CHAPTER – V

DISCUSSION

This research is a *case study* of a natural fresh water body called Diplai Beel, which is situated in the district of Kokrajhar, in the western part of Assam. It is a proposed Ramsar site forwarded by the wetland experts of Assam in the recent past.

The research is confined firstly to the study of diversity, density, abundance and dominance of the collected aquatic macrophytes of Dipai Beel in different periods of three study years. The second objective of research is the study of water qualities and their probable influences on macrophytes grown in Diplai Beel water during 2014-15 to 2016-17. Lastly phytoremedial study of floating macrophytes such as *Lemna perpusilla Torry, Azolla pinnata R.Br* and *Salvinia cucullata* is performed by estimating the presence of trace metals like Cu, Zn and Pb, in the plants biomass and in Diplai Beel water in different seasons of the study years.

A total of 47 species have been collected so far from Diplai Beel during the study period and considered as type species of study to carry out this research. In this chapter different graphs and tables shown in Result Chapter are discussed by indicating table and figure numbers.

1. Diversity studies of macrophytes in Diplai Beel:

The literary and ecological meaning of diversity is different. To know the ecological diversity of species in a community, the study of diversity indices of species is must. A diversity index is a mathematical measure of species diversity in a community. Diversity indices provide more information about community composition than simply species richness i.e. the number of species present; they also take the relative abundances of different species into account. Diversity indices provide important information about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologists to understand community structure. It shows community composition and takes into account the relative abundance of species that are present in the community (Shannon and Wiener, 1963, Simpson, 1949 and Pielou 1966).

Shannon-Wiener index and Simpson index are widely used ecological indices for quantitative measure of different types of species existing in a community. It is concurrently taken into account that how evenly the individuals are distributed among species types. The Shannon-Wiener index value ranges between 0 and 5 but when value ranges between 1.5 and 3.5 it indicates a healthy diversity in a community. This index is rarely greater than 4. In every study year (Table no.12) from pre monsoon to winter the Shannon-Weiner Index of Diversity is found gradually reduced but the species maintained healthy diversity in Diplai Beel plants community.

Simpson's Diversity Index (D) is a measure of diversity and dominance which takes into accounts both richness and evenness. The value of D ranges between 0 and 1. If the value is 0 it indicates the infinite diversity but when its value is 1 it means no diversity. The number of species that live in a particular location is called species richness. When species richness and evenness increase then diversity increases. Abundance is the number of individuals of each species. Evenness assumes a value between 0 and 1 but with value 1 being complete evenness. Diversity depends not only on richness, but also on evenness. Evenness compares the similarity of the population size of each of the species present. It is observed that the seasonal diversity indices of macrophytes are within the variable range in Diplai Beel during study periods. Species richness and Evenness ars found increased from Winter to Pre Monsoon in every study years in Diplai Beel.

1.a. Analysis of Diversity indices of macrophytes

The Diversity Indices of macrophytes in Diplai Beel in four seasons are discussed. In the year 2014-15 Diversity Indices are shown in Fig no.6. The values of Shannon-Wiener Index are 2.96 in Pre Monsoon, 2.67 in Monsoon, 2.34 in Post Monsoon, and 1.78 in Winter respectively. Macrophyte diversity in Diplai Beel is seen in a moderate state i.e. diversity is not too rich. The index increases from Winter to Pre monsoon where Monsoon is also not in favourable state. If we consider the results of Simpson's Diversity Index (D) of dominance it is poor in Monsoon (0.036) but it increases slightly from Post Monsoon to Winter by 0.057 and 0.075 respectively. Post Monsoon follows the Winter (0.042). The Simpson's Diversity Index (D) value is not above unity (1). The species richness is 23.21 in Pre Monsoon, 21.07 in Monsoon, 17.86 in Post Monsoon and 12.65 in Winter which is in good state. The Evenness index is in good range.

In 2015-16, the Shannon-Wiener Index is represented in Fig no.7 by 3.23 in Pre Monsoon, 2.98 in Monsoon, 2.81 in Post Monsoon, and 1.88 in Winter respectively. The diversity decreases from Pre Monsoon to Winter here. In winter Diversity index is poor means plant diversity reduces. The Sampson index of dominance is very low, 0.038 in Pre Monsoon and increases to 0.074 in Winter. Species richness is high in Pre Monsoon (27.87) and decreases gradually to Winter and also from Monsoon (0.792) to Post Monsoon (0.612). The species Evenness has shown in decreasing nature from Pre Monsoon to Winter period. The evenness of species below unity so the species diversity is very rich (Deka and Sarma, 2016)

In 2016-17 the Shannon-Wiener index of diversity is in between 1.50 and 3.50. In Pre monsoon it is 2.85, shown in Fig no.8**.** The other values 2.35 in Monsoon, 2.22 in Post Monsoon and 1.54 in Winter respectively follows Pre monsoon. There is no such notable species diversity in Monsoon in this time. The Winter value is very poor as it is touching the lower limit 1.50 of Shannon-Wiener index. In 2016-17 the Sampson index of dominance are 0.042 in Pre Monsoon, 0.056 in Monsoon, 0.046 in Post Monsoon and 0.088 in Winter. It indicates that there is no specific dominance over other species which is prominent. Dominance increases from Pre Monsoon to Winter. In this period species evenness is high thus evenness attains high value. Two factors i.e. number of species and importance values (number, biomass, productivity and so on) of individuals, determine the species diversity of a community (Odum, 1996). The index values above 3.0 indicate that the structure of habitat is stable and balanced; the values under 1.0 indicate that there are pollution and degradation of habitat structure. When the Evenness value is getting closer to 1 it means that the individuals are distributed equally.

Density Study of Macrophytes in Diplai Beel:

2.a. *Density analysis of Eichhornia crassipes* (Mart.) Solms

In plant ecology Density is defined as the number of individuals of a given species that occurs within a study area. Density is often used in a vegetation survey to describe a species status in a plant community.

Importance Value Index (IVI) is a useful quantitative parameter to evaluate the community structure, as it provides an overall picture of frequency and cover of a species in relation to community (Curtis and McIntosh, 1951).

The *Eichhornia crassipes* (Mart.) Solms. is studied separately from the total 47 *type macrophytes* collected from Diplai Beel. It is because of its higher density value in comparision to other macrophytes studied in Diplai Beel. It is represented in graphs both seprately or together with other macrophytes.

In 2014-15, the density of *Eichhornia crassipes* (Mart.) Solms. (Table no.13) increases from 10.600 to 14.325 from Pre monsoon to Monsoon. But in Post monsoon its density decreases to 8.950 and in Winter it comes to be 7.325. In this year the IVIs of *Eichhornia crassipes* (Mart.) Solms. are found 34.900 (Table no. 38), 75.526 (Table no. 39), 66.810 (Table no. 40) and 66.538 (Table no. 41) in Pre Monsoon, Monsoon, Post Monsoon and Winter respectively.

In 2015-16, the *Eichhornia crassipes* (Mart.) Solms. (Fig no.13) density in Pre moinsoon is 8.825 and increases to12.100 in Monsoon. But it decreases from 8.500 to 5.850 from Post monsoon to Winter. In this year the IVIs of *Eichhornia crassipes* (Mart.) Solms. are found to be 48.659 (Table no. 42), 59.794 (Table no. 43), 64.608 (Table no. 44) and 49.744 (Table no. 45) in Pre Monsoon, Monsoon, Post Monsoon and Winter respectively.

Again in 2016-17, *Eichhornia crassipes* (Mart.) Solms. (Fig no.13) density in Pre monsoon is 8.825 which increases to12.100 in Monsoon but from Monsoon *Eichhornia crassipes* (Mart.) Solms. comes down to7.550. In this year the IVIs of *Eichhornia crassipes* (Mart.) Solms. are found to be 57.747 (Table no. 46), 59.848 (Table no. 47), 49.139 (Table no. 48) and 52.856 (Table no. 49) in Pre Monsoon, Monsoon, Post Monsoon and Winter respectively. In Post Monsoon *Eichhornia crassipes* (Mart.) Solms. decreases from 2014-15 to 2016-17 consecutively.

Now it is observed that *Eichhornia crassipes* (Mart.) Solms., the floating macrophyte has dominated the water surface of Diplai Beel during the whole study period with a slite occurrence of flactuation. It seems that the water parameters in this period is moderatly favourable for this plant. These plants are an ecological burden to sub-tropical and tropical regions of the world. They can tolerate pH values from 4 to 10 (Center *et al.*, 2002). Optimal water temperature for their growth is 28-30 ˚C (Center *et al.*, 2002). Temperatures above 33˚C inhibit further growth of *Eichhornia crassipes* (Mart.) Solms., (Center *et al.*, 2002). Optimal air temperature is 21-30˚ C (U.S. EPA, 1988). As pH value of Diplai Beel is found around 4 and slit above, the existanace *of Eichhornia crassipes* (Mart.) Solms. is much more than the other macrophytes grown in Diplai Beel. The water temperature is also recorded favourable for it in this beel.

2.b. Density analysis of macrophytes other than *Eichhornia crassipes* (Mart.) Solms.

It is observed that about 29 macrophyte species of Diplai Beel have been found consecutively decreasing in numbers in different seasons of 2014-15, 2015-16 and 2016-17. The reasons behind of this fact may be due to the change of water qualities in Diplai Beel water and loss of immunity of the macrophytes in study years.

2.b.i. Consecutive decrease in Density of macrophyte species of Diplai Beel in Pre Monsoon during 2014-15, 2015-16 and 2016-17

During Pre Monsoon of the study years 18 species have been found consecutively decreased in density. They are under the category of *i. Free Floating*-1 (species no-4), *ii. Submersed- (anchored)* –3 (species no- 9, 10, 11), *iii. Submersed-(suspended)* - 2 (species no -13,14), *iv, Rooted Floating Shoot*-1 (species no-15), *v. Rooted Floating Leaves* – 2 (species no-17,18) and *vi. Emergents*-9 (species no-20, 26, 27,28,33,40, 41,43 and 45). The species are no. 4. *Azolla pinnata* R.Br. (Table no, 10.i.b), no.9. *Hydrilla verticillata* (L.f.) Royle.(Table no, 10.i.b), no.10. *Potamogeton crispus* L. (Table no,10.i.b.) , *no.*11. *Valisneria spiralis* Linn. (Table no. 10.i.b), *no.*13. *Ceratophyllum demersum* L. (Table no. 12.i.b), no.14. *Utricularia exoleta* R.Br**.** (Table no, 12.i.b), no.15**.** *Ipomoea aquatica* Forssk. (Table no. 13.i.b)., *no.* 17. *Nymphaea lotus* Linn. (Table no.14.i.b), 18. *Nymphaea rubra* Roxb. Ex Salibs**,** (Table no,14.i.b), 20. *Alternanthera philoxeroides* (Mart.) Grisep. (Table no, 15.a.i.B), 26. *Hymenachne assamica* Hitch. (Table no, 15.a.i.B), 27. *Echinodorus angustifolius*, (Table no, 15.b..i.B), 28. *Ipomoea fistulosa* Mart**.**ex.Choisy. (Table no, 15.b..i.B), 33. *Polygonum barbatum* Linn. (Table no, 15.b.i.B), 40**.** Brachiaria mutica (Forssk.) Stapf., (Table no, 15.c..i.), 41. *Eragrostis unioloides*(Retzius) Nees. (Table no, 15.d..i.B), 43. *Pogonatherum crinitum* (T.) Kunth (Table no, 15.d..i.B),. 45. *Hydrocotyl sibthorpioides* Lmmk. (Table no, 15.d..i.B),

2.b.ii. Consecutive decrease in Density of macrophyte species of Diplai Beel in Monsoon during 2014-15, 2015-16 and 2016-17

During Monsoon in every study year 3 species have been found consecutively decreased in density. They are under the category of *Emergents* and nos 3 (plant species no 28, 41 and 42). The species are 28. *Ipomoea fistulosa* Mart**.**ex. Choisy. **(**Table no, 15.b.iii.B), 41. *Eragrostis unioloides* (Retzius) Nees. (Table no, 15.d.ii.B), *and* 42. *Hemarthria compressa* L. (Table no, 15.d.ii.B**).**

2.b.iii. Consecutive decrease in Density of macrophyte species of Diplai Beel in Post Monsoon during 2014-15, 2015-16 and 2016-17

During Post-Monsoon in study years - 5 species have been found consecutively decreased in density. They are under the category of *iv. Rooted Floating Shoot*-1 (plant species no-16) and *vi. Emergents*-4 (plant species nos-37, 38, 41 and 46). The species are 16. *Hygroryza aristata (*Retz.) Nees. (Table no, 13.iii.b), 37. *Cynodon dactylon* (L.) Pers**,** (Table no, 15.c.iii.), 38. *Digitaria ciliaris* (Retzius) Koeler. (Table no, 15.c.ii.), 41. *Eragrostis unioloides* (Retzius) Nees. (Table no, 15.d.iii.b), 46. *Colocasia esculenta* (L.) Schott. (Table no, 15.d.iii.b),

2.b.iv. Consecutive decrease in Density of macrophyte species of Diplai Beel in Winter during 2014-15, 2015-16 and 2016-17

During Winter of the study years 3 species have been found consecutively decreased in density. They are under the category of *iv. Rooted Floating Shoot*-1 (plant no/serial no-16) and *vi. Emergents*-2 (plant no/serial no-27 and 35). The species are 16. *Hygroryza aristata* (Retz.) Nees. (Table no, 13.iv.b), 27. *Echinodorus angustifolius,* (Table no, 15.b.iv.B), 35. *Polygonum glabrum* Willd. (Table no, 15.c.iv.B),

3. Abundance analysis of macrophytes in Diplai Beel:

3.*a.* Abundance of *Eichhornia crassipes* (Mart.) Solms.in Diplai Beel during study years 2014-15, 2015-16 and 2016-17.

In 2014-15, the abundance of *Eichhornia crassipes* (Mart.)Solms. (Table No-16.iv.a) increases from 7.571 to 9.879 from Pre monsoon to Monsoon. But in Post monsoon its abundance decreases to 7.458 and in Winter it comes to be 6.388.

In 2015-16 the abundance of *Eichhornia crassipes* (Mart.) Solms.starts with 7.857 in Pre Monsoon and increases to 9.058 Monsoon But it goes down in Post Monsoon by 8.293 and 5.850 in Winter. Again In 2016-17 the abundance of *Eichhornia crassipes* (Mart.) Solms.starts with 7.844 in Pre Monsoon and increases to 8.963 Monsoon But it goes down in Post Monsoon by 7.366 and 8.171 in Winter,It is observed that in Monsoon the abundance value decreases 9.879 to 9.058 then to 8.963 from 2014-15 to 2016-17.

3.b. Abundance analysis of macrophytes other than *Eichhornia crassipes* (Mart.) Solms.

3.b.i. Consecutive decrease in Abundance *of macrophyte species of Diplai Beel in Pre Monsoon in 2014-15, 2015-16 and 2016-17*

It is observed during Pre Monsoon of the study years that 7 species (Table no.59) have been found decreased in abundance of the aquatic macrophytes. The plant nos are showen here by species nos. 2. *Pistia stratiotes* L. (Table no, 17.i.B), 15. *Ipomoea aquatica* Forssk., (Table no, 20.i.B), 24. *Cyperus compressus* L. (Table no, 22.i.B), 28. *Ipomoea fistulosa* Mart**.**ex.Choisy. (Table no, 23.i.B), 34. *Polygonum hydropiper* Linn.(Table no,24.i.B), 38. *Digitaria ciliaris* (Retzius) Koeler. (Table no, 24.i.B), 43. *Pogonatherum crinitum* (T.) Kunth. (Table no, 25.i.B).

3.b.ii. Consecutive decrease in Abundance of macrophyte species of Diplai Beel in Monsoon during 2014-15, 2015-16 and 2016-17

It is also observed during Monsoon of the study years that 2 species (Table no.59) have been found decreased in abundance of different macrophytes in Diplai Beel. The species nos are 1. *Eichhornia crassipes* (Mart.)Solms. (Fig no, 16.ii), *1*6. *Hygroryza aristata (*Retz.) Nees. (Table no, 20.ii.B),

3.b.iii. Consecutive decrease in Abundance of macrophyte species of Diplai Beel in Post Monsoon in 2014-15, 2015-16 and 2016-17

Again it is also observed during Post Monsoon in the study years that 5 species (Table no.59) have been found decreased in abundance of the macrophytes in Diplai Beel. The species nos are like 6. *Salvinia cucullata*, (Table no, 17.iii.B), 9. *Hydrilla verticillata* (L.f.) Royle (Table no, 18.iii.B), 21.*Vetiveria zizanoides* (L.) Nass. (Table no, 22.iii.B), 34. *Polygonum hydropiper* Linn. (Table no, 24.iii.B), 40. *Brachiaria mutica* (Forssk.) Stapf. (Table no, 24.iii.B).

3.b.iv. Consecutive decrease in Abundance of macrophyte species of Diplai Beel in Winter in 2014-15, 2015-16 and 2016-17.

Again it is also observed during Winter of the study years that 5 species (Table no.59) have been found decreased in abundance of the macrophytes in Diplai Beel. The species nos are mentioned by their serial plant nos like *27. Echinodorus angustifolius* (Table no, 23.iv.B), 34. *Polygonum hydropiper* Linn., (Table no, 24.iv.B), 38. *Digitaria ciliaris* (Retzius) Koeler. (Table no, 24.iv.B), 35. *Polygonum glabrum* Willd. (Table no, 24.iv.B), 36. *Sagittaria trifolia* L. (Table no, 24.iv.B), 41. *Eragrostis unioloides*(Retzius) Nees. (Table no, 25.iv.B).

4. IVI of individual macrophytes are shown in ascending order in different seasons of 2014-15, 2015-16 and 2016-17

In Pre Monsoon of 2014-15 the lowest and highest IVI of individual macrophyte distribution among 47 species (excluding Sl. no.1. *Eichhornia crassipes* (Mart.) Solms.) are from Sl. no. *3. Lemna perpusilla* Torry to Sl. no.32. *Monochoria* C. Presl.(Figure no. 28). In Monsoon Sl. no. *32. Polygonum barbatum* Linn. to Sl.no. 4. *Azolla pinnata* R.Br. (Figure no.29). In Post Monsoon Sl.no. 8. *Wolffia globasa* to Sl.no. 10. *Potamogeton crispus* L (Figure no. 30). In Winter Sl.no. 3. *Lemna perpusilla* Torry to Sl. no 30. *Marselia quadrifolia* L. (Figure no.31)

In 2015-16 the lowest and highest IVI of individual macrophytes distribution are in Pre Monsoon (Figure no. 32) from Sl.no. 25. *Cyperus corymbosus* Rottb. to Sl.no.30. *Marselia quadrifolia* L. In Monsoon (Figure no. 33) Sl.no. 14. *Utricularia exoleta* R.Br**.** to Sl. no. 9. *Hydrilla verticillata* (L.f.) Royle. In Post Monsoon (Figure no.34) Sl.no. 38. *Digitaria ciliaris* (Retzius) Koeler. to Sl.no. 17. *Nymphaea lotus* Linn. In Winter (Figure no.35) Sl.no. 37 *Cynodon dactylon (*L.) Pers. to Sl.no. 18 *Nymphaea rubra* Roxb. Ex Salibs

In 2016-17 the lowest and highest IVI of individual macrophytes distribution are in Pre Monsoon (Figure no. 36) Sl.no. 38. *Digitaria ciliaris* (Retzius) Koeler. to Sl.no. 18. *Nymphaea rubra* Roxb. Ex Salibs. In Monsoon (Figure no.37) Sl.no. 8. *Wolffia globasa* to Sl.no.18. *Nymphaea rubra* Roxb. Ex Salibs. In Post Monsoon (Figure no.38) Sl.no. 8. *Wolffia globasa* to Sl.no. 18. *Trapa natans* L. In Winter (Figure no.38) Sl.no.28. *Ipomoea fistulosa* Mart**.**ex.Choisy. to Sl.no. 9. *Hydrilla verticillata* (L.f.) Royle.

The above fluctuations in the IVI of individual macrophytes during study periods are reflected due to unfavourable changes in the nature of atmospheric and water temperatures of Diplai Beel. More over the changing character of water parameters have shown influences in the existence the specific macrophytes in different seasons of the study years. Especially the pH and DO values are found to be below the standard limits (BSI).

Discussion on Water Parameters and their influences on macrophytes (*see* Table No. 50 & 51)

1. Water Temperature (˚C)

Water Temperature plays a vital role in water plants. 90% of infrared rays from the sun light is absorbed by water bodies and converted in to heat energy into water. Nearly all infrared radiation is absorbed within one meter of the surface water (Wetzel, R. G., 2001). Heat is then slowly transferred throughout the water column due to water column stratification. Water temperature can affect the metabolic rates and biological activity of aquatic organisms (Fink, J. C. 2005). Temperatures above 35°C can begin to denature or breakdown enzymes, reducing metabolic functions (McNally *et al.* 2004). Tropical plants in particular show restricted growth and dormancy in water temperatures below 21°C (Oberrecht, K.). While dormancy is appropriate for surviving a cold winter, warmer temperatures are required for most plants to flourish. Temperature can also inhibit plant respiration and photosynthesis. High water temperatures can increase the solubility and toxicity of certain compounds (Wetzel, R. G., 2001). These elements include heavy metals such as cadmium, zinc and lead as well as compounds like ammonia (Griffiths, P. G. *et al.*, 2016). The solubility of oxygen and other gases will decrease as temperature increases (EPA, 2012). An increase in temperature is increase in conductivity (Southard, J., 2006). Conductivity increases approximately 2-3% per 1°C increase in temperature, though in pure water it will increase approximately 5% per 1°C (Southard, J., 2006). As the temperature increases or decreases, the ion concentrations will also shift, thus shifting the pH value (Crone, T., 2004). Warm water affects growth; disease tolerance and survival rate (EPA. 2012). Warm water cannot hold as much dissolved oxygen as cold water. Increased turbidity will increase water temperature because suspended particles absorb heat from solar radiation more efficiently than water. Water temperature regulates the amount of O_2 that can be dissolved in water, rate of photosynthesis by algae and other aquatic plants, metabolic rates of the organisms, sensitivity of organisms to the toxic wastes, parasites and diseases and timings of reproduction, migration and aestivation of aquatic organisms. Solubility of oxygen decreases as temperature increases ((Wetzel, R. G., 2001). Water temperature can affect the metabolic rates and biological activity of aquatic organisms (EPA, 2012). Water temperature can affect the metabolic rates and biological activity of aquatic organisms (Fink, J. C. 2005). Temperature affects conductivity by increasing ionic mobility as well as the solubility of many salts and minerals (Whipple, K. 2002).

1. i. *Water temperature in Diplai Beel water*

The water temperature in Diplai Beel as observed in 2014-15 (Table no. 60) from March to February, it is found that the highest temp 28.06˚C in August and lowest 16.87˚C in January. In 2015-16 it is observed highest 28.57˚C in August and lowest 17.18 ˚C in January. Again in 2016-17, the highest temperature noted is 28.22 ˚C in August and lowest 17.47˚C in January.

It is seen that in May (27.52 ˚C >27.57 ˚C >27.86˚C) and July (27.23˚C >28.97 ˚C > 29.04 ˚C) the water temperatures increase in 2014-15 to 2016-17. In October the water temperature increases consecutively from 26.87˚C to 27.05˚C to 27.56˚C in the study years of 2014-15 to 2016-17. But November shows decrease in temperature. In January it is found that the temperatures are in increasing nature again from 16.87 ˚C to 17.18˚C to 17.47 ˚C in study periods.

After the study of temperature pattern in the three years of study in Diplai Beel water, it comes to a conclusion that the varying ups and down in temperatures are harmful for growth and physiological metabolisms of macrophytes community of this Beel. Same temperature variation was observed in the studies of fresh water ponds in Ahmedadad district of Gujarat (Kotadiya, N.G. 2013). The water temperature of Diplai Beel is almost within the tolerable range but some observations reflect above the tolerance limit for floating macrophytes.

1. ii. *Correlation (r) of Water Temperature with other parameters of Diplai Beel water:*

From the study of correlation (r) (Table no.61) of water parameters in Diplai Beel water it is seen that the Water Temperature showed significant and positive correlation with Turbidity, Transparency, Total Alkalinity, BOD, Nitrate, Ammonia, Chloride, K, Mg, Cu, Zn. The Temp vs Turbidity showed correlation at ($r= 0.681$, $p<0.01$), Temp vs Transparency the correlation showed at (r= 0..681, $p<0.01$), Temp vs Total Alkalinity the correlation showed at (r= 0..349, $p<0.01$), Temp vs BOD the correlation showed at ($r=0.119$, $p<0.01$), Temp vs Nitrate the correlation showed at ($r= 0.022$, $p<0.01$), Temp vs Ammonia the correlation showed at (r= 0..336, $p<0.01$), Temp vs Cl the correlation showed at (r= 0..342, $p<0.01$), Temp vs K the correlation showed at ($r= 0.131$, $p<0.01$), Temp vs Mg the correlation showed at ($r= 0.501$, $p<0.01$), Temp vs Cu the correlation showed at (r= 0.0.135, $p<0.01$), Temp vs Zn the correlation showed at ($r= 0.674$, $p<0.01$).

Table no.50
Water Test Results of Diplai Beel in 2014-2015, 2015-16 and 2016-17

Sl no.	Water Parameters	Units	Pre-Monsoon			Monsoon			Post-Monsoon			Winter		
			Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
1	Water Temperature	ºC												
	20 14-15		23.45	25.35	27.52	26.92	27.23	28.06	26.73	26.87	22.36	19.16	16.87	19.46
	2015-16		23.48	25.45	27.57	28.07	28.97	28.57	27.04	27.05	21.97	18.35	17.18	20.78
	2016-17		23.12	25.01	27.86	27.07	29.04	28.22	26.46	27.56	21.68	19.13	17.47	20.22
2	Atm Temperature	ºC												
	2014-15		27.72	33.50	31.22	32.23	33.83	31.62	31.53	30.56	27.96	22.03	21.08	21.69
	2015-16		28.91	29.53	31.32	30.65	33.67	31.90	32.21	31.46	23.11	21.76	20.90	24.69
	2016-17		29.69	30.83	30.64	32.73	31.29	34.67	31.46	30.51	27.31	23.41	20.80	24.91
3	Colour - 2014-15	HU	14.62	14.02	13.78	11.24	10.94	9.84	8.78	10.02	12.10	13.74	14.02	14.24
	2015-16		14.80	14.20	13.12	11.40	10.50	10.23	8.50	10.20	13.01	14.02	14.05	15.12
	2016-17		14.40	14.02	12.40	10.80	8.04	8.50	9.40	10.20	11.62	13.40	14.02	14.40
4	Odour -	Agree/ disagree												
	2014-15													
	2015-16													
	2016-17													
5	Total Suspended Solids as TSS	mg/l												
	2014-145		270	252	115	99	73	68	273	295	300	315	350	299
	2015-16		281	262	119	97	78	65	263	285	315	341	359	256
	2016-17		262	245	125	101	79	60	289	312	323	387	402	306
6	Total Dissolved Solids as TDS	mg/l												
	2014-15		315	292	179	162	148	73	91	121	152	286	391	385
	2015-16		341	296	182	169	150	89	87	152	170	256	387	345
	2016-17		305	295	187	152	121	53	92	120	147	193	248	321
7	Turbidity	NTU												

	2014-15		48.10	53.10	60.72	68.82	64.10	70.20	70.10	60.72	50.95	50.36	45.92	45.01
	2015-16		46.60	56.02	60.20	60.24	64.80	71.02	71.25	60.57	61.10	59.12	59.56	50.10
	2016-17		50.01	56.07	56.59	60.40	64.05	69.51	69.07	64.02	60.20	56.12	50.23	45.21
8	Transparency	Secchi Disc m												
	2014-15		1.02	1.05	1.30	0.92	0.98	0.72	0.82	1.04	1.07	1.06	1.10	1.12
	2015-16		2.00	1.52	1.31	1.21	0.98	1.12	1.00	1.02	1.21	1.11	0.98	1.02
	2016-17		1.51	1.32	1.20	1.15	1.10	1.01	1.21	1.25	1.30	1.40	1.41	1.45
9	pH													
	2014-15		5.51	5.72	5.63	6.22	6.33	6.50	6.22	5.53	5.32	5.21	5.15	32.63
	2015-16		4.72	4.81	5.12	5.72	6.12	6.34	6.51	6.01	5.45	5.01	4.79	4.02
	2016-17		4.85	4.98	5.19	5.65	6.01	6.45	6.62	6.75	5.04	4.42	4.82	3.04
10	Electrical Cond.	µS/cm												
	2014-15		22.10	31.92	29.10	28.15	28.01	27.20	28.01	28.12	29.50	30.52	31.50	32.63
	2015-16		31.02	30.12	29.12	29.01	28.40	27.01	27.25	28.01	29.15	30.50	31.20	32.10
	2016-17		31.12	30.88	30.21	30.01	29.50	29.10	30.12	31.50	33.02	33.50	34.72	34.02
11	Total Alkalinity as CaCO3	mg/l												
	2014-15		43.11	45.27	48.12	50.13	54.11	47.03	49.10	52.27	55.11	48.11	42.13	39.12
	2015-16		40.53	40.83	41.52	48.11	43.01	45.11	52.01	53.11	56.11	51.11	48.27	42.01
	2016-17		40.26	40.32	49.82	45.10	45.15	50.10	51.01	52.01	45.91	40.01	37.11	32.01
12	BOD (27˚C for 3 days)	mg/l												
	2014-15		6.35	5.01	4.92	4.02	3.52	3.20	5.62	5.40	3.95	4.10	3.15	3.01
	2015-16		6.25	5.30	4.84	3.72	3.24	3.01	5.60	5.56	4.85	4.62	4.30	3.82
	2016-17		6.10	5.35	4.72	4.50	3.92	2.12	5.82	5.10	4.92	4.51	3.45	3.91
13	Chemical Oxygen Demand as COD	mg/l												
	2014-15		33.36	28.13	29.32	25.03	22.30	18.02	19.76	21.33	25.16	27.71	32.38	34.08
	2015-16		26.56	27.41	25.50	23.92	21.42	17.63	20.82	22.05	25.92	25.45	31.87	33.91
	2016-17		30.30	28.13	25.92	22.95	20.48	17.04	18.31	19.50	26.35	29.66	31.96	33.23

14	Dissolved Oxygen as DO	mg/l												
	2014-15		7.85	6.62	6.90	5.89	5.25	4.24	4.65	5.02	5.92	6.52	7.62	8.02
	2015-16		7.10	6.45	6.01	5.69	5.04	4.15	4.90	5.19	6.10	5.90	7.50	7.98
	2016-17		7.13	6.62	6.10	5.40	4.82	4.02	4.31	4.59	4.21	6.98	7.52	7.81
15	Sulphate as SO4	mg/l												
	2014-15		0.20	0.18	0.15	0.12	0.11	0.09	0.10	0.15	0.17	0.18	0.21	0.25
	2015-16		0.18	0.15	0.13	0.11	0.09	0.10	0.09	0.12	0.14	0.16	0.17	0.18
	2016-17		0.19	0.17	0.15	0.12	0.10	0.06	0.12	0.14	0.15	0.16	0.19	0.25
16	Nitrate as NO3	mg/l												
	2014-15		15.01	12.12	10.15	9.10	8.01.	10.01	10.11	12.01	12.00	9.12	9.01	8.02
	2015-16		13.09	12.92	10.90	9.92	9.90	8.50	8.40	9.12	10.11	12.12	14.01	15.01
	2016-17		4.91	5.11	5.31	5.51	5.72	5.92	0.16	0.14	0.13	0.05	0.02	0.10
17	Nitrite as NO2	mg/l												
	2014-15		6.20	6.10	5.92	5.12	4.20	4.01	3.95	4.10	4.52	5.81	6.01	6.20
	2015-16		6.20	6.52	6.81	6.32	5.93	4.12	4.92	5.11	5.52	5.92	6.52	6.91
	2016-17		5.91	5.25	5.01	4.91	4.31	4.10	5.87	5.11	5.62	5.51	5.03	4.85
18	Ammonia as NH4	mg/l												
	2014-15		2.01	2.05	2.08	2.09	2.21	2.29	1.95	1.81	1.71	1.45	1.42	1.30
	2015-16		2.11	2.18	2.20	2.41	2.52	1.92	1.12	1.25	1.32	1.80	2.10	2.01
	2016-17		3.01	3.03	3.06	2.09	2.11	2.27	2.51	2.32	2.21	2.23	2.10	2.01
19	Chloride as Cl	mg/l												
	2014-15		11.01	11.03	11.09	11.13	11.16	11.19	11.22	11.15	11.13	11.10	11.09	11.05
	2015-16		10.10	10.20	10.31	10.25	10.42	10.49	10.92	11.01	11.15	11.31	11.40	11.35
	2016-17		11.19	11.23	11.52	11.32	11.41	11.32	11.30	11.29	11.15	11.07	11.10	2.01
20	Phosphate as PO4	mg/l												
	2014-15		19.10	19.19	18.10	16.25	16.52	14.85	15.92	16.02	16.25	17.02	18.11	19.52
	2015-16		15.01	14.72	13.52	12.01	12.09	11.20	12.12	13.25	14.01	16.02	17.10	18.25
	2016-17		22.10	21.01	20.25	19.14	18.10	17.02	16.02	17.01	17.92	18.10	18.92	19.02
21	Sodium as Na	mg/l												
	2014-15		29.10	29.39	29.41	29.52	29.61	29.92	30.10	30.20	30.35	30.52	30.91	31.10
	2015-16		28.01	27.10	27.82	26.10	26.17	24.10	25.01	25.08	25.15	28.39	28.62	28.72
	2016-17		31.25	31.10	29.16	29.11	29.08	29.01	29.35	29.40	29.51	29.62	29.68	29.91

22	Potassium as K	mg/l												
	2014-15		0.31	0.30	0.29	0.21	0.25	0.27	0.20	0.22	0.21	0.29	0.30	0.32
	2015-16		0.32	0.39	0.40	0.45	0.49	0.52	0.41	0.39	0.35	0.21	0.11	0.15
	2016-17		0.35	0.32	0.30	0.21	0.15	0.01	0.26	0.29	0.31	0.32	0.35	0.39
23	Calcium as Ca	mg/l												
	2014-15		19.01	19.10	18.11	17.01	16.52	14.01	14.20	15.72	14.16	18.10	18.72	18.91
	2015-16		18.01	17.96	17.52	17.10	16.20	16.12	14.92	15.10	16.20	17.01	17.84	18.15
	2016-17		22.01	18.10	17.89	17.91	16.01	13.95	12.96	13.92	14.01	16.91	17.92	19.01
24	Magnesium asMg	mg/l												
	2014-15		28.11	27.91	27.81	27.01	26.52	25.11	24.92	29.08	25.32	26.01	26.72	27.02
	2015-16		27.50	29.24	27.01	26.91	26.58	26.01	15.91	16.03	16.32	17.39	17.89	18.11
	2016-17		26.01	25.91	25.35	25.11	24.92	24.03	24.11	24.52	24.92	15.02	15.32	16.11
25	Iron as Fe	mg/l												
	2014-15		0.17	0.10	0.20	0.21	0.13	0.16	0.12	0.18	0.20	0.19	0.17	0.70
	15-2016		0.15	0.18	0.20	0.21	0.17	0.15	0.18	0.19	0.17	0.15	0.14	0.14
	16-1207		0.12	0.17	0.18	0.20	0.18	0.16	0.18	0.19	0.12	0.09	0.07	0.11
	Heavy metals													
	Lead as Pb	mg/l												
26	2014-15		0.041	0.034	0.022	0.041	0.063	0.052	0.05	0.04	0.03	0.04	0.01	0.02
	2015-16		0.03	0.04	0.05	0.03	0.02	0.01	0.03	0.03	0.04	0.04	0.03	0.02
	2016-17		0.03	0.04	0.03	0.04	0.05	0.03	0.03	0.04	0.02	0.03	0.02	0.3
27	Cupper as Cu	mg/l												
	2014-15		0.023	0.025	0.024	0.027	0.028	0.029	0.021	0.022	0.021	0.022	0.023	0.024
	2015-16		0.023	0.024	0.25	0.027	0.026	0.028	0.022	0.021	0.023	0.025	0.024	0.023
	2016-17		0.024	0.025	0.026	0.028	0.027	0.026	0.022	0.021	0.023	0.025	0.026	0.024
28	Zinc as Zn	mg/l												
	2014-15		0.023	0.032	0.044	0.032	0.042	0.051	0.04	0.05	0.06	0.03	0.02	0.01
	2015-16		0.02	0.03	0.04	0.05	0.05	0.06	0.05	0.06	0.05	0.04	0.03	0.02
	2016-17		0.04	0.03	0.02	0.03	0.04	0.05	0.05	0.04	0.03	0.04	0.03	0.02

Table no. 51

Correlation coefficient (r) of water parameter values in study years 2014-15, 2015-16 and 2016-17

	Temp	Colour	TSS	TDS	Turby	Transp	pH	EC	TA	BOD	COD	DO	SO4	NO3	NO2	NH4	Cl	PO4	Na	K	Ca	Mg	Fe	Pb	Cu	Zn
Temp	1.000																									
Colour	-0.691	1.000																								
TSS	-0.793	0.483	1.000																							
TDS	-0.721	0.949	0.483	1.000																						
Turb	0.681	-0.875	-0.597	-0.898	1.000																					
Transp	0.681	0.139	0.139	0.044	-0.296	1.000																				
pH	-0.098	0.072	0.072	0.302	-0.318	0.024	1.000																			
EC	-0.572	0.462	0.462	0.493	-0.593	0.269	0.059	1.000																		
TA	0.349	-0.671	-0.671	-0.617	0.721	-0.623	0.004	-0.656	1.000																	
BOD	0.119	0.197	0.359	0.037	-0.105	0.038	-0.398	-0.398	0.179	1.000																
COD	-0.818	0.947	0.592	0.934	-0.923	0.059	0.178	0.550	-0.650	0.084	1.000															
DO	-0.763	0.948	0.506	0.935	-0.919	0.060	0.158	0.468	-0.668	0.055	0.983	1.000														
SO4	-0.844	0.862	0.731	0.865	-0.952	0.204	0.313	0.645	-0.609	0.145	0.936	0.889	1.000													
NO3	0.022	0.255	-0.104	0.301	-0.104	-0.395	0.054	-0.541	0.229	0.142	0.138	0.239	-0.004	1.000												
NO2	-0.442	0.255	0.338	0.763	-0.561	-0.006	0.117	0.270	-0.419	0.262	0.622	0.601	0.532	0.383	1.000											
NH4	0.336	0.766	-0.366	-0.064	0.078	0.538	-0.483	0.140	-0.321	0.132	-0.077	-0.098	-0.093	-0.349	-0.032	1.000										
Cl	0.342	-0.317	-0.294	-0.169	0.366	-0.388	0.257	-0.535	0.710	0.161	-0.357	-0.375	-0.341	0.380	-0.043	-0.018	1.000									
PO4	-0.385	0.418	0.262	0.436	-0.546	0.296	0.071	0.484	-0.380	0.115	0.541	0.476	0.587	-0.329	0.019	0.393	0.036	1.000								
Na	-0.369	0.273	0.243	0.320	-0.459	0.405	0.274	0.414	-0.255	-0.048	0.379	0.319	0.537	-0.285	-0.147	0.273	0.072	0.836	1.000							
K	0.131	0.160	-0.007	0.029	-0.086	0.254	0.016	-0.057	-0.281	0.114	0.048	0.072	0.046	-0.068	0.276	0.017	-0.452	-0.468	-0.541	1.000						
Ca	-0.419	0.844	0.083	0.834	-0.784	0.222	0.131	0.258	-0.708	-0.017	0.816	0.869	0.665	0.248	0.545	0.201	-0.230	0.486	0.245	0.169	1.000					
Mg	0.501	-0.084	-0.518	-0.070	0.043	0.565	0.297	-0.441	0.025	0.038	-0.233	-0.200	-0.133	0.244	0.014	0.324	0.416	0.039	0.279	0.016	0.072	1.000				
Fe	-0.507	0.205	0.254	0.414	-0.528	0.135	0.981	0.343	-0.304	-0.431	0.348	0.342	0.489	-0.024	0.157	-0.505	-0.056	0.092	0.262	0.117	0.253	0.188	1.000			
Pb	-0.339	0.177	0.288	0.038	-0.247	0.272	-0.357	0.537	-0.517	-0.140	0.294	0.296	0.283	-0.529	-0.273	0.075	-0.844	0.256	0.234	0.019	0.108	-0.509	-0.370	1.000		
Cu	0.135	0.284	-0.110	0.214	-0.175	0.407	-0.177	0.009	-0.364	0.278	0.041	0.132	0.004	0.292	0.429	0.114	-0.209	-0.274	-0.201	0.233	0.197	0.297	-0.056	0.006	1.000	
Zn	0.674	-0.798	-0.377	-0.862	0.834	-0.326	-0.340	-0.636	0.685	0.031	-0.812	-0.783	-0.813	0.049	-0.569	-0.132	0.153	-0.692	-0.627	0.200	-0.721	-0.071	-0.450	-0.177	-0.224	1.000

Correlation is significant at the 0.01 level (2-tailed).

1. ii. Correlation (r) of Water Temperature with other parameters of Diplai Beel water:

From the study of correlation (r) (Table no.61) of water parameters in Diplai Beel water it is seen that the Water Temperature showed significant and positive correlation with Turbidity, Transparency, Total Alkalinity, BOD, Nitrate, Ammonia, Chloride, K, Mg, Cu, Zn. The Temp vs Turbidity showed correlation at ($r= 0.681$, $p<0.01$), Temp vs Transparency the correlation showed at (r= 0..681, $p<0.01$), Temp vs Total Alkalinity the correlation showed at (r= 0..349, $p<0.01$), Temp vs BOD the correlation showed at ($r=0.119$, $p<0.01$), Temp vs Nitrate the correlation showed at ($r= 0.022$, $p<0.01$), Temp vs Ammonia the correlation showed at (r= 0..336, $p<0.01$), Temp vs Cl the correlation showed at (r= 0..342, $p<0.01$), Temp vs K the correlation showed at ($r= 0.131$, $p<0.01$), Temp vs Mg the correlation showed at ($r= 0.501$, $p<0.01$), Temp vs Cu the correlation showed at (r= 0.0.135, $p<0.01$), Temp vs Zn the correlation showed at ($r= 0.674$, $p<0.01$).

2. Atmospheric Temperature (°C)

When the earth surface absorbs heat from the sun, it becomes warmer than the surrounding atmosphere. The heat is then transferred by conduction (contact) from the warmer Earth to the cooler atmosphere (Kuring, N., *et al.*). Solar radiation levels are dependent on the time of day and on the sun’s angle toward the earth. When the air is cold, warm water will transfer energy to the air and cool off.

Atmospheric temperature of an area has a great influence on the water system of the water bodies present in an area. The water temperature of a water body gets fluctuated with the fluctuation of atmospheric temperature which is based on rain, coldness, evaporation and wind. The whole aquatic plants are affected in their growth and development and also in physiological metabolisms.

2. i. Atmospheric temperature in Diplai Beel water

During March in Pre Monsoon, August in Monsoon, February in Winter atmospheric temperature increases consecutively from 2014-15 to 2016-17 (Table no. 60) but this temperature decreases in July and January at a stitch. This fluctuating nature of atmospheric temperature has a great impact in floating macrophytes of Dipai Beel water in the study period.

3. Colour (HU)

Pure water has no colour, no taste and no odour. Apparent colour is a visual measure with the naked eyes of water colour. Colour of water is caused by decaying organic matter and naturally occurring metals such as Fe and Mn. It may be also due to presence of humic acids, fulvic acids, suspended matter, phytoplankton, water weeds and industrial wastes. The maximum desirable limit of colour of drinking water as per IS 10500:2012 is 5 HU. Brown-coloured water has several possible causes- dead and dying plank tonic algae produces a brown coloration that disappears once the material settles out, and suspended clay or peat silts can also produce brown colours (El-Gohary, et al., 1992; Bhuiyan. et al., 2007; Davis, et al., 2005; Adigun, 2005; Ukpaka, 2011; Abd-Ellah, 2003 and Dwivedi, et al., 2002).

3. i. Colour in Diplai Beel water

It is observed that (Table no. 60) the colour of water of Diplai Beel in different months of study years is found a varying nature. In 2014-15 the water colour value was highest in March (14.62 HU) and lowest in September (08.78 HU). In 2015-16 the highest value of colour was in February (15.12 HU) and lowest (08.50 HU) in September. In 2016-17 the highest is 14.40 HU in February and March and lowest is 08.04 HU in July. In July colour decreases but in October increases consecutively in study period which is notable. In winter the water colours become tea like brown colour. The tea-coloured water of Diplai Beel is the result of leaching from decomposing leaves in its water. The colour of Diplai Beel water is above the IS values 5 HU- 15 HU where 5 and 15 are acceptable and permissible limit in the absence of alternate source respectively, 2nd revision of IS 10500, FAD 25(2047) C.

3. ii. Correlation(r) of Water Colour with other parameters of Diplai Beel water:

From the study of correlation (r) (Table no. 61) of water parameters in Diplai Beel water it is seen that the water colour showed significant and positive correlation with TSS (r=0.483, p<0.01). TDS (r=0.949, p<0.01) is highly correlated with water colour. It showed highest value among the related parameters. Transparency (r=0.139, p<0.01), pH (r=0.072, p<0.01), EC (r=0.462, p<0.01), BOD (r=0.197, p<0.01) showed active role with water colour. COD (r=0.947, p<0.01), DO (r=0.948, p<0.01) have shown most active correlation with water colour. SO_4 (r=0.862, p<0.01), NO_3 (r=0.255, p<0.01), NO2 (r=0.255, p<0.01), NO4 (r=0.766, p<0.01), PO4 (r=0.418,

$p<0.01$) represented active role with water colour too. Among the elements Na ($r=0.273$, $p<0.01$), K ($r=0.160$, $p<0.01$), Ca ($r=0.844$, $p<0.01$), Fe ($r=0.205$, $p<0.01$), Pb ($r=0.177$, $p<0.01$), Cu ($r=0.284$, $p<0.01$) were sensitive with water colour.

4. Odour

Due to eutrophication accumulation of nutrients takes place especially more supply of P and N in water bodies. It results growth of large quantities of algae and other aquatic plants. It is a natural process but human can accelerate by adding wastes to water. When these plants die they are decomposed by bacteria and gives rise to foul odours in water. Eutrofication reduces the Dissolved Oxygen level to very low in water and leads to death of fish and small plants.

Diplai Beel water odour is found disagreeable for the growth of submerged macrophytes.The water of Diplai Beel gives bed odours in different seasons. In winter the odour is like that of rotten eggs, fishy and disagreeable but it is partial. It becomes prominent during pre monsoon and in winter and late winter period in every year.

5. Total Suspended Solids (TSS) mg/L

Suspended Solids are particles of sand, silt, clay, and organic material moving with water or along the bed of the stream. Suspended solids are any particles/substances that are neither dissolved nor settled in the water. It indicates the erosion nearby or in upstream. Sediment interferes with the function of organisms and decease oxygenation. They cause problems to aquatic organisms. Sediments may damage plants by abrasion, scouring and burial Sediment deposition encourages species shifting due to change of substrate. Salt concentration goes up. TSS reduces the penetration of sun light and as result photosynthesis is reduced along with plants and all metabolic activities. With the start of monsoon erosion starts in the hillocks nearby Diplai Beel and water becomes turbid.

5. i. TSS in Diplai Beel water

Diplai Beel water shows (Table no. 60) variation of TSS in different seasons of the year. It increases from August to February and starts reducing March to June in every year. During 2014-15 the TSS values 299 mg/L which is optimum in February and 73 mg/L the minimum is in July. In 2015-16 optimum is 359 m/L in January and minimum is 65 mg/L in August. Again in 2016-17 the optimum TSS is 402 mg/L in January and minimum by 60 mg/L is in August. The test results represent that during Monsoon TSS is lesser than winter. TSS increases siltation in this Beel.

5. ii. Correlation(r) of TSS with other parameters of Diplai Beel water:

From the study of correlation (r) (Table no. 61) of water parameters in Diplai Beel water it is seen that the TSS showed significant and positive correlation with TDS, Transparency, pH, EC, BOD, COD, DO, NH_4, NO_2, PO_4, Na, Ca, Fe, Pb. TSS showed significant with TDS (r=0.483, < p=0.01) and pH (r=0.072,<p=0.01). TSS showed significant to EC (r=0.462, < p=0.01) and BOD (r=0.359, < p=0.01). TSS showed 2^{nd} highest significant with COD (r=0.592, <p=0.01). DO (r=0.506, <p=0.01) shown highly significant. SO4 (r=0.731, <p=0.01) showed highest significant among others. NO2 (r=0.338, <p=0.01), PO4 (r=0.262, <p=0.01), Na (r=0.243, <p=0.01), Ca (r=0.083, <p=0.01), Fe (r=0.254,<p=0.01) had effective but lesser than others. Pb (r=0.288, <p=0.01) showed highest effective role among all elements. Above data reflect that TSS had active role with good number of other parameters of Diplai Beel water, where p is its significance.

6. Total Dissolved Solids (TDS) mg/L

The test for Total Dissolved Solids (TDS) provides a qualitative measure of the amount of dissolved ions but does not tell us the nature or ion relationships. It is a combined content of inorganic and organic substances contained in water in molecular, ionized or micro-granular suspended form. The most common chemical constituents are Mg, Ca, phosphates, nitrates, Na, K and chloride (Esmaeili, H.R. et al., 2005). Total dissolved solids concentration is the sum of the cations (positively charged) and anions (negatively charged) ions in the water. Conductivity is usually about 100 times the total cations or anions expressed as equivalents. Total Dissolved Solids (TDS) in ppm usually range from 0.5 to 1.0 times the electrical conductivity. 300-500 mg/l (EPA) is limit for lake water. TDS generally increases after monsoon season. The human interference also contributes to the enrichment of dissolved solids in water (Verma, P.U., 2011). According to BIS standard the maximum desirable TDS is 500 mg/L. WHO limit for TDS concentration is below 1000 mg/L.

6. i. TDS in Diplai Beel water

The study of Diplai Beel water (Table no. 60) quality in 2014-15, 2015-16 and 2016-17 shows the TDS value below the BIS limit in the water system. In 2014-15 high TDS, 391 mg/l is found in February and low in August. In 2015-16 highest value is found in Feb (345 mg/l) and the lowest (89 mg/l) in August. Again in 2016-17 the highest value becomes 321 mg/l in Feb and the lowest in 53 mg/l in August. In May, TDS values decrease from 2014-15 to 2016-17. But in Jan TDS values decrease continuously from 2014-15 to 2016-17. From the TDS study it can assume that TDS very low in comparison to IS standard values (500 mg/L to 2000 mg/L).

6. ii. Correlation(r) of TDS with other parameters of Diplai Beel water:

The study of correlation (r) (Table no.61) of water parameters in Diplai Beel water represents that the TDS showed significant and positive correlation with Transparency, pH, EC, BOD, COD, DO, NH_4, NO_3,NO2, PO_4, Na, K, Ca, Fe, Pb, Cu. of Diplai Beel water. The TDS showed the correlation with Transparency (r=0.898, <p=0.01) and the value was represented 2nd in highest, TDS had significant correlation with pH(r=0.302, <p=0.01). TDS had positive correlation with EC (r=0.493, <p=0.01), BOD (r=0.037, <p=0.01). TDS showed highest relation with DO (r=0.935, <p=0.01). NH_4 (r=0.865, <p=0.01), NO_3 (r=0.301, <p=0.01) and COD (r=0.934, <p=0.01) had active role with TDS, but COD showed the highest active role. NO2 (r=0.763, <p=0.01), PO4 (r=0.436, <p=0.01) showed their correlation with TDS. Na (r=0.320, <p=0.01), K (r=0.029, <p=0.01), Ca (r=0.834, <p=0.01), Fe (r=0.414, <p=0.01), Pb (r=0.038, <p=0.01), Cu (r=0.214, <p=0.01) were found active elements and showed correlation with TDS.

7. Turbidity (NTU)

Turbidity measures water clarity or the ability of light to pass through water. It is an optical characteristic of water and is an expression of the amount of light that is scattered by material in the water when a light is shined through the water sample. Water with high turbidity looks brown, cloudy or opaque. High turbidity causes increase in water temperatures. This is because suspended particles absorb more heat and reduces light penetration into water and affects submerged plants (Ukpaka C. P., 2013, September). It can measure the amounts of suspended solids. It can be measured by Secchi Disk. Usually less than 10 NTU reflects goodness of water. Turbidity readings can be used as an indicator of potential pollution in a water body. (NTU=Nephelometric Turbidity Unit)

7. i. Turbidity in Diplai Beel water

In 2014-15 Turbidity (Table no. 60) found high in August, 72.20 NTU and low in 45.01 NTU. In 2015-16 it is recorded high as 71.25 NTU in September and low as 46.60 NTU in March. Again in 2016-17 highest turbidity recorded is 69.07 NTU in September and the lowest is 45.21 NTU in February. In the month of April the turbidity is fond increasing from 2014-15 to 2016-17 by 53.10 NTU <56.02 NTU <56.07 NTU.The result of turbidity study shows that the Diplai Beel water has above the normal limits (10 NTU). It is far higher than the tolerance limit. As Diplai Beel is surrounded by hilly slopes so after heavy showering the soil and organic particles come down by water streams and mix with its water. The turbidity affects the submersed macrophytes lowering photosynthesis (Crone, T. 2004), oxygen demand (Palermo, M. R. et al., 2008) and rise in water temperature in water (Dagaonkar et al., 1992, Garg, R.K. et al., 2006 and Solanki, H.A. et al., 2011).

7. ii. Correlation(r) of Turbidity with other parameters of Diplai Beel water:

From the study of correlation (r) (Table no. 61) of Turbidity in Diplai Beel water it is seen that the Turbidity, showed significant and positive correlation with Total Alkalinity, Ammonia, Cl, Mg, Zn. Turbidity showed the correlation with Total Alkalinity ($r = 0.721$, $p<0.01$) which was the 2^{nd} highest among all parameters. Turbidity vs Ammonia showed the correlation at ($r = 0.078$, $p<0.01$). Turbidity showed the correlation with Cl ($r=0.366$, $p<0.01$), Turbidity showed the correlation with Mg ($r= 0.043$, $p<0.01$). Zn ($r= 0.834$, $p<0.01$) showed positive and the correlation with Turbidity which was the most effective significant and positive correlation among all.

8. Transparency (Secchi Disc) m

Transparency or Secchi depth is the depth to which one can see into a lake bottom and is an indication of water clarity. This measurement is done by lowering a black and white Secchi disk into the water and recorded the depth at which the disc is no longer visible as well as the differences in colour. Its unit is meter. Transparency of light into lake water represents healthiness of a water body. It is inversely proportional to health of a water body.

8.i. Transparency in Diplai Beel water

During the study period in 2014-15 is recorded (Table no. 60) minimum 0.72 m in August and maximum 1.12 m in February. Again in 2015-16 maximum recorded is 2.00 m in March with minimum 0.98 m in July. But in 2016-17 it is found maximum 1.51 m in March and minimum 1.01 m of light transparency. The overall transparency of sun light into Diplai Beel is poor; which affects the submerged plants and planktons reducing their photosynthetic productivities.

8. ii. Correlation(r) of Transparency with other parameters of Diplai Beel water:

Transparency showed positive and significant correlation (Table no. 61)) with pH (r=0.024, <p=0.01) but showed least. It showed positive and significant correlation with EC(r=0.269,<p=0.01). BOD showed correlation with Transparency by (r=0.038, <p=0.01). COD showed correlation with Transparency by (r=0.059, <p=0.01). DO showed correlation with Transparency by (r=0.060, <p=0.01). SO4 showed correlation with Transparency by (r=0.204, <p=0.01), but NH4 (r=0.538, <p=0.01) had shown 2^{nd} highest positive and significant correlation with Transparency. PO4 showed (r=0.296, <p=0.01). Na (r=0.405,<p=0.01), K (r=0.254,<p=0.01) and Ca (r=0.222,<p=0.01) showed less values with comparison to other parameters. Mg(r=0.565,<p=0.01) showed highest Transparency among all values. Fe(r=0.135,<p=0.01), Pb (r=0.272,<p=0.01) and Cu(r=0.407,<p=0.01) with in moderate value.

9. Electrical Conductance (EC) µS/cm

Higher the ion higher is the conductivity of water. Conductivity is an indicator of the amount of dissolved salts in water or in liquid. Conductive ions come from dissolved salts and inorganic materials such as Sodium, Potassium, Magnesium, chlorides, sulphates, carbonates, nitrates and bicarbonates compounds (Langland, et al., 2003). The major positively charged ions are sodium (Na_{+}), calcium ($Ca+_{2}$), potassium (K+) and magnesium ($Mg+_{2}$). The major negatively charged ions are chlorides, sulphates, carbonates, nitrates and bicarbonates compounds. Sulphates are the minor contributors to conductivity although they are very important biologically. Salinity is the measure of the salt in the water because dissolved ions increase salinity as well as conductivity, the two measures are related. Every kind of organism has a typical salinity range that it can tolerate.

9.i. EC in Diplai Beel water

The result of Electrical Conductance (Table no. 60) during the study years in Diplai Beel water, are found in moderate range. In 2014-15 it shows highest value 32.63 µS/cm in February and lowest, 22.10 µS/cm in March. In 2015-1116 the value 32.10 µS/cm is highest in February and lowest 27.10 µS/cm in August. Again in

2016-17 the EC value is highest, 34.72 μS/cm in January. It is observed in the months of March, May June, July and December that the EC value increases gradually in the study periods with the rise of temperature in atmosphere. The level of EC shows the pollution condition as well as trophic status of the water body (Ahluwalia, 1999). Seasonal variation in EC is due to acceleration of concentration of salt by evaporation (Solanki, 2001 and Trivedy et al., 1989).

9.ii. Correlation(r) of EC with other parameters of Diplai Beel water:

EC (Table no. 61) showed positive and significant correlation with COD ($r=0.550$, $p<0.01$), EC had significant correlation with DO ($r=0.468$, $p<0.01$), but it showed highest positive and significant correlation with SO4 ($r=0.645$, $p<0.01$) only than to COD. NO2 ($r=0.270$, $p<0.01$) showed as more than NH4 ($r=0.140$, $p<0.01$). PO4 ($r=0.484$, $p<0.01$) showed 4^{th} highest correlation with EC. Among the nutrient elements Na ($r=0.414$, $p<0.01$), Ca ($r=0.258$, $p<0.01$), Fe ($r=0.343$, $p<0.01$) but Pb ($r=0.537$, $p<0.01$) is observed highest among all elements and Cu ($r=0.009$, $p<0.01$) showed the least correlation in Diplai Beel water in the study period.

10. pH

pH is a measure of how acidic or basic (alkaline) the water is. The term pH come from French as 'puissance d'Hydrogéne' which means strength of hydrogen. It is defined as negative log of the hydrogen ion concentration. When pH decreases water becomes more acidic, but when pH increases water becomes more basic in nature. Many chemical cellular reactions inside the organisms require a narrow pH range. pH can also affect the solubility and toxicity of chemicals and heavy metals in the water (EPA. 2012). At the extreme end of pH scale (1 2 or 13) the physical damage of aquatic life takes place. Changes in pH may alter the concentrations of other substances in water to a more toxic form. Decrease in pH below 6 helps Pb solubility in water and when increases above 8.5 in water the ammonia gets changed non toxic to toxic form. Low pH levels can encourage the solubility of heavy metals (EPA, 2012). As the level of hydrogen ions increases metal cations such as aluminium, lead, copper and cadmium are released into the water instead of being absorbed into the sediment. As the concentrations of heavy metals increase, their toxicity also increases. Aluminium can limit the growth and reproduction of organisms while increasing mortality rates at concentrations as low as 0.1- 0.3 mg/L (Geomorphlist, 2007). The majority of aquatic organisms prefer a pH range of 6.5 -

9.0. A slight change in the pH of water can increase the solubility of phosphorus and other nutrients making them more accessible for plants growth. The process of photosynthesis by algae and plants uses hydrogen, thus increase in pH levels (Czuba, J. A., 2011). Differences in pH levels between water strata are due to increased of CO_2 from respiration and decomposition below the thermo cline. Harmful effects become noticeable when the pH of water is below 5.0 or rise above 9.6. CO_2 is the most common cause of acidity in water (Hakanson, L., 2005). Photosynthesis, respiration and decomposition all contribute to pH fluctuations due to their influences on CO_2 levels. The extremity of these changes depends on the alkalinity of the water, but there are often noticeable diurnal (daily) variations. This influence is more measurable in bodies of water with high rates of respiration and decomposition. In eutrophic lakes pH-tolerant algae can dominate; driving the pH levels to diurnal high and low extremes, forming algae blooms that can kill the lake.

10. i. pH in Diplai Beel water

The pH values recorded in Diplai Beel water (Table no. 60) in the study period of 2014-15, 2015-16 and 2016-17, have shown a vital role in the solvability of plants community in near future. In 2014-15 the pH value remains in between 6.50 (August) and 5.15 (January). Again in 2015-16 the pH becomes high (6.55) in August and low (4.02) in February. But in 2016-17 it is recorded highest, 6.75 in October and lowest, 3.04 .It is observed that pH decreases continuously in July, December, January and February from 2014-15 to 2016-17 but it increases in September and October consecutively. During last part of Monsoon and in whole Winter pH value declines but in Post Monsoon pH increases. This fluctuation of pH is due to temperature variation in water.

10. ii. Correlation(r) of pH with other parameters of Diplai Beel:

From the study of correlation (r) (Table no. 61) of water parameters in Diplai Beel water it is seen that the pH showed significant and positive correlation with Electric Conductivity, Total Alkalinity, COD, DO, Sulphate, Nitrate, Nitrite, Cl, Phosphate, Na, K, Ca, Mg, Fe. pH showed correlation with Electric Conductivity($r= 0.059$, $p<0.01$). It had shown correlation with Total Alkalinity ($r= 0.004$, $p<0.01$). pH showed activeness at COD ($r= 0.178$, $p<0.01$). pH vs DO the correlation showed at ($r=0.158$, $p<0.01$). Sulphate ($r= 0.313$, $p<0.01$) and Nitrate (r=.0.054, $p<0.01$) showed active correlation. Nitrite ($r= 0.117$, $p<0.01$), Cl ($r= 0.257$, $p<0.01$), Phosphate ($r= 0.071$, $p<0.01$), Na ($r=0.274$, $p<0.01$), K ($r= 0.016$, $p<0.01$), Ca ($r= 0.131$, $p<0.01$) and Mg ($r= 0.297$, $p<0.01$), Fe ($r= 0.981$, $p<0.01$) shown significant correlation with pH of the Beel water. The Fe value is the highest value seen correlated with pH. The other recorded values were negatively correlated with pH.

11. Total Alkalinity (mg/L)

Alkalinity is the capacity of water (Table no. 60) to resist changes in pH that would make the water more acidic. Alkalinity is the strength of a buffer solution composed of weak acids and their conjugate bases. The total alkalinity (TA) is a measure of how much of the alkaline substances there are in the water. When the total alkalinity (TA) is within this range, it prevents rapid pH changes and "stabilises" the pH level. Total alkalinity (TA) is the measure of water's ability to neutralize acids too. Alkaline compounds that are present in water, like hydroxides and carbonates, eliminate H^+ ions from the water, which lowers the acidity of the water and results in a higher pH. Measuring alkalinity is vital in identifying the capacity of water to neutralize the acidic and corrosive effects from waste water and other sources, such as rainfall. The levels of TA can be raised when necessary with the use of compounds like sodium carbonate. When lowering the TA, acid in dry or liquid form can be added, such as dry acid and hydrochloric acid. Both can be time-consuming processes, but are guaranteed to provide appropriate solutions.

11. i. Total Alkalinity in Diplai Beel water

The study of alkalinity value of Diplai Beel water comes down in March, April and June. This fall takes place consecutively in some months of study period i.e. 2014-15, 2015-16 and 2016-17. In 2014-15 its value is recorded 55.11 mg/L in November as highest and lowest by 39.12. In 2015-2016 the highest value is 56.11 mg/L in November and lowest 40.53mg/L in March. But in 2016-17 the highest value of alkalinity is 51.01mg/L in September and lower is 32.01 mg/L in February.

11. ii. Correlation(r) of Total Alkalinity with other parameters of Diplai Beel water:

Alkalinity (Table no. 61) showed its positive correlation with BOD ($r=0.179$, $p<0.01$), NO_3 ($r=0.229$, $p<0.01$), Cl ($r=0.710$, $p<0.01$), Mg ($r=0.025$, $p<0.01$), Cl ($r=0.710$, $p<0.01$) was directly correlated with Alkalinity where the values were more significant and highest in magnitude. It was followed by NO_3 ($r=0.229$, $p<0.01$) and BOD ($r=0.179$, $p<0.01$).

12. Biological Oxygen Demand (BOD) mg/L

BOD measures the amount of oxygen consumed by microorganisms in decomposing organic matter in lake water. It calculates the chemical oxidation of inorganic matter. It is tested generally 5 days at 20˚C. The rate of oxygen consumption in water is affected by temperature, pH, the presence of certain kinds of microorganisms and the type of organic and inorganic materials in the water. The BOD is proportional to rapidly depletion of oxygen in the water. It means less available of oxygen to higher forms of aquatic life. The sources of BOD are leaves and woody debris; dead plants and animals; animal manure and urban water runoff etc. Chlorine affects BOD measurement by inhibiting or killing the microorganisms that decompose the organic and inorganic matter in water. (APHA, 1992).

12.i. BOD in Diplai Beel water

From the study of the water qualities (Table no. 60) of Diplai Beel water in the study years it is found that the BOD values in 2014-15 are 3.01 mg/L and 6.25 mg/L the least in February and highest in March respectively. During 2015-16 the highest BOD was recorded at 6.25 mg/L in March and the lowest at 3.01 mg/L in August. Again in 2016-17 the BOD value is represented highest at 6.10 mg/L in March and lowest at 2.12 mg/L in August. The BOD values showed decreasing consecutively in the months of March, May, August, November and February during the study period.

12.ii. Correlation (r) of BOD with other parameters of Diplai Beel water

In Diplai Beel the water BOD had shown positive and significant correlation (Table no. 61) with COD ($r=0.084$, $p<0.01$). DO ($r=0.055$, $p<0.01$) showed moderate but SO_4 ($r=0.145$, $p<0.01$) and NO_3 ($r=0.142$, $p<0.01$) showed significant correlation. NO_2($r=0.262$, $p<0.01$) showed the highest correlation. NH_4 ($r=0.132$, $p<0.01$), Cl ($r=0.161$, $p<0.01$) and PO_4($r=0.115$,$p<0.01$), had shown almost equal value of significant with BOD. The elemental nutrient correlation of K($r=0.114$, $p<0.01$), Mg ($r=0.038$, $p<0.01$), Cu ($r=0.278$, $p<0.01$) and Zn($r=0.031$, $p<0.01$) were higher than that of others.

13. Chemical Oxygen Demand (COD) mg/L

Chemical Oxygen Demand (COD) represents the oxygen required to oxidize soluble and particulate organic matter in water. Higher COD levels mean a greater amount of oxidizable organic material in a sample, which will reduce the DO levels. A reduction in DO can lead to anaerobic conditions, which is deleterious to higher aquatic life forms.

13. i. COD in Diplai Beel water

The Chemical Oxygen Demand (COD) study of Diplai Beel water (Table no. 60) during the study year 2014-15 showed highest by 34.08 mg/L in February and lowest by 18.02 mg/L in August. In 2015-16 it became least by 17.63 mg/L in August and highest by 33.91 mg/L in February. Again in 2016-17 it is recorded the highest COD as 33.23 mg/L in February and lowest as 17.04 mg/L in August. During this study period the highest recorded value is 34.08 mg/L and lowest is 17.04 mg/L. In the month of June and July data reflects consecutive decrease of COD values in whole study time and on the other hand the value increases consecutively in August and November.

13. ii. Correlation (r) of COD with other parameters of Diplai Beel water:

The COD of Diplai Beel water had shown positive and significant correlation (Table no. 61) with DO($r=0.983$, $p<0.01$) and SO_4 ($r=0.936$, $p<0.01$). The value of NO_3($r=0.135$, $p<0.01$) and NO_2($r=0.622$, $p<0.01$) showed also the significant correlation with COD. The PO_4($r=0.541$, $p<0.01$) and Na($r=0.379$, $p<0.01$) values showed significant during study period. The nutrient elements were also significant in this period such as K($r=0.048$, $p<0.01$), Ca($r=0.816$, $p<0.01$), Fe($r=0.348$, $p<0.01$), Pb($r=0.294$, $p<0.01$) and Cu($r=0.041$, $p<0.01$). Among the elements Pb($r=0.294$, $p<0.01$) had high correlation with COD. NH_4 and Cl showed negative correlation.

14. Dissolved Oxygen (DO) mg/L

Dissolved oxygen means the amount of gaseous oxygen (O_2) dissolved in water or an aqueous solution. Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement), and as a waste product of photosynthesis. It is the well-established indicator of water quality. In limnology DO is an essential factor second only to water itself (Wetzel, R. G., 2001). Oxygen also enters through aeration by natural or by man-made process (Gao, Q., 2006, November). Dissolved oxygen level that is too high or too low can harm aquatic life and affects water quality. It has specific influence on the organisms living in water. Free oxygen molecules dissolve in water like the way salt or sugar does when it is stirred (Gray, J. R., 2000, August). Aquatic organisms use oxygen in respiration from water. Plant life and phytoplankton require dissolved oxygen for respiration when there is no light for photosynthesis (EPA.2014, February). The amount of dissolved oxygen needed varies from plants to animals.

Bacteria and fungi require DO to decompose organic material at the bottom of the water body. Microbial decomposition is an important contributor to nutrient recycling (Perlman, H., 2014, March). Dissolved oxygen is also produced as a waste product of photosynthesis from phytoplankton, algae, seaweed and other aquatic plants (EPA.2014, February). Most photosynthesis takes place at the surface (by shallow water plants and algae), a large portion of the process takes place under water and entirely depend on light penetration into water. As aquatic photosynthesis is light dependent, the dissolved oxygen produced will be peak during daylight hours and decline at night (EPA. 2012, March). The solubility of oxygen decreases as temperature increases (Wetzel, R. G., 2001). DO decreases exponentially as salt levels and pressure increase (Wetzel, R. G., 2001). DO concentrations are constantly affected by diffusion and aeration, photosynthesis, respiration and decomposition. When dissolved oxygen levels in water drops below 5.0 mg/l aquatic life is put under stress.

14.i . DO in Diplai Beel water

The DO analysis data of Diplai Bell water (Table no. 60) indicates that in 2014-15 the highest amount of DO is seen 8.02 mg/L in February and the least, 4.24 mg/L in August. In 2015-16, DO is recorded 4.15 mg/L and 7.98 mg/L as lowest and highest respectively. But in 2016-17, DO is found highest as7.81 mg/L and lowest as 4.02 mg/L. In Diplai Bell water Dissolved Oxygen is fallen consecutively in the months of June, July, August and February which was a specific symptom of dissolved oxygen deficiency in the study years. In this time DO level of Diplai Beel water is below 4 mg/L which is in critical stage where water plants remain in great stress and metabolisms start changing.

14.ii. Correlation (r) of DO with other parameters of Diplai Beel water:

In the study of correlation (Table no. 61) of DO with Diplai Beel water it is observed that SO_4($r=0.889$, $p<0.01$) is found high positively correlation with DO. The correlation of NO_3($r=0.239$, $p<0.01$), NO_2($r=0.601$, $p<0.01$) and PO_4(r=0. 476,

$p<0.01$) is seen medium in nature. The elemental nutrients like Na($r=0.319$, $p<0.01$), K($r=0.072$, $p<0.01$), Ca($r=0.869$, $p<0.01$), Fe($r=0.342$, $p<0.01$), Pb($r=0.296$, $p<0.01$) and Cu($r=0.132$, $p<0.01$) showed moderately positive correlation with DO. The fluctuation of values of DO in the study period had affected the metabolic reactions of organisms.

15. Sulphate as SO_4^{2--} (mg/L)

Sulphate (SO_4^{2--}) is a major anion in hard water. When naturally occurring, they are the result of the breakdown of leaves that fall in fresh water. Runoff from fertilized agricultural lands also contributes sulphates to water bodies. Dry deposition and Acid Rain promotes the increase of sulphate in fresh water. It is most common form of sulphur in well-oxygenated water. When sulphate is less than 0.5 mg/L, algal growth is not occurred. Sulphate promotes methylation of mercury to its most toxic and bio-accumulative form called methylmercury. Sulphate promotes release of nutrients from sediments (internal eutrophication). Sulphate also enhances biodegradation of organic soils (Orem, W.H.)

15. i. SO_4^{2--} in Diplai Beel water

Diplai Beel water analysis indicates (Table no. 60) that in 2014-15, the sulphate is found highest by 0.25 mg/L in February and the least is 0.09 mg/L in August. In 2015-16, SO_4 is recorded 0.18 mg/L as highest in February and March; but at the same time the least value is 0.09 mg/L in August. Again in 2016-17 the sulphate value is found 0.06 mg/L as least in August and 0.25 mg/L in February. During this study period, it is observed that sulphate readings found to be fluctuating with the reference of tolerance limit (0.50 mg/L), Diplai Beel water shows a moderate value and does not affect the water system.

15. ii. Correlation (r) of SO_4^{2--} with other parameters of Diplai Beel water:

The water analysis of Diplai Beel has shown the positive correlation (Table no. 61) with SO_4^{2--} anion during the study years PO_4($r=0.587, p<0.01$). Na($r=0.537, p<0.01$) shows its lesser correlation than PO_4. Among all elements Ca($r=0.665$, $p<0.01$) shows highest correlation in the system. K($r=0.046$, $p<0.01$), Fe($r=0.489$, $p<0.01$), Pb($r=283$, $p<0.01$) and Cu($r=0.004$, $p<0.01$) had less effective than other parameters of Diplai Beel water.

16. Nitrate as NO_3^- (mg/L)

Nitrogen remains in gaseous form in air. Plants cannot use it in gaseous form. Blue-green algae and legumes have the ability to convert nitrogen gas into nitrate (NO_3^-), the usable form of plants. Plants use nitrate to make proteins in them. Nitrogen is released into the environment as NH_4+ after the death of plants and animals. Ammonium is eventually oxidised by bacteria into nitrite (NO_2^-) and then into nitrate (NO_3^-). The nitrate form of nitrogen is relatively present in freshwater aquatic ecosystems. It enters into water from natural sources like decomposing plants and animal waste as well as human sources like sewage or fertilizer etc. Natural levels of nitrate are usually less than 1 mg/L. Concentrations over 10 mg/L will have an effect on the freshwater aquatic environment (EPA). Water with low dissolved oxygen may slow the rate at which ammonium is converted to nitrite (NO_2^-) and finally nitrate (NO_3^-)**.** Nitrite and ammonium are far more toxic than nitrate to aquatic life. Excess nitrogen can harm water bodies. Overstimulation of growth of aquatic plants and algae is due to excess nitrogen in water. As a result excessive growth of organisms takes place and can clog water intakes, more use of DO and block light entrance to deeper. Lastly eutrophication occurs. It results unsightly scrums of algae on the water surface killing plant and fish and lastly make lake deprived of oxygen.

16. i. NO_3^-in Diplai Beel water

In the first year, 2014 - 15 the study (Table no. 60) of the water analysis is recorded highest in March (15.10 mg/L) and lowest in July (8.01 mg/L). It is observed in Pre-Monsoon and Monsoon period. Again in 2015-16 analysis shows highest value in February by 15.01 mg/L and lowest by 4.40 mg/L in September. Here differentiation is seen in big time gap. But in 2016-17 water analysis data reflects highest value in August by 5.92 mg/L and optimum value by 0.02 mg/L in January. It is seen that 2016-17 nitrate values are far different than the other two years.

16.ii. Correlation (r) of NO_3^- with other parameters of Diplai Beel water

NO3$^-$ ions of Diplai Beel water during the study period shows positive correlation (Table no. 61) with NO2(r=0.383, $p<0.01$), Cl(r=0.380, $p<0.01$), Ca(r=0.248, $p<0.01$), Mg(r=0.244, $p<0.01$), Cu(r=0.292, $p<0.01$), Zn(r=0.049, $p<0.01$), K(r=0.046, $p<0.01$) and K(r=0.046, $p<0.01$). This correlation is closer to NO2 which is highest correlation among all parameter. Cl(r=0.380, $p<0.01$) and

Cu(r=0.292, p<0.01) values follow NO2. Zn and K show the lowest correlation with nitrate.

17. Nitrite as NO_2^-(mg/L)

Excess nitrogen can harm water bodies. Overstimulation of growth of aquatic plants and algae is due to excess nitrogen in water. As a result excessive growth of organisms takes place and can clog water intakes, more use of DO and block light entrance to deeper. Lastly eutrophication occurs. It results unsightly scrums of algae on the water surface killing plant and fish and lastly make lake deprived of oxygen. Plants use nitrite as a building block for proteins and nucleotides. Any decaying plant material can produce toxic nitrogen compounds like nitrite and ammonia. Nitrites can be good when they form nitric oxide, but when they form nitrosamines, it can have a negative effect. 1 mg/L for nitrite-nitrogen for regulated public water systems is sufficient (EPA)

17. i . NO_2^-in Diplai Beel water

In 2014-15 the water of Diplai Beel analysis shows (Table no. 60) the result that the ions of NO 2^- mg/L are found optimum (6.20 mg/L) in February and March and minimum (4.01 mg/L) in August. Again in 2015-16 water analysis results the ions of NO3 mg/L are highest (6.91 mg/L) in February and lowest (4.12 mg/L) in August. In 2016-17 nitrite ions are found as optimum (5.91 mg/L) in March but found minimum (4.85 mg/L) in February. It is observed in three years that nitrites ions are decreased little in March but in August , September and October nitrite values are increased . It may be said from observation that during 2015-16 nitrite values are higher than the values of 2014-15 and 2016-17. $NO2^-$ shows lower in Post Monsoon and Monsoon than the Pre Monsoon and winter . $NO2^-$is observed above the tolerance limit of 1.2 mg/L (BIS)

17.ii Correlation (r) of NO_2^- with other parameters of Diplai Beel water

During study period the Nitrite analysis of Diplai Beel water shows its positive correlation (Table no. 61) with PO4(r=0.019, p<0.01), K(r=0.276, p<0.01), Ca(r=0.545, p<0.01), Mg (r=0.014, p<0.01), Fe(r=0.157, p<0.01) and Cu(r=0.429, p<0.01). When Ca(r=0.545, p<0.01) shows highest value than other values of Mg, PO4, Fe and K come down by (r=0.014, p<0.01), (r=0.019, p<0.01), (r=0.157, p<0.01) and (r=0.276, p<0.01) respectively. Cu has shown its correlation next to Ca.

18. Ammonia as NH_3^+ (mg/L)

A dead or dying plant can decay which produces ammonia. Ammonia turns into nitrite. Ammonia is a colourless, pungent gaseous compound of hydrogen and nitrogen that is highly soluble in water. It is a biologically active compound found in most waters as a normal biological degradation product of nitrogenous organic matter (protein). It is also found its way to ground and surface waters through discharge of industrial process wastes containing ammonia and fertilizers. On dissolution in water, ammonia forms the ammonium cation; hydroxyl ions are formed at the same time. The degree of ionization depends on the temperature, the pH, and the concentration of dissolved salts in the water. Surface waters may contain up to 12 mg/litre (WHO, 1986). The environmental cycling of nitrogen relies mainly on nitrate, followed by ammonia and the ammonium cation, which predominates. The ammonium cation is less mobile in soil and water than ammonia and is involved in the biological processes of nitrogen fixation, mineralization, and nitrification (EPA, 1989). The presence of the ammonium cation in raw water may result in drinking-water containing nitrite as the result of catalytic action (Reichert and Lochtmann, 1984) or the accidental colonization of filters by ammonium-oxidizing bacteria.

18. i. NH_3^+ in Diplai Beel water

In 2014-15 the water content of ammonium N in Diplai Beel (Table no. 60) is found optimum, 2.29 mg/L in August. The minimum, 1.30 mg/L of ammonium is seen in February. The ammonium value increases from February to July which is seen decreasing from August to February. In 2015-16 the ammonium value in Diplai Beel is recorded optimum, 2.52 mg/L in July but minimum 1.12 mg/L in September. In 2016-17 ammonium is recorded optimum as 3.06 mg/L in May and minimum as 2.01 mg/L in February. During the study the ammonium value observed is below the tolerance limit of 12 mg/litre.

18. ii. Correlation (r) of NH_3^+ with other parameters of Diplai Beel water

NH_3^+ shows positive correlation (Table no. 61) with PO4(r=0.393, p<0.01), Na(r=0.273, p<0.01), K(r=0.017, p<0.01), Ca(r=0.201, p<0.01), Mg(r=0.324, p<0.01), Pb(r=0.075, p<0.01), and Cu(r=0.114, p<0.01). Ammonium has high positive correlation with PO4, Mg, Na and Cu than Pb. Pb shows the minimum value of correlation with ammonium ions. Pb value is very negligible. It is observed that

Chloride, Fe and Zn are negatively correlated with ammonium ions. These values are not affected by the ammonium ions during study years.

19. Chloride as Cl^- (mg/L)

Chloride concentrations between 1 and 100 ppm (parts per million) are normal in freshwater. Chloride ions come into water solution from underground aquifers, geological formations that contain groundwater. Anthropogenic source of chlorides in groundwater is fertilizer made with potash. Potassium chloride is the salt most commonly used in potash fertilizer and potassium is one of three essential nutrients (along with nitrogen and phosphorous) that are added to increase soil fertility in farms. However like nitrogen and phosphorous, chloride can leach from fertilized soils into rivers and streams. High chloride concentrations in freshwater can harm aquatic organisms by interfering with osmoregulation. Difficulty with osmoregulation can hinder survival, growth, and reproduction.

19. i . Cl^- in Diplai Beel water

In 2014-15 the water analysis of Diplai Beel for chloride shows that **(**Table no. 60) chloride value, 11.22 mg/L is optimum in the month of September and it becomes minimum of 11.01 mg/L in March. Again it is optimum value i.e. 11.40 mg/L in January and minimum of 10.01 mg/L in March during the study year of 2015-16. The chloride content of Diplai Beel water is found optimum i.e.2.01 mg/L in February and minimum of 11.07 mg/L in December in 2016-17.

19. ii . Correlation (r) of Cl^- with other parameters of Diplai Beel water:

Chloride is positively correlated (Table no. 61) with PO4 ($r=0.036$, $p<0.01$), Na($r=0.072$, $p<0.01$), Mg($r=0.416$, $p<0.01$) and Zn($r=0.153$, $p<0.01$). Mg value reflects the major correlation value. It is followed by value of the Zn which shows positively correlated with chloride during the study years.

20. Phosphate as PO_4^+ (mg/L)

Phosphate is a micro nutrient for plant growth and takes place in metabolic reactions in plants. It has large effect on the aquatic ecosystem. Phosphate induced algal blooms may initially increase DO via photosynthesis but after the death of blooms more oxygen is consumed by bacteria aiding their decomposition. It changes the type of plants which lives in an ecosystem. Sources of phosphate include animal wastes, sewage, detergent, fertilizer, disturbed land, and road salts used in the winter. In general, concentrations over 0.05 will likely have an impact while concentrations greater than 0.1 mg/L.

20. i . PO_4^{+} in Diplai Beel water

In 2014-15 the water analysis of Diplai Beel (Table no. 60) for phosphate shows that its value, 19.52 mg/L is optimum in the month of February and it becomes minimum of 14.85 mg/L in August. Again it is optimum value i.e. 18.25 mg/L in February and minimum of 11.20 mg/L in August during the study year of 2015-16. In 2016-17 the PO4 content of Diplai Beel water is found optimum of 22.10 mg/L in March and minimum of 16.02 mg/L in December.

20. ii. Correlation (r) of PO_4^{+} with other parameters of Diplai Beel water

It is observed (Table no. 61) that positive correlation of PO_4 is seen with Na(r=0.836, p<0.01), Ca(r=0.486, p<0.01), Mg(r=0.036, p<0.01), Fe(r=0.092, p<0.01) and Pb(r=0.256, p<0.01). Na shows highest correlation followed by Ca and Pb. The Fe and Mg showed least correlation with PO_4

21. Sodium as Na^{+}

Sodium ion is ubiquitous in water, owing to the high solubility of its salts and the abundance of sodium-containing mineral deposits. Anthropogenic sources of sodium that can contribute significant quantities of sodium to surface water, including road salt, water treatment chemicals, domestic water softeners, and sewage effluents. Water treatment chemicals such as sodium fluoride, sodium silicofluoride, sodium hydroxide, sodium carbonate, sodium bicarbonate, sodium phosphate, sodium silicate, and sodium hypochlorite provide a relatively small contribution when used individually, but when used together may result in concentrations of up to 30 mg/L (WHO, 1979).

21. i . Na^{+} in Diplai Beel water

In the study year 2014-15, Na content of Diplai Beel water (Table no. 60) is found to be optimum of 31.10 mg/L in February and minimum of 29.10 mg/L March. Same water analysis in 2015-16 it is observed as optimum of 28.72 mg/L in February and minimum of 24.10 mg/L in August. In 2016-17 again Diplai Beel water shows optimum of Na by 31.25 mg/L in March and minimum by 29.01 mg/L in August.

21. ii. Correlation (r) of Na^+ with other parameters of Diplai Beel water

The correlation (r) (Table no. 61) of Na with other parameters of Diplai Beel water is seen positive for Ca(r=0.245, p<0.01), Mg(r=0.279, p<0.01), Fe(r=0.262, p<0.01) and Pb(r=0.234, p<0.01). It is observed the range is almost in between 0.200 and 0.300 approximately but other parameters of water are negatively correlated.

22. Potassium as K^+ (mg/L)

Potassium reacts rapidly and intensely with water, forming a colourless basic potassium hydroxide solution and hydrogen gas, according to the following reaction mechanism: 2K (s) + $2H_2O$ (l) -› 2KOH (aq) + H_2 (g). Potassium occurs in various minerals, from which it may be dissolved through weathering processes. Potassium is an dietary requirement for nearly any organism but a number of bacteria, because it plays an important role in nerve functions. Potassium plays a central role in plant growth, and it often limits it. Potassium from dead plant and animal material is often bound to clay minerals in soils, before it dissolves in water. Consequently, it is readily taken up by plants again. Plants contain about 2% potassium (dry mass) on average, but values may vary from 0.1-6.8%.Potassium salts may kill plant cells because of high osmotic activity. Potassium toxicity is usually caused by other components in a compound, for example cyanide in potassium cyanide. A systematic study of the distribution of K ions in rain waters over India gave a mean value of 0.46 mg/l, with values ranging from 0.1 to 2.3 mg/l (Handa, B.K., 1975)

22. i . K^+ in Diplai Beel water

Potassium **(**Table no. 60) is mainly present as K^+ (aq) ions in water. Potassium reacts with water, forming a colourless basic potassium hydroxide solution and hydrogen gas, following reaction mechanism: 2K (s) + $2H_2O$ (l) -› 2KOH (aq) + H_2 (g). K reacts with water more rapidly than Sodium. Potassium plays a central role in plant growth. Potassium from dead plant and animal material is often bound to clay minerals in soils, before it dissolves in water. Consequently it is readily taken up by plants again. Plants contain about 2% potassium (dry mass) on average, but values may vary from 0.1- 6.8%. Potassium salts may kill plant cells because of high osmotic activity.

22. ii. Correlation (r) of K^+ with other parameters of Diplai Beel water

The water study reveals that K^+ is positively correlated (Table no.61) with Ca(r=0.169, $p<0.01$), Mg(r=0.016, $p<0.01$), Fe(r=0.117, $p<0.01$), Pb(r=0.019, $p<0.01$), Cu(r=0.233, $p<0.01$) and Zn(r=0.200,$p<0.01$).It is observed that Cu, Zn, Ca and Fe show higher correlation with potassium. Mg and Pb show poor correlation with potassium. Potassium takes a vital place in Diplai Beel water during the study period.

23. Calcium as Ca^+ (mg/L)

Calcium is naturally present in water. It may dissolve from rocks such as limestone, marble, calcite, dolomite, gypsum, fluorite and apatite. Calcium is a determinant of water hardness, because it can be found in water as Ca^{2+} ions. Water containing Ca^{2+} and Mg^{2+} ions is usually called hard water too. Water containing Ca^{2+}, Mg^{2+} and CO_3^{2-} ions is called temporary hard water. In a water solution calcium is mainly present as Ca^{2+} (aq), but it may also occur as Ca OH^+ (aq) or Ca $(OH)_2$ (aq). Calcium functions as a pH stabilizer because of its buffering qualities. Calcium gives water a better taste. Calcium reacts with water at room temperature as reaction mechanism: Ca (s) + $2H_2O$ (g) --› Ca $(OH)_2$ (aq) + H_2 (g). Calcium positively affects soil quality and various compounds when applied as a fertilizer. Water hardness influences aquatic organisms concerning metal toxicity. When Na and Cl content is low, various calcium compounds may become toxic. Calcium is normally found in between1 and 15 mg/L in natural water.

23. i . Ca^+ in *Diplai Beel water*

In 2014-15 the study of Calcium content in Diplai Beel water**(** Table no. 60) is found to be optimum by 19.10 mg/L in April and minimum by 14.01 mg/L in August. Same Ca value has been changed in 2015-16 by 18.15 mg/L as optimum in March and by 14.92 mg/L as minimum in September. Again in 2016-17 Ca amount is changed again by optimum value of 22.01 mg/L in March and minimum value of 13.92 mg/L in October. From the study it comes that Ca fluctuates in different times of the years.

23. ii. Correlation (r) of Ca^+ with other parameters of Diplai Beel water

The correlation (Table no. 61) study of the parameters of Dipai Beel water is positively correlated with Mg(r=0.072, p<0.01), Fe(r=0.253, p<0.01), Pb(r=0.108, p<0.01) and Cu(r=0.197, p<0.01). Iron and Cupper represents the highest correlation than Lead and Magnesium. Almost all the other parameters are negatively correlated with mentioned above.

24. Magnesium as Mg^+ (mg/L)

Magnesium is an alkali earth metal and responsible for water hardness. Magnesium generally is a slow-reacting element but reactivity increases with the presence of oxygen levels in water. Mg reacts with water vapour to Magnesium Hydroxide and Hydrogen gas as Mg (s) + $2H_2O$(g) -› $Mg(OH)_2$(aq) + H_2(g). Magnesium is mainly present as Mg^{2+} (aq) in surface water solutions. It is the central atom of the chlorophyll molecule and so its requirement is must for plant photosynthesis.

24. i . Mg^+ in Diplai Beel water

In 2014-15 the water study **(**Table no. 60) reveals that the maximum and minimum Mg content in Diplai Beel water are 19.10 mg/L in April and 14.01 mg/L in August respectively. But in 2015-16 the value of Mg is found as optimum 29.24 mg/L in the month of April and minimum 15.91 mg/L in September. Again in 2016-17 the water analysis shows 25.91 mg/L as optimum in April and 15.02 mg/L as minimum in December.

24. ii. Correlation (r) of Mg^{2+} with other parameters of Diplai Beel water

The study of Correlation (r) (Table no. 61) of Mg^{2+} with other parameters of Diplai Beel water is found to be Fe(r=0.188, p<0.01) and Cu(r=0.297, p<0.01) and where Cu is shows very active in being correlated with Mg than Iron (Fe).

25. Iron as Fe^{2+} (mg/L)

Dissolved iron is mainly present as Fe $(OH)_2^+$ under acidic and neutral, oxygen-rich conditions. Under oxygen-poor conditions it mainly occurs as binary iron. Iron is part of many organic and inorganic chelation complexes that are generally water soluble. Elementary iron dissolves in water under normal conditions. Many iron compounds share this characteristic. Naturally occurring iron oxide, iron hydroxide, iron carbide and iron penta carbonyl are water insoluble. The water solubility of some iron compounds increases at lower pH values. Usually there is a difference between water soluble Fe^{2+} compounds and generally water insoluble Fe^{3+} compounds. The latter are only water soluble in strongly acidic solutions, but water solubility increases when these are reduced to Fe^{2+} under certain conditions. Usually there is a difference between water soluble Fe^{2+} compounds and water insoluble Fe^{3+} compounds. The latter are only water soluble in strongly acidic solutions, but water solubility increases when these are reduced to Fe^{2+} under certain conditions.

25. i . Fe^{2+} in Diplai Beel water

The study of water qualities (Table no. 60) in 2014-15 reveals that optimum value is 0.70 mg/L in February and the minimum value is 0.10 mg/L in April. Again in 2015-16 water analysis shows optimum as 0.21mg/L in June and minimum 0.14 mg/L in January and February, whereas in 2016-17 water indicates optimum value as 0.20 mg/L in June and minimum 0.11 mg/L in February.

25. ii. Correlation (r) of Fe^{2+} with other parameters of Diplai Beel water

Correlation (r) (Table no. 61) of Fe^{2+} with other parameters of Diplai Beel water is shown *negatively correlated* by Pb ($r = -0.370$, $p<0.01$), Cu ($r = -0.056$, $p<0.01$),),and Zn ($r = -0.450$, $p<0.01$). It does not show any positive correlation with other parameters.

26. Phytoremediation study of *Lemna perpusilla Torry, Azolla pinnata R.Br* and *Salvinia cucullata* (see Table no. 26E, 26D and 26E)

The phytoremediation is an eco-friendly 'green' technology based on the use of metal accumulating plants to remove toxic metals from soil and water. The ability to accumulate heavy metals varies species to species and among cultivars within species, as different mechanisms of ion uptake is operative in each species. The metal removal rate depends on the plant biomass harvested and metal concentration in harvested biomass.

Only three accumulators or remediating plants such as *Lemna perpusilla* Torry, *Azolla pinnata* R.Br and *Salvinia cucullata* are selected to study the amount of toxic heavy metal sorption from Diplai Beel water during the study periods from 2014-15 to 2016-17. The plants are very small, floating and are found very less in distribution in Diplai Beel. It is observed the fluctuations in numbers of the spp. within the seasons in every study year. Cu, Zn and Pb metals are considered as the study trace metals.

Cu(Cupper) accumulation study in 2014-15, 2015-16 and 2016-17:

27. Cu accumulation in floating macrophytes during 2014-15: (see Table no. 26E, 26D and 26E)

From the biomass study of *Lemna perpusilla* Torry the Cu content recorded in different months during 2014-15 is recorded in between 0.16±0.310 mg/Land 0.15±0.011 mg/L. In case of *Azolla pinnata* R.Br it is found within 0.21±0.024 mg/L and 0.23±0.021 mg/L but in *Salvinia cucullata* biomass analysis showed within 0.26±0.041 mg/L and 0.24±0.722 mg/L . The highest Cu sorption among the floating macrophytes is observed in *Salvinia cucullata* which is followed by *Azolla pinnata* R.Br. for its high capability to retain Cu metals in its body as observed in year 2014-15. During this time the Cu content in Diplai Beel water is found to be within 0.028±0.030 mg/L and 0.021±0.03 mg/L.

28. Cu accumulation in floating macrophytes during 2015-16: (see Table no. 26E, 26D and 26E)

During the year 2015-16 the Cu accumulation in *Lemna perpusilla* Torry is recorded within 0.14±0.040 mg/L and 0.15±0.150 mg/L whereas in *Azolla pinnata* R.Br. Cu accumulation is observed within 0.22±0.053 mg/L and 0.21±0.003 mg/L and in *Salvinia cucullata* Cu sorption is seen within 0.25±0.500 mg/L and 0.24±0.212 mg/L. Cu content in Diplai Beel water is found within 0.028±0.032 mg/L and 0.021±0.055 mg/L. It is observed that the Cu accumulation is comparatively higher in *Salvinia cucullata* like the year 2015-16.

29. Cu accumulation in floating macrophytes during 2016-17: (see Table no. 26E, 26D and 26E

In 2016-17 Cu accumulation is recorded in *Lemna perpusilla* Torry in between 0.15±0.099 mg/L and 0.14±0.054 mg/L. In *Azolla pinnata* R.Br it shows within 0.22±0.085 mg/L and 0.21±0.032 mg/L. In *Salvinia cucullata* Cu content is recoded within 0.26±0.010 mg/L and 0.25±0.810 mg/L. Cu in Diplai Beel water is recorded also as 0.024±0.023 mg/L to 0.023±0.020 mg/L. From the observation it comes to know that *Salvinia cucullata has* higher Cu accumulation than others in 2016-17.

Table no. 26C

Monthly Results of Cu, Zn and Pb presence in Macrophyte biomass and Diplai Beel water during 2014-15

Months of 2014-15	Whole body Biomass									Diplai Beel water		
	Lemna perpusilla Torry			*Azolla pinnata* R.Br			*Salvinia cucullata*					
	mg/L(mean± SD)			mg/L(mean± SD)			mg/L(mean± SD)			mg/L(mean± SD)		
	Cu	Zn	Pb	Cu	Zn	Pb	Cu	Zn	Pb	Cu	Zn	Pb
March	0.15±0.011	0.06±0.033	0.48±0.083	0.22±0.013	0.05±0.005	0.29±0.090	0.25±0.030	0.06±0.003	0.66±0.090	0.023±0.01	0.021±0.01	0.038±0.01
April	0.15±0.150	0.06±0.050	0.49±0.051	0.22±0.035	0.05±0.120	0.29±0.079	0.25±0.024	0.06±0.026	0.56±0.061	0.025±0.02	0.032±0.02	0.034±0.02
May	0.16±0.111	0.05±0.051	0.50±0.062	0.22±0.451	0.05±0.021	0.29±0.072	0.25±0.041	0.05±0.032	0.58±0.054	0.021±0.03	0.035±0.01	0.028±0.03
June	0.16±0.120	0.06±0.051	0.49±0.074	0.22±0.461	0.05±0.031	0.29±0.070	0.25±0.052	0.05±0.621	0.54±0.032	0.026±0.01	0.031±0.03	0.030±0.03
July	0.15±0.230	0.04±0.023	0.50±0.012	0.22±0.542	0.04±0.112	0.30±0.010	0.26±0.041	0.05±0.010	0.59±0.025	0.028±0.03	0.037±0.01	0.038±0.03
August	0.15±0.011	0.04±0.020	0.49±0.080	0.21±0.024	0.04±0.013	0.29±0.051	0.25±0.050	0.04±0.034	0.54±0.030	0.025±0.02	0.025±0.02	0.041±0.02
September	0.15±0.310	0.05±0.091	0.49±0.560	0.21±0.983	0.04±0.012	0.29±0.251	0.25±0.041	0.03±0.085	0.64±0.052	0.021±0.04	0.021±0.03	0.036±0.02
October	0.15±0.512	0.05±0.120	0.50±0.051	0.22±0.251	0.04±0.021	0.28±0.211	0.25±0.060	0.05±0.051	0.57±0.071	0.022±0.03	0.010±0.03	0.031±0.04
November	0.16±0.310	0.05±0.122	0.49±0.021	0.23±0.021	0.04±0.012	0.29±0.321	0.25±0.422	0.04±0.054	0.58±0.025	0.021±0.03	0.016±0.03	0.027±0.02
December	0.15±0.012	0.04±0.070	0.49±0.230	0.22±0.121	0.04±0.047	0.28±0.681	0.25±0.084	0.04±0.025	0.56±0.023	0.025±0.01	0.019±0.02	0.022±0.03
January	0.15±0.510	0.05±0.510	0.48±0.045	0.22±0.031	0.04±0.051	0.29±0.351	0.25±0.042	0.05±0.061	0.64±0.316	0.023±0.03	0.014±0.03	0.027±0.03
February	0.16±0.012	0.05±0.240	0.47±0.281	0.22±0.011	0.05±0.011	0.28±0.023	0.24±0.722	0.04±0.035	0.65±0.033	0.022±0.02	0.012±0.01	0.032±0.02

Yellow= minimum limit **Green=optimum limit**

Table no. 26D

Monthly Results of Cu, Zn and Pb presence in Macrophyte biomass and Diplai Beel water during 2015-16

Months of 2015-16	**Whole body Biomass**									**Diplai Beel water**		
	***Lemna perpusilla* Torry**			***Azolla pinnata* R.Br**			***Salvinia cucullata***					
	mg/L(mean± SD)			mg/L(mean± SD)			mg/L(mean± SD)			mg/L(mean± SD)		
	Cu	**Zn**	**Pb**	**Cu**	**Zn**	**Pb**	**Cu**	**Zn**	**Pb**	**Cu**	**Zn**	**Pb**
March	0.15±0.021	0.06±0.011	0.48±0.101	0.22±0.053	0.05±0.301	0.28±0.030	0.25±0.330	0.06±0.303	0.66±0.030	0.024±0.032	0.030±0.022	0.033±0.054
April	0.15±0.020	0.06±0.020	0.48±0.131	0.22±0.021	0.05±0.204	0.28±0.035	0.25±0.332	0.06±0.333	0.66±0.033	0.024±0.032	0.031±0.032	0.041±0.059
May	0.15±0.030	0.06±0.051	0.48±0.191	0.22±0.011	0.05±0.211	0.28±0.041	0.25±0.232	0.06±0.221	0.66±0.035	0.025±0.021	0.042±0.052	0.033±0.021
June	0.15.±0.020	0.05±0.062	0.48±0.121	0.22±0.014	0.05±0.216	0.28±0.053	0.25±0.223	0.06±0.211	0.66±0.054	0.027±0.045	0.051±0.032	0.041±0.054
July	0.15±0.150	0.05±0.041	0.48±0.123	0.22±0.021	0.04±0.135	0.28±0.025	0.25±0.313	0.06±0.311	0.66±0.062	0.026±0.049	0.045±0.042	0.051±0.033
August	0.14±0.311	0.05±0.025	0.48±0.033	0.21±0.082	0.04±0.334	0.28±0.062	0.25±0.400	0.06±0.520	0.66±0.052	0.028±0.032	0.026±0.025	0.033±0.021
September	0.14±0.040	0.05±0.052	0.47±0.031	0.22±0.012	0.04±0.254	0.27±0351	0.25±0.500	0.06±0.051	0.66±0.033	0.022±0.054	0.051±0.025	0.031±0.021
October	0.14±0.044	0.06±0.024	0.47±0.024	0.22±0.025	0.05±0.021	0.27±0.021	0.24±0.322	0.05±0.091	0.65±0.035	0.021±0.055	0.042±0.035	0.032±0.023
November	0.15±0.011	0.06±0.012	0.47±0.122	0.21±0.003	0.05±0.031	0.27±0.023	0.24±0.212	0.05±0.025	0.65±0.551	0.023±0.022	0.031±0.065	0.024±0.011
December	0.15±0.057	0.05±0.032	0.48±0.021	0.21±0.021	0.05±0.411	0.28±0.025	0.25±0.001	0.05±0.210	0.65±0.052	0.025±0.022	0.041±0.045	0.032±.0.002
January	0.15±0.041	0.04±0.045	0.47±0.133	0.21±0.042	0.05±0.421	0.28±0.045	0.25±0.211	0.05±0.021	0.65±0.033	0.024±0.054	0.032±0.040	0.021±0.035
February	0.15±0.025	0.05±0.018	0.47±0.052	0.22±0.031	0.05±0.351	0.28±0.023	0.25±0.021	0.05±0.521	0.65±0.005	0.023±0.052	0.030±0.035	0.032±0.042

Yellow= minimum limit **Green=optimum limit**

Table no. 26E

Monthly Results of Cu, Zn and Pb presence in Macrophyte biomass and Diplai Beel water during 2016-17

Months of 2016-17	Whole body Biomass									Diplai Beel water		
	Lemna perpusilla Torry			*Azolla pinnata* R.Br			*Salvinia cucullata*					
	mg/L(mean± SD)			mg/L(mean± SD)			mg/L(mean± SD)			mg/L(mean± SD)		
	Cu	**Zn**	**Pb**	**Cu**	**Zn**	**Pb**	**Cu**	**Zn**	**Pb**	**Cu**	**Zn**	**Pb**
March	0.15±0.071	0.06±0.061	0.47±0.201	0.22±0.013	0.05±0.501	0.28±0.038	0.25±0.810	0.06±0.803	0.66±0.070	0.023±0.032	0.030±0.022	0.033±0.054
April	0.15±0.095	0.06±0.060	0.47±0.032	0.22±0.018	0.05±0.520	0.28±0.056	0.25±0.790	0.06±0.711	0.66±0.064	0.023±0.021	0.023±0.032	0.032±0.052
May	0.15±0.099	0.06±0.032	0.47±0.042	0.22±0.020	0.05±0.301	0.28±0.024	0.25±0.212	0.06±0.512	0.66±0.044	0.023±0.032	0.021±0.021	0.031±0.021
June	0.15±0.085	0.06±0.053	0.47±0.512	0.21±0.081	0.05±0.221	0.28±0.054	0.25±0.123	0.06±0.302	0.66±0.021	0.023±0.022	0.021±0.012	0.031±0.032
July	0.15±0.075	0.05±0.033	0.47±0.032	0.22±0.010	0.05±0.215	0.28±0.035	0.25±0.024	0.06±0.125	0.66±0.052	0.023±0.045	0.023±0.032	0.031±0.041
August	0.15±0.060	0.05±0.054	0.47±0.058	0.22±0.065	0.05±0.140	0.28±0.025	0.26±0.010	0.06±0.310	0.65±0.214	0.023±0.056	0.021±0.021	0.030±0.023
September	0.15±0.012	0.05±0.081	0.47±0.054	0.21±0.032	0.05±0.541	0.28±0.054	0.25±0.012	0.06±0.211	0.66±0.031	0.024±0.023	0.022±0.011	0.031±0.024
October	0.14±0.054	0.05±0.077	0.47±0.066	0.21±0.021	0.05±0.220	0.27±0.012	0.25±0.355	0.06±0.521	0.66±0.054	0.024±0.021	0.023±0.012	0.029±0.021
November	0.14±0.084	0.05±0.032	0.47±0.045	0.22±0.085	0.05±0.321	0.27±0.240	0.25±0.292	0.05±0.321	0.65±0.281	0.024±0.023	0.031±0.022	0.030±0.013
December	0.15±0.021	0.06±0.023	0.47±0.087	0.22±0.012	0.05±0.221	0.27±0.054	0.25±0.421	0.05±0.112	0.66±0.251	0.023±0.026	0.021±0.012	0.030±0.022
January	0.15±0.023	0.06±0.071	0.47±0.102	0.21±0.120	0.06±0.010	0.28±0.012	0.25±0.265	0.05±0.032	0.66±0.020	0.023±0.052	0.031±0.021	0.031±0.021
February	0.15±0.022	0.05±0.063	0.47±0.101	0.22±0.024	0.05±0.205	0.27±0.032	0.25±0.751	0.06±0.042	0.66±0.020	0.023±0.020	0.033±0.201	0.031±0.022

Yellow= minimum limit **Green=optimum limit**

Zn (Zinc) accumulation study in 2014-15, 2015-16 aznd 2016-17:

30. Zn accumulation in floating macrophytes during 2014-15: (see Table no. 26E, 26D and 26E)

In 2014-15 Zn accumulation is recorded in *Lemna perpusilla* Torry in between 0.06±0.051 mg/L and 0.04±0.020 mg/L. In *Azolla pinnata* R.Br. Zn present shows within 0.050.120 mg/L and 0.04±0.012 mg/L. In *Salvinia cucullata* Zn content is recorded within 0.06±0.003 mg/L and 0.03±0.085 mg/L. Zn in Diplai Beel water is recorded also as 0.037±0.010 mg/L to 0.010±0.030 mg/L. Zn sorption is found highest in *Lemna perpusilla* Torry (0.06±0.051) mg/L among the studied spp.

31. Zn accumulation in floating macrophytes during 2015-16: (see Table no. 26E, 26D and 26E)

In 2015-16 Zn accumulation is recorded in *Lemna perpusilla* Torry in between 0.06±0.051 mg/L and 0.04±0.045 mg/L. In *Azolla pinnata* R.Br. Zn present shows within 0.050.411 mg/L and 0.04±0.135 mg/L. In *Salvinia cucullata* Zn content is recorded within 0.06±0.520 mg/L and 0.05±0.091 mg/L. Zn in Diplai Beel water is recorded also as 0.051±0.032 mg/L to 0.026±0.025 mg/L. Zn sorption is almost equal in all the floating microphytes i.e slight fluctuations in sorption. The highest Zn accumulation is recorded in *Salvinia cucullata* (0.06±0.520 mg/L) in comparison to other floating macrophytes in 2015-16.

32. Zn accumulation in floating macrophytes during 2016-17: (see Table no. 26E, 26D and 26E)

In 2016-17 Zn accumulation is recorded in *Lemna perpusilla* Torry in between 0.06±0.071 mg/L and 0.05±0.032 mg/L. In *Azolla pinnata* R.Br. Zn present shows within 0.06±0.010 mg/L and 0.05±0.140 mg/L. In *Salvinia cucullata* Zn content is recorded within 0.06±0.803 mg/L and 0.05±0.032 mg/L. Zn in Diplai Beel water is recorded also as 0.033±0.201mg/L to 0.021±0.012 mg/L. Zn sorption is almost equal in all the floating microphytes i.e slight fluctuations in sorption. The highest Zn accumulation is recorded in *Salvinia cucullata* (0.06±0.803 mg/L) in comparison to other floating macrophytes in 2016-17

Pb (Lead) accumulation study in 2014-15, 2015-16 and 2016-17:

33. Pb accumulation in floating macrophytes during 2014-15: (see Table no. 26E, 26D and 26E)

In 2014-15 Pb accumulation is recorded in *Lemna perpusilla* Torry in between 0.50±0.062 mg/L and 0.47±0.281 mg/L. In *Azolla pinnata* R.Br it shows within 0.30±0.010 mg/L and 0.28±0.211 mg/L. In *Salvinia cucullata* Pb content is recoded within 0.66±0.090 mg/L and 0.54±0.030 mg/L. Pb in Diplai Beel water is recorded also as 0.041±0.020 mg/L to 0.022±0.030 mg/L. From the observation of Pb accumulation in water spp it comes to be known that *Salvinia cucullata has* higher accumulation in 2014-15.

34. Pb accumulation in floating macrophytes during 2015-16: (see Table no. 26E, 26D and 26E)

In 2015-16 Pb accumulation is recorded in *Lemna perpusilla* Torry in between 0.48±0.191 mg/L and 0.47±0.122 mg/L. In *Azolla pinnata* R.Br it shows within 0.28±0.062 mg/L and 0.27±0.021 mg/L. In *Salvinia cucullata* Pb content is recoded within 0.66±0.067 mg/L and 0.65±0.005 mg/L. Pb in Diplai Beel water is recorded also as 0.051±0.033 mg/L to 0.021±0.035 mg/L. From the observation of Pb accumulation in water spp it comes to be known that *Salvinia cucullata* (0.66±0.067 mg/L) has higher accumulation in 2015-16.

35. Pb accumulation in floating macrophytes during 2016-17: (see Table no. 26E, 26D and 26E

In 2016-17 Pb accumulation is recorded in *Lemna perpusilla* Torry in between 0.47±0.512 mg/L and 0.47±0.032 mg/L. In *Azolla pinnata* R.Br it shows within 0.28±0.056 mg/L and 0.27±0.012 mg/L. In *Salvinia cucullata* Pb content is recoded within 0.66±0.251 mg/L and 0.65±0.214 mg/L. Pb in Diplai Beel water is recorded also as 0.033±0.054 mg/L to 0.029±0.021 mg/L. From the observation of Pb accumulation in water spp it comes to be known that *Salvinia cucullata* (0.66±0.251 mg/L) has higher accumulation in 2016-17.

From the study of Cu, Zn and Pb accumulation in the floating herbs such as *Lemna perpusilla* Torry, *Azolla pinnata* and *Salvinia cucullata collected* from Diplai Beel is observed as highest than the two spp.