Macrophyte Ecology of Laiosipat Lake

INTRODUCTION

ECOLOGY AND ECOSYSTEM

The word ecology which was first proposed by the German biologist Ernst Haeckel (1869) refers to the study of the natural environment including the relations of organisms to one another and to their surroundings (Haeckel, 1869). The term "Ecology" has been derived from the Greek words "Oikoi" meaning "the household" and 'logos' meaning 'the study'. Many ecologists like F. E. Clements the pioneer contributor to plant ecology regarded it as "the science of the community" (Clements, 1905), Charles Elton (1927) regarded it as scientific natural history concerned with the sociology and economics of plants and animals. Victor E. Shelford (1937) regarded it as the branch of general physiology which deals with the organisms as a whole, with its general life processes as distinguished from the more special physiology of organs and the science of the environment (Friederichs, 1958).

Ecology is multidisciplinary in its approach and is also much concerned with the system levels beyond the level of organisms. Ecology has now emerged from biology as a new integrative discipline that links physical and
biological processes, thus forming a bridge between the natural sciences and the social sciences (Odum, 1977; Odum and Barrett, 2005). The substance of ecology is found in the multitude of non-living and living structures, processes and interrelations involved in moving energy and nutrients, in regulating populations and community structure and dynamics (Kormondy, 1999). The community and the nonliving environment function together as an Ecological System or Ecosystem. Tansley (1935) defined “Ecosystem” as the interacting system between the living organisms and their non-living environment. Ecosystem is also known as “Biogeocoenosis” (Karl Mobius, 1877), “Microcosm” (Forbes, 1887); “Biosystem” (Thienmann, 1939). “Geobiocoenosis” (Sukachev, 1944) and “Holocoen” (Friederichs, 1958). Odum (1971) describes the ecosystem as a unit comprising several organisms interacting with one another within a particular environment wherein occur the cycling of nutrients and flow of energy. The largest and most nearly self-sufficient biological system is termed as biosphere or ecosphere. It includes all the earth’s living organisms interacting with the physical environment as a whole to maintain a steady state system intermediate in the flow of energy between the high-energy input of the sun and the thermal sink of space (Odum, 1983). The ecosystem comprises two major components i) non-living or abiotic which includes physico-chemical substances, inorganic substances (C, N, CO₂, H₂O etc.), organic compounds (Proteins, Carbohydrates etc.) and ii) living or
biotic components which includes the particular assemblage of plants, animals or microbes in the abiotic setting.

The biosphere covers an area of about $510 \times 10^6$ km$^2$ and it extends about 8 km up in the atmosphere and as far as 8 km down into the depth of the sea. Life can exist in a narrow layer near the earth’s surface in contact with air, water and soil. Thus, a relatively narrow layer has got maximum spread of living forms (Santra, 2001). The total biomass of the biosphere is estimated to be about $1841 \times 10^9$ tons and the annual net primary productivity is about $172.50 \times 10^9$ tons year$^{-1}$ as estimated by Lieth (1975) and Whittaker and Likens (1975). The biosphere as a whole can be categorized into two major ecosystems viz., Terrestrial (Land) ecosystem and Aquatic (Water) ecosystem. Terrestrial ecosystems occupy an area of about $144 \times 10^6$ km$^2$ and represents about 30% of the total area of the Earth’s surface and it consists of forest, grassland, mountain, desert, tundra etc. The aquatic ecosystems occupy an area of about $365 \times 10^6$ km$^2$ constituting about 70% of the Earth’s surface. The aquatic ecosystem comprises freshwater, marine and estuaries.

The annual net primary productivity of the present day biosphere have been found reduced to $48.60 \times 10^{15}$ tons of carbon year$^{-1}$ or $97.20 \times 10^9$ tons of dry matter year$^{-1}$ (Esser, 1987; Lieth, 1992). The main cause for the degradation of ecosystems and its net primary productivity is the expansion of human population, urbanization and industrialization, overexploitation of our
natural resources and massive removal of vegetation coupled with tremendous increase in the concentration of CO$_2$ in the atmosphere.

The current annual net primary production of terrestrial ecosystem is estimated to be $120 \times 10^9$ tons year$^{-1}$ or 66.70% of the total production of the biosphere while the annual net production of aquatic ecosystem is about $60.00 \times 10^9$ tons year$^{-1}$ or roughly 33.30% of the total production of the biosphere (Mackenzie et al., 2001). Thus, the terrestrial ecosystems are more productive even though they occupy lesser area than the aquatic ecosystems (Mackenzie et al., 2001). Among the terrestrial ecosystem also, the rate of productivity differs. The tropical rain forests have highest production ($4 \times 10^{10}$ tons year$^{-1}$) while the deserts are less productive.

Swamps and marshlands have high production rate of $0.40 \times 10^{10}$ tons year$^{-1}$ (Whittaker, 1970). The net primary productivity of the entire Ocean is about $5.50 \times 10^{10}$ tons year$^{-1}$. Woodwell et al. (1978) also recognized the forests and oceans as the major sites of primary productivity in the biosphere.

There are about 1400 million Km$^3$ of water on the Earth but only 0.33% which are visible as surface water lies in the oceans as salt water while 2.15% in the frozen ice and the remaining 0.65% remains as freshwater. The aquatic habitats have been categorized into freshwater, estuaries and marine ecosystem. Some highly eutrophic freshwater lakes also have high magnitude of primary productivity (Likens, 1975). Thus, the study of freshwater ecosystems have an ecological importance. The ecologists of the world have given main importance
on the biological productivity of the ecosystem and the same has been the main focal theme of the International Biological Programme (IBP) and the Man and the Biosphere Programme (MAB) launched by UNESCO in 1964 and 1974 respectively. The IBP under its section on productivity of freshwater communities (PF) emphasized on the primary and secondary productivity of freshwater ecosystems, the conservation of aquatic communities and source of drinking water from freshwater bodies. The project V of the MAB is concerned with the impacts of human beings on the freshwater body.

**Freshwater ecosystems:**

The study of freshwater in all aspects *i.e.*, physical, chemical, geological and biological is termed as Limnology (Wetzel, 1975). Freshwater ecology deals with the relationship between the living organisms and their aquatic environment. Freshwater bodies are divided into two categories *viz.*, Lentic or standing water such as lakes, ponds, pools, swamps, bogs *etc.* and Lotic or running water such as springs, streams, rivers *etc.* Freshwater ecosystems occupy relatively a very small portion of the Earth's surface having a volume of $2.04 \times 10^5 \text{ km}^3$ (Lieth and Whittaker, 1975). The net primary productivity of freshwater ecosystems of the world is about $4.60 \times 10^9 \text{ tons dry matter year}^{-1}$ and they are found in the form of lakes, rivers, swamps *etc.* Thus, the contribution of net primary productivity by freshwater ecosystem is 2 % to the total biosphere production. Though freshwater ecosystems occupy a relatively
small portion of the earth’s surface as compared to the marine and terrestrial habitats, they are much important to the mankind (Santra, 2001). Freshwater ecosystems serve as the most convenient and cheapest source of water for domestic and industrial use, providing waste disposal system and they are the bottle-neck in the hydrological cycle (Odum, 1971).

Water is the most important natural resource and we depend on water for irrigation, industry, domestic needs, shipping, sanitation and disposal of waste. In living organisms, water is also essential and most abundant component of the protoplasm of the organisms. Since water is considered as the principle medium for both external and internal uses in aquatic habitats, freshwater ecosystems are considered as one of the most important natural resources of the living organisms for their survivability in the biosphere. For the survival and growth of living beings and for maintenance of ecological balance between various groups of living organisms and their environment, water is the most essential item (Narayana, et al., 2005). Such important natural resources have now become scarce due to over exploitation, misuse and pollution whereby it becomes less suitable for drinking, domestic use, agricultural, recreation, fisheries and other purposes. As man is abusing this natural resources to a great extent major efforts should be taken up immediately to reduce this stress, otherwise, water will become the limiting factor for the mankind (Odum, 1971).
Habitat degradation, poor land use practices, over population and pollution etc. pose more immediate and direct threats to the Earth’s freshwater resources (La Riviere, 1989; Schindler and Bayaley, 1990 and Allan and Flecker, 1993). The management of freshwater resources is needed immediately, but little efforts have been made for the protection and conservation of aquatic ecosystems though the existing water bodies have tremendous economical, ecological and aesthetic benefits (Kodarkar, 1995).

WETLANDS:

Ramsar Convention Bureau (1997) defined wetlands as areas of marsh, fen, peat land or whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salty, including areas of marine water and the depth of which at low tide does not exceed six meters (Article 1.1 of the Ramsar Convention held in 1971). Wetlands comprise lakes, swamps, rivers, marshes, bogs and similar areas and they are generally regarded as areas of land that remain waterlogged for a substantial period of the year (Santra, 2001). Cowardin et al. (1979) also defined wetlands as the lands, transitional between terrestrial and aquatic systems when the water table is usually at or near the surface or the land is covered by shallow water. According to Naiman and Decamps (1990) wetlands are regarded as the areas spatially sandwiched between land and water and hence considered as land --
water ecotones. Tiner (1993) viewed that wetlands are relatively distinct communities associated with hydric soils and are relatively stable.

According to Tindanmire (2003) wetlands form ecotones between open waters and terrestrial ecosystems. Dodds (2002) regarded wetlands as a land, hybrid between terrestrial and aquatic system characterized by constant or recurrent inundation or saturation at or near the surface of the substrate and possesses common diagnostic features of hydric soils and hydrophytic vegetation.

Wetlands cover about 6 % of the earth's surface. Maltby (1991) opined that the classification of wetlands is problematic due to differences in wetland types with highly dynamic characters and difficulties in defining the true boundaries of the same. Dugan (1990) classified the wetlands of the world into three major categories i.e., salt water (Marine, Estuarine, Lagooner and salt water lakes), fresh water (Riverine, Lœcustrine and Palustrine) and man-made wetlands (Aquaculture/Mariculture, Agriculture salt exploitation. Urban / Industrial and water storage areas). Wetlands occurring throughout the world in all climatic zones from boreal permafrost to tropics are the most productive ecosystems of the world (Harikumar et al., 2006). Wetlands are well known for their rich biodiversity and many physical, hydrological, chemical, biological and socio-economic functions (Williams, 1990) and they are indispensable for the livelihood of rural communities as they provide a wide range of hydrological and ecological benefits (Gibson, 1998). Wetlands provide feeding
and breeding areas for wildlife and also provide a stopping place and refuge for waterfowl (Prasad et al., 2002). Wetlands are also important in supporting species diversity of the biosphere as they are the habitats of 15 to 20% of all living organisms of the earth (Mitsch and Gosselink, 1986). Wetlands support 20% of the known range biodiversity in India (Deepa and Ramachandra, 1999). They are one of the most productive ecosystems and constitute rich natural resources. Wetlands perform many vital functions which includes downstream flood control, ground water discharge, recharge and storage, water purification, retention of sediment and nutrients, storm protection and shoreline stabilization as well as nourishing a broad spectrum of biodiversity. Though they have profound ecological and economic importance, they are prone to fragile, liable to degradation and degeneration.

Biodiversity or biological diversity means the diversities of life forms in our planet. Biodiversity is classified into 3 groups (i) Genetic diversity (ii) Species diversity and (iii) Ecosystem diversity. Since, the end of Mesozoic era, 65 million years ago, human population gradually expanded till today and degradation of the natural environment thereby reducing biological diversity occurred to its lowest level. In one sense, the loss of biodiversity is the most important process of environmental change. Every country can be said to have three forms of wealth viz., material, cultural and biological. Of these, the material and cultural ones have become the substances of our everyday life but biological wealth is taken much less seriously.
There are 34 biodiversity ‘hot spot’ regions in the world, of which three are located in India viz., Western Ghats and Sri Lanka, Himalayas and Indo-Burma hot spots. Thus, India is one of the 12 mega diversity countries of the world. The state of Manipur is included under the Indo-Burma hot spot. The loss of biodiversity, increase in salinisation, decrease in fertile top soil, damage to nutrient cycling and hydrological cycle are the major consequences and impacts of wetland loss in the ecosystem.

International Union for Conservation of Nature and Natural Resources (IUCN) recognized the importance of wetlands in order to conserve the global wetland loss. Ramsar convention (an intergovernmental treaty) was adopted by representatives of 18 nations on 2nd February, 1971 at Ramsar, a small town in Iran for the conservation of Wetlands of International Importance specially for waterfowl habitat. The World Wide Fund for Nature (WWF) and International Union for Conservation of Nature and Natural Resources (IUCN)) also launched the International wetland conservation programme concerning the impacts of wetland loss to the natural ecosystem in 1985, which is undertaken in over 20 countries in five continents. As measures towards the conservation of the biodiversity, ramsar convention recognized the wetlands as ecosystems, which are extremely important for biodiversity conservation and for the well being of human communities (Ramsar Convention Bureau, 1971). The article 10 of the Convention on Biological Diversity, (CBD, 1992) also gave special emphasis on the sustainable use of the components of biological diversity.
Keeping in mind the need for conservation of wetlands, more than 60 countries of the world joined the convention by 1991 consisting of 526 wetland sites across the world covering an area of about 30 million hectares of wetland habitats (Finlayson and Moser, 1991). By 2009, the number of contracting members gradually increased to 160 countries and the number of ramsar sites is increased to 1,889 wetlands covering 185.437 million hectares in area (Ramsar Convention Bureau, 2009). The main objective of the Ramsar convention, as adopted by the parties in 1999 and refined in 2005, is “the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution toward achieving sustainable development throughout the world” (Ramsar Convention Bureau, 2009).

India joined the Ramsar Convention in 1981 by contributing two Ramsar sites i.e., Chilika lake in Orissa and Keoladeo National Park in Rajasthan. By the end of 1990, four more Ramsar sites were included in the Ramsar list including Loktak lake (Manipur), Harike lake (Punjab), Wular lake (Jammu and Kashmir) and Sambhar lake (Rajasthan). By the end of 2006, the number of Ramsar sites in India increased to 25 sites covering an area of about 677.131 hectares (Ramsar Convention Bureau, 2006).

The Loktak lake of Manipur was included in the Ramsar list on March 1990 while the entire state of Manipur and the north east of India have been included under the Indo-Burma Biodiversity hot spot. Though the wetland ecosystems are the most productive ecosystems of the world, they are
threatened to extinction due to cultural eutrophication and conversion into agricultural lands. The loss of wetlands as a result of industrial developments and agricultural purposes have been reported by Dugan (1994) in different countries of the world viz., 80% wetlands in West France, 70% in Portugal, 90% in New Zealand, 54% in U.S.A. and 40% in Britain. Fresh water macrophytes are responsible for the regulation and stabilization of mineral cycling in the water bodies and hence they serve as indicators for the possible degree of damage in the ecosystem (Pieczynska and Ozimek, 1976).

Freshwater macrophytes also play a vital role in determining the productive nature of the water body and they are recognized as the most productive plant communities. The metabolic activities of macrophytic communities tend to accelerate the physico-chemical condition of the streams. Moreover, the physico-chemical characteristics of the freshwater environment are essential to understand the distribution and productivity of macrophytes in a freshwater ecosystem. The assessment of the biomass accumulation by the plant species is pivotal for estimating the primary productivity. Primary production is the most vital factor which controls the growth of the organisms in the community (Westlake, 1963). Therefore, to understand the structure, function and dynamics of wetlands, relevant and interrelated ecological approaches and studies are required. Phytosociological studies provide information on the community and environmental relationships, succession and the nature of community (Knight, 1975). The variations in the maximum
biomass in different months in a mixed community is attributed to the
combined effect of variations in growth rate and phonological changes
(Ovington et al., 1963; Wiegert and Evans, 1964 and Malone, 1968). The
study of net primary productivity of the freshwater macrophytes has become
necessary to assess the ecosystem dynamics of the aquatic ecosystems. The
physico-chemical characters of water are also the attributing factors for the
functioning, regulation and stabilization of the freshwater ecosystems.

THE PRESENT STUDY

The North East India including Manipur is one of the three biodiversity
hot spots of the world with 3 Ramsar sites i.e., Loktak lake (Manipur), Deepor
beel (Assam) and Rudrasagar lake (Tripura). But, most of freshwater
ecosystems of Manipur are subjected to advanced stages of pollution and
degradation and thus have reached the status of wetlands (Sharma, 1999). The
life span and hydrologic characteristics of the wetlands of Manipur are related
to the evolving geo-physical character of the land itself (Singh, 1999). In the
beginning of twentieth century, there were about 500 lakes reported in Manipur
but in the middle of 20th century, most of the lakes have become extinct
completely as a result of artificial eutrophication due to pisciculture and
agricultural activities in and around the lakes. Some of the existing lakes in the
Manipur which are threatened to extinction are Loktak, Ikop, Kharungpat,
Waithoupat, Sanapat, Utrapat, Oksoipat, Awangsoipat, Laisoipat (present study
site), Hidenkumpat, Yanapat, Lousipat etc. These lakes are much threatened to extinction due to artificial eutrophication through disposal of domestic garbages, paddy cultivation, leaching of chemical fertilizers, lodging of pesticides, insecticides and misuse of toxic chemicals for catching fishes and encroachment of human beings in and around the lakes (Sharma, 2001). The destruction and degradation of these lakes would continue leading to the death of these lakes if the conservation measures are not taken up as soon as possible (Sharma, 2000). But, the study of freshwater ecosystem is lagging behind in Manipur and north eastern India.

which may be helpful in finding out ways to protect the lake from further deterioration and extinction.

**Objectives and curricula of the present study:**

The present study of Laisoipat lake has been undertaken in accordance with the endeavour made by the IBP (1964 – 1974) and the MAB (1974) of the UNESCO and Wetlands Programmes by the IUCN. In the present study, an attempt has been made to assess the phytosociology, biomass dynamics, primary productivity of the different macrophytes and physico-chemical characters of water in Laisoipat lake, Manipur. The interactions among these characters may serve as a prerequisite in assessing the ecological status of the lake and the same would help in further plans for improving and conserving the present lake from extinction. For detailed study and to obtain accurate results, the lake under present investigation was divided into four different sites *viz.* Site I- Yangoi Manbi, Site II – Akakhong, Site III – Sanamanikom and Site IV – Athakhong. The main objectives of the present investigation are highlighted as follow:

**Objective:**

1. Field survey and sampling of the macrophytes of the lake at monthly intervals for a duration of 2 years, to assess the variations in floristic composition and distribution pattern of the various macrophytes which are growing in and around the lake.
2. Assessment of phytosociological parameters (quantitative characters) like Frequency, Density, Abundance and Importance Value Index (IVI) of the component plant species.

3. Study of the physiographical features of the lake such as basin topography, morphometry and bathymetry etc. in the various seasons during the study period.

4. Life form and growth form analysis of the macrophytes and designation of the possible phytoclimatic of the area under study.

5. Study of the changes in biomass of the dominant macrophytes both at species and community levels.

6. Analysis of net primary productivity of the dominant macrophytes on daily and annual basis.

7. Analysis of physico-chemical characteristics of water samples collected from the various study sites.

8. Analysis of correlation and regression among the various physico-chemical parameters of the water, biomass and productivity of dominant macrophytes.

9. Development of ecological status of the macrophytes and the probable trophic nature of the lake after the detailed ecological analysis of the various parameters.
Macrophyte Ecology of Laisoipat lake

THE THESIS:

The observations and findings of the ecological study of Laisoipat lake, Bishnupur (Manipur), have been properly assessed, computed and duly synthesized. The same has been presented in the thesis under the following chapters.

Chapter 1: Introduction
Chapter 2: Description of study sites
Chapter 3: Materials and methods
Chapter 4: Results
Chapter 5: Discussion
Chapter 6: Summary

Bibliography

Publication