

REVIEW OF LITERATURE

Wetlands include diverse type of habitats and form highly productive ecosystems on the Earth. Extensive works have been done by different workers on the physico-chemical and biological parameters of freshwater bodies.

Forel is considered as the founder of modern limnology. He worked on Swiss lakes and published the book, "Le Lemman" in 1892. He also published first limnological text book, 'The text book of limnology' in 1901 which provided an impetus for investigation in the limnological field. After him, Thienemann (1926) published the book "Limnologie".

Ganapati (1943) studied ecology of a garden pond. Moyle (1946) studied some chemical factors influencing the distribution of aquatic plants in Minesota and reported nitrates along with phosphates as important factors in freshwater productivity. Ruttner (1953) published "Fundamentals of Limnology". Roy (1955) found that the higher P^H is associated with the phytoplankton maxima. Barret (1957) revealed that water temperature affects other physico- chemical characteristics of water body. Das (1957) studied some physico-chemical parameters of Kathura Tal, Lucknow and reported their ranges viz. water temperature ($15\text{ }^{\circ}\text{C} - 30\text{ }^{\circ}\text{C}$), P^H (7.2 - 9.2), dissolved oxygen (4 mg/L - 6 mg/L) and free carbon dioxide (17 mg/L - 39 mg/L). Chakaraborty *et al.* (1959) studied physico-chemical conditions of the river Jamuna at Allahabad and recorded maximum dissolved carbon dioxide in monsoon months. Elmore (1961) stated that an increase in temperature of water results in the decrease of dissolved oxygen and increase in sediment concentration which hampers photosynthesis and reduces dissolved oxygen level. Needham and Needham (1962) published "A Guide to Study Freshwater Biology". Maçan (1963) published "Freshwater Ecology".

A high value of dissolved oxygen content was observed in winter season by Moitra and Bhattacharya (1965). George (1966) reported direct correlation between chloride content and P^H . Hutchinson (1967) provided a remarkable contribution in the field of limnology by publishing "Treaties on Limnology" Vol. II. Michael (1969) reported the seasonal trends in the physico-chemical factors of freshwater fish pond and their role in fish culture. He found direct correlation of carbon dioxide with the amount and

nature of biological activity in water. Munawar (1970) made a comparative study on the physico-chemical conditions of three ponds of Hyderabad and observed that shallower water body change water temperature more quickly. Nasar and Datta Munshi (1971) found direct correlation between bicarbonate alkalinity and P^H . McColl (1972) studied water chemistry and trophic status of seven New Zealand lakes.

Zutshi and Khan (1977) reported highest Sechhi transparency in the month of January from Surinsar and Mansar lake. A strong positive correlation was found between atmospheric temperature and water temperature by Kant and Anand (1978). Swarup and Singh (1979) reported high chloride during summer season. Laal (1981) studied the ecology and productivity of swamps in North Bihar in relation to production of fishes and other agricultural commodities. He reported narrow range of P^H in swamps. Das (1981) studied seasonal fluctuation in physico-chemical parameters of Nainital lakes. He reported maximum range of surface water temperature and P^H in summer and minimum in winter. Alkalinity was maximum in winter season and minimum in autumn season. Singh *et al.* (1982) studied seasonal and diurnal changes in physico-chemical features of the river Brahmaputra at Guwahati. They found high free carbon dioxide concentration to be related to low concentration of oxygen and vice-versa.

Bhowmick and Singh (1985) found that the low values of dissolved oxygen in the summer season were mainly due to high temperature as well as due to microbial demand for oxygen in decomposition of suspended and dissolved organic matters. Wright *et al.* (1985) studied the effects of physico-chemical parameters and seasonal changes in macro invertebrates in some rivers in the Great Britain. They found substantial effects of it on the community structure. Bhowmik (1988) reported physico-chemical parameters of water of ten lakes of West Bengal. He recorded temperature variations from 18 °C – 32 °C, P^H from 6.8 - 9.1, total alkalinity from 68 mg/L - 120 mg/L, and dissolved oxygen from 3 mg/L - 7.2 mg/L. Dobriyal and Singh (1989) observed negative correlation between free carbon dioxide and dissolved oxygen and positive correlation between free carbon dioxide and temperature. Lerman and Wevner (1989) found that the diffusion of carbon dioxide from the atmosphere and its storage in lakes cause increase in the alkalinity of water. Singh (1990) studied

distribution and seasonal fluctuation of certain physico-chemical features in the Brahmaputra river. He reported high bicarbonate alkalinity during winter months and minimum transparency during monsoon period. Jindal and Kumar (1993) observed inverse correlation of temperature with dissolved oxygen. Gupta and Srivastava (1994) studied the water quality of Varuna river. They reported increased amount of P^H when the dissolved oxygen and transparency decreased. Patralekh (1994) studied physico-chemical properties in river, spring and pond. He found higher dissolved oxygen in river than spring and pond. Lower hardness was observed in monsoon season in all the ecosystems. Minimum amount of free carbon dioxide was observed during summer in pond and maximum during winter in thermal spring. Hardness of water was observed greater in river than in pond and thermal spring. Haque and Khan (1994) studied extensively the temporal and spatial distribution of cladocerans along with the impact of certain physico-chemical characteristics of the environment on them. They reported maximum Secchi disc transparency in September and minimum in October. The maximum total alkalinity was noted during post winter months and low during monsoon months. The dissolved oxygen concentration was noted lower in winter than in spring. Sinha *et al.* (1994) studied the biodiversity and pollutional status in relation to physico-chemical factors of Kowar lake of North Bihar from November 1991 to October 1993. They reported various chemical factors *viz.* P^H (6.3 - 7.23), dissolved oxygen (2.15 mg/L - 7.6 mg/L) and free carbon dioxide (2.8 mg/L - 12.75 mg/L). Sharma *et al.* (1994) studied ecology of Kowar lake wetland, Bihar from 1993 to 1994. They reported the range of physico-chemical properties of water *viz.* P^H (6.65 - 7.08), dissolved oxygen (2.15 mg/L - 6.77 mg/L), free carbon dioxide (0.0mg/L - 9.68 mg/L) and total hardness (158.27 mg/L - 428.40 mg/L). Singh (1995) recorded higher transparency during winter months. Rawat *et al.* (1995) studied morphometry and physico-chemical profile of high altitude Lake Deoria Tal of Garhwal Himalaya from 1990-1991.

Singh and Singh (1995) studied physico-chemical conditions of the river Sone at Dalmianagar (Bihar). Pandey and Lal (1995) studied seasonal variation in physico-chemical factors of hill stream Khanda gad from January to December, 1993. They found positive correlation between atmospheric temperature and water temperature. Turbidity, water velocity, water discharge were positively related with each other and were found maximum in monsoon season. Dissolved oxygen was maximum in winter,

when temperature was low. However, free carbon dioxide was found maximum during monsoon with high temperature and turbidity. Hydrogen ion concentration was observed moderate throughout the year. Sharma (1996) studied ecology of the Koshi River in Nepal-India (North Bihar) from January 1992 to December 1993. He reported quite suitable physico-chemical characteristics of the Koshi river water with a high degree of ecological efficiency and enormous potential for biotic development. Mishra *et al.* (1998) studied the seasonal variation of certain physico-chemical parameters of a beel, Assam and reported marked seasonal variation in a number of parameters. Jain *et al.* (1999) reported positive correlation between P^H and dissolved oxygen of water of sacred lake of Sikkim. They also reported positive correlation of water temperature with P^H and dissolved oxygen but negative correlation with free carbon dioxide and alkalinity. Mishra *et al.* (1999) worked on limnology of a freshwater tributary during the year 1994 and reported maximum amount of dissolved oxygen, total alkalinity and chloride in winter season and free carbon dioxide in monsoon season. Latifa and Acharya (2001) studied the physico-chemical parameters of a freshwater pond (Jagir pond) in Jagir Manikganj, Bangladesh. They reported neutral to slightly alkaline P^H 7 - 7.5, dissolved oxygen 2 mg/L - 5 mg/L and free carbon dioxide 6 mg/L - 9 mg/L.

Though vast number of limnological investigations has been carried out in other countries, only a few works have been done in Nepal. Loffler (1969) reported the dominance of calcium among cations, low chloride and less than $1\mu\text{g/L}$ phosphorus from the high altitude lakes of Mount Everest region. Lohaman *et al.* (1988) studied pre and post monsoon limnological characteristics of lakes of Pokhara and Kathmandu valleys. They obtained low alkalinity and conductivity in the lakes of Pokhara valley. McEachern (1994) reported 8.4 P^H , 0.03 mg/L phosphate and 8.5 mg/L dissolved oxygen in Narayani, a lowland (< 1000 m) river of Nepal. Aryal and Lacoul (1996) studied water quality and diversity of diatoms in Punyamati river. They reported high P^H , total hardness, BOD at polluted site, where transparency and dissolved oxygen were low. Ormerod *et al.* (1996) reported the P^H range between 7.3 to 8, chloride 0.4 mg/L to 1.4 mg/L, nitrate 0.06 mg/L to 0.28 mg/L, and phosphate 0.02 mg/L to 0.04 mg/L from the highland (> 2000 m) rivers of Nepal. No work has been carried out earlier on the physico-chemical parameters of water of different wetlands of the Koshi Tappu Wildlife Reserve.

Regarding macrophytes, Biswas and Calder (1954) published "A hand book of common water and marsh plants of India and Burma". Kaul *et al.* (1978) studied the distribution and production of macrophytes in some water bodies of Kashmir and reported 43 species of aquatic macrophytes. Among these, 28 species were belonging to the emergent, 7 to the rooted with floating leaves and 8 to the submerged group. Shah and Abbas (1979) studied seasonal variation in frequency, density, biomass and rate of production of some aquatic macrophytes of the river Ganges at Bhagalpur (Bihar). They reported 28 species of macrophytes, among which 22 were emergent, 4 submerged, and 2 floating leaved. Devi (1993) reported 86 species from the Loktak Lake, Manipur. Prakash *et al.* (1994) studied on ecology of fishes in relation to macrophytes of a tropical wetland in Begusarai Bihar and reported 41 species of macrophytes belonging to 22 families. Sharma (1995) reported 52 species of aquatic macrophytes from Kawar lake wetland, Bihar. Bazmi *et al.* (1996) worked on biodiversity of a tropical wetland of Madhubani (Bihar) and reported 38 species of angiosperm plants belonging to 34 genera and 25 families. Okram *et al.* (1996) studied macrophytic vegetation of Waithou lake and reported thirty four species. Sharma (1996) reported 19 species of macrophytes from Koshi river basin belt of Nepal-India (North-Bihar). Gupta (1998) studied on the effects of biotic activities on primary productivity of aquatic macrophytes at Varuna river Corridor, Varanasi district and reported 14 species of macrophytes. Devi and Sharma (1998) studied vegetation ecology of macrophytes of Utrapat lake, Manipur and reported 26 species. Sharma *et al.* (1998a) studied on aquatic and marshy dicotyledonous plant of Manipur and reported 61 species belonging to 45 genera and 36 families. Sharma *et al.* (1998b) studied macrophytes of the Loktak lake, Manipur and reported 137 species of plants of which 117 were monocotyledons, 2 gymnosperms, 16 pteridophytes and 2 bryophytes.

The botanical exploration of Nepal began with the visit of Francis Buchanan-Hamilton to Kathmandu during 1802- 1803 followed by Nathaniel Wallich in 1820-1821. Thereafter, notable explorations of the country began only after the 2nd World War.

In 1952, The Natural History Museum, London sent its first exploration team to Nepal followed by one more team in 1954. Several Japanese expedition teams, from Kyoto University in 1952 and 1953, University of Tokyo in 1963 and 1972 and from Chiba

University in 1963 and 1971, extensively explored the country from east to west and led to the description of hundred of species new to science. A joint endeavour by the Natural History Museum, London and the University of Tokyo produced 3 volumes of the book "An Enumeration of the flowering plants of Nepal" edited by Hara *et al.* (1978, 1979 and 1982). Another important monument on phytodiversity of Nepal is the Himalayan Plants in 3 volumes (Ohba and Malla 1999), published by university of Tokyo. Yadav *et al.* (1983) recorded 39 species of macrophytes from Taudah lake of Kathmandu, Nepal. Siwakoti and Jha (1987) reported 234 species of angiosperms belonging to 185 genera and 65 families from Biratnagar area of Morang district. Smith *et al.* (1996) studied aquatic biodiversity in the Karnali and Narayani river Basins of Nepal. Siwakoti and Verma (1999) reported 743 species of angiosperms under 493 genera and 128 families from Biratnagar-Dharan areas. Jha and Jha (2000) recorded 946 species of vascular plants belonging to 172 families and 661 genera from Morang district and adjoining areas of eastern Nepal.

Regarding annelids and aquatic arthropods little work has been done in Nepal. Malla *et al.* (1978) studied aquatic insects from the different water bodies of Kathmandu valley and reported 59 species. Smith (1978) reported 8 species of gomphidae from Nepal. Smith (1981) reported two species of agriidae and 5 species of gomphidae from Nepal. Yadav and Mishra (1982) reported 4 species of freshwater leeches from Kathmandu valley. Yadav and Shrestha (1982) reported 11 genera of the larvae of chironomidae from Nepal. Yadav *et al.* (1983) studied on benthic fauna of four ponds of Godabari Fish Farm, Kathmandu. They reported 27 species of macro-fauna, among them chironomid larvae and oligochaeta were dominant. Yadav *et al.* (1983) studied biological parameters of Taudah lake, Kathmandu. They recorded 36 species of macro-invertebrates, among them oligochaeta, ephemeroptera, chironomidae and mollusca were major groups. Mahato and Yadav (1984) reported 31 species of macro-invertebrates from two ponds of Mahottary district, Nepal. Sharma (1996) reported 2 species of odonata, 3 species of ephimeptera, 3 species of diptera, 5 species of hemiptera, 7 species of coleopteran, 10 species of orthoptera and 2 species of crustacea from Koshi river basin belt of Nepal-India (North-Bihar). Thapa (1998) reported 37 species of aquatic insect fauna from Beesh Hazar Tal. Shrestha *et al.* (2001) reported 8 species of genus *Macrobrachium* from Kaligandaki and Narayani rivers. Shrestha *et al.* (2002) reported 119 species of insects belonging to order



orthoptera, hemiptera and coleopteran. Among the collected insects coleopteran had highest species diversity.

Regarding the studies on mollusca, Sharma (1996) reported 18 species of gastropods and 10 species of bivalves from the Koshi river basin belt of Nepal-India, (North Bihar). Yadav *et al.* (1980) reported 9 species of snail from a lake and three ponds of Kathmandu valley. Yadav (1981) reported some *Planorbis* and *Limnaea* spp. of mollusca from Godavari khola. Pfeiffer *et al.* (1999) reported 11 species of mussel from Nepal. Subba and Ghosh (2000) presented a list of molluscs collected from 9 districts and reported 25 species. Subba (2003) made a check list of molluscs of Ghodaghodi Tal Area of Kailali district which included 10 species belonging to six families. Chhetry (2003) reported 9 species of mollusca from Koshi Tappu Wildlife Reserve and its surroundings of which 5 were freshwater and 2 were terrestrial species. Surana *et al.* (2004) studied the molluscs from Chimdi Lake of eastern Nepal and reported 14 species belonging to 9 families.

The earliest record of fishery in Nepal goes back to the eighteenth century. Hamilton was the first author to provide a valuable reference on the fishes of Nepal. He noted some fishes from Nepal in his book "An account of the fishes found in the river Ganges and its branches" in the year 1822. Since then notable contribution concerning the ichthyo-fauna of Nepal has been made by Day (1878), Boulenger (1907), Regan (1911), Hora (1937), Menon (1949) and Shrestha (1981).

Boulenger (1907) reported a small collection of fishes from Nepal. Regan (1911) classified the teleostean fishes of the order ostariophysy and recorded 5 species from Nepal. Hora (1937) reported some fishes from Nepal. Menon (1949) described the fishes from the Koshi Himalayan region belonging to 11 families comprising 26 genera and 52 species. Swan (1954) collected a good number of fishes during California Himalaya expedition to Makalu. De Witt (1960) prepared a checklist of fishes of Nepal which included 102 species belonging to 21 families. Thapa and Rajbansi (1968) described about hill stream fishes of Nepal. Bhatt (1970) gave information about 57 species of fishes, in his book "The Natural History and Economic Botany of Nepal". Banarescu (1972) studied some cyprinoids fishes from the Khumbu Himal of Nepal. Bhatta and Shrestha (1973) gave an account of 27

species of fishes from the Mahakali river in their report, "The Environment of Suklaphanta". Shrestha (1981) published a book "Fishes of Nepal" describing scientific details of 120 species. Rajbansi (1982) gave a list of 171 fish species from various sources out of which 164 species were indigenous and 7 exotic species. Terashima (1984) has reported 3 new species of cyprinoids of the genus *Schizothorax* from Rara lake. Jha and Shrestha (1986) reported 57 species of fish from the Karnali river, western Nepal. Edds (1986) studied the fishes of Royal Chitwan National Park and listed 113 species. Shrestha (1994) reported 179 species of fish in her book "Fishes, Fishing Implements and Methods of Nepal".

Regarding herpetofauna, the first checklist of the herpetofauna of Nepal provided by Swan and Leviton (1962). They reported 69 species which comprised 16 amphibians, 15 lizards, 5 turtles and 33 snakes. Dubois (1974) reported 21 species of amphibians from western and central Nepal. Nanhoe and Ouboter (1987) described the distribution of reptiles and amphibians in Annapurna–Dhaulagiri region. Shrestha (1981a, 1981b) contributed notes on herpetology.

Shah and Giri (1992) reported some amphibians and their local uses in Arun basin. Schleich (1993) reported 125 species of herpetofauna of Nepal which included 38 amphibians, 24 lizards, 10 turtles and 53 snakes. Shah (1995) made a checklist of herpetofauna of Nepal which included 43 amphibians, 27 lizards, 14 turtles and 64 snakes. Shrestha (1996) reported 156 species of herpetofauna of Nepal. Shah (1998) made a checklist of herpetofauna of Nepal which included 51 amphibians, 36 lizards, 14 turtles and 74 snakes. Schleich and Kaestle (2002) published a book "Amphibians and Reptiles of Nepal".

The authentic study of birds in Nepal was started by the Hodgson. He stayed in Nepal about twenty years and collected huge amount of skin of mammals, reptiles and birds. He published the catalogue of birds of Nepal in 1855. Ali (1949) published "Indian Hill Birds" and added the knowledge concerning the birds of Nepal-India Border. Ripley made collection between 1947 and 1949 from the areas between far west and far east of Nepal and published an article "Birds from Nepal" in 1950. Fleming and Traylor (1968) published notes on birds of Nepal. Nepali and Fleming (1971) reported about some birds of Nepal. Scully (1979) described his observations on 300 species of

birds in a paper "A contribution to the ornithology of Nepal". Fleming *et al.* (1979, 1984) studied extensively on birds of Nepal and published "Birds of Nepal". Inskipp and Inskipp (1985) published "A Guide to the Birds of Nepal". Inskipp (1989) published a monograph on forest birds of Nepal. Subba (1994, 1995) made a checklist of birds of Biratnagar and Dharan. Baral *et al.* (1996) published "Threatened Birds of Nepal".

Taxonomic study on the mammals of Nepal was started by Hodgson. The contribution of Hodgson on the mammals of Nepal and Sikkim actually laid the foundation of Himalaya mammology. He (1831, 1833, 1835, 1836, 1837, 1838, 1839, 1841 and 1844) published papers on mammals of Nepal. Later Blyth (1844) and Horsefield (1855) added several species of mammals to the list of mammals of Nepal.

Hinton and Fry (1923) listed 34 genera and 44 species of mammals from Nepal. Biswas and Khajuria (1955, 1957) collected small mammals from Khumbu region of eastern Nepal and described several species of rodents and pikas. Caughly (1969) studied wildlife in Trisuli watershed. He gave an account of ecogeographic distribution of principle wildlife. Weigel (1969) investigated insectivora and rodentia of Nepal and listed 10 genera and 14 species. Similarly, Grueber (1969) studied the zoogeography, ecology and bionomics of small mammals of east Nepal. Schaller (1977) gave an excellent account of Himalayan mammals in his book, "Mountain Monarchs". Dahmer (1978) worked on the ecology of Wild water buffalo (*Bubalus bubalis*). Johnson *et al.* (1980) gave authentic records of doubtful mammals of Nepal. Abe (1982) reported 28 species of small mammals from central Nepal. Suwal and Verheught (1995) gave comprehensive account of mammalian fauna of Nepal; they recorded a total of 181 species of mammals belonging to 12 orders and 39 families. Shrestha (1997) published "Mammals of Nepal". Majupuria and Majupuria (1998) published a book on Wildlife, "National Park and Reserve of Nepal". Shah *et al.* (2002) reported 30 species of mammals including Tibetan wild ass (Kiang) *Equus hemionus kiang* and Tibetan gazelle (ghowa) *Procapra picticaudata*, which were recorded for the first time from Nepal.