CHAPTER-V
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Summary

Water resources are under pressure and in danger as a result of potential pollution and contamination risks due to overuse and misuse of the resources in the world. Most of the time peoples are found to live under negative impacts of these pressures. Due to the worldwide concern that good quality freshwater may become a scarce resource in the near future, developing countries and countries with transition economics have increased their interest in water quality monitoring programs during the past decades. Considering the present status of water quality in Indian rivers and lakes, the limnological study are becoming very important, and needs for this very hour. The present work entitled “Impact of Physico-Chemical Characteristics of Water on the distribution pattern of Macrophytes of Imphal and Irl River, Manipur” have been summarized below.

During the present investigation

1) The physico-chemical characteristics of water quality of the two rivers,
2) To study the distribution pattern of the macrophytes in relation to the water characteristics of the two rivers, to investigates the impact of the nutrients to the macrophytes of the two rivers,
3) To estimates certain biochemical components of the dominant species,
4) To study the phytosociological parameters (frequency, density, abundance and comparative analysis of the IVI) of the component plant species,
5) To investigation of probable correlationships among the various physico-chemical and other parameters under study.

The investigation was done in the two rivers for every month at the eight different sites of the two rivers. For Imphal River the study sites are Kiyamgei (site I) Mahabali (site II), Khuman Lampuk (site III) and Koiренgei (site IV) and for Irl
River, the study sites are Top Dusara (site I), Angom Leikai (site II), Sawombung (site III) and Pungdombam (site IV) are four selected site for Irl River. The macrophytes were studied Oct to Feb in every year of the consecutive two year (March’05- Feb’06 and March’06-Feb’07).

Different method and techniques were adopted for collection of macrophytes and water samples, for the Physico-Chemical analysis of water and biochemical analysis of macrophytes. Water analysis (Trivedi and Goyal, 1986); Phytosociological studies was done through quadrat method (Curtis, 1959; Misra, 1968) and Biochemical estimation (Protein-Lowry et al., 195; Carbohydrates-Hedge and Hofreiter, 1962; Amino acid- Yemm and Cocking, 1955; Chlorophyll- Arnon method, 1949).

During the investigation, the water temperature in Imphal River, water temperature range from 9.8–24.75°C. Among the site, it range from site IV (6.6°C) - site III (16.8°C). In the Irl River the temperature ranges from 7–23.5°C. Among the sites, site II was recorded to be of maximum value (5.1°C) and the site IV was recorded to be of minimum value (16.17°C). The site II was recorded to be of minimum value (5.1°C) and the site I was recorded to be of maximum value.

The value of pH in the Imphal River, ranges from 6.3–8.1. Among the sites it ranges from III and IV (6.6) to site II (6.8). In the Irl River, pH value ranges from 5.6–8.3°C. Among the site, it ranges from site I (7.1°C) to site III and IV (7.24°C).

In the Imphal River the value of turbidity ranges from 4.5-96.3 NTU. The site II was recorded to be of maximum value (78.6 NTU) and the site IV was recorded to be of minimum value (72 NTU). In the Irl River the value of turbidity ranges from 6-98 NTU. Among the site it range from site IV (60.9 NTU) to site I (69.25 NTU).

In the Imphal River the value of conductivity ranges from 75-183.75μmho cm⁻¹. The site II was recorded to be of maximum value
(153.5 μmho cm⁻¹) and the site III was recorded to be of minimum value (118.8 μmho cm⁻¹). The value of conductivity in the Iril River ranges from 123.8 μmho cm⁻¹-256 μmho cm⁻¹. The site III was recorded to be of maximum value (196.8 μmho cm⁻¹) and the site IV was recorded to be of minimum value (177 μmho cm⁻¹).

In the Imphal River the value of DO ranges from 8.2 - 28.49 mg l⁻¹. The site I was recorded to be of maximum value (18.1 mg l⁻¹) and the site II was recorded to be of minimum value (13.6 mg l⁻¹). The value of DO in the Iril River was found from 9.05 - 28.39 mg l⁻¹. The site IV was recorded to be of maximum value (16.95 ml l⁻¹) and the site I was recorded to be of minimum value (15.99 mg l⁻¹).

In the Imphal River the value of Free CO₂ ranges from 4.4 - 36.23 mg l⁻¹. The site III was recorded to be of minimum value (9.7 mg l⁻¹) and the site I was recorded to be of maximum value (13.57 mg l⁻¹). The value of Free CO₂ in the Iril River ranges from 4.4-31.9 mg l⁻¹. The site IV was recorded to be of minimum value (8.1 mg l⁻¹) and the site I was recorded to be of maximum value (9.39 mg l⁻¹).

In the Imphal River the value of Hardness ranges from 32.5-74 mg l⁻¹. The site II was recorded to be of maximum value (65.5 mg l⁻¹) and the site I was recorded to be of minimum value (44 mg l⁻¹). The value of hardness in the Iril River ranges from 40.5-95 mg l⁻¹. The site III was recorded to be of maximum value (76.67 mg l⁻¹) and the site I was recorded to be of minimum value (63.33 mg l⁻¹). The site I was recorded to be of minimum concentration (60.8 mg l⁻¹) and site IV was recorded to be of maximum concentration.

In the Imphal River the value of Calcium ranges from 5.8-26.45 mg l⁻¹. The site II was recorded to be of minimum value (10.2 mg l⁻¹) and the site I was recorded to be of maximum value (11.2 mg l⁻¹). The value of Calcium in the Iril River shows the ranges of 5.8-26.45 mg l⁻¹. The site I was recorded to be of minimum value (16.09 mg l⁻¹) and the site IV recorded to be of maximum value (20.5 mg l⁻¹).
In the Imphal River the value of Mg ranges from 1.3-14.1 mg/l. The site II were recorded to be of maximum value (5.05 mg/l) and the site I was recorded to be of minimum value (3.67 mg/l). The value of Magnesium in the Iril River ranges from 2.44-24.3 mg/l. The site III was recorded to be of maximum value (6.9 mg/l) and the site I was recorded to be of minimum value (4.8 mg/l).

In the Imphal River the value of chloride ranges from 8.88-52.5 mg/l with an average value of 24.85 mg/l. The site III was recorded to be of maximum value (25.9 mg/l) and the site IV was recorded to be of minimum concentration (17.9 mg/l). The value of chloride in the Iril River was found within the ranges of 8.5-55.7 mg/l with an average value of 24.6 mg/l. In both the year, site II recorded of maximum and minimum value (25.44 mg/l and 16.97 mg/l).

The value of Total alkalinity ranges from 44.4-997.5 mg/l with an average value of 64.9 mg/l in Imphal River. The site II was recorded to be of maximum value (389.2 mg/l) and the site I was recorded to be of minimum value (340.8 mg/l). The value of Total alkalinity in the Iril River shows the ranges between 233-632.5 mg/l. The site III was recorded to be of maximum value (512.5 mg/l) and the site IV was recorded to be of minimum value (459.3 mg/l).

In the Imphal River the value of Potassium ranges from 0.75-4.0 mg/l. The site IV was found to be of minimum and maximum concentration (1.8 mg/l and 12.0 mg/l). The value of Potassium in the Iril River ranges from 0.75-4.5 mg/l, the site I and II was recorded to be of maximum value (2.33 mg/l) and the site IV was recorded to be of minimum value (1.16 mg/l).

In the Imphal River the value of Sodium ranges from 5.3-24.25 mg/l. The site I was recorded to be of minimum value and maximum value (12.7 mg/l and 16.0 mg/l). The value of Sodium in the Iril River ranges from 4.5 to 26.5 mg/l. The site III was recorded to be of minimum value and maximum (14.67 mg/l and 17.4 mg/l).
In the Imphal River, the value of Nitrate ranges from 0.017 - 0.096mg/l. The site I was recorded to be of maximum value (0.042mg/l) and the site IV was recorded to be of minimum value (0.03mg/l). The concentration of Nitrate in the Iril river ranges from 0.02-0.18mg/l. The site IV was recorded to be of maximum value (0.114mg/l) and the site II was recorded to be of minimum value (0.057mg/l).

In the Imphal River, the nitrite concentration ranged from 0.02 to 0.19mg/l with an average value of 0.96mg/l. The site II and III was recorded to be of maximum (0.066mg/l) concentration and the site IV was recorded to be of minimum concentration (0.03mg/l). The value of Nitrite in the Iril River ranges from 0.014-0.257mg/l. The site I was recorded to be of maximum value (0.15mg/l) and the site III was recorded to be of minimum value (0.056mg/l).

In the Imphal River, the value of TP ranges from 0.041-0.56mg/l. The site III were recorded to be of maximum value (0.27mg/l) and the site IV was recorded to be of minimum value (0.16mg/l). The value of Total Phosphorus in the Iril River ranges from 0.063-0.55mg/l. The site II was recorded to be of maximum value (0.31mg/l) and the site I was recorded to be of minimum value (0.195mg/l).

In the Imphal River, the value of O.P. ranges from 0.022-0.39g/l. The site I was recorded to be of maximum value (0.16mg/l) and the site I and III was recorded to be of minimum value (0.097mg/l). The value of Organic Phosphorus in the Iril River ranges from 0.025-0.33mg/l. The site II and III was recorded to be of maximum value (0.16mg/l) and the site I was recorded to be of minimum value (0.106mg/l).

In the Imphal River, the value of In P ranges from 0.03-0.393mg/l. The site IV was recorded to be of maximum value (0.36mg/l) and the site II was recorded to be of minimum concentration (0.068mg/l). The value of Inorganic Phosphorus in the Iril River ranges from 0.05-0.317mg/l. The site I was recorded to be of maximum value (0.122mg/l) and minimum (0.087 mg/l).
In the Imphal River the value of turbidity ranges from 115-878.5mg/l. The site IV was recorded to be of maximum and minimum value concentration (335.8mg/l and 221.9mg/l). The value of Total Solid in the Iril River ranges from 950-066.5mg/l. The site II was recorded to be of maximum value (383.17mg/l) and the site II was recorded to be minimum concentration (266.7mg/l).

In the Imphal River the value of TDS ranges from 59.5 to 217.5mg/l. The site IV was recorded to be of maximum value (152.3mg/l) and the site IV was recorded to be of minimum concentration (101.1mg/l). The value of Total Dissolved Solid (TDS) in the Iril River ranges from 32.5-340mg/l. The site I was recorded to be of maximum value (261.8mg/l) and the site II was recorded to be of minimum concentration (127mg/l). The concentration of TDS in the Iril River ranges from 32.5 to 58 mg/l.

In the Imphal River the value of TSS ranges from 9.5-698.5 mg/l. The site III were recorded to be of maximum value (200.8mg/l) and the site IV was recorded to be of minimum concentration (120.8mg/l). The value of Total Suspended Solid (TSS) in the Iril River ranges from 34-965mg/l. The site III was recorded to be of maximum concentration (227.8mg/l) and the site I was recorded to be of minimum value (79.3mg/l).

The findings of the phytosociological studies, Floristic composition provides a reliable information about species diversity in a community as each species has got its own specific ecological amplitude and the same indicates the ecological nature of the habitat. It is one of the major anatomical characters of the plant community Dansereau, 1960.

Out of 12 macrophytes species which were found in the two river only one species *Nitella gracilis* were recorded under the submerged category. In the rooted submerged category two species i.e. *Hydrilla verticillata* and *Potamogeton crispus* were included. The submerged species are restricted to comparatively shallow areas
where light is abundantly available up to the bottom. Under the free floating category *Azolla pinnata, Salvinia natans, Pistia stratiotes* and *Lemna perpusilla* were included.

In the emergent category five species were recorded viz. *Alternanthera philoxeroides, Cyperus rotundus, Hygroryza aristata, Marsilea quadrifolia.*

Out of total species, the lowest number of species (8.3%) was recorded in Rooted floating leaved plants: 16.7% was recorded in submerged plants and 33.3% in the floating leaved plants category were recorded whereas the highest number of species belonged to emergent group (41.7%).

The macrophytes found in present study, one species belonged to the Geophytes viz. *Potamogeton crispus.* Hemicryptophytes of 2 species which belonged to the rooted floating and emergent communities viz. *Hydrilla verticillata, Hygroryza aristata.* 3 species belonged to the Therophytes viz. *Alternanthera philoxeroides, Echinochloa colonum, Cyperus rotundus.* 6 species belonged to Errant vascular Hydrophytes.

The percentage compositions of the different life-forms have been calculated. The highest percentage composition was shown by Errant Vascular Hydrophytes (50%) and the lowest by Geophytes (8.3%), Hemicryptophytes and Therophytes represented 16.7% and 25% respectively. Depending upon the percentage compositions of various life-forms classes of the species in all the study sites of the river, the phytoclimatic the river may be designated as the Thero-Errant vascular Hydrophytic type. The Therophytes and Errant vascular hydrophytes represent the dominant life-forms comprising higher number of plant species.

In the present study, the macrophytes belonged to 10 growth form classes out of the 23 growth forms recognized by Hogeweg and Brenkert (1969). The 7 growth forms were Ceratophylids, Parvopotamids, Helophytes, Lemnids, Marselids, Magnolemnids and Rhizopleustohelophytes. In total there were 12 macrophytes were
recorded during the study period. Parvopotamids has two species i.e. *Hydrilla verticillata* and *Potamogeton crispus*. They were undissected narrow leaved species. Helophytes included species i.e. *Cyperus rotundus*. Two species i.e. *Azolla pinnata*, *Lemna perpusilla* belonged to lemniids (species floating on the surface). *Marsilea quadrifoliata* belonged to Marsileids. The Magnolemnids floating on the surface included two species viz. *Pistia stratiotes*, *Salvinia natans*. Rhizopaleustohelophytes (emergent) comprised only one species which is *Alternanthera philoxeroides*. Helophytes comprises of *Cyperus rotundus*. Magnolemnids includes *Pistia stratiotes*, *Salvinia natans* and Lemnids includes *Azolla pinnata*, *Lemna perpusilla*.

In the Imphal River, ranges of percentage Frequency, Density and Abundance of different macrophytic species from the four study sites are recorded as:

**Site I**: During the period 2005-06, the highest range values of percentage frequency was found in *Nitella gracilis* (40-100%) and lowest frequency variation was observed in *Echinochoa stagnina* (20-40%). *Lemna perpusilla* had got the maximum density with values ranging from 20.8 to 41.6 plants m⁻² whereas lowest value was observed in *Echinochoa stagnina* (1.6-5.6 plants m⁻²). The highest abundance was recorded in *Azolla pinnata* (32.8-44 plants m⁻²) however the lowest value of abundance was reflected by *Pistia stratiotes* (5.2-10 plants m⁻²). And during the period 2006-07, the species *Hydrilla verticillata* showed the maximum ranges of percentage frequency (60-100%). The lowest frequency was found in *Echinochoa stagnina* and *Hygroryza aristata* (20-40%). Maximum density was observed in *Lemna perpusilla* (21.6-44 plants m⁻²) whereas minimum value was obtained in *Hygroryza aristata* (2.4-6.4 plants m⁻²). Highest abundance was recorded for *Lemna perpusilla* (54-73.2 plants m⁻²) and lowest value was found in *Echinochoa stagnina* (8-14 plants m⁻²).

**Site II**: During the period 2005-06, the highest frequency variation was observed in *Salvinia natans* and *Hydrilla verticillata* (40-100%) whereas lowest frequency range was obtained in *Hygroryza aristata* (20-40%). Density was found to be highest in
Azolla pinnata (30.4-38.4 plants m⁻²) and lowest in Echinochloa stagnina (1.6-4 plants m⁻²). Maximum abundance was recorded for Lemna perpusilla (32-53.2 plants m⁻²) and minimum in Pistia stratiotes (5.2-12 plants m⁻²). And during the period 2006-07, the species Potamogeton crispus showed the maximum ranges of percentage frequency (20-100%). The lowest frequency was found in Hygroryza aristata and Alternanthera philoxeroides (20-40%). Maximum density was observed in Azolla pinnata (28.8-48 plants m⁻²) whereas lowest value was obtained in Hygroryza aristata (1.6-6.4 plants m⁻²). Highest abundance was recorded for Lemna perpusilla (66.8-81.2 plants m⁻²) and lowest value was found in Cyperus rotundas (5.2-20 plants m⁻²).

Site III: During the period 2005-06, the highest frequency range was attained in Hydrilla verticillata (60-100%). Minimum frequency range was shown by Alternanthera philoxeroides (40-60%). Maximum density was found in Azolla pinnata (29.6-48 plants m⁻²) and minimum in Echinochloa stagnina (4-7.2 plants m⁻²). Abundance was found to be highest in Azolla pinnata (37.2-60 plants m⁻²) and lowest in Alternanthera philoxeroides (5.6-14 plants m⁻²). And during the period 2006-07, the species Azolla pinnata showed the maximum ranges of percentage frequency (40-80%) whereas the minimum frequency was found in Echinochloa stagnina (20-40%). Maximum density was observed in Azolla pinnata (32-61.6 plants m⁻²) and minimum value was obtained in Echinochloa stagnina (1.6-4.8 plants m⁻²). Highest abundance was recorded for Azolla pinnata (40-77.2 plants m⁻²) and lowest value was found in Cyperus rotundas (8-10 plants m⁻²).

Site IV: During the period 2005-06, the highest frequency variation was observed in Azolla pinnata and Marsilea quadrifoliata (40-100%) whereas lowest frequency range was obtained in Hygroryza aristata (20-40%). Density was found to be highest in Azolla pinnata (22.4-46.4 plants m⁻²) and lowest in Hygroryza aristata (4-5.6 plants m⁻²). Maximum abundance was recorded for Azolla pinnata (36-60 plants m⁻²) and minimum in Marsilea quadrifoliata (8-22.8 plants m⁻²). And during the period
2006-07, the species *Cyperus rotundas* showed the maximum ranges of percentage frequency (20-60%). The lowest frequency was found in *Alternanthera philoxeroides* (20-40%). Maximum density was observed in *Azolla pinnata* (29.6-94.4 plants m$^{-2}$) whereas lowest value was obtained in *Hygroryza aristata* (1.6-6.4 plants m$^{-2}$). Highest abundance was recorded for *Azolla pinnata* (37.2-110 plants m$^{-2}$) and lowest value was found in *Hygroryza aristata* (8-12 plants m$^{-2}$).

Ranges of percentage Frequency, Density and Abundance of different macrophytic species from the four study sites of Iril River are recorded as:

**Site I**: From site I during the period 2005-06, the highest frequency variation was observed in *Lemma perpusilla*, *Potamogeton crispus* and *Marsilea quadrifoliata* (60-100%) whereas lowest frequency range was obtained in *Alternanthera philoxeroides* (20-40%). Density was found to be highest in *Lemma perpusilla* (30.4-58.4 plants m$^{-2}$) and lowest in *Echinochloa stagnina* (2.4-3.2 plants m$^{-2}$). Maximum abundance was recorded for *Azolla pinnata* (52-65.2 plants m$^{-2}$) and minimum in *Hygroryza aristata* (10-14 plants m$^{-2}$). And during the period 2006-07, the species *Potamogeton crispus* showed the maximum ranges of percentage frequency (40-80%). The lowest frequency was found in *Alternanthera philoxeroides* (20-40%). Maximum density was observed in * Lemma perpusilla* (21.6-47.2 plants m$^{-2}$) whereas lowest value was obtained in *Alternanthera philoxeroides* (3.2-4 plants m$^{-2}$). Highest abundance was recorded for * Lemma perpusilla* (50.8-78.8 plants m$^{-2}$) and lowest value was found in *Salvinia natans* (9.2-20 plants m$^{-2}$).

**Site II**: From site II during the period 2005-06, the highest frequency range was attained in *Cyprus rotundas* (40-80%). Minimum frequency range was shown by *Alternanthera philoxeroides* (20-40%). Maximum density was found in *Azolla pinnata* (33.6-44.8 plants m$^{-2}$) and minimum in *Hygroryza aristata* (2.4-4 plants m$^{-2}$). Abundance was found to be highest in *Azolla pinnata* (41.2-53.2 plants m$^{-2}$) and lowest in *Hygroryza aristata* (10-16 plants m$^{-2}$). And during the period 2006-07, the
species *Marsilea quadricornis* showed the maximum ranges of percentage frequency (20-80%) whereas the minimum frequency was found in *Alternanthera philoxeroides* (20-40%). Maximum density was observed in *Lemma perpusilla* (40-48 plants m⁻²) and minimum value was obtained in *Cyperus rotundus* (2.4-4.8 plants m⁻²). Highest abundance was recorded for *Lemma perpusilla* (66.8-80 plants m⁻²) and lowest value was found in *Hygroryza aristata* (8-14 plants m⁻²).

**Site III:** During the period 2005-06, from site III the highest range values of percentage frequency was found in *Hydrilla verticillata* (40-100%). However, some other species like *Lemma perpusilla* and *Salvinia natans* exhibited range values from 60% to 100%. Narrow frequency range was exhibited by the species *Cyperus rotundus* and *Echinochloa stagnina* (20 – 40%). *Azolla pinnata* had got the maximum density with values ranging from 50.4 to 88.8 plants m⁻² whereas lowest value was observed in *Cyperus rotundas* (2.4 to 5.6 plants m⁻²). The highest abundance was recorded in *Lemma perpusilla* (66 to 85.2 plants m⁻²) however the lowest value of abundance was reflected by *Cyperus rotundas* (10 to 14 plants m⁻²). And during the period 2006-07, for the site III the species *Nitella gracilis* showed the maximum ranges of percentage frequency (40-100%). The lowest frequency was found in *Alternanthera philoxeroides* (20-40%). Maximum density was observed in *Azolla pinnata* (20-52 plants m⁻²) whereas lowest value was obtained in *Hygroryza aristata* (1.6-3.2 plants m⁻²). Highest abundance was recorded for *Lemma perpusilla* (36-76 plants m⁻²) and lowest value was found in *Echinochloa stagnina* (4-12 plants m⁻²).

**Site IV:** From site IV during the period 2005-06, the highest frequency variation was observed in *Azolla pinnata, Lemma perpusilla* and *Hygroryza aristata* (60-100%) whereas lowest frequency range was obtained in *Alternanthera philoxeroides* (20-40%). Density was found to be highest in *Azolla pinnata* (23.2-52.8 plants m⁻²) and lowest in *Alternanthera philoxeroides* (1.6-7.2 plants m⁻²). Maximum abundance was recorded for *Azolla pinnata* (38.8-64 plants m⁻²) and minimum in *Hygroryza aristata* (8-12 plants m⁻²). And during the period 2006-07, the species *Lemma perpusilla* and
Hydrilla verticillata showed the maximum ranges of percentage frequency (40-100%). The lowest frequency was found in Cyperus rotundas and Echinochloa stagnina (20-40%). Maximum density was observed in Lemma perpusilla (29.6-66.4 plants m⁻²) whereas lowest value was obtained in Cyperus rotundas (1.6-6.4 plants m⁻²). Highest abundance was recorded for Lemma perpusilla (52-74 plants m⁻²) and lowest value was found in Pistia stratiotes (6-10 plants m⁻²).

Ranges of relative frequency, relative density, relative abundance of different macrophytic species from the four study sites of Iril River are

**Site I:** From site I during the period 2005-06, relative frequency was found to be highest in Lemma perpusilla (13-17.9%) and lowest in Echinochloa stagnina (3.4-3.6%). The relative maximum density was recorded in Lemma perpusilla (20.7-33%) and minimum in Echinochloa stagnina (1.4-2.1%). Relative abundance was obtained highest in Azolla pinnata (25.8-29.5%) and lowest was observed in Hygrotyza aristata (4.4-7.3%). IVI was recorded highest in Lemma perpusilla (56.6-73.9) and lowest in Echinochloa stagnina (9.8-13). And during the period 2006-07, the species Azolla pinnata showed the maximum range of relative frequency (9.3-18.8%) and the minimum was shown by Alternanthera philoxeroides (4.5-9.5%). Maximum relative density was observed in Azolla pinnata (12.6-37.4%) and minimum value was obtained in Alternanthera philoxeroides (3.1-4.2%). Highest relative abundance was recorded for Lemma perpusilla (20-29.5%) and lowest value was found in Salvinia natans (8-25.4%). Highest IVI was observed in Azolla pinnata (37.4-83.8) and lowest IVI was found in Hygrotyza aristata (14.2-27.1).

**Site II:** During the period 2005-06, the highest relative frequency was observed in Azolla pinnata (12.5-16%) whereas lowest frequency range was obtained in Hygrotyza aristata (3.1-6.9%). Relative density was found to be highest in Azolla pinnata (23.8-30%) and lowest in Hygrotyza aristata (2.1-3.6%). Maximum relative abundance was recorded for Azolla pinnata (10-25.9%) and minimum in
Potamogeton crispus (4.4-4.9%). Maximum IVI was observed in Azolla pinnata (55-69.3) and lowest IVI was found in Alternanthera philoxeroides (9.9-21.3). And during the period 2006-07, the species Cyperus rotundas showed the maximum range of relative frequency (12-24%). The lowest relative frequency was found in Echinochloa stagnina (4-11.1%). Maximum relative density was observed in Lemma perpusilla (31.9-42%) whereas lowest value was obtained in Cyperus rotundas (1.6-6.5%). Highest relative abundance was recorded for Azolla pinnata (17.8-35.3%) and lowest value was found in Pistia stratiotes (2.7-4.8%). Highest IVI was observed in Lemma perpusilla (71.9-94.2) and lowest IVI was found in Pistia stratiotes (3.5-7.2).

Site III: From site III, during the period 2005-06, relative frequency was found to be highest in Hydrilla verticillata (7.7-25%) and lowest in Echinochloa stagnina (4.3-7.7%). The relative maximum density was recorded in Azolla pinnata (26.9-44.5%) and minimum in Echinochloa stagnina (1.6-2.3%). Relative abundance was obtained highest in Azolla pinnata (21.2-33.9%) and lowest was observed in Cyperus rotundas (3.7-6.3%). IVI was recorded highest in Azolla pinnata (67.1-97.6) and lowest in Cyperus rotundas (13-16.6). And during the period 2006-07, the species Azolla pinnata showed the maximum range of relative frequency (11.5-16%) and the minimum was shown by Hygroryza aristata (3.7-10.3%). Maximum relative density was observed in Azolla pinnata (21.8-40.1%) and minimum value was obtained in Echinochloa stagnina (1-4.5%). Highest relative abundance was recorded for Azolla pinnata (53.7-82.6%) and lowest value was found in Echinochloa stagnina (8-25.4%). Highest IVI was observed in Azolla pinnata (67.1-97.6) and lowest IVI was found in Cyperus rotundas (13-16.6).

Site IV: During the period 2005-06, the highest relative frequency range was attained in Marsilea quadrifoliata (11.5-21.7%). Minimum relative frequency range was shown by Alternanthera philoxeroides (3.7-7.7%). Maximum relative density was found in Azolla pinnata (18.9-35%) and minimum in Alternanthera philoxeroides (1.3-5.9%). Relative abundance was found to be highest in Azolla pinnata (16.5-
27.7%) and lowest in *Hygroryza aristata* (4.2-5.6%). IVI was recorded highest in *Azolla pinnata* (46.9-75.5) and lowest in *Potamogeton crispus* (10.3-29.2). And during the period 2006-07, the species *Azolla pinnata* showed the maximum range of relative frequency (14.2-21.7%) whereas the minimum relative frequency was found in *Cyperus rotundas* (4.2-7.4%). Maximum relative density was observed in *Lemma perpusilla* (28.5-38.6%) and minimum value was obtained in *Cyperus rotundas* (1.3-3.7%). Highest relative abundance was recorded for *Lemma perpusilla* (24.5-35.8%) and lowest value was found in *Pistia stratiotes* (2.7-4.8%). Highest IVI was observed in *Azolla pinnata* (64.5-88.3) and lowest IVI was found in *Hygroryza aristata* (9.7-14.2).

In the Imphal River, **Site I**: During the period 2005-06, the highest relative frequency range was attained in *Hydrilla verticillata* (11.8-18.5%). Minimum relative frequency range was shown by *Echinochloa stagnina* (2.6-5.9%). Maximum relative density was found in *Lemma perpusilla* (17.6-29.7%) and minimum in *Echinochloa stagnina* (1.7-4.6%). Relative abundance was found to be highest in *Lemma perpusilla* (17.3-30.8%) and lowest in *Echinochloa stagnina, Hygroryza aristata* and *Marsilea quadrifoliata* (2.6-9.5%). IVI was recorded highest in *Azolla pinnata* (44.3-67.5) and lowest in *Hygroryza aristata* (9-19.8). And during the period 2006-07, the species *Hydrilla verticillata* showed the maximum range of relative frequency (14-21.7%) whereas the minimum relative frequency was found in *Echinochloa stagnina* (4.3-9.5%). Maximum relative density was observed in *Lemma perpusilla* (22-33.3%) and minimum value was obtained in *Echinochloa stagnina* (1.6-10%). Highest relative abundance was recorded for *Lemma perpusilla* (27.3-31.5%) and lowest value was found in *Echinochloa stagnina* (4-8.8%). Highest IVI was observed in *Azolla pinnata* (36-92) and lowest IVI was found in *Echinochloa stagnina* (9.9-24.6).

**Site II**: During the period 2005-06, the highest relative frequency was observed in *Nitella gracilis* (9.1-16%) whereas lowest frequency range was obtained in *Echinochloa stagnina* (2.9-6.5%). Relative density was found to be highest in *Azolla*
pinnata (23.8-26.9%) and lowest in Salvinia natans (1.3-3.7%). Maximum relative abundance was recorded for Azolla pinnata (19.8-51.3%) and minimum in Pistia stratiotes (3.1-5.6%). Maximum IVI was observed in Azolla pinnata (59.2-87.1) and lowest IVI was found in Echinochloa stagnina (8.9-17.9). And during the period 2006-07, the species Hydrilla verticillata showed the maximum range of relative frequency (9.5-25%). The lowest relative frequency was found in Hygroryza aristata (4.2-10%). Maximum relative density was observed in Lemma perpusilla (35.2-35.6%) whereas lowest value was obtained in Hygroryza aristata (1.4-6.7%). Highest relative abundance was recorded for Lemma perpusilla (29.9-36.3%) and lowest value was found in Cyperus rotundas (2.7-11.9%). Highest IVI was observed in Lemma perpusilla (82.2-85.9) and lowest IVI was found in Hygroryza aristata (10.2-25.7).

Site III: During the period 2005-06, the highest relative frequency was observed in Marsilea quadrifoliata (13.8-19.3%) whereas lowest frequency range was obtained in Echinochloa stagnina and Hygroryza aristata (6.3-7.4%). Relative density was found to be highest in Azolla pinnata (26.8-39%) and lowest in Echinochloa stagnina (1.3-4.2%). Maximum relative abundance was recorded for Azolla pinnata (22.6-31.3%) and minimum in Alternanthera philoxeroides (3.7-8.4%). Maximum IVI was observed in Azolla pinnata (64.7-85.1) and lowest IVI was found in Alternanthera philoxeroides (15.7-24.4). And during the period 2006-07, the species Azolla pinnata showed the maximum range of relative frequency (19-22.2%). The lowest relative frequency was found in Echinochloa stagnina (4.8-9.5%). Maximum relative density was observed in Azolla pinnata (31-43.6%) whereas lowest value was obtained in Cyperus rotundas (1.8-3.6%). Highest relative abundance was recorded for Azolla pinnata (22.6-37.9%) and lowest value was found in Cyperus rotundas (3.9-5.4%). Highest IVI was observed in Azolla pinnata (75.8-95.2) and lowest IVI was found in Echinochloa stagnina (9.6-30.6).

Site IV: From site IV during the period 2005-06, relative frequency was found to be highest in Hydrilla verticillata (13.6-21.7%) and lowest in Hygroryza aristata (3-
9.1%). The relative maximum density was recorded in *Azolla pinnata* (22-25%) and minimum in *Echinochloa stagnina* (2.9-7.1%). Relative abundance was obtained highest in * Lemma perpusilla* (15-28%) and lowest was observed in *Alternanthera philoxeroides* (4-7.4%). IVI was recorded highest in *Azolla pinnata* (53.8-69.6) and lowest in *Echinochloa stagnina* (13.9-26.3). And during the period 2006-07, the species *Azolla pinnata* showed the maximum range of relative frequency (15.8-25%) and the minimum was shown by *Echinochloa stagnina* (2.4-10%). Maximum relative density was observed in *Azolla pinnata* (30.1-43%) and minimum value was obtained in *Hygroryza aristata* (1.6-3%). Highest relative abundance was recorded for *Azolla pinnata* (20.5-36.7%) and lowest value was found in *Echinochloa stagnina* (4.8-6.7%). Highest IVI was observed in *Azolla pinnata* (61.3-97.7) and lowest IVI was found in *Hygroryza aristata* (12-17.7).

The highest similarity index for the Imphal River was observed in between site I and site II and lowest similarity index was found in between site I and IV and between site II and site III during the period 2005 to 2006. During 2006 to 2007, the highest similarity index was observed in between site I and site II and lowest similarity index was found in between site III and IV and between site II and site III during the period 2005 to 2006. The highest similarity index in the Irlil River was observed in between site II and site IV and lowest similarity index was found in between site I and site III during the period 2005 to 2006. For the period 2006 to 2007, the highest similarity index was observed in between site II and site III and lowest similarity index was found in between site I and site IV during the period 2006 to 2007. The opposite trend in the highest and the lowest values was shown by dissimilarity index between the same sites. It might have been attributed to various physico-chemical characteristics of water. The maximum value of community coefficient for the Imphal River was obtained between sites I and II and minimum value was observed between site I and III during the period 05 to 06. During 06 to 07, the maximum value of community coefficient was obtained between site III and IV and minimum value was observed between site II and III. For the Irlil River, the maximum
value of community co-efficient was obtained between site I and III and minimum value was observed between site II and IV during the period 06 to 07. During 06 to 07, the maximum value of community co-efficient was obtained between site I and III and minimum value was observed between site I and IV.

For the Biochemical studies, the findings in the Imphal River are as: the protein content of species *Azolla pinnata* was found highest (0.06-0.29mgg⁻¹) Site IV to site I. The protein content of the species *Hydrilla verticillata* was found to be highest (0.07-0.24mgg⁻¹) site I to site II. The protein content of the species *Cladophora glomerata* was found highest (0.079-0.28mgg⁻¹) during the month of Dec’05 at the site I to site II. For the *Lemanea species*, the protein content was highest (0.08-0.31mgg⁻¹) site IV and the site II. The protein content of the species *Nitella gracilis* ranges from (0.05-0.19mgg⁻¹) site IV to site II. For the species *Fragilaria capucina*, the protein content was found (0.06-0.27mgg⁻¹) site IV to site I. The findings in the Iril River are as: Protein content of the *Azolla pinnata* species was found to be ranged (0.03-0.24mgg⁻¹) at the site III. The protein content of the species *Hydrilla verticillata* was found to be in ranged (0.07-0.19mgg⁻¹) at the site IV and II. The protein content of the species *Cladophora glomerata* was found to be highest (0.25mgg⁻¹) at the site II. The minimum protein concentration of the species *Cladophora glomerata* was recorded as (0.06mgg⁻¹) at the site IV. Species *Lemanea* was recorded to be highest (0.09-30mgg⁻¹). The maximum protein concentration and the minimum protein concentration at the site II and site IV. For *Nitella gracilis* species the protein content was recorded to be ranged (0.05-0.17mgg⁻¹) minimum protein concentration was site I and maximum concentration was at site II. The protein content of the species *Fragilaria capucina* was found in ranged (0.06-0.27mgg⁻¹) at the site I and II.

In the Imphal River Total Sugar concentration of the species *Azolla pinnata* was recorded as (0.11-0.39mgg⁻¹) at the site IV and II. For the species *Hydrilla verticillata*, Total sugar content (0.09-0.33mgg⁻¹) was at site II. For the *Cladophora*
glomerata, the minimum and maximum Total Sugar concentration (0.09-0.35mgg\(^{-1}\)) was at site IV. The Total Sugar concentration of the Lemanea species ranges (0.14-0.33mgg\(^{-1}\)) at site II to IV. Nitella gracilis species was found to have Total Sugar concentration (0.06-0.29mgg\(^{-1}\)) at site II and IV. The Total Sugar content of the species Fragilaria capucina ranges from (0.12-0.33mgg\(^{-1}\)) at site II to IV. In the Irl River, Total Sugar content (0.17-0.36mgg\(^{-1}\)) of the species Azolla pinnata was recorded at site IV and III. Total Sugar content of the species Hydrilla verticillata was recorded as (0.15-0.33mgg\(^{-1}\)) at the site II. Total Sugar content (0.09-0.35mgg\(^{-1}\)) of the species Cladophora glomerata was recorded at the site III and I. The Lemanea species was recorded of minimum and maximum Total Sugar content (0.12-0.33 mgg\(^{-1}\)) at site I and IV. The Total Sugar content (0.09-0.33 mgg\(^{-1}\)) of Nitella gracilis species was at site IV and II. The species Fragilaria capucina was recorded of maximum Total Sugar content (0.09-0.29mgg\(^{-1}\)) at the site IV and II.

In the Imphal River, the species Azolla pinnata have minimum and maximum Reducing Sugar content (0.04 and 0.21 mgg\(^{-1}\)) at the site IV and III. The species Hydrilla verticillata was found to have minimum and maximum Reducing sugar content (0.03 and 12 mgg\(^{-1}\)) at the site IV and II. The species Cladophora glomerata was found to have minimum and maximum Reducing Sugar content (0.03 and 0.107mgg\(^{-1}\)) at the Site IV and III. Reducing Sugar content of the Lemanea species was recorded as (0.03-0.18 mgg\(^{-1}\)) at the site IV to III. The minimum and maximum Reducing Sugar concentration the species Nitella gracilis was found to have (0.03 and 0.19mgg\(^{-1}\)) at the site IV and II. The minimum and maximum Reducing Sugar content of the species Fragilaria capucina (0.03 and 0.17mgg\(^{-1}\)) was at the site IV and III. In the Irl River, the minimum and maximum Reducing Sugar content of the species Azolla pinnata was recorded (0.05-0.14mgg\(^{-1}\)) at site III and II. The species Hydrilla verticillata was found to have the minimum and maximum Reducing Sugar content (0.03 and 0.09 mgg\(^{-1}\)) site III and II. The minimum and maximum Reducing Sugar content (0.03 and 0.17 mgg\(^{-1}\)) of the species Cladophora glomerata was recorded at the site I. The minimum and maximum Reducing Sugar content (0.03 and 0.12mgg\(^{-1}\))
of the *Lemanea species* was recorded at site I and II. The minimum and maximum and Reducing Sugar content (0.03 and 0.13 mgg⁻¹) *Cladophora glomerata* was at the site III and II. The minimum and maximum Reducing Sugar content (0.04-0.09mg⁻¹) *Fragilaria capucina* was at the site III.

In the Imphal River, the amino acid content of *Azolla pinnata* was found highest (1.4-3.6mgg⁻¹) at the site IV to III. The amino acid content of the species *Hydrilla verticillata* was found (1.5 and 2.8mgg⁻¹) at the site I and III. The amino acid content of the species *Cladophora glomerata* was ranges (2.2 -3.8mgg⁻¹) at the site II to III. The amino acid content of the *Lemanea species* was ranges (3.9-5.86mgg⁻¹) was recorded at the site III to IV. The amino acid content of the species *Nitella gracilis* was found to ranges (0.19-0.252mgg⁻¹) the site II and III. The minimum and maximum amino acid content was ranges (0.9-2.9mgg⁻¹) at the site II. In the Irl River, *Azolla pinnata* species was found to have (1.2-3.4mgg⁻¹) at site III and II. The species *Hydrilla verticillata* was ranges (0.66 -02.9mgg⁻¹) at the site III and II. The minimum and maximum amino acid content of the species *Cladophora glomerata* was found to ranges (2.11-4.15mgg⁻¹) at the site IV and III. The *Lemanea species* was found to have minimum and maximum amino acid content (2.15 and 5.89 mgg⁻¹) at the site III and IV. The *Nitella gracilis* species was recorded to have minimum and maximum amino acid content (0.12 and 0.46 mgg⁻¹) at the site III and IV. The amino acid content of the species *Fragilaria capucina* was found to ranges (0.81-2.7 mgg⁻¹) at the site III.

In the Imphal River, the minimum and maximum Total Chlorophyll content of species *Azolla pinnata* (4.4 and 7.8 mgg⁻¹) was recorded at the site II. The Total Chlorophyll content of the species *Hydrilla verticillata* ranges (15.5 -4.6mgg⁻¹) at the site II to IV. The minimum and maximum Chlorophyll content. The minimum and maximum of the species *Cladophora glomerata* was (4.7-10 mgg⁻¹) at the site I and III. Total Chlorophyll content of the *Lemanea species* (5.2-8.1 mgg⁻¹) at the site III and IV. The species *Nitella gracilis* shows of minimum and maximum Total Chlorophyll
content (3.2-7.8mgg⁻¹) at the site II and III. The species *Fragilaria capucina*, shows
the minimum and maximum Total Chlorophyll content (3 and 6.5mgg⁻¹) at the site II.
In the Iril River, the species *Azolla pinnata* was recorded to have minimum and
maximum Total Chlorophyll content (3.8 and 6.3mgg⁻¹) at the site II and I. The
minimum and maximum Total Chlorophyll content (4.6 and 6.7 mg⁻¹) of species
*Hydrilla verticillata* was recorded at the site II and IV. The minimum and maximum
Total Chlorophyll content (4.9 and 10.7mgg⁻¹) of the species *Cladophora glomerata*
was recorded at the site III. The minimum and maximum Total Chlorophyll content
(3.7-7.5mgg⁻¹) of the *Lemanea species* was recorded at the site IV. The Total
Chlorophyll content ranges (4.5-10.7mgg⁻¹) species *Nitella gracilis* was at the site IV
to III. The Total Chlorophyll content ranges (2.1-4.7mgg⁻¹) of the species *Fragilaria
capucina* was recorded at the site III to III.

In the Imphal River, the Chlorophyll ‘a’ content of species of *Azolla pinnata*
ranges from 2.0-4.1mgg⁻¹ at the site II and I. Chlorophyll ‘a’ content of species
*Hydrilla verticillata* (2.2-7.7mgg⁻¹) at the site II and IV. The Chlorophyll ‘a’ content
(2.4-8.3mgg⁻¹) of the species *Cladophora glomerata*, was recorded at site III. For the
*Lemanea species*, the minimum and maximum Chlorophyll ‘a’content (2.4-3.8mgg⁻¹)
was recorded at the site II and I. The species *Nitella gracilis* were having Chlorophyll
‘a’content (1.5-5.3mgg⁻¹) of the species was recorded at the site I and III. *Fragilaria
capucina* species was having minimum and maximum Chlorophyll ‘a’ content (1.6-
2.7mgg⁻¹) at the site II. In the Iril River, the chlorophyll a content of the species
*Azolla pinnata* ranges from (1.5-2.8mgg⁻¹) at the site II and IV. For the species
*Hydrilla verticillata*, Chlorophyll a content (1.6-5.7mgg⁻¹) was recorded at the site III
and IV. For the species *Cladophora glomerata*, minimum and maximum Chlorophyll
a content (2.1 and 6.6mg⁻¹) was recorded at the site I and IV. For the *Lemanea
species*, Chlorophyll a content (1.5-3.4 mgg⁻¹) was recorded at the site IV and III. The
species *Nitella gracilis* were having minimum and maximum Chlorophyll a content
(1.9 and 3.0mgg⁻¹) at the site IV and II. *Fragilaria capucina* species have Chlorophyll
a content (0.7-2.1mgg⁻¹) at the site III.
In the Imphal River, the minimum and maximum Chlorophyll b content (2.1 and 3.9mg⁻¹) of the species *Azolla pinnata* was recorded at the site II. The minimum and maximum Chlorophyll ‘b’ content (2.4-8.1mg⁻¹) of the species *Hydrilla verticillata* was recorded at the site II and IV. The Chlorophyll ‘b’ content of the species *Cladophora glomerata* ranges (2.3 and 5.2mg⁻¹) at the site III and I. The minimum and maximum Chlorophyll ‘b’ content (2.5 and 4.5mg⁻¹) of the *Lemanea* species was recorded at the site III and II. The species *Nitella gracilis* was having minimum and maximum Chlorophyll ‘b’ content (1.2 and 4.2mg⁻¹) at the site I and III. The minimum and maximum Chlorophyll ‘b’ content (1.1 and 3.7mg⁻¹) of the species *Fragilaria capucina* was recorded at the site II and I. In the Irl River, minimum and maximum Chlorophyll ‘b’ content (1.7 and 4.0mg⁻¹) of the species *Azolla pinnata* was recorded at the site III and IV. For the species *Hydrilla verticillata*, the minimum and maximum Chlorophyll ‘b’ content (2.4-3.8mg⁻¹) was recorded at the site III. The minimum and maximum Chlorophyll ‘b’ content (2.7-7.8mg⁻¹) of the species *Cladophora glomerata* was recorded at the site II and IV. For the species *Lemanea*, Chlorophyll b content ranges (2.2-5.2mg⁻¹) at the site IV. The species *Nitella gracilis* were having minimum and maximum Chlorophyll b content (2.5-6.7mg⁻¹) at the site II and III. *Fragilaria capucina* species was recorded to be of minimum and maximum Chlorophyll ‘b’ content (0.7 and 2.8mg⁻¹) at the site III and II.