Jimma University

College of Natural Sciences

Department of Biology

Composition and Abundance of Zooplankton in Relation to Physicochemical Factors in Gilgel Gibe Reservoir, Jimma, Southwest Ethiopia

A Research Paper Submitted to College of Natural Sciences, Department of Biology, Jimma University, in Partial Fulfillment of the Requirements for the Degree of Master of Science in Biology (Ecological and Systematic Zoology)

BY :Dereje Tamene

Advisores: Mulugeta Wakjira(PhD),Seid Tiku(phD) andTokuma Nagesho(Msc)

June 2019

Jimma, Etiopian

Jimma University

School of Gratuate Studies

Department of Biology

Title: Composition and Abundance of Zooplankton in Relation to Physico-chemical Factor In Gilgal-Gibe Reservoir,Jimma Southwest Ethiopia

By:Dereje Tamene

The thesis" Composition and Abundance of Zooplankton in Relation to physic-chemical Factor in Gilgal-Gibe Reservoir southwest Ethiopia has been approved by the Biology Department" for the partial fulfillment of the Degree of Master of science in Biology(Ecological and systematic zooloogy)

Approved by the examining board

1.Chairperson,examination board

Name______________________________Signature_____________Date__________________

2.Advisor

Name_______________________________Signature__________________Date____________

3.External Examiner

Name_______________________________Signature___________________Date___________

4.Internal Examiner

Name_______________________________Signature____________________Date________

Acknowledgement

I wish to express profound heartfelt gratitude to my Advisor Mulugeta Wakjira (PhD) for his scholastic guidance, encouragement and provision of materials and references, without his generous help and support, completion of my study would have been impossible.

I am a cordial gratitude to my co-Advisor Seid Tiku (PhD) and Mr. Tokuma Nagesho for their valuable comments, correction of the drafts and guidance throughout the study period.

I am in debt to thank Department of Environmental health science and technology for the material support.

I am grateful to Seyoum Derib for providing me with equipments for on-site measurement of physico-chemical parameters.

Finally, I also acknowledge individuals who helped me in one or another way during my study.

Table of contents

Contents pages

List of figure

List of tabel

Abstract

The present study aimed to assess the composition and abundance of zooplankton in relation to physico-chemical factors in Gilgel Gibe Reservoir. The zooplankton of Gilgel Gibe Reservoir was sampled at five stations in October concurrently with physico-chemical parameters. The data was analyzed using descriptive statistics, one-way ANOVA, canonical correspondence and biological indices. Conductivity of the reservoir at Asendabo site was significantly higher than at Deneba,Center, Nadi and Yedi sites ($p < 0.05$). There was significant difference in the mean pH values at Center dam (7.860± 0.399) and (7.68± 0.25) at Deneba site. The mean DO and water temperature of Asendabo site (7.22 ± 1.08mg/L, 25.20 ± 0.70^{0}C and varied significantly from the other three sites ($p < 0.05$). 31 species of zooplankton were identified in the reservoir. The Calanoid and Cyclopoid copepodes were the most dominant species throughout the study period. The diversity index narrowly ranged from 1.88 -2.03 spatially. The abundance of zooplankton wasmaximum at Asendabo and Yedi than other sites. The abundance of cladocerans and calanoid copepodes zooplankton showed spatially significant variation ($p < 0.05$) and the cyclopoid copepodes exhibited spatially significant difference ($p < 0.05$). Cyclopid copepodes were the dominant group (31%), followed by calanoid copepodsand cladocera (28% and 25%) and 15% of rotifers respectively.

Key words: Gilgel Gibe Reservoir, physico-chemical variables, *zooplankto*.

1. Introduction

1.1. Background

Water is an essential component of a biosphere which exists in gaseous, liquid and solid states. On the entire earth the total quantity of water estimated as 97.4% by volume is found in oceans. The remaining 2.6% is freshwater and is locked up in ice caps or glaciers or in ground water too deep or salty to be used. Freshwater is divided as ice caps and glaciers (1.984%), ground water (0.592%), lakes (0.007%), soil moisture (0.005%), atmospheric water vapor (0.001%), biota (0.0001%), manmade lakes (0.0001%) and river (0.0001%) (Patra et al., 2011).

Freshwaters are important habitats as they are generally very productive at the primary, secondary and tertiary levels. In the world the demand of freshwater is increasing due to human population growth and industrial development. According to the FAO (2006) agriculture is the largest user of water resources in the world (70%), followed by industry (20%) and domestic use (10%). Also freshwater are important in the evolution of fishes, that over 41 % of all fish species are found in freshwater, even though freshwater habitat represents only a small percentage (2.6 % by volume) of the earth's water resource (Miller and Harley, 2002).

Moreover, freshwaters such as lakes, rivers and reservoirs are one of humanity's most important resources, especially in the tropics, where they are often viewed as highly productive biological systems. They provide water for consumption, fishing, irrigation, power generation, transportation, recreation, as a storehouse of genetic information, in supporting the provision of ecosystem services (e.g. cleaning water) (Pearce, 1998; Hailu, 2011) and a variety of other domestic, agricultural and industrial purposes.

In spite the fact, that freshwater are very limited and sensitive resources that need proper care and management, they are probably the most abused resources. Because of freshwater ecosystems have been subjected to various environmental and human induced changes throughout the globe (Alfred, 2002; Magadza, 2010). The changes associated with environmental degradation range from loss of biodiversity to complete lose of ecosystems (Brook, 2003; Canonico et al., 2005; Tenalem and Dagnachew, 2007). The establishment of increasing human populations and intensive agricultural practices in the catchment area has resulted in significantdegradation and loss of pristine ecosystems (Alemayehu, 2006; Harte, 2007; Habiba, 2010; Hailu, 2011). The quality of water, unlike the very obvious physical changes that take place during the development of water resources, is an attribute that affects the biodiversity (flora and fauna) and productivity of aquatic systems. The term “Water quality” refers for the physical, chemical and biological parameters of water and all these characteristics directly or indirectly influences the survival and production of aquatic inhabitants (Margaleff, 1996; Chapman, 1997; Ogato, 2007).

Ethiopia is a country in the horn of Africa (Northeast) with an estimated area of 1,127,000k

[≈70,000 km2 covered with natural inland water bodies (Wood and Talling, 1988)] and endowed

with a variety of aquatic ecosystems including rivers, lakes and associated wetlands and reservoirs that are a great scientific interest, habitat of aquatic organisms, recreational value and economic importance (Shibru, 1973; Alemayehu, 2006; Tenalem, 2009; AKlilu, 2011).

Despite the fact, their countless uses, nowadays reservoir and their biodiversity are being threatened by a number of human activities including overexploitation, water pollution, shore-line modification and introduction of invasive alien species (Dudgeon et al., 2006). More than two decades human started impacting freshwaters like reservoirs in Ethiopia. Several studies have shown changes in the limnology of Ethiopian freshwaters owing to rapid population growth, urbanization and increased agricultural and industrial development practices (Fisseha, 1998; Zinabu, 1998; Brook, 2002; Zinabu and Zerihun, 2002; Zinabu et al., 2002; Seyoum et al., 2003). Additionally, the use and potential for added value of the reservoirs is, however strongly reduced because of poor water quality and massive soil erosion linked to land degradation (Nyssen et. al., 2004, 2005) and the associated of nutrients to sediment influx in the reservoirs (Nigussie et al., 2006; Tamene et al., 2006). Many reservoirs are characterized by pronounced phytoplankton blooms, and a substantial fraction of these show intensive blooms of potentially toxic cyanobacteria that affects the composition and abundance of aquatic inhabitants including zooplankton and other aquatic organism (Dejenie, 2008). Moreover, reservoirs are subject to high temporal variability, with frequent reorganization of the relative abundance and species composition of the aquatic organisms such as zooplankton and fish as a result of the interactions between physical (light and temperature) and chemical (nutrients, conductivity, pH, dissolvedoxygen and sediments) variables. In reservoirs, there are additional factors owing to the hydrodynamic differences arising from the location, morphometry and the main function of a given system that affects the aquatic organisms like zooplankton.

Zooplankton constitute an important component of freshwater ecosystems and their unique central position in food webs provide the ecological machinery for the processing and transfer of energy and matter from lower trophic levels to higher trophic levels. However, these important ecosystem activities of zooplankton are influenced by biological factors (Primicerio, 2000) through food web interactions mainly interspecific competition and predation that regulate zooplankton structure and function in lake and reservoir ecosystems (Carpenter and Kitchell, 1993; Sanful, 2008). Zooplankton are the major food source of fish and other aquatic animals, and they play an important role in aquaculture (Mavuti and Litterick, 1981; Yigit, 2002). Fishes are economically important, but their effects on the aquatic organisms, food web structure and ecosystem is very high. It was suggested by Kebede et al. (1992) that the stocked fish was the cause for the disappearance of cladocerans zooplankton. The impact of fish predation on zooplankton abundance is also reported by Serruya and Pollingher (1983), where significantly lower plankton density was associated with the presence of the planktivore fish (Mageed, 2006). Additionally, nutrients are chemical factors that affects directly the abundance of primary producers (phytoplankton) in freshwaters indirectly influenced primary consumers (zooplankton).

1.2. Statement of the Problem

Ethiopia has rich inland water resources, consisting of both natural water bodies such as rivers and lakes and manmade water bodies like reservoirs, which may provide admirable opportunities for comparative limnology importance to the considerable variations in their morphometric, physical and chemical features. These reservoirs are facing a problem of pollution or eutrophication owing to their establishment in the vicinity of industrial operations, or due to inputs from the catchment area with intensive agricultural activity (fertilizers) and dense livestock. This results in major changes in the biological structure including zooplankton and dynamics of the reservoirs in country. Ethiopia has rich inland water, however study on the liminological and aquatic biodiversity are scarcely especially on reservoirs (Dejenie, 2008). Dams and reservoirs have been constructed to reduce the risks of flooding from inundation, to generate energy for industry and domestic use, and to help secure a reliable source of water for domestic, industrial and/or agricultural use (Moss, 1998). In addition to, a number of reservoirs hold the promise of enabling the culture of fish (e.g. Gilgel Gibe Reservoir). Moreover; reservoir provided as habitat for aquatic organisms including planktons. However; the quality of reservoir water influenced by physico-chemical parameters and quantity of nutrients in water play significant role in the distributional patterns and species composition of plankton (Ahmed, 2003). In aquatic habitats, the environmental factors include various physical properties of water such as solubility of gases and solids, the penetration of light, temperature, and density. The chemical factors such as salinity, pH, hardness, phosphates and nitrates are very important for growth and density of phytoplankton on which zooplankton and some higher consumer depend on their existence. Zooplanktons play a central role in aquatic ecosystems relative to phytoplankton and higher trophic levels (Banse, 1995). However, understanding the influence of physico-chemical and biological factors on zooplankton population dynamics is still a gap in our knowledge (Dejenie, 2008).

The few studies which were conducted on the zooplankton of Ethiopian reservoirs have not been systematic. The studies made on the ecology of reservoirs in the semi-arid highlands of Tigray, Northern Ethiopia, with special reference to zooplankton (Dejenie, 2008) and the species composition of zooplankton in Ethiopian reservoirs (Melaku et al., 1988) on Koka Reservoir, whose investigations involved the analysis of single samples. Despite of Gilgel Gibe Reservoir was one of the reservoirs in Ethiopia.Research work was conducted for achieving the hydroelectric power production, malaria parasite vectors among pregnant women (Million et al., 2012), impact assessment of Gilgel Gibe hydroelectric dam on schitosomiasis (Alemeshet et al., 2010) and rainfall-runoff dynamics, and sediment source (Negash, 2011),Diversity and Ambundance of crustacean Zooplankton Community in Gilgel Gibe reservouir(Embaye *et al.*,*2017*).that studed only the dynamics of crustacean zooplankton.However,this study is a part of project that focuses on generating comprehensive information about the reservoir.therefore,the present study addressed all the three major freshwater zooplankton groups viz.cladocera,copepod and rotifer and ther dynamics in relation to the measured environmental variables.

1.3. Significance of the study

The study of a natural population in its environment requires a careful evaluation of the interrelationships between the population and the biological, chemical, and physical factors of the environment. Therefore, almost all project or research studies have their own predetermined objectives, aims that they initially sought to achieve and significances to provide in their endeavor. This study on its part significantly contributes to and mainly gives attention on the species composition and abundance ofzooplankton and physico-chemical factors in Gilgel Gibe Reservoir. Therefore, the finding of the study is hoped to fill the gap in providing baseline data that would help in the proper management of Gilgel Gibe Reservoir.

1.4.Objectives

1.4.1. General Objective

- The main objective of this study was to assess the species composition and abundance of zooplankton in relation to physico-chemical factors in Gilgel Gibe Reservoir.

1.4.2. Specific objectives

The research project aimed to achieve the following specific objectives:

- To investigate the taxonomic composition and numerical abundance of zooplankton of Gilgel Gibe Reservoir.
- To determine the physico-chemical variables of Gilgel Gibe Reservoir during the study period.

1.5. Limitation of the study

The present study was only conducted for one season (wet), due to financial and logistic limitations.

2. Literature Review

Water is a unique substance in the universe. The presence of water on earth is in itself unique, for the planet earth has few natural liquids. Water is the prime resource of man's food supply and his most important household and industrial tool. However; most important is the fact that water is a major constituent of all living matter, comprising up to two-thirds of the human body. Next to the air we breathe, water is mankind's most important substance (Ahmed, 2003).

Water is essential to sustain life especially the freshwater. The ecological, social and economic benefits that freshwaters provide are numerous. Reservoirs (manmade lake) are among finite freshwater resources used for municipal water supply, power generation, industrial, agricultural irrigation, commercial and recreational fisheries, and other recreational uses. Sustainable socio-economic development of any country is unlikely without freshwaters of sufficient quantity and acceptable quality (FAO, 2006). However, the rapid growth of human population and the consequent speedy expansion of activities related to industry, agriculture and urbanization have resulted in adverse impacts on freshwater resources and in the emergence and rapid growth of water pollution problems especially in Africa including Ethiopia (WHO, 1996).

Furthermore, agricultural development activities carried out as a response to reduce food shortage in developing countries like Ethiopia have demanded the widespread use by farmers of fertilizers and pesticides on agricultural lands. The fertilizers applied on the agricultural lands with a view to boost crop yield eventually find their ways into nearby water bodies and pollute them. The most common consequence of enrichments of water bodies with algal nutrients (from fertilizers) is eutrophication (Lampert and Sommer, 1997), one of the commonest water quality problems which is beginning to attract public attention in Ethiopia. High algal nutrients result in algalblooms, represent a very serious problem in lakes and reservoirs of commercial and recreational value and affects all aquatic animals (zooplankton, fishes, aquatic insects, amphibians, wetland birds and aquatic mammals like hippopotamus) and wild and domestic animals. There is evidence the Microcystis aeruginosa (Kutz.) algae is responsible for the nuisance and/or toxic algal blooms that occurred in Koka Reservoir (Sirage, 2006) and Legedadi Reservoir (Tesfay, 2007). Therefore when the aquatic system polluted by high nutrients (NO3-, PO43-) and algal plants, zooplankton and other aquatic animal are decline in number and composition, even if loss of aquatic biodiversity.

2.1. Zooplankton

Planktons are plants (phytoplankton) and animals (zooplankton) that live in the water with little or no means to propel themselves through their environment. Zooplanktons are microscopic organisms, acts as integral components of aquatic food web and contribute significantly to productivity of freshwater ecosystems. They are performing at second trophic level in energy flow and switch over to conversion of detritus matter into edible animal food. They occupy an intermediate position in the food web and mediate the transfer of energy from lower to higher trophic levels. Zooplankton includes many kinds of protozoan's, microcrustaceans and other micro invertebrates that are planktonic in water bodies. They are heterotrophic (sometimes detritivorous or main consumers of primary producers) type of plankton. They include both planktonic or microscopic animals and comprise representatives of almost all major taxa particularly the invertebrates (Dhargalkar and Verlecar, 2004) and larval stages of some marine fishes that rely on water currents to move any great distance. They also includes holoplanktonic and meroplanktonic organisms (Jitlang, 2008).

2.1.1. Classification of Zooplankton

The zooplanklon are classified according to their habitat, vertical distribution, size and duration of planktonic life. On the basis of habitat, the zooplankton is classified as marine (haliplankton) and freshwater (limnoplankton) (Vallino, 2011).

Table 1: Classification of zooplankton based on size (Vallino, 2011).

Size group	Size limits	Major organisms
Nanozooplankton	2-20 µm	Small zooflagellaes
Microzooplankton	20-200 µm	Foraminiferans, Ciliaes, Rotifers, Copepods
Mesozooplankton	>200 µm-2 mm	Cladocerans, Copepods, Larvaceans
Macrozooplankton	2-20 mm	Pteropods, Euphausiids, Chaetognaths
Megazooplankton	>20 mm	Scyphozoans, Thaliaceans
Micronekton	20-200 mm	Cephalopod, Euphauslid, Sergeslids,

With regard to the duration of planktonic life zooplankton grouped into holoplankton (e.g. Cladocerans, copepods, chactonaths and pteropods) and meroplankton (e.g. larvae of helminthic invertebrates and fish larvae ichthyoplankton) (Vallino, 2011).

2.1.2. Importance of Zooplankton

Zooplanktons are heterotrophic planktonic animals which constitute an important food source for many species of aquatic organism. Zooplankton plays a pivotal role in aquatic food web, since they are important food source of fish and invertebrates (e.g. predatory insects such as Notonecta and larvae of the phantom midge larva Chaoborus) (Dejenie, 2008). Zooplanktons especially rotifers and cladocerans, support the economically fish species. Rotifers are highly nutritive to planktivorous fish and determine the quantum of fish stock and also supports the fast growth of fish larvae and juveniles (Davies et al., 2008), as several other genera of cladocerans such as Daphnia spp., Diaphanosoma spp., Psuedosida spp. and Moina spp. that used for aquaculture. It may serve as indicators of water quality.

Zooplankton rich in the essential amino and fatty acids, docosahexacnoic acid (DHA) and elcosaptaenoic acid (EPA). Zooplankton provides fish with nutrients since fish require proteins, fats, carbohydrates, mineral salts and water in the right proportion. They acts as major mode energy transfer between phytoplankton and higher aquatic fauna (Iloba, 2002; Anene, 2003). Because of their small size and high metabolic rate, play a substantial role in nutrient regeneration in the water column (Saksena, 1987). Additionally, some species of zooplankton are considered to be useful indicator of chemical pollution (acidification, disturbances by agriculture and eutrophication) in water body and trophic status (Ashforth and Yan 2008). Moreover, zooplankton, help in regulating algal microbial productivity through grazing and in the transfer of primary productivity to fish and other consumers (Dejen et al., 2004, Ezekiel et al., 2011). Recently, Cyclopoid copepods have been used for the purpose of bio- controlling the larvae of mosquitoes to reduce the use of chemical compounds. Furthermore, some species of zooplankton, such as Brachionus calyciflorus and B. plicatilis have been used as test organism for toxicological studies (Hjorth, 2005).

2.2. Factors Regulating Species Composition and Abundance of Zooplankton

The environment in which an organism lives is never constant: it changes, for example, with the year or season or month even daily. Also, within the life cycle of a species, the environmental pressures and the tolerances of the organism can change (Lampert and Sommer, 1997). The presence and success of an organism or group of organisms depend on a combination of conditions. Any condition that approximates or exceeds the limits of tolerance of species is said to the limiting factor. Physico-chemical parameters and quantity of nutrients in water play significant role in the distributional patterns and species composition of plankton (Ahmed, 2003). In aquatic habitats, the environmental factors include various physical properties of water such as solubility of gases and solids, the penetration of light, temperature, and density. The chemical factors such as salinity, pH, hardness, phosphates and nitrates are very important for growth and density of phytoplankton on which zooplankton and some higher consumer depend on their existence. The seasonal variation in the ecological parameters exerts a profound effect on the distribution and population density of both animal and plants. Biomonitoring (biological surveillance) is the systematic use of living organisms or their responses to determine the quality of the environment.

Species composition, abundance and distribution of zooplankton communities influenced by a number of physical, chemical and biological factors (David et al., 2005). These factors can directly or indirectly influence the reproduction and survival of organisms (zooplankton).

2.2.1. Physico-chemical Factors

Species composition and abundance of zooplankton communities can be influenced by a number of physico-chemical factors such as wind induced mixing/thermal stratification, hardness of water, rainfall (Mohammed, 2010), temperature, salinity (Egborge, 1994; Ayadi, 2002), pH (Spirules, 1975), amount of dissolved oxygen, availability of light, total dissolved solids (TDS), concentration of carbon, nutrients, precipitations or turbidity and electrical conductivity (Mavuti, 1990; Pinto-Coelho et al., 1998) affect both composition and population density of zooplankton.

2.2.1.1. Temperature

Temperature is a measure of the intensity of heat stored in a volume of water measured in calories and is the product of the weight of the substance (in gms), temperature (ºC) and the specific heat (Cal g - ºC-1). In general atmospheric and water temperature depend on geographical location and meteorological conditions such as rainfall, humidity, cloud cover, and wind velocity. The atmospheric and water temperature go more or less hand in hand.

Water temperature is one of the most important and essential parameter of aquatic habitats, because almost all the physical, chemical and biological properties are governed by it (Makhlough, 2008). It influences the oxygen contents of water quantity and quality of autotrophs, while affecting the rate of photosynthesis and also indirectly affecting the quantity and quality of heterotrophs (Belay, 2007). The temperature of water is a physical parameter which varies throughout the year with seasonal changes influenced by latitude, altitude, season, length of day, air circulation, air temperature, solar radiations, depth, cloud cover and turbidity of the water column, which affects the composition and abundance of aquatic inhabitants including zooplankton. Animals are stressed when temperature changes rapidly, because there is no enough time for physiological adaptation (Ahmed, 2003). The intensity and seasonal variation in temperature of water directly affect the productivity of aquatic habitat. All organisms including fish, possess limits of temperature tolerance. The seasonal fluctuation of temperature influences the feeding habits of the aquatic inhabitants. All biological activities like ingestive variation, reproduction, population size, behavior, movement and distribution are greatly influenced by water temperature (Brönmark and Hansson, 2009). Decrease in temperature is also directly related to increase in DO (Ahmed, 2003).

Moreover, as water temperature increases, the rate of chemical reactions generally increases together with the evaporation and volatilization of substances from the water (Harrison et al., 2008).

Increased temperature also decreases the solubility of gases including the carbon source of photoautotrophic organisms (CO2) and indirectly affects the zooplankton, because zooplanktons are main predator of photoautotrophic (phytoplankton). The metabolic rate of aquatic organisms is also related to temperature, with respiration rates increasing and subsequently leading to increased oxygen consumption and decomposition of organic matter in warm waters (Chapman, 1996). Through its effect on the density of water, temperature also determines the stability of the water column in a reservoir by causing mixing/stratification (Grima, 2011).

Additionally, temperature have direct physiological thermal stress on zooplankton at temperatures exceeding 35°C, where fecundity, reproductive success and survival rates of many zooplankton species (Daphnia spp) decrease (Moore et al., 1996). Temperature (>35OC) also mediates sensitivity to other stressors such as toxic pollutants (Moore and Folt, 1993) and calcium depletion (Ashforth and Yan, 2008). Temperature also controls on locomotion (swimming speed), filtering/feeding efficiency, body size at maturation, rates of growth and reproduction, the timing of the switch from hatching to diapausing eggs, and ultimately, survival of zooplankton (Moore et al., 1996; Gillooly, 2000). Higher temperature alters spatially-dependent predator-prey interactions (zooplankton- fish) (Gillooly, 2000; Macphee, 2009).

2.2.1.2. Dissolved Oxygen

Dissolved oxygen has primary importance in natural water as limiting factor, because most organisms other than anaerobic microbes diminish rapidly when oxygen levels in water falls to zero. Of all dissolved gases, oxygen plays the most important role in determining the potential biological quality of water. Most freshwater organisms are dependent on so-called integumental respiration, which means that oxygen is taken up directly across the body surface without any specialized respiratory morphological adaptations (Ahmed, 2003). Oxygen in aquatic systems is measured in its dissolved form as dissolved oxygen (DO: mg/L) and normal DO levels in freshwater ranges from 8 to 10 mg/L (APHA, 1992). The range of dissolved oxygen concentrations reported worldwide is 0 mg/L (anoxic conditions) and 19 mg/L (supersaturated conditions). Supersaturated conditions are caused by algal blooms; high amounts of algae produce more dissolved oxygen in the aquatic systems (Margaleff, 1996). Anoxic conditions, orperiods of zero DO concentration in the water, leads to undesirable odours until oxic or aerobic conditions develop (Conde-porcuna et al., 2004). The amount of oxygen that water can hold in solution decreases with increasing temperature (metabolic rate), physical (mixing and wave action), and biological processes (respiration and photosynthesis). For example, lower DO conditions often form underneath macrophyte beds that have a large canopy, because gas exchange is limited between surface water and the atmosphere (Bekliog¢lu and Moss, 1995). Low dissolved oxygen or high pH (>9) may limit the volume in which fish can forage in shallow lakes. However, a pH exceeding 10.5 negatively impacts on growth, reproduction and survival of most zooplankton (Vijverberg et al., 1996).

2.2.1.3. Water Transparency

Secchi disk transparency is essentially a function of the reflection of light from its surface and influenced by the absorption characteristics both of the water and its dissolved and particulate matter. Water transparency determines the depth of the photic zone and consequently affects the lower limit of light penetration that influences the primary productivity of a lake. The quantity and quality of light in the water column changes because of changes in water transparency which is a determinant of the vertical extent in a water column to which light penetrates (Zipper et al., 2007). Water transparency in a reservoir depends on the turbidity of the reservoir water. Turbidity is a measure of how particles suspended in water affect water clarity. Turbidity depends largely on total suspended sediment (solids) constituted by algae, algal detritus or inorganic sediment, which attenuate light and reduce water transparency (Jassby et al., 1999; Dodds, 2002). Elevated turbidity arises water temperature, lower dissolved oxygen and harms zooplankton and fish gills and eggs (Beha, 1997). Also, light affects the distribution (DVM and DHM) of zooplankton (Ringelberg, 1993; Burks et al., 2002; Brönmark and Hansson, 2009).

2.2.1.4. pH

The pH is an important variable in water quality assessment as it influences many biological and chemical processes within a water body and all processes associated with water supply and treatment. A pH level is an important parameter that affects the abundance of zooplankton population (Chapman, 1996). A pH value outside the range 6.5 to 8 reduces the biodiversity in aquatic body, because it stresses the physical system of most organisms and can reduce reproduction. Low pH can also allow toxic elements and compounds to become mobile and "available" for uptake by aquatic plants and animals thereby producing conditions that are lethal to aquatic life, particularly to sensitive species (USEPA, 1991).

The taxonomic composition of zooplankton is also influenced by the alkalinity of water. Alkalinity refers to the equivalent concentration of titratable base present (i.e it is the acid-neutralizing capacities of water). It is mostly taken as an indication of the concentration of carbonate, bicarbonate, hydroxide, borax, phosphates, silicates and other basic compounds (Reynolds and Osulvan, 2004). A related chemical property of natural water that affects its ability to dissolve minerals and influence chemical reaction is pH (Chapman, 1996). The balance of positive hydrogen ions (H+) and negative hydroxide ions (OH-) in water determines how acidic or basic the water is. When acid waters (waters with low pH values) come into contact with certain chemicals and metals, they often make them more toxic than normal. Extent of changes in pH is a function of the alkalinity of the water. Changes in pH in response to the addition of a particular acid or base are smaller in higher alkalinity waters (i.e. high alkalinity waters are more buffered) (Kalff, 2002).

2.2.1.5. Conductivity

Electrical conductivity (EC) is a useful indicator of total dissolved solids (TDS) because the conduction of current in an electrolyte solution is primarily dependent on the concentration of ionic species (Hayashi, 2004). Most natural waters contain dissolved ions (atoms or molecules possessing a charge) derived from the water's interaction with soil, bedrock, atmosphere, and biosphere. As a result of these ions, water is able to conduct electricity. Electrical conductivity (EC) is widely used for monitoring the mixing of freshwater and saline water, separating stream hydrographs, and geophysical mapping of contaminated groundwater (Hayashi, 2004). The conductivity of most freshwaters ranges from 10 to 1,000 (µS cm-1 but may exceed 1,000 µS cm- 1, especially in polluted waters, or those receiving large quantities of land run-off (Chapman, 1996). Significant increases in conductivity may be an indicator that polluting discharges have entered the water and affect zooplankton. Conductivity is a surrogate for salinity, which influences the osmotic environment of organisms including zooplankton. Biological Factors

2.3. Distribution of Zooplankton

Zooplankton distribution is non homogenous. They inhabit oceans, seas and lakes. Local abundance varies horizontally, vertically and seasonally (Cottenie, 2002). Some zooplankton also mainly found in the littoral waters, while others are in selected limnetic waters. Their distribution is affected by both abiotic (David et al., 2005; Marques et al., 2007a, b) and biotic parameters (e.g. predation, competition) (Isari et al., 2007). Salinity and temperature are the main factors influencing zooplankton distribution, which is thus directly influenced by freshwater inputs (Marques et al., 2006; Primo et al., 2009). Also availability of light and nutrient, availability of food, limited nutrients such as nitrate, phosphate, silicate and water column stratification affect the distribution of zooplankton (Hakanson et al., 2003; Kumar et al., 2011)).

3. Materials and Methods

3.1. Study Area and Sampling Sites

Gilgel Gibe Reservoir is located in Jimma Zone, Oromia Regional State, Southwestern part of Ethiopia 260 km away from the capital city of Ethiopia, Addis Ababa and 75 km Northeast of Jimma city and lies at latitudes 7°42'50"N and longitudes 37°11'22"E and an altitude of 1671 m.a.s.l. (Million et al., 2012) (Fig 3.1). It was created on Gilgel Gibe River in 2004 to supply electricity and generates about 184 megawatt (Tadesse, 2008). The area has a sub-humid, warm to hot climate, receives between 1300 and 1800 mm of rain annually and has a mean annual temperature of 19°C. The main socio-economic activities of the local communities are mixed farming involving the cultivation of staple crops (maize, teff and sorghum), combined with cattle and small stock-raising (Million et al., 2012). At present the reservoir appears to support considerable fishing activities.

The reservoir was sampled at five sites namely dam area Nada gudda(Deneba site), the confluence of the river with the reservoir Gibe(Asendabo site - a major inlet) ,Yedi area (Yedi site -a minor inlet) of the reservoir ,Center of the dam and Nadi site. At all sites, zooplankton and measurementwere taken. The specific locations of these sampling sites were fixed using the global positioning system (GPS) device (Table 2). The selection of the sites was based on the presumption of Crustacean zooplankton abundance (e.g. Deneba and Yedi site which were an active landing site for habitat type), (e.g. riverine property [i.e. Asendabo and Yedi sites] vs. lacustrine property [Deneba site]) and accessibility.

Table 2: The location and sampling purpose for selection of sampling sites of Gilgel Gibe Reservoir

Site	Location	Sampling purpose
Asendabo	07^0 46 ’445 ’’ N 037^0 16’ 130’’ E	Physicochemical parameters Water sample for zooplankton
Deneba	07^0 47’ 712’’ N 037^0 13’ 377‘’E	Physicochemical parameters Water sample for zooplankton
Center	07^0 47’ 847’’ N 037^0 17’ 251’’ E	Physicochemical parameters Water sample for zooplankton
Nadi	07^0 50’ 941’’N 037^0 18’ 755’’E	Physicochemical parameters Water sample for zooplankton
Yedi	07^0 48’ 849’’N 037^0 19’ 409’’E	Physicochemical parameters Water sample for zooplankton

3.2. Study Period and Sampling Frequency

The study was conducted on October 2018, one wet season. In situ measurement of physico-chemical parameters, chlorophyll-a, sampling of zooplankton were conducted in October 2018 during the entire study period.

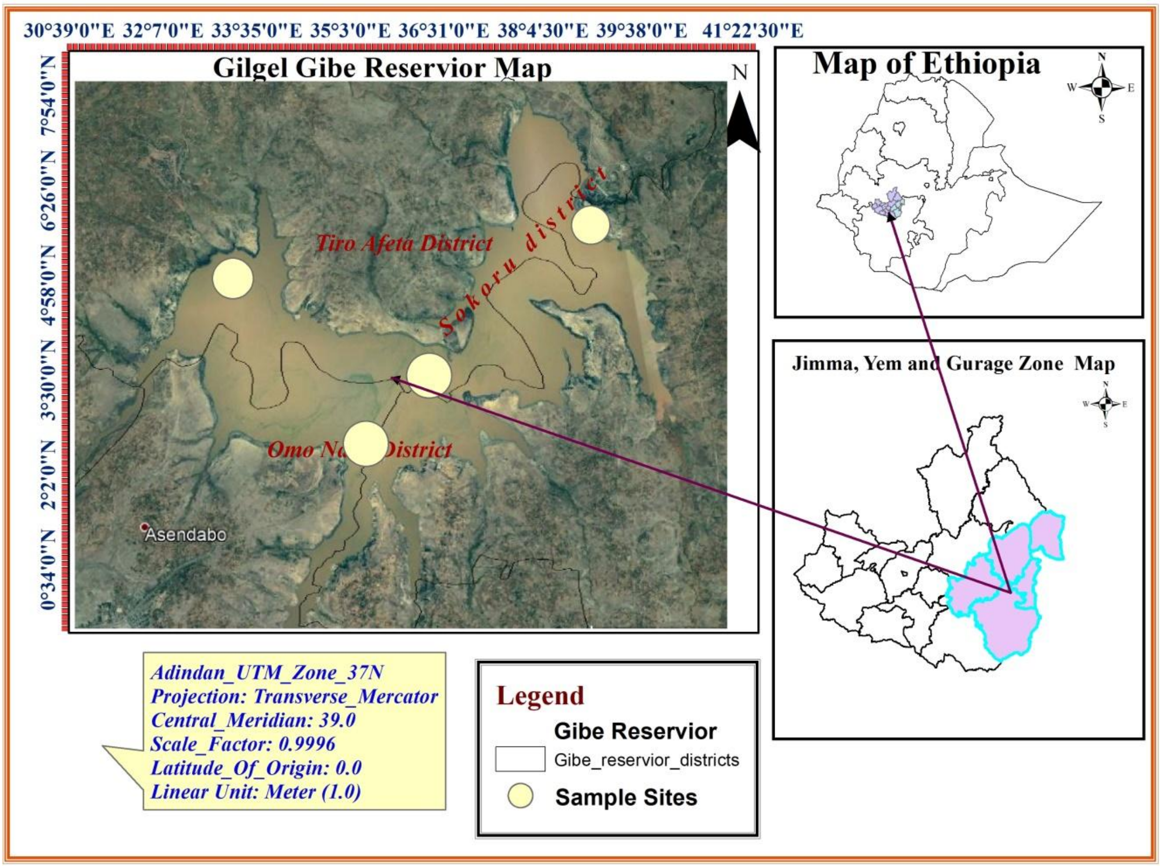

Figure 1: Map of Gilgel Gibe Reservoir

3.3. Sampling Protocols

Consistency and standard in the basic measuring and sampling procedures related to the physico-chemical parameters and biological samples were maintained as discussed below in their respective sections.

3.3.1. Physico-chemical Parameters

Liminological variables such as dissolved oxygen (DO) (mg/L), pH, water temperature (0C) and electric conductivity (µS/cm) were measured in situ using multiprobe parameter (HQ40d). Water transparency was measured as a Secchi depth using a Secchi disc. A Secchi depth is that depth of a water column at which the Secchi disc disappears and reappears when retrieved after being lowered to a certain depth. Secchi depth was measured as a rough estimate of an extent of light penetration into the depth of the water column (Kalff, 2001).

3.3.2. Zooplankton Sampling

Zooplankton was identified using astandard key for the tropical waters (Fernando,C.H 2002)

Water samples for zooplankton were taken with plankton net of mesh size of 55µm, and 6cm mouth diameter as recommended for retaining zooplankton. The plankton net was used throughout the sampling period, because it enabled a larger number of individuals to be gathered (Clesceri et al., 1998). The net was lowered below the water surface up to 0.55m depth and hauled up to the surface in order to obtain sufficient number and diversity of zooplankton. The water samples for zooplankton was taken in small size (300 ml) plastic sample jars and preserved using 4 % formalin solution immediately (Brook, 2011).

3.4. Sample Analysis

Water samples for zooplankton were analyzed in laboratory following standard procedures.

3.4.1. Zooplankton analysis

The enumeration of specimens in the total sample is laborious, time consuming and mostly impractical. For enumeration it is recommended that the subsample of a known volume be analyzed. Subsample was taken from homogenized sample with a manual pipette of 4mm mouth diameter (Edmondson and Winberg, 1971) and transferred into a petridish and counting chamber, then identified and counted under a lower power Compound microscope. Zooplanktons were identified in the laboratory to the lowest taxonomic units (species). Identification was done using standard literature and taxonomic keys (Sandercock and Scudder, 1994; Shiel, 1995; Fernando, 2002; Karen et al., 2004; Witty, 2004; Perumal and Rajkumar, 2008; Suthers and Rissik, 2009) and also software and internet source.

For the estimation of abundance, a subsample of 70ml was drawn from each homogenized sample using a 4mm mouthed pipette. Frequently individual zooplankton was counted and recorded for each subsample under lower magnification power using Compound microscope. The mean abundance was computed for the subsamples analyzed, and then the values were extrapolated for the whole sample. Finally, the zooplankton abundance data was expressed in terms of the actual quantity of water filtered from the reservoir. The abundances of zooplankton were expressed as number of individuals per cubic meter (m-3). Then abundances of zooplankton taxa per cubic meter (m-3) of water were estimated by the general expression provided by Greeson et al. (1977):

$$\text{Abundance}(m^3) = \frac{\text{Zooplankton/ml of con.sample} \times \text{Volume con.sample/ml}}{\text{Volume of water filtered}}$$

The volume of water filtered by plankton net was determined indirectly as a rough value assuming that the plankton net filters the volume of the column of water traversed by the net; V =πr2d, where V is the volume of water filtered by the plankton net, r is the radius of the mouth of the net, and d is the distance through which the plankton net is hauled or towed.

3.5. Data Analysis

SPSS v 20 was used to analyze the data. Means, standard deviations and range were estimated for physico-chemical factors, and abundance of zooplankton. One-Way ANOVA was used to infer variability of physico-chemical variables and abundance of zooplankton across the sampling sites. Multivariate analysis was used to evaluate the associations between the measured environmental factors and major zooplankton groups using CANOCO 4.5 (ter Braak and Smilauer, 1997-2002). Detrended Correspondence Analysis (DCA) yielded gradient lengths that were higher than three standard deviations suggesting using Canonical Correspondence Analysis (CCA).

Species richness and Shannon-Weaver diversity indices were used to analyze the diversities of the zooplankton species.

4. Result

4.1. Physico-chemical Parameters

4.1.1. Dissolved Oxygen

Concentration surface dissolved oxygen (DO) was minimum (7.43 mg/L) at Yedi site and maximum of 8.66 mg/Lat the Center dam. The maximum mean concentration of surface DO in the reservoir (7.22±1.028mg/L) was recorded at Asendabo site and mean minimum surface DO (6.450±1.100 mg/L) was measured atYedi site. Fig 2

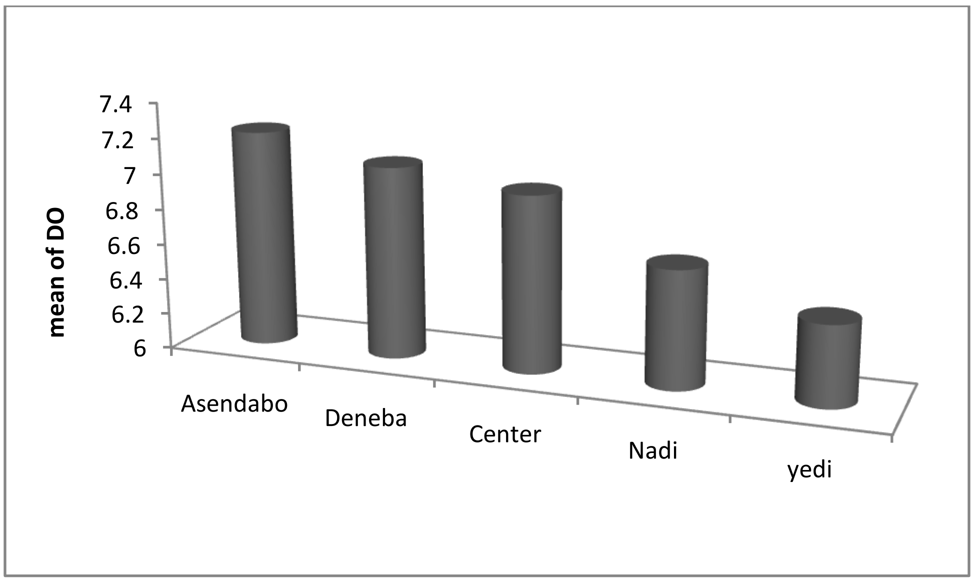

Fig.2: Spatial fluctuation of mean surface Dissolved Oxygen (mg/L) in Gilgel Gibe Reservoirs

4.1.2 Temprature

A maximum surface water temperature (28.7^0C) was measured at the Center dam site andminimum (24.9^0C) at Deneba site. Water temperature showed spatially variation. Fig 3

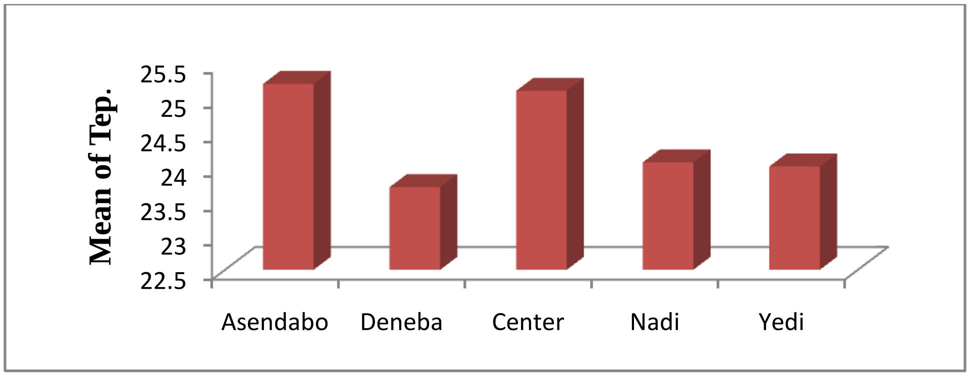

Fig 3: Spatial fluctuation of mean surface water temperature of Gilgel Gibe Reservoir

4.1.3. Conductivity

The conductivity of the reservoir was varied between 78.3µ/cm,with average value of 78.33±.0577µ/cm at Yedi to 89µS/cm with mean of 92.86±4.119 µS/cm at Asendabo site, The lowest conductivity value (78.3µS/cm) was recorded at Yedi and was the highest 97.2µS/cm at Asendabo site . The mean conductivity value of the reservoir was higher at Asendabo site and lower at Yedi site in the study period than the other sites.Fig.4

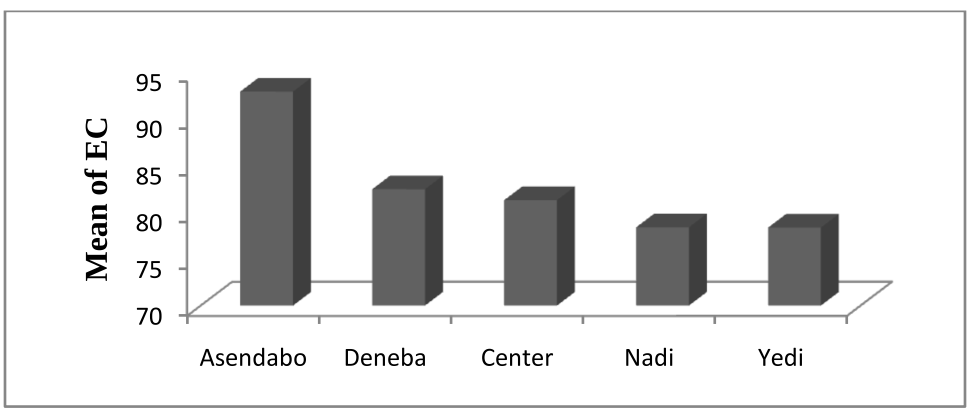

Fig 4: Spatial fluctuation mean conductivity of Gilgel Gibe Reservoir

4.1.4. pH

The pH of Gilgel gibe Reservoir was ranged from a minimum of 7.86 to a maximum of 8.29 at Deneba and Center site.

The highest mean pH measurement was recorded at Center site (7.860±.3996), whereas the lowest pH value was from Deneba site (7.683±.225). Fig 5

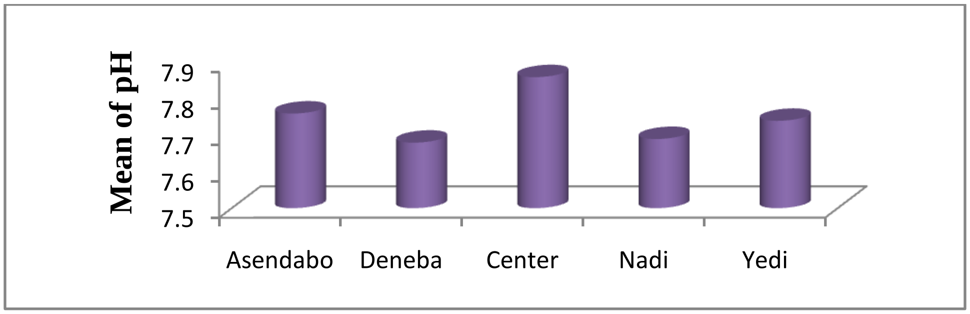

Fig 5: Spatio-temporal fluctuation of mean pH of Gilgel Gibe Reservoir

4.1.5. Water transparency

Water transparency was varied from the lowest of 0.307m at Yedi site to the highest of 0.81m at Asendabo site of the reservoir. High transparency of water was measured in the reservoir at Asendabo site and a low value was observed at the Center site. High and low mean value (0.87 ± 0.103 m and 0.29 ± 0.377m) of water transparency was recorded at Asendabo and Center site respectively. Fig 6

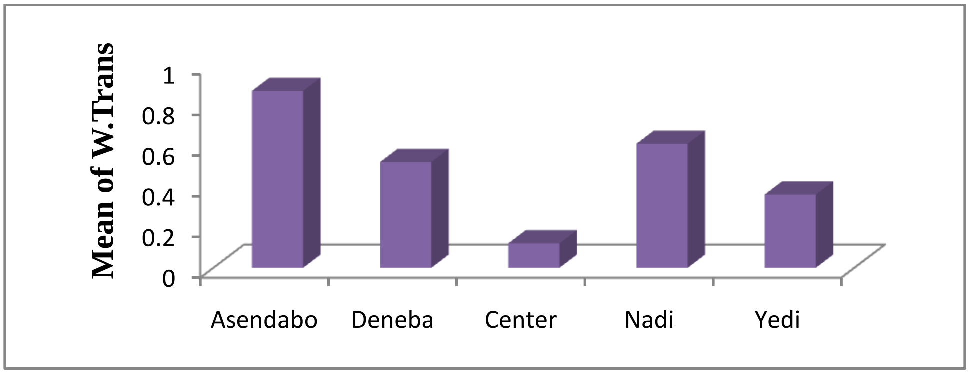

Fig 6: Spatial fluctuation of mean Secchi depth (water transparency) of Gilgel Gibe Reservoir

4.5. Composition and Abundance of Zooplankton

4.5.1 Composition

A total of 31 species of zooplankton belonging to class Crustacean, order Cladocerans and Copepode,6family(*Diaptomidae,Sididae,Daphniidae,Bosminidae,Cyclopidae,Tremoridae)* and five species of rotiferan namely *Keratella tropica, Trichocera capucina, Brachionus havanaansis trahea, Filinial pejler and Keratella Tecta*were identified in the present study (Table 3) in composite samples collected from Gilgel Gibe Reservoir.

The qualitative composition of the zooplankton community in Gilgel Gibe Reservoir which were dominated by Diaptomidae and Cyclopidae families of copepoida. The most interesting result of this study was the equal distribution of species among the taxa of Calanoida copepods (9 species), Cyclopoida copepode (10 species) and cladocerans (7 species) were found, but different in numerical abundance and distribution across sites.

(Table 3) zooplankton identified from water in Gilgal-Gibe Reservoir

Group	*Family*	*Species*
Cladocera		
	Daphniidae	*Daphnia retrocurva*
		Daphnia dubia
		Daphnia pulex
		Daphnia cephalata
	Bosminidae	*Bosminopsis deters*
		Bosmina meridionalis
		Bosmina berhmi
Copepoda	*Calanoidia*	*Boeckella dilatata*
	Diaptomidae	*Diaptomus caducus*
		Diaptomus nudus
		Metaboeckella dialatata
		Diaptomus oregonesis
		Diaptomus sicilis
		Acanthodiaptomus denticornis

		Naupli
		Eurtyemora affinis
	Tremoridae	*Epischura Nevadensis*
	Cyclopoidae	*Acanthacyclops vernalis*
		Megacyclops viridis
		Paracyclops fimbriatus
		Thermocyclops emini
		Mesocyclops edax
		Afrocyclops gibsoni
		Eucyclops agiloides
		Cyclops bicuspidatus
		Cyclops vicini
Rotiferan		*Keratella Tropica*
		Branchionus havanaesis
		Filinia pejiler
		Keratella Tecta
		Trichocerca Capucina

4.5.1.1. Biological index

4.5.1.1.1. Species richness

The number of cladocerans species was low (2 species) and high (5 species) at Asendabo and Yedi site respectively. The number of calanoid and cyclopoid copepodes species was a low in all sites .Deneba site supported more species of the cyclopoid copepods. More cladocerans species were found at Deneba site. The calanoid copepodes were more or less equally distributed in all sampling sites. Over half (15 specie) of the total number of species and (3 species) of rotifers observed at Asendabo site. Almost all (13; 4 cladocerans, 3 cyclopoida copepode ,5 calanoida copepode and 2 rotifers) of the zooplanktons species were presented at Deneba site

The qualitative analysis of the different zooplankton species of Gilgel Gibe Reservoir is summarized in table 4.2 according to Wondie (2006). According to this qualitative analysis ++++ = More abundant, +++ = Common, ++ = Sparse, +- =Rare and - - = Absent

Table 4: Qualitative analysis of zooplankton species of Gilgel Gibe Reservoir

Species	Asendabo site	Danaba site	Yedi site	Center site	Nadi site
Daphnia retrocurva	+-	++	++	+-	+-
Daphnia pulex	+-	++	++	+-	+-
Daphnia dubia	++	++	++	++	+-
Daphnia cephalata	++	++	+-	++	+-
Bosmina detersis	++	+-	++	+-	+-
Bosmina meridionalis	+-	++	+-	+-	+-
Bosmina berhimi	-	-	+-	-	-
Boeckella dilatata	+-	+-	--	--	-
Diaptomus oregonesis	++	+-	+++	+-	+
Diaptomus caducus	++	+++	+++	+++	+++
Diaptomus nudus	+++	+++	+++	+++	+++
Metaboeckella dialatata	++	+-	+-	+	+-
Diaptomus sicilis	+	-	-	-	-
Eurtyemora affinis	+-	++	+-	++	+-
Acanthadiaptomusdenticornis	++	+-	++	++	+-
Naupli	+++	+++	+++	+-	+++
Epischura Nevadensis	+++	+++	+++	+++	+++
Acanthacyclops vernasis	++	+++	++	-	+-
Megacyclops viridis	-	++	+-	-	+-
Paracyclops fimbriatus	--	--	+-	-	+-
Thermocyclops emini	--	--	+-	-	+-
Macrocyclops edax	+++	--	--	-	+-
Afrocyclops gibsoni	+-	-	-	-	+-
Eucyclops agiloides	+-	+-	+-	+-	+-

Cyclops bicuspidatus	+++	+-	+-	-	-
Cyclops Vicinis	+-	+-	+-	+-	+-
Keratella Tropika	++++	+++	+++	++	++
Branchionus havanaesis	+++	+++	++	++	++
Filinia pejler	++	+++	+++	+++	++
Keratela Tecta	+	-	-	-	-
Trichocerca capucina	+	+	-	+	-

4.5.1.1.2 Shannon Wiener Divesrsity Index

Comparison of the species diversity at the five stations showed that their values of species diversity were not very different (Table 5). However species diversity was lowest at Center site and highest at Yedi site. The maximum species diversity values generally coincided with maximum richness and vice versa.

Table 5.Shannon-Wiener diversity index(H') of Gilgal Gibe Reservoir

Site	Asendabo	Deneba	Yedi	Center	Nadi
H'	**2.03**	**2.09**	**2.15**	**1.88**	**2.02**

4.5.2. Abundance of zooplankton

Site variation in abundance of zooplankton was quite different throughout the sampling period in Gilgel Gibe Reservoir. The quantitative abundance of the zooplankton ranged from 1.88×108 to2.15×108 inds m-3 spatialy. The number of inds m-3 was peak at yedi site and lowest at Center dam site.

4.5.2.1. Abundance of cladocerans

Cladocerans were the least dominant (25%) zooplankton in the reservoir andThe maximum (26 ± 8.1 inds m-3) mean of cladocerans were recorded at Yedi site and a minimum was 2 ± 1 inds m-3 at Nadi site . Even though cladocerans abundance appeared to be high at Yedi site than at Asendabo, Deneba,Cente and Nadi site.fig 8.

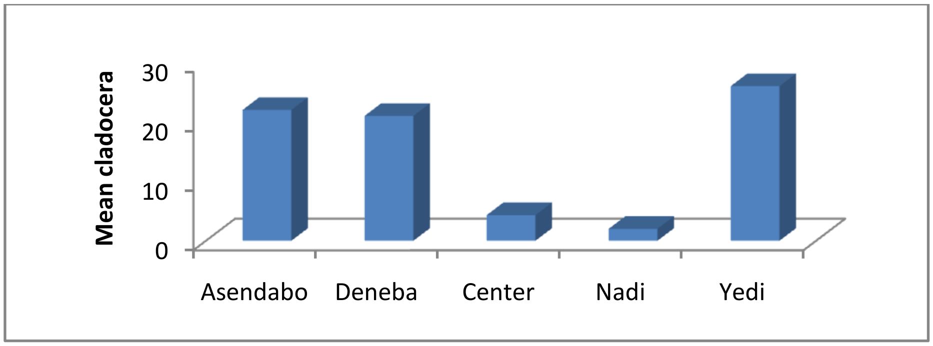

Fig 8: Spat1al fluctuation mean of cladocerans abundance (inds m-3)

4.5.2.2. Abundance of calanoid copepodes

Calanoid copepodes were the second dominant (28.1%)zooplankton in the reservoir. However, The maximum (15.3±2.5 inds m-3) mean of calanoid copepodes were recorded at Yedi site and a minimum was 1.3 ± 0.5 inds m-3 at Center site (Table 6). Calanoid copepodes exhibited a significant difference spatially in their mean abundance in Gilgel Gibe Reservoir. The variation in spatially of calanoid was highly significant ($p < 0.01$).

Table 6: Spatial fluctuation of mean calanoid copepodes (inds m-3)

Site	Asendabo	Deneba	Yedi	Center	Nadi
Mean±Sd	7±1	10±5.92	15.3±2.5	1.3±0.5	4±2.6

4.5.2.3. Abundance of cyclopoid copepodes

The cyclopoida copepodes was the most dominant (31.25%) of zooplankton in the reservoir and The maximum (23.6 ± 4.1 inds m-3) mean abundance of cyclopoid copepodes was observed at Yedi site, while the lowest was 1.33±0.5inds m-3 at Center site.

Table 7: Spatial fluctuation of mean cyclopoid copepodes (inds m-3)

Site	Asendabo	Deneba	Yedi	Center	Nadi
Mean±Sd	13.3±1.52	14.6±2	23.6±4.1	1.33±0.5	3±2

5. Discussion

5.1. Physico-chemical variables

The investigation was based on physico-chemical factors such as DO, water temperature, water transparency, conductivity and pH and biological statu on zooplankton and fluctuation of zooplankton composition and abundance with sampling sites.

Gilgel Gibe Reservoir provides water for domestic uses, fisheries and hydroelectric power generation. The Physico-chemical parameters and quantity of nutrients in water play significant role in the distributional patterns and species composition of plankton (Mahar *et al*., 2000). The role of water temperature, conductivity and level of dissolved oxygen which play a predominant role in bringing about spatially fluctuation in the zooplankton composition (Ahmed, 2003).

5.1.1 Dissolved Oxygen

The oxygen supply in water mainly comes from two sources atmospheric diffusion and photosynthetic activity of plants. The oxygen diffuses in water very slowly. The quantity of dissolved salts and temperature greatly affects the ability of water to hold oxygen. The solubility of oxygen increases with decrease in water temperature (Ahmed, 2003). The DO of the reservoir was little variation as compared to the other phsico-chemical variables of the reservoir, which could be relaterd to the property of water.At Yedi site lower DO was recorded throughout the study period, this could be due to low organic matter and low redox potential favor increased sediment oxygen demand and causing depletion of DO.

The DO of the reservoir was ranged from 7.43 to 8.66mg/L, Similar concentration of DO was reported from Lake Bishoftu (7.4 to 13.73mg/L; Ogato, 2007), Wonji Reservoir (7.4 to

8.56mg/L; Dill, 2010), Koka Reservoir (5 to 11.37mg/L; Tesfay, 2007) and the Ethiopian rift valley lakes (ERVL): Lake Kuriftu (2.04 to 16.53mg/L; Mohammed, 2010), Lake Hora-Arsedi (6.1 to 20.3mg/L; Wondie, 2006), Lake Babogaya (2.75 to 15.8mg/L; Major, 2006), Lake Hora (3 to 16.7mg/L; Gashaw, 2010), Lake Victoria Uganda (2 to 10mg/L; Kaggwa, 2006) and Lake Kuriftu (2 to 17.15mg/L; Dessalengn, 2007). but higher than those recorded from,Belbela Reservoir (2.5 to 7.9mg/L; Grima, 2011), Lake Ziway (3.2 to 8.4mg/L; Dagne, 2010) and the high land lake: Lake Hayq (2.6 to 8.42mg/L; Fetahi *et al.*, 2010).

Low DO retaining high capacity of water this could be due to increasing organism respiratory demand at high water temperature and conductivity and high decomposing of organic matter and low phytoplankton abundance and biomass and increased photoinhibition (Dagne, 2010; Mohammed, 2010), lower oxygen contribution of photosynthesis as a consequence of the presumably lower photosynthetic biomass and exponential decline in the level of irradiance and possibly due to the greater demand for oxygen for oxidative decomposition of organic matter by heterotrophs (Dessalengn, 2007) and also high conductivity (Ahmed, 2003). Water transparency and pH directly related ($r = 0.18$ and 0.22) to the fluctuation of DO. DO was increased with water transparency and pH, due to high phytoplankton bloom (*Microcystis*) (Dessalengn, 2007; Tesfay, 2007; Mohammed, 2010), increasing of light penetration and superficial thermal stratification, which usually implies a steep temperature gradient in the uppermost stratum during warm and calm weather, and this gradient is a barrier to turbulent mixing resulting in *in-situ* accumulation of oxygen produced by photosynthesis (Ogato, 2007; Belachew, 2010).

5.1.2Water temperature

Water temperature is important in terms of its affect on aquatic life. Variations in water temperature are usually governed by the climatic conditions. Rainfall and solar radiations are the major climatic conditions that influence most of the physico-chemical parameters of water bodies (*Kadiri, 2000*). Solar radiation is dependent on the duration and intensity or iridescence received daily by the water body. The intensity of solar radiations may be naturally modified by variations in cloud cover, water flow, species composition and diversity of the water body, surface area, depth, wind velocity, solid matter suspension, *etc*. All these factors influence daily, monthly and seasonally fluctuations in water temperature in the aquatic ecosystem (Atoma, 2004). Its measurement is useful to indicate the trend of various chemical, biochemical and biological activities. A rise in temperature leads to the fast chemical and biochemical reactions (Ahmed, 2003). The growth and death of micro organisms, kinetics of the biochemical oxygen demand is also regulated to some extent by water temperature (Khuhawar and Mastoi, 1995 cited in Ahmed, 2003).

The higher water temperature was recorded at Center site that was(28.7^0C), while a lower was observed at Deneba site(22.9^0C), this may be associated with high depth and large surface area of the reservoir.The values of water temperature of the reservoir was showed similar pattern with the other physico-chemical variables, but poorly negative correlated (r = -0.081) with DO and positive with pH (r = 0.27), conductivity (r = 0.15, and water transparency (r = 0.13). The maximum water temperature of Gilgel Gibe Reservoir was more closer to those Koka Reservoir (26.2 to 32.50C; Tesfay, 2007), Legedadi Reservoir (17 to 300C; Sirage, 2006), Lake Chamo (26 to 300C; Shumbulo, 2004), Lake Hayq (21 to 260C; Fetahi *et al.*, 2010), Lake Ziway (19.3 to 27.30C; Dagne, 2010), Lake Kuriftu (22.8 to 33.30C; Dessalengn, 2007), Lake Hora-Arsedi (23.1 to 300C; Wondie, 2006), Lake Abijata and Langano (25.5 to 29.40C; Wedajo, 1982 cited in Wondie, 2006), Badegry Creek from Nigeria (26 to 310C; Akintoal *et al*., 2005), but higher than Belbela Reservoir (18.5 to 24.10C; Grima, 2011), Lake Bishoftu (18.9 to 25.80C, Ogato, 2007), Wonji Reservoir (23.2-26.80C; Dill, 2010), Lake Arenguade (20.2-24.50C; Belachew, 2010) and Lakes Babogaya (22.3 to 26.80C; Major, 2006).

5.1.3Conductivity

Most of the salts dissolved in water are in ionic form by which water is capable to conduct electricity. Natural water possesses low conductivity, but contamination increases its level. Thus conductivity of water depends upon the concentration of ions and its nutrients status (Ahmed, 2003).

The conductivity of Gilgel Gibe Reservoir was ranged from 78.4µS/cm at yedi to 89µS/cm at Asendabo sites. The difference of conductivity of Gilgel Gibe Reservoir was large between sites ($p < 0.05$). The conductivity of the reservoir was more or less similar within the site.

At Asendabo site high value of conductivity was recorded, this is due to the imputes of solutes from the catchment area through runoff during precipitation and rainfall time, similarly reported by Grima (2011) from Belbela Reservoir. The maximum value conductivity of the reservoir was in the range of dirking water should have (25- 250µS/cm) (WHO, 1996). The change in conductivity of the reservoir was followed the same spatial patter with the water temperature and water transparency and strong positively correlated with water temperature ($r = 0.15$) and strongly negative with DO ($r = -0.081$) and pH ($r = -0.105$). The conductivity of Gilgel Gibe Reservoir more similar from the previously reported reservoirs in Ethiopia; Geffersa Reservoir (72.4- 136.56µS/cm; Ebisa, 2010), Leggedadi Reservoir (65- 163µS/cm; Sirage, 2006) and Oyun Reservoir in Nigeria (80.4- 178.8µS/cm; Mustapha, 2010), but lower than Belebela Reservoir (195.3-285 µS/cm, Grima, 2011), Lake Hora-Arsedi (2200- 2270µS/cm; Wondie, 2006), Lake Ziway (372-427µS/cm; Dagne, 2010) and Gathambra Reservoir in Kenya (127-228µS/cm, Mwuara, 2006).

Higher values of conductivity in the reservoir may be associated with increased physical disturbances in the inlet such as agriculture-induced sedimentation and dumping wastes and waste extraction (dung) of cattle from catchment area. Moreover, the differences in the conductivity of the reservoir depend largely on that of inflowing rivers, its large size, total dissolved solid is a function of the type and nature of the dissolved cations and anions in the water, the increasing the effect of water temperature on the viscosity of water related to ionic mobility, pH value and the soil of the catchment area. A similar suggestion were noted in Belebela Reservoir (Feyisa, 2011), Sebeta River (Tassew, 2006), Geffersa Reservoir (Ebisa, 2010), Sebeta River (Tassew, 2006), Oyun Reservoir in Nigeria (Mustapha, 2010) and Ballincollig reservoir in Ireland (Wakjira, 2005).

5.1.4 pH

The pH expresses the intensity of acidity or alkalinity of an aqueous solution. pH regulates most of the biological processes and bio-chemical reactions. In a balanced ecosystem pH is maintained within the range of 5.5 to 8.5 (*Chandrasekhar et al., 2003*). The pH of Gilgel Gibe Reservoir was ranged from 7.86 at Denaba to 8.29 at Center site. The pH value recorded in this study is comparable to those noted Geffersa Reservoir (7.29- 8.44; Ebisa, 2010), Koka Reservoir (8.11-8.3; Tesfay, 2007), Sebeta River (6- 8.5; Tassew, 2006), Lake Kuriftu (7.76-8.65, Mohammed, 2010), Lake Victoria Uganda (5.9-7.7; Kaggwa, 2006); Oyun Reservoir (6.72-8.24; Mustapha, 2010) and manmade ponds in Nigeria (5.9-8.3; Ahii *et al.*, 2011), whereas lower than those reported Lake Kuriftu (8.2-8.8; Dessalengn, 2007), Lake Bobagaya (8.84-9.09; Major, 2006), Lake Hawassa (6.5-9; Aklilu, 2011), Lake Bishoftu (9.17-9.54; Ogato, 2007), Lake Ziway (9.62-9.84; Dagne, 2010) and Belbela Reservoir (6.5-9.5; Grima, 2011). In balanced aquatic ecosystem the pH value is 6.5 to 8.5 (WHO, 1996) similarly the pH of Gilgel Gibe Reservoir was inside of this range.

The variation in pH is due to the presence or absence of free carbon dioxide and carbonate, and planktonic density between the sites. Among biotic factors, high photosynthetic activity due to increased production of phytoplankton may support an increase in pH. The higher pH values in Gilgel Gibe Reservoir could be due to the variation of water temperature diurnally this causes the pH to be varied diurnally and increased surface pH in the reservoir is due to increased metabolic activities of autotrophs, because they utilize the CO_2 and liberate O_2 thus reducing H^+ ion concentration. This type of observation was reported by *Satpathy et al. (2007).* Alkalinity of the water body (high bicarbonates and carbonates), high algal bloom and this result in an increase in the carbonate ions, which hydrolyze to yield hydroxyl ions and raise the pH (Tesfay, 2007) and high rates of primary productivity allow large daytime removal of CO_2 and HCO_3^- leading to an increase in pH (Maberly, 1996; Tesfay, 2007; Dagne, 2010)

5.1.5 Water transparency

The light in water is a factor of profound importance for its role in the photosynthetic processes of all chlorophyll bearing aquatic plants and thus for the primary production. The lower limit of transparency is the limit of algal photosynthetic activity, which has a major influence on the primary productivity of the aquatic body. It is often a limiting factor in the distribution of organisms in water particularly the plankton. Increase in the turbulence of water usually agitates all the suspended materials, especially in shallow water bodies.

The water transparency of Gilgel Gibe Reservoir was varied between sites with a difference of 0.51m. The transparency of the reservoir was high at Asendabo site, while a low was recorded at Yedi and Center site. The water transparency of this study is comparable with those reported Lake Kuriftu (0.35-0.6m; Dessalengn, 2007), Geffersa Reservoir (0.2-0.66m; Ebisa, 2011) and Lake Kuriftu (0.21-0.6m, Mohammed, 2010). The result of this is higher than those noted Belbela Reservoir (0.16-0.26m; Grima, 2011), Lake Arenguade (Hora-Major, 2006) and Lake Hora-Arsedi (0.63-1m, Wondie, 2006).

The water transparency of Gilgel Gibe Reservoir was varied between the sampling sites throughout the study period ($p < 0.05$). Low transparency of water was found in the reservoir at Center site. It could be associated with decomposition plant materials found in the catchment area. Increase in suspended matter during macrophytic decomposition and mixing or thermal stratification that cause low temperature, DO and pH. The concentration of total ions is expected to have decreased due to low evaporation and biological turn-over at bottom water column and cause low conductivity. Similar observation was reported by Fetahi (2005) Lake Hawassa and Fetahi *et al.* (2010) in Lake Hayq. Limnologist also agree that the depth in the water column where the drop in physico-chemical parameters with increasing depth from the surface (Brook, 2011). Baxter (2002) also suggested that destruction of thermal regime coincident with rapid surface cooling that resulted in a slight degree of unstable inverse stratification. The present study seems to conform to the findings of Baxter (2002) as steep thermal gradients were observed only in the 5m-10m stratum. Moreover, the concentration of carbon dioxide could be low at deep water body and that depleted pH at the bottom and wind-induced mixing cause pH, DO and water temperature (Belachew, 2010; Dagne, 2010).

5.3. Crustacean zooplankton: Composition and Abundance

5.3.1.Composition

Zooplanktons are considered to be the ecological indicators of water bodies (Ahmed, 2003). They play a pivotal role in mediating the transfer of energy from lower to higher trophic levels in aquatic systems. Its community composition, biomass and production determine the strength of the energy transfer. Zooplankton composition and abundance can be structured by physicochemical variables of the inhabiting body, resources, competition and/or predation pressure.

Gilgel Gibe Reservoir is more diverse water body than theERVL. The reservoir supports 31 species of zooplankton belonging to order Cladocerans (7) and Copepode [suborder calanoid (9) and cyclopoid (10)], and five species of rotiferan namely *Keratella tropica, Trichocera capucina, Brachionus havanaansis trahea, Filinial pejler and Keratella Tecta*were identified in the present study in Gilgel Gibe Reservoir.

In the present study seven species of cladocerans were identified. The qualitative occurrence of cladocerans species (*D. dubium, D. pulex, D. cephalata, D. retrocurva, B. deitersi, B. berhmi* and *B. meridionalis*) were sparsely and rarely at all sites. The cladocerans species were more occurred at Deneba and Yedi sites. The genus *Daphnia* (*D. pulex, D. retrocurva*) was occurred sparsely in almost all sites, but *D. dubium*and *D. cephalata* occurred rarely at Yedi and Nadi and sparsely at Asendabo and Deneba sites. The *B. berhmi* and *B. meridionalis* were rarely occurred at one or two sites in one and/or two sampling. The rarely and sparsely occurrence of cladocerans could be associated with dispersal, chlorophyll, fish predation due to its the larger size such as the *Daphnia spp.* and most cladocerans species are occurred and reach maxima during autumn of the year in tropical and subtropical reservoirs and lakes in agreement with Gliwicz (2002), Ahmed (2003), Poste *et al.* (2008), Dejenie (2008), Dagne, 2010, Ngirinshuti (2011) and Sanful (2011). *D. retrocurva* from the *Daphnia* genus less or disappeared in the study period. Similar trend was noticed by Gliwicz (2002) and Whitman *et al.* (2002). In addition, physico-chemicals factors could be affect its occurrence such as high water transparency contributed to high predation pressure and low DO and pH (acidic) affects its reproduction and survival. This is in agreement with several authors, who noticed that *Daphnia spp.* negatively correlate with acidic pH (Ogato, 2008), minimum threshold (<2mg/L; Fetahi *et* *al.,* 2010) DO and high water transparency (Dejenie, 2008; Fetahi *et al.,* 2010; Isumbisho *et al.,* 2006;) and the *Moina spp.* negatively correlated with water transparency (Whitman *et al.,* 2002; Mustapha, 2010). Temperature also has determinant effect in *Daphnia spp.* i.e. *Daphnia spp*. are frequently occurred at high (>250C) water temperature in accordance with Dejenie (2008) in small reservoirs of semi-arid highland Tigray. In contrast with Ahmed (2003) Manchhar Lake Pakistan reported that genus *Daphnia* is more abundant when water temperature is below 200C. Moreover; the presence of *Daphnia spp.* is the indication of the reservoir is clear and absence of organic pollution (Paerveen *et al.,* 2010). Generally cladocerans are low 59 tolerant to adverse conditions (Hannson *et al.,* 2007; Okogwu, 2009), highly preyed by planktivorous fishes (Dejenie, 2008; Fetahi *et al.,* 2010), have high grazing ability (Mustapha, 2010) and short term fluctuation (Isumbisho *et al.,* 2006).

Calanoid copepods was found to be the most dominant group in all sites and was represented by Ninespecies.*D. nudus, D. caducus, D. sicilis, A. denticornis,Metaboeckella dialatata E. nevadensis, B.dialatata,Diaptomus Oregonesis and Eurytemora affinsbelonging to two families. The genus Diaptomus (D. nudus, D. Caducus and D. sicilis)* were dominant throughout the study period and appeared commonly at all sites. This trend was noticed by Ahmed (2003) Manchhar Lake Pakistan, Gebre (2006) Lake Haro- Arsedi (Betemengist) and Sutherland (2010) in Sundays estuary South Africa. *E. nevadensis* were appeared commonly at all sites Except at the Center site and *Acanthodiaptomus and Metaboeckellaa dialatata*were rarely appeared at Deneba and Nadi sites, this could be associated with long generation time and passive feeders. The occurrence of*Epischura nevadensis* at all sites could be due to the feeding behavior or competing for the same resource (herbivorous) and different life cycle, reproduction of cluster egg from single mating in accordance with (Hebert, 1982; Sanderock and Scudder, 1994). Among the total crustacean zooplankton identified in the study cyclopoid copepodes were the dominant in species number in Gilgel Gibe Reservoir. In the present study Ten species (*A. vernalis, T. emini, M. edax, A. gibsoni, P. fimbriatus,E. agiloides, C.bicuspidatus, C. vicinus,M. viridis*) of cyclopoid copepodes has been identified. Most of the cyclopoid copepodes were appeared at Asendabo site and rare or none at Deneba , Yedi ,Center and nadi sites. The genus *Macrocyclops* (*M. edax*) was frequently occurred at Asendabo site, but rarely and/or absent at the other four sites. The *A. vernalis* was commonly occurred at Deneba, sparsely at Asendabo,Yedi and rare at Nadi and Absent at the center site.*T. emini, P. fimbriatus* and *M.*

viridis were occurred rarely at Yedi and Nadi site and absent in other site throughout the study period. *E. agiloides*, *C. vicinus*, and*A. gibsoni* were appeared rarely in all sites. The occurrence and disappearance of cyclopoid copepodes were could be associated with availability of food (diatoms and calanoid copepodes), habitat preference in tropical, tolerance of organic pollution, the presence of red pigment (hemoglobin), high water volume of the reservoir during wet season and having multiple generation for its occurrence and predation (fish, rotiferan and cladocerans), having obligatory sexual reproduction and longer life cycle and affected by flooding and mixing of the water body, length of the reservoir between the riverine and lacustrine, depressed growth of young cyclopoid copepodes by runoff during the wet season and low reproduction, predation by fish, growth and renewal rate for the sparsely and rarely or disappearance in agreement with Tamiru (2006), Dagne (2010), Fetahi *et al.* (2010) Lake Hayq, Ahmed (2003) Manchhar Lake, Jappesen *et al.* (2003) in pelagic zone lakes, Mustapha (2010) tropical African reservoir, Belay (2007) Lake Babogaya, Saunders and Lewis (1988) Lake Valencia and Isumbisho *et al.* (2006) Lake Kivu. Moreover; the physico-chemical factors could be affects the occurrence and disappearance of cyclopoid copepods.However water transparency and DO could affect the occurrence of cyclopoid copepodes species, however the cyclopoid copepodes can survive up to 0.8mg/L of DO and in deep water those inaccessible by predatory fish and invertebrates in low water transparency in accordance with Dagne (2010), Isumbisho *et al.* (2006) and Mustapha (2010)

5.3.2. Abundance of zooplankton

The abundance of zooplankton of Gilgel Gibe Reservoir was higher with peak value (2.15 × 108) inds m-3 atYedi, whereas minimum (1.88× 108) inds m-3 recorded at center. Moreover, there was a clear spatial variation in the abundance of zooplankton in the reservoir. The abundance (m-3) zooplankton was extremely low at the Cente dam .

A high abundance of inds m-3 was recorded at Yedi sites, this could be associated with high imputes of solute, organic matter such as fertilizers that encouraging the abundance phytoplankton on which the planktivorous feed (rise in food availability). In addition, relatively low conductivity, alkalinity of water pH, optimum temperature supports high blooms of phytoplankton (Myxophyceae) on which zooplankton feeding (Ahmed, 2003; Dagne, 2010). Furthermore, high flow rate of aquatic ecosystem favours most zooplankton with high reproductive capabilities and short generation time and this mechanism affects zooplankton to be dominance in a community (Gebre, 2006; Osmen, 2010a, Osmen *et al.,* 2010b). Moreover, the feeding abilities of zooplankton is increasing with water temperature up to 250C (low) and falls rapidly as a water temperature exceeded 250C (high), generalist nature of some species of cladocerans, low predation pressure and interspecific competition and mixing of the reservoir due to the cold runoff and wind introduced in to the reservoir. Furthermore, allochthonous dissolved nutrients washed in to the reservoir, induced higher phytoplankton (diatoms) production, which in turn supports higher crustacean zooplankton production, flooding of agricultural fertilizers and high alkalinity of water pH of the reservoir during the rainy months. This is in accordance with other several authors; who reported high abundance of zooplankton in rainy months of the year (Franks, 2000; Whitman *et al.,* 2002; Ahmed, 2003, Dejen *et al.,* 2004; Yarwood, 2005; Belay, 2007; Sorsa, 2008; Dejenie, 2008; Okogwu, 2009; Dagne, 2010; Fetahi *et al.,* 2010; Mustapha, 2010; Paerveen *et al.,* 2010; Sutherland, 2010; Sanful, 2011).

5.3.3. Abundance ofCladocerans

The relative abundance of cladocerans was high at Asendabo,Deneba and Yediand low at the Center and Nadi. This could be explained by food condition, physico-chemicals variables, interspecific competition. The relative abundance and numerical abundance of cladocerans was high in the study period, this could be with some perrineal species develop maxima in colder months of the year, its nature succession in rainy months in tropical lakes and reservoirs, some littoral species of cladocerans becomes more abundant in lentic habitat when the volume of the aquatic body is high, high food availability is also considering to influencing the morphology of individuals (eg. *Bosmina spp.* it grows continuously at high food availability and stop its growth at low food concentration). The cladocerans were more abundant at Yedi site than sites. This could be low water transparency (at Yedi) in accordance with Isumbisho *et al*. (2006) Lake Kivu and Fetahi *et al*. (2010) Lake Hayq, Asmelash (2009) in the Semi-arid highlands of Tigray and Alemayehu (2011) Lake Hora-Arsedi. Moreover; at Center and Nadi site the abundance cladocerans affected by conductivity, water temperature and at Asendabo affect by pH. Furthermore; cladocerans low in abundance could be the type and density of vegetation in the surrounding area and planktivorous fishes occurred in high densities at vegetation edges and predation by high abundance of copepodes (Yedi site) in agreement with Asmelash (2009) in the Semi-arid highland of Tigray, Sayeswara *et al.* (2011) in Brahmana Kalasi tank in India and Paerveen *et al.* (2010) in freshwater reservoir Gulbarga District in south India and low edible phytoplankton by filter-feeder cladocerans in agreement with Belay (2007) Lake Babogaya Ethiopia and Okogwu (2009) in Ehoma Lake Nigeria, whereas, high in abundance in littoral water (Yedi site) due to increased nutrients and phytoplankton availability.

some species cladocerans (*Bosmina spp*) are generalists and swimming (≈10m) out of cladocerans horizontal migration to open water at night. This trend is supported by other studies: Dagne (2010) Lake Ziway, Yarwood (2005) in lowland England and Wales and Sayeswara *et al.* (2011) in Brahmana Kalasi tank in India found cladocerans zooplankton to be more abundant in low vegetative and/or open water and inshore than edge area of small freshwater bodies and high in abundance due to its generalist in nature.

5.3.4. Abundance of Calanoid copepods

The Calanoid copepodes were most dominant throughout the study period in almost all sites. This is in accordance with several other authors: who reported that the dominance of copepodes in tropical and subtropical lakes and reservoirs (Ahmed, 2003; Dejene *et al.*, 2004; Tamiru, 2006; Belay, 2007; Primo *et al.*, 2009; Dagne, 2010; Fetahi *et al.*, 2010; Rajashekhar, 2010). The relative abundance of calanoida copepodes was low and high in the study period at site to sites in agreement with Gebre (2006) and Tamiru (2006). The calanoid copepodes were more abundant at Denebaand Yedi sites and they exhibited spatially variation ($p<0.05$). This could be hypothesize that calanoid copepodes have high reproductive ability at high imputes (Denebaand Yedi site) and/or low concentration (Center and Nadi), persisted at low DO(Yedi site) or survival in oxygen-depleted layer inaccessible by fish, ability of escaping from fish predation (Center,Asendabo and Nadi site), feed discontinuously, sensitivity to high water temperature (Asendabo,center), special physiological features, preference of higher water inflow (Asendabo,Nadi and Center), high phytoplankton (diatoms) blooms and low phytoplankton (Microcystis) bloom those affects its abundance in accordance with Belay (2007) Lake Babogaya, Gebre (2006) Lake Arsedi (Betemengist), Dagne (2010) Lake Ziway, Dill (2010) Wonji Reservoir and Fetahi *et al.* (2010) Lake Hayq in Ethiopia and Primo *et al.* (2009) Southern temperate estuary in Portugal. Asmelash (2009) also reported the preference of adult calanoid copepods to feed on large food dominated by filamentous cyanobacteria and herbivorous nature. Moreover; the Abundance calanoid copepodes was positively correlated with conductivity and water temperatures at Asendabo site and negatively with pH and DO at Yedi and Nadi site, this could be explained by at Asendabo the abundance of calanoid copepodes were affected by pH and DO.

5.3.5. Abundance of Cyclopoid copepods

The abundance cyclopoid copepodes were maxima with few species. Similar observation was reported by Ahmed (2003) Manchhar Lake Pakistan, and Tamiru (2006) Lake Hora-Arsedi (Betemengist) Belay (2007) Lake Babogaya and Dagne (2010) Lake Ziway Ethiopia. The cyclopoid copepodes were more abundant atYedi and Deneba site than Asendabo, Center and nadi sites. The Cyclopoid copepodes are pollution tolerant in nutrient rich and/orinlets of water body and due to this ability they have no relation with the physico-chemical variables at Asendabo,Center and Nadi sites and they prefer deep water rather than shallow in accordance with Gebre (2006) Ethiopia and Ahmed (2003) in Manchhar Lake in Pakistan and Sayeswara *et al.* (2011) in Brahmana Kalasi tank in India. Similar observation was observed in this study i.e. they are occurred at deep part of the reservoir (Yedi and Deneba site) with positive relation with water transparency . However; the cyclopoid copepodes were decline in numerical abundance due to its omnivorous and raptorial feeder's nature or interspecific competition (Deneba and Yedi) and high depth (Deneba) and high inflow of water, low water transparency, almost neutrality of water pH and high conductivity (Asendabo site and Nadi).

5.3. 6.Associations between Environmental variables and Zooplankton Abundance

In the CCA analysis, Axis-1 and Axis-2 explained 85.42% and 14.2% of variations in zooplankton abundance with eigenvalues of 01 and 0.02, respectively. The CCA plot is given in Fig. 9. The CCA showed that Calanoids negatively correlated with all the measured variables, Cyclopoids correlated positively with Tranisparence (TP), Cladocera correlated positively with EC, and Rotifers correlated some how positively with pH, water temperature and DO.

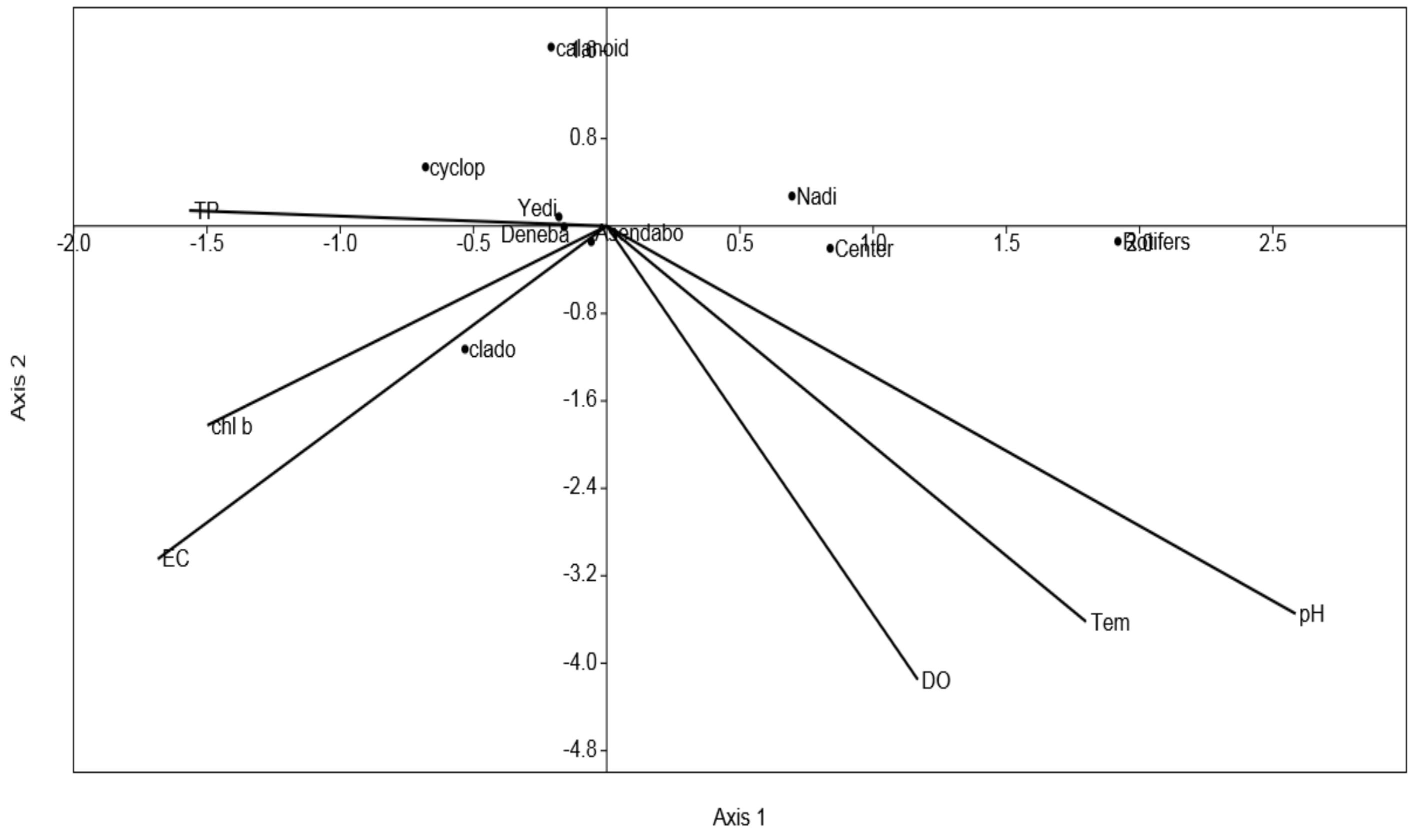

Fig 9. The CCA plot of the measured environmental variables and zooplankton abundance

6. Conclusion and Recommendation

6.1. Conclusion

The conductivity of the reservoir was high at Asendabo site,this is due to the impute of solutes from the catchment area through runoff during rainfall time. The pH of the reservoir was maximum (8.29) at Center site with a minimum (7.86) at Deneba site.

The variation inpH is due to the presence or absence of free carbondioxide and carbonate.The composition of zooplankton comprised of 31 species belonging to Cladocera, Copepoda(suborder of Calanoid and cyclopid) and rotifers. The present observations showed that the Cyclopoid were the most abundant of all groups contributing 31%, followed by Calanoid 28%,Cladocera 25% and 15% of Rotefers. The highest density of Cyclopoid was recorded at Yedi site than other site, while; minimum value was recorded at Center site.The spatial changes of the zooplankton of the reservoir related mainly to physico-chemical variables, mainly DO, water temperature and conductivity associated with hydrologic**.**

6.2. Recommendation

In order to have a better picture of the zooplankton and water chemistry of this aquatic ecosystem, future studies should involve a look into the significance physico-chemical parameters like nitrates, phosphate, chloride etc. and zooplankton such ostracods and protozoan and external loadings.

For further study on the physico-chemical parameters and zooplankton on the reservoir an authorized body should be fulfill necessary equipments like motor boats.

7. References

Ahii, M. C., Paul, S.B., Alonge, S.O. and Adamu, K. A. (2011). Green algal interactions with physicochemical parameters of some manmade ponds in Zaria, northern Nigeria, 34(3):285-295.

Ahmed, M. M. (2003). Ecology and taxonomy of plankton of Manchhar Lake (Distt. Dadu), Sindh, Pakistan. PhD. Thesis, University of Sindh, Jamshoro, Sindh, Pakistan, 320pp.

Akintola, S. L., Anetekhai, M. A. and Lawson, E. O. (2005). Some physicochemical characteristics of Badagry Creek, Nigeria. Lagos State University.W. sAfr. J. App. Eco., 18:96- 107.

Alemayehu, A. (2011). Effect of feed quality on growth performance and water quality in cage culture system for production of Nile Tilapia [Oreochromis Niloticus, (Linnaeus, 1758)] in Lake Hora-Arsedi, Ethiopia. MSc. Thesis, Addis Ababa University, Ethiopia, 87pp.

Alfred, M.B. (2002). Large freshwater lakes: present state, trends, and future prospects. Environ. Cons., 29:21-38.

Alemayehu, T. (2006). Groundwater occurrence in Ethiopia, Addis Ababa University, Ethiopia, 107pp.

Anene, A. (2003). Techniques in Hydrobiology In: Eugene, N.O. and O.O. Julian, (Eds.), Research Techniques in Biological and Chemical Sciences. Springfield Publishers, 174-189pp.

APHA (1992).Standard methods for the examination of water and waste water analysis. American Public Health Association, Washington, USA.

Ashforth, D. and Yan, N.D. (2008). The interactive effects of Ca concentration and temperature on the survival and reproduction of Daphnia pulex at high and low food concentrations. Limnology and Oceanography, 53: 420–432.

Ayadi, H. (2002). Etude qualitative et quantitative des peuplements phyto-zooplanctoniques dans les bassins de la saline de Sfax, Tunisie.

Banse, K. (1995). Zooplankton: pivotal role in the control of ocean production. ICES Journal of Marine Science, 52: 265-277.

Baxter, R. (2002). Lake morphometry and chemistry. In: Ethiopian Rift Valley lakes, Tudorancea, C. and Taylor, W.D. (eds.), pp. 45-60, Backhuys Publishers. Leiden, TheNetherlands.

Beha, S. (1997).Testing the Waters: Chemical and Physical Vital Signs of a river. 211pp.

Beklioglu, M. and Moss, B. (1995). The impact of pH on interactions among phytoplankton algae, zooplankton and perch (Perca fluviatilis) in a shallow, fertile lake. Freshwater Biology, 33: 497–509.

Belachew, M. (2010).Phytoplankton production in Lake Arenguade (Hora-Hado), Ethiopia. MSc. Thesis, Addis Ababa University, Ethiopia, 62pp.

Black, B.W. and Hairston N.G. (1988).Predator driven changes in community structure. Oecologia, 77:468-479.

Brett, M. T., Wiackowski, K., Lubnow, F. S., Mueller-Solger, A., Elser, J. J., and Goldman, C. R. (1994). Species-dependent effects of zooplankton on planktonic ecosystem processes in Castle Lake, California. E.S.A., 75 (8): 2243-2254.

British Columbia Ministry of Environment, Lands and Parks (1997). Fish Collection Methods and Standards, Fish Inventory Unit for the Aquatic Ecosystems Task Force, 64pp.

Brönmark, C. and Hansson, L. (2009).The Biology of Lakes and Ponds. 2nd edt Department of Ecology University of Lund, Sweden, 300pp.

Brook, L. (2002). Contrasting effect of human activities in aquatic habitats and biodiversity of two Ethiopian lakes. Ethiop.J. Nat. Res., 4 (1): 133-144.

Brook, L. (2003). Ecological changes in two Ethiopian lakes caused by contrasting human intervention. Limnologica, 33:44-53.

Brook, L. (2011). The impact of climate change and population increase on Lakes Haramaya and Hora-Kilole, Ethiopia. Addis Ababa University, Ethiopia.

Brooks, J. L. and Dodson, S. I. (1965).Predation, body size, and composition of plankton. Science ,150: 28-35.

Burks, R. L., Lodge, D. M., Jeppesen, E. and Lauridsen, T. L. (2002). Diel horizontal migration of zooplankton: costs and benefits of inhabiting the littoral. Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, U.S.A., 47: 343–365.

Canonico, G.C., Arthington, A., Mccrary, J.K. and Thiem, M.L. (2005). The effects of introduced tilapias on native biodiversity. Aquatic Conserv: Mar. Freshw. Ecosyst. 15:463–483.

Carpenter, S.R. and Kitchell, J.F. (1993).The Trophic Cascade in Lakes. Cambridge University Press, Cambridge. 385.pp.

Chapman, D. (1996). Water Quality Assessments: A guide to the use of biota, sediments and water in environmental monitoring. 2nd edt. E and FN Spon, London and New York. 653pp.

Clesceri, L. S., Greenberg, A. E., Eaton, A. D. (1998). Standard Methods for the Examination of Water and Wastewater.20th ed. American Public Health Association, USA.

Conde-Porcuna, J., M., Ramos-Rodri´guez, E. and Pe´rez-marti´nez, C. (2004). Correlations between nutrient concentrations and zooplankton populations in a mesotrophic reservoir. Institute of Water Research, University of Granada, Granada, Spain, 47: 1463–1473.

Cooper, J.J. and Vigg, S. (1985). Species composition and seasonal succession of the zooplankton community of Eutrophic Lahontan Reservoir, Nevada. Southwestern Association of Naturalists, 30(2):239-252.

Cottenie, K. (2002). Local and regional processes in a zooplankton metacommunity. Katholieke Universiteit Leuven Faculteit Wetenschappen, 189pp.

Dagne, A. (2010). Zooplankton community structure, population dynamics and production and its relation to abiotic and biotic factors in Lake Ziway, Ethiopia. PhD Thesis, 166pp.

David, V., Sautour, B., Chardy, P. and Leconte, M. (2005). Long-term changes of the zooplankton variability in a turbid environment: the Gironde estuary (France). Estuarine, Coastal and Shelf Science, 64: 171–184.

Davies, C.C. Tawari and Abowei, J.F. (2008). Zooplankton of Elechi Creek, Niger Delta Nigeria. Environ. Ecol., 26(4c): 2441-2346.

Dejen, E., Ngweheng, I., Nogelkerke, I. and Sibbing, E. (2004). Temporal and spatialdistribution of microcrustacean zooplankton in relation to turbidity and other environmental factors in large tropical lake (L. Tana, Ethiopia). Hydrobiologia, 513:

Dhargalkar, V.K. and Verlecar, X.N. (2004). Zooplankton methodology, collection and identification– a field Manual National Institute of Oceanography.

Dill, A. (2010). The effect of stocking density and supplementary feeding on growth performance and yield of Nile tilapia [Oreochromis Niloticus (L, 1758)] in cage culture in Wonji Reservoir, Ethiopia. MSc. Thesis, Addis Ababa University, Ethiopia, 65pp.

Dillon, P. J. and Rigler, F.H. (1974).The phosphorus-chlorophyll relationship in lakes.Limnol. Oceanogr., 19: 767-773.

Doddis, K.W. (2002). Freshwater Ecology: Concepts and Environmental Applications. Academic press, USA.

Dodson, S. I. (1974). Zooplankton competition and predation: an experimental test of the sizeefficiency hypothesis. E.S.A., 55(3):605-613.

Dudgeon, D., Arthington, A.H., Gessner, M. O., Kawabata, Z.I., Knowler, D. J., Leveque, C., Naiman, R. J., Prieur-Richard, A.-H., Soto, D., Stiassny, M. L. J. and Sullivan, C. A. (2006). Freshwater biodiversity: Importance, threats, status and conservation challenges. Biol. Rev., 81: 163-182.

Edmondson, W. and Winberg, G. (1971). A Manual on Methods for the Assessment of Secondary Productivity in Freshwaters.IBP, Handbook no. 17. Blackwell Scientific, Oxford, 358pp.

Egborge, A. B. (1994). Salinity and the distribution of rotifers in the Lagos Harbour-Badagry Creek system, Nigeria. Hydrobiologia, 272: 95-104.

Embaye (2017).Diversity and Ambundance of crustacean Zooplankton Community in Gilgal Gibe reservouir.

Ezekiel, E.N., Ogamba, E.N. and Abowei, J.F.N. (2011). The Distribution and Seasonality of Zooplankton in Sombreiro River, Niger Delta, Nigeria, 3(3): 234-239.

FAO (2006). "No global water crisis- but many developing countries will face water scarcity.

Fernando, C. H. (1994). Zooplankton, fish and fisheries in tropical freshwaters. Hydrobiologia,272: 105-123.

Fernando, C.H. (2002). A guide to freshwater identification, ecology and impact on fisheries. Backhuys publishers Leiden, Netherland, 289pp.

Fisseha, I. (1998). Metal concentrations of some vegetables irrigated with industrial liquid waste at Akaki, Ethiopia: SINET: Eth. J. Sci., 21: 133-144.

Franks, L.J. (2000). Spatial and temporal influences of water quality on zooplankton in Lake Texoma.PhD Thesis, University of North Texas, 162pp.

Gebre, T. (2006). Zooplankton community grazing rates study on the natural phytoplankton assemblages in Lake Arsedi (Betemengist). MSc. Thesis, Addis Ababa University, Ethiopia, 107pp

Ghosh, S., Barinova, S. and Keshri, P.J. (2012). Diversity and seasonal variation of phytoplankton community in the Santragachi Lake, West Bengal, India. A Qatar Foundation academic journal, 19pp.

Gillooly, J.F. (2000). Effect of body size and temperature on generation time in zooplankton.

J.Plan.Rese., 22: 241–251.

Gliwicz, Z. M. (2002). On the different nature of top-down and bottom-up effects in pelagic food webs. Fresw. Biol., 47: 2296-2312.

Gliwicz, Z. M. and Pijanowska, J. (1988). Effect of predation and resource depth distribution on vertical migration of zooplankton. Bulletin. Mar. Scie., 43(3): 695-709.

Gorni, R., Loibel, S., Goitein, R. and Amorim, F. (2012). Stomach contents analysis of Shortfin Mako (Isurus oxyrinchus) caught off Southern Brazil: a Bayesian analysis. 68(5): 1933-1937.

Habiba, G. (2010). Ecological assessment of Lake Hora, Ethiopia, using benthic and weed-bed fauna MSc. Thesis, Addis Ababa University, Addis Ababa, 67pp.

Hakanson, L., Boulin, V.V. and Ostapenia, A. (2003). The influence of Biomanipulation (fish removal) on the structure of lake food web, case studies using lake web- model. Inter. J.Aqua. Eco., 37:47-68.

Hailu, M. (2011). Ecosystem structure, trophic link and functioning of a shallow rift valley lake: the case of Lake Ziway (Ethiopia) MSc. Thesis, Addis Ababa University, Addis Ababa, 72pp.

Hanazato, T. and Yasuno, M. (1989). Zooplankton community structure driven by vertebrate and invertebrate predators. International Association for Ecology, 81(4):450-458.

Harrison, P., J., Anderson, M., D., Lee ,W., H., Jiang, Y., He, L., Yuan, X.,Yin, K., Xu, J. and Ho, T.,Y. (2008). Seasonal and spatial dynamics of nutrients and phytoplankton biomass in Victoria Harbour and its vicinity before and after sewage abatement. Marine Pollution Bulletin, 57: 313–324.

Harte, J. (2007). Human population as a dynamic factor in environmental degradation. Population and Environ., 28:223-236.

Hayashi, M. (2004). Temperature-electrical conductivity relation of water for environmental monitoring and geophysical data inversion. Environmental Monitoring and Assessment, 96: 119–128.

Hebert, P.D.N. (1982). Competition in zooplankton communities. Ann. Zool. Fennici., 19:349-356.

Hjorth, M. (2005). Responses of marine plankton to pollutant stress- Integrated community studies of structure and function. PhD Thesis.Roskilde University, 35pp.

Horppila, J., Peltonen, H., Malinen, T., Luokkanen, E. and Kairesalo, T. (1998). Top-down or bottom-up effects by fish: Issues of concern in biomanipulation of lakes. Restoration Ecology, 6(1):20–28

Hyslop, E. J. (1980). Stomach contents analysis: a review of methods and their application. J. Fish Biol., 17: 411-429.

Iloba, K. I. (2002). Vertical distribution of Rotifera in the Ikpoba Reservoir in Southern Nigeria. Trop. Fresh water Biol., 11: 69-89.

Isari, S., Psarra, S., Pitta, P., Mara, P., Tomprou, M.O., Ramfos, A., Somarakis, S., Tselepides, A., Koutsikopoulos, C. and Fragopoulu, N. (2007). Differential patterns of mesozooplankters' distribution in relation to physical and biological variables of the northeastern Aegean Sea (eastern Mediterranean). Mar. Biol., 151: 1035–1050.

Isumbisho,M., Sarmento, H., Kaningini, B., Micha, J. and Descy, J. (2006). Zooplankton of Lake Kivu, East Africa, half a century after the Tanganyika sardine introduction, 33pp.

Jassby, A. D., Goldman, C. R., Reuter, J. E. and Richard, R. C. (1999). Origins and scale depends of temporal variability in the transparency of Lake Tahoe. California florida. Limnol.Oceanogr., 44:282-294.

Jeppesen, E., Jensen, J.P., Jensen, C., Faafeng, B., Hessen, D.O., Søndergaard, M., Lauridsen, T., Brettum, P. and Christoffersen, K. (2003). The impact of nutrient state and lake depth on top-down control in the pelagic zone of lakes: A study of 466 lakes from the temperate Zzne to the Arctic. Springer, 6(4):313-325.

Jitlang, I., Pattarajinda, S., Mishra, R. and wongrat, L. (2008). Composition, Abundance and Distribution of Zooplankton in the Bay of Bengal. Andaman Sea Fisheries Research and Development Center, Thailand.

Kaggwa, R.C. (2006). Fingerponds: managing nutrients and primary productivity for enhanced fish production in Lake Victoria's wetlands, Uganda. PhD Thesis, Wageningen University, Netherlands, 214pp.

Kalff, J. (2002). Limnology: Inland water Ecosystems. Prentice-Hall, 592pp.

Karen, J., Carling, I.M., Ater, Megan, R. P., Adam, M. B. and Timothy, B. M. (2004). A Guide to the Zooplankton of Lake Champlain, 1:29.

Kebede, E., Tefera, G., Taylor, W.D. and Zinabu ,G. (1992). Eutrophication of Lake Hayq in the Ethiopian highlands. J.Plan. Rese., 14:1473-1482.

Khuhawar, M.Y. and Mastoi, G.M. (1995). Studies of some physico-chemical parameters of Manchhar Lake, Sindh. J. Anal. and Envi. Chem., 3: 66-71.

Kumar, N., Yamini, V. and Kumar, R.N. (2011). Spatial analysis of composition and species interactions with temporal variation of zooplankton community of shallow tropical lake**. Gujarat, India, 2: 151-159.**

Lampert, W. and Sommer, U. (1997). Limnology: The Ecology of lakes and Streams. Oxford University Press, New York, 400pp.

Lass, S. and Spaak, P. (2003). Chemically induced anti-predator defences in plankton: a review. Hydrobiologia., 491: 221-239.

Lauridsen, T.L. and Buenk, I. (1996). Diel changes in the horizontal distribution of zooplankton in the littoral zone of two shallow eutrophic lakes. Archiv fu¨r Hydrobiologie, 137: 167–176.

Maberly, S.C. (1996). Diel, episodic and seasonal changes in pH and concentrations of inorganic carbon in a productive lake. Freshwat. Biol., 35: 79-598.

Macphee, S.A. (2009).The effects of thermal habitat and macroinvertebrate predation on the crustacean zooplankton community of a small Boreal Shield Lake. MSc Thesis, Queen's University, Kingston, Ontario, Canada, 153pp.

Magadza, C.H.D. (2010). Environmental state of Lake Kariba and Zambezi River Valley: Lessons learned and not learned. Lakes and Reservoirs. Res. Manag., 15:167-192.

Mageed, A.A. and Konsowa, A.H. (2002). Relationship between phytoplankton, zooplankton and fish culture in a freshwater fish farm. Eypt.J. Aqual.Biol. and Fish., 16(2):183-206.

Mageed, A.A. (2006). Biomass, production, and turnover rate of zooplankton in Lake Manzala (South Mediterranean Sea, Egypt) Egyptian, J. Aqua. Res., 32(1): 158-167.

Mahar, M.A., Baloch, W.A. and Jafri, S.I.H. (2000). Diversity and seasonal occurrence of planktonic rotifers in Manchhar Lake, Sindh, Pakistan. Pakistan J. Fish., 1(1):25-32.

Major, Y. (2006). Temporal changes in the community structure and photosynthetic production of phytoplankton in Lake Babogaya, Ethiopia. MSc. Thesis, Addis Ababa University, Ethiopia, 94pp.

Makhlough, A. (2008). Water quality characteristics of Mengkuang Reservoir based on phytoplankton community structure and physico- chemical analysis. MSc. Thesis Universiti Sains Malaysia.

Margaleff, R. (1996). Limnology Now: A Paradigm of Planetary Problems. Elsevier, Amsterdam, 220-222 pp.

Marques, S.C., Azeiteiro, U.M., Marques, J.C., Neto, J.M. and Pardal, M.A. (2006). Zooplankton and ichthyoplankton communities in a temperate estuary: spatial and temporal patterns. J. Plan. Res., 28: 297–312.

Marques, S.C., Azeiteiro, U.M., Martinho, F. and Pardal, M.A. (2007a). Climate variability and planktonic communities: the effect of an extreme event (severe drought) in a Southern European estuary. Estua, Coas. and S. Sci., 73: 725–734.

Marques, S.C., Pardal, M.A., Pereira, M.J., Gonçalves, F., Marques, J.C. and Azeiteiro, U.M. (2007b). Zooplankton distribution and dynamics in a temperate shallow estuary. Hydrobiologia, 587: 213–223.

Mason, T. D. (2002). The influence of hydrilla infestation and drawdown on the food habits and growth of age-0 largemouth bass in the Atchafalaya River basin, Louisiana. MSc. Thesis, University of Wisconsin-Stevens Point, 113pp.

Matsumara-Tundisi, T. and Tundisi, J. G. (1976). Plankton studies in a lacustrine environment. Preliminary data on zooplankton ecology of Broa Reservoir.Oecologia., 25: 265-270.

Mavuti, K.M. and Litterick, M.R. (1981). Species composition and distribution of zooplankton in a tropical lake, Lake Naivasha, Kenya. Arch. Hydrobiol., 93: 52-58.

Mavuti, K.M. (1990). Ecology and role of zooplankton in the fishery of Lake Naivasha. Hydrobiologia, 208:131-140.

Melaku, M., Tudorancea, C. and Baxter, R. M. (1988). Some limnological investigations on two Ethiopian hydroelectrical reservoirs: Koka , Shewa Administrative District) and Ficha (Wolega Administarive District). Hydrobiologia, 157:47-55.

Miller, S. A. and Harley, J. P. (2002). Zoology, 5th edt. Mc Gram Hill companies, New York.

Million, G., Delenesaw, Y., Ketema, T., Yehenew, G. and Ahmed, Z. (2012). Anaemia and associated risk factors among pregnant women in Gilgel Gibe dam area, Southwest Ethiopia. Paras.and Vect., 5(1):296.

Mohammed, N. (2010). Temporal dynamics of the species composition and size fractionated biomass of phytoplankton in Lake Kuriftu, Ethiopia. MSc. Thesis, Addis Ababa University, Ethiopia, 68pp.

Moore, M. and Folt, C. (1993). Zooplankton body size and community structure: effects of thermal and toxicant stress. Tren in Eco and Evol., 8: 178–183.

Moore, M.V., Folt, C.L. and Stemberger, R.S. (1996). Consequences of elevated temperatures for zooplankton assemblages in temperate lakes. Archiv für Hydrobiologie, 135: 289–319.

Moss.B., Kornijo´w, R. and Measey, G.J. (1998). The effects of nymphaeid (Nuphar lutea) density and predation by perch (Perca fluviatilis) on the zooplankton communities in a shallow lake. Fre. Biol., 39: 689–697.

Moss, B. (1998).Ecology of fresh waters, man and medium. Blackwell Scientific

Mwaura, F. (2006). Some aspects of water quality characteristics in small shallow tropical manmade reservoirs in Kenya. Afri. J. Scie. and Techno., 7: 82 – 96.

Ngirinshuti, L. (2011). Seasonal variations in the abundance of zooplankton in the Northern basin of Lake Kivu. BSc. Thesis, National University of Rwanda, 32pp.

Nigussie, H., Poesen, J., Nyssen, J., De Wit, J., Mitiku, H., Govers, G. and Deckers, J. (2006). Reservoirs in Tigray: characteristics and sediment deposition problems. Lan. Degrad. and Deve., 17: 211–230.

Nyssen, J., Poesen, J., Moeyersons, J., Deckers, J., Mitiku, H. and Lang, A. (2004). Human impact on the environment in the Ethiopian and Eritrean Highlands – a state of the art. Ear. Sci. Rev., 64: 273-320.

Nyssen, J., Vandenreyken, H., Poesen, J., Moeyersons, J., Deckers, J., Mitiku, H., Salles, C. and Govers, G. (2005). Rainfall erosivity and variability in the Northern Ethiopian Highlands. J. Hydrol., 311: 172-187.

O'Brien, W.J. and Vinyard, G.L. (1978). Polymorphism and predation: the effect of invertebrate predation on the distribution of two varieties of Daphnia carinata in South India ponds. Limnology and Oceanography, 23: 452–460.

Okogwu, O. I. (2010). Seasonal variations of species composition and abundance of zooplankton in Ehoma Lake, a floodplain lake in Nigeria. Inter. J. Trop. Biol., 58 (1): 171-182

Onsem, S.V. (2010). Influence of submerged vegetation and fish abundance on water clarity in peri-urban eutrophic ponds. Hydrobiologia, 656:255–267.

Onsem, S.V., De Backer, S. and Triest, L. (2010). Microhabitat–zooplankton relationship in extensive macrophyte vegetations of eutrophic clear-water ponds. Hydrobiologia, 656:67–81.

Paerveen, Z., Vijaykumar, K. and Rajashekhar, M. (2010). Seasonal variations of zooplankton community in freshwater reservoir Gulbarga District, Karnataka, South India. Gulbarga Univeristy, India, Inter. J. Sys. Biol., 2(1): 6-11.

Patra, A.K., Sengupta, S. and Datta, T. (2011). Physico-chemical properties and Ichthyofauna iiversity in Karala River, a tributary of Teesta River at Jalpaiguri district of west Bengal, India.

Pearce, D. (1998). Auditing the Earth: the value of the world’s ecosystem services and natural capital. Environment, 40:23-27.

Pepin, P. And Penney, R. (2000).Feeing by larval fish community: impact on zooplankton. Marine Ecology Progress Series 204: 199-212.

Perumal, P. and Rajkumar, M. (2008). Faunal Diversity: Zooplankton, 23pp.

Peter Osam Sanful (2008). Seasonal and interannual variability of pelagic zooplankton community structure and secondary production in Lake Bosumtwi Impact Crater, Ghana. PhD Thesis Kwame Nkrumah University, Ghana, 240pp.

Pinto-Coelho, R. M. (1998). Effect of eutrophication on seasonal patterns of mesozooplankton in tropical reservoir: a 4-year study in Pampulha Lakr, Brazil. Fre.Biol., 40: 159- 173.

Post, J.R. and McQueen D.J. (1987). The impact of planktivorous fish on the structure of a plankton community. Fre. Biol. 17:79-89.

Primicerio, R. (2000). Seasonal changes in Vertical Distribution of Zooplankton in an Oligotrophic, Subarctic Lake (Lake Takvatn, Norway). Limnologica, 30: 301-310.

Primo, L.A., Azeiteiro, M.U., Marques, C.S., Martinho, F. and Pardal, A.M. (2009). Changes in zooplankton diversity and distribution pattern under varying precipitation regimes in a southern temperate estuary. Estuarine, Coastal and Shelf Scie., 82:341-347.

Rajasekar, K.T., Rajkumar, M., Jun, S., Prabu, V.A. and Perumal, P. (2010). Seasonal variations of phytoplankton diversity in the Coleroon coastal waters, southeast coast of India. Acta Oceanol.Sin., 29(5):97-108.

Renk, H. and Torbicki, H. (1972). Primary production and chlorophyll content in the Baltic Sea. Part I. Preliminary evaluation of diurnal changes in the Gdansk bay. Pol. Arch. Hydrobiol., 19 (3): 235-250.

Reynolds, C.S. and O'sullivan, P.E. (2004).The Lakes Handbook. Limnology and Limnetic Ecology. Blackwell Science, USA, 710pp.

Ringelberg, J. (1993). Phototaxis as a behavioural component of diel vertical migration in a pelagic Daphnia. Archiv fu¨r Hydrobiologie Ergebnisse der Limnologie, 39: 45–55.

Saksena, N.D. (1987). Rotifers as indicators of water quality.Acta.Hydrochim.Hydrobiol., 15: 481-485.

Sandercock, G.A. and Scudder, G.G.E. (1994). An introduction and key to the freshwater Calanoid Copepods (Crustacea) of British Columbia. University of British Columbia Vancouver, 136pp.

Saunders, J.F. and Lewis, W.M. (1988). Dynamics and control mechanisms in a tropical zooplankton community (Lake Valencia, Venezuela). E.S.A., 58(4):337-353.

Sayeswara, H. A., Goudar, M. A., Kumar, K. H. And Purushothama, R. (2011). Physico chemical profile and zooplankton community composition in Brahmana Kalasi Tank, Sagara, Karnataka, India, J.envi.scie., 5(1 and 2):43-48..

Serruya, C. and Pollingher, U. (1983).Lakes of the Warm Belt.Cambr. Univ. Press, Cambr.

Seyoum, L., Fassil, A. and Dalhammar, G. (2003). Characterization of tannery wastewater and assessment of downstream pollution profile along Mojo River, Ethiopia. SINET: Eth. J. Sci., 2:157-168.

Shannon, D. E. and Weaver, W. (1963).The Mathematical Theory of Communication. Urbana, Illinois: University of Illinois Press.

Shiel, R.J. (1995). A guide to the identification of rotifers, cladocerans and copepods from Australian island water. A cooperative research center for freshwater ecology identification guide No.3, 150pp.

Shibru, T. (1973). Fresh water fishes of Ethiopia. Haile Selassie I University, Dept. Biology, Addis Ababa, 101pp.

Shumbulo, E. (2004). The temporal and spatial variations in the biomass and photosynthetic production of phytoplankton in relation to some physico- chemical variables in Lake Chamo Ethiopia.MSc. Thesis, Addis Ababa University, Ethiopia, 72pp.

Sirage, A. (2006). Water quality and Phytoplankton Dynamics in Legedadi Reservoir.MSc. Thesis Addis Ababa University, Addis Ababa, 109pp.

Soberon, J., Rodriguez, P. and Vazquez-Dominguez (2000). Implications of the hierarchial structure of biodiversity for the development of ecological indicators of sustainable use. Ambio., 29(3): 136-142.

Sorsa, M.R. (2008). The structure of zooplankton communities in large boreal lakes and assessment of zooplankton methodology. PhD Thesis, University of Joensuu Yliopistopaino, Finland, 117pp.

Spirules, W. G. (1975). Zooplankton in acid-stressed lakes. J. Fish. Res. Bd. Can., 32(3): 390-393.

Striebel, M., Ptacnik, R., Stibor, H., Behl, S., Berninger, U., Haupt, F., Hingsamer, P., Mangold, C., Ptacnikova, R., Steinböck, M., Stockenreiter, M., Wickham, S. and Wollrab, S. (2010). Water column stratification, phytoplankton diversity and consequences for resource use and productivity. Proceedings of the HYDRALAB III Joint User Meeting, Hannover.

Sutherland, K. (2010). The dynamics of larval fish and zooplankton assemblages in the Sundays Estuary, South Africa. MSc. Thesis, Nelson Mandela Metropolitan University, South Africa, 142pp.

Suthers, I.M. and Rissik, D. (2009).Plankton. A guide to their ecology and monitoring for water quality, 273pp.

Tamene, L., Park, S. J. and Vlek, P. L. (2006). Reservoir siltation in the semi-arid highlands of northern Ethiopia: sediment yield catchment area relationship and a semiquantitative approach for predicting sediment yield. Earth Surface Processes Landforms, 31: 1364–1383.

Tamiru, G. (2006). Zooplankton Community Grazing Rates in Lake Hora. MSc. Thesis, Addis Ababa University, Addis Ababa, 90pp.

Tassew, A. (2007). Assessment of biological integrity using physico-chemical parameters and macroinvertebrate community index along Sebeta River, Ethiopia. MSc. Thesis, Addis Ababa University, Ethiopia, 71pp.

Tenalem, A. (2009). Natural Lakes of Ethiopia. Addis Ababa University Press, Addia Ababa, Ethiopia.

Tenalem, A. and Dagnachew, L. (2007). The changing face of the Ethiopian rift lakes and their environs: call of the time. Lakes and Reservoirs: Res. Manag., 12:149-165.

ter Braak, C.J.F and Smilauer, P. (1997–2002). CANOCO for Windows Version 4.5. Biometrics-Plant Research International, Wageningen, The Netherlands

Tesfay, H. (2007). Spatio-temporal variations of the biomass and primary production of phytoplankton in Koka Reservoir. MSc. Thesis, Addis Ababa University, Ethiopia, 92pp.

Tessier, A.J., Bizina, E.V. and Geedey, C.K. (2001). Grazer resource interactions in the plankton: Are all Daphniids alike? Limnol.Oceanogr., 46: 1585–1595.

Thompson, G.A., Dinofrio, E.O. and Alder, V.A. (2013). Structure, abundance and biomass size spectra of copepods and other zooplankton communities in upper waters of the Southwestern Atlantic Ocean during summer. J. Plankton Resrc., 0(0): 1–20.

USEPA (1991). Policy on the use of Biological Assessments and Criteria in the Water Quality Program.Office of Science and Techinology, Washington D. C.

Vallino, J. (2011). Microbial Grazers Lab. Size classification (revised).

Vijverberg J., Kalf D.F. and Boersma, M. (1996). Decrease in Daphnia egg viability at elevated pH. Limnology and Oceanography, 41: 789–794.

Wakjira, M.K. (2005). Factors influencing the dynamics of crustacean zooplankton in a small eutrophic reservoir. MSc. Thesis, University College Cork Ireland, 122pp.

Wedajo, K. (1982). Comparative limnology of Lake Abijata and Lake Langano in relation to primary and secondary production. MSc. Thesis, Addis Ababa University, Ethiopia

Wetzel, R.G. (2001). Limnology: Lake and River Ecosystems. 3rd edt. Academic Press. N.Y.1006 pp.

Whitman, R. L. Davis, B. And Goodrich, M.L. (2002). Study of The application of limnetic zooplankton as a Bioassessment tool for Lakes of sleeping bear dunes national lakeshore. USGS Lake Michigan Ecological Research Station Porter, Indiana, 79pp.

WHO (1996).Water Quality Monitoring. A practical guide to the design and implementation of freshwater quality studies and monitoring programmes. WhO/UNEP, 375pp.

WHO (1996).Guidelines for drinking water quality.2nd edition, volume 2. WHO Geneva. 94pp.

Williamson, C.E., Sanders, R.W., Moeller, R. E. and Stutzman, P.L. (1996). Utilization of subsurface food resources for zooplankton reproduction: Implications for diel vertical migration theory. Limnol.Oceanogr., 41: 224–233.

Witty, L.M. (2004).Practical guide to identifying freshwater crustacean zooplankton. Cooperative Freshwater Ecology Unit, 2nd edition, 60pp.

Yan, N.O., Keller, W., MacIsaac, J.H. and McEachern, L.J. (1991). Regulation of zooplankton community structure of an acidified lake by Chaoborus. E.S.A., 1(1):52-65.

Yigit, S. (2002).Seasonal Fluctuation in the Rotifer Fauna of Kesikk.pr. Dam Lake (Ankara, Turkey) Turk. J. Zool., 26: 341-348.

Zacharia, P.U. (2011).Trophodynamics and Review of methods for Stomach content analysis of fishes. Central Marine Fisheries Research Institute, Kochi, 12pp.

Zaret, T. M. (1980). Predation and freshwater communities. Yale University Press, New Haven, 187pp.

Zinabu, G. (1998). Human interactions and water quality in the Horn of Africa. In: Science in Africa: Emerging water management problems, 47- 61 pp.

Zinabu, G., Elizabeth, K. and Zerihun, D. (2002). Long term changes in chemical features of waters of seven Ethiopian rift valley lakes. Hydrobiologia, 477:81-91.

89

Zipper, C. C.,Younos, T. and Walker, J. L. (2007).Nutrients in lakes and reservoirs –a literature review for use in nutrient criteria development. Virginia Water Resources Research Center Special report .Varginia, 112pp.

Appendex.1. Summary of values obtained for waters abiotic variable and chlorophyll b in all site.

Paramters	Water body site					
	Gibe(Asendabo)	Nadaa guddaa(Deneba)	Center	Nadi	Yedi	Sig(p)
DO	7.22±1.028	7.080±1.0402	6.990±1.525	6.663±.5450	6.450± 1.100	.901
Tem	25.20±.700	23.70±1.081	25.133±3.1085	24.06±1.159	24.00±1.053	.719
EC	92.86± 4.119	82.433± .5131	81.266±1.650	78.366± .4725	78.333± .0577	.000
Ph	7.763±.4805	7.683±.225	7.860±.3996	7.696±.1955	7.743±.3008	.968
TP	.876±.103942	.52500± .120826	.296±.377	.61067± .082373	.36467 ±.0509	.026
Chla	12.606± .4826	13.190± .5802	12.713± .846	12.436± .0950	12.46±.3800	.463

Appendex.2 Abundance of zooplankton (individual)during study period.

Organism **Cladocera**	Asendabo site	Danaba site	Yedi site	Center site	Nadi site
D.retrocurva	4	13	9	1	1
D.pulex	1	6	11	-	-
D.dubia	11	5	5	-	-
D.cephalata	14	5	15	-	-
B.detersis	9	6	10	-	1
B.meridionalis	14	15	13	-	1
B.berhimi	6	8	5	7	-
Total Cladocera	66	63	80	16	5
Copepoda/Calanoid)					
B.dilatata	11	9	8	4	9
Diaptomus caducus	2	--	7	--	--
Diaptomus nudus	4	3	3	-	3
Diaptomus sicilis	1	13	16	-	-
Acanthadiaptomusdenticornis	-	1	9	-	1
E.Nevadensis	3	4	3	-	2
Total of calanoid copepod	21	30	46	4	15
Copepoda/Cyclopoida)					
A.vernasis	2	3	2	-	1
Megacyclops viridis	-	12	16	-	1

Paracyclops fimbriatus	-	-	14	-	1
Thermocyclops emini	-	-	11	-	-
Macrocyclops edax	3	-	-	-	1
Afrocyclops gibsoni	1	-	-	-	4
E.agiloides	7	11	-	-	-
C.bicuspidatus	13	10	13	-	-
Cycl.Vicinis	14	8	15		1
Total	40	44	71		9
Rotifera					
K.Tropika	10	3	4	2	2
B.havanaesis	20	3		2	2
F.pejler	1	3	3	3	2
Keratela Tecta	1	-	-	-	-
T.capucina	1	1	-	1	-
Total of rotifers	33	10	7	8	6

Appendex 3.When water sample taken from study area for zooplankton sampling and measuring physicochemical parameters.