IMPACTS OF FLORICULTURE PRACTICES ON SURFACE WATER QUALITY IN THE CASE OF LAKE DAMBEL, BATU TOWN, ETHIOPIA

ELIAS GIRMA GUGSA

A THESIS SUBMITTED TO

THE DEPARTMENT OF WATER RESOURCES ENGINEERING

SCHOOL OF CIVIL ENGINEERING AND ARCHITECTURE

PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER'S IN WATER RESOURCES ENGINEERING

(SPECIALIZATION IN WATER SUPPLY AND ENVIRONMENTAL ENGINEERING)

OFFICE OF GRADUATE STUDIES

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

JUNE, 2024.

ADAMA, ETHIOPIA

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Elias Girma

Advisor: - Keredin Temam (Ph.D.)

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DECLARATION

I hereby declare that this Master Thesis entitled **''Impacts of Floriculture Practices on Surface Water Quality In The Case of Lake Dambel, Batu Town, Ethiopia''** is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Elias Girma Gugsa ____________________ JUNE, 2024.

RECOMMENDATION

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled **''Impacts of Floriculture Practices on Surface Water Quality In The Case of Lake Dambel, Batu Town, Ethiopia''** prepared under my guidance by **Elias Girma** submitted in partial fulfillment of the requirements for the degree of Mater's of Science in Water Resources Engineering (Specialization in Water Supply and Environmental Engineering). Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

Keredin Temam (Ph.D.) ____________________ JUNE**, 2024.**

APPROVAL PAGE

I, the advisor of the thesis entitled entitled **''Impacts of Floriculture Practices on Surface Water Quality In The Case of Lake Dambel, Batu Town, Ethiopia''** and developed by **Elias Girma**, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Keredin Temam (Ph.D.)	____________________	**January, 2024.**
Advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by **Elias Girma Gugsa** have read and evaluated the thesis entitled **''Impacts of Floriculture Practices on Surface Water Quality In The Case of Lake Dambel, Batu Town, Ethiopia''** and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Water Resources Engineering (Specialization in Water Supply and Environmental Engineering).

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LIST OF ABBREVIATIONS

BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
CRV	Central Rift Valley
EC	Electrical Conductivity
EHPEA	Ethiopian Horticultural Producers and Exporters Association
EIA	Environmental Impact Assessment
EPA	Federal Environmental Protection Agency
EPE	Environmental Policy of Ethiopia
FAO	Food and Agricultural organization
ISO	International Standard Organization
m.s.a.l	meters above sea level
MoH	Ministry of Health
MoRAD	Ministry of Agriculture and Rural Development
MPL	Maximum Permissible Limits
NTU	
PH	Power of Hydrogen
PPM	Parts Per Million
PRRP	Pesticide Risk Reduction Programe
TDS	Total Dissolved Solid
TSS	Total Suspended Solid
SPSS	Statistical Package for Social Science
µS/cm	micro Siemens per centimeter
WHO	World Health Organization

ABSTRACT

Different pesticides, fertilizers, and mechanizations are used by huge floricultural companies to enhance and expand their production capacity by floriculture companies in Batu and other places. The main purpose of this research is to assess the overall impacts of floriculture practices on surface water quality and environment. Besides this research aims to identify the major sources of pollution load and manage the most source of floriculture chemical characteristics using water quality analysis. The study area of this research was Lake Dambel which is found 160 KMs south of Addis Ababa in the Ethiopian Central Rift Valley. Water samples were collected from purposely selected sampling point randomly from lake Dambel to evaluating physiochemical parameters and compliance to Ethiopian EPA standards and WHO guidelines were made. Furthermore information collected from stakeholders, floriculture companies, and community through interviews. The findings revealed that concentration of turbidity, BOD, COD, TSS. PO_4, NO_3, SO_4 *and* NH_3 *will not meet with minimum compliance standard while parameters such as* $_PH$, *EC, DO, TDS and hardness are will satisfy WHO and Ethiopian EPA standards. This indicates that high impact on environmental farming activities of local community and also becoming less suitable for the maintenance of fisheries and aquatic life.*

Key Words: Concentration, Floriculture, Lake Dambel, Physicochemical, Stakeholders, Surface Water, Water Quality.

1. INTRODUCTION

Currently, increasing trends of commercial agricultural activities and overall developments in the Central Rift Valley (CRV) of Ethiopia, where smallholder horticulture farmers and large-scale flower growing companies are located around Lake Dambel were experienced (Berhan M. Teklu et al., 2018). Local farmers and commercially estabilished companies in the area use pesticides and chemical fertilizers, which may affect the water quality of the lake and the surrounding surface waters through the release of some trace elements and residues from the agricultural fields into the surface waters (Berhan M. Teklu et al., 2018). Although in most cases, both organic and inorganic pollutants are subjected to biodegradation, biotransformation and abiotic processes that reduce concentrations in the environment, this will not be the case for contaminants like persistent organic pesticides and heavy metals (Berhan M. Teklu et al., 2018).

Therefore, because of bioaccumulation in the food chain and high toxicity, this component will cause damage and health risks to aquatic organisms and in turn to human beings. Hence, monitoring organic and inorganic pollutants in surface waters is essential to assess their risks to aquatic ecosystems and human health (Berhan M. Teklu et al., 2018). The increased use of fertilizers by smallholders and enterprises, the increased volumes of (untreated) agricultural waste water and can cause eutrophication, which can result in turbid water, algal blooms, fish mortality and poor quality of drinking water (Herco Jansen and Alterra, 2009).

Although a number of studies are being conducted in the Lake Dambel area, most of them focused on studying the hydro-geochemistry of waters around the lake by analyzing samples from groundwater and surface waters using only a single measurement, and on determining the low molecular mass (LMM) trace element species in the Ethiopian CRV lakes including Lake Dambel (Berhan M. Teklu et al., 2018). Others focus on the heavy metals and organochlorine pesticides present in fish species, sediment and water samples and the correlations between them (Berhan M. Teklu et al., 2018). To a better understanding of the spatial and temporal water quality changes in Lake Dambel this study was conducted to measure physiochemical parameters to develop pollution control and prevention strategies.

The underlying reason for deterioration of the Lake is the water use, does exceed the sustainable use. Recently, the ongoing water over abstraction from the surface water resources has been synergized with the groundwater development from the lacustrine aquifer of the areas of the lake. The newly intensive lacustrine aquifer development in connection with the extensive and intensive water harvesting activities in the floor of the rift valley will put its own impact on the water availability in the system (Terefe, 2007).

Furthermore, this study will assess the pesticide concentrations at some several time and sampling points in the Lake Dambel and surrounding ground water sources and compare the results that I get with previously measured pesticide concentrations in the area.

Finally, this research study provides a comprehensive analysis of the water quality of surface water around Lake Dambel and its surrounding area.

1.1. Background

The rapidly growing floriculture industry is using chemicals (pesticides and fertilizer) (Alemayehu P. Washe et al., 2018). Ethiopian floriculture sector is growing by 20% each year making the nation the second largest African exporter of roses (Getu, 2013). Within the span of fewer than three decades, Ethiopia emerged as a global player in the cut flowers business ranking only second to Kenya (Kassa, 2017). Virtually the entire output of the sector in Ethiopia is destined for export markets, markets characterized by intense international competition (Oqubay, 2015).

Lake Dambel is one of the lakes with in the central rift valley system which serves for wide range of socio-economic activity (Abraham T. et al., 2018). Lake Dambel is providing water for a wide variety of sectors in the central rift valley of Ethiopia. However, there is a lack of systematic study that informs the effect of water abstraction on the lake water balance (Goshime W. et al., 2021). On the other hand the amount of fresh water is very limited as compared to the total volume of water on earth and similarly in the study area. Still the existing usable fresh water is by far enough to satisfy the current demand. However, this resource is unevenly distributed both in space and time. This and uneven distribution of water makes it finite and scarce resource. So water must be managed in a sustainable way to meet human as well as ecological needs. In the absence of proper water resources management, it is inevitable that the existence of the resource will be questioned by shortage, and then by the depletion (Terefe, 2007).

A result of, the fast growing population expansion of farmlands, increased deforestation, overgrazing, irrigation and fishing activities leading the area to high water stressed area. Furthermore, future water and land use plans which include expansion of irrigation projects, small-, medium- and large-scale, community water supply schemes, artificial evaporation of lake water for soda ash production, geothermal resource development and expansion of resort areas substantial influence on the scarce water resources of the area (Terefe, 2007).

1.2. Statement of the Problem

Floriculture is one of the booming sectors in Ethiopia and a good way of generating income for both the owners and the government. Furthermore, now it is one of major sources of foreign currency for the national GDP. On the other hand high level public and complains on pollution load due to intensified uses of pesticides and chemical fertilizers (Hunde, 2018). However, floriculture companies are not accepting public complain rather trying to link with society awareness level. Wastes from agricultural land that comes from floriculture consists of mixture of different chemicals and pesticides that are used for agricultural purposes and which need beyond treatment capacity of floriculture wastewater treatment level. As a result of complexity of agricultural effluent mix-pollution load and compositions, emerging pollutants introductions to water body, physiochemical and biological changes to ecosystem which is resulting ecological degradation (Berhan M. Teklu et al., 2018).

Therefore, evaluation of impacts of floriculture practices on surface water quality in the case of lake Dambel, significantly important particularly for Batu town overall development and wellbeing. This will provide baseline information in relation to the impact of the effluent on ground water and protecting the lake ecology.

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of this research is to assess the overall impacts of floriculture practices on surface water quality and environment.

1.3.2. Specific Objectives

- To assess the water consumption of floriculture companies and its impact on surface water quality of lake Dambel.
- To evaluate the impacts of floricultural practices on surface water quality
- To identify the major sources of pollution load and manage the most sources of floriculture chemical characteristics using water quality analysis,

1.4. Research Questions

1. Which type of floriculture practices contribute more to the degradation of the sueface water quality in Lake Dambel?
2. To what extent does these floriculture companies contribute to the deterioration of the surface water quality of Lake Dambel and environment?
3. What are the impacts of floriculture practices affect the environmental condition and surface water quality of the study area?
4. How the floriculture practices around lake Dambel affect the surface water quality?

1.5. Significance of the Study

The primary benefit of this study will be getting the information about the current status of fresh water around Lake Dambel and how to protect the ecosystem from the coming floriculture effluents. This study also provides the baseline for further protection of our environment by controlling and managing the human anthropogenic activities specially the floriculture practices. Also this study will give a way of how to recover and protect the sensitive areas by providing possible solution with detail experiment. The effluents comes from agricultural areas through runoff entering in to the lake and the water that will infiltrate and recharge the ground water around the horticulture areas will be assessed in this study. This study also investigate the infiltration capacity of the horticulture areas and study its water content that will join the ground water which in turn study the effect of this condition on the availability and accessibility of fresh water resource. This study will benefit the local community by studying providing potable fresh water around the area for domestic purpose. The scientific community can be one of beneficiary of this study by using as a literature and having the current information around the area for further investigation. Regional or local governmental administrations and non-governmental organization might be use this paper as a reference for further regulation and guidelines.

1.6. Scope of the Study

The situation of study area is mostly covered with agricultural practices that produce different types of flowers as well as fruits vegetables and crops suitable according to the climate condition and environment. In this study I mainly focus on floricultural practices and its influence on Lake Dambel and its ecosystem. The major effluents that comes from floricultural practices are pesticides, fertilizers and chemicals that used for packaging. In Ethiopia Lake Dambel is one of fresh water resource and hence it has been used for water supply of the town even for domestic purposes. Therefore, protecting the lake will be crucial for sustaining water supply and keeping the aquatic environment.

2. LITERATURE REVIEW

2.1. Floriculture Industry in the Worldwide

Floriculture, or flower farming, is the term used to describe the production of beautiful and fragrant plants for gardens and floristry, which together comprise the floral industry. The top flower producing countries in the world today are Netherlands, Israel, and Germany. Africa too is making the cut, in which Ethiopia is an upcoming flower producing country, following fast on the heels of Kenya, the largest flower producing country in Africa. One of the main pursuits of floriculturists is the creation of new types through plant breeding (Wikipedia, 2011). According to encyclopedia environmental health (2011) Floriculture refers to the cultivation or farming of flowering and ornamental plants for gardening and floristry, including floral design.

Floriculture crops are typically herbaceous differentiating them from nursery crops, which are typically woody. Floriculture crops include flowering plants, bedding and garden plants, foliage or house plants, fresh cut flowers, and cultivated greens.

Globally, different countries participating in floriculture industry and enhancing the activities time to time. According to Brian (2009) The Cut Flower and Foliage Industry in Australia is part of the agricultural sector and engages in growing flowers and foliage for cutting and display.

Water use efficiency in Australia is an area of the highest priority for all primary production sectors including cut flower and foliage enterprises. There is significant opportunity to increase the efficient use of water through the application of sophisticated irrigation scheduling tools and techniques as those being developed and used in Israel and Europe (Brian, 2009).

In the leading world Israel is also in its application of these water use efficiency measures to its production areas such as greenhouse design and automation, irrigation scheduling as well as the use of lesser quality, recycled and marginal water in cut flower growing.

Effectively applying these technologies and techniques provides not only significant water savings potential but can also improve plant quality, crop yield and of course profitability (Brian, 2009).

The Netherlands has also a total area of 8,149 hectares of land for flower and pot plant production. 5,365 hectares is for protected cropping and 2784 hectares for open (inground) production. The value of this production is Euro 3890 million from 6,807 properties (International statistics flowers and plants, 2007).

2.2. Current Status of Floriculture Industry in Ethiopia

The growth and expansion of the floriculture business in Ethiopia is supported by favorable climatic condition, accessibility to markets in the Middle East and the EU, inexpensive and plentiful labor force, and reliable transportation infrastructure. Ethiopia is following this path, along with many other emerging countries, in order to generate foreign exchange, broaden its export market, and achieves quick economic growth. By doing this, its exposure to the price instability that frequently exists in global markets will be reduced. Beginning in the early 1990s, in Ethiopia the emergence of its first floriculture companies was raised. In recent years, Ethiopia has attracted international investors for its cut flower exports, mostly to European markets, appreciations to government regulations that are supportive and encouraging of this industry. An enhanced investment law, a five-year tax relief, duty-free machinery imports, simple bank loan application processes, and the availability of easily trainable labor are all factors that attract investors. Furthermore, the development is advantageous to the nation since it creates direct or indirect job opportunities for those who are unemployed. More significantly, seventy percent of the workers on these farms which are mostly in rural areas are women.

There are currently above 3,491.04 hectares of land dedicated to floriculture in the country, according to recent data. At the moment, about 80% of Ethiopia's horticultural revenue comes from the flower industry. The industry brought approximately 225 million USD, with cut flower exports making up the lion's share of income. Ethiopia is currently the second-largest rose exporter in Africa and the sixth largest in the world due to its level of production. The Ethiopian Horticulture Producers and Exporters Association (EHPEA), which was founded by the floriculture industry, is an organization that further supports the industry.

A variety of environmental issues eventually surface in any industry that is growing rapidly. The fast economic expansion of Ethiopia's floriculture sector has raised questions about whether social progress and the environment are being sacrificed in the process. It is inevitable that doubts over the new sector's effects on the surrounding environment arise whenever it is brought into a nation.

2.2.1. Floriculture Industries in Batu Town

Fresh cut flower productions for commercial use were first initiated during 1981 and 1982 cultivation season in Batu Town. Batu farm was not the only state farm that produced fresh cut flowers; Bishoftu and Tibila state farms also participated. Most of the currently established flower-growing areas are in Addis Ababa, the Upper Awash Valley, and Lake Dambel. The flower farm fields are situated between Lake Dambel and the major highway, with an altitude ranging from 1600–1700 meters above sea level. Lake Dambel is located in the southern part of the country, Ethiopia, 165 kilometers from Addis Ababa. One of the four primary areas with a significant concentration of cut flower production is the Lake Dambel area. The biggest freshwater source in the region, Lake Dambel is crucial resource for drinking water supply and domestic use for the town.

A large-scale horticultural and floricultural greenhouse complex called Sher Flower Farm was estabilished in 2005 near to Batu town on the shore of Lake Dambel. This development gave the locals, who mostly depend on smallholder agriculture and it offers much-needed work opportunities to local population.

Here are list of available floriculture industries around Batu Town, according to Ethiopian Horticulture Producers and Exporters Association (EHPEA) stated.

Table 2.1: list of floriculture companies in Batu Town (According to EHPEA)

R.N	Company	Product	Address	Location
1	AQ Roses PLC-ZEWAY-Flower	Rose Flowers	frank@aqroses.com;	Batu
2	Braam Flowers PLC	Rose Flowers	braam@ethionet.et;	Adami Tulu, Batu
3	Herburg Roses Plc	Rose Flower	head.office@herburgrosesplc.com;	Batu

4	Sher Ethiopia PLC	Rose Flowers	sherethiopia@ethionet.et;	Adami Tulu, Batu, Oromiya
5	Ziway Roses PLC	Rose Flower	marc.holla@hollaroses.com;	Batu

2.3. Water Requirement of Floriculture Industries and Available Water Resources

Lake Dambel is the main source of livelihoods for local communities, and a source of drinking and domestic water for Batu and Meki Towns, a source of water for open and closed farm irrigations, biological diversities such as fishes, birds, mammals e.g. hippo- potamus, etc.

One of the major nature of flower farm is it *consumes a high amount of water*. E.g., One hectare of a flower farm consumes over 900 cubic meter water per month (Organic consumers Association 2006). Some study shows that about 90% of the flower is made up with water. This means that exporting flower is like exporting water. Despite the use of high level water by flower farms, they are very reluctant to use an effective way irrigation system that will lead the case much worst (Ethiopian review 2010). Recent research showed that there is a loose of natural capacity in river Awash. Since Most farms follow the step of the Awash River valley or its tributaries around the Great Rift Valley in order to take their positional advantage to proximate themselves to the capital city, Addis Ababa, in which the main cargo flight service is located. This led to rivers and lakes to lose their natural capacity due to high water consumption. In this region particularly there are a lot of local farmers who are dependent on water for their crop cultivation and cattle breeding.

Decreasing the water level of those lakes and rivers in which their life is dependent on made them frustrate, instable and finally put their future livelihoods in danger. Considering Kenya's flower industry as a reference, still conflict going on by a concerned local people and flower farm investors those who depend on their live in Lake Navisha.

There is a clear procedure on Ethiopian legislation bodies and Ethiopian Horticultural Producers and Exporters Association (EHPEA) about how much water a single farm should use per area. However, the water level is dropping from time to time, and there is no action is implemented to tackle this problem. In the future, water expected to displace oil as the greatest resource challenge, and Water is central thing for survival, and without it, life would be impossible. Water is a central component of Earth's ecosystems, providing important controls on the weather and climate and it should be given high consideration for conservation.

The farm abstracts water from the lake and returns its wastewater through extensive reed bed areas of the littoral zone. The risk of pesticide residues reaching the lake is of concern, not of only because of the proximity of the farm to the lake but also because effluent is discharged year round. This effluent might contain residues of pesticides and fertilizers from the production process, presenting risks to the Lake Eutrophication and toxicity to wildlife. The biodiversity of the wetlands adjoining the lake is rich, and comprises many species of fauna and flora.

Greenhouses require water for irrigation, cooling, pesticide application, root-zone media preparation, and cleanup. A one-hectare greenhouse has the potential to use between 120 000 and 160 000 liters per day. The majority of this water is used for irrigation and its rate of use is dependent on the level of solar radiation, greenhouse shading, air movement in the greenhouse, types of plants grown, irrigation system design, and the degree of leaching employed. Best management practices in a greenhouse usually include runoff minimization, efficient irrigation system design, reduction in overwatering, integrated pest management using less pesticide application, fertility optimization, reduction in storm runoff by diversion and storage for irrigation, and proper disposal of greenhouse runoff through treating and recycling runoff and reverse osmosis (SE Newman, 2011).Moreover, too much use of water leads to conflict with the local community, as was the case in the Naivasha district in Kenya. It may also lead to depletion of water from its natural reservoir.

Lake Dambel is the largest fresh water Lake in the area and a critical resource for the drinking water supply of people and livestock. The Katar and Meki rivers that originate in the highlands drain in to the lake. At its southern end, near the town of Batu, the Bulbula River connects it to Lake Abijata. The lake's water level has declined over the past few decades as a result of water diversion from the two main feeder rivers for irrigation, as well as direct pumping from the lake (Vilalta, 2010). The lake is home to many endemic birds and a wide variety of fish, aquatic invertebrates and wild animals (IBC, 2005). It also is one of the main sources of commercial fish farming in Ethiopia (Vilalta, 2010).

2.4. Chemicals Regularly Utilized in the Floriculture Industries

Due to the growth of the industry, environmental concerns are indeed growing. Environmentalists are raising many concerns in relation to the expansion of floriculture in Ethiopia, such as the use of pesticides and chemical fertilizers, disposal of waste materials, and the protection of bodies of water. According to environmentalists, there is an overuse of pesticides and chemical fertilizers in the industry, which damages the environment. They believe that too much pesticide is getting into bodies of water, damaging the biodiversity. Excessive amounts of chemicals are killing useful organisms in the soil. Environmentalists are also concerned that waste materials will damage the environment that they will seep into the soil, into bodies of water, or be used by people and cause serious damage (Wikipedia, 2011).

Toxication in Bits Flower Industry Threatens Right to Water in Ethiopia CutFlower Production Practices, the Sector‘s Socio-Economic Contribution and Environmental Standards. Addis Ababa, Ethiopia.) While development has been reported in application of chemicals largely due to awareness of workers, pressure from labor unions within the farms, and directives of the Ministry of Agriculture, there are still some hazardous chemicals that are still in use which are extremely hazardous categories of the WHO that are still in use in the Ethiopian flower industry.

Pesticides and fertilizers used in the normal course of growing plants are the most important potential threats to groundwater. Pesticides having high leaching potentials, high surface loss potentials, or which are persistent in soil are of greatest concern. Method of application, pesticide formulation, soil type, and microbial activity in the soil are some other factors which affect how much chemical may reach the groundwater (Hengsdijk and Jansen, 2006).

2.4.1. Pesticides Mostly Used in the Floriculture Industries

According to Meer and Vander (1997) methyl bromide, an ozone deplete and a category acute toxin, is a heavily used and is among the most dangerous toxic substances known. There exists a wide array of other pesticides with known health risks. Some fungicides used, such as Mancozeb and Captan are suspected carcinogens, and such herbicides as paraquat, are extremely toxic through any route of exposure, whether absorbed through the skin, inhaled. Chemical pest controls, increase soil salinity and destroying its productivity. According to Afrogadaa (2010) in-house agronomist Ato Seyoum Fenya, talk about Ethiopian flower farm experiences on pest control, the containers which store twenty litres of pesticide used each day on Menagesha Flower farm, are reportedly buried in the grounds without being sealed. Even if the containers are sealed and then buried, thus following the advice of the Ethiopian Environmental Protection Authority, this probably only delays a huge future environmental catastrophe. Moreover, too much chemicals kill useful organisms in the soil. And if too much pesticide gets into water bodies it damages the biodiversity. What is more according to some researchers the land once used by the flower industries will take 40 to 60 years to rehabilitate if intensive treatment was conducted to that extent. Given the type of chemical being used, unregulated waste removal system and irresponsible government; it is very improbable that the land will be ready for agricultural use even in the coming century. If the flower farm expansion keeps with the current pace, the whole nation's crisis of food will be in unmanageable.

2.4.2. Fertilizers Mostly utilized in the Floriculture Industries

Use of excessive amounts of improper application of fertilizers and pesticides may result in harmful chemical contamination of ground water (David, 2002). Fertilizers are significant pollution treats because of their high solubility and the frequent application of large volumes of irrigation water (Thrupp and Lori, 1998).

Nitrogen and phosphorus must be managed carefully to ensure that excessive amounts do not degrade water quality. Too much nitrogen and phosphorus along with carbon in surface water cause eutrophication (excessive algae growth) in rivers, lakes, and ponds (David, 2002). And also, application of "bad" fertilizers or too many fertilizers can cause severe problems to plants or soil microbes. With increased soluble salt content in the soil, the ability of the roots to absorb water and nutrients is reduced, and the plants will wilt and die due to dehydration (Afrogadaa, 2010).

2.5. Effects of Anthropogenic Activities and Ecological Conditions around Lake Dambel

Abstraction of Water for irrigation

Previous studies have reported a slight decline of the water level of Lake Dambel (Ayenew and Legesse 2007). However, the recent irrigation-based agricultural developments around the shoreline and along the feeder rivers could result in additional significant declines in lake water levels. According to the study by Ayenew (1998) the annual volume of water abstracted for irrigation and drinking water was 28 million m3 and 0.63 million m3, respectively. Almost a decade later, the annual water abstraction for irrigation increased by 5–8 times, whereas the abstraction for drinking use and livestock watering seems to have remained constant (Eresso

2010; Desta et al. 2015). The annual total water inflow and outflow (including abstraction) of Lake Dambel estimated at 1 052.4 million m3 and 1 113.2 million m3, respectively, with an overall negative water balance (i.e. -61 million m3). This apparent overexploitation of the water resource from Lake Dambel may result in lower water levels and a reduction in lake surface area that will have ecological impacts, because of habitat destruction, such as deterioration of marginal wetlands and seasonal grasslands (Ayenew and Legesse 2007; Eresso 2010).

Sediment load

Due to rapid land use change, mainly conversion into agricultural lands, (Desta et al. 2015) at the watershed of Lake Dambel, annual sediment loads have increased significantly. This issue is likely to affect water clarity, salinity (through major ions enrichment, Ayenew 2007), nutrient concentrations (Smith et al. 1999) and lake depth. Detailed information about sediment load to Lake Dambel is, however, sparse. According to Berhane (2014), annually approximately 9 tons ha-1 of sediment was estimated to be deposited into Lake Dambel only from its western watershed. Similarly, the recent study by Aga et al. (2019) reported that the annual sediment load into Lake Dambel from its catchment area was estimated at approximately 2 039.59 × 103 tons. Based on the sediment load estimation by Aga et al. (2019), annually sediment thickness of lake Dambel is increased by 3.8 mm, which would amount to an approximately 3.8 cm decrease in lake depth per decade. This would be a serious deterioration in the lake ecosystem.

Plastics pollution

Plastics are synthetic polymers that widely found in the environment, as a result it is an emerging environmental concern (Solomon and Palanisami 2016; Koelmans et al. 2017). Plastics of various particle sizes may enter water ecosystems, for example, via drainage systems, aerial deposition and runoff (Castañeda et al. 2014; Free et al. 2014). Many recent studies have disclosed that microplastics (size <5 mm) are widely distributed in surface water and sediment and are ingested by aquatic animals (Foekema et al. 2013; Castañeda et al. 2014; Besseling et al. 2015). In addition, recent studies have shown the ecological effects of microplastics in water ecosystem (Redondo-Hasselerharm et al. 2018). Because plastic processing plants are absent around Lake Dambel, urban solid waste (Figure 5) and wastewater effluents can be a potential source of plastics pollution for the lake ecosystem. Plastic ropes for plant support that are widely used by smallholder tomato growers may exacerbate the pollution. However, we have found no quantitative studies on plastics pollution in Lake Dambel.

2.6. Impacts of Floriculture Industries on Surface Water and Environment

With the expansion of the floriculture industry, there is a growing concern as to its adverse effect on the national environment. Ato Tsegaye Abebe, Head of EHPEA, is aware of this concern and stated that, "When any new sector is introduced into a country there are inevitably concerns about the impact of the sector on the local environment (Mulugeta, 2009).

The only alternative to chemical/artificial fertilizers is the use of organic cultivation. Nitrogen in fertilizer can produce nitrates, which can be washed away from fields by rain or irrigation, eventually finding their way to water bodies and soil. Water pollution, soil and water quality degradation, human and cattle health effects, air pollution, risk on aquatic life, as well as water logging and salinization are only a few of the undesired impacts (Mulugeta, 2009).

Pesticides (which include herbicides, insecticides, fungicides and more) can contaminate organisms, soil, water, turf, and other vegetation. It is estimated that less than 0.1 percent of the applied pesticide reaches the target pest, leaving 99.9 percent as a pollutant in the environment, including the soil, air, and water, or on nearby vegetation. The adverse effect of pesticide use includes degrading water and soil quality, effect on non-targeted lives like soil organisms, aquatic life, human beings, insects, cattle etc, air pollution, and increase of pesticide resistance by targeted pests (Mulugeta, 2009).

2.6.1. Impacts on Surface Water

There are many fertilizers, which leak through the soil to the ground water or ditches and streams, thus causing water pollution. In a process known as eutrophication, fertilizer washed from fields into surface waters stimulates algae growth, which blocks sunlight needed by aquatic vegetation putting their survival at stake. This loss in vegetation disrupts the food chain, leading to the death of economically important aquatic life. Moreover, this causes depletion of oxygen found in the water thus degrading the quality and usability of the water (Mulugeta, 2009).

Pesticides can move from the site of application via drift, volatilization, leaking, and runoff. Pesticides, including herbicides, can and do leak to contaminate ground water. Once ground water is polluted with toxic chemicals, it may take many years, a huge expense and a complex process for the contamination to be cleaned up. As a result, the contamination (by pesticides) of ground and surface water, which supplies the greatest part of drinking water, is a serious problem worldwide. When pesticides contaminate water, they can be harmful to the fish and other marine or freshwater animals that live there (Mulugeta, 2009). Additionally, Solid wastes and toxic chemicals that contaminated water body can develop water born disease (Abiy, 2011).

Lake Naivasha in Kenya floriculture farms has been accused of polluting the lake water through extensive use of chemicals, which has had a heavy effect on the lake's biodiversity. Fishermen highly blame that fish stocks are declining and the lake is being polluted by chemicals. Because of this there is usually conflicts raised between the community and the flower farms and some of them are feeling insecurity to produce comfortably (Becht *et al.*, 2006).

Aquatic life is in danger with floriculture industries effluent of wastewater. As a result of the Second North Sea Conference in 1987, a number of countries agreed to reduce discharges of certain chemicals in to water systems (Megara and John, 1999).

Researchers took small samples of water from local rivers and flower farms, and samples of discarded flowers from the farms. Flower farmers deny channeling water into rivers and natural water courses after they have watered their flowers. But investigators found that very few would treat water after it had passed over the pesticide-covered flowers (Stevenson *et al.*, 1997).Most use of excessive amounts or improper application of fertilizers and pesticides that result in harmful chemical contamination of the total environment and high pollution effect on water bodies (Whiles *et al.*, 2000).

2.6.2. Impacts on Environment

Some fertilizers, like Urea, spread in the fields with the help of sprayers and the ammonia therein react with the water present in the air causing the formation of ammonia oxide, and hence air pollution. Foliage, moves away from the area of application, and contaminate the environment. As much as 80-90 percent of applied pesticides can be volatilized within a few days of application (Mulugeta, 2009). Due to its highly volatility nature , is estimated that only 0.1 percent of the total applied pesticide attain its intended goal but the rest 99.9 percent leaves as an air pollutant. And the pesticides applied in the greenhouses travels an average distance of 1,500 miles, adding significantly to global warming and air pollution (Anonymous, 2003).

According to Abiy (2011) there are still some hazardous chemicals that are still in use. The use of methyl bromide is not officially encouraged by any institution. However, it is not yet banned from application in flower production. Methyl bromide is a fumigant that is regarded to be a serious ozone depletion agent. Ethiopia ratified the Vienna Convention and Montreal Protocol in October 1994 to help support in the regulation of the use of ozone depleting chemicals.

2.6.3. Impacts on Human Health

With regard to matters dealing with workers' health and safety issues, different literature indicated that they face problems that affect their health conditions. For example, the absence of toilet facilities and their poor condition, absence of clean drinking water, showers, absence of maternity leave as well as absence of first aid and free medical care coupled with the presence of high temperature in the greenhouses create potentially hazardous effect on workers' health. However, chemical were seen damaging the health of the workers. Skin chemical allergies, respiratory problems, and unconsciousness because of inhalation of chemicals are among the direct health problems associated with the chemicals as witnessed by the health centers. In addition to these health problems mentioned by health centers, the workers added early abortion in women, birth problems, stomach aches, vomiting, and poor appetite.

According to Mulugeta (2009) many diseases such as *Methemoglobinemia*, Japanese encephalitis (JE), cancer etc. have been noted due to use of chemical fertilizers. Research demonstrates that "on rare occasions, nitrates have caused infants to become ill or die of *Methemoglobinemia* (more commonly known as blue-baby syndrome)." *Methemoglobinemia* occurs when the excess nitrates that remain in the soil move into the ground water and when this water is used for drinking by human beings as a result of which the nitrite interferes with the oxygen carrying capacity of the blood.

According to Workneh (2007) However, the management does not seem to be concerned about worker's health, as they do not seem to be taking measures to improve some of the important facilities such as the provision of safe drinking water and toilets on the farm. Instead, the management is more interested in protecting the flowers from plant diseases rather keeping the workers healthy.

According to Fatuma's (2008) study the floriculture farms were seen very close and there was only five meters between the farm and road to densely populated residents of the area. The neighboring households were strongly complaining of a pungent and irritating smell coming from the nearby farms especially while chemical spraying was going on in the farm greenhouses. Most of the time the chemical spraying was done in the morning times and the surrounding communities explained they were unable to eat their breakfast because of the disturbing bad smell coming out of the farms greenhouses.

UWEA (2006) mentioned from its research in Ugandan floriculture industries in the neighboring communities of flower farms complain of a smell when spraying was going on at the farm. According to UWEA (2006), it was also reported that bees which are necessary for pollination have disappeared due to spraying, hence poor yields in the surroundings.

2.7. Management on Waste Disposal

Floriculture activities produce different types of waste ranging from liquid to solid, hazardous to non-hazardous, and in effect require safe waste disposal and differentiated treatment. Empty chemical containers (fertilizers, pesticides) and their washing waters and obsolete chemicals are the major spheres of concern in addition to which other agricultural waste such as cut off crop parts, unused soil, and waste water are generated in the sector. According to Abiy (2011) Chemical containers, diseased plants, residue of cut-flower Stems and plastics are some of major solid wastes. It is known that up to 500 tons of residues per hectare per year are generated from flower farms. Liquid waste that cannot be reused or recycled should be collected and kept in impermeable containers or solar evaporation ponds. The waste residue should be transported off site for safe disposal at a local, council-approved waste disposal area. However, the flower farms in Ethiopia have been heavily criticized for not having adequate means of waste management systems.

2.8. Policies and Laws Stated for Environmental Protection in Ethiopia

In the 1990s, Ethiopia made significant progress in laying a foundation for addressing environmental problems. One major initiative for introducing environment into the national policy arena was the Conservation Strategy of Ethiopia (CSE) process, which started in 1989 and completed its work in 2003, culminating in a five-volume report. The CSE was instrumental in:

- Developing and obtaining government approval for the Environmental Policy of Ethiopia;
- Prompting the establishment of the Environmental Protection Authority;
- Introducing new thinking about environmental issues and development and put into circulation new ideas about sustainable development;
- Initiating and undertaking capacity-building activities for environmental management at the federal and regional levels;

- Facilitating the development and publication of a considerable amount of guidance, providing the government and donors with a basis for environmentally sustainable planning at the federal and regional levels.

The CSE was one of the influences that led to the inclusion of several references to environment in the 1995 Constitution of the transitional government. Article 44 guarantees the right to live in a “clean and healthy environment”. Article 92 refers to the state’s responsibility to design and implement programs and projects that do not damage the environment and establishes the joint responsibility of the government and citizens to protect the environment (CIDA, 2004).

The Environmental Policy of Ethiopia (EPE) included various policy directions which address the need to protect and develop the environment and conserve national resources for sustainable use. As a key guideline principle, the policy takes the position that when a compromise between short-term economic growth and long-term environmental protection is necessary, because rehabilitating a degraded environment is very expensive (Environmental Policy of Ethiopia (EPE), 1997).

EPE underlines recycling waste water when it is found to be safe for health and environment or when the recycling cost is not high. With regard to fertilizer use, EPE promotes the use of organic matters. EPE also regulates waste management by stipulating that waste disposal guidelines and strategies, and regulations to enforce them will be formulated, and an effective monitoring system will be established.

In the last quarter of 2002, three new environmental proclamations were approved. This legislation to a large extent operationalizes the objectives and the broad framework for environmental management stated in the Environmental Policy of Ethiopia.

1. Establishment of *Environmental Protection Organs* (Proclamation 295/2002) clarifies the institutional mandate and responsibilities of the EPA and aims to integrate environmental considerations into the policies and decision making of sectoral agencies through such means as the establishment of environmental units in these agencies at the federal level and the creation of independent environmental agencies at the regional level.

The proclamation is notable for its emphasis on human welfare and development. This is reflected in the EPA’s mission statement, which begins, “The mission of the EPA is human well being and ensuring environmentally sustainable development”. The environmental legislation requires that regions establish their own independent regional environmental agencies (REAs) or designate an existing agency for this work. The mandate of the REA is not clearly outlined in the proclamation, but there is a general understanding that it will involve functions similar to those of the federal EPA.

2. *Environmental Impact Assessment* (Proclamation 299/2002) specifies the projects and activities that will require environmental impact assessment. The EIA must be prepared by the proponent of the project, following the format specified in the legislation. The EPA will then review the EIA study, approve the project (with or without conditions), or reject it.
3. *Environmental Pollution Control* (Proclamation 300/2002) addresses the management of hazardous waste, the establishment of environmental standards for various environmental media (air, water, and soil), and the monitoring of pollution. The problem of improper handling of hazardous substances is increasingly important- for example, with respect to pest management and industrial development.

However, the attention given to the environmental impact of the floriculture wastes is very poor and is evident in the weak link between the farms and EPA.

2.9. Land Use Land Cover Change around the Study Area

Fatuma (2008) reports that the majority of the surrounding communities and former landowners understood and attributed the problem of land use change to the scarcity of building materials, fuel, and agricultural products, as well as to price increases and the area's rapid climatic change. They were highlighting that, because of most of agricultural areas and eucalyptus plantations were changed from forest cover and farm fields to floriculture farms, consequently, there have observed a lack of agricultural products and forest products. As a consequence of their meagre income and rising produce costs, the majority of the residents in the Holeta area indicated, they were unable to afford to buy the necessary amounts of agricultural and forest items.

This conclusion was supported by an ILO (2006) study document on Ethiopia, which mentioned that the issue of forest resource conservation is one of the negative consequences of floriculture expansion.

2.10. Climate Condition of the Study Area

According to weather and climate Batu town is located at an elevation of 1645.25 meters (5397.8 feet) above sea level, Batu has a Tropical wet and dry or savanna climate (Classification: Aw). The district's yearly temperature is 15.1ºC (59.18ºF) and it is -7.13% lower than Ethiopia's averages. Batu typically receives about 90.65 millimeters (3.57 inches) of precipitation and has 192.69 rainy days (52.79% of the time) annually.

Table 2.2: Climate condition of the area

Country	**Ethiopia**
Region	**Oromia**
City	**Batu**
Longitude	38.7211079
Latitude	7.92772
Attitude/Elevation	1645.25m (5397.8ft)
Annual high temperature	18.85ºC (65.93ºF)
Annual low temperature	8.75ºC (47.75ºF)
Average annual precip.	90.65mm (3.57in)
Warmest month	February (20.63ºC / 69.13ºF)
Coldest Month	December (7.05ºC / 44.69ºF)
Wettest Month	April (193.88mm / 7.63in)
Driest Month	December (18.73mm / 0.74in)
Number of days with rainfall (≥ 1.0 mm)	192.69 days (52.79%)
Days with no rain	172.31 days (47.21%)
Humidity	73.42%

In Batu, the wet season is mostly cloudy, the dry season is partly cloudy, and it is warm year round. Over the course of the year, the temperature typically varies from 59°*F* to 85°F and is rarely below 53°F or above 90°F.

Based on the tourism score, the best time of year to visit Ziway for warm-weather activities is from mid-September to late February.

Average Temperature in Batu

The hot season lasts for 3.0 months, from February 6 to May 8, with an average daily high temperature above 83°F. The hottest month of the year in Ziway is March, with an average high of 85°F and low of 65°F.

The cool season lasts for 2.4 months, from June 29 to September 11, with an average daily high temperature below 76°F. The coldest month of the year in Ziway is August, with an average low of 62°F and high of 74°F.

Precipitation

A wet day is one with at least 0.04 inches of liquid or liquid-equivalent precipitation. The chance of wet days in Ziway varies very significantly throughout the year.

The wetter season lasts 3.5 months, from June to September 21, with a greater than 42% chance of a given day being a wet day. The month with the most wet days in Ziway is August, with an average of 24.9 days with at least 0.04 inches of precipitation.

The drier season lasts 8.5 months, from September 21 to June. The month with the fewest wet days in Ziway is December, with an average of 0.7 days with at least 0.04 inches of precipitation.

Among wet days, we distinguish between those that experience rain alone, snow alone, or a mixture of the two. The month with the most days of rain alone in Ziway is August, with an average of 24.9 days. Based on this categorization, the most common form of precipitation throughout the year is rain alone, with a peak probability of 83% on August 9.

Rainfall

To show variation within the months and not just the monthly totals, we show the rainfall accumulated over a sliding 31-day period centered around each day of the year. Ziway experiences extreme seasonal variation in monthly rainfall.

The rainy period of the year lasts for 9.0 months, from February 4 to November 4, with a sliding 31-day rainfall of at least 0.5 inches. The month with the most rain in Ziway is August, with an average rainfall of 7.2 inches.

The rainless period of the year lasts for 3.0 months, from November 4 to February 4. The month with the least rain in Ziway is December, with an average rainfall of 0.1 inches.

Humidity

We base the humidity comfort level on the dew point, as it determines whether perspiration will evaporate from the skin, thereby cooling the body. Lower dew points feel drier and higher dew points feel more humid. Unlike temperature, which typically varies significantly between night and day, dew point tends to change more slowly, so while the temperature may drop at night, a muggy day is typically followed by a muggy night.

The perceived humidity level in Ziway, as measured by the percentage of time in which the humidity comfort level is muggy, oppressive, or miserable, does not vary significantly over the course of the year, staying within 1% of 1% throughout.

2.11. Population Diversity and Water Resources of the Town

The 2023 national census recorded Batu's total population become 102,553, of whom 51,312 were men and 51,241 women.

Table 2.3: Batu town, Ethiopia Population, Demographics, and Projections to 2030

Year	**Total Population**	**Male**	**Female**
2015	83,549	41,766	41,783
2016	85,842	42,924	42,918
2017	88,159	44,092	44,067
2018	90,499	45,269	45,230
2019	92,864	46,456	46,408
2020	95,255	47,656	47,599
2021	97,668	48,866	48,802
2022	100,101	50,085	50,016
2023	102,553	51,312	51,241
2024	105,021	52,547	52,474
2025	107,506	53,791	53,715
2026	110,005	55,042	54,963
2027	112,516	56,299	56,217
2028	115,037	57,560	57,477
2029	117,565	58,825	58,740
2030	120,096	60,091	60,005

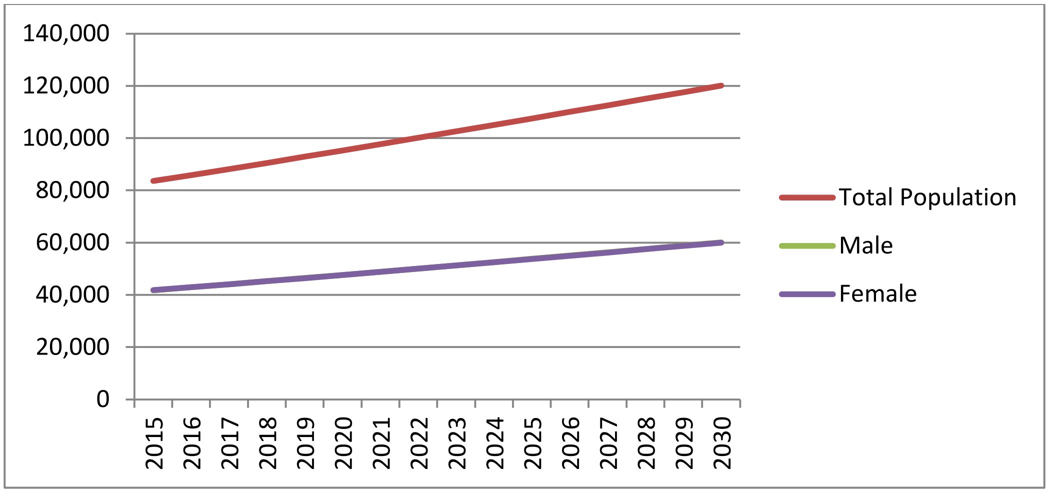

Figure 2.1: Graphical description of population demographics and projection of the area

The above graph provides information about the dynamics of changes in the quantitative composition of Batu, Ethiopia population: the Total number of inhabitants, the number of men, the number of women, and the average age of Batu, Ethiopia inhabitants.

The lake Dambel is an important element of the Ethiopian Central Rift Valley region because it currently serves as the water source for closed and open farm irrigation, and as the only potable water supply for Ziway Town. (The lake exhibits fresh water quality and is an important element of the Ethiopian Central Rift Valley region because it currently serves as the water source for closed and open farm irrigation, and as the only potable water supply for the Town of Batu. (Hayal Desta, Brook Lemma)

2.12. Methods of Water Quality Analysis

Water analysis refers to the process of testing and evaluating the quality of water. It involves examining various physical, chemical, and biological properties to determine the quality of water. These results help to identify any potential health risks or environmental concerns associated with the water source being analyzed.

Water analysis is a vital process used to assess the quality and composition of water. It is a critical step to ensure that water is safe and clean for drinking, industrial use, agriculture, and aquatic ecosystems, just to name a few. The water analysis process involves measuring various parameters (like pH, conductivity, etc) and contaminants present in the water to ensure its safety for consumption and suitability for specific applications.

One of the main reasons why water analysis is important is to ensure that the water we consume on a daily basis, is safe for drinking. Contaminated water can pose serious health risks, as the water may contain harmful bacteria, viruses, chemicals, or heavy metals. Therefore, if we conduct regular water analysis, we can identify any potential threats and take appropriate measures to treat or filter the water and improve the quality, before it reaches our taps. This is particularly vital for more vulnerable people such as children, pregnant women, and people who have compromised immune systems. These people are typically more susceptible to waterborne diseases.

Water analysis is also essential for environmental monitoring and protection. By analyzing the water in rivers, lakes, and oceans, scientists and environmentalists can assess the health of aquatic ecosystems and identify any pollutants or contaminants that may be affecting aquatic life. This information helps in planning effective conservation and management strategies to preserve these fragile ecosystems.

Water analysis also provides valuable data for research purposes, such as studying various aspects of water quality and its impact on different ecosystems and species. This data helps in understanding the long-term effects/trends, identifying emerging contaminants, and developing new technologies or treatment methods to address water-related challenges.

Importance of Water Analysis Methods in Industries

Water analysis methods are crucial for a wide range of industries that rely on water for their operations, like the food and beverage industry. In this industry, water is used extensively in daily operations, such as cleaning, cooking, and ingredient preparation. Therefore, it is essential to analyze the quality of water at different points along the process to ensure that it meets the required standards for consumption and production. By completing a water analysis, you can detect any contaminants or impurities that may affect the taste, safety, and overall quality of the final product.

The agriculture industry is also heavily dependent on water analysis methods. Irrigation is a vital stage in agriculture, and therefore, water quality plays a significant role in crop growth and yield. Analyzing the water used for irrigation helps pinpoint any harmful substances, such as pesticides or heavy metals that may be present in the water. This allows farmers to take appropriate measures to mitigate any negative impacts on their crops, ensure the safety of their produce, and prevent contaminating surrounding areas from surface runoff.

Types of Water Analysis Methods

Water quality analysis is a practice that involves examining the properties and parameters of water to ensure its safety and cleanliness.

Chemical Water Analysis Methods

Chemical analysis is a fundamental part of water quality analysis. It requires testing for different chemical parameters to identify contaminants and assess their levels in water. Some of the commonly tested chemical parameters include ammonia, chloride ion, nitrite, nitrate, phosphate, and water hardness.

Chloride Ion: The concentration of chloride ions in water can indicate contamination levels and the potential presence of saline water. High chloride ion levels can lead to a salty taste in water and may cause corrosion in water pipelines. These not only negatively affect the quality of water, but they can also incur higher maintenance costs.

Ammonia: Ammonia is often a byproduct of organic matter decomposition and can often be found in water sources. Ammonia concentrations increase with the use of chloramine in water disinfection processes. High levels of ammonia in drinking water can have adverse health effects, and its presence may lead to distinctive tastes and odors.

Nitrite & Nitrate: Nitrite and nitrate are forms of nitrogen that can be found in water due to organic matter decomposition and atmospheric nitrogen fixation. Nitrite can be toxic, especially in high concentrations, and can cause health issues such as “blue baby syndrome” in infants. Nitrate, on the other hand, enhances the growth of aquatic plants and can contribute to water eutrophication in natural water systems, where excessive plant growth in ponds and lakes takes place.

Phosphate: Phosphate is present in water in various forms, including dihydrogen phosphate ($H_2PO_4^-$), polyphosphate (polyP), and organic phosphate. Phosphate fundamentally comes from agricultural waste, sewage, and industrial effluents. While phosphate itself is not toxic, high concentrations can lead to water eutrophication.

Hardness: Water hardness refers to the presence of calcium and magnesium salts in water. Temporary hardness is caused by carbonate and bicarbonate ions, while permanent hardness is due to chloride and sulfate ions. Hard water can have certain benefits for drinking purposes, but excessive levels of certain ions can be a nuisance because of scale buildup.

Physical Water Analysis Methods

Physical analysis of water involves assessing its various physical properties, such as temperature, color, turbidity, and conductivity. These parameters provide valuable information about the clarity and suitability of water for various purposes.

Temperature: Water temperature plays a significant role in various physical and biological processes as it affects the dissolved oxygen content, the solubility of gases, and the growth of aquatic organisms. Temperature measurements are simple, yet essential for understanding the overall health and functioning of aquatic ecosystems.

Color: The color of the water can indicate the presence of suspended or dissolved substances. Apparent color refers to the color caused by suspended matter, while true color is caused by dissolved solids. Also, excessive color in water can be aesthetically unpleasant and may indicate the presence of organic compounds that can interfere with disinfection processes.

Turbidity: Turbidity is important as it measures the extent to which light is absorbed or scattered by suspended particles in water. It indicates the presence of particulate matter, such as sediment (like soil), algae, or organic particles, and can easily be measured with a turbidity meter. The problem with high turbidity levels is that high turbidity can affect the aesthetics of water and cause issues with disinfection processes.

Conductivity: Conductivity measures the ability of water to conduct an electrical current, which is influenced by the presence of dissolved salts, minerals, and other ions. The greater the number of ions, the higher the conductivity level. Conductivity provides insights into the overall mineral content and salinity of water and its suitability for various applications and industries.

Biological Water Analysis Methods

Biological analysis focuses on assessing the presence of microorganisms and other biological indicators in water. These indicators can provide an understanding of the overall health and safety of the water. A good example is bacteria testing.

Bacteria testing is essential in determining the safety and potability (suitability for drinking) of water. One of the most common bacteria tested for is E. coli, which is an indicator of fecal contamination. High levels of E. coli in water can indicate the presence of harmful pathogens that can pose serious health issues when consumed. Bacteria testing helps in identifying potential microbial contamination like E.coli and ensures the safety of water for drinking and other uses.

Water Analysis: Understanding Analytical Methods

Analytical methods are procedures designed to measure the concentration of specific contaminants in water samples. These methods provide a structure for collecting, preserving, and storing samples, in addition to separating, identifying, and quantifying contaminants. Analytical methods also establish quality control criteria and outline the reporting standards.

Analytical methods serve many purposes, including demonstrating regulation compliance, meeting monitoring objectives, and providing data for water samples that require routine analysis. These methods typically have upper and lower limits within which the concentration of drinking water contaminants should be. They also incorporate quality control measures to ensure accurate and reliable results.

Water quality analyzers are used for monitoring process chemistry including water quality, providing process optimization and control. Water quality parameters are of three types physical, chemical and biological – and are tested or monitored according to the desired water parameters. Water quality parameters often sampled or monitored include pH, ORP, conductivity, dissolved oxygen, chlorine, salinity, ozone, and corrosion rate. However water monitoring may also include measurement of chlorophyll, blue-green algae, ammonia nitrogen, nitrate, fluoride ions, or laboratory parameters such as BOD and COD.

Water quality analysis is essential for protecting capital assets including boilers and cooling towers, by preventing corrosion, minimizing maintenance, and maximizing uptime.

Water quality analysis key factors are sampling, selection of parameters, precision and accuracy of method selected, preservation, proper labeling and reporting the results.

Water Quality Assessment

- To measure concentration of the constituents in quantity for characterization of water for different uses
- Of the various parameters in potable water few are objectionable even when present in very small quantity
- Others if only present in unusual quantities as to relegate the water from the potable to the unusable class
- The analyst familiar with water quality characterisation will often select parameters to be measured based on experience and intuition

2.13. Previous Studies/ Literatures on Impacts of Floriculture Practices on Surface Water and Environment

(Gobie, August 15, 2019) reviewed that the Ethiopian floriculture industries with the objectives to explain the socio-economic significance of floriculture to the country, the Environmental view of floriculture industries and to identify the economic implication of floriculture in Ethiopia. To enhance the growth of the sector he (Gobie, August 15, 2019) recommended that initiate and promote by giving incentives to floriculture producers to exercise integrated pesticide management practices and use of environmentally friendly agro-chemicals as well as foster better awareness by providing health and safety training to the works. More Significantly, investors also make sure that projects are uphold the rule of law, economically feasible, and create long-lasting shared benefit.

(Berhan M. Teklu, Amare Hailu, Daniel A. Wiegant, Bernice S. Scholten, Paul J. Van den Brink., 2018) performs the understanding of how the pesticides and fertilizers used in horticulture industries influences the water quality of Lake Dambel, by gathering water quality data to study the dynamics of pesticide concentrations and physicochemical parameters for the years from 2009 to 2015. And the results indicate that for some physicochemical parameters, including pH, potassium and iron, over 50 % of the values were above the maximum permissible limit of the Ethiopian standard for drinking water. To minimize the influences of pesticides and fertilizers on Lake water quality (Berhan M. Teklu, Amare Hailu, Daniel A. Wiegant, Bernice S. Scholten, Paul J. Van den Brink., 2018) recommended that longer-term monitoring needs to be established to show the water quality changes across time and space.

(Alemayehu P. Washe, Tadelech Tiruneh, Ermias Haile, 2018) targeted to determine the level of environmental pollution by selected heavy metals (Ni, Cr, Cu, Zn, Co, Pb and Cd) in soil, water and vegetables around floriculture industry. (Alemayehu P. Washe, Tadelech Tiruneh, Ermias Haile, 2018) use the Flame Atomic Absorption spectroscopy to analyze the level of the selected heavy metals in soil, water and vegetables. The result indicates that the level of heavy metals in soil samples was found to increases as sampling distance from the factory decreases. (Alemayehu P. Washe, Tadelech Tiruneh, Ermias Haile, 2018) shows that all of the metals are concentrated on the surface soil, and decreased in the lower part of the soil, this is due to reflect their mobility and physical properties of soil and its alkaline pH values.

(Getu, May, 2013), believes that one of the environmental tools that could mitigate the impacts of floriculture industries on environment and optimally benefit from the sector was environmental impact assessment (EIA). However, even though the existence of many laws (ranging from Constitutional provisions to specific EIA guidelines) and multiples of institutions (both government and private) functioning around the floriculture sector, EIA remains too weak and relegated. International laws and practices have not stimulated the practice here in Ethiopia nor do the Constitutional provisions on environmental rights. (Getu, May, 2013) argues that the EIA regime is too weak to safeguard the environment owing to multiples of factors.

(Biruk Gobena, Abera Kinfu and Mohammed Berhanu, Dec, 2020) conducted the study to assess social and environmental concerns of flower farms in Central Ethiopia using field visits, questionnaires and focus group discussion. They (Biruk Gobena, Abera Kinfu and Mohammed Berhanu, Dec, 2020) concluded that the study exposed that there are a poor waste management and unsustainable activities by the flower farms. They (Biruk Gobena, Abera Kinfu and Mohammed Berhanu, Dec, 2020) recommended that the government should closely monitor these farms and undergo a holistic study to quantify environmental and local inhabitant's opportunity costs of flower farming activity.

(Hunde, 2018), performs the ecological implication of floriculture industries on surrounding environment. Environmental implication of floriculture involved the intensive use of water as well as soil and air pollution because of its intensive and toxic chemical usage and waste disposal system of the industries. Therefore, (Hunde, 2018) has made a decision to assure the environmental sustainability of the booming projects of the floriculture industry. (Hunde, 2018) recommended that to improve the environmental problems different environmental protection strategies were developed. As (Hunde, 2018) explains wastewater recycling, Wastewater treatment, Vegetation Buffer preparation, integrated pest management (IPM) practices, health, and safety training to workers, and application of Strategic Environmental Assessment (SEA) are good practices to reduce the impact of floriculture industries.

(Kassa, Apr, 2017), performed the Ethiopian floriculture industry and their impact on the environment. Ethiopia has developed policies and legislation to protect the environment issues. However, (Kassa, Apr, 2017) understands that there are some gaps in the implementation and governing of the regulatory framework of the floriculture sector. (Kassa, Apr, 2017) recommended that with the expansion of the floriculture industry, there is a growing concern as to its adverse effect on the national environment; to achieve the above advantage, Fertilizer and pesticide management, organic cultivation, wastewater treatment and recycling and environmental audit have to be taken into consideration.

(Tegegne, June, 2022), the objective of this research was to analyze the water quality of the lake. He (Tegegne, June, 2022) analyze the water quality of the lake for color, odor, pH, EC, TDS, turbidity, ammonia, total hardness, sodium, potassium, total iron, manganese, calcium, magnesium, alkalinity, bicarbonate, chloride, Sulfate, nitrate, nitrite, fluoride, phosphate, DO, BOD and COD at seven sites from February to March in 21 runs. (Tegegne, June, 2022) utilized international and national drinking water quality guidelines and standards for the statistical evaluation of experimental results. (Tegegne, June, 2022) shows that the major causes of water quality deterioration are the inflow of effluents from the floriculture industry, domestics, agricultural practices, saline seeps, and other uncontrolled human interventions as observed in sites one, two, three, four, and five. The other causes result from people’s activities in boats and islands. Run-off, silt, waste effluents, etc.

(Mekuria Mergia, Ermias Deribe Weldemariam, Ole Martin Eklo and Girma Tilahun Yimer, Jan, 2021) conducted the assessment of the level of knowledge, attitude, and practices of the small-scale vegetable farmers towards the use of pesticides in Ethiopia along the littoral of Lake Ziway. They, (Mekuria Mergia, Ermias Deribe Weldemariam, Ole Martin Eklo and Girma Tilahun Yimer, Jan, 2021), applied a chi-square test method to evaluate whether the collected data and their probable association were significant. Results show that WHO class II pesticides (moderately toxic) are the most frequently used pesticides in the study area. (Mekuria Mergia, Ermias Deribe Weldemariam, Ole Martin Eklo and Girma Tilahun Yimer, Jan, 2021) concluded that the Knowledge of small-scale farmers on pesticides was poor. Furthermore inappropriate disposal of pesticides and its container will damage the environment and train the framers concerning safe and proper use of pesticides to prevent health and environmental hazards is needed.

(Abera Kinfu, Mohammed Berhanu, Biruk Gobena and Birhanu Hailu, 2021) performed to assess the environmental pollution status of five selected flower farms in Central Ethiopia. To determine physio-chemical parameters of wastewater and heavy metal concentrations in soil samples of flower farms, a cross-sectional study was conducted. According to (Abera Kinfu, Mohammed Berhanu, Biruk Gobena and Birhanu Hailu, 2021), physicochemical parameters (pH, EC, TDS, PO43- , SO42- and COD) of wastewater and heavy metals (Pb, Co, and Zn) of soil samples were determined by APHA method. The results obtained shows that most values of the investigated physicochemical parameters and heavy metals were not in the recommended ranges to be discharged to the environment without treatment. Therefore, they, (Abera Kinfu, Mohammed Berhanu, Biruk Gobena and Birhanu Hailu, 2021) concluded that all concerned bodies should take initiative of support to conduct more comprehensive investigation with its emphasis on socio economy.

(Dibaba, Jan, 2020), conducted to examine the safety and health conditions of the floriculture workers in Batu Town. Results of qualitative data gathered indicate that the safety and health of workers in the study area are at risk. He also indicate that the elements of safety and health, like the provision of personal protective equipment’s, the availability of regular medical checkups by the employers to employees, the provision of training on occupational safety and health were not provided as required by law. There are also some weaknesses from the government on implementing those laws made to protect and promote safety and health of workers. There is a problem of budget, motivation, authority and lack of coordination or networking among the stakeholders.

Finally, (Birkie, 2019), performs the review about gaps in the regulatory framework and the problem of why not having the effective regulation in such kind of floriculture industry.

3. MATERIAL AND METHODS

3.1. Description of the Study Area

The study area, Lake Dambel is found 160 Kms south of Addis Ababa in the Ethiopian Central Rift Valley. Its Watershed falls in between 7°15’N to 8°30’N latitude and 38°E to 39°30’E longitude. The altitude is 1636 meters above sea level. Lake Ziway covers an area of 460 square kilometers. The surface area of the lake fluctuates between 435 to 485 km^2 with a mean depth of 2.5 meters. Its shoreline is 137 kilometers long within a catchment area of about 6834 km^2. The lake has two feeder rivers which are Katar River from the southeastern and Meki from the northwestern direction and has one outlet, the Bulbula River.

The climatic conditions are not uniform throughout the watershed. The minimum and maximum annual precipitation in the watershed is 729.8 mm and 1227.7 mm respectively with the mean annual temperature of 18.5 °C. The wet season – June to September – accounts for about 55% of the annual precipitation, while the dry season contributes 15% (Paolo Billi & Franceska Caparrani, 2006). The temperature in Batu is relatively constant throughout the year. The daily maximum temperature is 24.2 to 30.5 oC and the daily minimum temperature varies between 10.4 and 16.8. Ziway is relatively sunny with an average sunshine hour of 8.6 per day. But there is a distinct decrease in sunshine hours during wet periods.

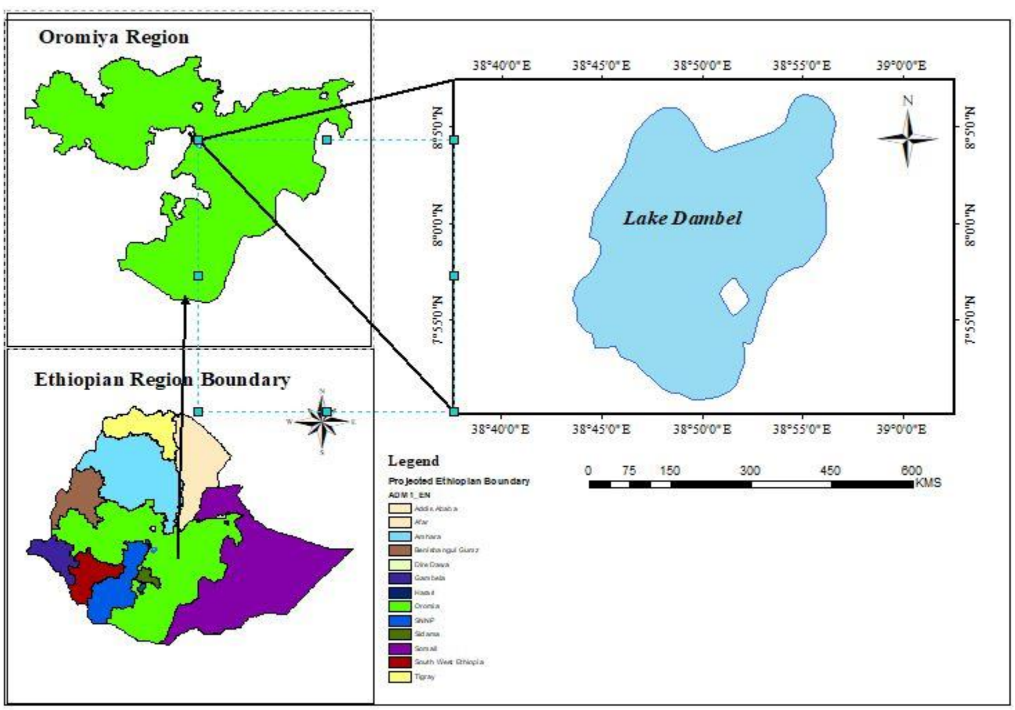

Figure 3.1: A map showing the location of the study area

3.2. Availability of Data and its Analysis

The data that were used to investigate the impacts of floriculture practices on surface water quality of Lake Dambel could be gathered from physical site observation, convenient interviews, sampling, laboratory experiment and reviewing related literatures. Physical observation provides the current existing situation of study area and one can realize the most influenced by the floriculture practices. The convenient interview of stakeholders were guide to explore issues of floriculture practices implemented including utilization of water resource, application of fertilizers and pesticides, liquid and solid waste disposal that observed fluctuations quality of water through time. Community awareness regarding quality of water and its impact on human health and livelihoods were also investigated using interviews. By preparing questionnaires of having twenty five questions, the necessary data were collected interviewing the stakeholders and communities randomly.

Physiochemical parameters of Lake Dambel were analyzed by taking representative samples and testing the sample content using laboratory experiments. Three representative sample sites were developed in this study and experimenting twelve physiochemical parameters whether it fulfils the requirement of Ethiopian EPA standards, WHO and FAO Guidelines for irrigation and domestic uses. Over twenty related literatures, journals, publications and reports were reviewed in this study to comprehend guide the way how to perform and develop this research.

Statistical analysis method was implemented to collect and analyze the physiochemical parameters in this study. Experimental laboratory was applied for variation in physicochemical parameters Turbidity, EC, pH, Dissolved Oxygen (DO), Biological oxygen demand (BOD), chemical oxygen demand (COD), Total Suspended Solids (TSS), Hardness, Ammonia (T-NH_3), Total Nitrogen (T-N), reactive Phosphate (PO_4), Total Phosphorus (as P), Nitrite(NO_2), Nitrate (NO_3), Sulfate (SO_4) concentrations in the surface water.

3.2.1. Sources of Data

Convenient interview was used to get general overview of the lake status and pollution sources before directly executing the sampling procedures. A questionnaire with twenty five questions (attached at the back) was prepared for the interviewees to answer. The interviewees consisted of Ziway town residents, boat sailors, health workers and particular persons from monasteries.

In addition to the general information found from the convenient interview, the choice of sampling location was made based on specific pollution driver's intensity, the imposed pressures and impacts in the environment and community, state of the environment and societal responses. So, the samples were determined based on specific potential risk areas, topology of the lake and intensity of human activities.

3.3. Methods of Data Collection

A qualitative data were collected from questionnaire, reviewing relative literatures including journals, scientific publications and organizational reports. Visiting study area by physical site observation was also used to investigate the current existing situation of the lake.

Taking representative samples were collected by using standard sampling technique to examine the physiochemical parameters of the lake and compare with provisional standards and guidelines.

To determine the potential pollutant loads and water balance entering and leaving of the lake, flow measurements were conducted at inlet and outlet of the lake. GIS tools were used to collect spatial data on the location and size of floriculture farmlands, land cover changes and drainage patterns.

3.4. Site Monitoring and Selection Techniques

To identify the main sources of pollutants that come from industry effluents, an inspectional analysis has been conducted around the Lake Dambel. Some floriculture industries take water from the lake as a main source and discharge their effluent back to the lake. By understanding this concept and using physical site survey, three points were chosen along the floriculture farms to evaluate the concentration of nutrient and physicochemical parameters.

Samples are taken from surface water of the area around Lake Dambel. The sampling sites were located by using GPS (Global Positioning System) and accurately marked on the map using Google Earrth Pro. Water sample is taken from the lake and was done by direct immersion of the plastic bottle in to the lake from three different sampling sites that are adjacent to the floriculture farming.

The water samples were determined based on specific potential risk areas, topology of the lake and intensity of human activities.

3.4.1. Sampling Sites

The sites for sampling were generally located at the water input in to the farm, central around the boat sailors and the output discharge area of the lake. Accordingly, three sites were selected to collect water samples throughout the study period.

Sample Site 1 was taken from the output of floriculture industries which is located near the lake area where runoff and drainage discharges through pipes. Its depth is 1 – 2.5 meters and the latitude and longitude was 7°54'42.1'' N and 38°44'00.6'' E respectively. This site has a drainage discharged from the floriculture industries where the rainfall water come out as a runoff using pre-arranged pipes.

Sample Site 2 was taken from around Hamere Berhane St. Gabriel Monastery where the water supplied to the floriculture industries as a main input component were nearby. This sample site was characterized by high public activities including agricultural and washing activities where the water used is abstracted from the lake. The depth is 0.5 – 2 meters and the latitude and longitude was 7°54'19.2'' N and 38°44'14.5'' E respectively.

Sample Site 3 was taken from Lake Shoreline at 1 – 1.5 meters. Activities being undertaken near to this site were boat sailors, water mixing by boats and cloth washing by the dwellers of the island community. The latitude and longitude was 7°55'05.5'' N and 38°43'45.3'' E respectively.

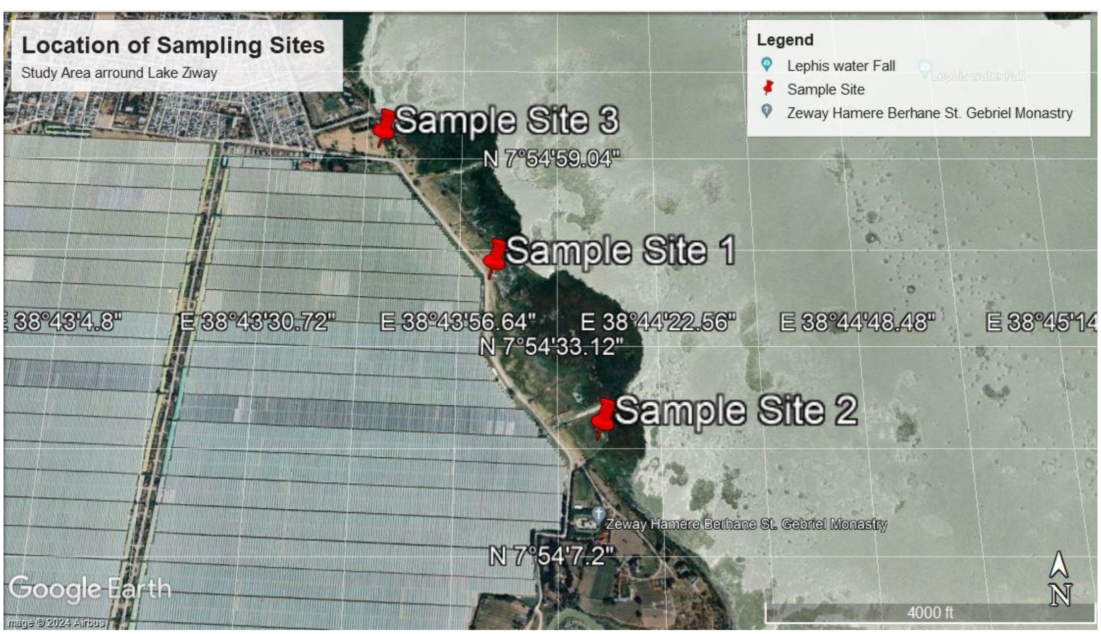

Figure 3.2: Location of Sampling Sites

3.4.2. Analysis of Surface Water Sampling

Water samples were collected from three representative areas along the Lake. From this water samples, the study has been attempt to analyze Turbidity, EC, pH, Dissolved Oxygen (DO), Biological oxygen demand (BOD), (COD), Total Suspended Solids (TSS), Hardness, Ammonia (NH_3), Total Nitrogen (T-N), reactive Phosphate (PO_4), Total Phosphorus (as P), Nitrite(NO_2), Nitrate (NO_3), Sulfate (SO_4) concentrations in the surface water.

The method of analysis for water pH and electrical conductivity (EC) was electroanalytical, the turbidity and total suspended solids (TSS) was analyzed by photometric method. Reactive phosphate (PO_4) and total phosphorus (as P) was tested using molybdovanadate. Ammonia (NH_3) was experimented by using salicylate. The method of testing for total nitrogen was TNT persulfate digestion. The COD was analyzed by reactor digestion method. The nutrient contents of nitrate and nitrite were experimented by using cadmium reduction and diazotization methods respectively. Sulfate (SO_4) was tested by the method called sulfa ver 4.

3.5. Methods of Data Analysis

To analyze the data that gathered from questionnaire by interviewing the stakeholders, local communities, labor workers of the flower farms, boat sailors and residents the SPSS software was used. The results has been analyzed with the software and interpreted to guide the location of samples, situation of the lake and the condition of the town status regarding pollution of surface water and environment.

The physiochemical parameters gained from surface water samples examined using laboratorial experiment by testing the concentration of each samples. The parameters were also analyzed by using analytical method to guide the selection of indicators and relate with provisional standards and assess whether they accomplish the minimum criteria. Analytical method provides a well – structured approach to gather the physiochemical parameter data and interpreting the obtained data by managing to the better decision. The variation in physiochemical parameters in this study were evaluated and compared with Ethiopian EPA Standards, WHO and FAO guidelines. The effluent and overall impacts of floriculture practices were checked using the results of physiochemical parameters whether it fulfils the requirement of Ethiopian Environmental Protection Authority (EPA) standards, WHO and FAO Guidelines for irrigation and domestic purposes. Geospatial analysis can be used to visualize spatial relationship between floriculture farms, land use patterns and water quality variations.

4. RESULTS AND DISCUSSIONS

4.1. Surface Water Consumption

One of the major environmental concerns of the flower production is its enormous consumption of water from the Lake Dambel and its corresponding deterioration of the water quality. The floriculture industry extracts around 115 cubic meter of water per day from the lake generating using pumps that work by electrics. Water consumption is one of the main characteristics of flower farms. It is used more extensively in the floriculture industry than in the cultivation of regular vegetables. The flower farm daily water consumption varies occasionally based on the availability of optional water resources and production capacity, the farm area, soil type, climatic change, and water-using mechanism and flower farms daily water consumption is varying from farm to farms.

From five floriculture industries found in Batu town most of them were utilizing surface water (Lake Dambel) as their main water resource. Some floriculture companies like Sher and Ethioflora use ground water resources by drilling 15 – 30 m boreholes around their farmlands. The rest flower companies achieve their water requirement by preparing manmade reservoirs to store more water and consume during dry season. Almost all flower farms use drip irrigation mechanism in entire green houses to save water and fertilizers. Among them especially Sher Ethiopia uses drip irrigation by mixing fertilizer and water together and release in drip line to save more consumption. In total there is over 4800 kilometers of dripline in Sher Ethiopia greenhouses which can able to produce more flowers per drop.

4.2. Wastewater Recycling and Disposal Mechanism

4.2.1. Waste Water Recycling

High water consumption cannot be avoided in process manufactures like floriculture industries, but there are ways to use water more efficiently. Water has a significant cost and energy footprint, making conservations, efficiency and reuse are important considerations for economic, social and environmental reasons. Water recycling is a viable way to reduce overall water consumption and the amount of polluted water that is released in to the environment.

It obvious, that in the production of cut flower the planting media plays a significant role for the waste water recycling. There are two types of planting media. The first one is a soil media which is naturally familiar and it is cost effective but difficult to recycle because of the water enters in to soil bed. The second is hydroponic media which the farm enables to reuse the water by recycling but it expenses high cost comparing to a soil media. Therefore, The farm who use only the hydroponics as media is recycling the waste water and reuse it. Most flower farm companies found in Batu town uses soil as a planting media but some of them have a water recycling mechanism. Sher Ethiopia especially uses a unique closed loop system for water recycling which has been particularly developed to filter and reuse water. Wetlands were designed in collaboration with Wageningen University and research in Netherlands. These wetlands purify all wastewater and after purification, the water is reused to irrigate the rose plants.

Figure 4.1: Recycling using Wetlands and its storing reservoirs

4.2.2. Waste Disposal Mechanism

Chemical containers and their washing waters, diseased plants, the residue of cut flower stems (green wastes), obsolete solid chemicals, and plastics are the primary solid and liquid wastes produced by flower farmers.

Waste waters that cannot be reused or recycled might release to a surface water body without treatment by flower farms which causes eutrophication. Eutrophication results by directly disposing of waste water into a body of water, claims Art (1993). It is the process that results in an excessive concentration of nutrients, especially phosphates and nitrates, in a body of water. These typically promote an excessive amount of algae growth. Because of the decomposition of the algae and the large amounts of organic detritus that lower the oxygen content of the water, fish and other species die.

The majority of the time, the farm's other waste water sources are obtained from after the flowers are harvested, and the drained waste water to land originates from the pipe residues that supply fertilizer to the plants. To reduce the capacity of the fresh flower to mature and perish, it must be preserved in a solution of chemicals (calcium hypochloride and aluminum sulfate) and water. Ultimately, this chemical solution is not maintained appropriately and instead recklessly drains into the ground.

Almost all of the flower farms in Batu have also established a vegetation buffer area, which allows water-loving plants like grasses and shrubs to be planted. This vegetation buffer zone allows for the filtering of waste water, the solubility of toxic elements in the water, and the conversion of toxic to intoxicated condition. Some of flower farms that remove their post-harvesting solution which is wastewater drain to the land or enter into water body through surface runoff.

Solid waste includes chemical containers, cartons and plastics. The other waste is called green waste, which is the leftover material from plants; undesirable leaves and stems are cut off and gathered before the flowers are ready to be packed. All of flower farms companies especially Sher Ethiopia burn their solid trash in incinerators set at higher temperatures (800°C to 1000°C). among five floriculture industries found in Batu town, only 10% of flower companies burn their rubbish in a dangerous or careless manner outside. Sher Ethiopia used the green wastes as compost for their own organic fertilizer needs. The other flower farming companies collect the solid waste and burned it outside in open air.

4.3. Outcomes of Questionnaires

For more precise information, a convenient interview method was employed before the sampling procedures around Lake Dambel were carried out. The background data, views, opinions, and attitudes of the communities regarding the condition of the lake and their relationship to it were all very helpfully gathered. The results of the interviews were useful in choosing suitable locations for sample collecting.

The interviewees who gave a convenient interview comprised of stakeholders, local communities, boat sailors, health professionals, dwellers and special personalities from the monasteries around the lake. Based on the twenty two questions of the pre-arranged questionnaire, the above interviewees were willingly asked to give their responses freely.

All respondents agreed that Lake Dambel is a crucial water resource for the domestic, commercial and agricultural purposes. It is heartbeat of the town. The most respondents acknowledge that flower farms offer both personal and societal financial benefits. Nevertheless, they made no mention of the need for the locals around Lake Dambel to be aware of the devastating consequences that pollution has on the lake, its inhabitants, and the surrounding ecology. From the result of interview the respondents said that flower farms utilize more surface water than ground water but most farms uses both surface and ground water as a water resource for their water requirement.

The respondents suggested that one of the main causes of Lake Dambel's contamination, among other reasons, was the direct discharge of effluents from Sher Ethiopia, the largest floriculture plant. The human activities and agricultural practices in Batu town were the other causes of pollution. A respondent stated that the majority of those who suffer from health hazards are those who work in flower farms. Numerous birth abnormalities in neonates, cancer, and related illnesses are prevalent. About the St. Gabriel monastery, which is located close to Sher Ethiopia's floriculture output, was the source of potable water for Batu town. But as of right now, it's not functional. It was relocated to Tuffa, which is 62.4 kilometers away from the town, since it was discovered to contain substances that were harmful to human health.

Overall, the interview provided a general overview of the lake and the factors that pose a threat to it. Therefore, by collecting samples from specific sites, it supports more analytical research.

4.4. Impacts of Floricultural Practices on Surface Water Quality

Physiochemical parameter results have led me to devise a set of standards for assessing floriculture operations from the standpoints of environmental effect and surface water quality issues. There are two primary criteria and two key environmental repercussions have been established as a result of the environmental issue. The first criteria set to assess issues related to environmental was pollution of surface water by analyzing the physiochemical parameters and the consequence on environment will be degradation surface water quality. The other criteria that related with environmental issue was utilization of environmental resources including air, land and water resources and the measuring parameter was using Landsat image analysis. The result will have an influence on environment by making increment of runoff and erosion which consequences natural disaster, uncontrolled usage of soil content and intensive utilization of surface water for irrigation and domestic uses that causes shortage of fresh water available.

4.5. Results of Physiochemical Parameters

In order to assess the effects of the floriculture industry on a body of water, samples are collected from three separate locations and then analyze each site individually and bringing into one result as cumulative by calculating the mean of those three sites to determine the overall outcome for the lake.

Measured are fifteen parameters. Turbidity, EC, pH, Dissolved Oxygen (DO), Biological oxygen demand (BOD), chemical oxygen demand (COD), Total Suspended Solids (TSS), Hardness, Ammonia ($T\text{-}NH_3$), Total Nitrogen (T-N), reactive Phosphate (PO_4), Total Phosphorus (as P), Nitrite(NO_2), Nitrate (NO_3), Sulfate (SO_4).

Table 4.1: Values of physicochemical parameters at three study areas

Physiochemical Parameters	Sampling Sites		
	Site 1	**Site 2**	**Site 3**
Turbidity (NTU)	**35.30**	**21.50**	**58.70**
Electrical Conductivity (EC), µs/cm	**42**	**56.50**	**46**
pH	**7.70**	**7.40**	**7.40**
Dissolved Oxygen (DO), mg/l	**1.50**	**5.80**	**3.60**
Biological Oxygen Demand (BOD), mg/l	**15.80**	**7.50**	**27.30**
Chemical Oxygen Demand (COD), mg/l	**18**	**7**	**56**
Total Suspended Solids (TSS), mg/l	**41**	**46**	**98**
Hardness	**116**	**92**	**85**
Total Ammonia ($T\text{-}NH_3$), mg/l	**1.10**	**1.80**	**2.90**
Total Nitrogen (T-N), mg/l	**24**	**9**	**6**
Reactive Phosphate (PO_4), mg/l	**4.20**	**5.60**	**9.30**
Total Phosphorus (as P), mg/l	**0.12**	**0.80**	**0.05**
Nitrite (NO_2), mg/l	**0.173**	**0.07**	**0.02**
Nitrate (NO_3), mg/l	**10.70**	**1.75**	**0.70**
Sulfate (SO_4), mg/l	**38**	**49**	**13**

4.5.1. Turbidity

Turbidity is the amount of particulate matter that is suspended in water. Turbidity or cloudiness in water is caused by suspended materials that scatter light passing through the water. In addition to blocking out the light needed by submerged aquatic vegetation. Based on this classification, the lake water around the farm was slightly cloudy and aquatic life in this water could be threatened. When we look the cumulative value, it is beyond WHO guideline but slightly lower from EPA Standards.

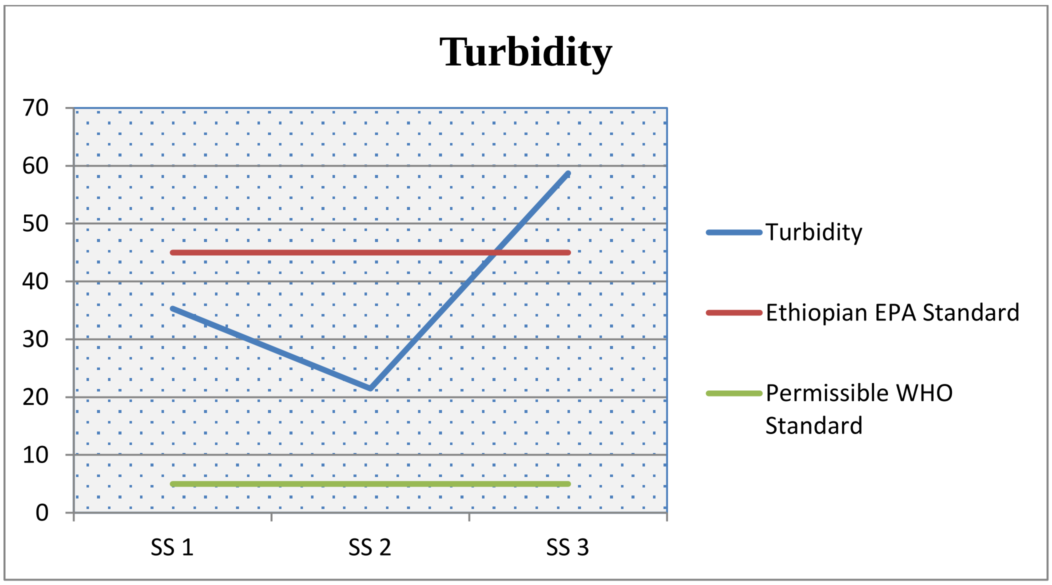

Figure 4.2: Graphical Description of Turbidity at different Sampling Sites Compared to Ethiopian EPA and WHO Standards

4.5.2. Electrical Conductivity (EC)

The electrical conductivity of the lake may increase due to the ions from fertilizer and pesticides which are directly discharged to the water body or enters into water body through surface runoff, the EC values are significant increase at the sampling sites and even exceeded the standards of (EPA, 2013) the optimum EC for lake is100 1000(µs/cm). According to FAO water quality guidelines, electrical conductivity values less than700 µs /m has no potential irrigation problem but values between 700-3000 µs /m could create slight to moderate problems on irrigated lands. EC estimates the amount of total dissolved salts or the total amount of dissolved ions in the water. High electrical conductivity indicates the risk of salinity of the lake. Therefore, as we have seen the cumulative value of EC it has no adverse impact on irrigated land.

4.5.3. pH

The PH of Lake Dambel is neutral to slightly alkaline due to the geology and rocks of the surrounding catchment, this makes average pH of Lake Dambel is around 7.5. Even though the cumulative result falls between the ranges of the standards (6.5-8.5), it showed slight difference among the sampling sites. These gradual fluctuations in PH value affect the solubility of nutritive chemicals; as a result, the availability of these substances to aquatic organisms is increased. This could create unfavorable environment for fish and other aquatic organisms in the lake.

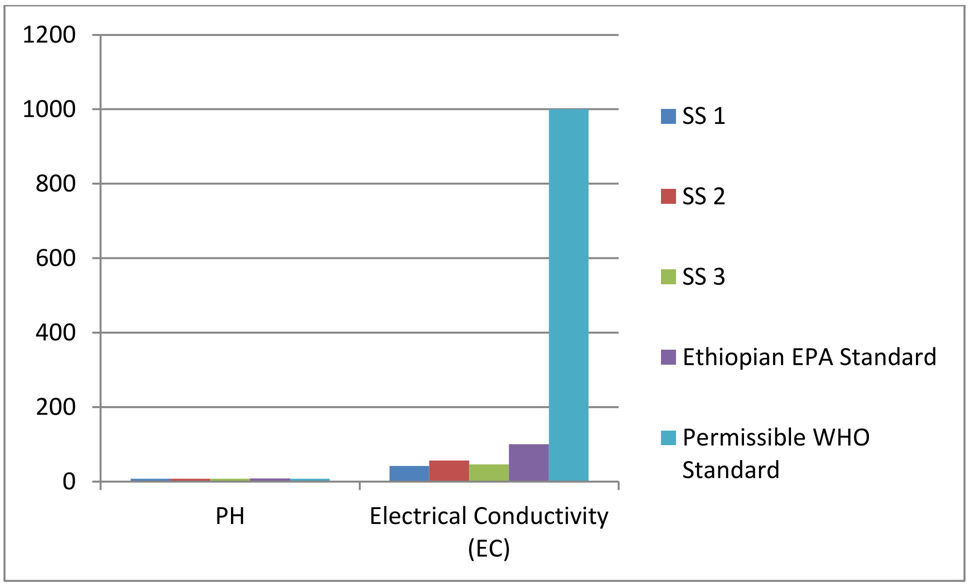

Figure 4.3: Levels of pH and EC comparing with EPA and WHO Standards

4.5.4. Dissolved Oxygen (DO)

The oxygen dissolved in Lakes, rivers, and oceans is crucial for the organisms living in it. As the amount of dissolved oxygen drops below the normal levels in water bodies, the water quality is harmed and aquatic organisms begin to die off. The values of DO were compared with Ethiopian EPA standards and WHO standard, the level of dissolved oxygen both in all sampling sites were below the standard values. Studies indicate that; this might be due to the speed of the water flow, when the movement of the water is slow there will be less aeration.

Besides, bacteria in water can consume oxygen as organic matter decays. In addition to that the reduction of dissolved oxygen level at the lake could be due to nutrient enrichment from the farm effluent which promotes excessive growth of algae and aquatic vegetation; when the vegetation decomposes the level of dissolved oxygen decline.

Table 4.2: Dissolved Oxygen Levels According to EPA Standard

Dissolved Oxygen Levels (mg/l)	EPA Standards for Aquatic Life
DO Levels < 2	Aquatic Life not Supported
DO Levels < 3ppm	Stressful for most Aquatic Organisms
DO = 5 – 6	Growth and Activity of most Aquatic Life is Supported

4.5.5. Biological Oxygen Demand (BOD)

Organic wastes from the farm effluent act as a food source for water born bacteria. Bacteria decompose these organic materials using dissolved oxygen, thus reducing the dissolved oxygen which is present for fish. The difference in the concentration of BOD could be due to excessive concentration of nutrients at the downstream area which increased the demand for dissolved oxygen by bacteria to decompose these organic materials.

BOD values in all sampling sites found to be above the limit of the guideline. According to EPA (2013) the optimum BOD for lake water is< 5 mg/l and as WHO the concentration of BOD should be less than 2 mg/l

The result indicates that the rate of BOD increases with an increasing time and high risk for aquatic life. This could be due to excessive organic and inorganic wastes in the farm effluent.

4.5.6. Chemical Oxygen Demand (COD)

COD is a measure of the total quantity of oxygen required to oxidize all organic material in to carbon dioxide and water. Similarly the average result of COD of Lake Dambel has highly significantly increased and exceeds WHO standard.

The optimum COD for lake water is 10 mg/l (as WHO). Similarly when comparing the cumulative results which have been, conducted on the same area; it shows significant increment which has a value of 27; it indicates how the volume of effluent from floriculture farms is increased from time to time and affecting the lake.

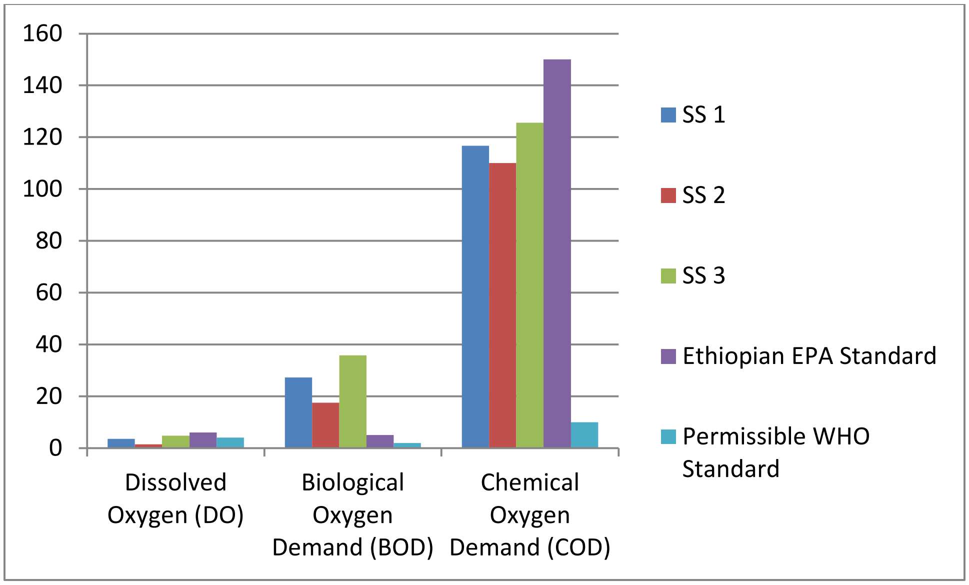

Figure 4.4: Levels of Oxygen Demanding Parameters Comparing with EPA and WHO Standards

4.5.7. Total Suspended Solids (TSS)

Total suspended solids are the dry-weight of suspended particles that are not dissolved, in a sample of water that can be trapped by a filter that is analyzed using a filtration. TSS could be anything that floats or "suspends" in water, including sand, sediment, and plankton. When certain water sources are contaminated with decaying plants or animals, the organic particles released into the water are usually suspended solids. While some sediment will settle at the bottom of a water source, other TSS will float on water's surface or remain suspended somewhere in between. TSS affects water's clarity, so the higher a water source's TSS content, the less clear it will be.

The cumulative total suspended solids (TSS) value (61.667 mg/l) is generally above WHO permissible limit (25mg/l) and excessively high compared to other reported values in the region.

4.5.8. Hardness

Water hardness refers to the presence of calcium and magnesium salts in water. Temporary hardness is caused by carbonate and bicarbonate ions, while permanent hardness is due to chloride and sulfate ions. Hard water can have certain benefits for drinking purposes, but excessive levels of certain ions can be a nuisance because of scale buildup.

Hardness can pose a potential problem if it is too low or too high. If the water hardness is too low, such as < 50 mg/L, the water may be corrosive to metal piping, fixtures, and appliances. If the hardness is high, it is possible for the multivalent cations to react with the carbonates in the water to produce chemical precipitates.

General guidelines for classification of waters are: 0 to 60 mg/L (milligrams per liter) as calcium carbonate is classified as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and more than 180 mg/L as very hard.

According to the cumulative result (97.667 mg/l) shown, it is below both WHO guidelines and Ethiopian Environmental Protection Agency (EPA) standards. The result indicates that it is suitable for irrigation and other domestic use rather than drinking purpose.

Table 4.3: Water Hardness General Guideline

General Guidelines for Water Hardness	
0 – 60 mg/l	**Soft**
61 – 120 mg/l	**Moderately Hard**
121 – 180 mg/l	**Hard**
> 180mg/l	**Very Hard**

4.5.9. Total Ammonia (T-NH_3)

The total ammonia of Lake Dambel showed small difference among the sampling sites and the WHO guideline. The Ethiopian EPA (2013) standard states that the optimum NH3-N for lake water is < 0.025 mg/l. However, the value increases at the downstream area; which is closer to the floriculture farm, which might be the source of excess nutrient due to fertilizer use and filled the lake with ammonia much beyond the standard level.

4.5.10. Total Nitrogen (T-N)

Nitrogen is essential to all forms of life. Nitrogen in the atmosphere and soil goes through many complex chemical and biological processes. For example, the nitrogen cycle is the process by which nitrogen is converted between its various chemical forms. Nitrogen occurs in natural waters in various forms including nitrate (NO_3), nitrite (NO_2), and ammonia (NH_3). These three compounds are interrelated through the process of nitrification – the biological oxidation of ammonia to nitrate. In this process, nitrite is produced as an intermediate product.

4.5.11. Reactive Phosphate (PO_4)

Floriculture industries are known for using excessive fertilizers and the effluents from the farm drained directly to the water body. Excessive amounts of phosphorous in a system can lead to an abundant supply of vegetation and excessive growth of algae, consequently low dissolved oxygen.

The mean phosphate of lake is 0.41 mg/l and the EPA (2013) provisional standard for PO_4 is 0.005mg/l and the standard for Phosphates should not be exceeded from 0.1mg/l in any lake. This all shows that the lake is highly concentrated by phosphate and exposed to emerging of phytoplankton that leads to eutrophication.

4.5.12. Total Phosphorus (as P)

Phosphorus is an essential nutrient for plants and animals. However, excessive phosphorus in surface water can cause explosive growth of aquatic plants and algae. This can lead to a variety of water-quality problems, including low dissolved oxygen concentrations, which can cause fish kills and harm other aquatic life.

4.5.13. Nitrite (NO_2)

Nitrite is the intermediate oxidation state of nitrogen in the oxidation of ammonia to nitrate, and in the reduction of nitrate. Therefore, although it is generally a short-lived compound it provides important information on the kinetics of nitrification and denitrification processes. Nitrogen as Nitrite – Nitrite (NO2) is extremely toxic to aquatic life. It is usually present only in trace amounts in most natural freshwater systems and is rapidly oxidized to nitrate.

4.5.14. Nitrate (NO_3)

In the study area the concentration of nitrate at Sampling Site 1 is beyond the standard limits. But in the Sampling Site 2 and 3, they are relatively within the standard limit. Hence, the acceptable WHO standard to protect aquatic ecosystems is 10 mg/l and up to 20 mg/l (EPA, 2013). The main Sources of nutrient in the area is the intensive use of Nitrogen concentrated fertilizer and direct effluent discharge by the flower farms. Plants do not absorb all the fertilizers that are applied, and much of the excess fertilizer runs off into the Rift Valley Lake water systems. The residue of these fertilizers can cause water pollution, eutrophication of fresh waters, and increased nitrate concentrations in ground and surface waters.

4.5.15. Sulfate (SO_4)

Significant increase of sulfate is found at the Sampling Site 1 and site 2 when comparing with the Sampling Site 3; moreover, the results indicate that there is a high concentration of sulfate in the water which is > 40m/l.

Table 4.4: Values of Sulfate (SO_4) Concentration in Water

Status of Sulfate (SO_4) Concentration in Water (in ppm)	
< 2	Very Low
2 – 5	Low
5 – 20	Medium
> 20	High

4.6. Deliberations

Statistics describe (Range, mean, maximum, minimum, standard deviation and variance) are listed for water quality parameters (Table4.20). (Note that all parameter values are in line with the values listed in the Ethiopian EPA and WHO standards column).

Table 4.5: Range, mean, minimum and maximum values for Water Quality Parameters

Physiochemical Parameters	Min.	Max.	Range	Mean	WHO Guideline	EPA Standard
Turbidity (NTU)	21.50	58.70	37.20	38.5	5 NTU	45 NTU
Electrical Conductivity (EC), µs/cm	42	56.50	14.50	48.1667	1000 µs/cm	100 – 1000 µs/cm
pH	7.40	7.70	0.30	7.50	6.5 – 8.5	6 – 9
Dissolved Oxygen (DO), mg/l	1.50	5.80	4.30	3.633	4 – 6 mg/l	6 mg/l
Biological Oxygen Demand (BOD), mg/l	7.50	27.30	19.80	16.867	2 mg/l	5 mg/l
Chemical Oxygen Demand (COD), mg/l	7	56	49	27	10 mg/l	< 150 mg/l

Total Suspended Solids (TSS), mg/l	41	98	57	61.667	25 mg/l	30 mg/l
Hardness	85	116	31	97.667	300 mg/l	500 mg/l
Total Ammonia ($T\text{-}NH_3$), mg/l	1.10	2.90	1.80	1.933	1.5 mg/l	0.0025 mg/l
Total Nitrogen (T-N), mg/l	6	24	18	13	1000 mg/l	1000 mg/l
Reactive Phosphate (PO_4), mg/l	4.20	9.30	5.10	6.367	0.3 mg/l	0.005 mg/l
Total Phosphorus (as P), mg/l	0.05	0.80	0.75	0.323	0.1 – 1 mg/l	0.1 – 1 mg/l
Nitrite (NO_2), mg/l	0.02	0.173	0.153	0.087	1 mg/l	1 mg/l
Nitrate (NO_3), mg/l	0.70	10.70	10	4.38	10 mg/l	1 – 10 mg/l
Sulfate (SO_4), mg/l	13	49	36	33.33	40 mg/l	20 mg/l

The gathered and examined water samples undergo testing for Turbidity, EC, pH, Dissolved Oxygen (DO), Biological oxygen demand (BOD), chemical oxygen demand (COD), Total Suspended Solids (TSS), Hardness, Ammonia ($T\text{-}NH_3$), Total Nitrogen (T-N), reactive Phosphate (PO_4), Total Phosphorus (as P), Nitrite(NO_2), Nitrate (NO_3), Sulfate (SO_4) and the obtained cumulative parameter result were compared with Ethiopian EPA and WHO standard.

Table 4.6: The overall result of sample water, with comparing to Ethiopian EPA and WHO standards

Physiochemical Parameters	Cumulative Results	Provisional Ethiopian EPA standards	WHO Standards
Turbidity (NTU)	38.5	45 NTU	5 NTU
Electrical Conductivity (EC), µs/cm	48.1667	100 – 1000 µs/cm	1000 µs/cm
pH	7.50	6 – 9	6.5 – 8.5
Dissolved Oxygen (DO), mg/l	3.633	6 mg/l	4 – 6 mg/l
Biological Oxygen Demand (BOD), mg/l	16.867	5 mg/l	2 mg/l
Chemical Oxygen Demand (COD), mg/l	27	< 150 mg/l	10 mg/l

Total Suspended Solids (TSS), mg/l	61.667	30 mg/l	25 mg/l
Hardness	97.667	500 mg/l	300 mg/l
Total Ammonia (T-NH_3), mg/l	1.933	0.0025 mg/l	1.5 mg/l
Total Nitrogen (T-N), mg/l	13	1000 mg/l	1000 mg/l
Reactive Phosphate (PO_4), mg/l	6.367	0.005 mg/l	0.3 mg/l
Total Phosphorus (as P), mg/l	0.323	0.1 – 1 mg/l	0.1 – 1 mg/l
Nitrite (NO_2), mg/l	0.087	1 mg/l	1 mg/l
Nitrate (NO_3), mg/l	4.38	1 – 10 mg/l	10 mg/l
Sulfate (SO_4), mg/l	33.33	20 mg/l	40 mg/l

4.7. Water Pollution Load of Surface Water of Lake Dambel

Due to high levels of water contamination, many of the lakes close to floriculture greenhouses are endorheic (Ramsar, 1992), which can be troublesome. However, human activity is largely responsible for the accumulation and spread of salt issues with the growth of irrigated agriculture. According to Tadelle (1993), the government has been focusing on significant irrigation expansion since the 1970s, using water straight from Lake Dambel and its two feeder rivers, the Meki and Katar rivers. Lake Dambel is the freshest lake located within the main rift valley area.

By extracting water for irrigation and returning waste water that contains fertilizer and pesticide residue to lakes, the floriculture sector places a great deal of strain on Lake Dambel (Jansen &Harmsen, 2011) In the majority of the Lake Dambel physico-chemical parameters analyzed, the results exceeded the WHO and EPA thresholds. Furthermore, there's a growing concern that the incidence of contamination is occasionally rising.

4.7.1. Protective and Management Options

Prior studies conducted in the vicinity of Lake Dambel have demonstrated that, in the absence of control over the sources of pollution, the aquatic life and human consumers of the lake may be in danger. A study conducted by Berhane et al., for instance, it was evident that the majority of the parameters in the majority of the sampling sites were found to be typically above the maximum allowable levels of WHO guidelines. However, after two year time it was observed that the parameters' values did not surpass the WHO guidelines by far. The results of this research indicate that the tendency is declining from prior years, however not enough to be generalized. The measures taken by the regional government may have led to this situation. According to the residents of the area who participated in informal interviews, the floriculture enterprises have been given obligations by the regional administration to either vacate the leased land or abstain from any environmental offenses.

A buffer zone of vegetation has been established between 7.62 and 30.50 meters from the lake by the Floriculture Company, under the name Sher Ethiopia. Unfortunately, the buffer zone that separates the company from the lake is not long enough to stop pollution discharge into the lake, both directly and indirectly. The minimum standard for the construction of buffer zones is 7.62 meters, while larger buffers are set up for wider and more delicate lakes, ranging in width from 15.25 to 30.50 meters.

4.7.2. Building Buffer Zones

The benefits of buffer zones are numerous and include stabilizing the shoreline, preserving fish and shoreline habitat, reducing noise, preserving aesthetic values, and filtering runoff. It removes hazardous pollutants and nutrients from runoff produced by nearby land uses. By preserving equilibrium in delicate aquatic environments, it also acts as a habitat for important aquatic insects, microbes, fish, and other creatures. However, natural coastal vegetation is removed or damaged for a variety of reasons. As a result, buffers become crucial; that is, a naturally occurring buffer strip at the edges of marshes, lakes, and streams is necessary for the wellbeing and quality of the water body.

It is recommended that the buffer consist of the kind of vegetation that is naturally present in the coastline environment. Using pesticides or fertilizers on buffers is not recommended. And about the size, it may be 7.62 meters broad around a small urban pond and 30.50 meters wide along a unspoiled rural lake (Illinois Environmental Agency and the Northeastern Planning Commission, Lake Notes, 1996)

Before constructing any buffer zone, it is essential to take note of the water body's characteristics and local conditions in order to determine the appropriate kind of buffer zone to establish. As a result, the local environment affects the features of typical buffer zone types like prairie, woodland, and vegetative wetland. But, it is still necessary to rely on certain fundamental minimum requirements.

The minimum width requirement is 7.62 meters though wider buffers with the width of 15.25 – 30.50 meters are established for wider and sensitive lakes. For the protection of water quality, the US Department of Agriculture suggests filter strips with a length of 20.13 to 30.50 meters. If access to lakes is required, it is advised to do so with the fewest possible disruptions. Limiting any movement through the buffer zone is necessary. The buffer vegetation should be native species of plants because they can quickly get accustomed to the soils, hydrology and climate of the area. Its function should also be reflected in buffer vegetation. For example, if screening noise is the goal, a buffer with trees is better. On the other hand, if nearby people require a view of the lake, then it might not be suitable. In order to create a buffer, the initial unwanted vegetation must be removed. Otherwise, they would be regarded as weeds that compete with the native species. Because only native plants are able to adapt to the environment . In order to retain native plant diversity and reduce weeds, buffer care is crucial. After buffers are built, maintenance usually takes one to three years (Illinois Environmental Agency and the Northeastern Planning Commission, Lake Notes, 1996).

The prairie and vegetated marsh that stretches between 7.62 and 30.50 meters from the lake edge constitute the buffer zone of Lake Dambel. About 2 meters in width makes up the contaminated water collection pool. It is below standard, which is the main issue with this designed buffer zone. As per Ministry of Urban Development and Housing Infrastructure (2016), the buffer zone and the lake shall be separated by a minimum of 30.50 meters. Pollutants that are soluble and extremely small in size may enter the water body by the shortest path, which speeds up the induction of water.

The other issue with Lake Dambel's buffer zone construction is that, although intrusions should be rigorously prohibited, many human and animal activities occur in and around the buffer zones, making this not the case in Lake Dambel. Naturally, there are fences in certain areas of the buffer zones.

Benefits of Built Buffer Zones for Enhancement of Water Quality

There are several benefits to buffer zones, including enhanced environmental services and surface water quality monitoring. Sifting runoff before it reaches surface water bodies is the most advantageous feature to filter the upcoming effluents. Diverse elements of the runoff, such as contaminants and silt, are filtered by the buffer as it flows into the lake from surrounding areas.

Thus, through filtration and settling processes, plants and plant residues will remove silt and associated contaminants. Plant roots absorb soluble contaminants, such as nutrients from plants, and microorganisms in the soil use them. The root systems of native plants, especially prairie vegetation, are more denser and deeper than those of ordinary turf grasses, which effectively increases the amount of surface runoff that penetrates the ground. It can filter out 70–95% of incoming silt, 25–60% of incoming nutrients, and other contaminants from runoff, depending on its breadth and other properties.

In addition to providing runoff filtering, buffers—especially naturally occurring ones that stretch down the border of a body of water—effectively prevent shoreline erosion more effectively than traditional turf grass, which has shallow roots and is intolerant of flooding. The dense, deeply rooted networks of natural riparian vegetation effectively stabilize shoreline soils.

The majority of the lives of many aquatic species, especially insects, are spent in highland habitats. A vital transition area between upland and aquatic/wetland habitats is provided by buffers. Buffers, depending on their width, can also protect vulnerable species—especially birds—from potentially disruptive activities taking place in nearby land uses.

Buffers, such as forested buffers, can stop noise from highways and industrial operations, safeguarding lake recreational usage in addition to protecting wildlife uses. This pertains to Lake Dambel and serves to safeguard the monastic regions of St. Gebriel and Kidane mihret monasteries for their usage as recreational and religious spaces. Considering that a lot of human activity and noisy environments surround these.

These have to do with properly landscaping the coastline to improve the view of the lakes. It is crucial to understand that a lake with buffering offers a better perspective than the one without.

4.8. Best Management Practices (BMPs)

According to the State of Hawaii's Department of Land and Natural Resources (1996), best management practices are efficient, realistic, structural or nonstructural techniques that stop or significantly reduce the flow of sediments, fertilizers, pesticides, and other pollutants from the land into surface waters. Techniques for conserving soil and water, social responsibility for environmental preservation, and other management strategies are all included in BMPs.

Combining several BMP applications is crucial to improving the quality of water and soil because there is little chance of resolving pollution issues in these areas with a single application. Best management practices (BMPs) can be as basic as applying manure after rainfall forecasts or as complex as changing farming practices like crop rotation and conservation tillage.

Conservation tillage is one of the greatest management techniques currently in use. The main objective of conservation tillage, a soil management technique, is to boost agricultural output. But in addition to aiding with soil management, it also helps to enhance water quality. According to a 1997–2010 study on improving lake water quality in the United States, the mean concentrations of total suspended particles and total phosphorus dropped by 72 and 45–56 percent, respectively.

Conservation tillage systems range from no - till to mulch - till. No – till conservation tillage system is used by covering a crop residue on the soil surface from harvesting time to seeding time. This system is very important in sloppy areas with high degree of soil erosion. The Mulch – till on the other case comprises all types of techniques except no tillage and ridge tillage systems. Utilizing certain cultivars and planters, ridge till is a type of till that involves clearing the remains of earlier tillage. One type of mulch-till system is strip-tilling. Less muddy fields or areas with inadequate drainage are suitable for its application. The field is left tillled in most places, with the exception of a few thin strips that are tilled. In deep-tillage, soil is combined with crop leftovers to create another kind of mulch-till.

For the control of soil and water quality, social initiatives like afforestation and reforestation are essential. Water quality control can also be achieved through soil conservation or management. Therefore, improving water quality requires taking steps like forest management. In order to reduce soil erosion and surface runoff and, consequently, the amount of sediment, pesticide, and nutrient pollutants that would have entered surface water bodies, forests especially those found upstream of water bodies are essential.

Additional best management practices (BMPs) include the application of engineering techniques, waste prevention and treatment at the source, public education about the causes and mitigation procedures of factors aggravating the degradation of water quality.

Construction of a bypass canal upstream of the lake, where the Meki and Ketari Rivers join, is one engineering method that might be useful to prevent pollution inlets into Lake Ziway. This can also be constructed in any other tiny ways of emergency runoff that can arise during rainy. This approach could be very beneficial, since impurities and silt entering the lake through rivers are one of the causes of its water quality issues. Therefore, by diverting pollutants and sediments from the lake, bypass canals can either prevent or lessen problems with water quality. According to Yang and Liu (2010), research has already been done on the efficacy of bypass canal building as a pollution reduction technique.

Employing all available preventative, reduction, and treatment techniques at the source is imperative for small-scale farmers and companies that have an impact on the lake's pollution levels. They ought to accept the obligations to carry this out.

Another critical issue is raising public awareness of the conditions of water, the sources of pollution in water bodies, and the effects these factors have on the socioeconomic well-being of local people. More than any other stakeholder, including the government and other nongovernmental groups, the general public should be the one to make the largest commitment to protect the natural environment.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The floriculture sector plays a significant economic role and adds significantly to the GDP of the nation, but because of the inputs it uses, it also has an impact on social and environmental health. This research paper analyzes the negative effects of the industry, which include fertilizer, chemicals, intensive use of surface and ground water, conversion of wetlands and farmlands for flower industries.

The lake that surrounds flower farms is heavily exposed to direct fertilizer waste effluents, changing the lake's water quality and causing eutrophication, which ultimately has detrimental effects on the lake's ecosystem.

Laws and policies pertaining to the environment exist in Ethiopia; the floral business is heavily involved in environmental impact assessments. This investigation showed that flower farms have a major influence on Batu Town, and that the environmental impact assessment conducted at the project level is insufficient to control and amplifies the overall environmental impact of all the enterprises.

The extensive use of chemicals by floriculture farms has a detrimental effect on the environment, particularly on the quality of surface water and surrounding areas. The contamination was primarily caused by untreated effluent.

Parameters analyzed at the sampling sites (i.e. turbidity, BOD, COD, TSS, PO_4, NO_3, SO_4 and NH_3) results were beyond the permissible limits. But pH, EC, DO, TDS and hardness are under the permissible limits of WHO and Ethiopian EPA standards. Based on the guideline values, the potential irrigation problem of the lake water near the farm were slight to moderate; furthermore, it indicates that it is also becoming less suitable for the maintenance of fisheries and aquatic life.

Moreover, it can be concluded that sites that has human interventions have direct or indirect impacts on water quality deterioration of Lake Dambel. The results were compared with international water quality WHO guidelines to check if the water the water quality of Lake Dambel complies with the standard ranges.

In this study the water quality parameters for some parameters at southern shoreline, floriculture outlet, Sher Ethiopia buffer zone and specific sampling sites were found to be above the ranges of the WHO guideline values. But, with this study, the water quality of Lake Dambel can be generally acceptable for irrigation with the current condition. However, this doesn’t mean it is possible for drinking and hence if pollution prevention methods are not taken on the Lake, the water quality of the Lake may seriously deteriorate and aquatic life of the lake and human life would be endangered.

The descriptive analysis shows that there are no extremely large variations between the means and the WHO water quality guidelines.

The ecology is negatively impacted by floriculture farms' heavy chemical use, especially when it comes to the surrounding parts and surface water quality. The main source of the contamination was untreated wastewater.

Treatment of point sources and waste water management are therefore crucial. Systems for managing pesticide use must be developed for both big and small-scale agricultural operations, including commercial floriculture farms. Regular evaluations of the waste management practices of the surrounding farms and industry should also be conducted by the competent authorities.

5.2. Recommendations

It is consequently essential to treat point sources and control waste water. Agricultural enterprises of all sizes, including commercial floriculture farms, need to establish pesticide usage management systems. It is also imperative that the responsible authorities regularly assess the waste management procedures used by the nearby farms and businesses.

In order to reduce future environmental degradation and to gain a deeper understanding of the environmental degradation that has occurred over the previous 10 years, the Ethiopian government ought to think about imposing EIAs on entering floriculture enterprises.

Before being dumped into the neighboring lake, the waste water must be treated because it contains a variety of pollutants that contaminate the adjoining water body.

The control of fertilizer helps to limit the quantity of surplus fertilizer that enters the lake and the surrounding soil by supplying nutrients in the appropriate amounts at the appropriate times.

Waste water recycling: In addition to preventing pollution of the lake water, this technique also helps to minimize excessive water abstraction.

Investigate the large-scale usage of natural detoxifying programs like Vitivar to prevent deterioration.

The timing and application techniques of fertilizer should be known by flower and horticulture farms that use a lot of it, as runoff from rainfall following fertilization can contain significant levels of nitrogen and phosphorus in both sediment and runoff water.

The recommendation is that small buffer zones of a forest plantation surrounding the lake shoreline must be created or maintained in order to preserve the Batu freshwater habitat without delaying agricultural output.

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APPENDICES

Appendix I: Measurement Units of Water Quality Parameters

R.N	Water Quality Parameters	Units of Measurement
1	Turbidity (NTU)	NTU
2	Electrical Conductivity (EC), µs/cm	µs/cm
3	pH	PH
4	Dissolved Oxygen (DO)	mg/l
5	Biological Oxygen Demand (BOD)	mg/l
6	Chemical Oxygen Demand (COD)	mg/l
7	Total Suspended Solids (TSS)	mg/l
8	Hardness	mg/l
9	Total Ammonia (T-NH_3)	mg/l
10	Total Nitrogen (T-N)	mg/l
11	Reactive Phosphate (PO_4)	mg/l
12	Total Phosphorus (as P)	mg/l
13	Nitrite (NO_2)	mg/l
14	Nitrate (NO_3)	mg/l
15	Sulfate (SO_4)	mg/l

Appendix II: Results of Physiochemical Parameters of Sampling Sites

Physiochemical Parameters	Sampling Sites		
	Site 1	**Site 2**	**Site 3**
Turbidity (NTU)	**35.30**	**21.50**	**58.70**
Electrical Conductivity (EC), µs/cm	**42**	**56.50**	**46**
pH	**7.70**	**7.40**	**7.40**
Dissolved Oxygen (DO), mg/l	**1.50**	**5.80**	**3.60**
Biological Oxygen Demand (BOD), mg/l	**15.80**	**7.50**	**27.30**
Chemical Oxygen Demand (COD), mg/l	**18**	**7**	**56**
Total Suspended Solids (TSS), mg/l	**41**	**46**	**98**
Hardness	**116**	**92**	**85**
Total Ammonia (T-NH_3), mg/l	**1.10**	**1.80**	**2.90**
Total Nitrogen (T-N), mg/l	**24**	**9**	**6**
Reactive Phosphate (PO_4), mg/l	**4.20**	**5.60**	**9.30**
Total Phosphorus (as P), mg/l	**0.12**	**0.80**	**0.05**
Nitrite (NO_2), mg/l	**0.173**	**0.07**	**0.02**
Nitrate (NO_3), mg/l	**10.70**	**1.75**	**0.70**
Sulfate (SO_4), mg/l	**38**	**49**	**13**

Appendix III: Questionnaires

1. What is the main source of water for domestic usage of the Batu Town?

Ground Water   Surface Water or Lake   Reservoir   Other Source

2. What is the resource of water for floriculture industry?

Ground Water   Surface Water or Lake   Reservoir   Other Source

3. How many cubic meter of water is utilized by flower farm?

10 – 50 m3   50 – 100 m3   100 – 200 m3   Above these

4. What is the daily frequency of water supplying for flowers?

One Times   Two Times   Three Times   Above These

5. Are there any irrigation mechanisms that can prevent the loss of water?

Yes   No

6. If yes, what kinds of systems do you use for irrigation?

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7. Is there any recycling method of waste water for re-utilization?

Yes   No

8. Are you aware of what constitutes water pollution?

Yes   No

9. Do you know if there is water contamination in the Ziway area?

Yes   No

10. Do you realize that your "Right to Life" includes living in a clean and healthy environment?

Yes   No

11. What causes the water contamination around Lake Ziway?

Urbanization   Industrial Effluents   Agriculture   Floricultural farms   Others

12. Have you ever heard of any complaints made to any authorities regarding the contaminating of the water at Lake Ziway by any person or group?

3.Yes   No

14. Has the water pollution in Lake Ziway been prevented or controlled by any individual, government official, or non-governmental organization?

☐ 5.Yes ☐ No

If yes, What actions have been carried out?

____

16. Has anyone—a government employee, an NGO, or another individual—made an attempt to educate you about water contamination and the ways in which you may help reduce its occurrences?

☐ Yes ☐ No

17. What kinds of visible injuries & health impact are seen in workers?

____

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18. Is the workers properly using health protecting materials?

☐ Yes ☐ No

19. Is there any medical treatment after and before injuries?

☐ Yes ☐ No

20. How many personnel participating totally in the farm to spray chemicals?

____

21. How and where the liquid and solid waste is disposed?

☐ Move to permitted open area ☐ Water body ☐ Recycled ☐ Disposed on land ☐ Others

22. What visible impact does waste have on residents' surrounding environments in societies?

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