CHAPTER – ONE

GENERAL INTRODUCTION

The term "Limnology" is derived from the Greek word "limne" means lake and "logos" means knowledge which studies the structure and function of inland waters. Limnology mainly deals with the study of micro and macro organisms of biological interest. According to Lampert (1993), limnology has been called a subfield of ecology that includes "everything that affects fresh water" (Robert *et al.*, 2008). It encompasses biological, physical, chemical, geological and hydrological aspects. Limnology itself has traditionally been viewed as a "synthetic science for which purely zoological or botanical studies, though necessary, is no more than preliminaries" (Wetzel, 1975). In modern terms, it may be said that this holistic approach is very much instrumental to understand the structure and function of inland waters. Limnology deals with the biological productivity of inland water and with all its casual influences, involve the meteorological, physical, chemical and biological factors that determine the quality and quantity of biological production by Hutchinson (1957, 1967 and 1975).

The prefix 'limno' in the world limnology refers to the lakes (Agrawal, 2014). The floodplain lakes form an integral component of the major river systems of the world. The combine salient features of lentic and lotic ecosystems along with its aquatic and semi aquatic environments as well present a rich mosaic of ecological dimension. These interesting ecotones are colonized by a wide variety of micro and macro-organisms and are known to harbour the richest aquatic biodiversity (Segers *et al.*, 1993). Beside, wetlands are considered to be the most productive fresh water biotopes (Odum, 1978; Mitsch and Gosselink, 1986).

The flood plain lakes are commonly known as beels, chaurs, tals, pats, moans and jheels in different parts of the country and are mainly distributed in Eastern Bihar,

Uttar Pradesh, West Bengal and the North Eastern India. They comprise of an important component of inland aquatic resources of India covering an area of 0.20 million hectors of which north-east region cover a water spread area of 0.12 million hector occur primarily in the Brahmaputra and Barak river basins of Assam and in the Iral, Imphal and Thoubal river basin of the state of Manipur. These floodplain lakes or beels play vital role in socio-economic development of the north-east region in general and that of Assam in particular, because of their significant potential in fisheries which could be potentially increased through proper scientific management (Sugunan, 1997).

Various floodplain lakes of India are under severe environmental stress due to the degradation of general habitat, encroachment of land for agriculture and human settlements and various anthropogenic activities which, in turn, threaten their aquatic biota. This generalization also holds true for the floodplain lakes (beels and tals) of NE India, majority of which are neglected even for inventorization of their aquatic biodiversity. Hence, conservation of these interesting ecotones, their natural biological resources and sustainable utilization of their aquatic production need priority attention.

In an aquatic ecosystem, all the life processes are dependent directly or indirectly upon the various physical and chemical factors. The frequent rise and fall of these factors affect the biota, altering the number and diversity. In other words, the growth, reproduction and development of biota are influenced by the physico-chemical factors. Biological production in any aquatic body gives direct correlation with its physico-chemical status which could be used as trophic status and fisheries resources potential (Jhingran *et al.*, 1969). Life in aquatic environment is largely governed by physico-chemical characteristics as well as their stability. These characteristics have enabled biota to develop many adaptations that improve sustained productivity and regulate Lake Metabolism. The physico-chemical study of a lake enables in drawing out vital conclusions regarding the eutrophic status of the water bodies (Prescott, 1984). Limnologist have always considered that the study of physico-chemical status of a given lake water is an indispensable component that would specify the relationships, interdependencies as well as interaction functioning in the ecosystems with respect to the abiotic factors. It is noteworthy to mention that in Lake

ecosystem, there is significant direct and inverse relationship between the physico-chemical parameters, and it further influences the plankton fluctuation in water. Physico-chemical analysis indicates the changes in different factors and their influence on biological status of the system.

The term plankton has been used to describe free floating and weakly swimming marine and fresh-water organisms. The term "plankton", coined by Hensen (1887) and it was more precisely defined by Haeckel (1891). The plankton comprises of those entire aquatic organisms which are free-floating, freely swimming, drifting, and mostly microscopic and have relatively small power of locomotion or none at all. The planktons are carried away by the water current from one place to another. Presently the plankton could be defined as free floating organisms, which have the intrinsic power of locomotion, if present, is so feeble that they remain almost at the mercy of water currents and waves. Qualitatively plankton could broadly be classified as phytoplankton and zooplankton. Phytoplankton includes the chlorophyll bearing organisms capable of photosynthesis and non-photosynthetic plant or sapro-plankton against the plankton of animal origin termed as zooplankton.

Most of the planktons are cosmopolitan in distribution and occur in almost all types of water bodies (Hutchinson, 1967). They are classified on the basis of site of occurrence (Welch, 1952) as limnoplankton or the lake plankton, rheoplankton or running water plankton, heleoplankton or small bodies' fresh water or pond plankton, halioplankton or salt water plankton and hypalmyroplankton or brackish water plankton.

Planktons are supposed to be a biological wealth of water for fishes. In general the plankton plays a prominent role in providing the fishes with food. Nearly all aquatic animals are ultimately dependent upon planktonic life for existence. Plankton may be defined as population of minute plants and animals having limited movements and floating passively on the surface layer of fresh water.

The phytoplankton is consisting of micro and macroscopic suspended or free-floating non-motile or weakly-motile unicellular, colonial or filamentous algae. The

majority of the phytoplanktons are non-motile and are therefore at the marshy of water turbulence within the upper water mass. However, motile phytoplanktons like *Chlamydomonas, Volvox* and members of Dinoflagellates and Chrysophytes etc. are unable to swim against water current. In aquatic ecosystem phytoplanktons stands on the baseline of different food webs and are considered to be one of the most important primary producers. The growth and multiplication of phytoplankton is primarily dependent on temperature, solar lamination and the availability of certain essential nutrients viz. nitrates, phosphates, sulphate etc. Phytoplanktons due to having their photosynthetic ability are capable of producing their own food and therefore they form the foundation of all the food webs in an aquatic ecosystem. Phytoplanktons are represented by a mass of passively floating algae including chiefly the green algae (Chlorophyceae), blue-green algae (Cyanophyceae), diatom (Bacellariophyceae), the yellow-green algae (Xanthophyceae) and the flagellates (Euglenophyceae). The phytoplankton species like *Volvox, Spirogyra, Eudorina, Closterium, Oedogonium, Oscillatoria, Nostoc* and *Anabaena* species etc. are commonly available in ponds and beels which are consumed in large quantities by the herbivorous fishes and thus their quantify determines the productivity of beel.

Although most of the planktonic groups are widely distributed, the Cyanobacteria are found to flourish in the warm and nutrient–rich water with some exception. The planktonic Chlorophyceae represent a number of organisms of very different nature (Hutchinson, 1967) among which the Volvocales and Chlorococcales seen to occur most abundantly in ponds and productive lakes. Another important group belonging to Chlorophyceae which spectacularly develop in the regions of dilute acid water is the Desmids. Besides, the Euglanophyceae are often abundant in the water rich in organic matter. On the other hand, Bacillariophyceae is considered as one of the dominant fresh water group (Hutchinson, 1967) which present in significant number in aquatic system.

Planktonic animals (zooplanktons) must necessarily have the capacity to remain a float and hence the exhibit wonderful adaptations. The zooplanktons unlike phytoplankton are patchily distributed horizontally and vertically in an ecosystem.

They also undergo diurnal vertical distribution and migration. The number of zooplankton in water bodies is usually much lower than phytoplankton. The major groups of zooplanktons are Rotifera, Cladocera, Copepoda, Protozoa and Ostracoda. Many of them feed on algae and bacteria and in turn are fed by numerous invertebrates and fishes. The zooplanktons occupy a central position between the autotrophs and other heterotrophs and form an important link in aquatic food webs. Generally planktonic animals in fresh water are dominated by Rotifera, Cladocera and Copepoda. Protozoa also forms a significant part of the fresh water zooplankton, especially in systems exhibiting advanced trophy.

In an aquatic ecosystem, zooplankton forms the major micro-faunal component and is the primary consumers in an aquatic ecosystem. They are considered as good indicators of environmental status, water quality and aquatic productivity. Presence and dominance of zooplankton species play a vital role in functioning of freshwater ecosystems and the seasonal changes in zooplankton species are clearly related to the water quality and biological regime of the aquatic environment (Chandrasekhar, 2010). Zooplanktons also play significant role in conversion of plant protein to animal protein. In fish culture, pond zooplankton has considerable importance as they serve as live feed for the fish juveniles.

The Rotifers and Crustacean zooplanktons are essentially filter-feeders and mostly feed on the algal cells. The Rotifers, along with the two crustacean groups namely Cladocera and Copepoda share the major part of the fresh water zooplankton. The majority of planktonic species of Rotifers show a wide range of adaptability to varying environment and are potentially cosmopolitan, while a few exhibit zoographical limitations.

Zooplanktons are of great importance not only as a major link in a food chain of an aquatic system but also as food directly to fish as well as large animals. Among zooplankton, crustaceans are abundant everywhere and form a very important link in connecting the primary producers - phytoplankton with primary carnivores. Crustaceans are represented in the plankton either by the adults or by their larvae. The copepods are of more importance that specially constitutes the major part of the diet of

many small, young and larger fishes. As a whole the zooplanktons are the most important connecting links of food chain between primary producers and the carnivores. During rainy season the numbers of zooplankton population decrease abruptly in the beels or ponds and it may be due to the increases of aquatic vegetations and a large numbers of tadpole larvae in the wetlands in that period.

Periodic fluctuation of plankton, qualitatively and quantitatively, in different seasons occurs usually in almost all types of aquatic habitats. Certain planktonic populations found to disappear at specific period and reappear during other. Such temporary disappearances may be due to physiological activity of plankton or environmental factors. Davis (1955) showed that a number of physical, chemical and biological factors acting simultaneously must be taken into consideration in understanding the fluctuation of plankton. The factors responsible for seasonal succession of planktons are categorised as partially independent physical factors, which includes temperatures, light and turbulence; independent biochemical factors that include inorganic nutrients, accessory organic materials and antibiotics while the third category, biological factors emerged parasitism, predation and competition (Hutchinson, 1967). As such, in aquaculture lakes, the seasonal fluctuations of planktons are governed by the biological as well as the physico-chemical parameters of water.

Macrophytes, as a component of fresh-water ecosystems play an important role in the structure and functioning of the aquatic ecosystems (Wetzel, 2001). The aquatic macrophyte comprises a diverse group of macro-organisms including vascular plants, aquatic bryophytes and some macro algae that occur in seasonally or permanently in wet environments (Jones *et al.,* 2010). The macrophytes serve as a base of food chains and also actively contribute to the promotion and maintenance of aquatic food webs (Scheffer and Jeppesen, 2007). The macorphytes may be classified in to Submerged aquatic (SA), Floating aquatic (FA), Emergent aquatic (EA), Free-floating (FF) and Marshy amphibious (MA). Macrophytes play a significant role in the dynamics of physico-chemical and biological characteristics of aquatic habitat. The macrophytic plants provide energy to herbivores as well as increase the strength of the detritus food chain

of the beel ecosystem which is most important for enhancement of fish production point of view. Aquatic macrophytes also act not only as important bio-indicators of environmental conditions and long term ecolological changes in water quality (Lacoul and Freedman, 2006) by exuding various organic and mineral components but also as an efficient accumulator of heavy metals.

Macrophytic diversity and its role in understanding the beel ecosystem have tremendous significance. Macrophytes use nutrients from the aquatic environment and play important role in the natural process self purification of water. The macrophytes are the important source of food, fodder, herbal medicine and domestic household materials for the people residing in its vicinities. Thus, limnological studies carried in aquatic environments must consider the aquatic macrophytic community as an essential component for ecosystem functioning and aquatic biodiversity conservation.

The limnological study of a wetland is of great importance because an aquatic ecosystem has been performing various important functions like ecological, socioeconomic and piscicultural for the surrounding community. The biotic as well as the abiotic factors affect the abundance, variation and distributional patterns of the planktonic organisms directly or indirectly to make an aquatic system productive and unproductive from the fisheries point of view. Therefore, limnological research in aquaculture systems are of great significance as the information obtained from such studies are essential for augmenting the fish production, which is considered as a major component of economic potential of a country.

Hydro-biological studies in fresh water ecosystems of India began nearly one century ago. But till date one can find very limited information on aquatic biodiversity of the floodplain lakes of this country in general and on composition of their littoral and limnetic invertebrate communities in particular. Certain related works in the Indian floodplain wetlands are those by Khan (1987), Khan (2002, 2003), Laskar and Gupta (2009), Sharma (2009, 2010), Sharma and Sharma (2001), Bhat *et al.* (2010), Brraich and Kaur (2015) including north-eastern India.

In north-eastern India the river Brahmaputra flowing through the state of Assam with its numerous perennial tributaries and connected beels affords lucrative aspects of various kinds of fresh water habitats. Some of the remarkable contribution from different floodplain wetlands of Assam (Dey, 1981; Goswami, 1985; Acharjee *et al.*, 1995; Goswami and Goswami, 2001; Sharma, 2011; Sharma and Sharma, 2012, 2013; Hussain *et al.*, 2015*;* Kar and Kar, 2016).

In the Goalpara district of Assam there are numbers of beels and among them, Urpod beel has been designated as the largest, incorporated in Asian Wetland Directory due to its aquatic avifaunal diversity (Scot, 1989). On the wetlands of Goalpara including Urpod beel some remarkable contributions were made by Kalita and Goswami (2008), Saha and Bordoloi (2009), Saha (2011), Saud *et al.* (2012), Choudhury *et al.* (2013), Sarma *et al.* (2013), Barhai *et al.* (2015), Haque and Devi (2015). But all these research works are mainly restricted only to the ichthyofaunal diversity. Though Sarma *et al.* (2013) carried out their work on plankton and physico-chemical analysis, yet no numerical density and diversity of plankton and macrophyte as well correlation among the variables were found. Though there are enormous scopes for diverse work in the aquatic resonance and ingredients, yet no systematic attempt has been made in regard to planktonic and macrophytic diversity. Therefore, it has been aimed to investigate the diversity of plankton as well macrophyte during different seasons of a year. Hence the following objectives have been sorted:

1. Evaluation of the physico-chemical characters of beel water and their influence upon the plankton and macrophyte diversity.
2. Plankton diversity (Phytoplankton and Zooplankton)
3. Macrophyte diversity.