that pollute the environment and water supplies. The fast industrialization in Ethiopia has resulted in the production of hazardous industrial wastes. However, very little is known about these wastes and how they affect people and the environment.

As it promotes financial stability and human well-being, industrialization serves as the foundation for development. Global environmental degradation and ecosystem damage are caused by the expanding industrial activity, nevertheless. Like other cities in developing nations, Addis Ababa is one of the key towns in Ethiopia where industrialization has grown significantly. Addis Ababa is home to the majority (more than 65%) of Ethiopia's medium and large-scale industry.

Addis Ababa is one of the key cities in Ethiopia where industrialization has dramatically increased, much like other cities in emerging nations. More than 65% of Ethiopia's medium- and large-scale enterprises are found in Addis Ababa. In addition to their adverse effects on the environment, industrial wastes also have an impact on human welfare. For instance, rising industrial waste leads to pollution stress on surface water (Osibanjo & Ajayi, 1981). When local sources dry up or become contaminated, this in turn affects how communities can get access to clean water. Additionally, it leads to inadequate sanitization services and poor water supply coverage. Utilizing contaminated river water for agriculture and other purposes exposes downstream communities to a variety of socioeconomic issues (Abrha & Chen, 2017). This is true of the rivers in and around Addis Ababa, where the inhabitants who depend on these water supplies are suffering due to the dumping of untreated industrial wastewater into these rivers (Teklehaimanot.R, 2005). Solid waste from industry are generated by a variety of industrial-based operations. They are released during the various production steps. These wastes can be corrosive (able to corrode metal containers like tanks), ignitable (able to start fires), reactive (naturally unstable and capable of exploding and releasing hazardous gases when heated), toxic (damaging or fatal when swallowed or absorbed), and noxious.Solid industrial waste management has become a significant concern in many developing nations (Abebe, 2018). This is also the case in Ethiopia, where industrialization and rising urban populations put strain on the ability to handle the country's steadily growing amounts of solid garbage (Timar & Milkiyas , 2019).

More than 65% of industries are located in the metropolitan area of Addis Abeba. However, the majority of the industries in Addis Abeba have their own distinct effects on the economy, the environment, and the health of people and animals. The most prevalent visual issues in the majority of the city's roadside drains are improper dampening of domestic wastes and sewage odor. The majority of the rivers and reservoirs in the city's main industrial zones are overly polluted as a result of these serious environmental health issues, which have a negative impact on people's quality of life, the city's appeal to foreign investors, and the competitiveness of the tourism sector.

Due to the vast amounts of water required in their manufacturing processes, many companies, like those that produce steel and paper, are situated along river banks. As a result, waste from these enterprises that contain acids, alkalies, dyes, and other chemicals is eventually dumped and discharged into rivers as effluents. Fluoride is widely released into the atmosphere by chemical companies that produce aluminum through emissions and effluents into water sources. Steel mills produce cyanide, while fertilizer businesses produce a lot of ammonia. In industrial procedures, chromium salts are used to make sodium chromate and other chromium-containing compounds. All of these wastes eventually become effluents and enter aquatic bodies, where they have an adverse effect on both human health and the species that dwell there (Gupta, 2016).

Municipal wastes

Due to the increasing pollution loads being introduced to waters from many sources, human activities can have a substantial impact on the quality of the surface waters (Meghdad et al., 2013). Due to the high concentrations of nutrients and organics in untreated municipal wastewater, it is thought to be the point source that poses the greatest threat to aquatic ecosystems. Modern wastewater treatment plants (WWTPs) are able to ensure wastewater discharge limits regarding biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, nitrogen (N), and phosphorus (P) loads set by legal regulations in nearly every country. Currently, municipal wastewater in developed countries undergoes advanced nutrient removal processes carried out in WWTPs. Numerous researches have examined the impact evaluation of metals and pesticides on agricultural and human health in relation to the consequences of untreated wastewater discharge (Preisner, 2020).

Large-scale municipal wastewater and urban drainage discharge into river basins is mostly to blame for the high average annual range in biochemical oxygen demand (BOD), total coliform (TC), and low dissolved oxygen (DO) levels reported in rivers in several South Asian countries. Furthermore, several studies have revealed that untreated sewage is the most serious source of water contamination because 40% of the world's population lacks access to basic sanitary facilities. Water quality and water

balance are altered by human-caused changes to land use, land cover, or river basins in watershed areas, such as extensive agricultural operations, haphazard infrastructure development, and sand mining. affecting the river basin's water quality directly (Chamara P. & Koichi , 2017).
Municipal wastewater contributes as much to water pollution as industrial waste. A century ago, most municipal discharges had no treatment at all. Since then, both the population and the pollution caused by municipal discharge have grown.

Addis Abeba has sufficient waste management facilities while producing significant volumes of solid waste as a result of residential activities. As a result, solid garbage is frequently placed on accessible open space, the banks of streams, and in close proximity to bridges, where it is washed into rivers. According to the 2014 Ethiopia Mini Demographic and Health Survey (EMDHS), only 4.5% of the population had access to a flush toilet or an improved pit latrine. And pit latrines are used in 65% of the societies. 25% of homes in the city lack toilets. As a result, the locals relieve themselves in the river. Additionally, homes that are constructed alongside the city's waterways have direct access to them through their toilets. As a result, river contamination is getting worse over time. As a result, there are no aquatic animals or vegetation in the city's rivers (aquatic diversity). Additionally, the majority of residential buildings, businesses, and organizations that provide services have untreated direct connections between their septic tanks and latrines with major rivers.

The primary cause of water pollution in Addis Abeba City is domestic or household garbage, which is produced from daily activities. When compared to other Ethiopian cities, Addis Ababa's population is rising at an alarming rate, which has led to a growth in domestic and residential garbage. It is believed that between 40 and 60 percent of the country's rural residents migrate to urban areas. Due to the lack of well-organized management facilities, the enormous amount of solid wastes (such as organic wastes, plastics, and papers) produced by domestic activities in the city are typically dumped in open areas, along stream banks, next to bridges, and in close proximity to residential areas before being washed into rivers. Gray water from kitchens and bathrooms, domestic liquid waste from overflowing and seeping pit latrines, septic systems, public and communal toilets, open ground excreta defection, and liquid waste from different drainage lines all discharge into the Addis Ababa River, particularly the big and small

Akaki River. Due to poor management, Addis Abeba produces daily residential wastes from toilets and kitchens that are about comparable to 100,000 m^3 in size (Worku & Giweta , 2018).

More than 2,000 industries, or 65% of all industries in the nation, are located in Addis Abeba. The bulk of these businesses release their effluents straight into the river from locations along the riverbanks, especially in the western and southern areas of the city. Up to 90% of these industries don't have any sort of treatment facility, therefore they release their solid, liquid, and gaseous wastes into the environment untreated. Others dump effluent into adjacent streams and have some sort of on-site treatment facility. The waterways of Addis Abeba have been poisoned with heavy metals as a result of numerous industrial wastes. As a result, it is a common practice in Addis Abeba to dispose of hazardous materials, including solid and liquid waste, in rivers and riverbanks (Yonannes & Elias, 2017).

Medical waste

Numerous types of liquid, solid, and gaseous waste are produced in significant amounts by healthcare facilities. Medical waste is regarded as a type of hazardous waste because, if improperly managed, it can have a detrimental effect on society, the public health, and the staff members of healthcare facilities. Perhaps the lack of appropriate knowledge about the significance of medical waste, which has resulted in improper implementation of waste management systems, especially in the countries of the Third World, is what makes it more difficult and complicated (Awad & Firas , 2018).

First, it's important to define medical waste and what it can include. Medical waste is defined by the World Health Organization as garbage produced by healthcare operations. According to the World Health Organization (WHO), public waste includes household garbage accounts for 80% of total waste from health care activities, with hazardous substances that may be radioactive or toxic accounting for 20%. There are two categories of medical waste. The first category is nonhazardous organic waste, which includes regular food and soil waste from public spaces like hospital lobbies, and the second category is toxic chemical and biological waste. Syringes, various laboratory instruments, rolls, and other trash from operating rooms and laboratories are among these, as well as human organs. 95 percent of these hazardous wastes are infectious waste, including patient contact with blood, infected equipment (especially sharp objects), and sheets, towels, and other body fluids. Prior to burning or disposing of infectious waste (from patients with active illnesses), sterilization is advised. The 5% of hazardous waste is made up of a variety of items, including severed organs, medications, organic solvents, and cleaning sterilizers. The most dangerous are tissue-damaging compounds, heavy metals such as mercury, arsenic, and lead, as well as radioactive materials, which are regarded as the most toxic materials utilized in medicine (Abrha & Chen, 2017).

The waterways in and surrounding Addis Abeba city are being contaminated by clinical wastes, which is also causing the water quality to decline. The remaining 75%–90% of wastes are made up of non-clinical wastes, with medical centers producing only 10%–25% of the overall wastes. For instance, 29 hospitals in Addis Abeba City produce 430.7 tons of infectious trash each year. The primary hospital wastes are pathological wastes, including placenta, body parts, blood, and human fetuses, as well as infectious wastes including human excrement, laboratory cultures, tissues, and clothes from wounds. Most hospitals don't have waste treatment facilities on-site, thus they release their garbage either directly or indirectly into waterways that are tributaries of the major and small Akaki Rivers, which eventually flow into Aba Samuel Lake (Worku & Giweta , 2018).

According to a FEPA research, Addis Abeba's 29 hospitals produce 430.7 tons of infectious trash annually. Laboratory cultures, wound dressings, blood and other bodily fluids, and needles are a few examples of the infectious clinical waste. Despite the fact that the majority of hospitals have treatment facilities for waste, some clinical waste nevertheless makes its way into the tributaries of neighboring waterways (Yonannes & Elias, 2017).

The negative effects of inadequate management of collection techniques and disposal of solid waste in healthcare facilities, whether in terms of the well-being of medical staff members working within the facility or in terms of protecting the environment in general, to the existence of the healthcare facility or at the city level. When it comes to management and procedures, the disposal of solid wastes can lead to the spread of pollutants contained in these wastes by rodents, insects, or wind, as well as by rain or floods, which can cause the leakage of these compounds through the fluids into the soil or groundwater. These wastes may transfer their toxins to groundwater or the food chain if their liquid wastes are dumped into sewage. Medical waste disposal on landfills, as well as its transfer to soil or dumping on the seafloor, may cause serious harm to the ecosystem and fisheries. At relatively low temperatures (below 1200C^o), the combustion products and incinerators used to burn these wastes are regarded unsuitable or insufficient. These gases are subsequently discharged into the atmosphere, where they are either left to accumulate over time or are carried by rain to nearby lands or plantations where the burning of medical waste is a substantial source of emissions. Mercury and dioxin are both toxins (Awad & Firas , 2018).

2.5.2 Non-point sources

The main causes of Non-point sources contamination include hydrologic alteration, drainage, seepage, precipitation, air deposition, and land runoff. NPS pollution originates from numerous diffuse sources, in contrast to pollution from sewage treatment plants and industrial sources. The movement of precipitation or snowmelt across and through the ground is what causes NPS contamination. Pollutants, both naturally occurring and caused by humans, are gathered and carried away by runoff, ending up in lakes, rivers, wetlands, coastal waters, and ground waters.

Fertilizer and pesticide-rich agricultural drain waters are a significant nonpoint source of input into recipient rivers. Because of agricultural practices, pesticides some of which are extremely hazardous and difficult to degrade can be found in urban rivers.

2.6 Source of pollution to the Bulbula River

In Ethiopia, rising human population, unregulated urbanization, and poor sanitary infrastructure all contribute to substantial degradation of surface water quality. In Addis Abeba and the neighboring areas, where the vast majority (more than 40%) of big and medium-sized manufacturing enterprises are situated, contamination of water from industrial effluent disposal is currently a serious environmental concern. As a result, many rivers and streams that pass through major cities and towns are extremely polluted. Single point sources of pollution, such as discharges from factories and treatment plants for waste water, can introduce pollutants into surface waters. However, the bulk of contaminants are the result of non-point source pollution, which includes runoff from failed septic tanks, urban areas, construction sites, and agricultural fields.

2.6.1 Municipal sources

Ethiopia is one of the emerging nations with one of the fastest rates of urban population increase. Particularly, growth in Addis Abeba is more rapid than in other cities. It goes without saying that as the population grows, so do the amounts of solid and liquid municipal garbage produced. Because it is not developed proportionally, the country's municipal solid and liquid waste service coverage is very low. Therefore, it is clear that municipal garbage from Addis Abeba city is one among the origins for the Bulbula river's contamination.

The garbage is produced from several sources, including 76% of households, 6% of street cleaning, and 5% of industries. Hospitals make up 1%, 9% of the total, followed by hotels with 3% (FEPA, 2005). In Addis Abeba, 65% of the daily solid waste produced is collected, 5% is recycled, and 5% is composted. The remaining 25% is just thrown on vacant land, drainage canals, rivers, and valleys, in addition to the streets (FEPA, 2005).

The principal recipients of this trash are the Bulbula River and its tributaries, which run through highly populated portions of the city. Leachates that are also transported by run-off during the rainy season eventually end up in waterways. Additionally, because solid waste is not divided into the proper fractions for disposal (i.e., organic, chemical, and other categories), it is possible for harmful substances from homes and other sources to reach rivers.

The three primary methods used to dispose of liquid waste produced by the city are the centralized system, pit latrines, and open space urination and feces. 12.4% of Addis Abeba's total population utilizes flash toilets, 57% uses pit latrines, and 30% has no facilities at all (AAEPA, 1999). According to a research done by AAWSA and UNEP in 2000, those who use flash toilets have their sewage systems connected to separate septic tanks, the centralized system, or both. According to estimates, 57% of the population uses pit latrines, with 17% using private and 40% using shared or communal ones. According to estimates from the shared restrooms, 40% of them are in poor physical condition and overflowing (FEPA, 2005). As was already said, 30% of residents of Addis Abeba lack access to a toilet. These individuals urinate outdoors in any open area, but preferably near river banks. Because of this, waste can quickly join the Bulbula River through runoff, and the river itself can easily sweep waste away and mix it with itself (Tilahun, 2007).

Figure 1: The movement of solid waste to Bulbula river

Figure 2: Municipal waste water disposal in to Bulbula river

2.6.2 Fuel station and garage operations

A significant quantity of oil can seep into the environment while various petroleum products are being extracted, transported, stored, and distributed. The most harmful of these oil pollutants are phenolic wastes because even modest amounts of their chlorinated derivatives give water an unpleasant flavor and odor. In the city of Addis Abeba, gas stations, government garages, and private garages are the sources of oil wastes (FEPA, 2005).

River and subsurface water as well as the soil can be contaminated by car washing, oil spills, and open-air storage of such oils. The related garbage, including mud and wastewater from washing cars and replacing used oil (laviajo), also contaminates the river. The health of humans and other living creatures are both at risk from oil waste, which is a sort of hazardous waste. Therefore, proper consideration must be paid to how these wastes are disposed of in the environment.

CHAPTER THREE: MATERIALS AND METHOD

3.1 The study area: Bulbula River

3.1.1 Location and description

Ethiopia's capital, Addis Ababa, is situated in the geographic center of the nation and is encircled by the regional state of Oromia. It is the biggest city in the nation and has a major symbolic, political, and economic significance for Ethiopia. Addis Abeba lies in the middle highlands at an elevation of 2000 to 2800 meters above sea level. Rivers, streams, valleys, and hills make up the topography. The temperature is moderately stable throughout the year, varying very slightly from 20 to 250 degrees Celsius during the day to 7 to 110 degrees Celsius at night. About 1200 mm of rain fall falls on average annually between June and September (Tilahun.D, 2007).

One of the largest rivers in Addis Abeba City, the Bulbula River flows through the heart of the town and has many tributaries, but it gets a lot of liquid and solid waste from various sources. The river can contain (300-400 mg L-1) of all waste types, including those produced by homes, buildings, garages, gas stations, and hospitals. The primary causes of pollution in the Bulbula River are daily household refuse, industrial discharges, and waste from the Ethiopian Metal Tools Factory (Worku & Giweta, 2018).

Bulbula River runs through Addis Abeba, first through Entoto and then through the densely populated Ketchene region. It also functions as the primary location for disposing of domestic and commercial waste. The river is now known as the Ketchene River, and it merges with another creek known as Kostre at Afincho-Ber before continuing on to Ras Mekonen Bridge and the Eri-bekentu region. The river is known as Bantiketu from this point on and flows down to Estifanos Church and the Economic Commission for Africa (ECA). After that, it goes through residential areas and gas stations. These businesses' sewer systems empty their waste materials into the waterway. The streams in this region act as the primary dumps for all types of trash coming from homes, businesses, building sites, public sewers, and public and private organizations. The river is now known as the Bulbula River after this point. This river empties into the Kebenna River before merging with the Great Akaki Rivers. (Tilahun, 2007).

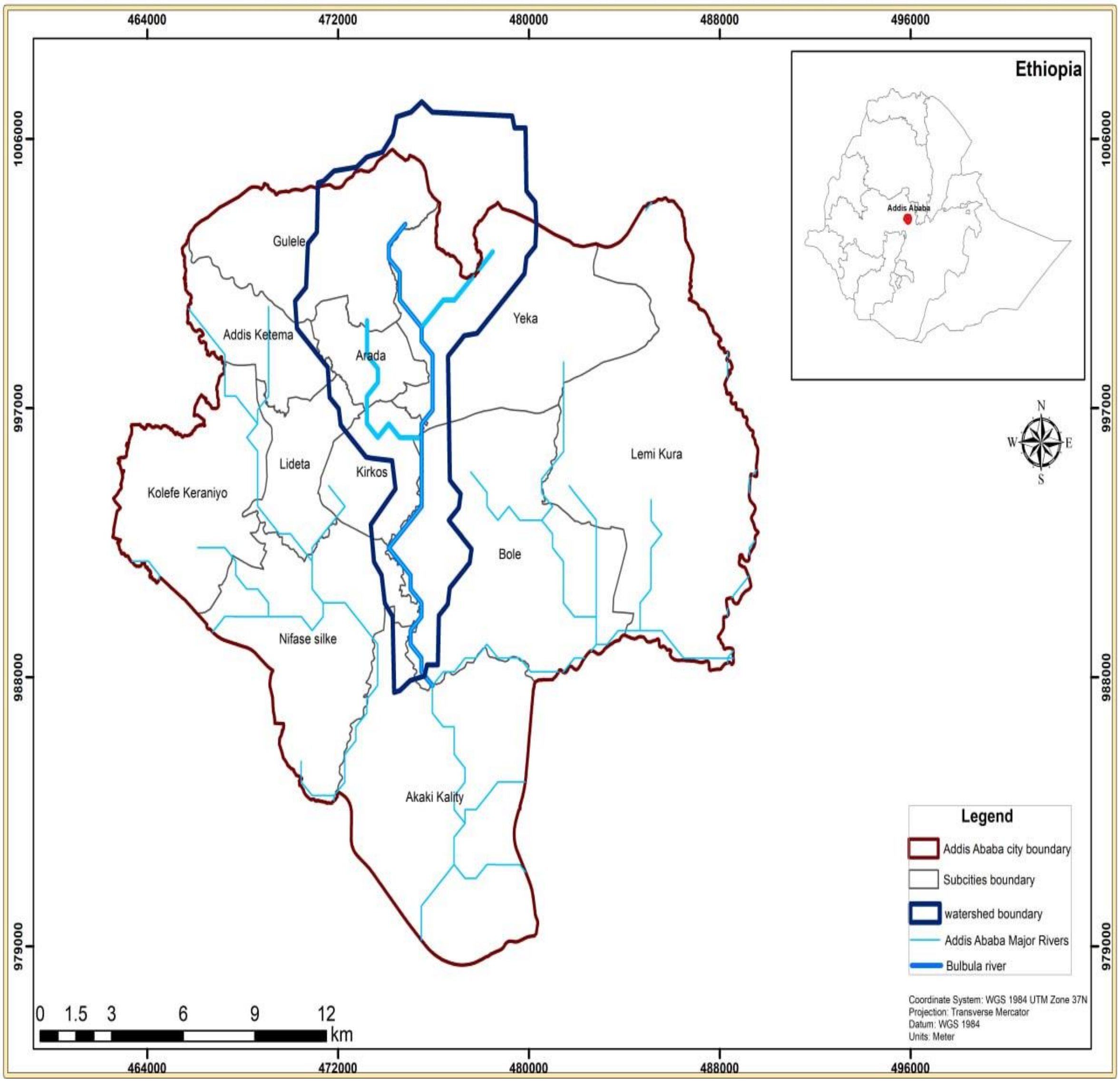


Figure 3: Location map of Bulbula river

3.1.2 Climate

With a maximum elevation range just above 2800 meters and a minimum elevation range just below 2000 meters, respectively, the majority of Addis Abeba falls under the Weina Dega (Sub tropical) climate category. The altitude-influenced subtropical climate of Addis Abeba has a rainy season from June to September. The driest month is January, then follows November. Even if there are more rain showers from February to May, there are also many hours of sunshine. After the rains, the weather returns to being generally favorable in October and November. According to Ethiopian Mapping Authority, the climate of the Addis Ababa region is characterized by two distinct seasons: the wet season, which lasts from June to September and contributes to about

70% of the total annual precipitation, and the dry season, which continues for from October to May with a brief rainy season in March and April well known for its frequent failure (1981).

Table 1: Mean monthly rainfall at four station (RF in mm)

Station name	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Mean Annual RF
Entoto		38.3	61	87.3	61.8	140	306.9	322.5	145.4	27.2	9.9	9.8	1225.7
Addis Ababa	19	45	73	95.1	83.7	138.1	267.9	292.8	183.9	38.9	8.6	10.1	1256.1
Bole	15.6	36.3	68	88.7	78.1	120	237.8	238.3	137.6	33.3	5.6	5.2	1064.5
Akaki	14.3	40.6	63	95.1	66.2	129.3	272.1	295.2	142.7	23.3	4.6	3.6	1150.4

3.1.2 Vegetation

The river bank's vegetation has a fairly varied composition. The types of different species of the vegetation that grows along the Bulbula river banks are Juniperus procera, Maesa lanceolata, Vernonia amygdalina, Arundo donax, Justicia schimpeirana, Erythrian spp., Ricinus communas, Acacia abyssinica, Grevilea robusta, Millettia ferruginea, Enset ventricosum, Croton macrostachys e.t.c,. But along the river's course, Arundo donax is the dominant species.

3.1.3 Land use intensity and watershed

Different land uses for different locations are shown by the land use intensity of Addis Abeba city along the Bulbula River stream. An environmentally protected region and a low density mixed residential (LDMR) area may be seen in the river's upper stream. EA-12 Environmentally protected River Buffer is located in the lower stream of the river, while the middle stream is covered in Medium density mixed residential (MDMR) land use type.

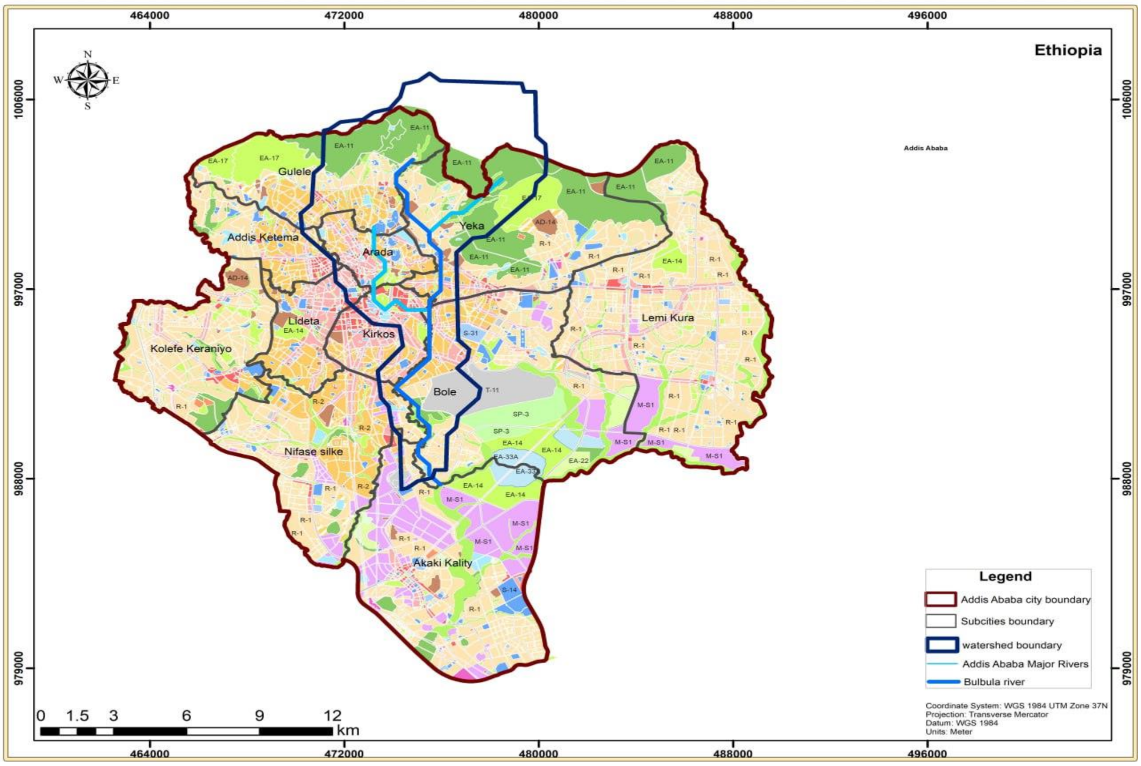


Figure 4: Land use map along bulbula river stream

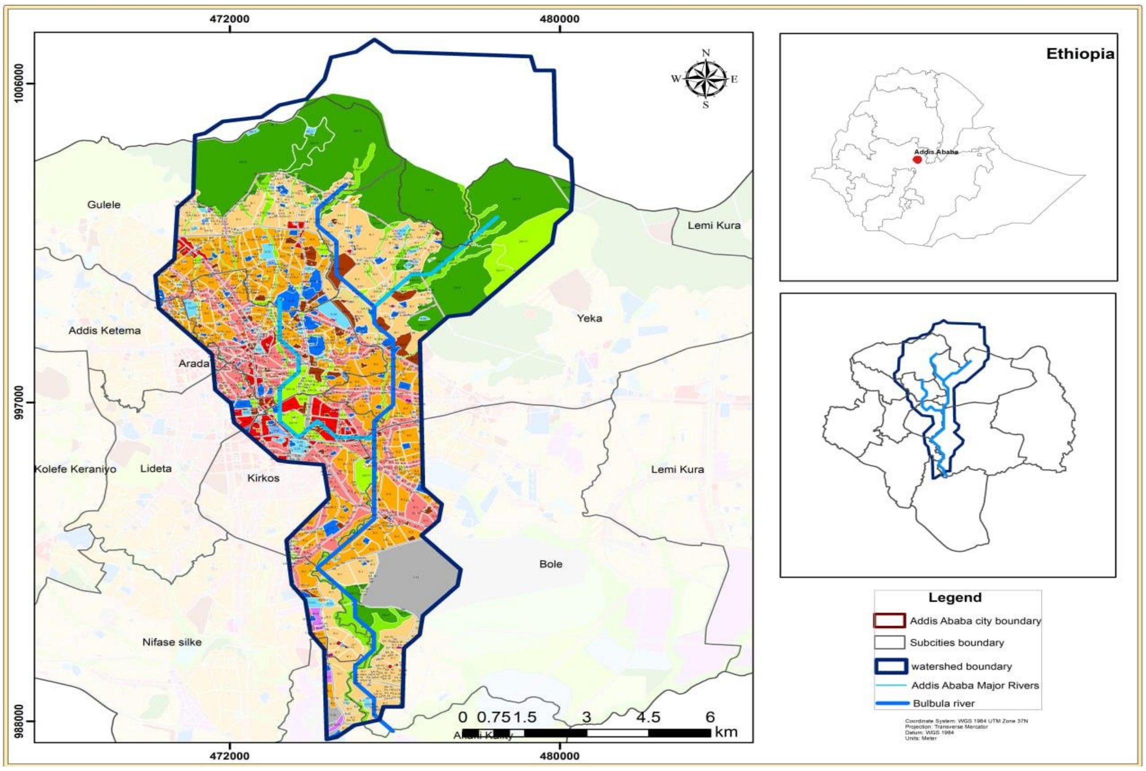


Figure 5: Watershed map of Bulbula river

3.2 study design

To evaluate and determine potential sources of contaminants entering the river, a reconnaissance assessment has been carried out along the stream within the research regions. This survey was carried out starting at the river's Entoto source and moving down the river to Bulbula within the study area. The survey's findings led to the identification of potential causes of river pollution. The contaminants tested were chosen based on relevant literature. As a result, the principal contaminants studied in this study are PH, Total suspended solid (TSS), Reactive phosphate, Chemical oxygen demand (COD), nitrate (NO^{-}_{3}), Ammonia (NH_3), Total phosphorus (P) and Total Nitrogen (N).

The research field was separated into three sections. There are three different types: upstream zones, middle or transfer zones, and lower or depot zones. The stream's headwaters are located in the upstream zone. This area is uninhabited, so there aren't likely to be any of the pollution sources mentioned above. The center, or transfer zone, is a highly populated area where many pollution sources (such as garages and municipal trash) can be found. The lower zone is similarly populated, although there are also fuel stations and construction trash. At this point, the stream merges with other streams.

3.3 Sampling and data collection

Water sampling locations were chosen to acquire a representative sample of the specific water quality indicators based on geographic differences in the water stream and pollution system. The sampling sites were found using GPS and hence correctly noted on the map. All analytical parameters were collected in polyethylene tubes. The sample containers were immersed in the stream directly to collect the samples. But to get rid of any contaminants that might have been within the container, the clear plastic containers were thoroughly cleaned and disinfected with distilled water before use. As a result, composite water samples were collected at three different locations for two different seasons named winter(kiremet) and summer(bega) for rainy and dry seasons respectively. The higher portions of the stream, where there is less pollution, were chosen as the first location (Fig 6). The second place, where pollution was fairly significant, was in the stream's transfer zone (Fig. 6). The third spot was down by the stream (Fig. 6).

In each part of the stream, three data collectors were tasked with collecting samples simultaneously. On the same day, early in the morning, water samples were taken. Three water samples, each with two litters, were obtained from the three sites.

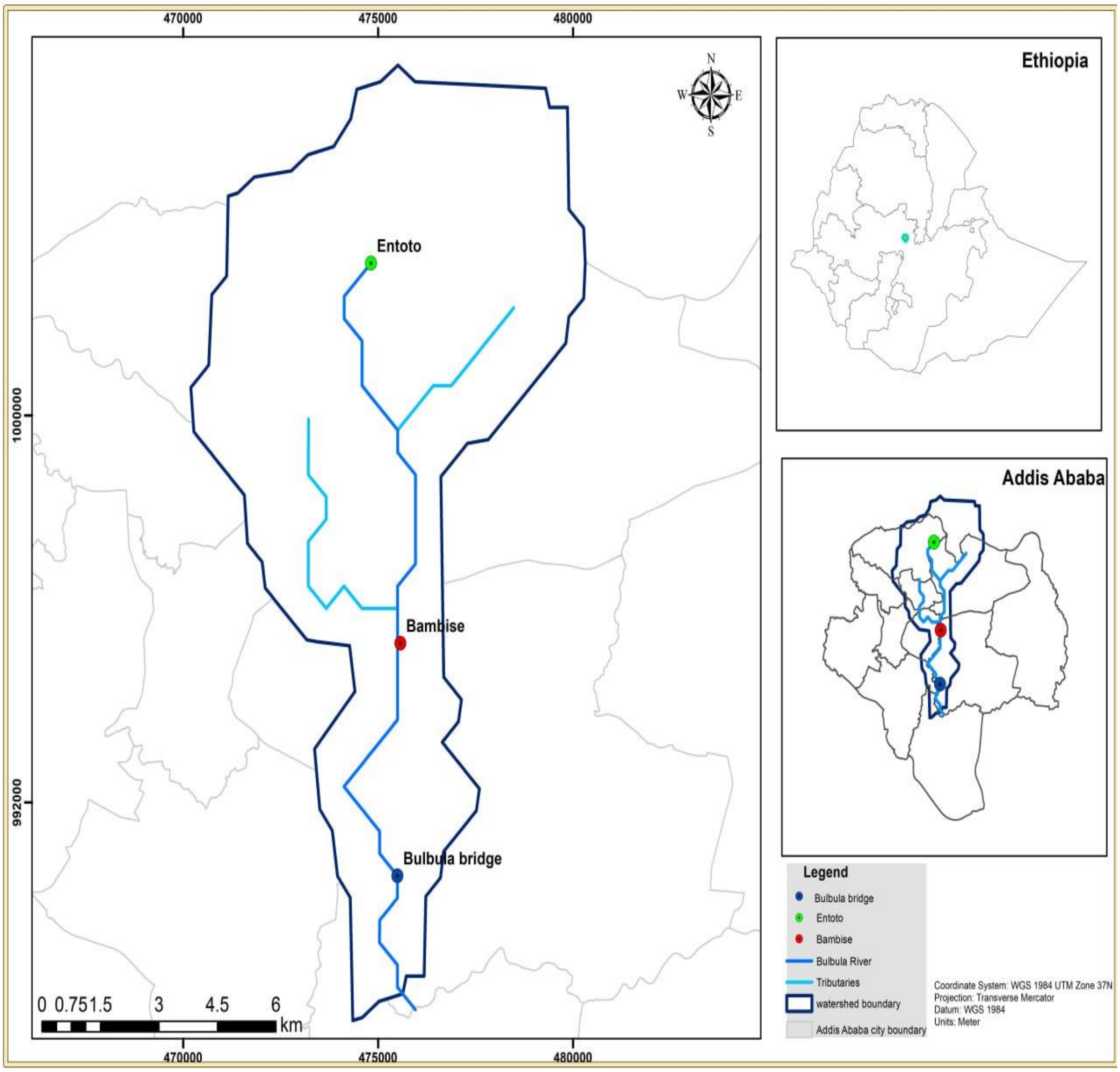


Figure 6: Sampling location map

Figure 7: Sampling site 1 (Entoto)

Figure 8: Sampling site 2 (Bambis)

Figure 9: Sampling site 3 (Bulbula bridge)

3.4 Laboratory analysis

At Addis Ababa City Administration Environmental Protection Authority, samples were tested for PH, TSS (Total suspended solid), NO^-_3 (Nitrate), Ammonia (NH_3), Reactive Phosphorous, Total Phosphorous, Total Nitrogen, and COD (Chemical Oxygen Demand). The PH was determined using an electro analytical approach, the TSS was determined using a photometric method, and the NO^-_3 was determined using a cadmium reduction process. The Salicylate method was used to test NH_3, the Molybdovanadate method was used to measure Reactive and Total Phosphorus, TNT Per Sulphate was used to measure total Nitrogen, and the reactor digestion method was used to assess COD.

3.5 data analysis

The statistical package for social sciences (SPSS) software, version 27.0, was used to analyze the data. The variation in pollutants between each of the three zones (upper zone, middle zone, and lower zone) in water data was examined. To determine whether there are any variations between the three zones, descriptive analysis was conducted with an acceptable skewness threshold of -1.7 to 1.225.

CHAPTER FOUR: RESULT AND DISCUSSION

4.1 Impacts of land use intensity on Bulbula River

It is often acknowledged that the type of land use and water quality are closely related. The quality of river water is greatly impacted by the land use along the watershed. As human activity increases, the patterns of land cover within a watershed may alter, leading to a decline in the quality of the water in rivers. For this reason, while studying the effects of land use on water quality, it is important to consider both land use and land cover patterns at the same time (Juan Huang et.al, 2013). In many places, changes in land use and land cover are the cause of the deterioration of urban water quality. Their connections to elements of water quality such suspended solids, nutrients, and dissolved salts have been the subject of several investigations. The connections change in tandem with the biological landscape as a result of population growth and urbanization. Considering this, it can be said that urban land use, which reflects human settlement, significantly affects the concentrations of nutrients in water (Liu et.al, 2022).

The biochemical pollutants in the water samples that were collected were analyzed in laboratory tests. The pollutants included total nitrogen, total phosphorous (P), reactive phosphorous (PO4), nitrate (NO-3), ammonia (NH3), PH, TSS, and COD along the three sample sites. Typical pollutants from wastewater and household or industrial waste include organic materials, heavy metals, and microorganisms. These materials may be discharged by irrigation, runoff, or direct discharge into water, which can affect the concentration of nutrients (Nguyen et.al, 2023). According to the Bulbula watershed's land use cover, the upstream area is a low-density mixed residential area. Additionally, laboratory results indicate that the levels of nitrate, TSS (reactive phosphorus), and total nitrogen exceed the limits set by the Environmental Protection Authority.

The "Beautifying Sheger" project, which aims to revitalize the Sheger River basin, includes the middle stream of the Bulbula River, which is situated near Bambis. With the exception of reactive phosphorous, total nitrogen, and TSS, which have values that are comparatively higher than the discharge limit, the parameters of this medium-density mixed residential area are within the EPA's discharge limit. human settlement as represented by urban land use has a significant influence on water nutrient concentrations. Next, the relationships between landscape composition and water quality provide an important basis for effectively addressing urban planning and non-point sourced management problems (Liu et.al, 2022).

One of the main sources of pollution in receiving aquatic bodies is urban storm runoff. The runoff process of total suspended solids (TSS), chemical oxygen demand (COD), ammonia, and total phosphorus (TP) to the downstream of Bulbula river was researched in order to evaluate the influence of urban storm water runoff on an urban river. Although the downstream watershed is a protected area for the environment, there is a lot of water runoff. The findings indicate that the levels of nitrate, TSS, COD, reactive phosphorus, and total nitrogen exceed the EPA's discharge limit.

4.2 Pollutant concentration in Bulbula River

4.2.1 Dry season

The analysis of water samples revealed that concentration of pollutants vary across the river stream. The value of Ammonia and Nitrate are higher in the upper stream of the river. Results show there is a high chemical oxygen demand (COD) in the middle stream than that of the other streams. The lower stream of Bulbula river show higher value of Reactive phosphorous, PH, total phosphorous & nitrogen and total suspended solid.

Table 2: Pollutant concentration in Bulbula River during dry season

	Dry season		
	Sampling site		
Water quality parameter	Upper zone	Middle zone	Lower zone
PH	6.4	6.3	6.9
Nitrate (NO^-_3)	15.1	1.3	9.6
Total Suspended Solid	126	197	4875
Ammonia (NH_3)	8.1	2.3	0.5
Reactive phosphorous (PO_4)	19.1	17.7	279
Total phosphorus (as P)	0.8	0.001	4
Total Nitrogen (as N)	279	550	580
Chemical oxygen demand	31	261	127

values are in mg/l except for PH

4.2.2 Wet season

The concentration of pollutants varies in the rainy season as well. The upper stream in this season shows higher values in PH, Ammonia, and nitrate. As for the middle stream it shows a greater value in total nitrogen. Total suspended solid, reactive phosphorous, total phosphorous and chemical oxygen demand show a greater value in the downstream of Bulbula River than that of the other two zones.

Table 3: Pollutant concentration of Bulbula River during wet season

	Wet season		
	Sampling site		
Water quality parameter	Upper zone	Middle zone	Lowe zone
PH	8.15	7.52	7.41
Nitrate (NO^-_3)	33	2.3	15.5
Total Suspended Solid	56	29	474
Ammonia (NH_3)	5.1	1.4	0.3
Reactive phosphorous (PO_4)	17.4	6.9	60.7
Total phosphorus (as P)	0.6	<0.001	3.2
Total Nitrogen (as N)	280	570	530
Chemical oxygen demand	232	185	689

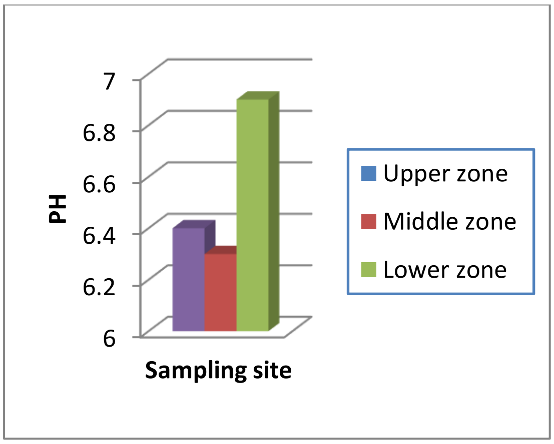
NB: Values are in mg/l except for PH

4.1.3 Water quality parameters

PH

The PH of Bulbula river shows variation between the two seasons and the corresponding sample sites. As for the Dry season PH of Bulbula river lower value at the middle zone which is 6.3, 6.4 at the upper zone and 6.9 at lower zone. (Table 2).

The PH value for Rainy season is 8.15 at the upper zone, 7.52 at middle zone and 7.41 at lower zone of the river, slightly higher at the upper zone (Table 3). Most naturally occurring waters have a PH between 6.0 and 8.5. (Chapman.D, 1992). Water's acidity or alkalinity is gauged by its PH. The major purpose of PH is to quickly assess any potential water abnormalities. The PH value for three zones throughout the course of both seasons is the natural range of water as a result.



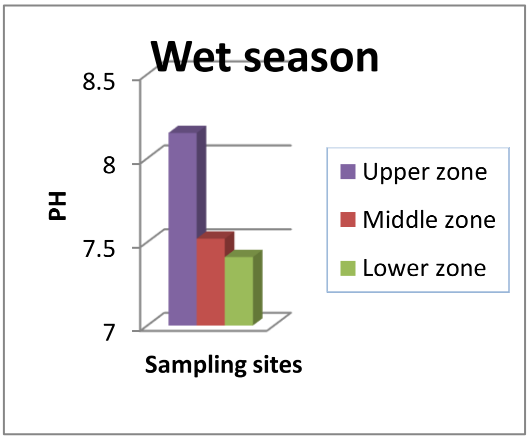


Figure 10: PH of water at three zones for dry and wet season

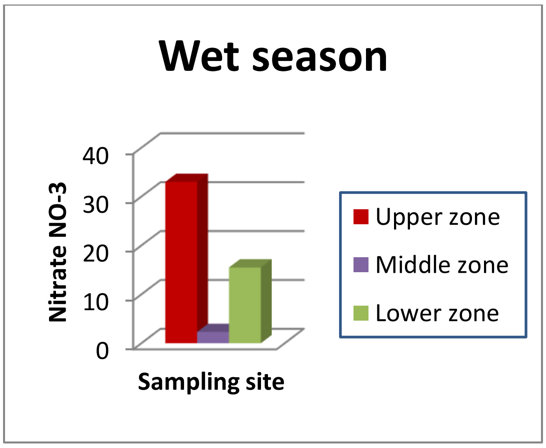
Table 4: EEPA discharge limit for water quality parameters

	Sampling site						
	Wet season			Dry season			Discharge limit by EEPA
Water quality parameter	S1	S2	S3	S1	S2	S3	
PH	8.15	7.52	7.41	6.4	6.3	6.9	6.9
Nitrate (NO^-_3)	33	2.3	15.5	15.1	1.3	9.6	3.1-5
TSS	56	29	474	126	197	4875	50
Ammonia (NH_3)	5.1	1.4	0.3	8.1	2.3	0.5	30
Reactive phosphorous (PO_4)	17.4	6.9	60.7	19.1	17.7	279	2
Total phosphorus (P)	0.6	<0.001	3.2	0.8	0.001	4	10
Total Nitrogen (N)	280	570	530	279	550	580	60
COD	232	185	689	31	261	127	500

NB: Values are in mg/l except for PH

Nitrate (NO_{-3})

Due to the rapid conversion of nitrite to nitrate, nitrate is the molecule that occurs most frequently in groundwater and surface waters. By contaminating water with fertilizers that include nitrogen, the amount of nitrate in the water can rise. (such as potassium nitrate and ammonium nitrate), as well as organic waste from people or animals. Both the dry and the wet seasons exhibit a comparable change in nitrate content. Since NO_{-3} values are greater in the upper stream of the Bulbula River, they are 15.1 and 33 for the dry and rainy seasons, respectively. The middle stream in Addis Ababa, which is a heavily inhabited area, exhibits a somewhat lower concentration than both the upper and lower stream, 1.3 and 2.3 for the dry and rainy seasons, respectively, due to the continuous urban renewal effort around rivers. For both the dry and wet seasons, the lower stream of the river has a value of NO_{-3} that is higher than the middle stream and lower than the upper stream, respectively, 9.6 and 15.5. Nitrate levels between 3.1 and 5.0 mg/L are regarded as fair, over 5.0 mg/L as bad or hazardous for consumption, and concentrations above 10 mg/L can result in methemoglobinemia (blue baby syndrome) (Enviro sci Inquiry, 2000-2011).



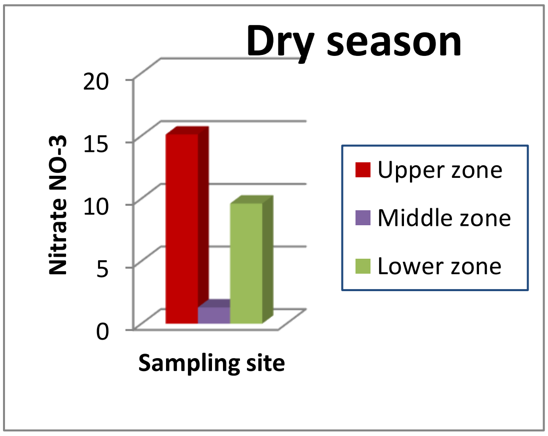


Figure 11: Nitrate of water at three zones during wet and dry season

Total suspended solid (TSS)

The turbidity (cloudiness) of the water is frequently linked to TSS readings. If TSS is elevated and the water is muddy light from the sun will not enter the water adequately, making it more difficult for plants and algae to flourish. TSS could be any substance that floats or "suspends" in water, such as sand, silt, and plankton. Typically, suspended solids are the organic particles that get released into water bodies when perished plants or animals contaminate various water sources. Other TSS may float to the top or remain suspended somewhere in the middle, while some silt may sink to the bottom of a body of water. TSS affects water clarity; as a result, the amount of TSS in a water supply affects how clear it is (Campbel, 2021).

Strong wastewater has a TSS greater than 220 mg/L, medium wastewater has a TSS greater than 100 mg/L but less than 220 mg/L, and weak wastewater has a TSS less than 100 mg/L, according to published research (Reda, 2016). According to the findings of this study, the Bulbula River is more polluted throughout the dry season of the year. Results indicate a high amount of contamination during the dry season, with values for the three stream zones of the bulbula river being 126 mg/L, 197 mg/L, and 4875 mg/L.

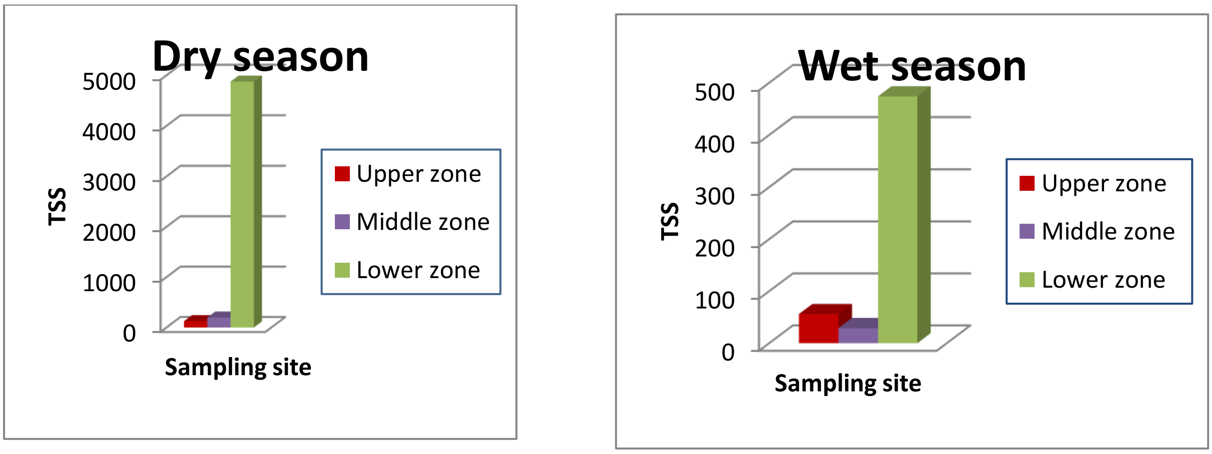


Figure 12: TSS value of bulbul river during dry and wet season

The results of the Bulbula River during the wet season demonstrate relatively less contamination in the upper and lower zones along the stream. Upper, middle, and lower streams have values for the three zones of 56, 29 and 474, respectively. Except for the middle of the rainy season, all sampling stations' TSS readings were greater above the FEPA (30 mg/L) and EEPA (50 mg/L) discharge limits.

Ammonia (NH_3)

When the water's ammonia levels are high enough, aquatic organisms cannot adequately remove the toxin, which leads to toxic buildup in internal tissues and blood and possible death. The manufacturing of ammonia is necessary for industrial applications such as commercial fertilizers. Natural sources of ammonia include nitrogen fixation processes, gas interaction with the atmosphere, forest fires, human and animal waste, and the decomposition of organic waste. Both direct and indirect ammonia entry sites exist in aquatic environments. Wastewater from municipalities discharges, thus animal excretion of nitrogenous waste, and air deposition are some sources of ammonia that enter the environment directly (EPA, 2023).

The findings of this investigation indicate that the concentration of ammonia is somewhat below the 30 mg/L discharge limit set out by the EEPA. Because of this, the river is not in risk from a high ammonia concentration in any of the three zones during the dry or wet seasons.

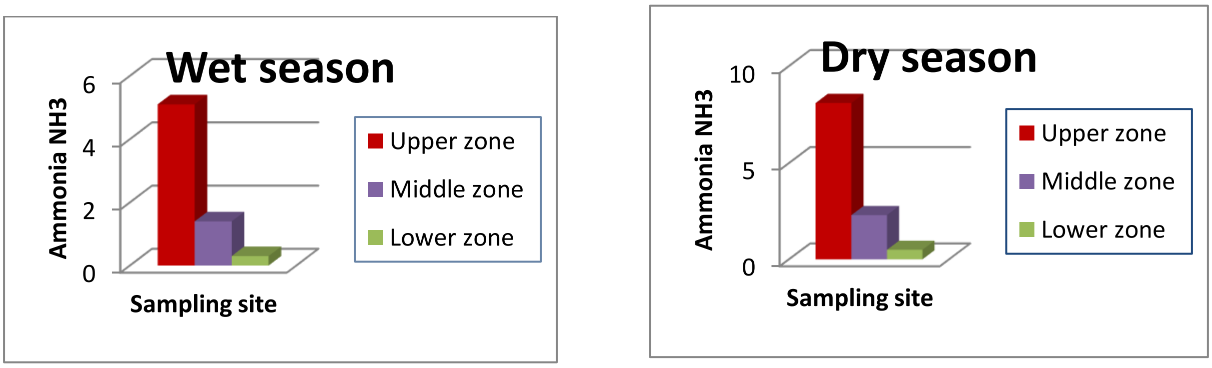


Figure 13: NH_3 concentration in Bulbula River for dry and wet season

Reactive phosphorous (PO_4)

Reactive phosphorous (phosphate), which is caused by humans, can be found in pet waste, fertilizer, farmland and urban runoff, industrial and home sewage, and malfunctioning or overburdened septic systems. The majority of the time, it is thought that phosphates are mostly produced from wastes emitted by municipal solid and liquid wastes. Phosphate levels in the Bulbula River have varied from upper to lower stream. The results are higher in the upper and lower stream, but the values are comparatively lower in the wet and dry seasons. Phosphates are typically thought to be primarily produced from wastes emitted from municipal solid and liquid wastes.

The values for the upper, middle, and lower streams of the Bulbula River during the wet season are 17.4 mg/L, 6.9 mg/L, and 60.7 mg/L, respectively. Accordingly, during the dry season, the results for upper, middle, and lower streams are 19.1 mg/ L, 17.7 mg/ L, and 279 mg/ L, respectively. The maximum permitted phosphate concentration in irrigation water is 2 mg/lt (Abdallah & Bader , 2011).

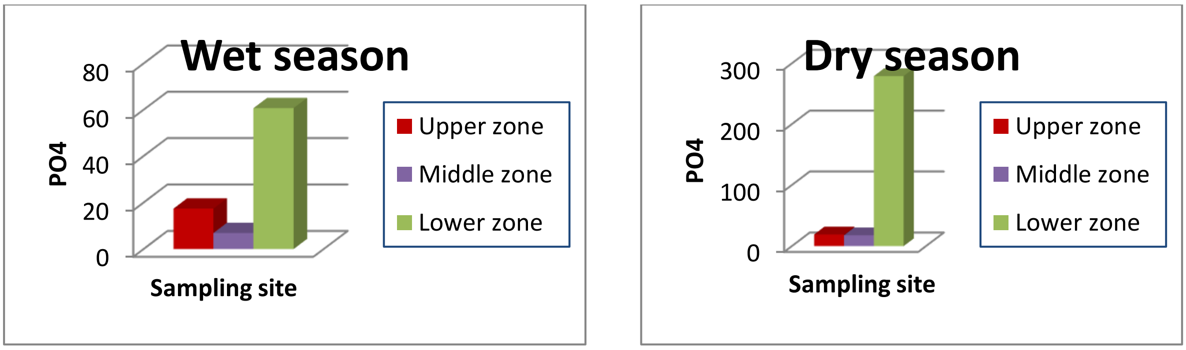


Figure 14: PO_4 concentration of Bulbula River during Dry and season

Total phosphorous

The primary sources of phosphorus in water from waste include human waste, household detergents that contain phosphorus, and some industrial and commercial effluents. If combined sewer systems are used, rainfall runoff has a negligible contribution to P-loads in waste water. Phosphorus concentrations along the wastewater channel (stream) ranged from 0.6 mg/L in the upper stream, 0.001 mg/L in the middle stream, and 3.2 mg/L during the rainy season.

Results for dry season also have a slight difference starting from 0.8mg/L in upper stream to 0.001mg/L at middle and 4mg/L at lower stream of the river. The value of phosphorous is below the limit that is stated by EEPA (EEPA, 2001), which is 10mg/L for both dry and wet season along the three zones.

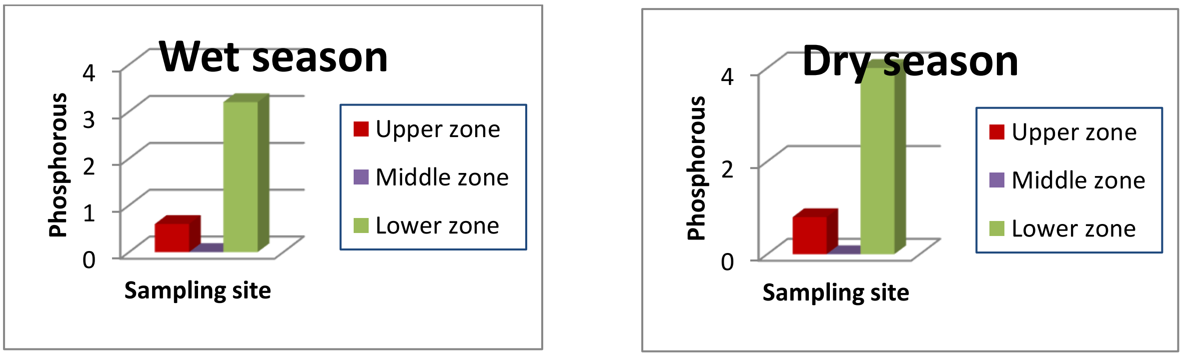


Figure 15: Phosphorous concentration of Bulbula River during dry and wet season

Total Nitrogen (N)

The nitrogen flow into waters has been considerably accelerated by human activity, which has led to a decline in water quality. The condition of surface water in dry places requires regular observation due to the water crisis caused by nitrogen pollution.

Despite the fact that various studies have shown that land use patterns frequently affect the nitrogen content of streams. Industrial, municipal, residential, and agricultural sources all contribute to the anthropogenic nitrogen that enters our rivers. Another significant anthropogenic source of nitrogen that enters surface waters is nitrogen deposition from the burning of fossil fuels in the atmosphere. Additionally, point sources (like municipal wastewater treatment facilities) and non-point sources (such agricultural practices and atmospheric deposition) are used to categorize chemical inputs to aquatic bodies (Yuxian et al., 2021).

Results from this study show a high concentration range of total nitrogen for both wet and dry season along the river stream. Dry season total Nitrogen values are rather higher than the limit stated by EEPA which is 60mg/L. 279mg/L upper stream ,550mg/L middle stream and 580mg/L for lower stream (table 2).

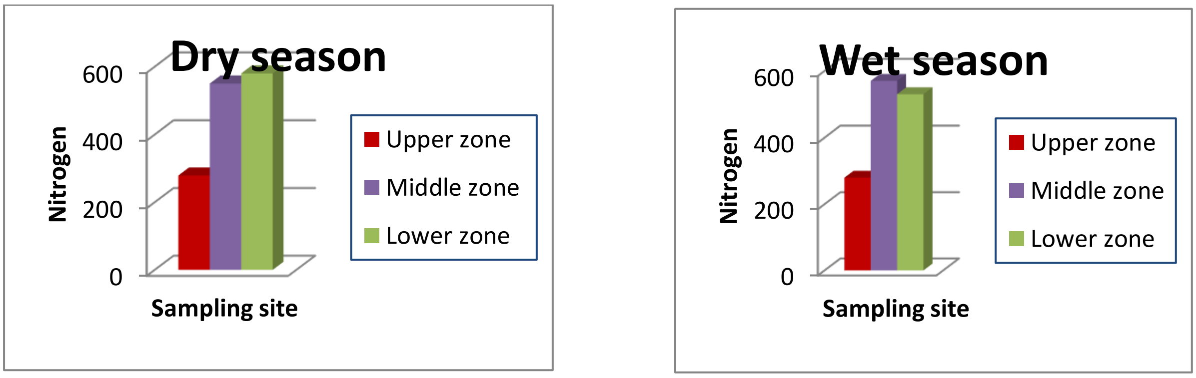


Figure 16: Total Nitrogen concentration of Bulbula River during dry and wet season

For wet season nitrogen concentration also shows higher values which are greater than the limit stated by EEPA. 280mg/L, 570mg/L and 530mg/L for upper, lower and middle zone respectively. Study results also show higher values in the middle stream for both seasons.

Chemical oxygen demand (COD)

The study's findings indicate that the chemical oxygen demand during the dry season is lower than the EEPA-mandated level of 500 mg/L. The levels in the upper and middle zones are within the permitted range for the rainy season (232 mg/L and 185 mg/L, respectively), while the lower stream value of 689 mg/L is beyond the permitted limit.

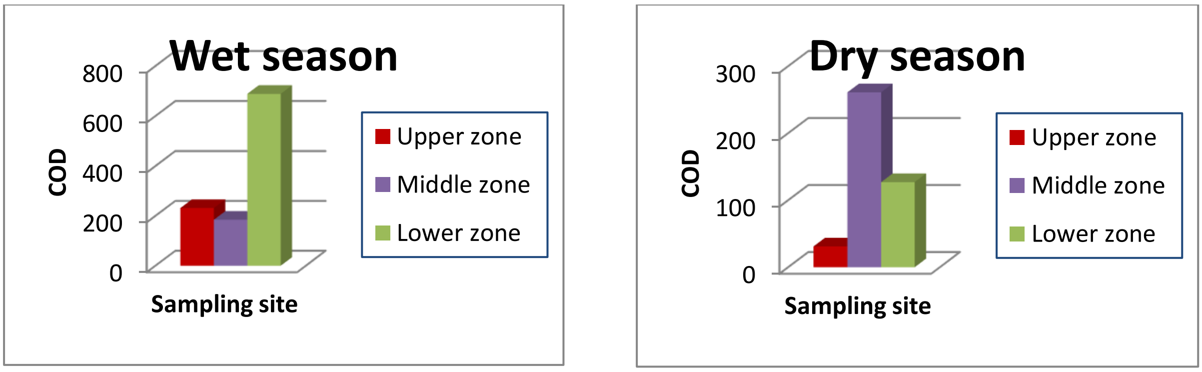


Figure17: COD of Bulbula River for dry and rainy season

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Despite the fact that urbanization helps individuals live better lives and has a positive impact on work prospects, education, and health, unplanned and uncontrolled urbanization can have a negative impact on the environment and society's health and well-being. The goal of the study was to investigate the effects that various watershed land uses have on the Bulbula River's water quality throughout the year. Additionally, the relationships between the predominant land use categories and the pollution levels were investigated. After possible water pollutants were evaluated, it was discovered that the Bulbula River is extremely polluted.

Municipal trash, garages, gasoline stations, building debris, hospitals, crowded settlements, and other sources are the main pollutant sources in the Bulbula River. There is a greater likelihood that the watershed's downstream (deposition) zones and areas that receive trash in the middle or transfer zone will pollute the Bulbula River. It is discovered that the Bulbula River's main pollutants are PO_4, NH_3, and $NO\text{-}_3$.

The physicochemical parameters investigated in this study revealed that almost all effluent characteristics were above the Environmental Protection Agency's (EPA) provisional discharge limit, indicating poor treatment mechanisms used by various factories around the river and uncontrolled municipal discharges to the river. The majority of the physicochemical characteristics in the river water were likewise above the discharge limit.

In general, rapid and uncontrolled urbanization leads land use change, which leads to uncontrolled factory construction and unplanned waste water disposal systems, which leads to the disposal of untreated waste water into rivers that surround cities and have direct or indirect connections with society, thereby affecting the surrounding environment.

5.2 Recommendation

The study's key finding has led to the following recommendations being made.

- Municipal trash, garages, petrol stations, construction debris, hospitals, and other forms of pollution are major causes of pollution in the Bulbula River. These sources of pollution discharge trace metals and nutrients into the river. As a result, pollution from those sources should not be discharged into rivers, but rather diverted away from river basins.
- The municipal government should implement strict waste water management measures to ensure that factories that discharge waste water into rivers satisfy the EPA's standard.
- Riverbank development designs, as well as improved wastewater disposal infrastructure, can help to keep the river stream clean and beautiful, enabling for safe, sustainable, and joyful urban environments.

Bibliography

Abdallah , A., & Bader , A.-A. (2011). Comparison between the irrigation qualities of conventional tertiary and UF + RO advanced treated wastewaters. *Agricultural Sciences*.

Abebe, M. (2018). Challenges and practice of Plastic Bottles, paper and carton Generation and Collection in Addis Ababa City, Ethiopia. *European journal of researh*.

Abrha, B., & Chen, Y. (2017, June 28). Analysis of Physico-Chemical Characteristics of Effluents from Beverage Industry in Ethiopia. *Journal of Geoscience and Environment Protection, 5*, 172-182.

Awad, A., & Firas , A. B. (2018, May). ENVIRONMENTAL IMPACTS OF MEDICAL WASTE TREATMENT AND MANAGEMENT BY BURNING INSIDE HEALTH FACILITIES. *International Journal of Civil Engineering and Technology (IJCIET), 9*(5), 51-53.

Baojie Lei et.al. (2022, May 29). Prediction of the Impact of Land Usage Changes on Water Pollution in Public Space Planning with Machine Learning. (P. N. Mahalle, Ed.)

Campbel, B. (2021). what are total suspended solids. *Utility management*.

Chamara P. , L., & Koichi , Y. (2017). Impact of Population Growth on the Water Quality of Natural Water Bodies. *sustainability*.

Chang Xia et.al. (2020, January). Analyzing spatial relationships between urban land use intensity and urban vitality at street block level: A case study of five Chinese megacities. *193*.

Chapman.D. (1992, January). Water Quality Assessments: A Guide to the Use of Biota, Sediments and Water in Environmental Monitoring.

Dechao et.al. (2020). A Study on the Relationship between Land Use Change and Water Quality of the Mitidja Watershed in Algeria Based on GIS and RS. *sustainability*, 20.

Earth:Urbanization. (n.d.). (HANDWIKI, Producer) Retrieved from https://handwiki.org/wiki/Earth:Urbanization: https://handwiki.org/wiki/Earth:Urbanization

EEPA. (2001). Situation Analysis; the Industrial Sector.

Enviro sci Inquiry. (2000-2011). *LEO Envirosci inquiry*.

(2023). *EPA.* United states environmental protection Agency.

EPA. (2023). Aquatic life criteria . *EPA, United states Environmental protection Agency*.

Gupta, A. (2016). Water pollution source effect and control. *pointer publishers jaipur*.

Iacoba, S. (2013). The Wastewater - a Problem of Integrated Urban Water Management. *International Economic Conference of Sibiu 2013 Post Crisis Economy: Challenges and opportunities* (pp. 436-443). Sibiu: Elsevier B.V.

Ismael et al. (2022). Assessment of urban river water pollution with urbanization in East Africa. *Environmental Science and Pollution Research*, 40812–40825.

Juan Huang et.al. (2013, july 1). Evaluation of the Impacts of Land Use on Water Quality: A Case Study in The Chaohu Lake Basin. *The Scientific World Journal, 2013*, 7.

Liu et.al. (2022). Urban Land-Use Type Influences Summertime Water Quality in Small- and Medium-Sized Urban Rivers: A Case Study in Shanghai, China. 14.

Malin , E., & Jonathan , s. (2019). *Causes and impact of surface water pollution in Addis Ababa Ethiopia.* Uppsala: the Department of Earth Sciences, Uppsala University,.

Mark, E., & Helen, M. (2012). Rediscovering the value of urban rivers. *Urban Ecosyst*.

Maryna et.al . (2021). Urbanization: an increasing source of multiple pollutants to rivers in the 21st century. *npj Urban Sustainability*.

Meghdad et al. (2013). A comparison between extended aeration sludge and conventional activated sludge treatment for removal of linear alkylbenzene sulfonates (Case study: Kermanshah and Paveh WWTP). *Desalination and water treatment*.

Moriken et.al. (2019). Impact of land use on water quality in Malaysia.

Narwaria , & kush. (2012). Environmental assessment of air pollution on road side plants species at dehrdun, uttrakhand, India. *Journal of Environmental Research and Development, 7*(2), 710-714.

Nguyen et.al. (2023). nfluences of key factors on river water quality in urban and rural areas: A review. *Case Studies in Chemical and Environmental Engineering*.

Nicoli, T. (2022). The value of urban rivers:European experiences and a south american perspective. *Urban design lab*.

Osibanjo, O., & Ajayi, S. (1981). Pollution Studies on Nigeria Rivers: Water Quality of Some Nigeria Rivers. *Environmental Research Series B, II*, 87-95.

Pattacini, L. (2021). Urban Design and Rivers: A Critical Review of Theories Devising Planning and Design Concepts to Define Riverside Urbanity. *Sustainability*.

Preisner, M. (2020, july18). Surface Water Pollution by Untreated Municipal Wastewater Discharge Due to a Sewer Failure. *Environmental Processes*, 767-780.

Rai, M. S. (2017). Impact of Urbanization on Environment. *International Journal on Emerging Technologies*, 127-129.

Reda, A. H. (2016). Physico Chemical Characterization of Tannery Effluent and Its Impact on the Nearby river. *Open Access Library Journal, 3*.

Rodriguez, R. S. (Ed.). (2007). *Urbanization, Global Environmental change and sustainable development in latin America.* (L. S. Fernández, Trans.) São José dos Campos, Brazil: Digital Graf Press.

Sanyaolu, P. S. (2018). Urbanization.

Satyavati et.al. (2013). Effects of Increasing Urbanization on River Basins- State of Art. *International Journal of Engineering Research & Technology (IJERT)*, 2742-2747.

Teklehaimanot.R. (2005). Program on the sustainable consumpion and production in the Akaki River Basin. A situation Analysis of the Akaki River. 1-99.

Teshome et.al. (2020, november 25). An overview of water pollution status in Ethiopia with a particular emphasis on Akaki River:A Review.

Tilahun, D. (2007). *The Role of Arundo donax in riparian vegetation in mitigating river pollution in Addis Ababa: the case of bulbula river.*

Timar , P. M., & Milkiyas , P. M. (2019, October 31). Industrial Wastes and Their Management Challenges in Ethiopia. *Chemistry and Materials Research, 11*.

Viacheslav et al. (2018). Megacities 2050:Environmental Consequences of urbaniation. *International Conference on Landscape Architectureto Support City Sustainable development.* Switzerland: Springer International Publishing.

Wambebe , N., & Xiaoli , D. (2021, April). Environmental Pollution and Health Effects -Addressing Pollution (Air, Water and Noise) Challenges in Africa and Possible Solutions Towards Attaining Sustainable Green Environment. *International Journal of Environmental Sciences & Natural Resources, 27*(4), 1-8.

weldetsadik et.al. (2018). Farmers’ perceptions on irrigation water contamination,health risks and risk management measures in prominent wastewater-irrigated vegetable farming sites of Addis Ababa, Ethiopia. *Environmental systems a d decision, 38*, 52-64.

Worku , Y., & Giweta , M. (2018). Can We Imagine Pollution Free Rivers around Addis Ababa city, Ethiopia? What were the Wrong-Doings? What Action Should be Taken to Correct Them? *Journal of Pollution Effects & Control*(3).

WWD. (2010). *World Water Day ; Africa's water quality.* RSC.

Xizhe et al. (2018). *Urbanization and its consequence.* Encyclopedia of Life Support Systems (EOLSS).

Yonannes, H., & Elias, E. (2017). Contamination of Rivers and Water Reservoirs in and Around Addis Ababa City and Actions to Combat It. *Environment Pollution and Climate Change, 1*(2), 13 pages.

Yuxian et al. (2021). Human Activities Increase the Nitrogen in Surface Water on the Eastern Loess Plateau. (Y. Xue, Ed.)

Appendix 1

Dry Season

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
PH	3	.60	6.30	6.90	6.5333	.32146
Nitrate	3	13.80	1.30	15.10	8.6667	6.94718
total suspended solid	3	4749.00	126.00	4875.00	1732.6667	2721.57203
Ammonia	3	7.60	.50	8.10	3.6333	3.97157
reactive phosphorous	3	261.30	17.70	279.00	105.2667	150.45911
total phosphorous	3	4.00	.00	4.00	1.6003	2.11622
total nitrogen	3	301.00	279.00	580.00	469.6667	165.80209
chemical oxygen demand	3	230.00	31.00	261.00	139.6667	115.52200
Valid N (listwise)	3					

Descriptive Statistics

	Variance	Skewness	
			Std. Error
PH	.103	1.545	1.225
Nitrate	48.263	-.594	1.225
total suspended solid	7406954.333	1.731	1.225
Ammonia	15.773	1.340	1.225
reactive phosphorous	22637.943	1.732	1.225
total phosphorous	4.478	1.458	1.225
total nitrogen	27490.333	-1.668	1.225
chemical oxygen demand	13345.333	.487	1.225
Valid N (listwise)			

Appendix 2

Rainy Season

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
PH	3	.74	7.41	8.15	7.6933	.39929
Nitrate	3	30.70	2.30	33.00	16.9333	15.40011
total suspended solid	3	445.00	29.00	474.00	186.333	249.49215
Ammonia	3	4.80	.30	5.10	2.2667	2.51462
reactive phosphorous	3	53.80	6.90	60.70	28.3333	28.51777
total phosphorous	3	3.20	.00	3.20	1.2670	1.70061
total nitrogen	3	290.00	280.00	570.00	460.0000	157.16234
chemical oxygen demand	3	504.00	185.00	689.00	368.667	278.41037
Valid N (listwise)	3					

Descriptive Statistics

	Variance	Skewness	
			Std. Error
PH	.159	1.585	1.225
Nitrate	237.163	.415	1.225
total suspended solid	62246.333	1.709	1.225
Ammonia	6.323	1.367	1.225
reactive phosphorous	813.263	1.472	1.225
total phosphorous	2.892	1.493	1.225
total nitrogen	24700.000	-1.607	1.225
chemical oxygen demand	77512.333	1.677	1.225
Valid N (listwise)			

The relationship between urban land use intensity and urban river quality The Case Study of Bulbula River

Tizita Gezahegn 1 and Hayal Desta 2

Abstract

Land use is one feature of an urbanization that can have a big impact on the quality of the surface water. Many urban rivers have been replaced by built-up areas as a result of urbanization. Rivers and water reservoirs may be impacted by pollution from both point and non-point sources. The study evaluated the land usage within the Bulbula River watershed and the associated inflow of waste into the river. Various laboratory analyses were carried out to evaluate the degree of pollution present in the Bulbula River basin. Three sample locations were used for the dry and wet seasons. The water analysis for the Bullbula River indicated that the stream is significantly contaminated by NO_3, PO_4, N, and TSS.

Key words: - Bulbula River, Urbanization, Land use Intensity, River pollution, Water quality

Introduction

The phrase "land use" refers to how people use land. It is a representation of the commercial, industrial, mining, residential, and recreational activities that are carried out in a certain location. Land use changes happen often and on a variety of scales. They can have distinct and combined effects on the quality of the air and water, the functioning of watersheds, the production of waste, the quantity and caliber of wildlife habitat, the climate, and the health of people (EPA, 2023). The phrase "land use" refers to how people use land. It is a representation of the commercial, industrial, mining, residential, and recreational activities that are carried out in a certain location. Land use changes happen often and on a variety of scales. They can have distinct and combined effects on the quality of the air and water, the functioning of watersheds, the production of waste, the quantity and caliber of wildlife habitat, the climate, and the health of people (EPA, 2023).

Changes in land use, building, and structure all have an effect on the urban environment when it comes to urban public space design. The ecosystem surrounding urban surface water is altered by land utilization in a variety of ways. A few factors in the development of urban public spaces, such as changes in land use, land structure, and construction on land, have a particular impact on the urban environment (Baojie Lei et.al, 2022). Changes in land use have the tendency to exacerbate non-point source contaminants in the watershed by strengthening soil erosion and having an impact on all the hydrological cycle's connections. The level of water contaminants is positively connected with land usage related to economic conditions and human activities. Natural woods and other undeveloped regions have higher-quality water. Nonetheless, not all land use types have the same effects on water quality (Dechao et.al, 2020).

River water quality is greatly impacted by the land use within the watershed. As human activity increases, the patterns of land cover within the watershed may alter, potentially leading to a decline in the quality of the water in rivers. The main elements impacting the hydrological system's alteration, which in turn affects runoff and water quality, have been identified as changes in land cover and land management techniques (Juan Huang et.al, 2013).

Despite being the sole city having sewer networks, Addis Abeba has a very limited sewer network coverage that accounts for 7.5% of the built-up areas. Because only parts of the city's older areas are connected to the central sewer system, both residential and commercial properties use septic tanks. The city authority is currently working to control and treat the river in Addis Ababa, including a recent massive river and waterfront development project and a few private sectors. However, these efforts are limited and do not address the city's overall pollution problem (Yonannes & Elias, 2017).

Rivers and water reservoirs may be impacted by pollution from both point and non-point sources. For example, a factory, which typically has a pipe or channel coming from it, is an example of a point source a recognized location that discharges directly into a body of surface water. Groundwater is also affected by point sources, which are places where pollutants seep into the soil and rock from a specific source, such as pit latrines, septic systems, or underground fuel tanks. Point sources include, for instance, pipes used for municipal and industrial discharge. Non-point or diffuse sources are those where pollution spreads over a wide area.

Description of the study area

One of the largest rivers in Addis Ababa City, the Bulbula River flows through the heart of the town and has many tributaries, but it gets a lot of liquid and solid waste from various sources. The river can contain (300-400 mg L-1) of all waste types, including those produced by homes, buildings, garages, gas stations, and hospitals. The primary causes of pollution in the Bulbula River are daily household refuse, industrial discharges, and waste from the Ethiopian Metal Tools Factory (Worku & Giweta, 2018).

Bulbula River runs through Addis Ababa, first through Entoto and then through the densely populated Ketchene region. The river is now known as the Ketchene River, and it merges with another creek known as Kostre at Afincho-Ber before continuing on to Ras Mekonen Bridge and the Eri-bekentu region. The river is known as Bantiketu from this point on and flows down to Estifanos Church and the Economic Commission for Africa (ECA). The river is now known as the Bulbula River after this point. This river empties into the Kebenna River before merging with the Great Akaki Rivers. (Tilahun, 2007).

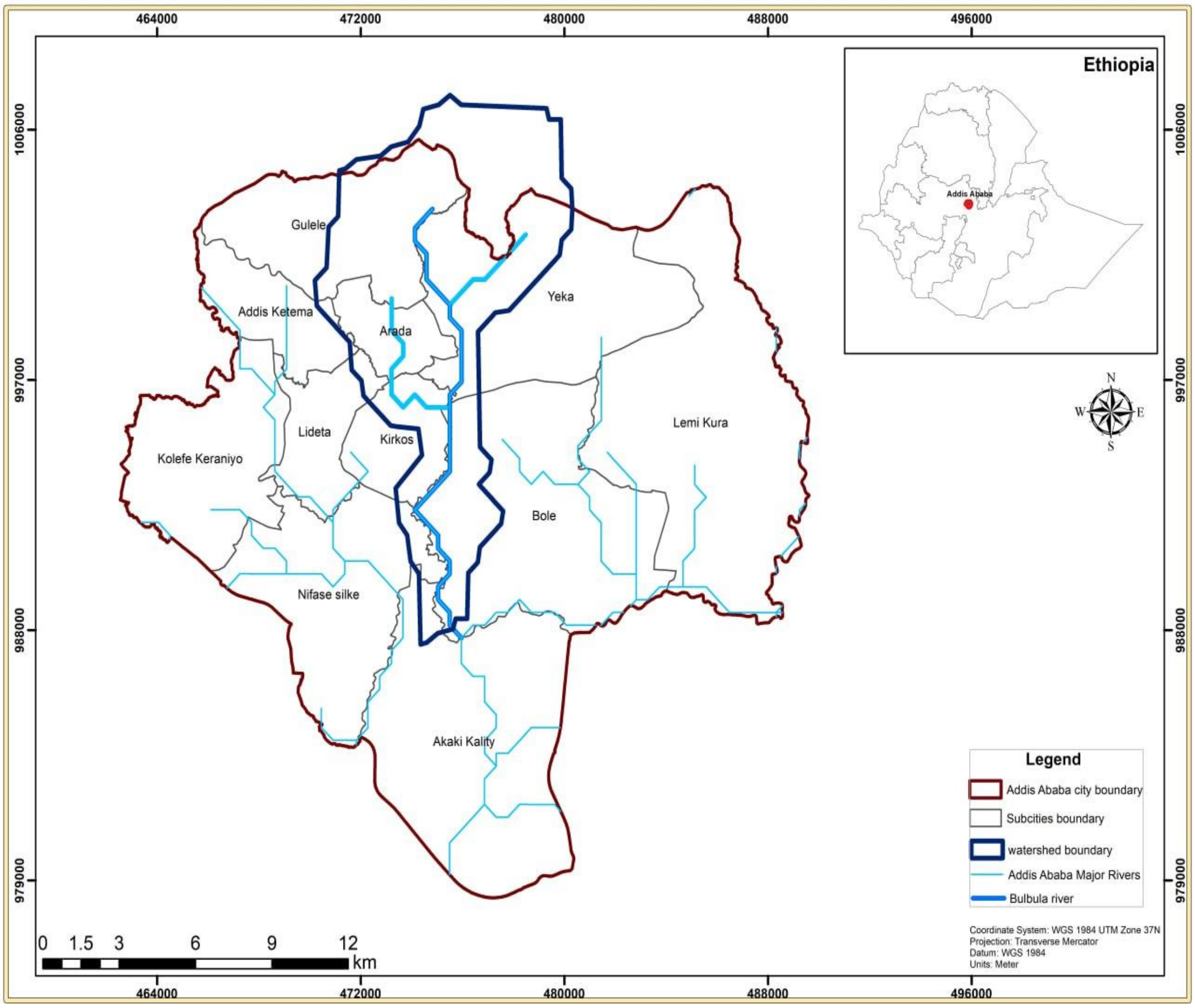


Figure 1: Location map of Bulbula River

Different land uses for different locations are shown by the land use intensity of Addis Abeba city along the Bulbula River stream. An environmentally protected region and a low density mixed residential (LDMR) area may be seen in the river's upper stream. EA-12 environmentally protected River Buffer is located in the lower stream of the river, while the middle stream is covered in Medium density mixed residential (MDMR) land use type.

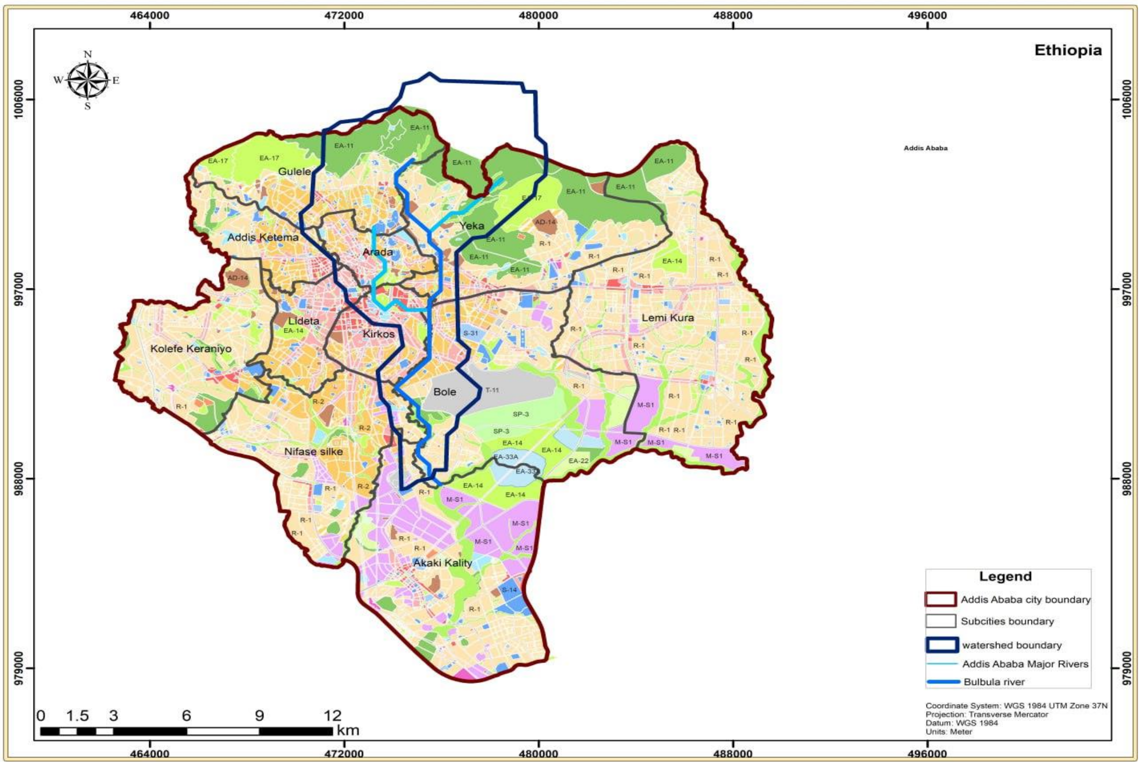


Figure 2: land use map along bulbula river stream

Material and Method

To evaluate and determine potential sources of contaminants entering the river, a reconnaissance assessment has been carried out along the stream within the research regions. This survey was carried out starting at the river's Entoto source and moving down the river to Bulbula within the study area. The research field was separated into three sections. There are three different types: upstream zones, middle or transfer zones, and lower or deport zones. The stream's headwaters are located in the upstream zone.

Water sampling locations were chosen to acquire a representative sample of the specific water quality indicators based on geographic differences in the water stream and pollution system. The sampling sites were found using GPS and hence correctly noted on the map. All analytical parameters were collected in polyethylene tubes. The sample containers were immersed in the stream directly to collect the samples.

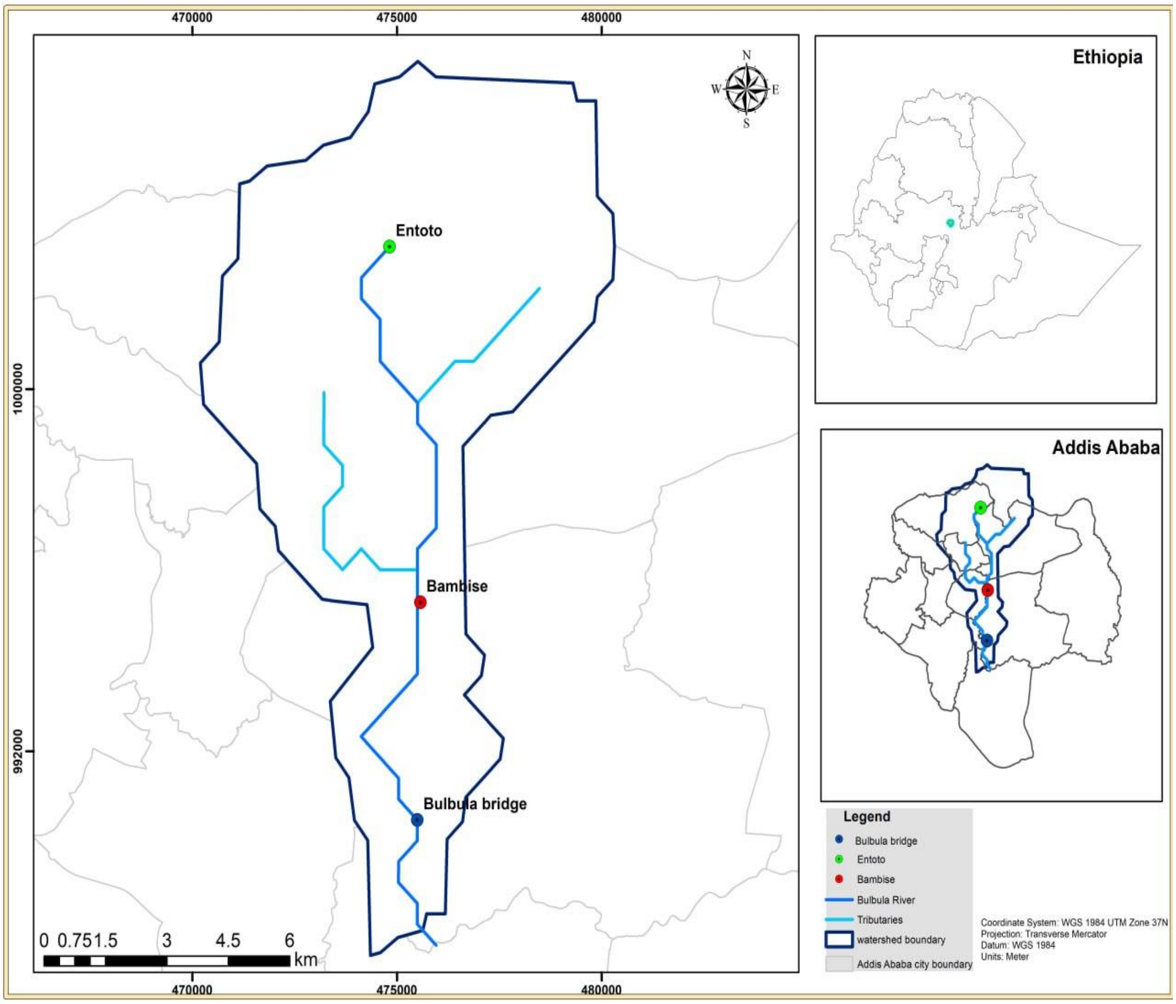


Figure 3: Sampling location map

The statistical package for social sciences (SPSS) software, version 27.0, was used to analyze the data. The variation in pollutants between each of the three zones (upper zone, middle zone, and lower zone) in water data was examined. To determine whether there are any variations between the three zones, descriptive analysis was conducted with an acceptable skewness threshold of -1.7 to 1.225.

Figure 4: Movement of pollutant across Bulbula River

Result and discussion

In many places, changes in land use and land cover are the cause of the deterioration of urban water quality. Their connections to elements of water quality such suspended solids, nutrients, and dissolved salts have been the subject of several investigations. The connections change in tandem with the biological landscape as a result of population growth and urbanization. In light of this, it can be said that urban land use, which reflects human settlement, significantly affects the concentrations of nutrients in water (Liu et.al, 2022).

Table 1: EEPA discharge limit for water quality parameters

	Sampling site						
	Wet season			Dry season			Discharge limit by EEPA
Water quality parameter	S1	S2	S3	S1	S2	S3	
PH	8.15	7.52	7.41	6.4	6.3	6.9	6.9
Nitrate (NO^{-}_{3})	33	2.3	15.5	15.1	1.3	9.6	3.1-5
TSS	56	29	474	126	197	4875	50
Ammonia (NH_3)	5.1	1.4	0.3	8.1	2.3	0.5	30
Reactive phosphorous (PO_4)	17.4	6.9	60.7	19.1	17.7	279	2
Total phosphorus (P)	0.6	<0.001	3.2	0.8	0.001	4	10
Total Nitrogen (N)	280	570	530	279	550	580	60
COD	232	185	689	31	261	127	500

NB: Values are in mg/l except for PH

The biochemical pollutants in the water samples that were collected were analyzed in laboratory tests. The pollutants included total nitrogen, total phosphorous (P), reactive phosphorous (PO4), nitrate (NO-3), ammonia (NH3), PH, TSS, and COD along the three sample sites. Typical pollutants from wastewater and household or industrial waste include organic materials, heavy metals, and microorganisms. These materials may be discharged by irrigation, runoff, or direct discharge into water, which can affect the concentration of nutrients (Nguyen et.al, 2023). According to the Bulbula watershed's land use cover, the upstream area is a low-density mixed residential area. Additionally, laboratory results indicate that the levels of nitrate, TSS (reactive phosphorus), and total nitrogen exceed the limits set by the Environmental Protection Authority.

The "Beautifying Sheger" project, which aims to revitalize the Sheger River basin, includes the middle stream of the Bulbula River, which is situated near Bambis. With the exception of reactive phosphorous, total nitrogen, and TSS, which have values that are comparatively higher than the discharge limit, the parameters of this medium-density mixed residential area are within the EPA's discharge limit. human settlement as represented by urban land use has a significant influence on water nutrient concentrations. Next, the relationships between landscape composition and water quality provide an important basis for effectively addressing urban planning and non-point sourced management problems (Liu et.al, 2022).

The analysis of water sample revealed that concentration of pollutants variety across the river stream. The analysis of water sample revealed that concentration of pollutants variy across the river stream. The value of Ammonia and Nitrate are higher in the upper stream of the river. Results show there is a high chemical oxygen demand (COD) in the middle stream than that of the other streams. The lower stream of bulbula river show higher value of Reactive phosphorous, PH, total phosphorous & nitrogen and total suspended solid. The concentration of pollutants varies in rainy season as well. The upper stream in this season show higher values in PH, Ammonia and nitrate. As of the middle stream it shows a greater value in total nitrogen. Total suspended solid, reactive phosphorous, total phosphorous and chemical oxygen demand show a greater value in the downstream of Bulbula River than that of the other two zones.

PH

The PH of Bulbula River shows variation between the two seasons and the corresponding sample sites. As for the Dry season PH of Bulbula river lower value at the middle zone which is 6.3, 6.4 at the upper zone and 6.9 at lower zone. (Table 1). The PH value for Rainy season is 8.15 at the upper zone, 7.52 at middle zone and 7.41 at lower zone of the river, slightly higher at the upper zone (Table 1). Most naturally occurring waters have a PH between 6.0 and 8.5. (Chapman.D, 1992). Water's acidity or alkalinity is gauged by its PH. The major purpose of PH is to quickly assess any potential water abnormalities. The PH value for three zones throughout the course of both seasons is the natural range of water as a result.

Nitrate (NO_{-3})

Due to the rapid conversion of nitrite to nitrate, nitrate is the molecule that occurs most frequently in groundwater and surface waters. By contaminating water with fertilizers that include nitrogen, the amount of nitrate in the water can rise. (Such as potassium nitrate and ammonium nitrate), as well as organic waste from people or animals. Both the dry and the wet seasons exhibit a comparable change in nitrate content. Since $NO\text{-}_3$ values are greater in the upper stream of the Bulbula River, they are 15.1 and 33 for the dry and rainy seasons, respectively. The middle stream in Addis Ababa, which is a heavily inhabited area, exhibits a somewhat lower concentration than both the upper and lower stream, 1.3 and 2.3 for the dry and rainy seasons, respectively, due to the continuous urban renewal effort around rivers. For both the dry and wet seasons, the lower stream of the river has a value of $NO\text{-}_3$ that is higher than the middle stream and lower than the upper stream, respectively, 9.6 and 15.5. Nitrate levels between 3.1 and 5.0 mg/L are regarded as fair, over 5.0 mg/L as bad or hazardous for consumption, and concentrations above 10 mg/L can result in methemoglobinemia (blue baby syndrome) (Enviro sci Inquiry, 2000-2011).

Total suspended solid (TSS)

The turbidity (cloudiness) of the water is frequently linked to TSS readings. If TSS is elevated and the water is muddy light from the sun will not enter the water adequately, making it more difficult for plants and algae to flourish. TSS could be any substance that floats or "suspends" in water, such as sand, silt, and plankton. Typically, suspended solids are the organic particles that get released into water bodies when perished plants or animals contaminate various water sources. Other TSS may float to the top or remain suspended somewhere in the middle, while some silt may sink to the bottom of a body of water. TSS affects water clarity; as a result, the amount of TSS in a water supply affects how clear it is (Campbel, 2021).

Strong wastewater has a TSS greater than 220 mg/L, medium wastewater has a TSS greater than 100 mg/L but less than 220 mg/L, and weak wastewater has a TSS less than 100 mg/L, according to published research (Reda, 2016). According to the findings of this study, the Bulbula River is more polluted throughout the dry season of the year. Results indicate a high amount of contamination during the dry season, with values for the three stream zones of the Bulbula River being 126 mg/L, 197 mg/L, and 4875 mg/L. The results of the Bulbula River during the wet season demonstrate relatively less contamination in the upper and lower zones along the stream. Upper, middle, and lower streams have values for the three zones of 56, 29 and 474, respectively. Except for the middle of the rainy season, all sampling stations' TSS readings were greater above the FEPA (30 mg/L) and EEPA (50 mg/L) discharge limits.

Ammonia (NH_3)

When the water's ammonia levels are high enough, aquatic organisms cannot adequately remove the toxin, which leads to toxic buildup in internal tissues and blood and possible death. The manufacturing of ammonia is necessary for industrial applications such as commercial fertilizers. Natural sources of ammonia include nitrogen fixation processes, gas interaction with the atmosphere, forest fires, human and animal waste, and the decomposition of organic waste. Both direct and indirect ammonia entry sites exist in aquatic environments. Wastewater from municipalities discharges, thus animal excretion of nitrogenous waste, and air deposition are some sources of ammonia that enter the environment directly (EPA, 2023). The findings of this investigation indicate that the concentration of ammonia is somewhat below the 30 mg/L discharge limit set out by the EEPA. Because of this, the river is not in risk from a high ammonia concentration in any of the three zones during the dry or wet seasons.

Reactive phosphorous (PO_4)

Reactive phosphorous (phosphate), which is caused by humans, can be found in pet waste, fertilizer, farmland and urban runoff, industrial and home sewage, and malfunctioning or overburdened septic systems. The majority of the time, it is thought that phosphates are mostly produced from wastes emitted by municipal solid and liquid wastes. Phosphate levels in the Bulbula River have varied from upper to lower stream. The results are higher in the upper and lower stream, but the values are comparatively lower in the wet and dry seasons. Phosphates are typically thought to be primarily produced from wastes emitted from municipal solid and liquid wastes.

The values for the upper, middle, and lower streams of the Bulbula River during the wet season are 17.4 mg/L, 6.9 mg/L, and 60.7 mg/L, respectively. Accordingly, during the dry season, the results for upper, middle, and lower streams are 19.1 mg/ L, 17.7 mg/ L, and 279 mg/ L, respectively. The maximum permitted phosphate concentration in irrigation water is 2 mg/lt (Abdallah & Bader , 2011).

Total phosphorous

The primary sources of phosphorus in water from waste include human waste, household detergents that contain phosphorus, and some industrial and commercial effluents. If combined sewer systems are used, rainfall runoff has a negligible contribution to P-loads in wastewater. Phosphorus concentrations along the wastewater channel (stream) ranged from 0.6 mg/L in the upper stream, 0.001 mg/L in the middle stream, and 3.2 mg/L during the rainy season. Results for dry season also have a slight difference starting from 0.8mg/L in upper stream to 0.001mg/L at middle and 4mg/L at lower stream of the river. The value of phosphorous is below the limit that is stated by EEPA (EEPA, 2001), which is 10mg/L for both dry and wet season along the three zones.

Total Nitrogen (N)

The nitrogen flow into waters has been considerably accelerated by human activity, which has led to a decline in water quality. The condition of surface water in dry places requires regular observation due to the water crisis caused by nitrogen pollution. Despite the fact that various studies have shown that land use patterns frequently affect the nitrogen content of streams. Industrial, municipal, residential, and agricultural sources all contribute to the anthropogenic nitrogen that enters our rivers. Another significant anthropogenic source of nitrogen that enters surface waters is nitrogen deposition from the burning of fossil fuels in the atmosphere. Additionally, point sources (like municipal wastewater treatment facilities) and non-point sources (such agricultural practices and atmospheric deposition) are used to categorize chemical inputs to aquatic bodies (Yuxian et al., 2021). Results from this study shows a high concentration range of total nitrogen for both wet and dry season along the river stream. Dry season total Nitrogen values are rather higher than the limit stated by EEPA which is 60mg/L. 279mg/L upper stream ,550mg/L middle stream and 580mg/L for lower stream (table 1). For wet season nitrogen concentration also shows higher values which are greater than the limit stated by EEPA. 280mg/L, 570mg/L and 530mg/L for upper, lower and middle zone respectively. Study results also show higher values in the middle stream for both seasons.

Chemical oxygen demand (COD)

The study's findings indicate that the chemical oxygen demand during the dry season is lower than the EEPA-mandated level of 500 mg/L. The levels in the upper and middle zones are within the permitted range for the rainy season (232 mg/L and 185 mg/L, respectively), while the lower stream value of 689 mg/L is beyond the permitted limit.

Conclusion

The physicochemical parameters investigated in this study revealed that almost all effluent characteristics were above the Environmental Protection Agency's (EPA) provisional discharge limit, indicating poor treatment mechanisms used by various factories around the river and uncontrolled municipal discharges to the river. The majority of the physicochemical characteristics in the river water were likewise above the discharge limit. In general, rapid and uncontrolled urbanization leads land use change, which leads to uncontrolled factory construction and unplanned waste water disposal systems, which leads to the disposal of untreated waste water into rivers that surround cities and have direct or indirect connections with society, thereby affecting the surrounding environment.

Bibliography

Abdallah , A., & Bader , A.-A. (2011). Comparison between the irrigation qualities of conventional tertiary and UF + RO advanced treated wastewaters. *Agricultural Sciences*.

Abebe, M. (2018). Challenges and practice of Plastic Bottles, paper and carton Generation and Collection in Addis Ababa City, Ethiopia. *European journal of researh*.

Abrha, B., & Chen, Y. (2017, June 28). Analysis of Physico-Chemical Characteristics of Effluents from Beverage Industry in Ethiopia. *Journal of Geoscience and Environment Protection, 5*, 172- 182.

Awad, A., & Firas , A. B. (2018, May). ENVIRONMENTAL IMPACTS OF MEDICAL WASTE TREATMENT AND MANAGEMENT BY BURNING INSIDE HEALTH FACILITIES. *International Journal of Civil Engineering and Technology (IJCIET), 9*(5), 51-53.

Baojie Lei et.al. (2022, May 29). Prediction of the Impact of Land Usage Changes on Water Pollution in Public Space Planning with Machine Learning. (P. N. Mahalle, Ed.)

Campbel, B. (2021). what are total suspended solids. *Utility management*.

Chamara P. , L., & Koichi , Y. (2017). Impact of Population Growth on the Water Quality of Natural Water Bodies. *sustainability*.

Chang Xia et.al. (2020, January). Analyzing spatial relationships between urban land use intensity and urban vitality at street block level: A case study of five Chinese megacities. *193*.

Chapman.D. (1992, January). Water Quality Assessments: A Guide to the Use of Biota, Sediments and Water in Environmental Monitoring.

Dechao et.al. (2020). A Study on the Relationship between Land Use Change and Water Quality of the Mitidja Watershed in Algeria Based on GIS and RS. *sustainability*, 20.

Earth:Urbanization. (n.d.). (HANDWIKI, Producer) Retrieved from https://handwiki.org/wiki/Earth:Urbanization: https://handwiki.org/wiki/Earth:Urbanization

EEPA. (2001). Situation Analysis; the Industrial Sector.

Enviro sci Inquiry. (2000-2011). *LEO Envirosci inquiry*.

(2023). *EPA.* United states environmental protection Agency.

EPA. (2023). Aquatic life criteria . *EPA, United states Environmental protection Agency*.

Gupta, A. (2016). Water pollution source effect and control. *pointer publishers jaipur*.

Iacoba, S. (2013). The Wastewater - a Problem of Integrated Urban Water Management. *International Economic Conference of Sibiu 2013 Post Crisis Economy: Challenges and opportunities* (pp. 436-443). Sibiu: Elsevier B.V.

Ismael et al. (2022). Assessment of urban river water pollution with urbanization in East Africa. *Environmental Science and Pollution Research*, 40812–40825.

Juan Huang et.al. (2013, july 1). Evaluation of the Impacts of Land Use on Water Quality: A Case Study in The Chaohu Lake Basin. *The Scientific World Journal, 2013*, 7.

Liu et.al. (2022). Urban Land-Use Type Influences Summertime Water Quality in Small- and Medium-Sized Urban Rivers: A Case Study in Shanghai, China. 14.

Malin , E., & Jonathan , s. (2019). *Causes and impact of surface water pollution in Addis Ababa Ethiopia.* Uppsala: the Department of Earth Sciences, Uppsala University,.

Mark, E., & Helen, M. (2012). Rediscovering the value of urban rivers. *Urban Ecosyst*.

Maryna et.al . (2021). Urbanization: an increasing source of multiple pollutants to rivers in the 21st century. *npj Urban Sustainability*.

Meghdad et al. (2013). A comparison between extended aeration sludge and conventional activated sludge treatment for removal of linear alkylbenzene sulfonates (Case study: Kermanshah and Paveh WWTP). *Desalination and water treatment*.

Moriken et.al. (2019). Impact of land use on water quality in Malaysia.

Narwaria , & kush. (2012). Environmental assessment of air pollution on road side plants species at dehrdun, uttrakhand, India. *Journal of Environmental Research and Development, 7*(2), 710-714.

Nguyen et.al. (2023). nfluences of key factors on river water quality in urban and rural areas: A review. *Case Studies in Chemical and Environmental Engineering*.

Nicoli, T. (2022). The value of urban rivers:European experiences and a south american perspective. *Urban design lab*.

Osibanjo, O., & Ajayi, S. (1981). Pollution Studies on Nigeria Rivers: Water Quality of Some Nigeria Rivers. *Environmental Research Series B, II*, 87-95.

Pattacini, L. (2021). Urban Design and Rivers: A Critical Review of Theories Devising Planning and Design Concepts to Define Riverside Urbanity. *Sustainability*.

Preisner, M. (2020, july18). Surface Water Pollution by Untreated Municipal Wastewater Discharge Due to a Sewer Failure. *Environmental Processes*, 767-780.

Rai, M. S. (2017). Impact of Urbanization on Environment. *International Journal on Emerging Technologies*, 127-129.

Reda, A. H. (2016). Physico Chemical Characterization of Tannery Effluent and Its Impact on the Nearby river. *Open Access Library Journal, 3*.

Rodriguez, R. S. (Ed.). (2007). *Urbanization, Global Environmental change and sustainable development in latin America.* (L. S. Fernández, Trans.) São José dos Campos, Brazil: Digital Graf Press.

Sanyaolu, P. S. (2018). Urbanization.

Satyavati et.al. (2013). Effects of Increasing Urbanization on River Basins- State of Art. *International Journal of Engineering Research & Technology (IJERT)*, 2742-2747.

Teklehaimanot.R. (2005). Program on the sustainable consumpion and production in the Akaki River Basin. A situation Analysis of the Akaki River. 1-99.

Teshome et.al. (2020, november 25). An overview of water pollution status in Ethiopia with a particular emphasis on Akaki River:A Review.

Tilahun, D. (2007). *The Role of Arundo donax in riparian vegetation in mitigating river pollution in Addis Ababa: the case of bulbula river.*

Timar , P. M., & Milkiyas , P. M. (2019, October 31). Industrial Wastes and Their Management Challenges in Ethiopia. *Chemistry and Materials Research, 11*.

Viacheslav et al. (2018). Megacities 2050:Environmental Consequences of urbaniation. *International Conference on Landscape Architectureto Support City Sustainable development.* Switzerland: Springer International Publishing.

Wambebe , N., & Xiaoli , D. (2021, April). Environmental Pollution and Health Effects -Addressing Pollution (Air, Water and Noise) Challenges in Africa and Possible Solutions Towards Attaining Sustainable Green Environment. *International Journal of Environmental Sciences & Natural Resources, 27*(4), 1-8.

weldetsadik et.al. (2018). Farmers' perceptions on irrigation water contamination,health risks and risk management measures in prominent wastewater-irrigated vegetable farming sites of Addis Ababa, Ethiopia. *Environmental systems a d decision, 38*, 52-64.

Worku , Y., & Giweta , M. (2018). Can We Imagine Pollution Free Rivers around Addis Ababa city, Ethiopia? What were the Wrong-Doings? What Action Should be Taken to Correct Them? *Journal of Pollution Effects & Control*(3).

WWD. (2010). *World Water Day ; Africa's water quality.* RSC.

Xizhe et al. (2018). *Urbanization and its consequence.* Encyclopedia of Life Support Systems (EOLSS).

Yonannes, H., & Elias, E. (2017). Contamination of Rivers and Water Reservoirs in and Around Addis Ababa City and Actions to Combat It. *Environment Pollution and Climate Change, 1*(2), 13 pages.

Yuxian et al. (2021). Human Activities Increase the Nitrogen in Surface Water on the Eastern Loess Plateau. (Y. Xue, Ed.)