CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

FACULTY OF FORESTRY AND WOOD SCIENCES

Assessment of water eutrophication on Boyo Lake Ethiopia

MASTER'S THESIS

Prague 2022

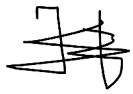
Author: **Haydiso Bereket**

Chief supervisor: doc. Ing. Jakub Štibinger, CSc.

Declaration

I hereby declare that this master's thesis, titled " Assessment of water eutrophication on Boyo Lake Ethiopia by chemical and physical evaluation" is my own dissertation, completed under the supervision of my thesis supervisor and consultant and that all sources have been referenced and accepted using full references. As the author of the thesis, I announce that I did not infringe on any third-party copyrights while writing it.

In Prague date



30/03/2022

Bereket Haydiso

Acknowledgments

In the beginning, I would like to thank Almighty God, for giving me much love and strength to keep going through all the difficulties. I have experienced your guidance day by day. Then I would like to acknowledge and give my warmest thanks to my supervisor Prof. Doc. Ing. Jakub Štibinger who made this work possible. My project would not have been possible without his guidance and advice. In addition, I would also like to thank my consultant and advisor Prof. Adane Woldemedhin Kalsido for your consistent support and guidance during the running of this project. Finally, I would also like to give special thanks to my wife Beza Zelalem, my dearest son Yeamlak Bereket and my family as a whole for their continuous support and understanding when undertaking my research and writing my project. It has been your prayers that have kept me going thus far. In the end, I will close by saying Thank you Jesus.

Abstract

Eutrophication is one of the most complex forms of water pollution, caused by the high level of nutrients in the water, mainly phosphate and nitrate. In most developing countries like Ethiopia, Runoff is collected from agricultural areas during rainfall and irrigation activities from different catchments flowing directly to receiving water bodies without treatment. Nutrients like nitrogen and phosphorus that are carried away from main agricultural farming areas by runoff directly flow into the water bodies like rivers and lakes. Eutrophication of lakes and deteriorating water quality have become major environmental problems in urban areas and fertilized basins in developing countries worldwide. The purpose of this paper is to illustrate the effect of excessive fertilizer use on receiving water bodies at Boyo Lake in Ethiopia and suggest a solution to reduce the excess nutrients flowing to water bodies. The paper compared the water quality standard of WHO freshwater nutrient guidelines with the Eutrophication standard of Boyo lakes and evaluated the degree of eutrophication of the lakes. Further, the show recommended best practices to prevent Lake Eutrophication. This paper has advanced the assessment of water eutrophication from simple individual parameters like total phosphorus and total nitrogen. Also, evaluate the water chlorophyll-a level. However, further studies are needed to determine how eutrophication affects biomass and species composition in this lake.

Keywords: Eutrophication, Nutrient enrichment, Water quality, fertilizers, nitrogen and phosphorus. Trophic level

Table of **Contents**

Contents

List of tables

List of figures

List of APPENDEX

List of the abbreviations used in the thesis

Chl a	Chlorophyll-a
CO_2	Carbon dioxide
CWs	Constructed wetlands
DAP	Diammonium phosphate
DIN	Dissolved inorganic nitrogen
DO	Dissolved oxygen
EFASA	Ethiopian Fisheries and Aquatic Sciences Association
HABs	Harmful algal blooms
H_2O	Water
N	Nitrogen
NH3	Ammonia
NO_2	Nitrite
NO3	Nitrate
O_2	Oxygen
P	Phosphorus
SDG	Sustainable development goals
SNNPR	South nation nationality people region
TKN	Kjeldahl nitrogen
TN	Total nitrogen
TNI	Total Nutrient Index
TP	Total Phosphorus
TSI	Trophic Status Index
US EPA	United State Environmental Protection Agency
WHO	World health organization

1. Introduction

A water body covers three-quarters of Earth's surface, contains 97 percent of the Earth's water, and occupies 99 percent of all living space by volume. The oceans absorb about 30% of the carbon dioxide humans produce, protecting the Earth's climate. Sustainable development goals (SDG) 14 aims is water bodies drives global systems that make the Earth habitable for humankind (SDG 2022). The water bodies provide and regulate our rainwater, drinking water, weather, climate, coastlines, much of our food, and even the oxygen we breathe. Saving our water must remain a priority. Eutrophication is the process and condition, which occurs when a body of water receives excess nutrients, thereby promoting excessive growth of plant biomass (Fareed and Abid 2005). As the algae die and decompose, decomposing organisms deplete the water of available oxygen, causing harm or death to other organisms, such as fish. Eutrophication is a process that results from the accumulation of nutrients in lakes or other water bodies. Eutrophication is a natural process but can be greatly accelerate by human activities and excessive use of chemical fertilizers that increase the rate at which nutrients enter the water (Khan 2014).

Algae growth limited by the available supply of phosphorus or nitrogen, so if excessive amounts of these nutrients added to the water, algae and aquatic plants can grow in large quantities (Ron , Geoff and Ben 2011). When these algae die, they decomposed by bacteria, which use dissolved oxygen. This process called Eutrophication. Dissolved oxygen concentrations can fall too low for fish to breathe; resulting in fish kills. Rapid decomposition of dense algae scums with associated organisms can give rise to foul odor.

Eutrophic waters characterized by high nutrient concentrations, resulting in high productivity of plant growth (Zublee 2010). Such waters are usually shallow, with algal blooms and periods of oxygen insufficiency. Relatively eutrophic water can support a complex plant and animal life web. These Waters are generally unwanted for drinking water and other needs. Waters with excessive nutrient concentrations are called hypereutrophic. Plant productivity is average in oligotrophic waters due to low nutrient concentration (Mueller and Helsel 1996). An oligotrophic lake is one that has low nutrient levels and is therefore inadequate for the development of aquatic plants and animals. Lakes of this type typically have deep bottoms, little plant life, high dissolved oxygen levels, and sandy bottoms. Lakes with phosphorus concentrations below 0.010 mg/L classified as oligotrophic, phosphorus concentrations between 0.010 and 0.020 mg/L are indicative of mesotrophic lakes, and eutrophic lakes have phosphorus concentrations exceeding 0.020 mg (Zublee 2010) .

1.1 General

Water is an abundant natural resource and life-sustaining liquid. Water management involves planning, distributing, and maximizing water resources according to defined policies and regulations (Swamulu 2018). Using chemical fertilization necessary practice and significantly increased crop yields. Without fertilizer, we would not be able to feed the global population. The main fertilizer elements are phosphorus, nitrogen, and potassium compounds, but many fertilizers are nitrogen-based. Nitrogen is an essential nutrient for plants, as plants do not receive all of it naturally. However, it known that an excess of nitrogen has shown to be a bad thing; another reason that fertilizer can be hazardous is that it contaminates groundwater. Nitrogen leaching occurs when dissolved nitrogen leaves the root zone and flows into groundwater or other freshwater sources, such as lakes and streams. Fertilizer is also susceptible to runoff, leading to the contamination of running water. These factors make runoff collected from agricultural areas during rainfall and irrigation activities from different catchments ultimately return to receiving water bodies. When Farmers use artificial fertilizer, Agricultural wastewater may contain high levels of the nutrients nitrogen and phosphorus. Eutrophication can result from the excess release of nutrients into the environment.

Currently, approximately 40% of lakes and reservoirs worldwide affected by different degrees of eutrophication (Istvánovics 2009). A complex form of water pollution, eutrophication, occurs due to the high amount of nutrients in the water, particularly phosphates and nitrates, which come from fertilizer runoff from agricultural land and untreated disposal of agricultural, domestic, and industrial wastewater.

1.2 Most common method to prevent Lake Eutrophication

During eutrophication, lakes receive nutrients (phosphorus and nitrogen) and sediment from the surrounding watershed and become more fertile and shallow. Therefore, reducing the amount of nutrients and sediment added to the lake can slow eutrophication.

- The following is a list of methods that can be used to control eutrophication:

1. **planting vegetation along streambeds to slow erosion and absorb nutrients.**

Root systems of trees, shrubs, and grasses bind and hold the bank together much in the same way those reinforcements improve the strength of concrete. When streams and rivers run fast after heavy rain, vegetation helps absorb the force of the flow and reduces the erosion caused by the water. In addition, vegetation on the banks and within the stream provides shade and shelter for aquatic and terrestrial fauna. Finally, grasses and other groundcover plants help filter sediment, nutrients, and pollutants before entering streams. In this way, vegetation serves as a buffer for our streams, preventing algal blooms and toxins. There is increasing recognition of stream bank vegetation's essential functions and its aesthetic appeal.

Figure 1 Planting vegetation along streambeds (Million Metres Streams Project 2017)

2. **controlling application amount and timing of fertilizer**

Limited knowledge on fertilizer use and management among the farmers and high market prices of mineral fertilizers constrained their usage (Peter , et al. 2015). Farmers purposely over-fertilize their land in developing countries to avoid losing it to runoff or groundwater. The nitrogen from fertilizer contaminates the water bodies and affects surrounding plants, and it affects the animals and people that drink that water. The runoff contaminates other freshwater bodies and the animals who drink it. Things are getting worse. The timing of fertilizer application could be an indicator of improved farming practices. Currently, most farmers have lack awareness of for timing of fertilizers. It is best to fertilize landscape plants when they begin to grow actively.

3. **controlling runoff from Farming land**

Runoff collected from agricultural areas during rainfall and irrigation activities from different catchments must ultimately return to receiving water bodies. However, when well-planned and managed, the farming land can minimize the risk of water entering the farmland, the amount of water running off from a precipitation event, and the potential for pollution. The advances made in agricultural activities and extensive use of artificial fertilizers and insecticides are the main factors that may cause serious pollution of surface waters. Plants need several things to grow, like nitrogen and phosphorus. Plants get the entire required nutrient from the soil through the root. When the soil affects erosion and leaching, use artificial fertilizer in agricultural activities. However, the case is many farmers use this fertilizer with the excess amount. This nutrient mixes with rainwater in the rainy season or irrigation system and finds its way to the water body like ponds, lakes, rivers, and oceans. In addition to converting sunlight into usable energy, phosphorus is essential to cellular growth and reproduction. A hard surface permits the cleaning operation to done without forming pockets that collect leachate or change the flow of runoff. Runoff water should collected and stored, or treated. Gravity flow to an appropriately sized waste storage facility is preferred if it is to be held. If the runoff is treated, pretreatment by settling to remove most of the solids, nutrients, and topography is helpful for barnyard construction. Various management practices are available to collect and treat the runoff from barnyards and farmland.

The best, easiest, and most efficient way to prevent eutrophication is by preventing excess nutrients from reaching water bodies. This done in a number of ways, the simplest of which is just being aware of the chemicals and fertilizers that we are using.

Environmentally friendly (eco-friendly) processes are sustainability and marketing terms that refer to goods, services, laws, guidelines, and policies that reduce, minimize, or do not harm ecosystems.

The most common and best eco –friendly method used treating Agricultural wastewater

1) Constructing a Denitrifying Woodchip Bioreactor

An efficient way of removing nitrate from wastewater and agricultural drainage waters is to use a denitrifying bioreactor. Simply, these are structures containing a slowly degrading carbon source, such as woodchips, through which water-containing nitrate passed. Denitrifying woodchip bioreactors filters provides a unique, engineering approach for dual nutrient removal from waters impaired with both nitrogen and phosphorus (Laura , et al. 2017) . The primary purpose of a wood chip bioreactor is to remove nitrates from subsurface tile drainage water at the edge of a field prior to the water entering a ditch or a stream. The bioreactor is made up of a trench buried with woodchips where tile water flows before entering a surface body of water. Microorganisms from the soil colonize the woodchips. These microorganisms eat carbon from the wood chips, and nitrate from the water breathed in.

2) Constructed wetlands

Constructed wetlands (CWs) “eco-friendly” planned systems designed and constructed to employ wetland vegetation to assist in treating wastewater commonly agricultural wastewater in a more controlled environment than natural wetlands. CWs remove organic materials, suspended solids, nutrients, pathogens, heavy metals, and other hazardous pollutants. Constructed wetlands are relatively inexpensive to construct and operate, easy to maintain, provide effective wastewater treatment, are relatively tolerant of fluctuating hydrologic and contaminant loading rates, and provide indirect benefits such as green space, wildlife habitats, and recreational and educational facilities. The experimental constructed wetlands with horizontal flow surface in combination with low inflow loadings the nutrient loads sequestered in the aboveground biomass amounted to 62% of removed nitrogen and 58.2% of removed phosphorus. (Vymazal 2020).

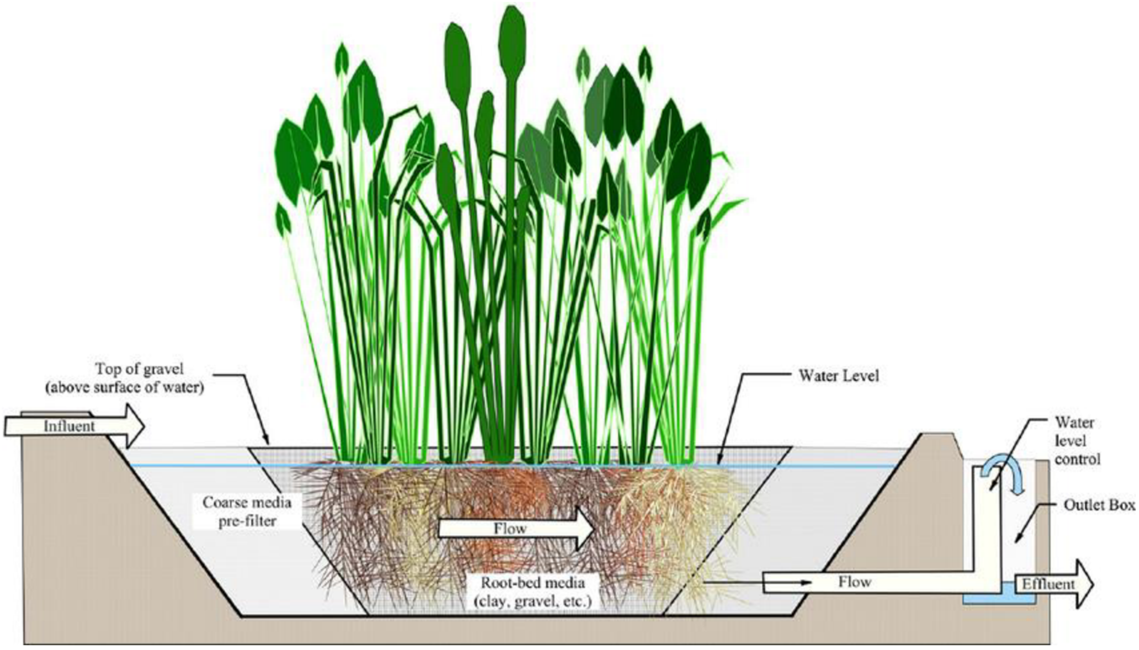


Figure 2 Water flow path through a subsurface flow constructed wetland (Sarah 2013)

1.3 Current Eutrophication prevention method in Ethiopia

More than 80% of the Ethiopian population lives in rural areas, where livelihoods based on agriculture information from the central statistics Authority in 2017. Ethiopia is deteriorating due to economic growth, unwise use, and eutrophication. The trophic state of all major Ethiopian lakes considered in the present assessment ranges from eutrophic to hypereutrophic (Tadesse 2019). A major cause of eutrophication is the use of chemical fertilizers that have grown to >186 times in 2012 than of the 1970s (Tadesse 2019). To control eutrophication and avoid its devastating consequences, raising public awareness, creating buffer strips, development of chemical fertilizer use guidelines based on plant removal rates and soil types, wastewater treatments, issuance of policy on Water Quality Guidelines, and the establishment of a National Aquatic Ecosystem Monitoring Program are recommend. Agriculture, the mainstay of the country, has been intensified and inputs, including chemical fertilizers and pesticides, have increased over the past decade. All these activities, however, produce large volumes of solid and liquid wastes that tremendously affect the water quality of our freshwaters upon their introduction into the ecosystem. Traditionally most farmers used planting vegetation at the border of their farming land to prevent both eutrophication and soil erosion. However, most parts of the country farmers obtains most of the water for their crops from rain. Rainwater that is not absorbed by the soil and plant roots runs into streams and rivers. Nutrient losses from sloping farmland areas lead to the decline in land productivity and nonpoint source pollution. The losses of total nitrogen and total phosphorus, in surface and underground runoff initially increased and then gradually stabilized with the extension of rainfall duration and increased with increasing rainfall intensity and the amount of nutrient runoff.

2. Objectives

Eutrophication is one of the most complex forms of water pollution, caused by the high level of nutrients in the water, mainly phosphate and nitrate. In most developing countries like Ethiopia, Runoff collected from agricultural areas during rainfall and irrigation activities from different catchments flowing directly to receiving water bodies without treatment. Nutrients like nitrogen and phosphorus that carried away from main agricultural farming areas by runoff directly flow into the water bodies like rivers and lakes. Eutrophication of lakes and deteriorating water quality have become major environmental problems in urban areas and fertilized basins in developing countries worldwide. The complex question of which contaminants in agricultural wastewater must remove is to protect the environment (water bodies) and to what extent must answered specifically for each case. Mostly agricultural Wastewater may contain high levels of the nutrients nitrogen and phosphorus. Farmer used artificial fertilizer in agricultural activities. This nutrient mixes with rainwater during the rainy season or in the irrigation system and finds its way to the water body like ponds, lakes, rivers, and oceans. The main objective of this paper has advanced the assessment of water eutrophication from simple individual parameters like total phosphorus, total nitrogen and chlorophyll-a. The paper compared the water quality standard of WHO freshwater nutrient guidelines with the Eutrophication standard of Boyo lakes and evaluated the degree of eutrophication of the lakes. In addition, suggest a solution to reduce the excess nutrients flowing to water bodies. However, further studies are need to determine how eutrophication affects biomass and species composition in this lake. However, the case is many farmers use this fertilizer with the excess amount.

3. Literature Review

3.1 Eutrophication

Eutrophication of a lake is a process in which a lake accumulated excessive amounts of plant nutrients (Ayele and Atlabachew 2021). The word originally comes from the Greek word eutrophos meaning “well nourished” (Fageria 2009). Eutrophic lakes are usually overly nutrient-rich due to runoff from fertilized land, sewage effluent, and human residential and industrial settlements, which promote the growth of algae and other plant life in the water, which depletes the lake of oxygen. A chemical engineer defines eutrophication as the growth of vegetation in a particular area of a lake due to the runoff of nutrients (Pathak and Pathak 2012). According to ecologists, eutrophication is the disturbance of the aquatic ecosystem with excessive nutrients, resulting in the rapid growth of algae and the loss of oxygen. As defined by Limnologists, organic matter defined as "an increase in the rate of supply of organic matter to an ecosystem." In water bodies, the term "organic substance" refers to carbon-based compounds in living or previously living organisms and their leftover products (Ayele and Atlabachew 2021).

The environmentalist defines it as a common phenomenon of nutrient enrichment in enclosed lakes and estuaries due to a combination of agricultural runoff and human settlement (Karydis 2009). Biologically, eutrophic lakes are lakes where there is an abundance of food (nutrients) that favors the growth and development of plants and algae rapidly (Ayele and Atlabachew 2021). Therefore, the fact that different experts interpret and understand eutrophication differently makes its definition and characterization of Lake Eutrophication unclear and biased. Nevertheless, in general, the criteria seem more or less similar, except that specific criteria depend on the location and geography where the lake is located. Eutrophication in aquatic environments, including lakes, is characterized by nutrient enrichment, increased primary productivity, hasty algal growth, changes in species composition of algae and higher plants, considerable changes in the dissolved oxygen curve (concentration), and changes in fauna biodiversity (Ayele and Atlabachew 2021).

These criteria categorize the trophic status of lakes from abiotic elemental viewpoint into five categories: high, good, sufficient, poor, and bad ecological status. In this classification, the high environmental status lake has an almost undisturbed biological a serious alternation of physical quality elements.

According to their study there identified three main criteria for the degree of eutrophication levels., total phosphorus concentration, mean chlorophyll concentration, and mean Secchi disk visibility were criteria to classify lake and reservoir as ultra-oligotrophic, oligotrophic, mesotrophic, or hypereutrophic (Ayele and Atlabachew 2021). Oligotrophic lakes had low nutrient enrichment and primary productivity, high clarity, and a diverse biota. Generally, eutrophic lakes are enrich in nutrients and have high primary productivity, low transparency, and high biomass of fewer species with a relatively high proportion of cyanobacteria. Thus, both of the above characterizations' strategies have no delimited scale for each trophic status level since both are qualitative and interpreted moderately to classify lakes at different trophic levels.

3.2 Sources of Eutrophication

Nutrient pollution released to freshwater and coastal areas comes from various sources, including agriculture, aquaculture, septic tanks, urban wastewater, urban storm water runoff, industry, and fossil fuel combustion (Eutrophication and Hypoxia 2010). Nutrients enter aquatic ecosystems from the air, surface water, and groundwater. There are significant variations in the relative importance of nutrient sources from region to region. For example, in Africa, agricultural sources, chemical fertilizers, and animal manure are typically the primary sources of nutrient pollution in waterways. At the same time, urban wastewater is often a primary source of nutrients in the coastal waterways of Africa.

Generally, the source of eutrophication classified in to three main source (Lin, et al. 2021)

1. Agricultural Sources
   - Chemical fertilizers
   - Manure
   - Aquaculture
2. Urban and Industrial Sources
3. Fossil Fuel Sources

3.2.1 Agricultural Sources

Chemical fertilizer leaching and runoff from agricultural fields, manure and aquaculture operations are among the sources of agricultural nutrient pollution.

3.2.2 Chemical fertilizer Leaching

Chemical fertilizer refers to any compound purposely created to increase crop yield. Nitrogenous fertilizers, for example, contain nitrogen, while phosphate-based fertilizers contain phosphate, and fertilizers are potassium. In the intensive use of chemical fertilizer, soils, and the environment has been degraded. Organic amendments lead to an improvement in soil physicochemical and biological properties of tropical soils (Payne and Edis 2008). Organic amendments potentially increase the soil organic Carbon level of degraded soils that further leads to improvement in overall soil quality. Several studies have reported increased microbial biomass and soil respiration under organically amended tropical soils due to soil temperature and moisture interaction. The relative availability of inorganic nitrogen pools has also been identifies as a determinant of soil organic carbon dynamics in dry tropical ecosystems. To meet the demands of the growing world population, fertilizers play an essential role in increasing food production.

The use of chemical fertilizers is widespread worldwide, although they are less prevalent in developing countries due to their high cost. The nitrogen content in chemical fertilizers known and application rates can be determined accurately but vary depending on the cropping system used. Nutrients are more immediately available for plant uptake in chemical fertilizers than in manure; however, they may be more easily leached into groundwater if used in excess (Aravind 2017). Slow-release fertilizers reduce this loss.

The most commonly used fertilizer is a chemical substance that makes the soil fertile enough to allow us to feed our ever-growing population. Over the years, fertilizing fields has become widespread: a necessary practice. It has greatly increased crop yields. Without fertilizer, we would not be able to feed the global population.

There are several types of fertilizer. Ammonium sulfate and urea are some of the most commonly used fertilizers.

Here is a list of some common synthetic fertilizers:

- Anhydrous Ammonia
- Urea
- Ammonium Nitrate
- Ammonium Sulphate

These fertilizers can be very detrimental to the environment; the production and use of fertilizer can contaminate groundwater and increase nitrogen emissions (Fageria 2009). This affects everybody because the pollution contaminates the drinking water. It then hurts the plants and the animals that drink the water and eat the plants; it is a slippery slope.

There are definitely better times of the year to use fertilizer than other times of the year. Urea, for example, produces the best crop when the moisture content is low (Our Fertilized World 2017). While some people think that fertilizer needs to stop being used altogether, the paper describe the need to continue using and improving fertilizer so that it will be less harmful to the environment. Recommend those knowledgeable farmers become more informed on fertilizer use, then that will also prove beneficial for our world.

3.2.3 Benefits and disadvantage of Fertilizer

The farmer already knows that fertilizer is a necessity but there are definitely some things that may make some people feel strained at the thought of using synthetic fertilizer because of all of the negative effects of using it (Our Fertilized World 2017).

First off, the production and use of fertilizer can be hazardous to people. A person working directly with fertilizer has to be extremely careful not to expose himself or herself to it. (Our Fertilized World 2017)

Using synthetic fertilizer also can make the land less fertile; the chemicals in fertilizer deplete the land of its organic matter, ultimately decreasing the quality of the soil. The main components of fertilizer are phosphorus, nitrogen, and potassium compounds (Our Fertilized World 2017). Many fertilizers are nitrogen-based. This is a good thing because plants do not receive all of the nitrogen they need naturally. Both ammonium sulphate and urea are nitrogen-based fertilizers.

However, excess of nitrogen has shown to be a bad thing; another reason that fertilizer can be hazardous is the fact that it contaminates groundwater. Known as "nitrogen leaching," it happens when the nitrogen that has already dissolved in water leaves the root zone, leaching into groundwater or other types of fresh water, like lakes or streams (Our Fertilized World 2017). This affects not only the people that drink that water, but also plant and animal life in and around this water. Fertilizer is also susceptible to runoff, which also leads to the contamination of running water. Fertilizer has a negative impact on the atmosphere; the more nitrogen fertilizer that is used, the more nitrogen emissions are produced.

3.3 Factors driving Lake Eutrophication

Eutrophication factors vary from one lake to another based on the environmental settings in which the lake is situated. The major cause of eutrophication in the world is the runoff of nutrient-rich water from cultivated land use catchments as well as runoff from industrialized, populated, and urbanized area (Ayele and Atlabachew 2021). A natural process like volcanic eruptions and dissolution of mineral rocks underneath can also add nutrients to the lake, increasing its productivity and driving factors for some lakes. Though nutrient enrichment, either anthropogenic or with the natural process, is taken as the leading cause of lake eutrophication, the proportion between total nitrogen with phosphorus and other conditions shall be taken into consideration (Clemens and Patrice 2004). That means an excessive amount of nitrogen and phosphorus does not lead necessarily to eutrophication unless the optimum condition that leads to eutrophication fulfilled. The TN to TP ratio is high in oligotrophic lakes and very low in eutrophic lakes constantly, but this ratio accompanied by conditions like temperature and light transparency (Liqiang , et al. 2003).

The major factor that causes eutrophication of lake includes

- Nutrient enrichment of phosphate and nitrate;
- Light transmittance, adequate temperature, and

- water residence time or flushing rate; microbial and biodiversity; and
- Climate change and exploitation of natural resources.

The fulfillment of all of these causes directly or indirectly increases eutrophication in water bodies, including lakes.

3.4 Excessive nutrient loads

The excessive amount input of plant nutrients chiefly phosphorus and nitrogen typically from anthropogenic pressure to a water body enhanced lake eutrophication (Hemant and Deepak 2012). The main consequence of excessive nutrients to the body of water is an inequality in the food web that results in increased levels of algal bloom and phytoplankton biomass in water bodies and results in depletion of oxygen in the lake ecosystem is toxic for the aquatic community. Considering how nitrogen and phosphorus contribute to eutrophication, there are different analogies regarding nutrient loads into bodies of water.

Phosphorus is typically the limiting factor in algal growth and released from point sources such as sewage works or from fertilized catchments, which causes more eutrophication than nitrogen.

Reaction equation of algal bloom.

$$106CO_2 + 16NO_3{-} + H_2PO_4 + 122\ H_2O + 17H+ \leftrightarrows \text{Protoplasm} + 138O_2 \qquad \textbf{3.1}$$

The low lake TN: TP ratio considered as a cause of the eutrophication process and responsible for most of the lake trophic state change (Liqiang , et al. 2003). s a result, the TN to TP ratio differs based on the trophic status of a lake. TN to TP ratios are very high in oligotrophic lakes and very low in eutrophic lakes. The positive relationship of N (TN) to total P (TP) exists in the pelagic zone of variety of the world's lakes.

The excessive enrichment of Nitrogen and Phosphorus is critical for eutrophication in lakes. However, the vital and significant is the phosphorus input into the body of water that upsets eutrophication in bodies of water. The assessment of the trophic status of lakes showed that in the vast majority of lakes, the limiting element is phosphorus for growth of algal biomass (Pełechata, Pelechaty and Pukacz 2006). According to these studies, phosphorus is the limiting element for developing algal biomass and phytoplankton. Therefore, the concentration of total phosphorus taken into account to estimate a trophic state index of lakes. This study also shows that phosphorus, regardless of nitrogen concentration, is a critical factor affecting primary productivity, including phytoplankton growth. Therefore, the primary productivity and phytoplankton biomass are estimate based on total phosphorus, not total nitrogen concentration.

The primary productivity and the growth of phytoplankton biomass are influence by the ratio of total nitrogen and total phosphorus (Lv, Wu and Chen 2011). Changing the N to P ratio from the reference can cause eutrophication problems.. According to most studies, there is a positive correlation between nitrogen (TN) and total phosphorus (TP) in lakes worldwide. Many activities change Lakes enriched with phosphorus as well as nitrogen. Generally, nitrogen and phosphorus deposition play a large role in accelerating eutrophication; however, phosphorus deposition caused substantial eutrophication. Phosphorus is the limiting factor for eutrophication and phytoplankton growth in many cases. The crucial factor for Lake Eutrophication is nutrient accumulation in water; phosphorus plays the dominant role in this process. As a result, this gives a clue as to what is the crucial factor when proposing a mechanism to protect lakes from eutrophication.

3.5 Forms of nutrients in the water

Nutrients are chemical elements that plants and animals need to grow and survive. While many kinds of nutrients exist, nitrogen and phosphorus are the most abundant and essential. Phosphorus and nitrogen are both find in various forms or species, and the species present vary according to the environment in which they are find.

3.5.1 As a form of nitrogen in water

There are numerous ways for nitrogen to enter water, including both organic and inorganic forms. Inorganic forms of nitrogen include ammonia, ammonium, nitrate, and nitrite (Wall 2013). Organic-nitrogen (organic-N) found in proteins, amino acids, urea, living or dead organisms and decaying plant material. The amount of organic nitrogen is usually determined using the laboratory method called total Kjeldahl nitrogen (TKN), which is a combination of organic nitrogen and ammonia + ammonium. As nitrogen can take numerous forms, it often referred to as 'total nitrogen (TN).

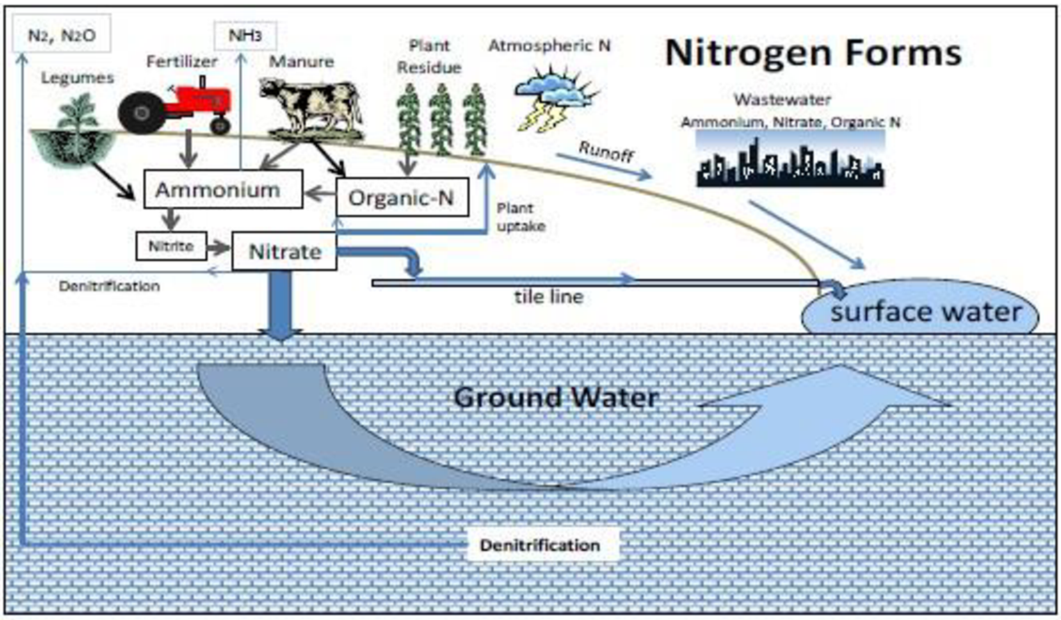


Figure 3 Nitrogen cycle, N sources, forms and routes to surface waters (Wall 2013)

In order for plants to utilize N2, they must undergo a process called nitrogen fixation. By fixing nitrogen in the atmosphere, plants can absorb it through their roots. Lightning can fix a small amount of nitrogen when it provides the energy necessary for N2 to react with oxygen, producing nitrogen oxide (NO), and nitrogen dioxide (NO2). The nitrogen in these forms then enters the soil through rain or snow. A process used to produce fertilizer can also fix nitrogen. The higher the protein content of a plant such as legumes has more nitrogen it will return to the soil. By cutting down these plants and tilling them into the soil, the nitrogen will returned to the soil. Atmospheric nitrogen and hydrogen combined to form ammonia (NH3), which can be further processed into ammonium nitrate (NH_4NO_3), which can be added to soils and used by plants. Plants are used nitrate for growth and development. Nitrogen fertilizers and manure can also release nitrates where crops are grown. Nitrate, regardless of its source, in the form of nitrogen that can get into groundwater. In addition, bacteria release nitrogen into the air to combine with oxygen, which forms nitrates. It rains, which brings these nitrates into the soil. Thus, we get nitrogen into our bodies. Denitrification is the microbial process that converts nitrate and nitrite to gaseous forms of nitrogen, predominantly nitrous oxide (N_2O) and nitrogen (N_2).

3.5.1.1 Nitrate (NO_3) and nitrite (NO_2)

Nitrate (NO_3) due to its soluble nature in water and its negative charge, nitrate (NO_3) can easily permeate the soil profile with soil water, reaching subsurface tile lines and groundwater (Wall 2013). Nitrate can travel in the groundwater until it reaches surface waters as long as the groundwater is oxygenated. Nitrate can also move downward into tile lines, which drain water to ditches and surface waters. In the presence of low oxygen/anoxic conditions in soils or groundwater, nitrate converted to N gasses through a biochemical process called "denitrification." As a result, groundwater nitrate is often lost to gaseous nitrogen before the groundwater can discharge into streams. The amount of nitrate that reaches streams in storm water runoff is typically smaller than that which reaches them via subsurface pathways.

Nitrite (NO_2) when anaerobic bacteria in the intestinal tract to become nitrites convert nitrates (Nitrates and Nitrites 2020). When nitrate units lose one oxygen atom, they become nitrite, which has the chemical formula NO_2^-. There can be very serious health consequences here, especially for pregnant women, infants, and other individuals. Typically, an intermediate product produced when ammonium transformed into nitrate by microscopic organisms. It rarely reaches high levels in water for extended periods. Water and soil contain nitrogen-containing compounds called nitrites (NO_2). Generally, the presence of nitrate and nitrite indicates contamination from a pasture, manure pile, decomposed vegetation, agricultural fertilizers, or sewage, though it may also come from erosion of natural deposits.

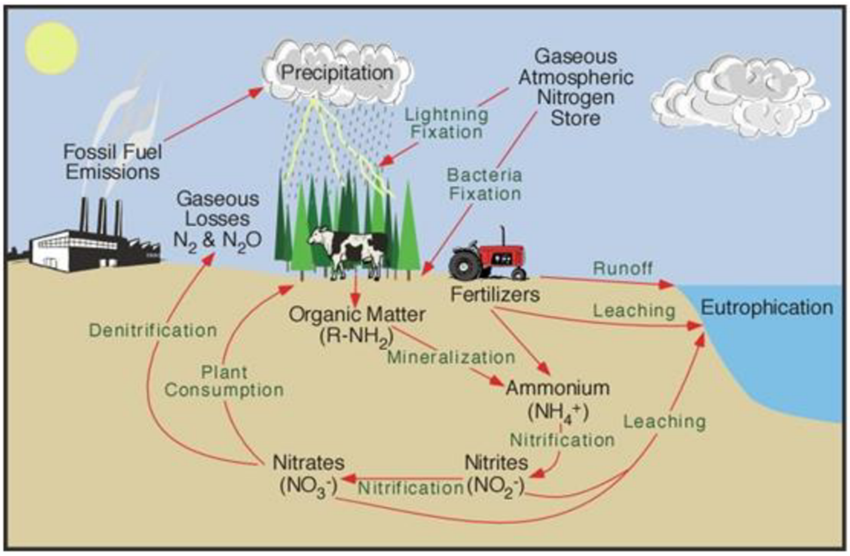


Figure 4 Formation nitrate and nitrate and Nitrogen cycle (AquaNui 2022)

Most laboratories test for both combinations of nitrite and nitrate, but when analyzing nitrate separately, nitrate is usually much higher than nitrite. The combined laboratory concentration of nitrite plus nitrate is often referrers to in reports as nitrate because nitrate is typically higher than nitrate. The most prevalent form of nitrogen in groundwater is nitrate, and it dominates in rivers and streams with elevated TN levels (Wall 2013).

3.5.1.2 Ammonia and ammonium

Ammonia (NH3) is a toxic substance for fish and other aquatic life. In natural waters, ammonia (NH4), the most prevalent form, is less toxic to fish than nitrate (Wall 2013). Aquatic environments contain several forms of nitrogen, including ammonia. Ammonia is toxic to aquatic life directly, as opposed to other forms of nitrogen that can cause over-enrichment of nutrients in water bodies at high concentrations as well as indirect effects on water bodies.

Human and animal waste, fertilizers, and industrial wastes are the most common sources of ammonia/ammonium. Overland runoff or direct discharges from wastewater sources are the most common ways in which ammonia and ammonium enter surface waters (Wall 2013).

3.5.1.3 Inorganic-nitrogen

Inorganic nitrates, nitrites, ammonia, and ammonium-N constitute most of the inorganic-N in waters (Wall 2013). Inorganic N is typically in the dissolved form in waters. Where sampling or laboratory methods ensure that all of the nitrite, nitrate, ammonia and ammonium is in the dissolved forms, it is referrers dissolved inorganic nitrogen (DIN).

3.5.1.4 Organic-nitrogen

Soil organic N consisting of proteins, chitins, amino acids, and nucleic acids represents about 90–98% of total soil Nitrogen (Eulene , et al. 2019). The term organic-N includes all substances in which N is bond to carbon. It occurs in both soluble and particulate forms. Proteins, amino acids, urea, living and dead organisms, and decaying plant material are all sources of organic-N. Soluble organic-N comes from wastes excreted by organisms, including livestock manure and human wastes. It is also produce when particulate organic-N from plants and plant residues is degraded.

In soil particles, organic nitrogen is associated with sediment losses to water. Different soils have varying amounts of organic-N. Organic-N concentrations in water are typically not measure directly in the laboratory. However, computed by subtracting the ammonia + ammonium-N from the total nitrogen (TN) laboratory analysis. Organic-N can be transform to ammonium, nitrite, and nitrate in nature.

3.5.1.5 Total nitrogen

Total nitrogen refers to the combination of both organic and inorganic N (Eulene , et al. 2019). The possibility for N to transform into different forms in water makes TN a critical parameter when estimating potential downstream effects.

3.5.2 Forms of Phosphorus in water

Phosphorus is a nutrient required by all organisms for the fundamental processes of life and natural element found in rocks, soils, and organic material. However, human activities have led to excessive phosphorus loading into many freshwater systems. As a result, excessive algae growth can cause water pollution, particularly in lakes (Dennis

2007). Phosphorus clings tightly to soil particles and used by plants, so its concentrations in clean waters are generally deficient. In areas of human activity, phosphorus found in greater concentrations. It used extensively for fertilizer and chemicals. An excess of phosphorus can result from a variety of seemingly harmless activities combined.

Phosphorus exists in water in either a particulate phase or a dissolved phase (Dennis 2007). Particulate matter includes:

- Living and dead plankton.
- Precipitates of phosphorus.
- Phosphorus adsorb to particulates.
- Amorphous phosphorus.

Phosphorus in natural waters usually found in the form of phosphates (PO_4^{-3}) and an inorganic form such as orthophosphates and polyphosphates or organic form such as organically bound phosphates.

3.5.2.1 Organic phosphate

Organic phosphate is phosphate that is bound to plant or animal tissue (Zublee 2010). Primarily biological processes form organic phosphates. They are form by receiving water biota or from sewage and may be form from orthophosphates in biological treatment processes. Organic phosphates may occur because of the breakdown of organic pesticides, which contain phosphates (Zublee 2010).

3.5.2.2 Inorganic phosphate

Inorganic phosphate is phosphate that is not associated with organic material and it include orthophosphate and polyphosphates (Zublee 2010). Orthophosphate is reactive phosphorus and it is the most stable kind of phosphate, and is the form used by plants. Orthophosphate comes from natural processes and can be found in sewage.. Polyphosphates are strong complexing agents for some metal ions and used for treating boiler waters and in detergents. In water, polyphosphates are unstable and will eventually convert to orthophosphate (Murphy 2007).

3.6 Physical factors

An important factor in determining the level of eutrophication in a lake or reservoir is the flushing rate, which is determine by the amount of water entering and leaving the lake. The average residence time of the water in the lakes determined using the volume of water present divided by the flow rate into the lake or discharged from the lake (Hudnell 2009). Also, describe the water under pick flow circumstances especially in the open lake, the average residence time of water will be smaller which could hinder the growth of slow-growing phytoplankton such as cyanobacteria, yet more nutrients and pollutants carried into the water body. The evapotranspiration will also promote the residence time of water in the open and closed lake system, but the water's duration remains in closed lakes is much longer than in open lakes. Therefore, closed lakes are more frequently expose to eutrophication than open water bodies. In addition, lakes are largely affected by tides and containment because of their outlet; they are frequently refreshed and are unlikely to become eutrophic. The self-purifying is due to the short residence time of the polluted water.

Thermal stratification in standing water bodies, temperature, light transmittance or clarity of water bodies and depth of water influences the development of aquatic algae and phytoplankton (Wells, et al. 2019). The optimum temperature is associated with adequate sunlight energy penetration through the depth of the water profile to undergo photosynthesis that results in an algal bloom. The temperature is an essential variable because the rate of chemical and biological processes differs as temperature differs. High temperatures can lead to more extended growth periods and favor cyanobacterial growth. Algae and phytoplankton grew at a high rate and covered the water's surface. This causes an algal bloom, a rapid growth in the algae population. Positively used carbon dioxide gives much oxygen to the environment and negatively reduces the biological diversity and ecosystem. The exploded phytoplankton and algae form an impenetrable roof and block the penetration of solar light into the water body (Fetahi 2019).At this time; this phytoplankton did not allow the solar light into the water. Without solar light, no plants could take part in photosynthesis. This causes many plants to store enough energy to weird out this condition. When this energy is finished, the water cannot support life. At this time, excess algae and phytoplankton died off and started to settle to the bottom of the water. Bacteria and other decomposers feed the dead body of phytoplankton with chemical process decay and consume a lot of oxygen. In a typical aquatic ecosystem, dead matter and oxygen levels stay relatively constant. Therefore, when a bloom occurs, matter that is organic reads to decompose and uses much oxygen in the water body used during the decomposition. At this time, oxygen deficiency occurs, and animals exposed to a shortage of oxygen. This means the animal cannot survive and goes to death and decomposition. This phenomena cause damage to many aquatic ecosystems and lead to the decrease of biodiversity globally. The affected water body takes much time to recover back. The recovery time depends on the number of nutrients leached to the water, the volume of the water and the type of organisms present in the water.

3.6.1 Degradation of biodiversity

Eutrophication is a complex process and is often associated with not only a change in overall algal biomass but also with a change in biodiversity (Patricia 2017). Ecosystems affected by eutrophication by changing the availability of light and nutrients. As a result, there is a change in the composition of species, which boosts the invasion and out-competition of new competitive species. Microalgae and their massive biomass are examples of this, inhibiting the growth of other aquatic plants. Such unnatural relations, especially in the aquatic environment, result in unbalancing microbial activity that results in algae bloom, which is a sign of eutrophication.

The increment of algae bloom limits the sunlight available to bottom dwelling organisms and causes wide swings the amount of dissolved oxygen in the water. The algae and plant community die off, sink to the lake bottom, and decompose. After aquatic plant communities die, the oxygen taken up from the water to facilitate the decaying process of dead plant communities. Decomposition of phytoplankton biomass consumes all of the oxygen left at the bottom of the lake or estuary after it dissolved. Aquatic plant communities die when their oxygen levels drop, which subsequently facilitates the decaying process of the dead plant communities. As a result, creatures such as fish, shrimp, and especially immobile bottom dwellers die off." species like fish die-off due to the oxygen dropout, which seriously affects biodiversity in the lake ecosystem. The remaining fish species often forced to migrate to other large bodies of water because their habitat was disturbed or died. It affects both new and older bodies of water since these latest fish species have become invasive. The new body of water will suffer if some of these insidious species are strong and predatory, as many fish communities would die to provide food for the new fish community. This would bring a consequence of new fish community emergent in the new lake ecosystem and would reduce some of the species of fish that had previously made that body of water their territory.

3.6.2 Overexploitation of natural resources and climate change

Due to human intervention, the natural process of oxygen exchanges and other nutrient cycles in the aquatic environment disrupted, leading to a species dominating other species. Eutrophication particularly caused by the overexploitation of natural resources that upsets the ecological balance of the marine system. A reduction in the lake's self-purification capacity is one factor that accelerates eutrophication by overexploitation of natural resources, as well as ecological imbalances. The deposition of sediments or sands used naturally to absorb and filtrate large amounts of nutrients and pollutants. However, exploitation of these sediments usually sands for construction purposes upsets the self-purification capacity of lakes.

3.6.3 Climate change

Climate changes could affect Lake Eutrophication because surface water quality expected to deteriorate in response to global warming. Climate change and global warming effects had led to arise of toxin-producing cyanobacteria algal blooms in freshwater ecosystems. Increasing temperatures and more intense rainfalls expected with climate variation will also aggravate mineralization of nutrients from catchment soils and increase soil erosion.

Though nutrient load is a primary factor that drives eutrophication once it is reaching a constant level in water bodies, an increase in some phenomena such as temperature, precipitation, wind velocity, and radiation from sunlight believed to raise the risk of water eutrophication. Excessive nutrient input in lakes and estuaries is directly proportional to runoff water caused due to heavy precipitation in the catchment. High runoff water around the catchment area increases nutrients into the water bodies and high temperature increases the growth of cyanobacteria than other phytoplankton species.

3.7 Impacts of Lake Eutrophication

Lake Eutrophication caused several consequences ranging from economic loss to biodiversity losses. Economic losses can arise from the loss of tourism revenue, navigation and boating opportunities, loss of property value due to aesthetic issues, costs to maintain a disturbed ecosystem that influenced by eutrophication, costs related to taste-and-odor problems with water, and costs related to fishing. In addition, social issues linked back to the environmental and economic issues like loss of recreation, and loss of the aesthetic values of lakes and other water bodies can negatively affect many people.

3.7.1 Decline o of water quality

Deterioration in water quality is described by changes in physicochemical water quality parameters that are significant effects on water quality polluting activities, such as the spreading of chemicals on agricultural land in the drainage basin and the discharge of domestic, industrial, urban, and other wastewaters into the water.

3.7.2 Ecological impacts

Chemical and physical water quality parameters in most case considered as a criterion to show the impact of eutrophication on the lake ecosystem. The ecological impacts of Lake Eutrophication considered as relative consistency and with minimal range of fluctuation. Among these common ecological impacts observed during eutrophication in lakes and that facilitate primary production, decreased biodiversity, changes in species composition and dominance, and toxicity are the primary ones.

3.7.3 Changes in species composition and dominance of alien species

Natural processes can result in changes in speciation composition and dominance due to eutrophication and its impact on biodiversity. A decrease in biodiversity often accompanied by changes in composition and domination of other species, usually alien species. The alien species introduced in the lake ecosystem in most case after the serious effect of eutrophication in the lake or estuaries. Consequently, the eutrophication may cause aggressive effects by making abundant a normally limiting nutrient.

3.8 Sign of existence of eutrophication on water bodies

The indicators of eutrophication can be measure directly by analyzing nutrients or indirectly by examining processes that caused by or related to nutrients, such as algal growth and dissolved oxygen levels.

3.8.1 Dissolved Oxygen

In water or other liquids, dissolved oxygen refers to the level of free, non-compound oxygen. The influence it has on the organisms living within a body of water is an important parameter when assessing the quality of water. The dissolved oxygen in lakes is second only to the water itself as an essential factor in limnology. An oxygen level that is too high or too low can harm aquatic life and affect water quality. On-compound oxygen, or free oxygen (O2), is oxygen that is not bond to any other element. The presence of free oxygen molecules within water referred to as dissolved oxygen. Water (H2O) contains bonded oxygen molecules that do not contribute to dissolved oxygen levels.

3.8.2 Aquatic Life

Dissolved oxygen is essential to many types of life, including fish, invertebrates, bacteria, and plants. Similar to organisms on land, these organisms use oxygen for respiration. While fish and crustaceans obtain oxygen through their gills, plant life and phytoplankton require dissolved oxygen for respiration when there is no light for photosynthesis. Dissolved oxygen requirements vary from creature to creature. Crabs, oysters, worms and bottom feeders need minimal oxygen (1-6 mg/L), while shallow water fish require higher levels (4-15 mg/L). Through the air or as a byproduct of plants, oxygen is dissolved in water. From the air, oxygen can slowly diffuse across the water's surface from the surrounding atmosphere and mixed in quickly through aeration, whether natural or artificially. Wind (creating waves), rapids, waterfalls, groundwater discharge or other forms of running water can cause the aeration of water. There are a number of man-made aeration methods, ranging from an aquarium air pump to a hand-turned waterwheel to a large dam. Dissolved oxygen produced as a waste product of photosynthesis from phytoplankton, algae, seaweed and another aquatic plant. Bacteria and fungi also require dissolved oxygen. The organisms use DO to decompose organic material at the bottom of a body of water. Microbial decomposition contributes significantly to nutrient recycling. If, however, there is an excess of decaying organic matter in a body of water with infrequent or no turnover (also known as stratification), the oxygen at lower levels will deplete quickly.

The majority of photosynthesis occurs underwater (by seaweed, subsurface algae, and phytoplankton). Despite the fact that light can penetrate water, the depth to which it can reach varies due to dissolved solids and other light-scattering elements present. Water depth affects wavelengths available to plants, with red light absorbed quickly and blue light visible beyond 100 m. Beyond 200 m, no photosynthesis can occur, and aquatic plants cannot grow. This photic zone (light-penetrating zone) is often much shallower in turbid water. No matter what wavelength is available, the cycle remains the same. In addition to the needed light, CO2 readily absorbed by water (it is about 200 times more soluble than oxygen) and the oxygen produced as a byproduct remains dissolved in water. The basic reaction of aquatic photosynthesis remains:

$$CO2 + H2O \rightarrow (CH2O) + O2 \quad \textbf{3.2}$$

Coldwater fish are most affect by low dissolved oxygen levels. As for bottom-dwelling microbes, DO changes do not bother them much. If all the oxygen at their water level gets up, bacteria will start using nitrate to decompose organic matter, a process known as denitrification. When organic matter accumulates faster than it does all of the nitrogen has spent, they will begin reducing sulfate. Composes, the organic material simply enriches sediment at the bottom of a lake.

Discharging Agricultural wastewater directly without treating highly affect that water bodies exposed by eutrophication. Eutrophication is difficult to measure. By constant interaction between physical, chemical, and biological components, the aquatic ecosystem is extremely complex. Several indicators can used to assess the degree of eutrophication.

3.8.3 Lack of Dissolved Oxygen or Hypoxia (oxygen depletion)

Hypoxia, or oxygen depletion, occurs when the concentration of dissolved oxygen in the water column falls to a level where aquatic organisms cannot exist. Fish mortality rates will increase if dissolved oxygen concentrations drop below a certain level. Even sensitive freshwater fish cannot reproduce at levels below 6 mg/L. Coastal fish begin to avoid areas where DO falls below 3.7 mg/L, with some species abandoning an area completely below 3.5 mg/L. Invertebrate and leave below 2.0 mg/L, and even benthic organisms show reduced growth and survival below 1 mg/L. Eutrophic lakes are more prone to fish kills because they have high concentrations of nutrients (particularly nitrogen and phosphorus). Nutrient levels are high in algae blooms, which initially boost dissolved oxygen levels. In addition, more algae mean more plant respiration, which draws on dissolved oxygen, and when algae die, bacterial decomposition increases, consuming most or all of the available oxygen. An anoxic, or oxygen-depleted, environment created in which fish and other organisms cannot survive. Nutrient levels of this kind can occur naturally, but they are more often a result of fertilizer runoff or poorly treated wastewater. In eutrophic waters (rich in nutrients), dissolved oxygen level fluctuates. Algae consume oxygen. Thus, a large algal biomass can lead to very low oxygen concentrations in the water, sometimes so low that even fish cannot live.

Figure 5 Dead fish due to oxygen deficiency in the lake (Conserve Energy Future 2022)

As low dissolved oxygen can cause problems, so can high concentrations. Fish and invertebrates can suffer from gas bubble disease in supersaturated water. When dissolved oxygen remains above 115%-120% air saturation for an extended period, significant death rates occur. Total mortality occurs in some fish under three days at 120% dissolved oxygen saturation. Invertebrates, while also affected by gas bubble disease, can usually tolerate higher levels of super saturation than fish. Extended periods of super saturation can occur in highly aerated waters, often near hydropower dams and waterfalls, or due to excessive photosynthetic activity. Algae blooms can cause air saturations of over 100% due to large amounts of oxygen as a photosynthetic byproduct. This often coupled with higher water temperatures, which also affects saturation. Water becomes 100% saturated at lower concentrations at higher temperatures, so higher dissolved oxygen concentrations mean even higher air saturation levels. In a dead zone, there is little or no dissolved oxygen present in the water. They are so name because aquatic organisms cannot survive there. Dead zones often occur near heavy human populations. They can occur in large lakes and rivers as well, but better known in the oceanic context. Fertilizer-induced algae and phytoplankton growth usually causes these zones. Microbes at the seafloor decompose organic matter when algae and phytoplankton die. These anoxic conditions usually stratified, occurring only in the lower layers of the water. Some fish and other organisms are able to escape, but shellfish, young fish and eggs are usually killed. Naturally, occurring hypoxic (low oxygen) conditions not considered as dead zones. Local aquatic life (including benthic organisms) have adjusted to low-oxygen conditions, so the adverse effects of a dead zone (mass fish kills, sudden disappearances of aquatic organisms, and growth/development problems in fish and invertebrates) are not evident.

3.8.4 Water transparency

The amount of light that penetrates into the water determined by this parameter. Turbidity increases when algae block the light. A Secchi disk commonly used to measure this parameter. A disc lowered into the water and the depth at which it is no longer visible is a measure of the clarity of the water.

Figure 6 Algae bloom block the entrance of light into water (LAURA 2013)

3.8.5 Chlorophyll a

Chlorophyll a is a measure of the amount of algae growing in a body of water. It used to classify the trophic condition of a waterbody. A natural component of freshwater ecosystems, algae can, however, cause aesthetic problems, such as green scums and bad odors, and can result in decreased levels. The amount (or concentration) of chlorophyll a in surface waters can be calculated by measuring the color of the water (also known as "ocean color"), which can be detected by sensors on satellites in space, similar to the way your eyes perceive the color of the ocean. The chlorophyll a (Chl a) concentration is a measure the amount of algae in the water column. Algae can be compare to plants, they need light and oxygen to grow and use chlorophyll as their photosynthetic. This parameter indicates the water quality based on the presence of organisms (species and numbers). Since fish live such a long time, they are an important indicator of the environmental quality of their habitat.

3.8.6 Water bloom

Water blooms are can caused by many different types of algae in freshwater ecosystems, and can triggered by nutrient enrichment. Most frequent and severe blooms caused by cyanobacteria, the only freshwater algae known to be capable of producing toxins harmful to humans. In warm waters rich in nutrients (especially phosphorus compounds), microscopic blue-green algae rapidly spread and form a blue-green skin on the surface of the water. When the algae cells die, oxygen in the water consumed and substances poisonous for plants and animals released. Consequently, fish can start suffocating. Not recommended to go swimming and water livestock in such water. Many types of algae can cause harmful algal blooms (HABs) in freshwater ecosystems, and they can influenced by nutrient enrichment. Typically, the most frequent and severe blooms are caused by cyanobacteria, the only freshwater algae known to produce toxins potent enough to harm humans. Cyano HABs can threaten human health and aquatic ecosystems. Cyano HABs cause economic damage due to the loss of recreational revenue, decreased property values, and increased costs for treating drinking water. By accumulating nutrients in lakes or other bodies of water, eutrophication occurs. Algae that feed on nutrients grow as a scum on water's surface, reducing its recreational value and clogging water intake pipes. A decaying mat of dead algae can produce a foul taste and odor in the water; the bacteria that consume it consume dissolved oxygen from the water, causing fish to die. Eutrophication can accelerated by increasing the rate at which nutrients enter the water. Algal growth is generally limited by the availability of either phosphate or nitrate, and we say a water body is nitrogen limited if the ratio of nitrogen species to phosphorus species (N: P) is low, or that a water body is phosphorus limited if N: P is high.

3.9 The Trophic Level of the lake

Scientists like to classify lakes and give names to the different types of lakes so they easily identified. Lake fertility determines trophic states. "Trophy" means nutrients, so lakes classified according to the amount of available nutrients (Phosphorus and Nitrogen) for organisms. Lakes with more nutrients have more plants and algae. In these newly formed lakes, the edges and bottom are exposed rock, which does not erode very quickly, so there are not many nutrients available. As a lake ages, sediment from the watershed is washed in and fills in the bottom. Since this sediment is rich in nutrients, it increases the fertility of the lake. There are four types of water bodies: oligotrophic, mesotrophic, eutrophic, and hypereutrophic. Four alternative trophic status indicators used to determine the trophic state of water bodies: Chlorophyll-a, Secchi transparency, Total Nitrogen, and Total Phosphorus.

Accordingly, nutrient loaded the lakes classified into four trophic levels

- Oligotrophic,
- Mesotrophic,
- Eutrophic, and
- Hypereutrophic

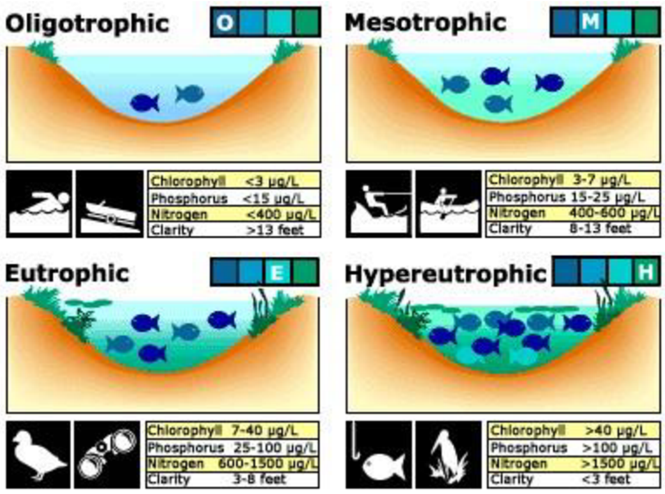


Figure 7 Lake Trophic states, concentrations of constituents, (Madriñán 2008)

3.9.1 Oligotrophic

Oligotrophic: An oligotrophic lake or water body is one, which has a relatively low productivity due to the low nutrient content in the lake. The waters of these lakes are usually quite clear due to the limited growth of algae in the lake. The waters of such lakes are of high-drinking quality. Such lakes support aquatic species who require well-oxygenated, cold waters such as lake trout. Oligotrophic lakes are usually found in the cold regions of the world where mixing of nutrients is rare and slow due to the low temperatures of the lake waters.

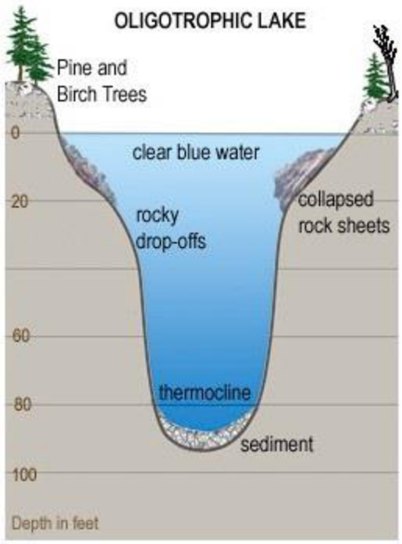


Figure 8 Oligotrophic Lake sample (RMB Environmental Labratory 2022)

3.9.2 Mesotrophic

Mesotrophic: Lakes with an intermediate level of productivity called mesotrophic lakes. They have medium nutrient levels and are usually clear, with submerged aquatic plants.

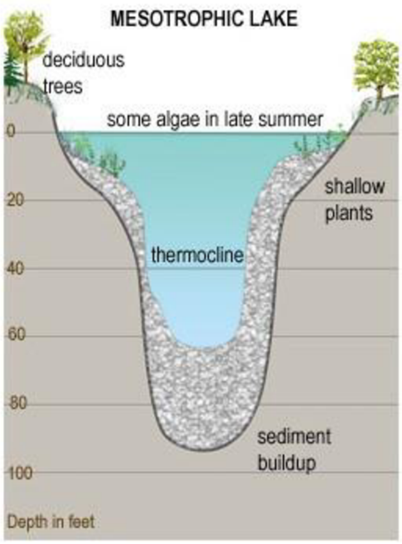


Figure 9 Mesotrophic lake sample (RMB Environmental Labratory 2022)

3.9.3 Eutrophic

Eutrophic: Lakes that eutrophic have high levels of biological productivity. An abundance of plants supported by such lakes due to their rich nutrient composition, especially nitrogen and phosphorus. The high levels of oxygen provided by a large number of plants growing in eutrophic lakes initially accelerates the multiplication and growth of Lake Fauna. When things overflow and plants and algal blooms overcrowd the lake, the lake fauna suffers from the high levels of respiration caused by the vegetation. Eutrophication can occur naturally or because of human intervention in the environment.

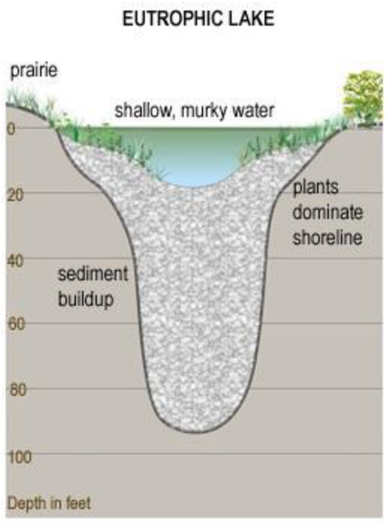


Figure 10 Eutrophic Lake sample model (RMB Environmental Labratory 2022)

3.9.4 Hypereutrophic

Hypereutrophic: Due to high levels of nutrients, hypereutrophic lakes suffer from excessive plant and algae growth. There is little transparency in these lakes due to the dense growth of algae or aquatic plants. Visibility is typically limited to three feet or less in these lakes. Moreover, hypereutrophic lakes contain more than 100 micrograms/liter of phosphorus and more than 40 micrograms/liter of total chlorophyll. Overgrowth of algae can suffocate the fauna below the water depths, causing dead zones below the surface.

4. Characteristics of the study area

4.1 Site description

Boyo lake is a shallow lake located 26 km from north of Alaba Kulito, exist in south nation nationality region in Hadiya Zone lemo wereda. The geographical coordinate for the area where the Boyo Lake exist is in latitude and longitude of 7° 30' 10" North (7.50°) 38° 1' 8" East (38.02°).The current total area of the lake is 13.88 km^2 and with average altitude of 1880 m. The source of Boyo Lake is from Bilate river basin that drains from the Gurage highlands south flow into Lake Abaya. The two main tributaries rivers for Bilate River are the Guder river, which originates in the mountains near the zonal capital Hosanna and the Weira (Foto) river which merge at Boyo Lake.

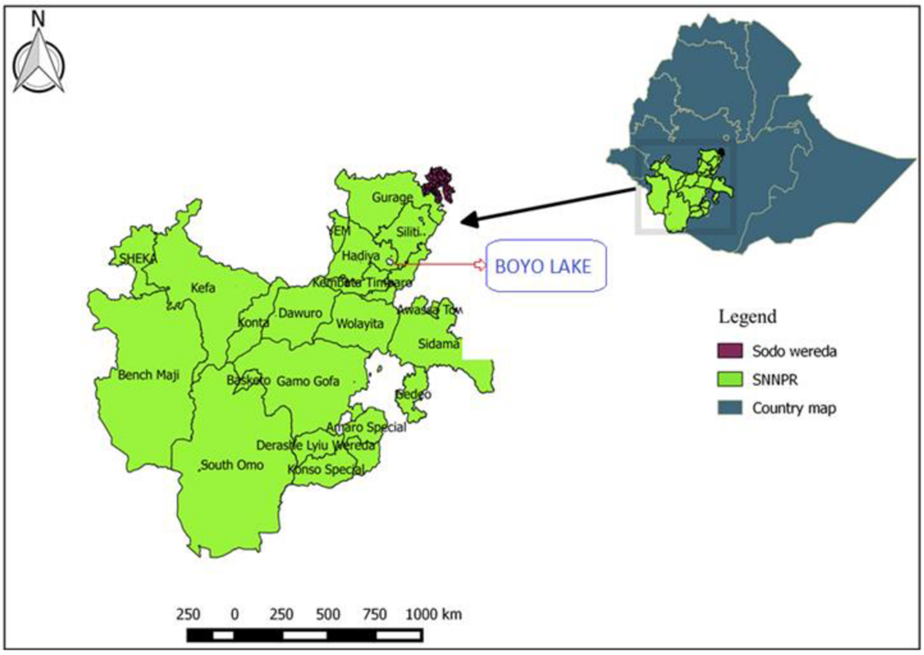


Figure 11 Boyo lake location ma (Lemo Woreda 2000)

The lake is the home of high concentration of water birds. The vegetation of this lake has not been studied and it need deep studies. Walta Jalala is the village near to the lake is town for its high population density and farming of maize, sorghum, potato, and cash crops such as coffee and chat. The area around the lake, especially the western side, used as range- and farmland, and the hills denuded of trees and grass cover. As a result, the land heavily eroded, and the lake has become silty. Increasing amounts of silt have led people to expand cultivation in the area, and farmers are planting Eucalyptus trees, and unknown tree species known for drying out soil. Birds face disturbance from people and domestic stock.

4.2 Agricultural activities

Agricultural waste is waste produced because of various agricultural operations. Farm wastes, poultry house and slaughterhouse debris, harvest wastes, fertilizer runoff from fields, pesticides entering the air, water, soil, and salt and silt discharged from fields form part of this category. The major crops grown in the wereda are wheat, barley, maize, teff, and sorghum. In addition, perennial crops such as enset, chat, and banana cover a large area. However, for it is among essential food for most of the highlanders, we included only enset from the root crops. Pesticides and fertilizers used for the crop in agriculture can contaminate groundwater and surface water, such as organic livestock wastes, antibiotics, silage effluents, and processing wastes.

Mostly in Ethiopia, Urea and DAP are the only fertilizers used in agricultural productivity. Nitrogen and phosphorus in soil are suitable for crops that do not produce enough of their nitrogen; fertilizer increases crop yields because of this added nitrogen and phosphorus. The soil is like a sponge. During rain, soil near the top absorbs water and keeps the moisture available when plants grow. Once the soil has fully saturated the water it can hold, it begins to leak down through the layers of rock and subsoil beneath the nearest water bodies. When the water sinks down, it takes soluble chemicals, such as nitrogen, phosphorus, and other fertilizer components. Any pesticides start to move as runoff you may have used, and this is the first of the types of leaching. However, the plants directly use not all of the nitrogen; most farmers in Ethiopia use over-fertilize their land because they know that they will lose a lot of it from runoff or in water bodies and groundwater.

Figure 12 Agricultural activity around Boyo Lake

4.3 Temperature

Ethiopia is located within the tropical zone of climatic classification. The yearly temperature variation of the area Boyo Lake briefly shown below Fig 14. According to Ethiopia meteorology agency data, the temperatures at Lemo wereda Boyo Lake are between 15 degrees Celsius at the extremely highlands and 30 degrees Celsius at the lowlands. Because these ranges of temperatures are suitable for most tropical crops, the wereda is not as susceptible to temperature variations.

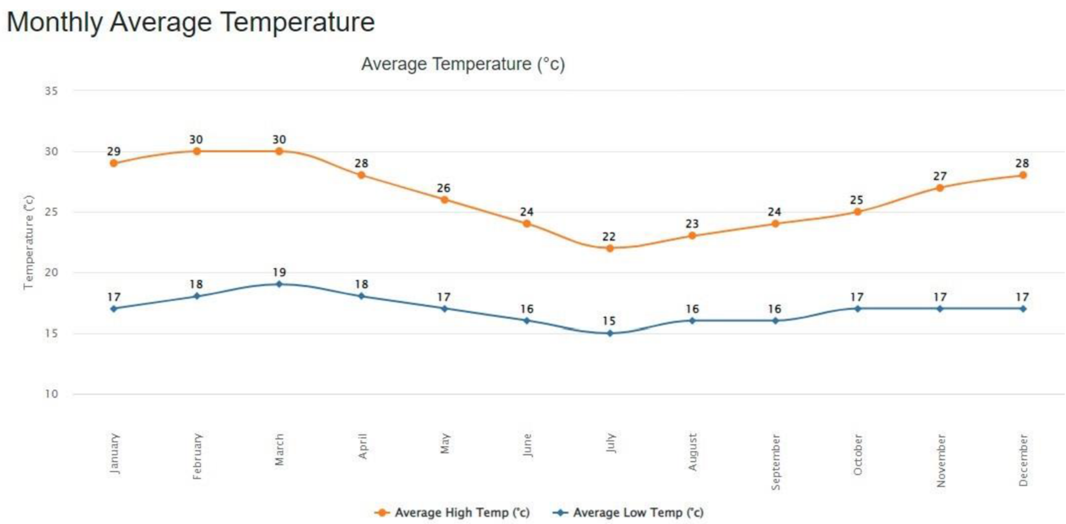


Figure 13 Monthly average temperature around Boyo lake (ENMA 2022)

4.4 Topography

The topographies around Lake Boyo are steep slopes that usually excessively drained, forming coarse textured shallow soils. On the other part of the lake, the topography is flat plains that are often poorly drained, black in color, clay in texture, and relatively deep. Areas with average slope gradients of 3 to 6 % usually well-drained reddish-brown deep and moderately fertile soils (Lemo Woreda 2000). Physical hazards like flooding commonly occur in flat plains surrounded by steep sloping hills and mountains. In contrast, hazards like severe soil erosion usually affect the side slopes of hills, rolling plains, and mountains with poor land cover. According to the data obtained on-site visitation, about 45 % of the land around Boyo Lake is flat. These flat plains, primarily located in the Shashogo area, well known for their repeated flood hazard. On the other hand, the remaining hilly and rugged terrain dominating the intermediate high land and high land exposed to severe soil erosion.

4.5 Rain fall

Southern Nation Nationality regions of Ethiopia experience two distinct wet seasons, Belg, from February to May, and the Bega occurring from October to December, which has drier and colder conditions. Mean annual rainfall distribution is approximately 2,000 mm over the southwestern highlands and less than 300 mm over the southeastern and northeastern lowlands.

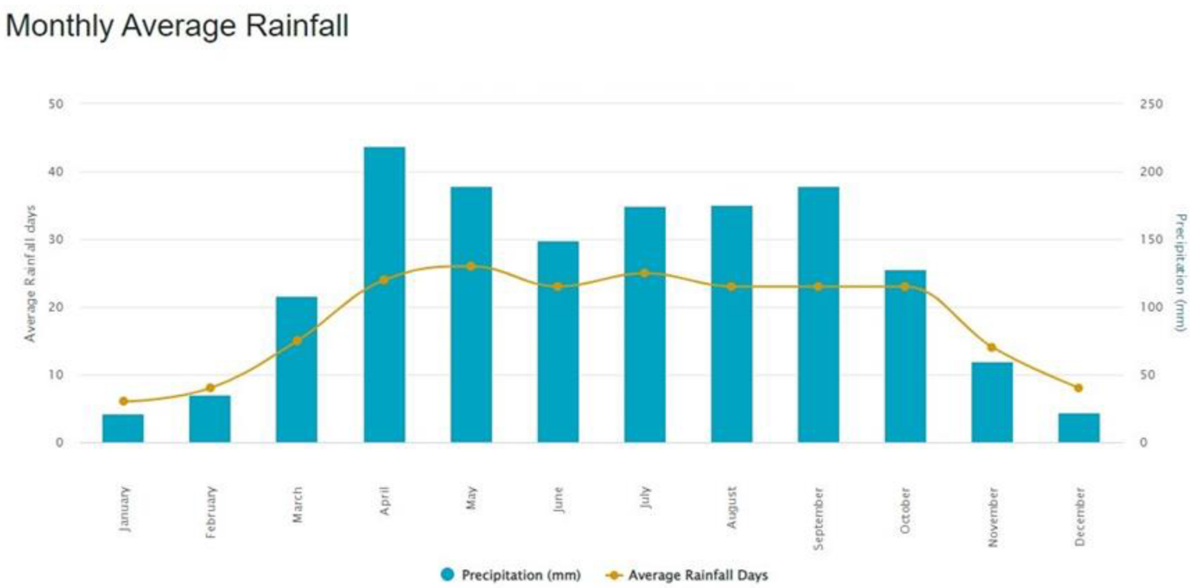


Figure 14 Monthly annual Rainfall distribution around Boyo lake (ENMA 2022)

4.6 Soils

Fertility, depth, color, texture, and drainage conditions of soils are among the essential interrelated elements. Heavy clay soils retain soil moisture but are challenging to work with, whereas sandy soils are easier to work with but do not retain soil moisture. Furthermore, heavy clay soils are poorly drained and often dark in color; while sandy soils are excessively drain. The soils around the lake area are silt clay loam and sandy clay loam. Based on the above slop angle classes, 34 % of the soil around Lake Boyo considered poor or imperfectly drain, 31 % well drained, and 35 % may be excessively drain (Lemo Woreda 2000).

4.7 Drainage Density and Surface Water Resources

Drainage density indicates to what extent the surface water is available, the total length of the channel in a drainage basin divided by the total area. By crude drainage density, we mean the ratio of the total length of rivers in the area to the total area of the catchment. In calculating drainage densities, the major rivers considered are Bilate, also known as Foto, and Guder. Unfortunately, the drainage density is very low in area. Thus, 1 km2 land area of the catchment is served by about 0.16 km of permanent rivers (Lemo Woreda 2000). From this, the area is in a vulnerable position concerning water availability, especially in the dry seasons.

5. Methods

5.1 Nutrients

Spectrophotometers are commonly used to quickly and accurately measure nitrogen and phosphorus. In this project, we used a spectrophotometer (Hach Lange Xion 500 LPG385) to analyze nitrogen and phosphorus. The main elements that measured in this paper analysis are total phosphorus (TP), total nitrogen (TN), and Chlorophyll. The most important nutrients for plants are nitrate and phosphate. High nutrient concentrations also increase algae biomass.

Figure 15 Spectrophotometer (Hach Lange Xion 500 LPG385) (Profcontrol GmbH 2022)

5.2 Chlorophyll a

Chlorophyll measured by passing a known amount of sample water through a filter, usually a glass fiber filter. In an acetone solution, the filter is ground up, which is then processed and analyzed. Total Chlorophyll a (mg) in original tissue sample equal to Chlorophyll a (mg/mL) x final volume (mL).The chlorophyll a (Chl a) concentration is a measure of the amount of algae in the water column. In comparison to plants, algae require light and oxygen to grow, and they use chlorophyll for photosynthetic pigments.

This refers to the primary productivity of a system. By measuring chlorophyll content, a lake or pond can classified or identified for potential problems. In order to maintain a balance between recreational usage and potential nuisance concerns, recreational waters should contain < 0.025 mg/L chlorophyll a.

Table 1 Lake Trophic Classification for Chlorophyll a (Ecosystem and Lake Productivity by Chlorophyll Analysis 2020)

Lake Trophic level	Classification for chlorophyll	Condition	
Oligotrophic	< 2 ppb (µg/L)	No problems evident, no water discoloration	0–10ppb (µg/L)
Mesotrophic	2- 6 ppb (µg/L)	Algae scum evident, some discoloration	11–20ppb (µg/L)
Eutrophic	6 – 40 ppb (µg/L)	Nuisance condition, considerable discoloration	21–30ppb (µg/L)
Hypereutrophic	>40 ppb (µg/L)	Sever condition encountered, very deep discoloration	>30 ppb (µg/L)

6. Results

In fresh water aquatic systems, the recommended level of phosphate on lakes by World Health Organization less than 0.03 mg/L (WHO 2010). According to WHO water levels of total phosphorus are generally less than 0.03 mg/L. Natural levels of phosphate typically range from 0.005 to 0.05 mg/L.

The natural levels nitrate usually for fresh water range from 20 to 50 mg/L (Jackson 2018). In general, freshwater tanks are at the higher end, marine fish-only setups are at the lower end and reef tanks are as near zero as possible. When aquarium nitrate levels reach intolerable levels, fish may become lethargic and have open sores or red blotches on their skin.

The weight values of TN and, TP, TNI in various eutrophicated water (Xiao-e , et al. 2008). According to this paper result, Eutrophication or red tide occurs when N concentration in water reaches 300 μg/L and P concentration reaches 20 μg/L. The surface water mean TP threshold concentration of 15 μg/L causes an ecological imbalance in algal, Macrophyte and macroinvertebrates (Richardson, et al. 2007). Therefore, it is considered that a threshold zone (12~15 μg/L) of TP may be more realistic and protective for all trophic levels (Likens, et al. 1977).

Table 2.The burden values of N and P in various eutrophicated water (Likens, et al. 1977), (Cheng, and Li 2006)

Eutrophic status	**Total Phosphorus (μg/L)**	**Total Nitrogen (μg/L)**	**Total Nutrient Index**	**chlorophyll-a (ppb)**
Oligotrophic	5 - 10	250 -600	0 - 30	0 - 5
Mesotrophic	10 - 30	500 - 1100	30 - 60	5 - 10
Eutrophic	30 - 100	1000 -2000	60 - 100	10 - 30
Hypereutrophic	>100	> 2000	>100	30 - 150

Table 3 . Trophic Status Index (TSI) and Water Quality (Water research Ceneter 2020)

Trophic status Index Range	Chlorophyll a (mg/m^3 or ppb)	Phosphorus(P) (µg/L)	Trophic class
30 - 40	0 – 2.6	0 - 12	Oligotrophic
40 - 50	2.6 - 20	12 - 24	Mesotrophic
50 - 70	20 - 56	24 - 96	Eutrophic
70 – 100+	56 – 100+	96 – 384+	Hypereutrophic

The level of chlorophyll a used to estimate the general classification of a lake or pond or identify potential problems. The amount of chlorophyll-a in waters should be < 0.025 mg/L, which permits some balance between recreational use and potential nuisance issues.

Table 4 Boyo Lake concentration of Total Nitrogen, Total Phosphorus and Chlorophyll-a

Sample number	**Total Nitrogen (µg/L)**	**Total Phosphorus (µg/L)**	**chlorophyll-a (ppb)**
1	104.65	20.89	35.35
2	102.87	21.78	32.48
3	90.23	32.92	37.65
4	99.68	26.34	20.58
5	75.64	13.88	5.43
6	82.16	15.82	2.28
7	72.86	16.36	1.92
8	88.94	10.96	4.48
9	93.61	10.57	6.93
10	69.34	9.17	4.86
11	88.62	14.74	11.39
12	103.006	30.44	14.18
13	119.16	19.98	7.34
14	90.23	28.04	8.23
15	108.72	16.82	6.12
16	92.56	26.22	10.32
17	80.42	29.68	12.78
18	94.45	23.14	13.98

19	101.98	35.24	19.45
20	105.98	29.86	16.56

The summary of the result water parameters, total nitrogen (TN) is 93.25 µg/L, total phosphorus (TP) is 21.64 µg/L, and chlorophyll a (chla a) is 13.61 µg/L. A standard deviation (or σ) is a measure of how dispersed the data is in relation to the mean ant the result is total nitrogen (TN) is 14.12 µg/L, total phosphorus (TP) is 7.93 µg/L, and chlorophyll a (chla a) is 10.70 µg/L. High standard deviation indicates data are more spread out around the mean. The result shows high standard deviation indicates result of chlorophyll a are more spread out and it means , and. Low standard deviation indicates data are clustered around the mean. Low standard deviation of Total phosphorus means clustered around the mean.

Table 5 Table summary of water parameters, total nitrogen, total phosphorus, and chlorophyll a.

Results: Summary Statistics 1

Variable	Label	Mean	Std Dev	Minimum	Maximum	N
Total Nitrogen (µg/L)	Total Nitrogen (µg/L)	93.2553000	12.8828566	69.3400000	119.1600000	20
Total Phosphorus (µg/L)	Total Phosphorus (µg/L)	21.6427000	7.9349007	9.1720000	35.2400000	20
chlorophyll-a (ppb)	chlorophyll-a (ppb)	13.6155000	10.7010927	1.9200000	37.6500000	20

Correlation analysis used to quantify the degree to which two variables are related. The correlation analysis evaluates the correlation coefficient, which tells you how much one variable changes when the other does. In the result, the Correlation analysis shows the linear relationship between water parameters, total nitrogen (TN), total phosphorus (TP), and chlorophyll a (chla “a”).all variable are positively related and the dependency one to another is high as we see below on the table 6.

Table 6 The correlation between total nitrogen, total phosphorus, and chlorophyll a

3 Variables:	Total Nitrogen (µg/L) Total Phosphorus (µg/L) chlorophyll-a (ppb)

Pearson Correlation Coefficients, N = 20			
	Total Nitrogen (µg/L)	Total Phosphorus (µg/L)	chlorophyll-a (ppb)
Total Nitrogen (µg/L) Total Nitrogen (µg/L)	1.00000	0.68149	0.71005
Total Phosphorus (µg/L) Total Phosphorus (µg/L)	0.68149	1.00000	0.54349
chlorophyll-a (ppb) chlorophyll-a (ppb)	0.71005	0.54349	1.00000

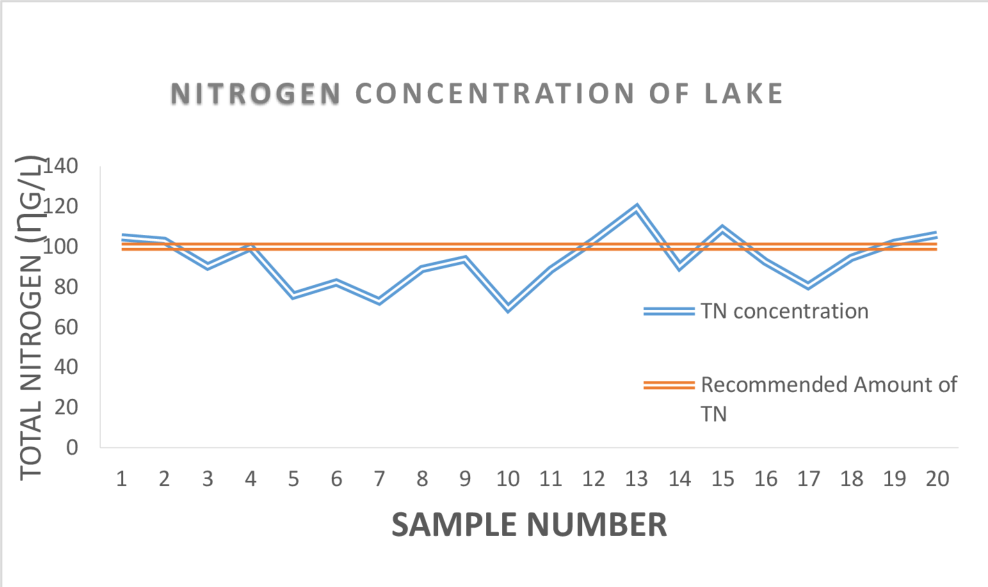


Figure 16 Total nitrogen concentration on Boyo Lake

The results of nitrate ion levels in the sampling Boyo Lake presented in the Table. With the mean value of 93.25 µg/L From the results, it is evidently clear that all the sampling sites had nitrate level below the guideline. To identify at-risk surface water bodies and protect them from eutrophication, the US EPA developed guidelines, which state that N concentrations should not exceed 0.3 mg/Lin streams and rivers or 0.1 mg/Lin lakes and reservoirs (Zhiwei Xu, et al. 2014). However, give a reflection of the nitrate level in some part of the Boyo lake water higher than the standard because of the around the vicinity of irrigated farmland. However, the current results may not likely be a landmark for safety because while nitrate is a common nitrogenous compound due to natural processes of the nitrogen cycle, anthropogenic sources could greatly increase the nitrate concentration of nitrogen-rich fertilizers and manure.

Levels of nitrates in lake water in some parts of the maybe above the US EPA developed guidelines limit of 0.1mg/l. Particularly in the part of the lake areas near to farming land where there is the continuous application of nitrate rich-fertilizers in the farmlands during rainy season.

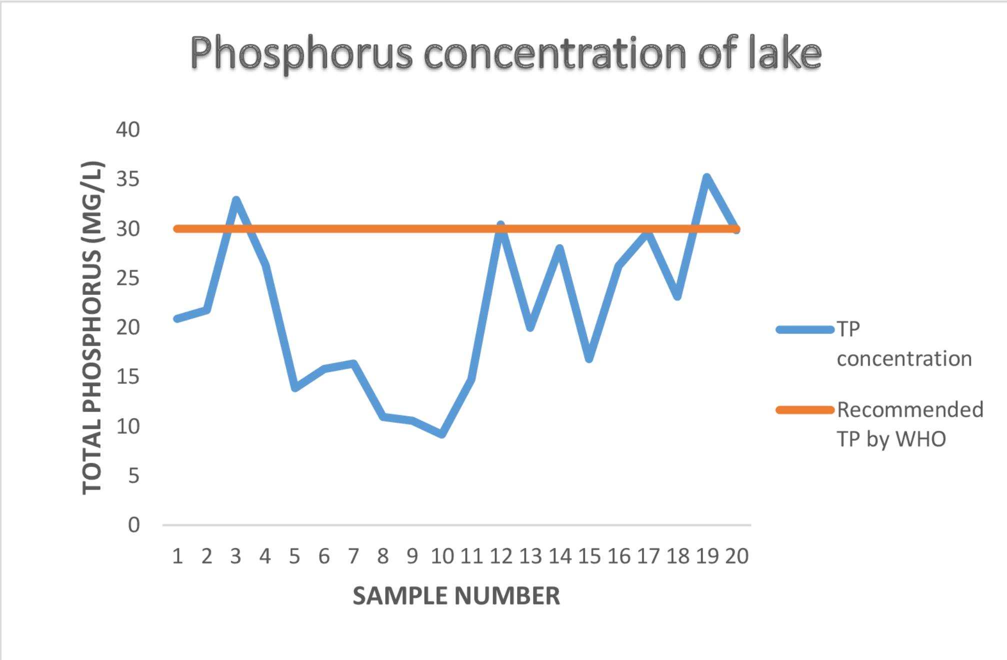


Figure 17 Total phosphorus concentration on Boyo Lake

Natural levels of phosphate typically range from 0.005 to 0.05 mg/L (WHO 2010). The results of phosphate levels in Boyo lake water samples obtained from different part of the lake sampling sites including the area directly contacted to irrigated farmlands is presented in Fig 1. The mean value of 21.64 µg/L From the results it shows that all the sites had phosphate levels above the recommended level set for fresh lake water by World Health Organization i.e. 0.03mg/L (WHO, 2010). It is during the rainy season or the dry season that the water flows from land affected by leaching. The high concentration of phosphate ions in the lake water is because agricultural activities are the major source of income in these communities, and these activities made possible only by synthetic and natural fertilizers. The areas closer to these farmlands are prone to this high level of phosphate, particularly where leakage of Agricultural wastewater takes place during the rainy season. The reason for seasonal agricultural activities that the concentrations of phosphate and nitrate ions might increase during the wet season when agricultural activities are at their peaks.

The primary productivity of a system measured in this way. The chlorophyll level used to classify a lake or pond or identify potential problems. Recreational waters should be < 0.025 mg/L, to achieve a balance between recreational use and potential nuisance issues. The chlorophyll a content of a waterbody provides information about how much algae is growing there. It used to classify the trophic condition of water bodies. Phytoplankton biomass and abundance in coastal and estuarine waters determined by chlorophyll-a concentrations. High levels often indicate poor water quality, while low levels often indicate good conditions.

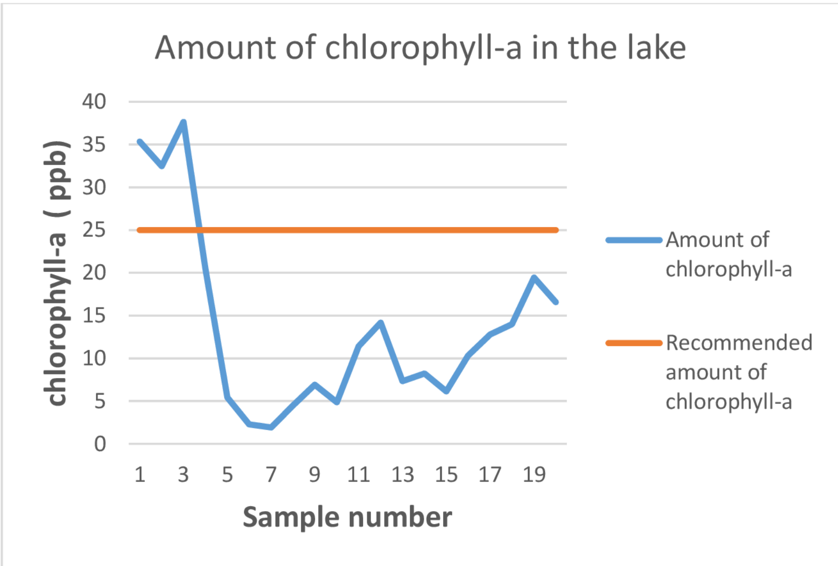


Figure 18 The chlorophyll level on Boyo Lake

According to the result of nutrients and level of chlorophyll exist the in the lake according table and study (Likens, et al. 1977), (Cheng, and Li 2006) (Water research Ceneter 2020) the Lakes with an intermediate level of productivity are called mesotrophic lakes. The Mesotrophic lakes priority habitat characterized by areas of standing water that have moderate alkalinity and nutrient levels, which result in a high diversity of aquatic plant and macroinvertebrate species. The mean value of sampling result of Boyo lake total phosphorus concertation is 21.64 µg/L.

Mesotrophic lakes Concentrations of total phosphorus (TP) in the water column are expected to be between 10 - 35 µg/L (OECD 1982). These lakes have medium nutrient levels and are usually clear with submerged aquatic plants. Lake Boyo water is high turbidity effects of soil erosion go beyond the loss of fertile land. It has led to increased pollution and sedimentation in lakes, clogging these waterways and causing declines in fish and other species. And degraded lands are also often less able to hold onto water, which reduces the amount of water in the lake as shown in fig 19.

Figure 19 Water hyacinth and sediment deposition concentration on Boyo Lake

As water moves down through the soil, it carries away some of the nutrients that plants use, such as nitrates and phosphorus called leaching. Typical rainfall causes mild levels of leaching, and organic matter on the surface resupplies the soil.

During rainy season high amount of soil, erosion appear from agricultural catchment area of the lake cause physico-chemical degradations. The loss of soil nutrients through runoff and sediment is a major cause of soil fertility decline. The eroded sediments or soil is highly concentrated with crop nutrients, which washed away from farmlands.

.

7. Discussion

According to (Wassie 2020)the major treats of Africa's lakes include but not limited to land use/cover changes due to rapid population growth, depletion of water resources through pollution, deforestation, overgrazing, soil erosion, and invasive alien species. For example, Lake Boyo, which is located on the border of SNNPR, near to Hosanna city over the past four decades, has reportedly highly sediment deposition and erosion. Eutrophication of Lake Boyo clearly linked to the rapid population growth and changes in land use pattern, which happened in the lake catchments that constitute 5,000 ha of total area. To mention one specific case related to this lake, about km2 of the catchment exposed and affected by soil degradation due to this land utilized for agriculture

In the form of chemical fertilizers and animal manure, farmers apply nutrients to their fields, supplying crops with the nitrogen and phosphorus they need to grow and produce the food we eat. Most farming activities are responsible for water pollution through the excessive usage of pesticides and chemical fertilizers, which ultimately leach into groundwater and drain into surface water bodies. The change in Physico-chemical properties of water caused by agricultural activities harms the aquatic ecosystem. The high levels of nitrogen and phosphorus in water can cause eutrophication.

As a result, sign of algae bloom and growth of cyanobacteria over the surface of the lake investigated in association with an invasive of alien species commonly called water hyacinth. Currently showed that more than 1/4 portion of Lake Boyo covered by water hyacinth seen in Appendix D. The fig. shows coverage of water hyacinth compiled in the report presented. Several reports made on external loads of nutrient and water quality status of Lake Boyo ecological condition and the coverage of water hyacinth, and algal bloom and trophic status of the lake. In summary, the results found by the above reports presented in Table. The reports linked to the surface water quality status of the lake indicated in Table 4 used different indexes. Currently all deterioration in water quality of the lake, which associated with non-point sources, sediment, and nutrient inflow and high erosion rate from the watershed especially from the agricultural shown in fig 20 below.

Figure 20 Sediment deposition in Boyo Lake cause of high erosion

When lakes become more eutrophic, organic deposition and sedimentation increase, promoting vegetation growth. Thus, material that is more organic is added to the sediments, hastening the death of the lake. Oxygen demand also increases with increased organic sedimentation. Sediment increases the cost of water treatment and can affect taste and odor. Sediments, reducing resistance to diseases, lowering growth, and impairing the development of fish eggs and larvae, can clog fish gills. Sediments in suspension can have a significant impact on water quality because sediments reduce water clarity, which reduces visibility. Turbidity is a measure of the clarity of the water. Lake Eutrophication is caused by the overabundance of nutrients, primary phosphorus from agriculture and construction sites.

Improve the water quality of the lake, including but not limited to soil and water conservation strategies, reduced recession agriculture adjacent to the lake, and wetland management practices.

When the concentration of nutrients increases amount light entering to the lake water is decreases. Microscopic blue-green algae rapidly spread in warm waters rich in nutrients and even form a blue-green skin on the surface of the water. Too much nutrients cause stream damage and excessive algae growth. Nutrient, which can, encourage the overgrowth of weeds, algae, and phytoplankton exploded in number. Algae and phytoplankton growth at a high rate and covered the surface of the water. This causes an algal bloom, a rapid growth in the population of algae. Algae can keep out of the light, causing turbidity. The exploded phytoplankton and algae form an impenetrable roof and block the penetration of solar light into the water body. At this time, this phytoplankton not allow the solar light into the water and without solar light, no plants can take part in photosynthesis. The cause many plant store enough energy to weird out this condition. When this energy finished the water cannot support so much life. At this time excess algae and phytoplankton died off and starting to settle to the bottom of the water.

Bacteria and other decomposers feed the dead body of phytoplankton with chemical process decay and consume a lot of oxygen.in a normal aquatic ecosystem, the amount of dead matter and oxygen level stay relatively constant. Therefore, when a bloom occurs more organic matter read to decompose and used much oxygen that exists in the water body used during the decomposition. At this time, oxygen deficiency occurs and animals exposed to a shortage of oxygen. This means the animal cannot survive and goes to death and decomposition. When the algae cells die, oxygen in the water consumed and substances poisonous for plants and animals released. Consequently, fish can start suffocating. This phenomena cause damage many aquatic ecosystem and leads to the decrease of biodiversity globally. The affected water body takes much time to recover back. Algal species can deoxygenate water as well as produce toxins that contaminate drinking water supplies.

The growth of invasive aquatic plants caused by the sediment also contains nutrients such as nitrogen and phosphorous. When sediment builds up, the lake becomes shallower, the bottom sediments become more fertile, and the conditions in the lake become more favorable for aquatic plant growth. Exotic species degrade water quality by decreasing water flows and reducing the transportation of nutrients, or by increasing runoff and erosion, resulting in hyper-eutrophication. Generally, invasive plants in natural ecosystems can cause a reduction of native biodiversity, changes in species composition, loss of habitat for dependent and native species (including wildlife), and altered disturbance regimes.

At present, 5% of aquatic plants found belong in the 100th of the world's worst invasive alien species list (Ismail, et al. 2019), such as water hyacinth (Eichhornia crassipes), water fern (Salvinia molesta) and a few more to be named. Floating aquatic plants could hinder fishing and water transportation activities by forming dense mats on the surface, clogging waterways, blocking sunlight, and competing with native plants for nutrients (Ismail, et al. 2019).

Pandanus helicopus is invasive plants on Boyo Lake. It have roots their leaves and plant tissue floating on top of the water, and can spread rapidly over the surface of a lake.

8. Conclusions

Using organic fertilizer is the best way of protecting water bodies from eutrophication. Discharging Agricultural wastewater directly without treating highly affects water bodies exposed by eutrophication. Measuring eutrophication is extremely challenging. By constantly interacting with physical, chemical, and biological components, aquatic ecosystems are very complex. There are several indicators available to assess the degree of eutrophication: The removal rates of nitrate and phosphate are significant. In addition, the nitrate and phosphate values in wastewater must be treated before discharging from water bodies. The aquatic woody plants in the wetland treatment system had good purification effects on nitrogen and phosphorus in the water body. In addition, the wetland treatment system is a kind economical and effective method.

There is many methods used to remove nitrate and phosphate to remove from wastewater. I recommend Constructed wetlands are an “eco-friendly” design of watered substrates, riparian vegetation, and associated wildlife that dwells at the natural wetland. It consists of a properly designed basin that contains wastewater, a substrate, and wetland plants. The principle of wetland purifying is the synergetic interaction of plants, soil, and microorganisms in the wetland. It has a good performance in treating sewage and purifying Eutrophication from the water bodies. The sewage is treated in an artificial wetland by regrouping physical, chemical, and biological actions in the ecosystem. According to many studies, the use of the aquatic plant's treatment system to control water pollution has many advantages, such as low investment, maintenance, and operating costs, easy management, good treatment effects, improving, restoring a healthy environment, recycling resources, and energy, and harvesting economic plants, etc.

This problem needs further research. It also needs further research to resolve the difficult problem of Eutrophication causing the elimination of biodiversity. The common and most suggested prevention mechanism in this area is generalized in three parts.

1. The first one is controlling nutrient loads more targeting on phosphorus reduction, which includes catchment management, treating agricultural wastewater before entering the lake.

2. The second one is mechanical methods, which include in Lake Remediation including physical, biological, and chemical application.
3. Thirdly, employing an ecological mechanism, which entails ecosystem restoration, oxygenation, shellfish introduction into estuaries, and seaweed farming.

Nitrogen in soil is good for crops that do not produce enough of their own nitrogen; fertilizer increases crop yields because of this added nitrogen. However, not all of the nitrogen gets directly uses by the plants; farmers intentionally over-fertilize their land because they know that they will lose a lot of it from runoff or in groundwater. The nitrogen from fertilizer contaminates the groundwater and affects surrounding plants, and it affects the animals and people that drink that water. Water from the runoff reaches other freshwater and pollutes it as well as the animals who drink it. It is a very slippery slope. It is for this reason that water must treated before entering water bodies. As a result, we can try to reduce the treatment time by preventing nitrogen leaching in the first place.

The farmers must rotate crops and use fertilizer only as needed, no questions asked. By rotating crops from a grass crop to a legume crop, the soil will increase in nitrogen content. This would be Step Number One. Step Two would be to use fertilizer only as needed: do NOT over-fertilize.

You farmers also have to decide what type of fertilizer is best to use at the time according to the moisture content of your soil. If you want an in-depth explanation of fertilizers and their effects, click here. I cannot spell it out any clearer.

Eutrophication primarily caused by agriculture, urbanization, and industries, which have all increased in Ethiopia over the past few decades. The review examined eleven rift valleys and highland lakes to illustrate the trophic state of Ethiopian water bodies, all of which classified as eutrophic to hypereutrophic, indicating a serious threat to eutrophication in Ethiopia.

In order to increase public awareness and to control eutrophication, the following management measures are recommend. Raising public and stakeholder awareness through workshops, pamphlets, and media discourses. There is a need for a policy/legislation to control the eco-friendly agricultural wastewater treatment system.

In addition, agriculture, and intuitively waste products are growing, regulatory bodies should be held more accountable and responsible than currently. Water quality guidelines should be prepared and enforced by the appropriate institutions such as the Ethiopian Fisheries and Aquatic Sciences Association, Environment, Forest and Climate Change Commission, and Ministry of Water, Irrigation and Energy. Promote the use of chemical fertilizers based on plant removal rate and soil type.

9. References

Ayele, Hailu Sheferaw, and Minaleshewa Atlabachew. 2021. "Review of characterization, factors, impacts, and solutions of Lake eutrophication: lesson for lake Tana, Ethiopia." *Springer Link* Environmental Science and Pollution Research volume 28, pages14233–14252. doi:10.1007/s11356-020-12081-4.

Hudnell, H Kenneth. 2009. "The state of U.S. freshwater harmful algal blooms assessments, policy and legislation." *Research GATE* 1024-34. doi:10.1016/j.toxicon.2009.07.021.

Ismail, S N, L Subehi , A Mansor , and M Mashhor. 2019. "Invasive Aquatic Plant Species of Chenderoh Reservoir, Malaysia and Jatiluhur Reservoir." *Earth and Environmental Science.*

Lin, Song-Shun, Shui-Long Shen, Annan Zhou, and Hai-Min Lyu. 2021. "Assessment andmanagement of lake eutrophication: A case study in Lake." *Science of the Total Environment* 751. doi:10.1016/j.scitotenv.2020.141618.

Madriñán, Max Jacobo Moreno. 2008. "Eutrophication trend of lakes in the Tampa Bay watershed and the role of submerged aquatic vegetation in buffering lake water phosphorus concentration." *Research Gate.* https://www.researchgate.net/publication/254706973_Eutrophication_trend_of_lakes_in_the_Tampa_Bay_watershed_and_the_role_of_submerged_aquatic_vegetation_in_buffering_lake_water_phosphorus_concentration.

Sarah, White A. 2013. "Wetland Technologies for Nursery and Greenhouse Compliance with Nutrient Regulations." *Research Gate* (48(9)): 1103-1108. doi:10.21273/HORTSCI.48.9.1103.

AquaNui. 2022. *Nitrates in Drinking Water.* Accessed 03 30, 2022. https://myaquanui.com/nitrates-in-drinking-water/.

Aravind, Ramya. 2017. "Agricultural contaminants." *Agricultural contaminants.* Bangalore, : SlideShares, Nov. 07.

Arkadi , Parparov, Gal Gideon , Hamilton David , Kasprzak Peter , and Ostapenia Alexandr . 2010. "Water Quality Assessment, Trophic Classification and Water Resources Management." *Scientific Research* 907-915.

Cheng, , X.Y, and S.J Li . 2006. "An analysis on the evolvement processes of lake eutrophication and their characteristics of the typical lakes in the middle and lower reaches of Yangtze River." *Chinese Science Bulletin* 1603-1613. doi:10.1007/s11434-006-2005-4.

Clemens , Reimann, and Caritat de Patrice . 2004. "Distinguishing between natural and anthropogenic sources for elements in the environment: regional geochemical surveys versus enrichment factors." *science Direct.* doi:10.1016/j.scitotenv.2004.06.011.

Conserve Energy Future. 2022. *Conserve Energy Future.* Accessed 03 30, 2022. https://www.conserve-energy-future.com/causes-effects-and-solutions-to-eutrophication.php.

Dennis , Wasley. 2007. *Phosphorus: Sources, Forms,Impact on Water Quality.* Minnesota: Minnesota Pollution Control Agency.

ENMA. 2022. *Ethiopia National Metrology Agency.* Accessed 03 16, 2022. http://www.ethiomet.gov.et/daily_weather.

Eulene , Francisco da Silva, Ferreira Melo Marlenildo , Ewerton Santos Sombra Kássio , and Severo Silva Tatiane. 2019. *Organic Nitrogen in Agricultural Systems.* Edited by Cid Rigobelo Everlon and Pereira Serra Ademar . 2020. doi:10.5772/intechopen.77834.

Eutrophication and Hypoxia. 2010. *About Eutrophication.* https://www.wri.org/initiatives/eutrophication-and-hypoxia/learn.

Fageria, N. K. 2009. *The USE of NUTRIENTS in CROP PLANTS.* Taylor & Francis Group, LLC.

Fareed, Khan A. , and Ali Ansari Abid. 2005. "An Ecological Vision." *Explore JSTOR* (Springer) 71: 449-482. Accessed Feburary 12, 2022.

Fetahi, Tadesse. 2019. "Eutrophication of Ethiopian water bodies: a serious threat to water quality,." *African Journal of Aquatic Science* (African Journal of Aquatic Science). doi:10.2989/16085914.2019.1663722.

Hemant , Pathak, and Pathak Deepak . 2012. "Eutrophication: Impact of Excess Nutrient Status in Lake Water Ecosystem 02(05)." *Journal of Environmental & Analytical Toxicology.* doi:10.4172/2161-0525.1000148.

Istvánovics, Vera. 2009. "Eutrophication of Lakes and Reservoirs." *Research Gate* 157-165. doi:10.1016/B978-012370626-3.00141-1.

Jackson, Sara . 2018. "Keeping Up with Nitrate." *Freshwater*, October: 84 -117.

Karydis, Michael . 2009. "Eutrophication Assessment of Coastal Waters based on Indicators: A Literature Review." *Global Nest Journal 11(4).*

Khan, M. Nasir. 2014. "Eutrophication: Challenges and Solutions." *Eutrophication: Challenges and Solutions.* Researchgate, March.

Lake Monitoring Program. 2021. *RMB Environmetal Labratories,inc.* https://www.rmbel.info/primer/chlorophyll-a/.

Laura , E. Christianson, Lepine Christine , Sibrell L. Philip, Penn Chad, and Summerfelt T. Steven . 2017. "Denitrifying woodchip bioreactor and phosphorus filter pairing to minimize pollution swapping." *science Directy* Volume 121: Pages 129-139. doi:10.1016/j.watres.2017.05.026.

LAURA , MICHELLE BURNS. 2013. *Climate Change Chokes Lake Erie.* LATEST ARTICLES ON CLIMATE CHANGE EXTREME WEATHER, Moms Clean Air Force. Accessed 03 30, 2022. https://www.momscleanairforce.org/lake-erie/.

Lemo Woreda . 2000. *Strengthening Emergency Response Abilities.* SERA Project at Lemo Woreda Hadiya Zone, Lemo Woreda: Southern Nations, Nationalities and Peoples Region.

Likens, G.E., F.H Bormann, R.S., Pierce, J.S Eaton, and N.M Johnson. 1977. *Biogeochemistry of a Forested Ecosystem.* New York: Springer-Verlag.

Liqiang , Xie, Xie Ping , Li Sixin , Tang Huijuan , and Liu Hong . 2003. "The low TN:TP ratio, a cause or a result of Microcystis blooms?" *science Direct.* doi:10.1016/S0043-1354(02)00532-8.

Lv, Jin , Hongjuan Wu, and Mengqiu Chen. 2011. "subtropical, urban shallow lakes in Wuhan, China." *Science Direct* Volume 41, (Issue 1): 48-56. doi:10.1016/j.limno.2010.03.003.

Million Metres Streams Project. 2017. *Mangapapa Stream Planting at Ratahiwi Farm.* river project, Papatawa: Million Metres Streams Project. https://millionmetres.org.nz/completed-project/mangapapa-stream-planting.

Mueller, David K. , and Dennis R. Helsel. 1996. *Nutrients in the Nation's Waters--Too Much of a Good Thing?* USGS Numbered Series, Geological Survey (U.S.). doi:10.3133/cir1136.

Murphy, Sheila . 2007. "General Information on Phosphorus in the water." *General Information on Phosphorus.* Boulder: City of Boulder/USGS Water Quality Monitoring, April 23.

Nitrates and Nitrites. 2020. *MyWaterBusiness.* March 22. https://mywaterbusiness.com/nitrates-and-nitrites/.

OECD. 1982. *Eutrophication of Waters, Monitoring Assessment and Control.* Paris: Organisationfor Economic Co-operation and Development.

Our Fertilized World. 2017. *Nitrogen and Fertilizer.* Feburary 08. https://denitrifyingtheworld.weebly.com/.

Pathak, Hemant , and Deepak Pathak. 2012. "Eutrophication: Impact of Excess Nutrient Status in Lake Water Ecosystem." *Journal of Environmental & Analytical Toxicology* (Hilaris Publisher). doi:10.4172/2161-0525.1000148.

Patricia , Glibert M. 2017. "Eutrophication, harmful algae and biodiversity — Challenging paradigms in a world of complex nutrient changes." *science Direct* 124 (2): Pages 591-606. doi:10.1016/j.marpolbul.2017.04.027.

Payne, Timothy E. , and Robert Edis. 2008. "Tropical Radioecology." *ScienceDirect* (Developments in Quaternary Sciences,).

Pełechata, Aleksandra , Mariusz Pelechaty, and Andrzej Pukacz. 2006. "An attempt to the trophic status assessment of the lakes of Lubuskie Lakeland." *Research Gate.*

Peter , Bilson Obour, Asankom Dadzie Frederick , Lakkenborg Kristensen Hanne , Holton Rubæk Rubæk Gitte , Kjeldsen Chris , and Kosi Setsoafia Saba Courage . 2015. "Assessment of farmers' knowledge on fertilizer usage for peri-urban vegetable production in the Sunyani Municipality, Ghana." *science direct* Pages 77-84. doi:10.1016/j.resconrec.2015.07.018 .

Profcontrol GmbH. 2022. *Profcontrol GmbH.* Accessed 3 30, 2022. https://profcontrol.de/Hach-Lange-XION-500-LPG385-Spectrophotometer-Spektralphotometer-Spektrometer_1.

Richardson, CJ, RS King , SS Qian , P Vaithiyanathan , RG Qualls , and CA Stow . 2007. "Estimating ecological thresholds for phosphorus in the Everglades." *Environmental Science and Technology* 8084–8091. doi:10.1021/es062624w.

RMB Environmental Labratory. 2022. *RMB Environmental Labratory.* Accessed 03 30, 2022. https://www.rmbel.info/primer/lake-trophic-states-2/.

Ron , Pate, Klise Geoff , and Wu Ben . 2011. "Resource demand implications for US algae biofuels production scale-up." *Science Direct* 88 (10): 3377-3388. doi:10.1016/j.apenergy.2011.04.023.

SDG. 2022. *UNDP SUSTAINABLE DEVELOPMENT GOALS.* Accessed Feburary 12, 2022. https://www1.undp.org/content/seoul_policy_center/en/home/sustainable-development-goals/goal-14-life-below-water/.

Swamulu, V. . 2018. "Water Management." *International Journal of Engineering Science Invention.* Department of History, Sir C.R. Reddy Autonomous College, Eluru - 534 007, A.P., India. 42-44. doi:ijesi.org || PP. 42-44.

Tadesse , Fetahi. 2019. "Eutrophication of Ethiopian water bodies: a serious threat to water quality, biodiversity and public health." *African Journal of Aquatic Science* (Researchgate) 303-312. doi:10.2989/16085914.2019.1663722.

Vymazal, Jan . 2020. "Removal of nutrients in constructed wetlands for wastewater treatment through plant harvesting – Biomass and load matter the most." *science Direct* Volume 155. doi:10.1016/j.ecoleng.2020.105962.

Wall, Dave . 2013. *Nitrogen in Waters: Forms and Concerns.* Minnesota: Minnesota Pollution Control Agency, A2-2. https://www.pca.state.mn.us/sites/default/files/wq-s6-26a2.pdf.

Wassie, Simachew Bantigegn . 2020. "Natural resource degradation tendencies in Ethiopia: a review." *Environmental Systems Research.*

Water research Ceneter. 2020. *Ecosystem and Lake Productivity by Chlorophyll Analysis.* https://www.knowyourh2o.com/outdoor-4/ecosystem-and-lake-productivity-by-chlorophyll-analysis#:~:text=The%20level%20of%20chlorophyll%20a,use%20and%20potential%20nuisance%20issues.

Wells, Scott A. , Jin Juxiang , Liu Defu , and Yang Guolu . 2019. "Thermal stratification and its relationship with water quality." *IWA Publishing* (IWA Publishing) 19 (3): 918–925. doi:https://doi.org/10.2166/ws.2018.142.

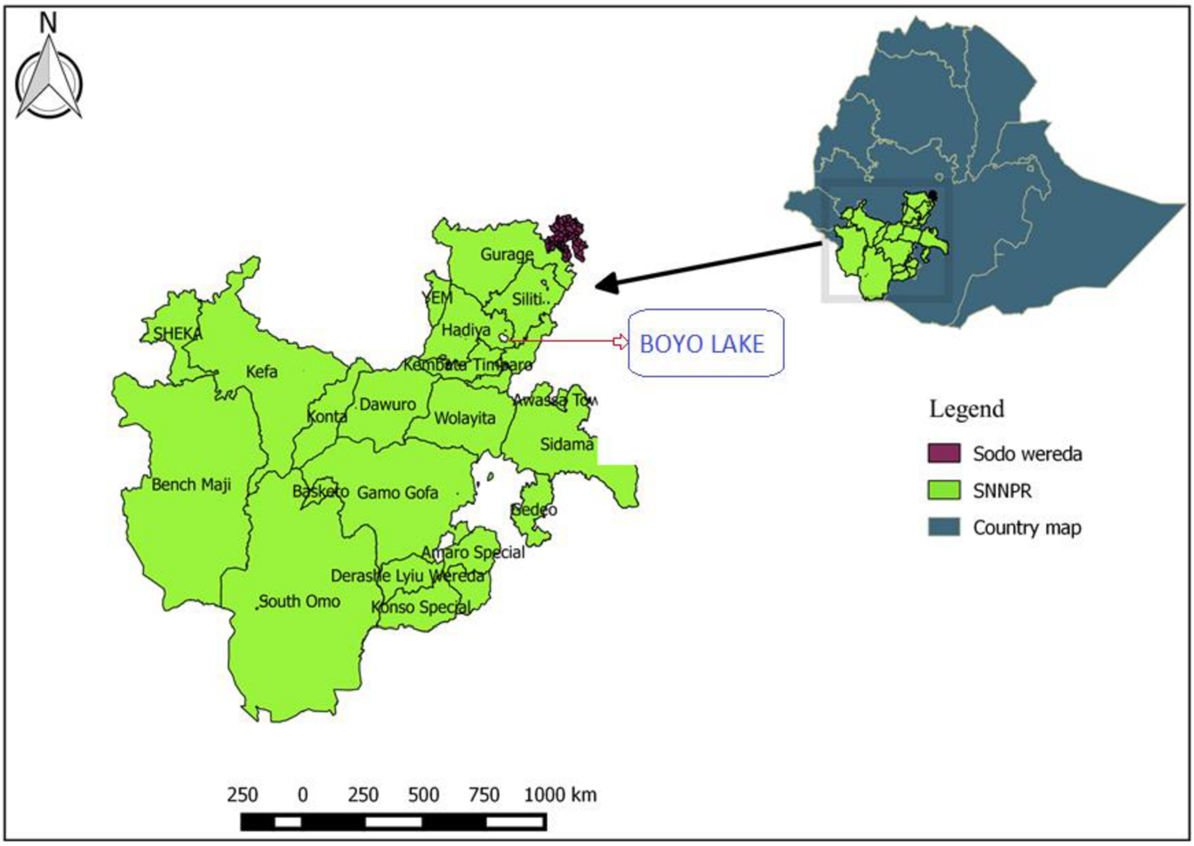
WHO. 2010. *Guideline for Drinking Water Quality.* Geneva: WHO, Pp22-23.

Xiao-e , YANG, WU Xiang , HAO Hu-lin , and HE Zhen-li . 2008. "Mechanisms and assessment of water eutrophication." *Journal of Zhejiang University SCIENCE B* 197-209.

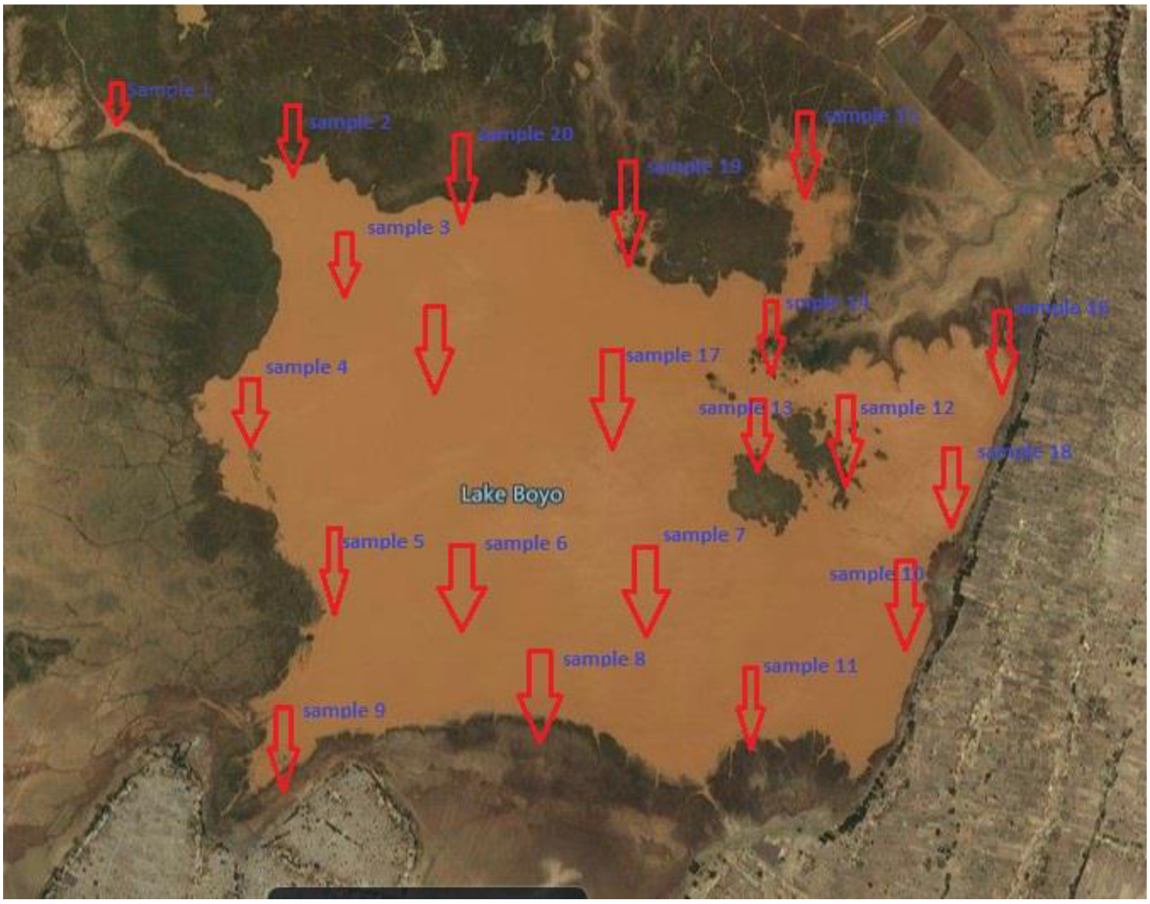
Zhiwei Xu, Xu, Zhang Xinyu , Xie Juan , Yuan Guofu, Tang Xinzhai , Sun Xiaomin , and Yu Guirui . 2014 . "Total Nitrogen Concentrations in Surface Water of Typical Agro- and Forest Ecosystems in China." *National Center for Biotechnology Information.* doi:10.1371/journal.pone.0092850.

Zublee, M. 2010. "How to Determine the Water Quality ? | Water | Environment." *India Essays.*

Appendix A: Map of Boyo Lake



Appendix B :sample points and Area of Boyo Lake



Appendix C :Total Area of Boyo Lake

Appendix D : Water hyacinth on Boyo Lake