CHAPTER 10: SUMMARY AND CONCLUSION
SUMMARY & CONCLUSION

Rapid urbanization in Bangalore has affected the wetlands, which is evident from 78% loss of wetlands during the last 4 decades. Few wetlands that still exist, need to be conserved and managed sustainably, which entails regular monitoring of physical, chemical and hydrological integrity. Monitoring of 43 wetlands across various ecological and environmental gradients through physical, chemical and biological parameters reveal that diatoms could be adopted for regular monitoring studies. In the current study, diatom based biomonitoring has recorded 181 diatom taxa belonging to 45 genera from 43 wetlands of Bangalore urban region. Major and predominant species were *Gomphonema parvulum* Kützing, *Nitzschia palea* (Kützing) W.Smith, *N. umbonata* (Ehrenberg) Lange-Bertalot, *Diadesmis confervaceae* Kützing, *Cyclotella meneghiniana* Kützing, *C. atomus* Hustedt, *Nitzschia williamsii* Alakananda et al., *Nitzschia taylorii* Alakananda et al., *Diadesmis confervacea*, *Staurosirella pinnata*, *Aulacoseira granulata*, *Gomphonema gracile*, *G. angustum*, *G. dharwarensi* and *Achnanthidium* sp.

Investigations of the role of environmental variables in diatom assemblage formation resulted in grouping Bangalore wetlands into three ecological classes (i) industrially impacted (hyper-eutrophic) wetlands, (ii) sewage fed (eutrophic) wetlands and (ii) rural clean (oligotrophic) wetlands. The relationship between water quality and diatom assemblages along the rural-urban gradient is evident and it aided understanding ecological preferences of each taxa. The variability in species is explainable to conductivity, biological and chemical oxygen demand, which acts as barriers for distribution and community assemblages of benthic diatoms. The environmental factors act as a limiting variable in structuring diatom assemblages in an ecosystem at a regional scale. Most of the pollution tolerant taxa acted as indicator species with the understanding of autecological aspects would indicate pollution conditions.

Seasonality assessment of diatom species composition revealed the impact of urban pollution on species assemblages. Polluted wetlands are influenced by continued inflow of contaminated water throughout the year, which understates the seasonal pattern. Species such as *Nitzschia palea* and *Cyclotella meneghiniana* did not reflect any ecological pattern but % relative abundance varied in post monsoon across sites and *Achnanthidium* sp. was characteristic of monsoon and post monsoon season. Thus, biomonitoring of urban
wetlands could be effective during post monsoon for appropriate and accurate data both on water quality and habitation. Further, studies of the autecological values of seasonal dominant species and several other indicator groups of diatoms would aid to develop better understanding about species habitation, prediction of bloom formation and species adaptation in all seasons.

Application of diatom indices calculated through OMNIDIA software (based on Zelinka and Marvan, 1961) developed for European conditions has certain drawbacks to apply to Indian wetlands due to difference in temperate to tropical regions for optimum values of sensitivity and tolerance towards physical and chemical variables. In this regard Peninsular India diatom index (PIDI), specific for biomonitoring Peninsular India wetlands was developed to assess the ecological status of wetlands. PIDI compared to other indices showed a significant correlation (p<0.05) with the variables conductivity, biological oxygen demand and chemical oxygen demand and chlorides. PIDI also aided in evaluating the nutrient and ionic status through diatoms. PIDI is thus a promising tool in biomonitoring for assessing extent of potential pollution sources. PIDI, with the validation considering wider spectrum of wetlands would provide precise classification of wetlands in routine water regulatory program of the government agencies and other institutions, which would help in arriving at appropriate management strategies for conservation of wetlands.

The effectiveness of wetlands restoration was evaluated through diatom biomonitoring of wetlands with restoration in progress with the ones, which were restored earlier. Assessment of diatom community structure before and after restoration of wetlands revealed no major improvisation in water quality or biological diversity. Restoration involving changes in physical aspects through de-silting has increased water storage capacity. Construction of concrete bunds-and removal of shoreline macrophytes has affected the shoreline biota, especially loss in bird diversity and their breeding habitats. Variations in species assemblage aided in assessing the water quality status. Dominance and composition of pollution tolerant species in Ulsoor and Madiwala- that has been restored a decade ago continued to be under severely polluted conditions without showing any signs of restoration. This necessitates relook at restoration strategies currently practiced for restoring polluted or eutropic wetlands. There is a need to consider
sedimentation rate, suspended sedimentation concentration, habitat availability and nutrient uptake by different group of organisms. Further, analyses on past species composition of diatoms through deep sediments (>300 years ago) analysis would aid in understanding the past water quality, rate of sediment deposition, water depth and pollution conditions.

The current study on the diatom community structure and its relevance in biomonitoring has contributed to science the following:

1. The record of >180 diatom taxa distributed across 40 urban wetlands and the description of two species *Nitzschia williamsii* Alakananda et al., *Nitzschia taylorii* Alakananda et al. abundantly inhabiting moderately- slightly eutrophic water bodies are new to science. Other cosmopolitan taxa belonging to genus *Nitzschia* are pollution tolerant taxa and are key indicator species in diatom indices. This demonstrates the required study on larger biogeographic level for better exploration of complexity in taxonomy and morphology of *Nitzschia* species.

2. Environmental variables like conductivity, chlorides, biological and chemical oxygen demand play an important role and influence microscopic algal community structure especially diatoms. This highlights the role of diatoms as bioindicators ecological significant wetlands, which need to be monitored on routine basis.

3. The variability in species assemblages is triggered by organic content present in the form of sewage waste than the seasonal fluctuations indicating the influence of human induced disturbances through the discharge of sewage and effluents. This is evident from the diatom species composition with the domination of cosmopolitan species. This also highlights the need for autecological investigations.

4. Peninsular India diatom index (PIDI), specific for biomonitoring Peninsular India wetlands was developed to assess the ecological status of wetlands. This is based on the relationship between diatom distribution and water chemical parameters, which aided sensitivity and tolerance values for each taxon and in formulation of new PIDI indices. PIDI correlated significantly with conductivity, chlorides, oxygen demand and phosphates and was comparable to other diatom indices.
5. Diatom species distribution with characteristics of pollution affectionate species in restored wetlands reveals the continued contamination highlighting the need for appropriate management strategy during the post restoration period.

6. The study demonstrates that diatom-based biomonitoting would be cost effective and easily implementable approach for regular monitoring of aquatic ecosystems. This study would aid as benchmark study for decision makers and environmental managers and help in the evaluation of the effectiveness of wetlands restoration.