Several studies have been conducted on various aspects of the riverine ecosystem which includes the riparian vegetation and its dynamics, the physico-chemical as well as biological properties of water and sediment as well as the phytoplankton, zooplankton and benthic macroinvertebrates. All these studies were conducted either across a gradient of human disturbances or were location specific. The following review of literature summarizes all those studies.

Naiman et al. (2000) studied the biophysical interactions in and around the immediate vicinity of the riverine systems and their effect over the structural and functional dynamics over the riverine ecosystems. They advocated that variations in local geomorphology, climate, natural disturbance regimes and the dynamic features of the riparian forest are reflected in the characteristics of streams and rivers. They also added that hierarchical interactions between these components result in a rich variety of distinct stream communities which, when considered in combination with strong biotic feedbacks to the physical environment, present formidable challenges in discovering and understanding fundamental, system level characteristics of natural rivers.

Post the proposal of River Continuum Concept (Vannote et al., 1980) and the Nutrient Spiralling Concept (Minshall et al., 1983; Newbold et al., 1981) riparian zones have been fully integrated as major compartments for stream ecosystem functioning. Subsequently, quite a number of studies have focused on the role of riparian vegetation as a source of energy and matter for the aquatic ecosystem (Hynes, 1975; Naiman and Decamps, 1997). Tabacchi et al. (1998) studied the development, maintenance and role
of riparian vegetation in the river landscape and found that vegetation dynamics within the riparian corridor are influenced substantially by hydrological disturbance regimes. Studies were done on the impact of vegetation on river basin geomorphology/hydrological regimes. Significant among them was the study done by Pande (1991) who investigated the impact of vegetation on the basin geomorphology in Central Himalaya. He found that the under-growths and tree cover provide a significant resistance to soil loss, which automatically reduces slope formation processes and retains moderate gradients. Kumar and Verma (1991) studied the hydrological regime influenced by vegetation type in the Kumaun Himalaya and found that oak watershed discharges more constantly as it intercepts more rainfall and minimizes runoff intensity as compared to pine watershed.

Willby et al. (1998) studied a base-poor floodplain mire located in Strathspey in Scottish Highlands and tried to find the way in which measures of the vegetation, with soil hydrochemical factors and management influences, can be used as predictors of plant biodiversity. Long term approach to study plant diversity was conducted by Reddy (1998). He tried to find out the changes in floristic composition, diversity and dominance of herbaceous communities subjected to different types of disturbances for twenty years. A number of contributions were made pertaining to the ecology of wetland pteridophytes of the Himalayas (Schelpe, 1954; Mehra and Bir, 1964; Awasthi and Sharma, 1980; Bir et al., 1982; Khullar and Sharma, 1989). Macrophytes constitute a major component of the riparian vegetation and determine the overall ecosystem physiognomy, indicating the degree of pollution and hence they are responsible for the immense role in biogeochemical cycling of nutrients (Hutchinson, 1975; Wetzel, 1975). Sharma et al.
(2001) observed the differences in the vegetation composition in response to pollution in Amanishah drain around Sanganer, Jaipur city. Anbumozhi et al. (2003) while making a study on the riparian land use activities within the Upper Ciliwung watershed in West Java, Indonesia observed that riparian paddy fields are useful in controlling the nutrient flow into the stream.

Productivity is one of the most important attributes of an ecosystem and provides basic energy and matter for all other biotic components (Richard and Francis, 1964; Billore and Mall, 1977). In fact, productivity is an index of fertility of an ecosystem (Odum, 1971). Because N and P are the primary nutrients limiting productivity in wetlands (Schlesinger, 1991; Vitousek and Howarth, 1991; Bridgham et al., 1996), these nutrients usually are responsible for changes in ecosystem function and structure that occur when wetland assimilative capacity is exceeded (Carpenter et al., 1998).

Waters and Shay (1992), Newman et al. (1998) and Kellogg et al. (2003) found that wetland plant productivity and nutrient uptake can be influenced by hydrological parameters including flood depth. According to Newman et al. (1998) the most influential factor for plant productivity and nutrient uptake in wetland vegetation is the flood duration while Giovannini and Da Motta Marques (1998), Tanner (1999), Casanova and Brock (2000) opined that flooding frequency plays the major role in wetland plant productivity and nutrient uptake. According to Mitsch and Ewel (1979), Mitsch et al. (1979), Junk et al. (1989), Day et al. (2000) water level fluctuations associated with a pulsing hydrology may increase wetland productivity and nutrient uptake. Spink et al. (1998) observed that in flowing flood pulses usually occur sporadically throughout the year and can be laden with higher than normal concentrations of nutrients that can
provide a “fertilizing effect” for plant growth. Further increases in nutrient availability can occur in wetland sediments by the release of phosphorus during anaerobic conditions. However, prolonged wetland inundation increases the potential for anoxic conditions that can be detrimental to macrophyte vegetation (Van der Valk and Davis, 1978). The temporary nature of river flood pulses often leads to rapidly dropping water levels, thus decreasing the chance for soil anoxia while increasing nutrient mineralization and the potential for greater macrophyte productivity (Mitsch and Rust, 1984). The benefit of a pulsing hydrology has been well demonstrated for wetland forests (Mitsch et al., 1991; Brown, 1981) and planktonic communities (Hein et al., 1999), but has been less predictable for herbaceous wetlands. Herbaceous wetland vegetation may be more sensitive to the variable conditions (depth, duration, etc.) associated with flooding waters that may make a pulsing effect more difficult to detect. Bayley et al. (1985) found that merely the presence of standing water, regardless of its nutrient content, can influence marsh primary productivity and credited this to the release of P that is triggered by the onset of anoxic conditions. Taheruzzaman and Kushari (1988) observed that production rate of *Eichhornia crassipes* was positively correlated with ammonia nitrogen and total phosphorous in water. They also observed that the concentration of total nitrogen and total phosphorous of the plant varied seasonally and it decreased with increased production rate.

Questions regarding the effects of nutrient availability on nutrient-resorption efficiency, internal recycling of nitrogen (N) and phosphorus (P), and the role of evergreenness on nutrient retention by plants growing in nutrient-poor wetland ecosystems have been addressed since the late 1960s (Monk, 1966; Small, 1972; Tilton, 1977). It has
been postulated that low nutrient losses or efficient retranslocation of nutrients can increase the fitness of certain plant species or plant populations in nutrient-poor ecosystems (Grime, 1979; Ingestad, 1979; Chapin, 1980; Veerkamp et al., 1980; Berendse and Aerts, 1987; May and Killingbeck, 1992). High-efficiency retranslocation of nutrients can significantly reduce litter nutrient content and in turn alter ecosystem biogeochemical cycling rates (Bridgham et al., 1995). Moreover, nutrient additions increase plant productivity and may change community metabolism and structure in wetlands (Chapin, 1980; Shaver and Melillo, 1984; Richardson and Marshall, 1986; Craft and Richardson, 1995; Delucia and Schlesinger, 1995). Bridgham et al. (1995) noted that species with high nutrient-use efficiency drive infertile ecosystems towards even greater nutrient deficiency because low litter nutrient content and reduced mineralization rates further slow nutrient recycling. They also suggest that some minimum level of nutrients is required to sustain an ecosystem and that a balanced carbon: nitrogen: phosphorus (C: N: P) stoichiometry is essential to sustain ecosystem productivity. More importantly, they found that nutrient-use efficiency decreases at a low suboptimal concentration of limiting nutrients. Nevertheless, maintaining high nutrient-use efficiency to produce new biomass and increased accumulation of secondary compounds may be an important adaptation of plants growing in infertile habitats. Increased P and Na additions as well as hydrologic changes along the P gradient were highly correlated with a shift of plant community composition as well as increased net primary and secondary productivity (Urban et al., 1993; Rader and Richardson, 1994; Craft and Richardson, 1997).

McJannet et al. (1995) observed that increased nutrient loading to wetlands often results in an increase in emergent plant biomass and a decrease in species diversity.
However, plants with 'ruderal' life history traits (e.g. annual or functional annual/fast-growing) had significantly lower N and P tissue concentrations than plants having 'interstitial' or 'matrix' life-history traits. Interstitial perennials had significantly higher N concentrations than matrix perennials. Therefore, plant functional groups are likely to respond differently to eutrophication. Koerselman and Meuleman (1996) based on the review of 40 fertilization studies in a variety of European freshwater wetland ecosystems (bogs, fens, wet heathlands, dune slacks, wet grasslands) revealed that an N:P ratio >16 indicates P limitation on a community level, while an N:P ratio <14 is indicative of N limitation. At N: P ratios between 14 and 16, either N or P can be limiting or plant growth is co-limited by N and P together.

Sharma and Kushwaha (1999) while making a study on the nutrient dynamics in an *Arundo donax* wetland in Jaipur observed that tissue concentrations are governed by many factors such as the nutrient status of the water and sediments, hydrology, age of plant, climatic conditions and competition with other macrophytes. Boyd (1978), Herskowitz (1986), Suzuki *et al.* (1989), Breen (1990), Sharma and Heritage (1992), Sharma and Kushwaha (1999) observed that young shoots contain more nutrients than the old shoots. Mason and Bryant (1975), Klopatek (1978), Kovacs *et al.* (1978), Sharma and Kushwaha (1999) observed that nutrient concentration are usually higher in above-ground organs than in the below-ground organs.

Soil is the most basic of all natural resources. In addition to biomass production it regulates the environment. Decline in soil quality has a strong adverse impact on soil's environmental/ecological functions that maintain water and air quality (Lal, 1998). Numerous studies have examined spatial variability in upland soils (Harradine, 1949;
Ball and Williams, 1968; Drees and Wilding, 1973; Campbell, 1978; Mausbach et al., 1980; Edmonds et al., 1985; Thomas et al., 1989; Mausbach and Wilding, 1991; Stolt et al., 1992). A few studies have made spatial comparisons between soils of uplands and adjacent wetlands. Hammer et al. (1987) compared soil variability within three landscape units: first-order bottomlands, sloping landscapes, and level uplands soils on bottomlands and observed a significant spatial variability along the three landscapes. Reese and Moorland (1996) examined changes in soils properties from the basin of a Carolina Bay digressional wetland to the upland rim. Significant differences in organic C and clay content were observed between the wetland and surrounding upland rim. Considerable differences in soil parameters were also recognized within the wetland portion, even though the change in elevation was minimal. Stoeckel and Miller-Goodman (2001) while making a study on the Coosawhatchie River floodplain, South Carolina observed that soil chemical and biological processes varied with microtopography and the concomitant differences in soil structure and hydroperiod. In India a comparative study of the physico-chemical properties of the soil, sediments and water along the Sharavathi river basin, Bangalore was made by Kumar and Ramachandra (2003) and they found land use patterns lead to alteration of the physico-chemical properties of soil in the catchment area accompanied by the alteration in the sediment and water in the river.

Sediments represent essential elements of aquatic ecosystems because they support both autotrophic and heterotrophic organisms (Brills, 2004) particularly the rooted emergent plants and periphyton which absorb nutrient from the sediments (Salodia, 1996) besides providing habitat for the zoobenthos in the aquatic system as well as to make an assessment to any changes in the status of water bodies resulting from the
different types of land uses (Barceló and Petrovic, 2004). Sediments of different Indian rivers were examined with respect to heavy metal. A detail study was undertaken in the river Cauvery (Seralatham, 1987) and metal levels were reported from sediments collected from river channel, estuary, tidal channels, mangrove swamps and marine waters. Analysis of various components revealed that sediments accumulate significant amount of the metals in the total metal budgets. Bhatt and Pathak (1991) observed that the bank materials of most of the rivers are found to be composed of fine sand and silt; in addition, those of Kosi, Gomti and Gaula watersheds evince occasional clay. Salodia (1996) observed the differences in chemical characteristics of sediments of water bodies of Rajasthan with change in season.

Johnston et al. (1984b, 1997) observed that differences in soil nutrient content accompany variation in soil texture and organic matter, with total phosphorous inversely related to grain size, and total nitrogen increasing with organic matter content. James (1985) observed that soil texture varied substantially across river floodplains, predictably affected by differences in flow velocity and turbulence. According to Omernik et al. (1981) P concentrations in streams were more strongly related to overall watershed characteristics than stream-side vegetation proximity. Johnston et al. (1997) observed that the organic matter content of floodplain soils also typically increases with distance from actively flooded stream banks to less actively flooded slack water areas. Lyons et al. (1998) found that P retention capacities in riparian soils vary with drainage class, with moderately well drained soils having greater retention than somewhat poorly drained soil. In all cases, P retention appeared to be controlled by organic matter and Fe- and Al-oxides. In some regions, acidification by decomposition of organic matter and/or oxygen
depletion may cause increased releases of P from riparian sediments (Pedrozo and Bonetto, 1991). Groffman et al. (1992) found that plant uptake was the dominant sink for nitrate during the growing season in riparian soils. Ashby et al. (1998), Jordan et al. (1998) and Correll (1991) found that the ability of a riparian zone to remove large quantities of nitrate from water or soil is influenced by the type and quantity of existing vegetation and by soil conditions. Hill (1996) and Bilby (1988) observed that riparian zones contain potential hotspots of denitrification due to the presence of high water tables that may produce the anoxic conditions required for the process to occur besides this he also found that nitrogen released from riparian soils through decomposition or leaching has the potential to impact aquatic systems.

Golterman (1993) observed that in the shallow water environment of wetlands the nature of sediments was found to greatly influence the nitrogen and phosphorous cycles and the growth of macrophytes. Froend and McComb (1994) observed the variation in productivity with change in the sediment nutrient concentration and soil type within the same water regime, whereas Oliveira et al. (1994) found that the variation in the biomass of emergent plants and their distribution were related to the sediment features and salinity. Svendsen et al. (1995) observed that stream sediments may play a major role in regulating P concentrations in the water column, especially when residence time of water is longer. Tao et al. (2000) studied the release kinetics of water soluble organic carbon from river sediment and wetland soil in river Yichum in China and found that release process of soluble organic carbon depends on flow velocity of water, texture, temperature and pH. Sharpley et al. (2002) observed that the affinity of dissolved inorganic P for sediments results in the important processes of adsorption and desorption which in turn
controls P concentrations in freshwaters. According to Heggie et al. (2002) N and P when discharged into a waterway, are deposited in bottom sediments incorporated into organic matter after which bacterial decomposition of organic matter takes place, liberating N and P to the pores waters and overlying water. Franklin et al. (2002) showed that dissolved P in streams was not related to morphological characteristics of the watershed such as stream order, drainage density, contributing area, and stream length. Koschorreck and Darwich (2003) observed that both the soil physical and chemical changes directly caused by the flood pulse and the vegetation have a great impact on microbial nitrogen turnover in the soils. Kumar and Ramachandra (2003) investigated the water, soil and sediment to explore ecosystem of river Sharavathi, Kerala. Gathumbi et al. (2005) found that plant and soil nutrient enrichment and storage in temporary wetlands were impacted by adjacent land use practices, which potentially lead to the alteration of the structure and functions of the wetland ecosystems. Till now much smaller proportion of sedimentation research has focused on freshwater wetlands (Harter and Mitsch, 2003). The focus and outcome of many of these sedimentation studies has been to demonstrate that freshwater wetlands are highly effective in nutrient retention, especially as phosphorus sinks (Mitsch et al., 1977 and 1979 a,b; Craft and Richardson, 1993; Meeker, 1996). Other studies have examined the physical factors that affect sedimentation in freshwater systems (Kadlec and Robbins, 1984; Hupp and Blazemore, 1993; Kleiss, 1996; Wardrop and Brooks, 1998; Braskerud et al., 2000; Braskerud, 2001). These studies have recognized the importance of factors such as basin morphology, hydrology, and biota, but further research is needed to determine how these factors interact together to influence sediment dynamics at the ecosystem level.
Microorganisms are omnipresent in wetlands even living within the individual submerged roots of some wetland shrubs (Fisher et al., 1991). Through interactions with wetland plants and hydrology, wetland microbial assemblages can remove inorganic nutrients, heavy metals, dissolved organic carbon, particulate organic matter, and suspended solids from the water column and sediments (Mickle, 1993) as well as play a key role in supporting food webs (Schallenberg and Kalff, 1993) and influencing global climate change through their role in methanogenesis (Bartlett and Harriss, 1993; Kumaraswamy et al., 2000). Soil microbial biomass comprises less than 5% of organic matter in soil. However, it performs at least 3 critical functions in soil and the environment. It is a labile source of carbon, nitrogen, phosphorus, and sulfur. It is an immediate sink of carbon, nitrogen, phosphorus and sulfur and is an agent of nutrient transformation and pesticide degradation. In addition, microorganisms form symbiotic associations with roots, act as biological agents against plant pathogens, contribute towards soil aggregation, and participate in soil formation (Dalal, 2004).

A marked seasonal cycle of microbial biomass has been reported for both tropical and temperate forest soil by Singh et al. (1989); Diaz-Ravina et al. (1995). Whereas Ross et al. (1981) reported large annual fluctuations in soil microbial biomass, Patra et al. (1990) observed only small annual changes. Some studies by Shrivastava and Singh (1991) and Diaz-Ravina et al. (1995) have highlighted the influence of land use and soil physico-chemical properties on microbial biomass. Haycock and Pinay (1993) observed that contributions of above-ground biomass to soil C levels benefits soil microbes that reduce nitrate during winter months. Goodfriend (1998) observed that substrate type have a great influence than local geography on microbial taxonomic composition. Jordan et al.
(1998) found rapid responses of denitrifiers to treatments with water, nitrate, and sucrose additions and concluded that denitrifying bacteria have a stock of enzymes poised to opportunistically exploit quickly changing soil conditions. Holmes et al. (1998) investigated the impact of flash flooding on microbial distribution and biogeochemistry in the parafluvial zone of a desert stream and observed the importance of surface-subsurface interaction to stream ecosystem functioning and showed that the nature of these interactions changed substantially in successional time. Gaillard et al. (1999) observed that the addition of a readily available substrate modified the spatial distribution of microorganisms in soil. The microbial biomass and community structure of eight Chinese red soils with different fertility and land use history was investigated by Yao et al. (2000). Two community based microbiological measurements, namely, community level physiological profiling (CLPP) using Biolog sole C source utilization tests and phospholipid fatty acid (PLFA) profiles, were used to investigate the microbial ecology of these soils and to determine how land use alters microbial community structure and they found that land use history and plant cover type had a significant impact on microbial community structure. White and Reddy (2000) observed the highest values of microbial biomass C and N, total P, extractable NH$_4^+$, and PMN (potentially mineralizable nitrogen) in the detrital layer.

According to Ingold (1942) the micro flora of freshwater habitats includes a spectacular array of Hyphomycetes and these have also been recorded from non-aquatic habitats (Park, 1974; Webster, 1977; Sanders and Webster, 1978). Sati (2001) reviewed a study on the conidial aquatic fungi in the Kumaun Himalaya and found a total of fifty two species including three new taxa and twenty two new additions to Indian mycoflora.
Helmut et al. (2002) explored the relationships between bacterial abundance and production and the gradients of organic matter quality and quantity in sediments of a sixth-order lowland river (Spree, Germany). They found that detrital variables correlated strongly with bacterial abundance and production. Their findings demonstrated that sediment dynamics significantly foster organic carbon metabolism in river systems. Florian et al. (2002) observed that micro-organisms used more dissolved organic matter and nutrients in the presence of invertebrates because invertebrate activities increased the contact between the biofilm and water. Sekiguchi et al. (2002), Brummer et al. (2000, 2003) and Arya et al. (2003) observed that river microbial community is dominated by $\beta$-proteobacteria and Cytophaga-Flavobacterium cluster both in sediment and water column.

An understanding of the physico-chemical aspect of river is a very important tool for monitoring the extent of pollution and the physico-chemical properties of water of several Indian rivers have been the subject of detailed investigations. These include Ganga (Saxena et al., 1966; Ray et al., 1996; Agarwal et al., 1976; Bhargava, 1985; Bilgrami and Dutta Munshi, 1985; Sharma and Singh, 1993; Sabata and Nayar, 1995), Alakananda (Badola and Singh, 1981; Nautiyal et al., 1986), Jhelum (Raina et al., 1984), Malampuzha (Chacko et al., 1953), Adyar (Chacko and Ganapati, 1949), Kanhan (Desmukh et al., 1964), Daha (David and Ray 1996), Thambaraparani and Godavari (Ganapati, 1956 and 1964), Kali (George et al., 1969), Cooum (Konnur et al., 1986), Periyar (Shankarnarayanan et al., 1986), Cauvery (Srinivasan et al., 1979; Somasekhar, 1984), Tungabhadra (Reddy et al., 1984), Mossi (Venkateswarlu, 1968a), Sabarmati (Venkateswarlu and Jayanti, 1968), and Aurang and Ambika (Zingde et al., 1985 and
Several studies have also focused on the impact of organic pollutants including sewage, inorganic pollutants and industrial effluents on the water quality, biota and fisheries potential of several rivers such as the Ganga (Ray and David, 1966; Ghosh and Basu, 1968; Basu and Ghosh, 1970; Gopalakrishnan et al., 1970; Chattopadhyaya et al., 1984; Basu, 1985; Sharan and Singh, 1993; Singh, 1985), Chambal (Agarwal et al., 1986), Vaigai (Mahadevan and Krishnaswami, 1983), Tungabhadra (Reddy and Venkateswarlu, 1987), Damodar (Singh, 1985), Amaravati (Sivakumar et al., 1987), Moosi (Venkateswarlu and Sampath Kumar, 1982) and Yamuna (Sengar et al., 1985). Sinha et al. (2001) studied the status of river Ganga ten years after implementation of the Ganga Action Plan and found a significant positive result in the Ganga river water quality through the ecological restoration measures and they also found that restoration of ecosystem function in streams and rivers clearly requires to be looked beyond the banks, to the quality of the riparian and perhaps the entire landscape that meets special needs of individual species. Physico-chemical, biological and bacteriological characterization of river Amaravathy, Tamil Nadu was studied by Karthikeyani and Ramesh (2002) and found that the effluents from a sugar factory contributed to the main source of pollution in the river water and lead to the deterioration of the water quality in that river.

Phytoplankton are free-floating microscopic photosynthetic organisms which contribute significantly to the primary production of a water body. Studies spanning over the last 4 to 5 decades, have documented the phytoplankton diversity of many Indian rivers like Ganga, Kosi, Tapti, Ajee, Cooum, Varuna, Gomti, Cauvery, Moosi and others (Biswa, 1943; Gonzalves and Joshi, 1946; Roy, 1955; Basu, 1965; Lakshminarayana, 1965; Saha et al., 1975; Singh, 1979; Prasad and Manjula, 1980; Prasad and Saxena,
These studies have identified several factors influencing phytoplankton diversity and density such as pH, dissolved oxygen, organic matter, nutrients, etc. Somashekher (1984) showed phytoplankton constituent as indicator of water quality of Cauvery. Nandan and Patel (1985a) studied the seasonal variation in phytoplankton diversity in the Vishwamitri river in Baroda. Mishra (1990) studied the hydrobiological characteristics of Morar river in relation to plankton and productivity and found that the river is polluted by domestic sewage, municipal sewage and other discharges along its course in the city, Gwalior. Patralekh (1991) studied the periodicity of phytoplankton in the river Ganga at Bhagalpur Bihar. Mishra (1993) studied the phytoplankton composition of sewage polluted Morar (Kalpi) river of Gwalior (M.P.).

The phytoplankton community, although one of the best documented, is of little use in indicating pollution in flowing waters (Fjerdingstad, 1960; Patrick, 1957) except where flow is reduced. In this regard, algal/periphytonic communities play an important role in the riverine ecosystem. They are also a part of the overall primary production system in an aquatic ecosystem. Fjerdingstad (1960) devised a system in which benthic algae are used as indicators of water pollution. Rao (1954) reported that blue green algae are plentiful in water having a high proportion of oxidizable organic matter; and sunshine appeared to be the factor affecting their productivity. Somashekher (1984) made observation of algal flora of Kapila river. Venkateswarlu and Reddy (1985) studied the ecology of algae in relation to paper mill effluent in the river Tungabhadra and proposed that algae could act as potential biomonitoring agents. Mittal and Sengar (1991) studied the distribution of algal flora in polluted regions of Karwan River at Agra. They observed that several species showed interesting pattern of succession in relation to pollution load.
Investigations on the selected Central Himalayan rivers and their tributaries (Bodola and Singh, 1981; Bhatt et al., 1984, 1990) revealed that the phytoplankton population in the rivers was dominated by Bacillariophyceae (*Cyclotella, Melosira, Navicula* etc.), followed by Chlorophyceae (*Chlorella, Cladophora, Hydrodictyon, Spirogyra, Ulothrix* etc.) and Cyanophyceae (*Microcystis, Oscillatoria* etc.) that reflected their diverse nature. In this regard, Round (1965) advocated that the epipelic and epiphytic algae might act as excellent indicators of the degree of pollution. Iyengar and Venkataraman (1951) and Venkateswarlu (1969c, 1970) made notable contributions on benthic algae or the periphyton community of lotic bodies, which otherwise have been negligibly studied in India. Other workers have concentrated on the phytoplankton only, though a few workers have taken up the study of diatoms in Indian rivers and streams. Laal et al. (1982) showed species diversity of periphyton as an index of pollution of Ganga river. Nandan and Patel (1983-1986, 1990, 1992) observed the algal communities of river Vishwamitri flowing through Baroda city, as indicators of organic pollution. Unni (1996) found the family Bacillariophyceae as the most dominant group of periphyton in river Narmada along with Chlorophyceae and Cyanophyceae. Prasad and Singh (1996) studied the ecology of benthic river algae with special reference to Bacillariophyceae in river Gomati. Richard et al. (2004) observed that multiple factors regulate phytoplankton growth in regulated rivers and that spatial complexity may arise from differences in discharge and water aging.

Zooplankton are yet another heterogenous group of tiny animals adapted to suspension in water systems and occupy the level of primary consumers. Zooplankton constitute an important link in food chain as grazers and serve as food for fishes directly
or indirectly (Shrivastava et al., 2002). Earliest contributions to zooplankton studies in India come from the Zoological survey of India (Prasad, 1916). However, the bulk of zooplankton studies in relation to hydrobiology have been done only during the last 50 years (Nayar, 1968; Vasisht and Sharma, 1976; Mishra et al., 1978. Ray et al. (1966) and Shrivastava (1984-1988) investigated the zooplankton community at the confluence point of rivers Ganga and Yamuna at Allahabad. Verma et al. (1984) studied the impact of industrial effluents on the distribution and abundance of zooplankton in river Kali. Verma and Shukla (1969) also studied the same parameters in a perennial stream Khala at Laksar (Uttar Pradesh). Sampath et al. (1979) quantified the zooplanktons in river Cauvery. Arora (1961, 1966), Rao and Chandramohan (1977) and Mahajan et al. (1981) have discussed the importance of zooplankton as indicators of pollution. Verma et al. (1980) reported that the highly polluted Hindon river supported very little zooplankton (1-3 organisms litre$^{-1}$) due to pollution stress compared to moderately polluted Yamuna (25-40 litre$^{-1}$) (Verma et al., 1987). Unni (2003) found a decline in diversity of zooplankton in the Ganga during the past two decades of pollution. Bilgrami (1991) studied the zooplankton density in Ganga at Hardwar and Bijnoor. Sharma (1992) listed a number of rotifers from eutrophic alkaline waters. Hameed et al. (1995) quantified the zooplankton at the downstream of Cauvery. Unni (1996) studied the zooplankton community in river Narmada and found that the dominant zooplankton belonged to the group Rotifera. Kulshrestha (1992) reported that Rotifera comprised the dominant group in the river Chambal and its tributaries and found that the species Keratella, Brachionus and Calyciflous were most tolerant at the highly polluted sites and were correlated with high
alkalinity, chloride and hardness. Copepods were found tolerant to pollution and were significantly related to nitrate and phosphates.

Benthic macroinvertebrates are insect and other non-insect bottom-living communities of water that are relatively sedentary and comprise a range of species with varying tolerances to pollutants, and occupy a variety of niches involved in ecosystem functioning (Burton, 1991). In addition to this because river macro invertebrates integrate processes occurring at the watershed scale they are important indicators of natural processes such as gradient, discharge fluctuations, water chemistry and geology, riparian zone characteristics (Milner and Roberts, 1997). Though ecological studies on benthic fauna are not sufficient in tropical waters, there are many studies in India because of large area of inland water that exists over 1.6 million hectare in the country (Shrivastava, 1956; Michael, 1968; Mandal and Moitra, 1975; Krishnamoorthy and Sarkar, 1979; Bhandal, 1979; Reddy and Rao, 1988; Reddy, 1991). Orth and Maughan (1983) made a study on the estimates of numbers, biomass, and diversity of benthic macroinvertebrates to investigate microhabitat preferences and they observed that although biomass of most taxa was significantly different among sampling times, physical factors also appeared to be important in determining abundance of many taxa.

A few studies have also been conducted to identify the environmental variables influencing their community structure in lotic systems (Cosser, 1989). Corkum (1992) made a study to test the biome dependency hypothesis, which predicted that similar assemblages of macroinvertebrates occur along rivers both within and among drainage basins if the basins occupy the same biome. He observed that macroinvertebrate composition was more strongly associated with local, site-specific factors (riparian
vegetation and land use) than with longitudinal gradients. Besides, the interpretations on these invertebrates in terms of bioindicators of environmental pollution are inadequate and very much scattered in India (Krishnamoorthy and Sarkar, 1979; Patel et al., 1983; Khan, 1985; Dudani et al., 1988). Review of literature on the benthic macro invertebrates in India reveal that most of the studies are from fish ponds whereas such studies for rivers especially on Ganga are very scanty except a few important contributions made by Pahwa (1979) and Jhingran (1988) in different stretches of the river. Sehgal (1991) observed different aspects of benthic biota at a number of stations along the principal rivers and their tributaries of Indus, Yamuna and Ganga systems. Singh (1995) observed the effects of sewage on macrozoobenthic community and physico-chemical properties of the water of river Ganga at Patna. Kishor et al. (1998) studied the variations in the density of benthic macroinvertebrates in the Western Ganga and three other canals emerging laterally from the impounded sections of the river Ganga near Hardwar. Pandey et al. (1999) studied the various aspects like physicochemical parameters, phytoplankton, zooplankton and benthic macroinvertebrates, macrophytes and coliforms. Monthly fluctuations in the population density of macroinvertebrates at different sites in river Tamiraparani, South India were studied by Martin et al. (2000). They studied the relationship between macroinvertebrates and environmental variables using an ordination technique whereby density and occurrence of macroinvertebrates were correlated with dissolved oxygen, biological oxygen demand and chemical oxygen demand. Reddy and Rao (2002) studied the benthic macroinvertebrate community in relation to water quality in an urban canal in Telangana region of Andhra Pradesh. Moreover meager information is available on the relationship between the seasonal variation between the physico-
chemical factors and population densities of different benthic macroinvertebrates (Reddy and Rao, 2002). Florian et al. (2002) investigated the impacts of an assemblage of three taxa - asellids, chironomid larvae, and tubificid worms on sediment distribution, water fluxes, sediment organic carbon, biofilm (attached bacteria) characteristics, and $O_2$, dissolved organic carbon $NO_3^-$, $NO_2^-$, and $NH_4^+$ concentrations in slow filtration sand-gravel columns and they observed that invertebrates clearly modified the distribution of particles in the sediment column, probably because of the structures (tubes, macropores, and faecal pellets) produced by the three taxa in the sediment.

According to Hynes (1974), nature of the river bed/substratum is the major controlling factor in the distribution and density of benthic invertebrates. Peterson et al. (1985), Rosemond et al. (1993) and Hill et al. (1995) observed that nutrient or light amendments could also affect the density and distribution of stream invertebrates. In this regard Mundie et al. (1991) also observed greater number of emerging insects from nutrient-enriched experimental streams than in controls. Kohler (1992) found that increased standing stocks of algae could affect interactions among grazers. Removal of a dominant herbivore, the caddisfly (Glossosoma nigror), led to an increased abundance of other grazers as a result of increased availability of periphyton. Feminella and Hawkins (1995) and Steinman (1996) found that grazing group could be very efficient in removing periphyton biomass and shaping their community structure in aquatic ecosystems.

The evaluation of primary productivity of any water body is imperative in understanding its ecological status. It is a well-known and established fact that various abiotic and biotic components establish very intricate interrelationships between one another that are again subject to diverse fluctuations due to natural as well as manmade
interference. The intricate interplay of the physico-chemical parameters further influences the primary producers and subsequently secondary and tertiary producers (Paul and Verma, 1999).

Khan and Zutshi (1979) observed that the rate of production of phytoplankton to a large extent is dependent upon the temperature conditions of the water body. Nandan and Patel (1985b) studied the eutrophication in Vishwamitri river flowing through Baroda city. Saha et al. (1985) investigated the factors affecting phytoplankton productivity and density in the river Ganges at Bhagalpur. Mishra (1990) studied the hydrobiological characteristics of Morar river in relation to plankton and productivity and noticed that river is polluted by domestic sewage, municipal sewage and other discharges along its course in the city Gwalior. Unni (1996) studied the phytoplanktonic productivity in river Narmada and found that water current and phytoplankton play more important role in river than water temperature in planktonic productivity. Khan et al. (1999) observed the seasonal variations in gross and net primary productivity along with variation in total phyto-and zooplankton in the selected stretch of river Ganga from Narora to Kannauj. Lakshminarayana and Somashekar (2002) studied the planktonic productivity in relation to various physico-chemical properties of the water of river Cauvery, Karnataka which established the impact of alterations in physico-chemical parameters on the rate of production in the river water.

Chlorophyll a serves as an important indicator of primary productivity (Milner and Roberts, 1997). In this regard, it can be mentioned that, Stockner and Shortreed (1978) observed that adding inorganic nitrogen and phosphorus increased chlorophyll a in periphyton. Sondergaard and Jensen (1979) measured phytoplankton biomass as
chlorophyll a and observed that chlorophyll values coincided with lower values of secchi disc transparency. According to Keithan et al. (1988), Bourassa and Cattaneo (1998) and Hill et al. (2000) interpreting algal responses to nutrient limitation on the basis of chlorophyll a commonly is misleading, because algae are sensitive to a number of different stresses, including light, predation, iron, water color, and the percentage of the watershed in urban and suburban land use. According to Power (1990) and Rosemond et al. (1993) algal biomass is controlled by a variety of abiotic (e.g. nutrients, scour) and biotic (e.g. grazers) factors that interact in complex ways. A review of literature investigating the affects of periphyton grazers showed positive removal rates of algal biomass (Cattaneo and Roberge, 1991). However, manipulations of light and nutrient supply can also profoundly affect algal biomass, nutrient content, productivity, and species composition (Hill et al., 1992; Rosemond, 1993; Hillebrand and Sommer, 1997; Francoeur, 2001). Feminella and Hawkins (1995) and Steinman (1996) observed that grazers could be very efficient in removing periphyton biomass and shaping community structure. Hill et al. (1995) studies the effects of light on periphyton growth and they suggested that light might be limiting only in heavily shaded water bodies, where leaf canopies can intercept more than 95% of the incident radiation. Lamberti (1996) reviewed freshwater experiments on benthic food webs and concluded that light and nutrient can simultaneously affect periphyton. Wellnitz et al. (1996) found that light may be instrumental in establishing periphytic community structure and in modifying the impact that grazers have on algae. Kupferberg (1997) examined how interactions between resources that varied in edibility and herbivores that varied in ability to acquire resources, control primary productivity in a northern California river. Kiffney et al. (2004) inferred
biotic control of periphyton during the early part of the channel study, whereas light appeared to control periphyton at the end of the study. Results from the large-scale and channel experiments suggested that light was the primary constraint on periphyton biomass accrual. Their study further showed that light indirectly influenced consumer performance as mediated by increased primary production.

In contrast to the substantially large volume of data available on the rivers from other regions of India and elsewhere, the northeast Indian rivers have not been studied in any detail for their water quality, biodiversity, pollution and sediment analysis except some studies on the different aspects of the ecology of the hill streams of Meghalaya (Ao et al., 1984; Gupta and Michael, 1983, 1992; Gupta, 1994, 1995) and one limnological study of river Haora in Tripura (Bhattacharya and Saha, 1997). A few studies have attempted to evaluate the potential and status of capture fishery in river Brahmaputra (Choudhury et al., 1980; Biswas and Phukan, 1986; Bhagawati, 1990; Phukan and Biswas, 1991; Biswas and Michael, 1992; Biswas et al., 1995). In river Barak study was made related to the impact of a paper and pulp mill in its water sediment and biota (Gupta and Gupta, 1995) and on its trace metal levels in a few sites (Gupta, 1998). Besides some ecological studies in some selected stretch of river Barak have also been made (Rout and Das, 2002; Das, 2002). In Arunachal Pradesh, Arunachalam and Arunachalam (2002) investigated the impacts of flood in the sediment of Dikrong river and observed significant changes in sediment in terms of physico-chemical and microbial properties.

Rao et al. (1999) identified Arunachal Pradesh as one of the humid to perhumid, sub-agro ecological zones for soil conservation, as the soil in this region experience severe degradation due to natural disturbance (landslides, floods) and human activities.
(road networking, shifting cultivation). These disturbances accelerate soil erosion resulting in reduced productivity. It is worth re-iterating that the state covers an area of 83,740 km² that acts as a watershed to the major drainage basin, Brahmaputra. However no holistic measures have been taken to check soil erosion and to apply appropriate management of watershed for sustained production (Singh, 1999). Further studies by Arunachalam et al. (2001) in this region showed that there were changes in soil properties due to the type of land use and associated micro environmental conditions.

The above review of literatures clearly reveals that in most of the cases the riverine system has been studied in a fragmented manner. For example, one group took into consideration the physico-chemical and biological properties of water and the other group studied the sediments leaving aside the upland soil. Studies on riverine wetland covering the entire watershed are scanty. In this regard, studies comprising the upland area, riparian area and the thalweg portion in river are very important so as to relate the aquatic system with various land use patterns. Hence, the objectives of the present study becomes pertinent and holistic in examining the Dikrong river and the study has integrated various structural and functional components of the river ecosystem both from water and soil as physical entities and biological production as the living entity.