ABUNDANCE AND SEASONAL VARIATION OF PLANKTONIC COMMUNITY STRUCTURE IN THE RAMSAGAR LAKE, DINAJPUR, BANGLADESH

A Thesis

By

MD. RAHAT ALAM

Examination Roll No: 1605531
Registration No: 1605531
Session: 2016-2017
Semester: July-December, 2017

MASTER OF SCIENCE

IN

FISHERIES MANAGEMENT

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

December 2017

ABUNDANCE AND SEASONAL VARIATION OF PLANKTONIC COMMUNITY STRUCTURE IN THE RAMSAGAR LAKE, DINAJPUR, BANGLADESH

A Thesis

By

MD. RAHAT ALAM

Examination Roll No: 1605531
Registration No: 1605531
Session: 2016-2017
Semester: July-December, 2017

Submitted to the

Department of Fisheries Management

In Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE

IN

FISHERIES MANAGEMENT

DEPARTMENT OF FISHERIES MANAGEMENT
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY
UNIVERSITY, DINAJPUR

December 2017

ABUNDANCE AND SEASONAL VARIATION OF PLANKTONIC COMMUNITY STRUCTURE IN THE RAMSAGAR LAKE, DINAJPUR, BANGLADESH

A Thesis

By

MD. RAHAT ALAM

Examination Roll No: 1605531
Registration No: 1605531
Session: 2016-2017
Semester: July-December, 2017

Approved as to the style and contents by

----------	----------
(Rubaiya Pervin)	(Krishna Chandra Roy)
Assistant Professor	Lecturer
Supervisor	Co-Supervisor

(Prof. Dr. Zannatul Ferdoushi)

Chairman of Examination Committee and

Chairman

Department of Fisheries Management
Hajee Mohammad Danesh Science and Technology University, Dinajpur

December, 2017

DEDICATED

TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises are due to Almighty Allah, who enabled the author to pursue his education in a discipline like Fisheries Science and to submit this thesis in time for the degree of Master of Science (M.S.) in Fisheries Management.

The author expresses his heartfelt gratitude, deepest sense of appreciation, best regards and profound indebtedness to his honorable supervisor Rubaiya Pervin, Assistant professor, Department of Fisheries Management, Hajee Mohammad Danesh Science and Technology University, Dinajpur for her, scholastic guidance, valuable suggestions, constant encouragement, constructive criticism and untiring help throughout the research work and during writing up of this thesis.

The author gratefully acknowledges sincere gratitude to his co-supervisor Krishna Chandra Roy, Lecturer, Department of Fisheries Management, Hajee Mohammad Danesh Science and Technology University, Dinajpur Bangladesh for his criticism, spiritual direction and cooperation throughout the entire period of research work.

The author also likes to express his sincere gratitude of her respectable teachers, especially Professor Dr. Zannatul Ferdoushi, Chairman, Department of Fisheries Management, Hajee Mohammad Danesh Science and Technology University, for the help, encouragement and suggestions to carry out the research work successfully.

The author wishes to express his deepest sense of respect to all the teachers of the Faculty of Fisheries, Hajee Mohammad Danesh Science and Technology University, for their valuable advice and encouragement during the period of study. The author also grateful to his well wishers and all the friends especially Habiba for her friendly help and encouragement. Cordial co-operation, friendly collaboration, fruitful advice and guidance were received from many other parsons from the start to the end of this piece of work. The author immensely grateful to all of them and regret his inability for not to mention everyone by name.

Last but not least, the author expresses grateful acknowledgement and indebtedness to his beloved parents who sacrifice all their happiness during the entire period of study and also grateful to his family members for their continuous inspiration, sacrifices and blessings in carrying out the higher study which can never ever be forgotten.

The author
December 2017

ABSTRACT

An experiment was conducted on Abundance and seasonal variation of plankton community structure in the Ramsagar Lake, Dinajpur, Bangladesh for a period of one year (January 2017 to December 2017). After two months pre-sampling three sampling sites were selected on the basis availability of plankton. Samples were collected monthly from three sites with three replication for each. Water quality parameters namely, temperature, p^H, dissolved oxygen and transparency were measured at monthly intervals. All water quality parameters showed significant difference ($P<0.05$) among different seasons. During the study period the air temperature of water range found from 18.23 to 35.82^0C among the seasons. Air temperature highest mean value found in Autumn (33.33±3.99) and lower in the winter (24.45±3.99). The water temperature ranged varied 20.03 to 34.89 ^{0}C. Water temperature mean value was found higher in Autumn (31.66±1.89) and lower in the Spring (22.23±2.17) season. Water transparency range was varied from 28.50 to 54.43 cm in the experimental lake. The highest mean value of transparency was found in the Autumn season (47.52±4.37) cm and the lowest value was in Spring (36.91±6.53) cm. The dissolved oxygen concentrations under various treatments were found to fluctuate from 5.25 to 8.67 mg/l. The highest mean value of dissolved oxygen concentration was found in winter season (8.01±0.42) and the lowest value was observed in spring season (6.98±1.06). The p^H values ranged varied from 6.25 to 8.00. An average ranged p^H was found during the study period. The highest mean value of p^H was found in spring season (7.51±0.27) and the lowest value of p^H was found in Autumn (6.85±0.25). All parameters are suitable for growth and reproduction of fish and the fish culture. The qualitative and quantitative study of plankton was carried out at the laboratory of Fisheries Management, Faculty of Fisheries, HSTU by using microscope. A diversity of plankton was found in Ramsagar lake. In total 4 groups and 31 genera of phytoplankton were observed in the lake among them Chlorophyceae was the dominant group of phytoplankton. 15 genera of Chlorophyceae, 8 genera of Bacillariophyceae, 7 genera of Cyanophyceae and one genera of Euglenophyceae were found during the study period. Phytoplankton abundance showed significant difference ($P<0.05$) among different seasons. The highest phytoplankton was observed in summer season and the lowest observed in winter. In terms of month the highest phytoplankton was observed in June-July and the lowest observed in December- January. On the other hand 4 groups and 7 genera of zooplankton were found during the study period. Among the genera of Rotifera, 2 genera of Copepoda, one genera of Cladocera and one genera of crustacean were found. Rotifera was the dominant group among the zooplankton. Seasonal variation of total zooplankton was found in the study. Zooplankton abundance showed significant difference ($P<0.05$) among different seasons. Considering all the facts the total plankton production was found highest in summer season and the mean values were (9.78±1.70) and lowest in winter season and the mean values were (8.09±1.62). Seasonal variation of plankton abundance was found throughout the year. It might be suggest that Ramsagar is a water resource with a diversity of plankton which is an important primary producer and important for fish production. While more and more research will be needed. This research gives guideline to the researcher for future study of Ramsagar lake.

LIST OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

ACRONYMS AND SYMBOLS

ANOVA : Analysis of Variance

DO : Dissolved Oxygen

SDR : Secchi Disk Reading

S-R CELL : Sedgwick- Rafter cell

SPSS : Statistical analysis for social science

Mg/L : Milligram per liter

CM : Centimeter

CHAPTER I

INTRODUCTION

Bangladesh is a country which is land of water. The country has suitable geographical location with the expected fisheries resources such as coastal estuaries, rivers, haors, baors, canals, lakes, reservoirs, khal-*beels* and ponds. These water resources are the very important for fish and other aquatic animals, plants and other aquatic organism for their residence. These water resources have higher economic importance and the resources plays an important role in the socio-economic elevation, alimentation, create opportunity of service or employment, poverty palliation etc. The fisheries resources also have a large number of foreign exchange earnings sectors which is important for the economy of Bangladesh.

Bangladesh has 3901900 ha area of water body. The total fish production by the water resources (River and Estuary) is 3878324 mt. (DoF, 2017).

Planktons are microscopic and free non- partisan organisms in water body. The plankton can flows with the currents and winds the plankton can be divided into two types, one is the phytoplankton and the other is zooplankton. The word plankton comes from the Greek word "wandering" which meaning Traveling. According to Hosetti and Kumar (2002), Plankton is a combined term used to identified all those types of existence whose power of stroll are not enough to prevent them from being uplifted by water currents. The Plankton can be classified in different ways, this involve whether they are true or false plankton, their nutritional requirements (Phytoplankton and zooplankton), their size, their environments and their life history. There is illustrious diversity in the construction of plankton not only in various seasons and at different depths, but also at several hours, and likely even in different season in the same place and depth. The plankton constitutes the primary producers in any certain water body. According to Biddanda and Benner (1997), one of the main sources of carbohydrates in many aquatic ecosystems is phytoplankton, where biomass is typically made up of from 16 to 35% carbohydrate. The phytoplankton in water are also detrimental as they produce biomass which generate bad smell, causing de-oxidation and damage to aquatic life (Bellinger, 1992). Therefore, water quality administration has to monitor the phytoplankton content in order, for example to come up with prohibitive measures such as aeration to prevent fish kills during the corrosion of the planktonic biomass. According to Khatri (1987) based on the allocation model of the plankton the attribute of the periphery can be counted. The allocation, abundance, species variation and construction of the phytoplankton are used to assess the biological fidelity of a water body. Panigrahi *et al.* (2013) opine that species composition of the phytoplankton community is an efficient bio-indicator for water quality. Plankton is the premier elementary creators in water bodies which influence formation and firmness of consumers and the distinctness of water. Besides of phytoplanktonic organisms which are impressible indicators, as phytoplankton formation and metabolism changes quickly in reaction to environmental changes. Outgrowth rate and stagnancy of phytoplankton are subject to cyclic changes restlessness and succession.

Phytoplanktons are called as autotrophic compounds of the plankton community which plays a vital role of the major part of seas and the freshwater ecosystem. Most of the phytoplankton are very small to be individually seen with e necked eye, however, when

present in high enough numbers in water body, there are some kinds of plankton which are noticeable as colored patches on the water body due to present of green particles called as chlorophyll within their cells and various elements like phycobiliproteins or xanthophylls, they are called as accessory pigments present in some species. The phytoplankton which is photosynthesizing microscopic organisms that inhibit the upper sunlight layer of the water of marine water or fresh water they are primary producers in water the process of making of organic compounds from CO_2 dissolved in water. It is the process that sustains the water food chain. a large number of phytoplankton species are obligate photo autotrophs, there are some types which are mix autotrophic and the others are non pigmented species. The non pigmented species are heterotrophic types; phytoplankton plays a vital role to serve as the base form of the chain of aquatic food web which can provide an essential ecological function for every aquatic organism. Plankton in water are the diverse group of organism which incorporate protestant eukaryotes and both eu-bacterial and archaebacterial prokaryotes organism, there are more than 4500 species of marine phytoplankton and 500 of zooplankton are found in marine water body (Khatri, 1987). Plankton of different types fill different tropic level within different ecosystem, Phytoplanktons which are comprise a major part of aquatic vegetation are the primary producers which adjuvant the growth of aquatic flora and fauna .The phytoplankton produce oxygen by the process of photosynthesis. Several of them may cause filth by alternating the quality of water in which they generate. They are specious significatives of water nature, retention of water to sustain heterotrophic denomination. Phytoplankton play a vital role in biosynthesis of organic substance in lentic ecosystem, on which straight away overhang all the living organisms in aquatic system as source of food and their metabolism activity of body. Even if they have no quick effect on fish yield, they are at least categorically good indicators of the biological productivity.

In general, the outgrowth of a fish is affected or influenced by the quality and quantity of food material which are available and consumed by the fishes. Thus, any transformation in quality and quantity of food particles will affect the out growth rate of the fish. The qualitative and quantitative variations of physical food materials in a water body are influenced by various abiotic and biotic factors. The total production of fish largely depends on the plankton production. They play a vital role directly or indirectly in fish production. Various water quality parameters have been influences on the growth and production of both the phytoplankton and zooplankton. There are a number of research works on

ecological, limnological and biological aspects of pond and river is very much needed in Bangladesh for better management practices in our water body. This will also protect the vulnerable fishery resources from environmental degradation through proper management practice which will ultimately increase the total capture and culture production.

Various water quality parameters are important for the production of plankton and also important for the metabolism activity of fish and other aquatic organism. The parameters are divided into three types these are physical, chemical and biological parameters. Among these parameters temperature, transparency, pH and dissolved oxygen are very impotent.

The most essential and one of the most enormous elements of the ecosystem is water. Almost all the organism which is living in nature directly depends on water for their growth and survival. Both plants and animals needed water for their existence. For the growth of plankton in water body there are some parameters which can provide the best growth of plankton in water. It is very important to test the water before it is used for drinking, domestic, agriculture and the industrial purpose. Water must be tested for different physico-chemical parameters. Election of parameters for testing of water solely depends upon for what purpose we going to use that water and what extent we need its quantity and purity some physical test should be needed for determine the physico-chemical parameters such as temperature. PH, transparency, dissolves oxygen etc. Water temperature can controls all the chemical reaction and affects the growth of plankton, fish growth, their metabolism, immunity and the reproduction. Drastic temperature changes can be dangerous to fishes and other aquatic animals living in water body.

p^H is most necessary in realizing the digestive nature of water. Lowest the p^H value highest is the digestive nature of water. p^H was certainly correlated with electrical conductance and total alkalinity (Patil *et al*. 2012). The attenuate rate of photosynthetic activity the assimilation of carbon dioxide and bicarbonates which are ultimately responsible for increase in pH, the lower O_2 values coincided forgather with high temperature during the summer month. Different factors fetch about changes the pH of water. The higher pH values accomplished suspects that carbon dioxide, carbonate-bicarbonate equality is affected more due to change in physico-chemical condition.

DO is one of the most important parameter. Its interrelation with water body pays direct and indirect massages e.g. bacterial activity, photosynthesis, availability of nutrients, stratification etc. (Premlata and Vikal, 2009). In the prosperity of summer, dissolved oxygen

decreased due to increase in temperature and also due to increased microbial activity. The high DO in summer which is due to increase in temperature and duration of shine sunlight has influence on the percent of soluble gases (O_2 & CO_2).

Transparency is the cloudiness and the hazards of any fluid caused by suspended solids that are usually invisible to the necked eyes. It is other physico-chemical parameters which are important to determine the quality of water it is an aggregate optical property of water and does not identify individual substances. There are various particles that caused the water turbid. The turbidity or the water transparency is determined by the Secchi disk.

According to Oxford dictionary "A large area of water surrounded by land is called as lake" The area of Ramsagar is surrounded by land. So that we can say Ramsagar is a lake. Ramsagar lake is located in the village name is Tejpur in the district of Dinajpur. It is the largest man-made lake in Bangladesh. The Ramsagar Lake is situated about 8.1 km from the south of the Dinajpur town. The maximum length of the lake is 1.032 km or 0.641 mile and the maximum wide of the lake 0.364 km or 0.226 mile the surface area of the lake 43.75 ha or 108.1 acres and the average about depth 10.1 meters or 33.2 feet. It is an important resource not only for fish production but also for tourism aspects.

Objectives

While plankton community of a water body consists the basis of a food chain and very essential for food production the study associated with plankton diversity and their seasonal variation in relation to water quality parameters is very few. Considering the importance of plankton production this study was carried out to evaluate the diversity and seasonal variation of plankton in Ramsagar. In order to evaluate the present condition of Ramsagar Lake the following objectives have been set out-

- To analyze the abundance of plankton of Ramsagar lake in Dinajpur district.
- To analyze the seasonal variation of density of plankton.

- To analyze the impact of water quality parameters on the seasonal variation of density of plankton in Ramsagar.

CHAPTER II

REVIEW OF LITERATURE

Before setting up any proper experimental work it is very important to review the research works related to the proposed study. Parameter in water quality appreciation and be reflected the physical and biological procedure governing in the waters.

The science which is deals with aquatic ecosystem and hydrology has achieved great significance in recent years. Lakes and riverine system is called as freshwater system. We can use this water for our domestic, industrial, sports, transport and other purpose. Interchange of the relationship of these elements depend on their physico-chemical properties changes in the environment. Illustrating the progressive and pleasant balance of the system in nature. Behavior is somewhat practically effectively keeping symmetry in the population of being through biological control, but the usefulness of biological control of animal population now a day is disturbed by anthropogenic thrusting. The importance of the

study of ecology of water resources in our country has been realized in the recent days. The various physico-chemical characteristics, the dynamics of plankton population both phytoplankton and zooplankton, the fishery potent and the methods of development of the water bodies formed a subject of detailed discussion by various scientists. Onyema *et al.* (2010) conducted an water-born eco-toxicity appreciation in extremely polluted urban river and lakes pictorial the benefit of using algal bioassays in assess the eco-toxicological attribute of water receiving affluent of industrial and domestic origin .More appropriate and variegated research is going on in the hydrology, phytoplankton study and fisheries sector in this century also. Cabo *et al.* (2003) while studying the effect of physico-chemical variance on plankton from delta of the Paraná lake in Argentina reported that lowest plankton densities coincides with minimum temperature and also commented that the plankton variables would be affected directly or indirectly by water level and by seasonal climatic condition.

2.1.1 Physical parameters

Temperature (^{o}C)

Temperature is a measure of the water kinetic energy and aids in the system of ecosystem hygiene by its physiologic effects on the organisms in the Aquatic environment.

Temperature is a very important growth and reproduction regulating parameter. The changing of temperature directly plays a vital role metabolism of fish and their feeding intensity. Temperature is also important for other aquatic organisms in water.

The Phytoplankton production directly or indirectly depends on the changing of temperature. Temperature as a factor in phytoplankton community dynamics has been researched for many species and certain phytoplankton species have been observed to have a unique temperature range for growth. When water temperatures change, biological, physical and chemical reactions within an organism are altered, thus affecting community structure by selecting those best suited to survive. Reproduction, growth, metabolism, microbial processes and especially photosynthesis rates can all be increased or decreased by water temperature changes. For example, during the springtime in the Chesapeake Bay, phytoplankton can undergo rapid population growth or algal blooms when water temperatures rise in the presence of excess nutrients (Fisher *et al*., 1999).

Ferdoushi *et al*. (2015) studied on the limnological aspects of Ramsagar Lake and found the water temperature range (16.70-33.80^{0}C) during the experimental period.

Islam *et al.* (2015) studied the water quality parameters (physical-chemical) of a lake in Faridpur and found the value of temperature was 23.38 degree Celsius.

Gupta *et al*. (2011) studied the physico-chemical parameters of various lakes of Jaipur, India and found the temperature fluctuate (23-26 ^{0}C).

Chowdhury (2008) was studied the seasonal variation of plankton in relation to various *beels* ecosystem and found the temperature of water (13.50-30.50^{0}C).

Sharma *et al.* (2007) found the temperature fluctuation (21-29^{0}C) in a limnological study at Udaipur lake India.

Akter (2007) studied on monthly adequacy of phytoplankton in relation to water quality in nursery water body at the laboratory which is situated in BAU. She filed the temperature variation from 20.5°C -30.9°C.

Niu *et al.* (2003) suggested that the consumption of Food increases or decrease directly with increasing temperature or decreasing. When the temperature rise 1°C of water metabolic rate increases 10 %, and then metabolic rate becomes double when the rate rises for 10°C.

Phlips *et al.* (2002) measured phytoplankton concentrations at multiple points in a restricted lagoon along the Indian lake, and concluded that there was a positive correlation between increasing temperature and increasing chlorophyll *a* concentrations in most of the study sites.

Phlips *et al.* (2002) measured phytoplankton concentrations at multiple points in a restricted lagoon along the Indian lake, and concluded that there was a positive correlation between increasing temperature and increasing chlorophyll *a* concentrations in most of the study sites.

Rahman (1999) was studied the pond ecology at BAU and found the values of water temperature ranged from 26.2 to 34.5°C.

Ali (1998) suggested that the water temperature ranged from 23.6 to 36.6°C in Some ponds at the BAU.

Ahmed *et al.* (1992) studied the water quality parameters in Kaptai Lake and found the mean value range of temperature (33.8- 25^{0}C).

2.1.2 Transparency (cm)

Transparency is one of the water quality parameter or factor which can be deliberated in plankton growth and the attendance or absence of food in water body is turned by the water transparency. The plankton density determined by the Secchi disk. When the adequacy of phytoplankton increment in a water body, then the Secchi disk study becomes lower and vice-versa. When there are heavy phytoplankton blooms they may constrict secchi disc visibility to less than 20 cm.

Ferdoushi *et al*. (2015) studied on the limnological aspects of Ramsagar Lake and found the water transparency range (22-76) cm during the experimental period.

Naser and Kabir (2007) research the physico-chemical parameters of on oxbow lake in Meherpur District in Bangladesh. They observed that the transparency of this lake ranged from 8.89 to 53.34cm.

Akter (2007) studied on every monthly adequacy of phytoplankton in relation to water quality in nursery water body at the laboratory which is situated in BAU. She found the range of transparency variation 15.33 to 48 cm.

Zealem (2007) investigated the biomass and photosynthetic productivity of phytoplankton in lake Kuriftu, Ethiopia and observed that the lakes transparency was always less than 0.6 m with smaller values coincident with periods of rainfall and negatively correlated with phytoplankton biomass.

Rahman (2000) found the ranges of water transparency were recorded 26.5 to 36.3 cm and 15 to 58 cm by Kohinoor (2000) in some ponds of BAU, Mynansingh.

Rahman (1999) studied about the ecosystem of some water body at BAU, Mymensingh. In his study he invented that the values of water transparency ranges from 12.0 to 46.5 cm.

Hasan and Paul (1998) found that the mean water transparencies were found 30.6 cm and 31.8 cm.

Ahmed *et al.* (1992) studied the water quality parameters in Kaptai Lake and found the mean value range of transparency (1.5 m-3.4 m).

Boyd (1982) suggested that the transparency ranges 15-40 cm is suitable for fish culture. He studied in water quality in lake for Aquaculture, Department of Fisheries and Allied Aquaculture. Alabama, United State of America.

2.2 Chemical parameters

2.2.1 Dissolved Oxygen

Dissolved oxygen is of paramount importance to all living organisms and is considered to be the lone factor, which to a greater extent can reveal the nature of the whole aquatic system at a glance, even when information on other physical, chemical and biological parameters is not available. Several abiotic and biotic factors determine the dissolved oxygen content of the system. The occurrence of dissolved oxygen in water is attributed to two phenomena direct diffusion from the air which depends on the solubility of oxygen under the influence of temperature, salinity etc and photosynthetic evolution by aquatic autotrophs which depend on the availability of light.

Ferdoushi *et al.* (2015) studied in a limnological aspects of Ramsagar Lake and the range of DO were found (5.10- 9.90) mg/L.

Khondokar *et al.* (2011) practiced on the limnological aspects on the Ramsagar lake in Dinajpur. They found that dissolved oxygen concentration was 7.99 mg/L.

Joaddar (2009) studied in the limnological aspects of Arial beel in Rajshahi and found the DO range (5.26-6.08) mg/L in his study.

Khondokar *et al.* (2011) Studied about the phytoplankton of Ramsagar, where they DO rate was 7.2-7.7 mg/L water quality abstract in Ramsagar, investigated limnologically, mean alkalinity, DO concentration of phosphorous, silicate nitrete –nitrogen concentration.

Malu (2001) studied the phytoplankton diversity in Lonar lake and found that some of them are the bio-indicators of water quality. The algae are pollution indicators and can be used for assessing water quality of rivers. He found the DO rate 7.2-7.8mg/L.

Wahab *et al.* (1995) observed effect of introduction of common carp on the pond ecology of BAU, and growth of fish in polyculture that the Dissolved Oxygen rate was 2.6 to 6.2 mg/L.

Ahmed *et al.* (1992) studied the water quality parameters in Kaptai Lake and found the mean value range of transparency (6.4-9.1) mg/L

Ali, (1998) observed that 3.91 mg/l. (Hasan, 1998), 4.20 mg/l. 6.0 to 8.0 mg/l, (Rahman, 1999), 2.0 to 7.4 mg/l. Kohinoor (2000) and 4.9 to 5.2 mg/l by Rahman (2000) in some research ponds of the Fisheries Faculty BAU.

p^H

p^H is a the acidic [H^+] or alkaline [OH^-] behavior of water which is describe on a numerical measure from 14 (alkaline) through 7 (neutral) to 0 (acidic).

Ferdoushi *et al.* (2015) studied on a limnological aspects of Ramsagar Lake and found the range of pH were (6.53-7.84) during the study period.

Khondokar *et al.* (2011) practiced on the limnological aspects on the Ramsagar Lake in Dinajpur. They found that p^H concentration was 6.63.

Alavi and Jafari (2010) studied about the physico-chemical parameters in a lake situated in Iran which is polluted by industrial effluents and he found the P^H range 7.18-8.12 during his study period.

Joadder (2009) studied on the Joshi *beel* Rajshahi district and he found the p^H value 7.5-8.2. In his study period he found the highest value of p^H in the month September and lowest in April month.

Araoye (2009) studied the p^H and DO concentration was positively correlated (0.54) in Asa lake, Nigeria.

Islam *et al.* (2008) found the p^H value of 7.8-8.4 during his study period. His study was about the water quality parameter of some ponds situated in BAU, Mymansingh.

Akter (2007) studied on every monthly adequacy of phytoplankton in relation to water quality in nursery water body at the laboratory which is situated in BAU. She found the value of p^H 7.14 to 9.00.

Ahmed *et al.* (1992) studied the water quality parameters in Kaptai Lake and found the mean value of p^H and ranged from 7.5 to 8.4.

Mumtazuddin *et al.* (1982) determined p^H range of 7.0 or slightly more than 7.0 during the Limnological studies of four selected ponds at the Aquaculture Experiment Station, Mymensingh.

Mollah and Haque (1978) recorded p^H value and ranged from 7.19 to 7.74 during the Studies on monthly variations of plankton in relation to the physico-chemica1 conditions of water and bottom soil of two ponds.

Hossain (1997) was studied in the Kola-Barnl *beel*. He studied the physico-chemical water parameters and found the p^H range values 6.53-7.12.

Swingle (1967) found the p^H ranged from 6.5 to 9.0 which are suitable for pond fish culture and p^H more than 9.5 is undesirable because free CO_2 is not available in this situation. Consequently the nutrients remain in dissolved condition.

2.2 Plankton Production

Plankton plays a vital role in water bodies as the source of food for fishes. It is the main food organisms in an aquatic environment. Plankton is an important factor affecting production. Zooplankton are the main link between small phytoplankton and large carnivorous, primarily fish. Plankton influences primary productivity and oxygen supply for aquatic fauna through photosynthesis. Planktons are widely studied throughout the world.

Ferdoushi *et al.* (2015) studied on a limnological aspect of Ramsagar Lake and found the She found 29 genera of plankton. She found 4 groups of phytoplankton and 4 groups of zooplankton. Chlorophyceae was the dominant group of phytoplankton and Rotifera was the dominant group among the Zooplankton. She observed that the number of genera and density of plankton showed seasonal variations during the study period.

Hossain *et al.* (2015) studied about the abundance of plankton in Ramsagar Lake in Dinajpur. And found the dominance of Chlorophyceae then other plankton.

Suresh *et al. (*2013) conducted on the density and dynamics of plankton succession in a lake, Karnateka, India and estimated significant correlation between phytoplankton density and physico-chemical properties of water and Cynophyceae showed the highly significant and positive correlation with temperature and Chlorophyceae showed negative correlation with Ph and DO. Bacillariophyceae and Euglenophyceae showed significant correlation and negative with temperature and DO.

Sharmin (2013) found thirty five genera of phytoplankton an about thirteen genera zooplankton. She studied about the tilapia polyculture. The mean abundance of both phytoplankton and zooplankton were found to show significant difference ($P<0.05$) among the treatments with higher in treatment 2 where fertilization was done in Treatment 1, alone, fertilization and supplementary feeding were done in Treatment 2 (commercial tilapia feed at half the amount of feed typically applied to commercial production) and feeding has done in Treatment 3 alone at the full amount of feed typically applied to commercial 1 in Bangladesh (20% down to 5%) of body weight.

Alam (2012) studied to count the effects of various types of inorganic fertilizers and the experiment occurs in 6 ponds and the works were done in three months from October to December. Mean phytoplankton and zooplankton densities under treatments 1, 2 and 3 estimated were 57.08±1.35, 8.80±0.09 and 77.29±3.72, 12.88±0.74 and 98.93±1.61, and 16.16±1.75 ($\times 10^3$) cells/l.

Hoque (2012) studied the water quality and the number of plankton composition in (*Amblypharyngodon mola)* the studied were done. In the research laboratory field which is situated in BAU. About thirty eight genera of phytoplankton and thirteen genera of zooplankton were found of which Chlorophyceae found twenty genera which are dominant group. The mean value of total plankton population ($x10^3$ cells/l) was 158.42±53.33, 191.17±62.24 and 240.17.

Saha *et al.* (2011) studied on physico-chemical properties and Bacteriological properties of Gulshan Lake. They observed the seasonal variation of Bacterial load during the study. The load of bacteria in Gulshan lake water were highest in winter and lowest were found in summer season.

Khondokar *et al.* (2011) practiced on the limnological aspects and plankton abundance on the Ramsagar Lake in Dinajpur. They found that Chlorophyceae were the dominant group.

Das *et al.* (2011) studied in a Oxbow lake in Assam and found Chlorophyceae were the dominant group of phytoplankton. They observed the physic-chemical properties of water planktonic community of water are relatively in satisfactory condition.

Islam *et al. (*2010) studied in the limnological aspects in Ramna Lake and found a large number of Rotifera in this study.

Ibrahim (2009) studied on a survey of zooplankton diversity in an Indian lake and analyzed the physico-chemical properties of water. He found positive relation of Zooplankton with transparency, DO and p^H.

Chowdhury *et al.* (2007) studied about 51 genera of various plankton in Boro-beel which is situated in Rangpur district. He studied the seasonal variation of the plankton and found the plankton range 98.3×10^4 to 35×10^5 per cells and the Euglenophyceae was the dominant group.

Akter (2007) studied on every monthly adequacy of phytoplankton in relation to water quality in nursery water body at the laboratory which is situated in BAU. She filed the

temperature variation from 20.5°C -30.9°C, p^H 7.14 to 9.00 and transparency variation 15.33 to 48 cm. In his study he determined the variation of planktons with changing the water quality parameters.

Akhtar *et al.* (2007) studied about the use of variety of Agrochemicals and human activities provoke the inanition of aquatic biota due to water contamination in the case of rivers and lakes. During monsoon water turbidity caused by agricultural and surface maximum runoff and soil erosion can affect the production of phytoplankton and zooplankton.

Tiwari *et al.* (2006) studied the seasonally changing of the phytoplankton abundance along with physicochemical conditions of pond water which is situated in Bhopal, India, over year and then result were made by taking out the mean values of the seasonally changing. The climatic conditions were strongly influenced by plankton variation seasonally. He studied the bimodal of phytoplankton adequacy was observed with main winter and subsidiary in summer season. He also found about twenty nine algal fauna of Chlorophyceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae were found. The highly oxidative and eutrophic in nature were found in pond.

Prasad and Singh (2003) studied the attempt designated on Composition, adequacy and phytoplankton distribution and the zooplankton also in a tropical water body. The principal sourced formed in water by the Zooplankton.

Kadir (2003) Studied the experiment on the temporary changes in water quality parameters in empirical fish ponds special emphasis on Euglenophytes was conducted by assemblage naturally micro algal population was found by him and found to be composed of forty one genera belonging to 4 vital groups such as Euglenophyceae three species Cyanophyceae seven species Chlorophyceae twenty four and Bacillariophyceae seven species during the experimental period.

Arauzo (2003) studied about that during phytoplankton blooms are formed in the stratification periods elevated un-ionized ammonia contented values.

Uddin (2002) studied an attempted for a period of 5 months to found the effects of put of small fish on pond ecosystem and production in poly culture at the laboratory field, BAU, He identified about twelve genera of zooplankton belongs two groups Rotifera and Crustacea. The mean abundance ($x10^4$/l) of total zooplankton was 2.51±0.37 and 1.94±0.34 in treatment 1 and treatment 2 respectively. The zooplanktons which were found are,

Lecane, Asplanchna, cyclops, Diaptomus, Diaphanosoma, Moina, Nauplius, Brachionus, Keratella and Filinia.

Yeamin (2000) practiced the water quality parameter and biological production of ponds at the Fisheries Laboratory Field, BAU He found in number in pond water body nineteen to twenty one genera of phytoplankton and seven to eight genera of zooplankton during the empirical period. Among the plankton population, Chlorophyceae are the most dominant groups of plankton.

Raihan (2001) studied the plankton adequacy in poly culture system of carps with small fish mola for the period of 5 months at the Fisheries Laboratory Field, BAU, situated in Mymensingh. He evidences those thirty one genera of phytoplankton belonging to Bacillariophyceae (four), and Euglenophyceae (three) Chlorophyceae (eighteen), Cyanophyceae (six). Among the phytoplankton, the dominance group is chlorophyceae, and the least abundance group is Euglenophyceae. Phytoplankton was 1.5 times more than the zooplankton in relative limnological study in a semi intensive and fish extensive culture in pond.

Ahmed (1992) studied on the limnological aspects of Kaptai lake and found Rotifera were the dominant group of Zooplankton among the Zooplankton.

Khatrai (1984) studied on the seasonal variation of the ecosystem and the relationship between transparency and phytoplankton. He has negative relationship of pH with free CO_2 and positive relation with bicarbonate. He also studied that phytoplankton and chlorophyll (a) has a positive relationship with primary production, but inversely related with zooplankton.

CHAPTER III

MATERIALS AND METHODS

3.1. Ramsagar Lake

3.1.1 Location of the lake and its description

A comparative study on Abundance and Seasonal Variation of Planktonic community structure in the Ramsagar Lake, Dinajpur, Bangladesh was carried out from January to December in 2017. The experiment was done in the Ramsagar Lake which is located in the southern part of Dinajpur district. This is situated about 8.1 kilometers from the south of the dinajpur town. The lake coordinates $25^{0}38''$ N to $88^{0}39''$ E. The maximum length of the lake is 1.032 km or 0.641 mile and the maximum wide of the lake 0.364 km or 0.226 mile. The surface area of the lake is 43.75 hectares or 108.1 acre and the average depth is about 10.1 meters or 33.2 feet. The lake is about 1078 meter long from north to south and 192.6 meter wide from the east side to west.

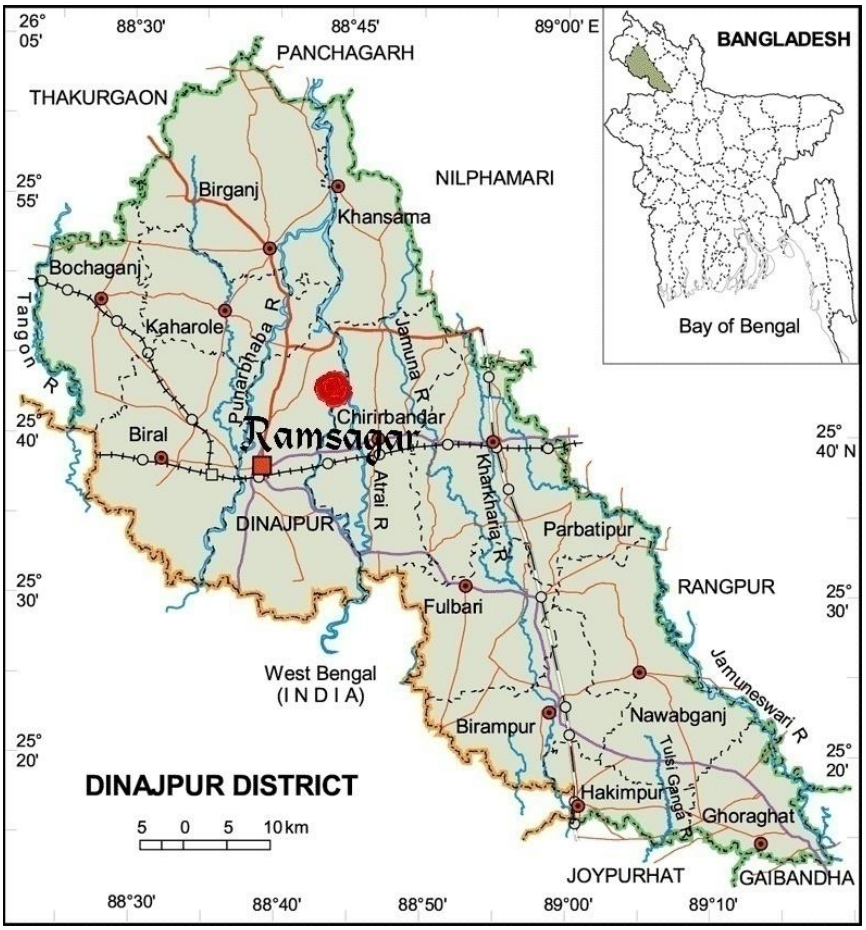

Fig 3.1 Map of Study area

Fig 3.2 Ramsagar lake

Fig 3.3 Study sites of Ramsagar lake

3.1.2 Selection of sampling sites

Sampling sites were chosen in the Ramsagar lake after two month pre-sampling in the early morning as plankton are available in this time. Finally, three sites namely, Site 1, Site 2, Site 3 were selected on the basis of availability of plankton. The whole year was divided by four seasons. April, May and June were selected as Summer season. July, August and September were Autumn season. October, November and December were Winter and January, February and March were selected as Spring season Ara (2015).

3.1.3 Methodology

Determination of various physico-chemical parameters (Temperature, Transparency, Dissolved oxygen and pH) and phytoplankton observation were made between 7.00 am to 10.00 am on monthly basis. The three sampling sites which were chosen for the research purpose were the southern part, middle of the lake and the north western part of Ramsagar Lake and the microscopic identification of plankton were done in the Laboratory of the Department of Fisheries Management under Faculty of Fisheries, HSTU Dinajpur.

3.2 Sampling technique

3.2.1 Water collection

The physico-chemical parameters determination was done by collecting the water sample and kept into different bottles. The volume of each water sample bottles was 250 milliliter capacity. Each bottles then labeled according to the name of collection point, as for example site 1 and point 1 sample the labeled was S-1, P-1. The sample was then kept in the laboratory for identification the plankton.

3.2.2 Physical parameters

Temperature of water

Digital Celsius Thermometer was used to measure air and water temperature.

Transparency of water

For determination of transparency of water the secchi disk was used. The secchi disk was dipped into the water on a calibrated line until it disappeared. The reading was recorded where the disk disappeared and the depth where it reappeared. The secchi disk reading (SDR) was the average of these two readings.

Calculation:

S.D.R (cm) = $\frac{A-B}{2}$ (Lind, 1979)

Where:

A = Depth at where Secchi disc disappears

B = Depth at where Secchi disc reappears

2 = Standard value of equation

3.2.3 Chemical parameter

p^H

p^H meter (HANNA instruments, model: H1-8140) was used to determine the p^H of water of the study points. The meter was calibrated according to its manual provided by the manufacturer company.

Dissolved oxygen (mg/L)

For the determination of dissolved oxygen a digital dissolved oxygen meter (YK-22DO) was used.

Fig 3.4 Determination of air temperature

Fig 3.5 Determination of tater temperature

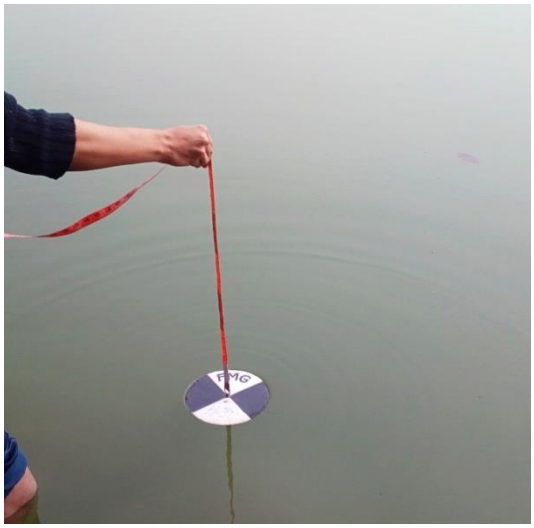

Fig 3.6 Determination of water transparency

Fig 3.7 Determination of p^H

Fig 3.8 Determination of DO

3.3 Plankton enumeration

3.3.1 Collection of plankton sample and preservation

Plankton sample were collected monthly by pooling 10 L of water from three locations of each sites and passing it through plankton net (mesh size 0.04 mm). Each filtered sample was transferred to a measuring cylinder and made up to a standard volume of 50 ml with distilled water and buffered formalin (10%) and preserved in a small sealed plastic bottle until analysis.

Fig 3.9 Collection of plankton sample

Fig 3.10 Preservation of plankton sample

3.3.2 Analysis of phytoplankton

(a) Qualitative analysis

For the qualitative analysis a binocular microscope was used which magnification was 10× 0.25. Taxa of plankton were identified to genus level using keys from APHA (1992).

(b) Quantitative analysis

For quantitative study of plankton, S-R (Sedgwick-Rafter) cell was used. One ml of concentrated plankton sample from each preserved sample was taken in S-R cell. The sample was taken in the cell by a dropper and then placed on the counting chamber of S-R (Sedgwick-Rafter) cell.

The Sedgwick-Rafter cell used to count plankton is approximately 50 mm in length and 20 mm wide. The depth of the cell is 1 mm deep and the entire volume is 1000 mm^3 or 1 ml. The counting chamber is separated into 1000 fields equally and each having a volume of 0.001 ml. The S-R cell was allowed to stand at least fifteen minutes to settle the planktons on the cell. The cell was then set on an electric microscope (XSZ-107BN). Planktonic organisms present in 10 fields from the total 1000 fields which was randomly chosen for phytoplankton counting. After that the plankton abundance was calculated using the following formula (Rahman, 1982).

$$N=\frac{A\times 1000\times c}{V\times F\times L}$$

Where,

N= number of plankton cells per liter

A= Total number of plankton counted

C= Volume of final concentrate of samples in ml

V= Volume of a field in cubic millimeter

F= Number of the fields counted

L= Volume of original water in liter

The average number of plankton was recorded which was expressed numerically per liter of water (cells/L).

Fig 3.11 Identification and counting of plankton by using S-R cell

3.4 Statistical Analysis

For the analysis of data one-way ANOVA (Analysis of variance) was done by using SPSS (Statistical analysis for social science) version 16.0 for windows. The significance was assigned at 0.05% level.

CHAPTER IV

RESULTS

4.1 Water quality parameters

In the experimental study seasonal variations of various physical and chemical parameter of the Ramsagar lake were measured under Summer, Autumn, Winter and Spring seasons. Each seasons consists of three months, as April to June (Summer), July to September (Autumn), October to December (Winter), January to March (Spring). The physical parameters (Temperature in air and water, transparency) and the chemical parameters (DO and p^H) were measured during the experimental period. The mean values of different water quality parameters are shown in Table 4.1.

Table 4.1 Mean values (SD±) and ranges of physical parameters in four seasons during the study period

Parameters	Sampling season			
	Summer	Autumn	Winter	Spring
Air temperature (˚C)	31.23±2.72	33.33±3.99	24.45±3.99	20.88±2.54

	(27.70-34.10)	(31.58-34.82)	(19.68-29.33**)**	(18.63-24.82)
Water temperature (˚C)	31.42±1.92 (28.90-33.12)	31.66±1.89 (29.94-33.89)	23.45±2.56 (21.16-27.11)	22.23±2.17 (20.43-25.44)
Transparency (cm)	43.72±5.76 (34.48-50.04)	47.52±4.37 (40.66-54.23)	43.42±2.89 (38.93-47.32)	36.91±6.53 (27.47-45.77)

Table 4.2 Mean values (SD±) and ranges of chemical parameters in four seasons during the study period

Parameters	Sampling season			
	Summer	Autumn	Winter	Spring
Dissolved Oxygen (mg/l)	7.25±0.42 (6.46-7.75)	7.33±0.23 (6.82-7.61)	8.01±0.42 (7.38-8.63)	6.98±1.06 (5.32-8.17)
p^H	7.27±0.36 (6.67-7.77)	6.85±0.25 (6.45-7.32)	7.26±0.27 (6.88-7.69)	7.51±0.27 (7.12-7.98)

Table 4.3 Comparison of physical parameters (mean) of four seasons using ANOVA (N=108).

Parameters	Sampling Season					Level of significance
	Summer	Autumn	Winter	Spring	P value	
Air temperature (˚C)	31.23^{c}	33.33^{c}	24.45^{b}	20.88^{a}	38.59	*
Water temperature (˚C)	31.42^{b}	31.66^{b}	23.45^{a}	22.23^{a}	56.05	*
Transparency (cm)	43.72^{b}	47.52^{b}	43.42^{b}	36.91^{a}	7.74	*

*Values with different superscript letters in the same row indicate a significant difference at 5% significance based on one way ANOVA followed by Tukey's test

Table 4.4 Comparison of chemical parameters (mean) of four seasons using ANOVA (N=108)

Parameters	Sampling season				P value	Level of significance
	Summer	Autumn	Winter	Spring		
DO (mg/L)	7.25^{a}	7.33^{ab}	8.01^{b}	6.98^{a}	4.48	*

p^H	7.27^b	6.85^b	7.26^b	7.51^a	7.66	*

*Values with different superscript letters in the same row indicate a significant difference at 5% significance based on one way ANOVA followed by Tukey's test.

4.1.1 Physical parameters

4.1.1.1 Air temperature

Figure 4.1 represents the variation of air temperature monthly consequent to the season during the study period. The temperature of air gradually decreased from summer to winter season and after the winter the temperature again increased. During the study period the temperature was found to vary 18.23 to 35.82˚C where the highest value was 35.20˚C, which was found in June month of Summer season at site 2 and the lowest value was 18.23 which was found in January month of Spring season at site 1. The mean values (±SD) of temperature of air was found in four seasons were Summer (31.23±2.72˚C), Autumn (33.33±3.99˚C), Winter (24.45±3.99˚C) and Spring (20.88±2.54˚C). Air temperature varied significantly ($P<0.05$) during the study period.

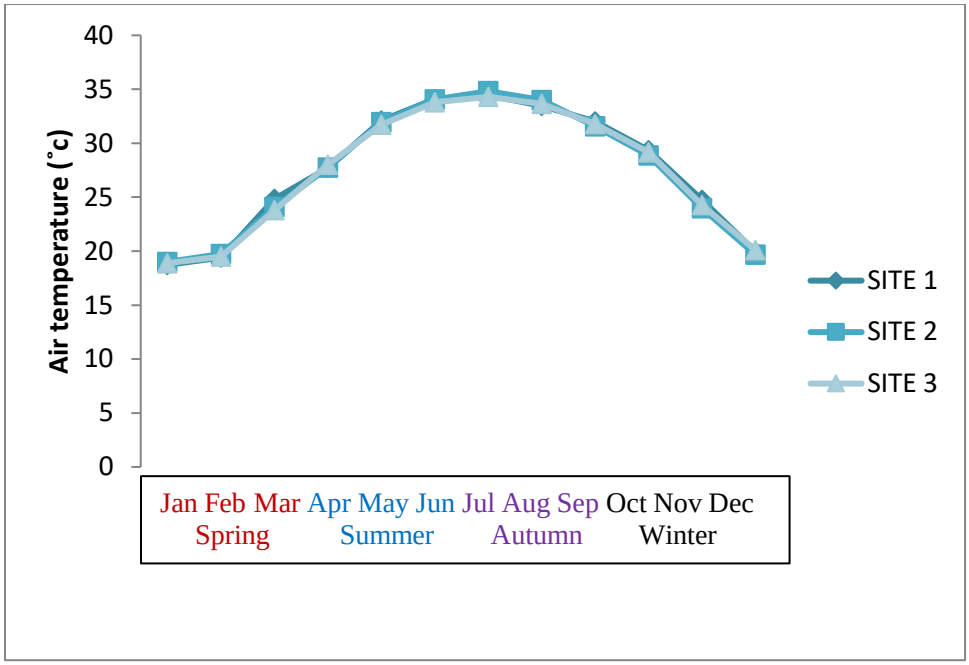

Figure 4.1 Monthly/ Seasonal variation of air temperature in different sites

4.1.1.2 Water temperature

Figure 4.2 represents Monthly/Seasonal variation of water temperature in different sites and seasons. The water temperature gradually decreased from summer to winter season and after the winter the temperature again increase. During the study period the temperature was found to vary 20.43 to 33.89˚C degree Celsius where the highest value was which was found in June (33.89˚C) of Summer season at site 2 and the lowest value was which was found in January month of spring season (20.43˚C) at site 1. The mean values (±SD) of temperature of water was found in four seasons were (31.42±1.92˚C) in Summer, (31.66±1.89˚C) in Autumn, (23.45±2.56˚C) in Winter and (22.23±2.17˚C) in Spring. Water temperature varied significantly ($P<0.05$) among the seasons during the study period.

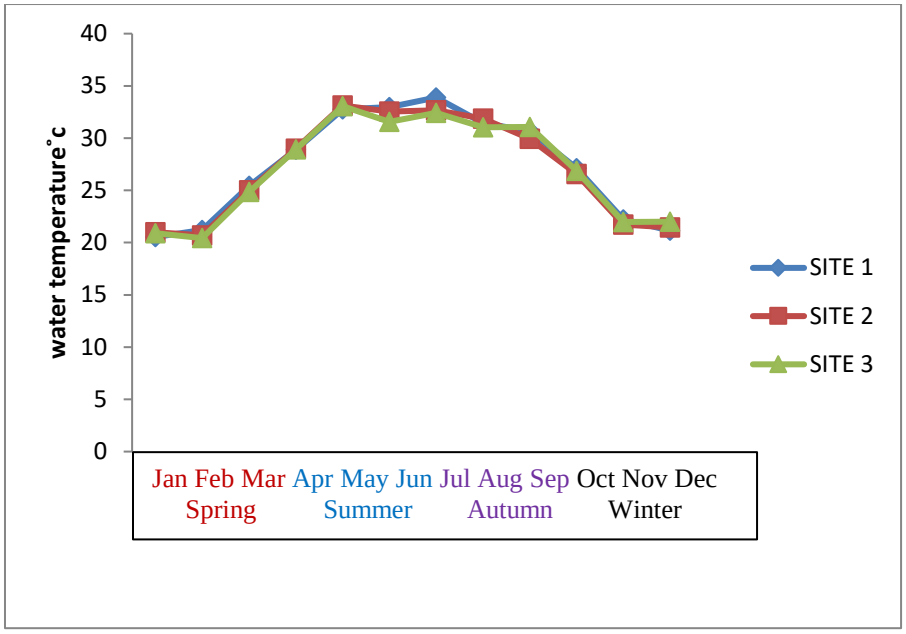

Figure 4.2 Monthly/Seasonal variation of water temperature in different sites

4.1.1.3 Water transparency

Figure 4.3 represents the monthly/ seasonal variation of water transparency in different sites. The values of transparency were from 28.50 to 54.43(cm) in Ramsagar lake water. The mean values of Secchi depth (cm) were highest in July month of autumn season and the lowest value was found in March of spring season. The highest values of transparency were found 54.43 cm in the July month at site 2 and the lowest value 28.50cm was recorded in March. The mean (±SD) values of transparency in four seasons were found as Summer (43.72±5.76cm), Autumn (47.52±4.37cm), Winter (43.42±2.89) and Spring (36.91±6.53). There the significance ($P<0.05$) of transparency among the four season was observed. The monthly/seasonal variation of transparency is shown in figure 4.3.

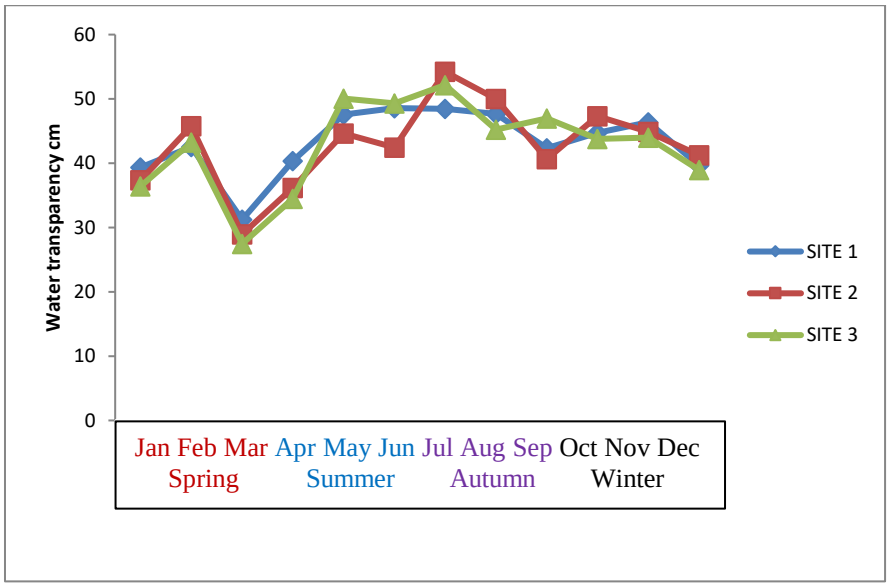

Figure 4.3 Monthly/Seasonal variation of water transparency in sampling sites

4.1.2 Chemical parameters

4.1.2.1 Dissolved oxygen (mg/L)

In Ramsagar the dissolved oxygen concentrations under various treatments were found to fluctuate from 5.25 to 8.67 mg/Lin October (site1) to January (site 3). The highest mean value of dissolved oxygen concentration were 8.01mg/L in winter season and the lowest value of DO was observed 6.98mg/L in spring season. The Dissolved oxygen was varied significantly ($P<0.05$) among the sampling sites and seasons. The mean values of four seasons were 7.25±0.42 in summer, 7.33±0.23 in autumn, 8.01±0.42 in winter and 6.98±1.06 in spring season. Figure 4.4 represents the monthly/ seasonal variation of transparency in different sites.

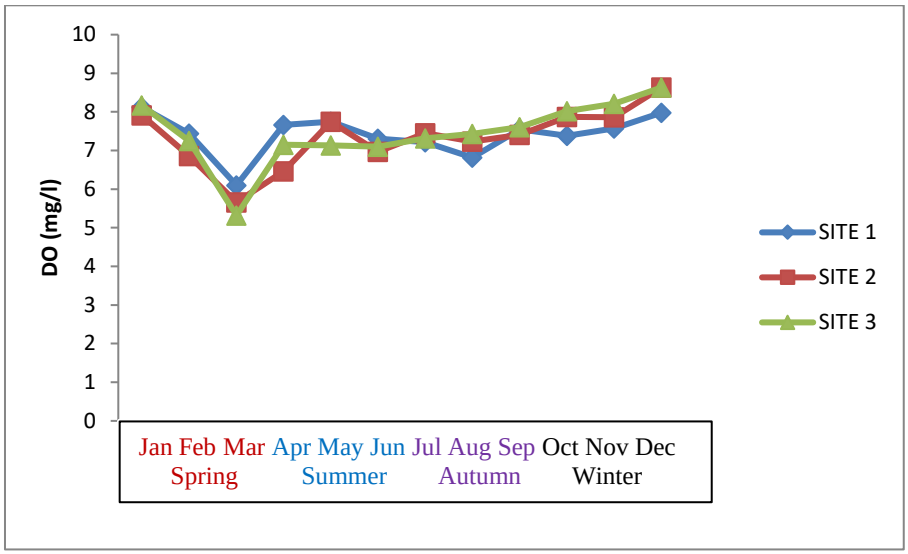

Figure 4.4 Monthly/Seasonal variation of DO in three sampling sites

4.1.2.2 p^H

The p^H values ranged from 6.25 to 8.00. The highest value of p^H was found in January (8.00) of spring season and the lowest values of p^H was found in August (6.25). The sampling was done in the morning (8am-10 am). The highest mean (±SD) values of water were 7.51±0.27 in spring season. The mean (±SD) values were of p^H in 7.27±0.36 summer, 6.85±0.25 in autumn, 7.26±0.27 in winter and 6.98±1.06 in spring. According to the season the p^H of water was varied at ($P<0.05$) significantly. Figure 4.5 represents the seasonal variation of transparency in different months and seasons.

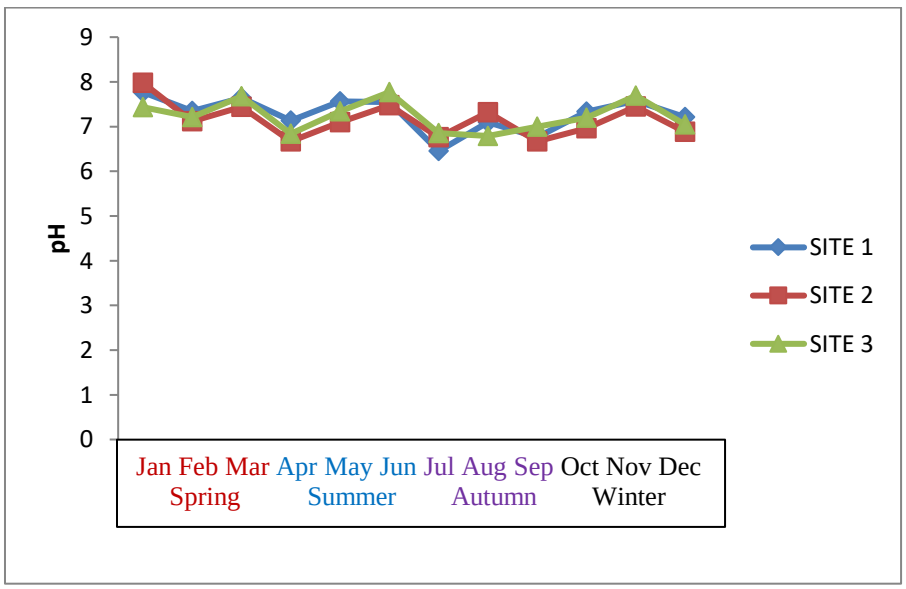

Figure 4.5 Monthly/ Seasonal variation of p^H according to sites and season

4.2 Seasonal variation of plankton community

Chlorophyceae, Bacillariophyceae, Cynophyceae and the Euglenophyceae were the phytoplankton groups of Ramsagar Lake and Cladocera, Copepoda, crustacean and Rotifera are the zooplankton. About 24 species of phytoplankton and 07 species of zooplankton were found in the lake. Among the phytoplankton 10 species of Chlorophyceae, 06 species of Bacillariophyceae seven species of cyanophyceae and one species of euglenophyceae were identified the lake and among the zooplankton three species of Rotifera, one species of cladocera and crustacean and two species of copepod were found. The name of identified plankton community are given below in Table 4.5

Table 4.5 List of plankton genera recorded from the Ramsagar Lake during the study period

Phytoplankton	Phytoplankton	Phytoplankton	Zooplankton
Chlorophyceae	**Bacillariophyceae**	**Cyanophyceae**	**Rotifera**
Ceratium	*Astorionella*	*Anabaena*	*Asplanchna*
Chlorella	*Cyclotella*	*Gloeocapsa*	*Brachionus*
Coelastrum	*Fragillaria*	*Microcystis*	*Keratella*
Oocystis	*Navicula*	*Nostoc*	**Cladocera**
Microspora	*Nitzschia*	*Oscillatoria*	*Daphnia*
Pediastrum	*Surirella*	*Spirulina*	**Crustacean**
Scenedesmus	*cosmarium*		*Nauplius*
Ulothrix		**Euglenophyceae**	**Copepoda**
Volvox		*Euglena*	*Cyclops*
Zygnema			*Diaptomus*

Table 4.6 Mean values (SD±) and ranges of phytoplankton groups (×10^{3}Cells/L) in four seasons during study period

Plankton groups (×10^{3}Cells/L)	Sampling seasons			
	Summer	Autumn	Winter	Spring
Chlorophyceae	4.25±0.93 (2.75-6.00)	3.68±0.67 (2.75-5.25)	3.07±0.61 (2.00-4.75)	3.20±0.79 (1.255.25)
Bacilllariophyceae	1.62±0.36 (1.0-2.50)	0.97±0.44 (0.25-1.75)	1.11±0.32 0.75-1.75)	1.07±.36 (0.50-2.00)
Cyanophyceae	1.69±0.46 (0.75-2.50)	1.05±0.44 (.25-2.00)	0.86±0.31 (0.25-1.5)	1.21±0.40 (0.5-2.00)
Euglenophyceae	0.34±.22 (0.00-.75)	0.25±0.18 (0-.50)	0.14±.14 (0.00-0.5)	0.23±0.20 (0.00-0.5)

Table 4.7 Mean values (SD±) and ranges of zooplankton groups (×10^{3}Cells/L) in four seasons during study period

Plankton groups (×10^{3}Cells/L)	Sampling seasons			
	Summer	Autumn	Winter	Spring
Rotifera	0.73±0,23 (0.00-1.25)	0.96±0.42 (0.25-2.00)	0.68±0.38 (0.25-1.50)	0.54±0.25 (0.25-1.00)
Cladocera	0.25±0.15 (0.00-0.50)	0.23±0.15 (0.00-0.50)	0.16±0.15 (0.00-0.50)	0.20±0.13 (0.00-0.50)
Copepoda	0.51±0.21 (0.25-1.00)	0.44±0.21 (0.00-0.75)	0.41±0.19 (0.00-0.75)	0.50±0.22 (0.25-1.00)
Crustacean	0.34±0.19 (0.00-0.75)	0.30±0.18 (0.00-0.50)	0.20±0.12 (0.00-0.50)	0.24±0.14 (0.00-0.50)

Table 4.8 Mean values (SD±) and ranges of plankton groups (×10^{3}Cells/L) in four seasons during study period

Plankton groups (×10^{3}Cells/L)	Sampling seasons			
	Summer	Autumn	Winter	Spring
Total phytoplankton	7.91±1.49 5.25-11	5.96±1.03 4.50-7.75	5.19±0.91 3.75-6.75	5.75±1.00 3.75-8.25
Total zooplankton	1.94±0.53 1.0-3.0	1.47±0.57 0.50-2.50	1.39±0.43 0.75-2.25	1.87±0.45 1.0-2.75
Total plankton	9.78±1.70 6.75-13.25	8.09±1.62 5.75-1.25	6.66±1.08 4.75-8.00	7.15±1.14 5.00-10.0

Table 4.9 Comparison of abundance of plankton (×10 ^{3} Cells /L) with their different groups of four seasons using ANOVA

Plankton groups (×10 ^{3} Cells /l)	Sampling seasons				P value	Level of significance
	Summer	Autumn	Winter	Spring		
Chlorophyceae	4.25^c	3.68^b	3.07^a	3.20^a	13.39	*
Bacillariophyceae	1.62^b	0.97^a	1.11^b	1.07^a	16.16	*
Cyanophyceae	1.69^c	1.05^{ab}	0.87^a	1.25^b	20.56	*
Euglenophyceae	0.34^b	0.25^{ab}	0.14^a	0.23^a	4.47	*
Total Phytoplankton	7.91^b	5.96^a	5.19^b	5.75^c	143.03	*
Rotifera	0.75^{ab}	0.96^b	0.68^a	0.54^a	7.23	*
Cladocera	0.25^a	0.23^a	0.16^a	0.20^a	1.55	NS
Copepoda	0.34^c	0.30^b	0.20^a	0.24^{ab}	3.82	*
Crustacean	0.51^a	0.44^a	0.41^a	0.40^a	1.60	NS
Total zooplankton	1.94^b	1.47^a	1.39^c	1.87^a	33.54	*
Total planktom	9.78^b	8.09^b	6.66^a	7.15^c	113.50	*

*Values of various superscript letters in the same row determine the difference of significance at 5% level of significance founded on one-way ANOVA followed by Tukey's test.

Table 4.10 Correlation Matrix between different physico-chemical parameters and phytoplankton

Parameters	Total phytoplankton			
	Summer	Autumn	Winter	Spring
Water temperature	0.688**	0.192	-0.688**	-0.383
DO	0.939	-0.707**	-0.691**	-0.266
P^H	-0.397	0.297	0.388	-0.139
Transparency	-0.575	0.027	0.768**	0.211

Table 4.11 Correlation Matrix between different physico-chemical parameters and zooplankton

Parameters	Total zoooplankton			
	Summer	Autumn	Winter	Spring
Water temperature	-0.595	0.759**	0.809**	-0.076
DO	0.852**	0.443	-0.396	0.880**
P^H	-0.559**	-0.794	-0.691**	0.100
Transparency	-0.678**	0.442	-0.359	0.889**

Table 4.12 Correlation Matrix between different physico-chemical parameters and Total plankton

Parameters	Total plankton			
	Summer	Autumn	Winter	Spring
Water temperature	-0.559	0.528	-0.993**	-0.107
DO	-0.470	-0.794**	0.809**	-0.143
P^H	-0.833**	0.081	-0.404	-0.877**
Transparency	0.983**	0.759**	0.474	0.880**

**correlation is significant at 0.05 levels (2-tailed)

4.2.1 Chlorophyceae

Chlorophyceae was the dominant group of phytoplankton and ranked first position in respect of number of genera and cell density. Figure 4.6 represent the variation of Chlorophyceae cell density per liter during the experimental period. The Chlorophyceae range lowest counts (1.25×10^3) Cells/L in the spring season and the January month and the highest range counts (6.0×10^3) Cells/L in the summer season and June month. The Chlorophyceae mean in four seasons were summer (4.25±0.93) Autumn (3.68±0.67), Winter (3.68±0.67) and Spring (3.20±0.79) Cells/L. Chlorophyceae seasonal variation occurs significantly seasonally. The genera which are dominant were *Ceratium, Cosmarium, Chlorella and Closterium*.

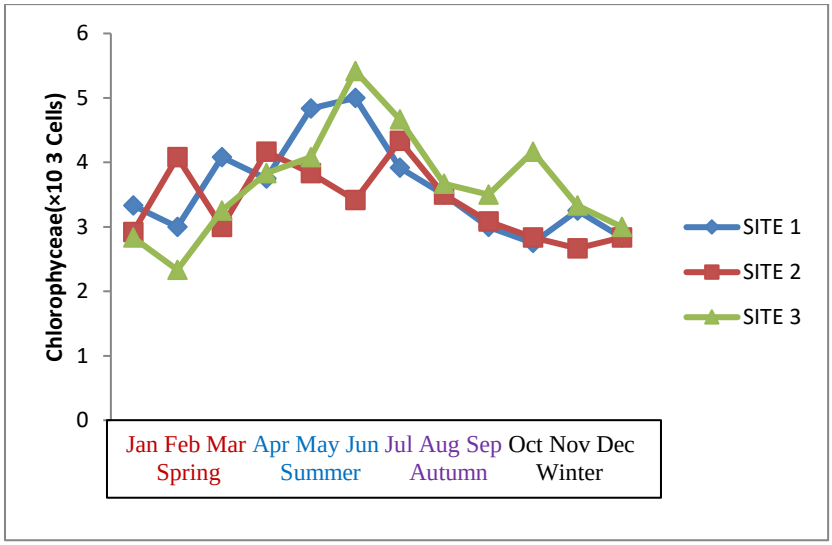

Figure 4.6 Monthly/ Seasonal variation of Chlorophyceae (×10 ^{3} Cells) in different sites

4.2.2 Bacillariophyceae

Bacillariophyceae was the second dominant group of phytoplankton and ranked second position in respect of number of genera and cell density. Figure 4.7 represent the variation of Bacillariophyceae cell density per liter during the experimental period. The Bacillariophyceae range lowest counts (0.25×10^3) Cells/L in the Autumn season. The highest range counts (2.50×10^3) Cells/L in the summer season. The highest amount of plankton found in the June month of summer season and the lowest was found in September month the Bacillariophyceae mean in four season were summer (1.62±0.36) cells/L, Autumn (0.97±0.44) cells/L, Winter (1.11±0.32) cells/L and Spring (1.07±.36) cells/L.

Bacillariophyceae seasonal variation occurs significantly seasonally. Dominant phytoplankton were *cyclotella, Astorionella, Fragillaria, Navicula.*

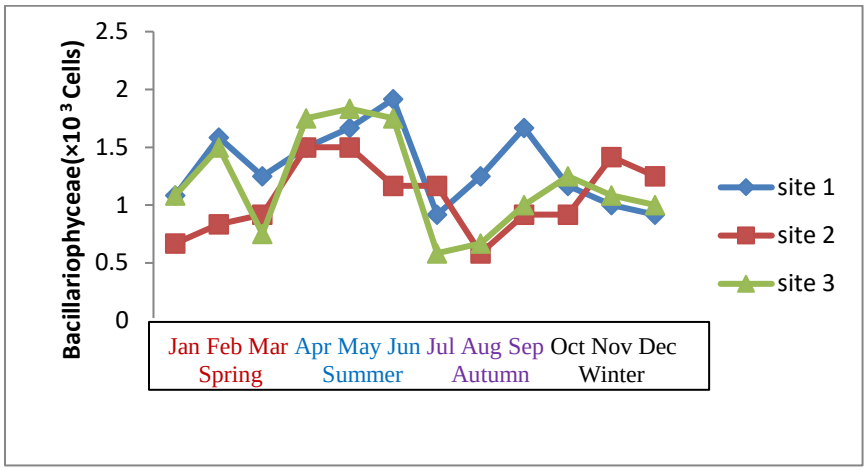

Figure 4.7 Monthly/ Seasonal variation of Bacillariophyceae (×10 3 Cells) in different sites

4.2.3 Cyanophyceae

Cynanophyceae comprised of 4 genera had ranked third in respect of abundance. Among7 genera *Anabaena, Microcystis Nostoc, oscillatoria* were dominant. Figure 4.8 represent the variation of cynanophyceae cell density per liter during the experimental period. Cynanophyceae seasonal variation occurs significantly seasonally. The cynanophyceae range lowest counts (0.25×10^3) Cells/L in the winter season. The highest range counts (1.69×10^3) Cells/l in the summer season. The highest amount of plankton found in the June month of summer season and the lowest was found in December month the cynanophyceae mean in four seasons were summer (1.69±0.46) Autumn (1.05±0.44), Winter (0.86±0.31) and Spring (1.21±0.40).

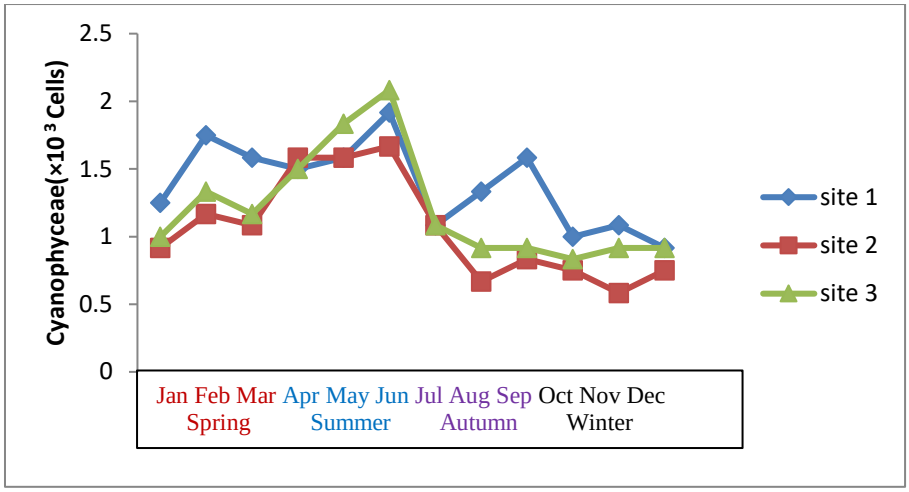

Figure 4.8 Monthly/ Seasonal variation of Cyanophyceae (×10 3 Cells) in different sites

4.2.4 Euglenophyceae

Euglenophyceae comprised of 4 genera had ranked third in respect of abundance and observed rarely over the year. There are only one genera of Euglenophyceae were found during the study period. Figure 4.9 represent the variation of Euglenophyceae cell density per liter during the experimental periods the lowest range counts (0.34×10^3) Cells/L in the summer season. The highest amount of Euglenophyceae was found in the June month of summer season. Month the Euglenophyceae mean in four seasons were Summer (0.34±.22) Autumn (0.25±0.18), Winter (0.14±.14) and Spring (0.23±0.20).

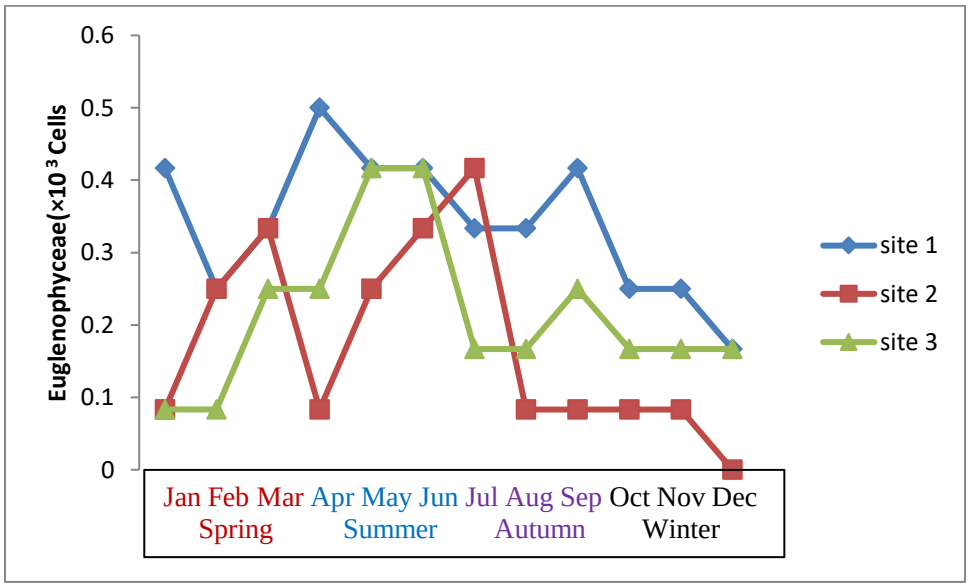

Figure 4.9 Monthly/ Seasonal variation of Euglenophyceae (×10 3 Cells)in different sites

4.2.5 Total phytoplankton

Chlorophyceae and Bacillariophyceae were the most dominant group of phytoplankton among the all phytoplankton groups but Euglenophyceae was the least abundant groups. The total phytoplankton was highest in the summer season and lowest in the winter. Phytoplankton abundance was varied in four season were Summer (7.91±1.49), Autumn (5.96±1.03), Winter (5.19±0.91) and Spring (5.75±1.00) Cells/L. Figure 4.10 represented phytoplankton production is positively correlated with water quality parameters (Temperature, DO, Transparency and p^H).

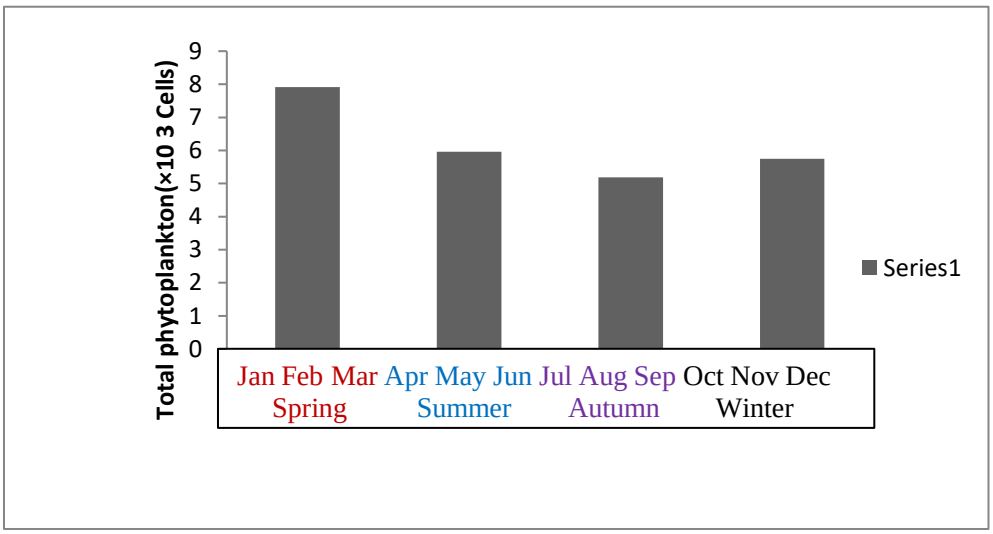

Figure 4.10 Seasonally variation of Total phytoplankton (×10 ^{3} Cells) in different sites

4.2.6 Rotifera

Rotifera was the most dominant group of zooplankton found during the study period. Total 7 genera of zooplankton were found in Ramsagar lake and among them *Asplancha*, *Brachionus* and *Keratella* was most dominant over others. The Rotifera abundance varied significantly ($P<0.05$) among various season (Table 4.9). Maximum Rotifera abundance was observed in the Autumn season and September month and the minimum in the spring season and January month. The mean values of Rotifera were Summer (0.73±0.23), Autumn (0.96±0.42), Winter (0.68±0.38) and Spring (0.54±0.25) Cells/L. Figure 4.11 represent the variation of Rotifera cell density per liter during the experimental period.

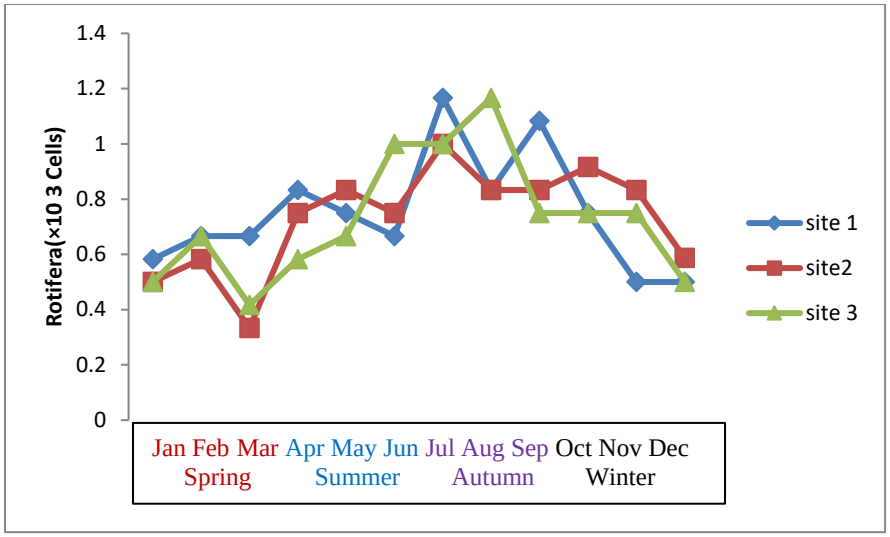

Figure 4.11 monthly/seasonal variation of Rotifera (×10 ^{3} Cells) in different sites

4.2.7 Cladocera

There are only one genera of cladocera was found during the study period. Daphnia was found in four seasons and highest number of Daphnia was found in June month of summer season and lowest number was found in December month of winter season. The cladocera abundance was not varied significantly ($P<0.05$) among various season (Table 4.9). The mean values of Rotifera were Summer (0.25±0.15), Autumn (0.23±0.15), Winter (0.16±0.15) and Spring (0.20±0.13) Cells/L Figure 4.12 represent the variation of Cladocera cell density per liter during the experimental period.

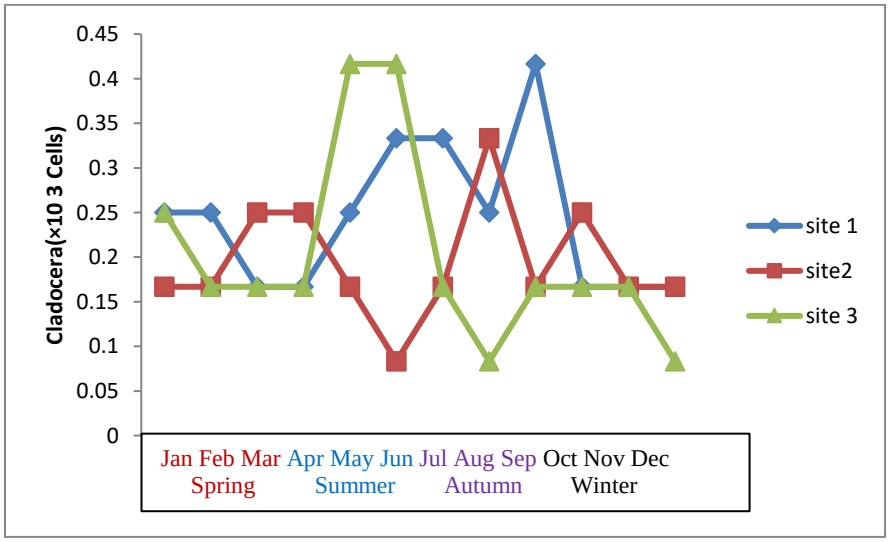

Figure 4.12 monthly/seasonal variation of Cladocera (×10 ^{3} Cells) in different sites

4.2.8 Copepoda

Copepoda was the second dominant group of zooplankton found in Ramsagar lake water during the study period. There are two genera were found, they are *Cyclops* and *Diaptomus* and *Cyclops* was dominant. Copepoda was found maximum in summer season and may month and minimum in winter season and December month. The Copepoda abundance varied significantly ($P<0.05$) among various season (Table 4.9). The mean values of Copepoda were Summer (0.34±0.19), Autumn (0.30±0.18), Winter (0.20±0.12) and Spring (0.24±0.14) Cells/L Figure 4.13 represent the variation of Copepoda cell density per liter during the experimental period.

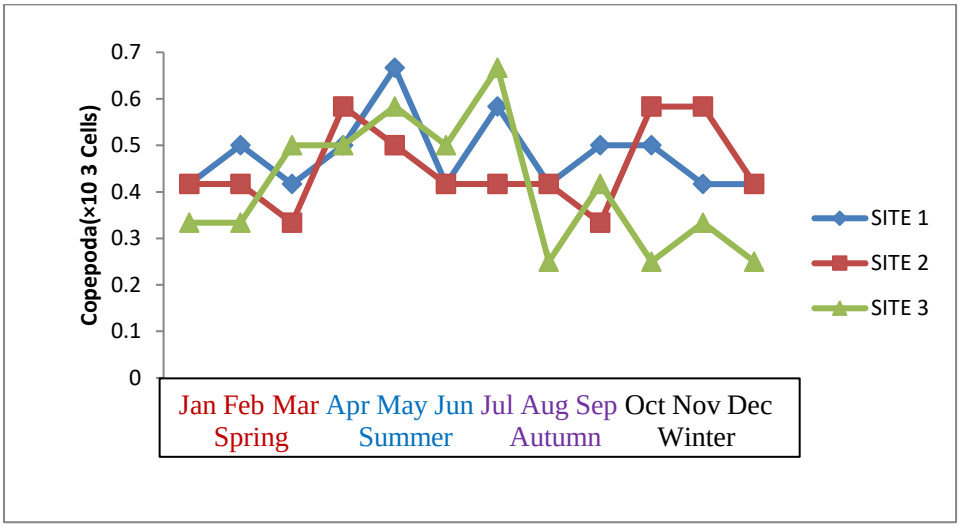

Figure 4.13 Monthly/seasonal variation of Copepoda (×10 ^{3} Cells) in different sites

4.2.9 Crustacean larva

There are only one genera of crustacean larvae were found during the study period. Crustacean was least abundant group phytoplankton in Ramsagarlake during the study period. *Nauplius* was only one genera of crustacean which was dominant. Crustacean larvae were found maximum in summer season and June month and minimum in winter season and November month. The crustacean larvae abundance was not varied significantly among various seasons (Table 4.9). The mean values of crustacean larvae were summer (0.51±0.21), Autumn (0.44±0.21), Winter (0.41±0.19) and Spring (0.50±0.22) Cells/L. Figure 4.14 represent the variation of Copepoda cell density per liter during the experimental period.

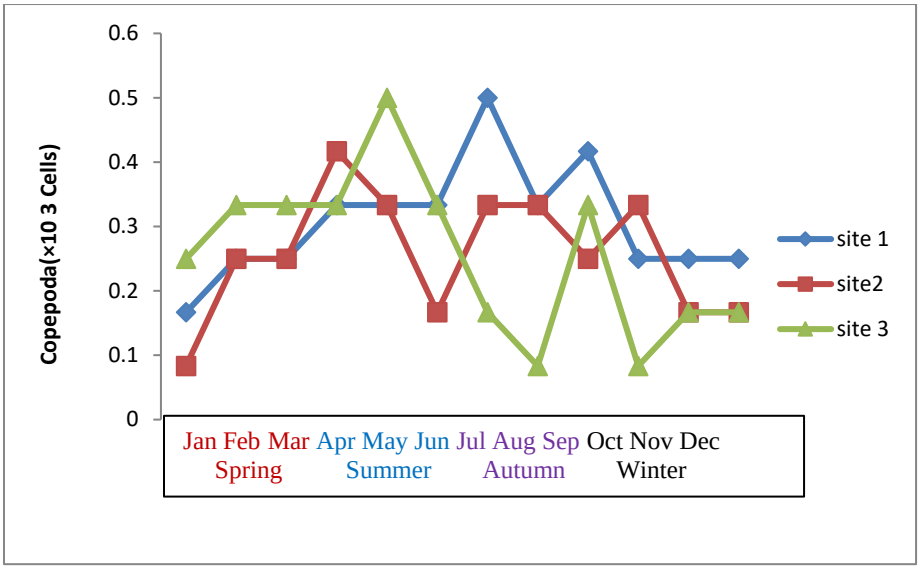

Figure 4.14 Monthly/Seasonal variation of Crustacean (×10 ^{3} Cells) in different sites

4.2.10 Total zooplankton

Total zooplankton abundance was highest in the summer season (1.94×10$^{3)}$ and lowe3st in the winter season (1.39×10^{3}) cell/L. During the rest of the year the abundance of total zooplankton was decreased gradually and after than increased. The abundance varied significantly (P<0.05) during the study period (Table 4.9). Zooplankton abundance was varied in four season were summer (1.94±0.53), Autumn (1.47±0.57), Winter (1.39±0.43) and Spring (1.87±0.45) Cells/L. Figure 4.15 represented phytoplankton production is positively correlated with water quality parameters (Temperature, DO, Transparency and p^{H}).

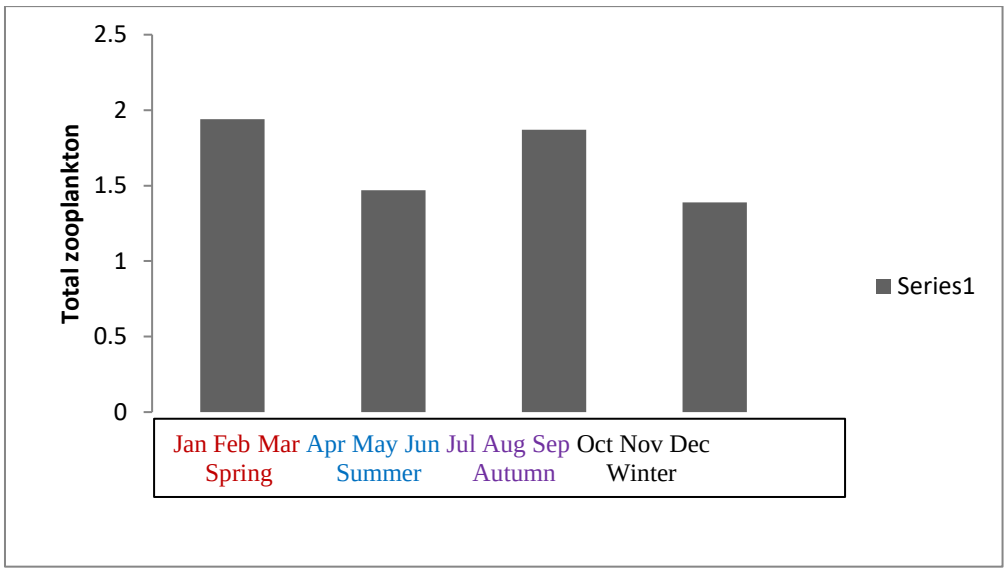

Figure 4.15 Seasonal variation of Total zooplankton

4.2.11 Total plankton

Figure 4.15 represent the seasonal variation of zooplankton during the study period. Total zooplankton abundance maximum in the summer season and minimum in the winter period. The abundance varied significantly during the study period (Table 4.9) plankton abundance was varied in four seasons were Summer (9.78±1.70), Autumn (8.09±1.62), Winter (6.66±1.08) and Spring (7.15±1.14) Cells/L.

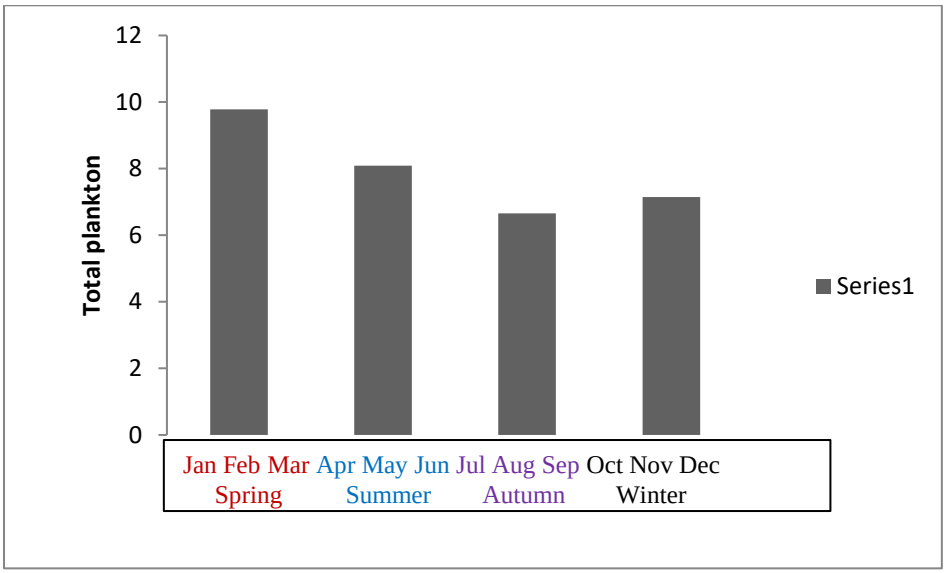

Figure 4.16 Seasonal variation of Total plankton

4.2.12 Composition of Plankton community

During the overall experimental period phytoplankton was dominant in the community. About 20% of phytoplankton and 20% of zooplankton consists all over the year (Fig 4.16)

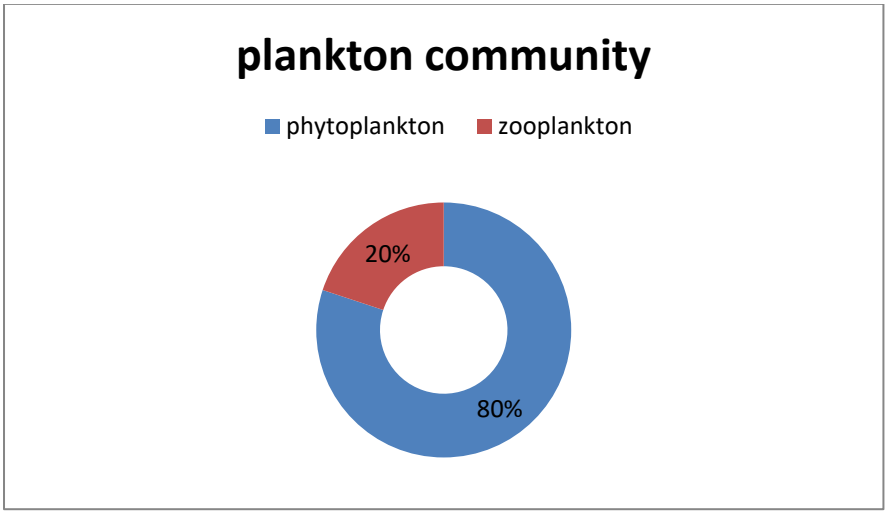

Figure 4.17 percentage composition of plankton of Ramsagar during the study period

Plankton composition variation in different season are given below-

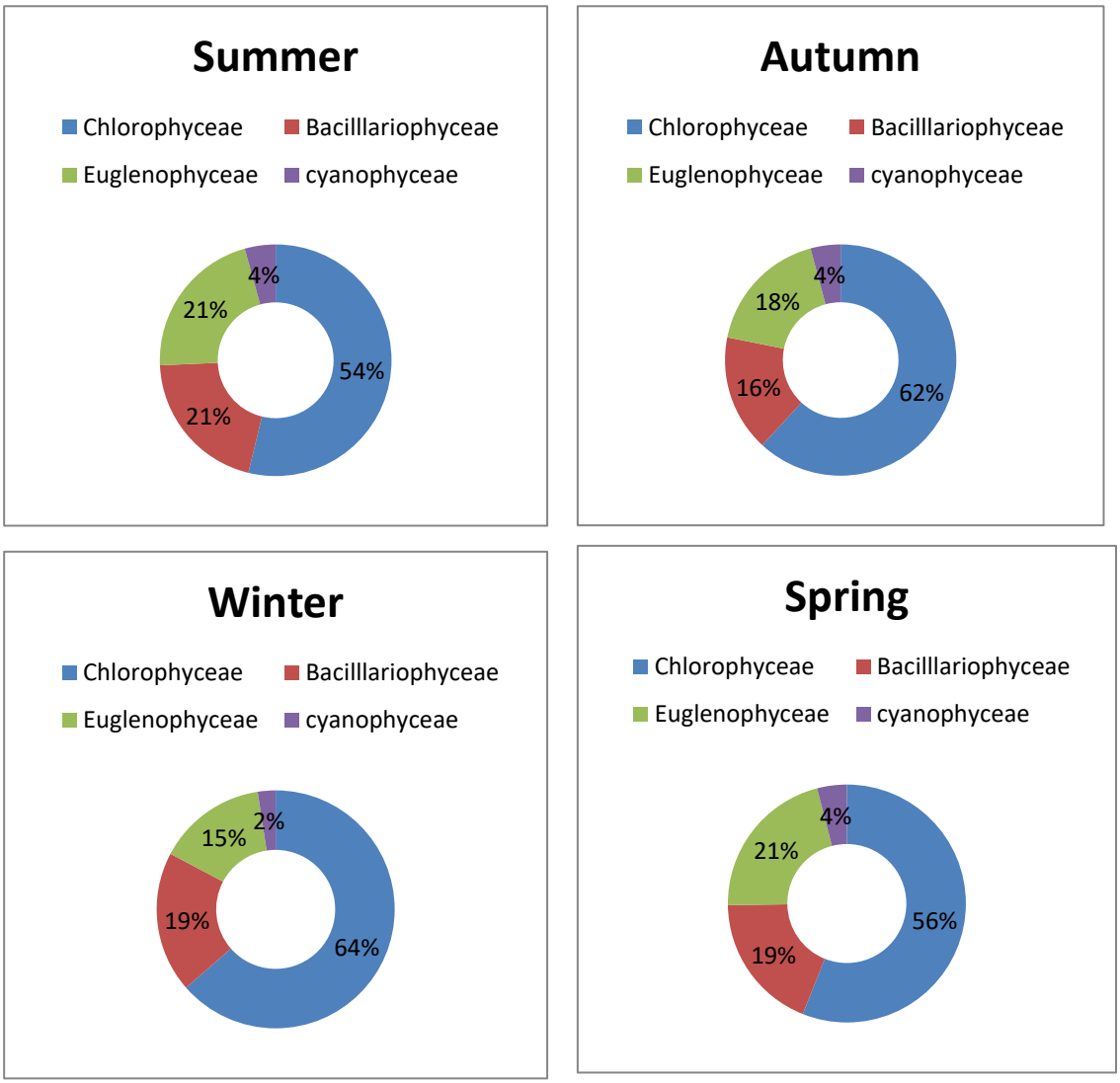

Figure 4.18 percentage composition of each group phytoplankton of Ramsagar seasonally during the study period

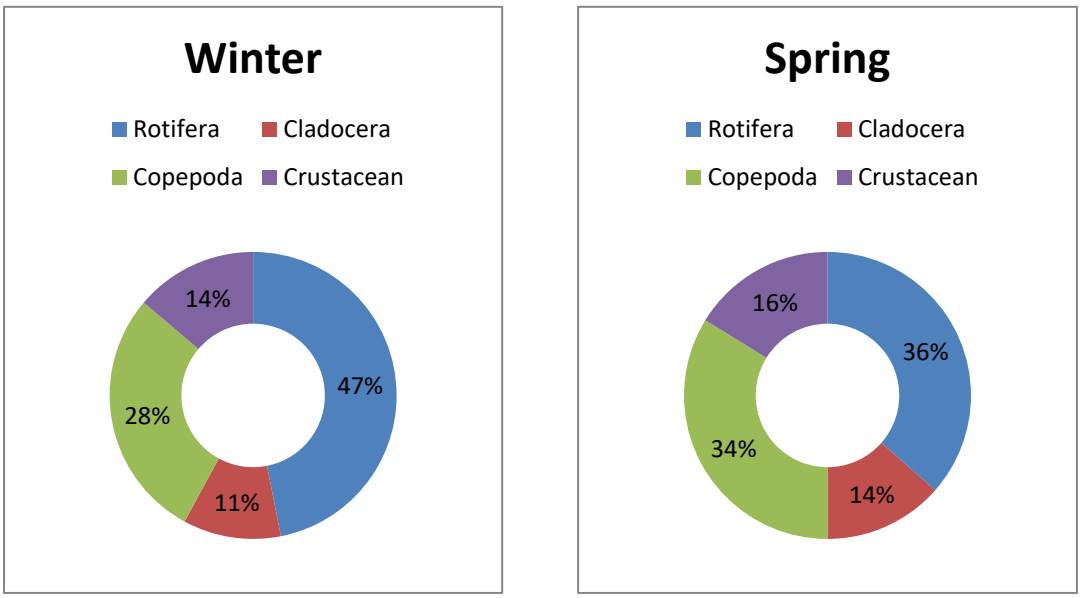

Figure 4.19 percentage composition of each group Zooplankton of Ramsagar seasonally during the study period

CHAPTER V

DISCUSSION

Water quality parameters are very important for the growth and reproduction of aquatic organisms. Initial production of water and growth of phytoplankton and zooplankton are fully dependent on various water quality parameters. Physical, chemical and biological parameters can maintain the water environment (Rahman, 1992). The results of the study on various water quality parameters, plankton populations, their diversity and seasonal variation in the Ramsagar lake are discussed below.

5.1 Water quality parameters (physical and chemical)

5.1.1 Water temperature

Temperature is the most significant environmental water quality factor with large effects on primary production and aquatic plants and animals. Aquatic ecosystem is influenced by temperature. Metabolic activities of all aquatic animals are depending on the fluctuation of temperature. During the study period the air temperature ranged from 18.23 to 35.82^{0}C among the months and seasons and the water temperature ranged varied 20.03 to 34.89^{0}C in the Ramsagar lake water. Water temperature ranges were higher in the summer season and the lower in the winter season, which is within the ranges (18.64-37.82^{0}C) for suitable plankton production (Begum *et al*. 2007); Ferdoushi *et al*. (2015) found the water temperature range (16.70-33.80^{0}C) in a study in Ramsagar Lake which is similar to our study. For fish culture the suitable range of temperature is (20-32^{0}C). In our study we found the suitable range of temperature which is essential for fish culture. There was significant difference between four seasons were found in case of temperature, when performed the statistical analysis.

5.1.2 Transparency

Transparency of water has direct relation with food production in water body. During the experimental session, water transparency ranged was (28.50 to 54.43) cm in the experimental lake, Boyd (1990) suggested that the transparency of water affected by different factors such as silt, microscopic organisms, suspended organic matter, latitude and intensity of light, application of fertilizers, grazing pressure of fishes and recommended a suitable range of transparency in lake between 15 and 40 cm. (Rahman *et al.*1982) suggested that the transparency of water bodies range should be (40 cm) or below it, which is similar to our study There was significant difference ($P<0.05$) between four seasons in case of water transparency, when statistical analysis was performed (Table 4.3).

5.1.3 Dissolved Oxygen

DO is a vital water quality parameter which plays important role for the aquatic organism. In Ramsagar, the dissolved oxygen concentrations under various treatments were found to fluctuate from (5.25 to 8.67) mg/L in October (site1) to January (site3). Where Banerjee (1967) said that the range (5.0 to 7.0 mg/L) DO in water to be suitable in respect of productivity and water having dissolved oxygen below 5.0 mg/L are not productive for aquatic organism. Ferdoushi *et al.* (2015) studied in Ramsagar lake and the range of DO were found (5.10- 9.90) mg/L which is more or less similer to our study. Wahab *et al*.

(1995) found lower DO range from (2.0 to 7.2) mg/L by their study from the ponds of BAU, Mymansingh. The suitable range of a water body for plankton growth would be (5- 8.0) mg/L for DO, DoF (1996). In our study the DO were in suitable range which is important for fish culture.

5.1.4 p^H

During the study period the pH values ranged from (6.25 to 8.00). The highest value of p^H was found in January (8.00) of spring season and the lowest values of p^H was found in August (6.25). An average ranged p^H was found during the study period. Mostly alkaline situation were shown. Ferdoushi *et al.* (2015) studied in Ramsagar lake and the range of p^H were found (6.53-7.84) during the study period, which is more or less similer to our study. (Ahmed *et al.* 2010) found similar results during the study. Begum *et al*. (2007) found the p^H range (6.6-8.0) during the study period. The suitable range of p^H for fish culture is (7-8) DoF (1996). The p^H range of Ramsagar Lake is suitable for culture and growth of other productive species in water. There was significant difference ($P<0.05$) among the four seasons when statistical analysis was performed.

5.2 Plankton population

5.2.1 Phytoplankton

In Ramsagar lake water there are high density of plankton present and between phytoplankton and Zooplankton phytoplankton are dominant group. About 80% of total plankton was phytoplankton and *Ceratium, Closterium, Cosmarium, Anabaena, Cyclotella, Fragillaria*, etc are present in high density. High density of phyplankton present in summer and Autumn season and low density were found in winter. Chlorophyceae was the most dominant group of phytoplankton in abundance during the whole year. Ferdoushi *et al.* (2013) studied in Ramsagar and found Chlorophyceae was most dominant, which is similar with the present study in Ramsagar lake.

Bacillariophyceae was the second dominant group of phytoplankton in Ramsagar lake. Ferdoushi *et al* (2015) studied in Ramsagar Lake and found the Bacillariophyceae was the second dominant group. Highest amount were found in july month and lowest in December. The density was highest in summer season. Dewan (1973) studied the seasonal variation of phytoplankton in a lake of BAU campus where Bacillariophyceae dominant in summer season. There was significant difference between three sites was observed.

Cyanophyceae was the third position in abundance in Ramsagar lake water. Most dominant species under Cyanophyceae were *Anabaena, Microcystis, Oscilllatoria.* In summer season the abundance of cynaphyceae was high. Cyanophyceae was third dominant phytoplankton group reported by Ahmed *et al.* (1992)) in kaptai lake. Was no seasonally significant difference between three sites was observed during the study period. Ferdoushi *et al* (2013) studied in Ramsagar Lake and there were no significance difference found, which is similar with our study.

Euglenophyceae was observed the forth and least dominant in Ramsagar lake. Ferdoushi *et al.* (2013) studied in Ramsagar lake and found the Euglenophyceac was the last abundance group of phytoplankton then other groups. This finding consents with our findings. Fewer abundance of Euglenophyceae was found during the study. There is only one genus *Euglena* was identified from the lake. Arimoro *et al.* (2008) observed only one genus of Eugenophyceae during the study period in a lake.

Total phytoplankton was the highest in June and the lowest in February. The highest Phytoplankton observed in June and July by Aziz *et al.* (2003) in Ramsagar lake. Total phytoplankton abundance was the highest in June and the lowest in January by Arimoro *et al.* (2008). This is more or less same to our experimental study. Phytoplanktons are the primary producer in water body. These phytoplanktons are the main food for fish, and they shall be helpful for the growth and reproduction of fish in Ramsagar Lake.

5.2.2 Zooplankton

There are four group of zooplankton were found in Ramsagar lake water and 20% of total plankton during the study. Changing of different water quality parameters are directly related with zooplankton production. Among the zooplankton Rotifera was most dominant. Roy *et al*. (2009) studied in a lake in Khulna and found Rotifera was most dominant species which is similar with our study. Ahmed *et al*. (1992)) found that Rotifera was the most dominant group during the study in Kaptai lake which similar with our study. Chowdhury *et al.* (2008) also observed the Rotifera was the most dominant group then other groups in the study. Total zooplanktons were dominant in June and July month and least in December. Chowdhury *et al.* (2008) also observed in beel that the maximums zooplankton found in

August and the minimum in October. It may be due to variance of location and water quality.

In our study Copepoda was the second dominant group. There are two genus of Copepoda were found. In June and July month the abundance was maximum. Ahmed *et al*. (1992)) found that Cladocera was the second dominant group during the study in Kaptai lake which similar with our study. Similar result was found Nesar (2008) in a lake and a baor in Meherpur.

Cladocera was the third dominant group and crustacean was least group of zooplankton found in Ramsagar Lake. There are only genus of both groups were found. Seasonal variation and abundance fluctuation were observed during the study period. Cladocera found higher amount in April and may and lower in October month. Crustacean abundance was highest in April and may and least November. In Kaptai lake Ahmed (1992) *et al*. found highest amount of Cladocera and Copepoda in August and lowest in January. This is not similar with our study. This variation occurs due to environmental changes. The zooplanktons are used as food by the fish and they can help for the growth of fish and remove the cost of artificial food in Ramsagar Lake.

CHAPTER VI

SUMMARY AND CONCLUSION

The experiment on Abundance and seasonal variation of planktonic community structure in the Ramsagar lake was carried out for a period of one year (January to December 2017). Some water quality factors such as air temperature, water temperature, transparency, DO and p^H were recorded monthly. Three specific sites of the Ramsagar lake were selected for the experimental study.

During the study period the air temperature of water ranged from 18.23 to 35.82^{0}C among the seasons. The highest mean value of air temperature was found in Autumn and lowest in the winter. The mean values (±SD) of temperature of air were found in four seasons as summer (31.23±2.72˚C), autumn (33.33±3.99˚C), winter (24.45 ±3.99˚C) and spring (20.88 ±2.54˚C). Water temperature was found to varied from 20.03 to 34.89 ˚C which is suitable for plankton production. The mean values (±SD) of temperature of water were found in four

seasons as summer (31.42±1.92˚C), Autumn (31.66±1.89˚C), Winter (23.45±2.56˚C) and spring (22.23±2.17˚C). The range of transparency in Ramsagar lake were found to be 28.50 to 54.43cm. The highest value of transparency was found (54.43) in the July month at site 2 and the lowest value (28.50cm) was recorded in March. The mean (±SD) values of transparency in four seasons were as found summer (43.72±5.76cm), Autumn (47.52±4.37cm), winter (43.42±2.89) and spring (36.91±6.53). The dissolved oxygen concentrations under various treatments were found to fluctuate from 5.25 to 8.67 mg/L in October (site1) to January (site 3). The highest value of dissolved oxygen concentration was 8.01mg/L in winter season and the lowest value of was observed 6.98mg/L in spring season. The mean values of DO four seasons were as (7.25±0.42) in summer, (7.33±0.23) in autumn, (8.01±0.42) in winter and (6.98±1.06) in spring season. The pH values ranged from 6.25 to 8.00. The highest value of p^H was found in January (8.00) of spring season and the lowest value of p^H was found in August (6.25). The mean (±SD) values p^H of were as (7.27±0.36) in summer, (6.85±0.25) in autumn, (7.26±0.27) in winter and (6.98±1.06) in spring. From this study it was termed that all water quality parameters are suitable for growth and reproduction of fish and the fish culture.

In total 4 groups and 31 genera of phytoplankton were observed in the lake. The highest phytoplankton was observed in June-July and the lowest observed in December-January. Seasonally the highest abundance was found in summer and the lowest was in winter. Among the different groups of phytoplankton Chlorophyceae (15) was found to be the dominant group followed by Bacillariophyceae (8), Cynophyceae (7) and Euglenophyceae (1) during the experimental period. The lowest abundance of Chlorophyceae was (1.25×10^3) Cells/L in the spring season and the January month and the highest abundance was (6.0×10^3) Cells/L in the summer season and June month. The Bacillariophyceae abundance lowest was (0.25×10^3) Cells/L in the autumn season. The highest abundance was (2.50×10^3) Cells/L in the summer season. The lowest abundance of Cynanophyceae was (0.25×10^3) Cells/L in the winter season. The highest abundance was (1.69×10^3) Cells/L in the summer season. The lowest abundance of Euglenophyceae was (0.34×10^3) Cells/L in the summer season and the highest amount of Euglenophyceae was found in the June month of summer season.

On the other hand total 7 genera of zooplankton belonging to 4 major groups namely Rotifera (3), Copepoda (2), Cladocera (1) and Crustacea (1) were found during the study period. Among the zooplankton Rotifera was the dominant group. Maximum Rotifera

abundance was observed in the Autumn (0.96×10^3) Cells/L season and September month and the minimum in the spring season (0.54×10^3) Cells/L and January month. Cladocera was found in the four season and highest number of Cladocera was found in June month of Summer season (0.25×10^3) cells/L and lowest number was found in December month of Winter season (0.16×10^3) cells/L. Copepoda was found maximum in Summer season (0.51×10^3) cells/L and May month and minimum in winter season (0.41×10^3) cells/L and December month. Crustacean larvae was found maximum in summer (0.34×10^3) cells/L season and June month and minimum in winter season (0.20×10^3) cells/L and November month. The variations of total plankton were observed in four seasons.

The seasonal variation of plankton density was observed during the study period significantly. In summer season plankton density were found the highest abundance (mean values 9.78±1.70 cells/L) and the winter season the plankton abundance were lowest mean (mean values 6.66±1.08 cells/L).

From the present study it is evident that the Ramsagar is an important water resource with a great diversity of plankton. They can play important role as primary and secondary producer influencing fish production. The present study concludes that all the physico-chemical parameters were the productive range throughout the year and the highest cell density and species diversity of plankton was found in June of summer season. Therefore, the findings of the present study would be helpful as baseline information for further plankton related research.

REFERENCES

Ahmed A, Hoque SM, Ohlson MAS, Akanda, Moula MG 2010: Phytoplankton standing crop and its diversity in the Buragauranga river estuary in relation to chemical environment. *Bangladesh Journal of Botany* 39(2):143-151.

Ahmed GU, Hossain MAR, Wahab MA, Rahman KMA 1997: Effect of fertilizers on soil and water quality parameters and growth of carp (*Labeo rohita*) fry. Progressive Agriculturists 8: 111-114.

Ahmed KK, Halder GC, Saha SB 1992. Limnological studies on Kaptai lake, Final Report, Fisheries Research Instute, Kiverine Sub-Station, Rangamati, Bangladesh. Pp. 36.

Akter HM 2007: Effect of fertilizer on plankton production, MS Thesis, Department of Aquaculture and Management, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Alam MA 2012: Effects of different kinds of inorganic fertilizers on the production of fishes in polyculture, MS Thesis, Department of Fisheries Management, Bangladesh Agriculture University, Mymensingh, Bangladesh.

Alavi SS and Jafari N 2010: Phytoplankton community in relation to physico-chemical characteristics of the Talar River, Iran. *Journal of Applied science Environment and Management* 14(2):51-56.

APHA 1992: Standard Methods for the Examination of Water and waste water.18th ed. America Public Health Association, Washington DC. Pp.1268.

Ara Y 2015: Study on some physico-chemical parameter and their seasonal variation and diversity index of plankton community of Dhepa River, MS Thesis paper, Department of Fisheries Management, HSTU, Dinajpur.

Araoye M 2009: Harmful effect of un-ionized ammonia on the zooplankton community in Asa Lake, Nigeria 37(2): 1048-1054.

Arauzo M 2003: Harmful effect of un-ionized ammonia on the zooplankton community in deep waste treatment pond. Water Resources 37: 1048-1054.

Arimoro FO, Edema NE, Amaka RO 2008: Phytoplankton community responses in a perturbed tropical stream in the Niger delta, Nigeria. *Tropical Freshwater Biology* 17(1): 37-52.

Aziz A and Tanbir M 2003: Algal flora of some northern districts in Bangladesh. Bangladesh. *J. plant Taxon* 10(1): 63-78.

Banerjee MS 1967: Water quality and soil condition of fish ponds in some states of India in relation to fish production. *Indian Journal of Fisheries* 14: 115-144

Begum ZNT and Alam MJ 1987: Plankton abundance in relation to physico-chemical variables in two ponds in Maijdee court, Noakhali. *J. Asiat. Soc. Bangladesh, Sci.* 13: 55-63.

Begum ZNT and Alam MJ 2007: Plankton abundance in relation to physico-chemical variables in two ponds in Maijdee court, Noakhali. *J. Asiat. Soc. Bangladesh Sci.* 13: 55-63.

Bellinger EG 1992: A Key to the common Algae. The institution of water and Environmental Management. pp.138

Biddanda B and Benner R 1997: Carbon, Nitrogen and Carbohydrates fluxes during the production of particulate and dissolved organic matter by marine phytoplankton. *Limnol. Ocanogr*. 42 (3): 506-518.

Boyd CE 1982: Water Quality Management for Pond Fish Culture, Elsevier Scientific Publishing Company, Amsterdam-Oxford, New York. pp. 318.

Boyd CE 1990: Water Quality in Ponds for Aquaculture, Department of Fisheries and Allied Aquaculture, Alabama Agricultural Experiment Station, Auburn University, Alabama, United State of America. pp. 482.

Cabo C 2003: Ecohydrological process and Sustainable flood plain Management 8 (2-4): 242-262.

Chowdhury MMR, Mondol MRK, Dewan S 2008: Seasonal dynamics of plankton in relation to some environmental factors in a *beel* ecosystem. *University journal of Zoology, Rajshahi University* 27: 55-58.

Chowdhury MMR, Mondol RK, Sarker C 2007: Study in seasonal variation of plankton population of Boro- *Beel*, Rangpur. *Univ.j. zool. Rajshahi univ*. 26: 49-54.

Das T, Pathak K, Devi MB 2011: Phytoplankton and Zooplankton communities of an Oxbow lake in valley, Assam, Assam University. *Journal of science and technology* 7(1) 67-75.

Dewan S 1973: Investigations into the ecology of fishes of Mymensingh lake. Ph.D. thesis, Bangladesh Agricultural University, Mymensingh, Bangladesh pp. 235.

DoF (Department of Fisheries) 1996: *Jatio Matshwa Saptaha.* Ministry of Fisheries and Livestock, Dhaka, Bangladesh.

DoF (Department of Fisheries) 2017: *Jatio Matshwa Saptaha.* Ministry of Fisheries and Livestock, Dhaka, Bangladesh.

Ferdoushi Z, Chowdhury RH, Fatema K , Islam A 2015: A study on limnological aspects of Ramsagar Lake in Dinajpur District, Bangladesh. *J. Bangladesh Agri. Univ.* 13(1):145-152.

Ferdoushi Z, Rana M, Mamun M, Fatema K 2013: Water quality and planktonic biodiversity of Punarbhaba river in the north-west part of Dinajpur. *J. Bangladesh Soc. Agri. Sci. Technol.* 10 (1&2):89-96.

Fisher FT, Donald M 1999: Study on harmful algal blooms and eutrophication: Nutrient sources, Composition, and Consequences 25: 704-726

Gupta U and Mathur A 2011: Assesment of ground water quality of Jaipur lake. *International Bulletion of Mathmetical research* 2:83-86.

Hasan MA 1998: Development of polyculture tethniques with indigenous fish species mola (*Amblypharyngodon mola*), chela (*Chela cachius*), punti (*Puntius sophore*), MS Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Hoque MM 2012: Water quality and plankton composition in fed mola *(Amblypharyngodon mola*) pond stocked at different density, MS Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Hosetti BB and Kumar A 2002: *A Text Book of Environmental Impact assessment and management*. Pp. 15-22.

Hossain JM, Ashaduzzaman, Akther S 2015: Abundance of zooplankton in Ramsagar, Dinajpur. *Bangladesh J Zool.* 43 (2):303-312.

Ibrahim S 2009: Studied on a survey of Zooplankton diversity and evaluation of some physic-chemical properties of Challawa River, Kano, Bayero. *Journal of pure and applied Science* 2 (1): 19-26.

Islam AKMN, and Nahar L 1967: Preliminary studies on the phytoplankton of polluted waters. *Sci. Res.* 3: 94-109.

Islam MA, Chowdhury AH, Zaman M: 2015. Seasonal occurrence of plankton in a Lake, Faridpur, Bangladseh. *Univ. J. Zool. Rajshahi Univ*. 17: 51-60.

Islam MM and Chowdhury AH: 2008. Effects of different kinds of fertilizers on growth and production of fishes, MS Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Islam SM, Rahman RM, Ahmed R, Sahabuddin AKM 2010: Study on changes in wetlands in Ramna Lake, Dhaka. *J. Life earth science* 5: 37-42.

Joadder AR 2009: An ecological study on the *beel* Joshi, Rajshahi district, northern Bangladesh. *Journal of Fisheries International* 4(2):23-29.

Kadir A 2003: Temporal changes in water quality parameters in experimental fish ponds with special emphasis on Euglenophytes, MS Thesis, Department of Fisheries Management, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Khatrai TC 1984: Seasonal variation in the ecosystem of the Lakhotia lake in Rajastan. *Indian Journal of Fish* 31:122-129.

Khatri TC 1887: Seasonal distribution of zooplankton in Idukki Reservior of kerala, India. *Environmental Ecology* 6: 241-243.

Khondokar M, Alfasane MA, Islam MS 2011: Limnological notes on Ramsagar, Dinajpur, Bangladesh. *Bangladesh Journal of Botany* 41(1): 119-121.

Khondokar M, Mujaddaded AM, Gani AM 2011. Limnological notes on Ramsagar lake Dinajpur. *J.Bot*. 41(1):119-121.

Lind OT 1979: *Handbook of common methods in limnology*. St.louis: C.V.Mosby Co.

Malu JB 2001: Some indices at lake productivity. *Transaction of the American Fisheries Society* 26: 322-339.

Mollah MFA and Haque AKMA 1978: Studies on monthly variations of plankton in relation to the physico-chemica1 conditions of water and bottom soil of two ponds. *Bangladesh Journal of Fisheries* (1): 29-39.

Mumtazuddin M, Rahman MS, Mostafa G 1982: Limnological studies of four selectedpondsat the Aquaculture Experiment Station, Mymensingh. *Bangladesh Journal Fisheries Research* 2: 83-90.

Naser NM and Kabir NAKM 2007: Physico-chemical aspects of Chandbill oxbow lake of Meherpur, Bangladesh. *Dhaka University Journal of Biological Science* 20(1):31-39.

Niu CD, Lee S, Goshima S, Nakao CJ, Lee DX 2003: Effects of temperature on food consumption, growth and oxygen consumption of freshwater prawn, *Macrobrachiumresenbergii* (De Man, 1879) post larvae. Aquaculture Research 34(6): 501-506.

Onyma IC, Nkwoji JA, Erutiya OJ 2010: The water chemistry and plankton dynamics of a tropical high energy erosion Beach in lagos. *Journal of American Science* 6 (1):111-122.

Panigrahi S and Patra AK 2013: Studied on phytoplankton seasonal variation diversity Odisha. *Indian journal scientific Research* 42(2):211-13.

Patil PN, Sawant DV, Deshmukh RN 2012: Physico-chemical Parameters for testing of water. *International journal of Environmental science* 3(3):201.

Paul 1998: Comparison between carp polyculture system with silver carp (*Hypophthalmichthys molitrix*) and with small indigenous fish mola (*Amblypharyngodon mola*), MS Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Phlips Ej, Budylak S, Grosskopt T 2002: Factors affecting the abundance of phytoplankton in an Indian river. *Estuaries, coastal and shelf science* 55: 385-402.

Prasad BB and Singh RB 2003: Composition, abundance and distribution of phytoplankton and Zoobenthos in a tropical water body. *Nature Environment and Pollution Technology* 2: 255-258.

Premlata and Vikal 2009: Multivariant analysis of drinking water quality parameters of lake pichhola in Udaipur, India. Biological Forum. *An International Journal* (1):97-102.

Rahman MM 1999: Effect of species combination of pond ecology and growth of fish in Carp-SIS polyculture system MS Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Rahman MM 2000: Effects of addition of *Labeo calbasu* in the periphyton-based aquaculture system of rohu (*Labeo rohita*) and catla (*Catla catla*), MS Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Rahman MS 1982: Water Quality Management in Aquaculture BRAC Prokashana, Dhaka. Pp. 84.

Rahman MS 1982: Water Quality Management in Aquaculture BRAC Prokashana, Dhaka. Pp. 84.

Rahman MS, Chowdhury MY, Haque AKMA, Haq MS 1982: Limnological studies of four fishpond. *Bangladesh J. Fish* 2-5 (1-2): 25-35.

Raihan 2001: To assess the effect of adding Punti (*Puntius sophore*) and mola *(Amblypharhgodon mola*) in Carp polyculture, MS Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Roy U, Shaha BK, Mahabuddin KH, Haque MF, Sarower GM 2009: Study on the diversity and seasonal variation of zooplankton in a brood pond, Khulna, Bangladesh. Dept. of Marine research Aquaculture 1(1): 30-37.

Saha H, Bhuiyan RH, Haque S 2011: Study on physico-chemical properties and Bacteriological properties of Gulshan Lake, Dhaka, Bangladesh, *Dhaka Univ. J. Biol. Sci.* 19(1): 53-61.

Sharma R, Vipul S, Sharma MS, Varma VK, Rachana M 2007: Studies on limnological characteristics, planktonic diversity and fishes in Lake Pichhola, Udaipur, Rajestan. *Journal of environmental research and technology* 1(3): 274-285.

Sharmin R 2013: Evaluation of experimental pond units used for polyculture of tilapia and silver carp in fertilized and fed conditions, MS Thesis, Department of Fisheries Management, Bangladesh Agriculture University, Mymensingh, Bangladesh.

Suresh B, Manjappa S, Puttaaiah ET 2011: Seasonal variation of phytoplankton in Tungabadra River, karnateka, India. *Journal of Microbiology and anti-microbials* 6(2):65-68.

Swingle HS 1967: Standardization of chemical analysis for waters and pond mud. FAO Fisheries Report pp. 397-421.

Tiwari M, Tayyab-saify, Tiwari SL 2006: An ecological study of a polluted pond containing abundant phytoplankton. *Flora and Fauna Journal Jhansi* 12: 186- 188.

Uddin MM 2002: Effects of addition of small fish on ponds ecology and production in polyculture, MS Thesis, Department of Fisheries Management, Bangladesh Agriculture University, Mymensingh, Bangladesh.

Wahab MA, Ahmed ZF, Islam A, Rahmatullah SM 1995: Effect of introduction of common carp on the pond ecology and growth of fish in polyculture. *Bangladesh Journal of Aquaculture* 26: 619-628.

Yeamin HM 2000: Effects of ISO phosphorus organic production, MS Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Zealem D 2007: Temporal Dynamics of Biomass and Primary production of Phytoplankton in relation to some physic-chemical factors in lake Koriftu, Ethiopia. MS thesis, Department of Biology, Addis Ababa University, Ethiopia. pp. 324.