



# Bioremediation Potential of Macrophytes in Varthur and Bellandur Lakes, Bangalore

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**Abstract—** Wetlands are the ecological barometers of a city as they regulate nutrients and also the micro-climate. Wetlands constitute a vital ecosystem performing the functions of nutrient uptake, shoreline stabilization, and groundwater recharge and provide fish, fodder and so on for the dependent local population. Wetland plants (Macrophytes) are the base of the food chain. Through photosynthesis, they link the inorganic environment with biotic one. They provide habitat for other groups such as epiphytic bacteria, periphyton, macroinvertebrates and fish. Wetland Plants influence water chemistry, acting as both nutrient sinks through uptake and as nutrient pumps moving compounds from sediment to water column. The current study carried out analysis of nutrients in water, sediment and macrophytes of Varthur and Bellandur lakes in Bangalore. Macrophyte diversity was also studied. 13 species of macrophytes were recorded. *Eichhornia crassipes*, *A. venanthera*, *philoxeroides* were the dominant macrophyte species found in these lakes. Nutrients in water (nitrate and phosphate) Carbon and Nitrogen in sediment and macrophyte samples were analysed. The range of phosphate and nitrate was 0.5 to 2.65 mg/l and 0.23 to 0.35 mg/l respectively. The Nitrates and Phosphates in the water were higher in the inlets and shorelines due to the untreated sewage entry. The Carbon and Nitrogen in sediments and macrophytes samples also followed the same trend as nutrient in water. The study showed direct relation of nutrients in macrophytes with sediment and water. This highlights the phytoremediation potential of macrophytes.

**Keywords—** Wetlands, Bangalore, Bioremediation, Macrophytes

## INTRODUCTION

Wetlands aid in regulating nutrients and also moderating the micro-climate. Wetlands constitute a vital ecosystem performing the functions of nutrient uptake, shoreline stabilization, and groundwater recharge and provide fish, fodder and so on for the dependent local population. These fragile ecosystems functions as kidneys of the landscape and are rich repository of biodiversity. Unplanned rapid

urbanization during the post globalization period has led to the large-scale land cover changes threatening the very existence of wetlands.

Aquatic plants (Macrophytes) are the base of the food chain and through photosynthesis, they link the inorganic environment with biotic one. They provide habitat for other groups such as epiphytic bacteria, periphyton, macroinvertebrates and fish. Wetland Plants influence water chemistry, acting as both nutrient sinks through uptake and as nutrient pumps moving compounds from sediment to water column. They have the ability to uptake nutrients, metals and other contaminants (Gersberg et al., 1986; Reddy et al., 1989; Peverly et al., 1995; Rai et al., 1995). They influence the hydrology and sediment regime of wetlands through for example, sediment and shoreline stabilization, or by modifying currents and helping to desynchronize flood peaks. They are routinely used to help identify or delineate jurisdictional boundaries of wetlands. Act as biological indicators of the health or ecological integrity of the wetland. Eutrophication or nutrient enrichment in water bodies is the byproduct of agricultural activities, urbanization and industrialization result in pollution (Koorosh et al., 2009) and degradation of the available water resources. Physico-chemical characteristics are highly important with regard to the occurrence and abundance of species. Discharge of urban, industrial and agricultural wastes have increased the quantum of various chemicals that enter the receiving water, which alter their Physico-chemical characteristics. Nutrients like phosphorus, nitrogen from the domestic wastes and fertilizers accelerate the process of eutrophication.

Bangalore city is situated on a high altitude with a ridge that divides the region into three valleys, wherein rainwater cascades down to form major

stream systems. The three valleys of Bangalore are Koramangala-Challagatta Valley, Hebbal Valley and Vrishabavathi Valley. There were 262 lakes (in 1960) within the Green belt area of the city, which has fallen to 81 in 1985 (Ramachandra et.al, 2003). The existing water bodies are contaminated by residential, agricultural, commercial and industrial wastes/effluents (Ramachandra et.al,2003). Most of the lakes have vanished due to encroachment and construction activity for infrastructure expansion.

Phytoremediation is the use of living green plants for in situ risk reduction of contaminated soil, sludge, sediments, and ground water through contaminant removal, degradation, or containment (U.S. Environmental Protection Agency, 1998). The basis of phytoremediation is that all plants extract nutrients, including metals, from soil and water. Some plants have the ability to store large amounts of metals, more than required for plant function. In order for the metals to be removed from the system, the plants need to be harvested frequently and processed to reclaim the metals. While most phytoremediation is of soils or groundwater, the use of wetland plants may be feasible when shallow water is contaminated (Miller 1996; U.S. Environmental Protection Agency 1998). The accumulation of nutrients in macrophyte tissues determines the ability of these plants to form a protective barrier. The amount of accumulated nutrients depends in the physiological capacity for nutrient uptake by particular species, as well as on the macrophyte biomass. Nutrient composition in the tissues can be an important feature for identifying the ecological strategy of the species and for predicting the result of competitive interactions in plant communities. Plant detritus and sediments influence the nutrient budget and reflect upon the ecology, trophic status and fate of evolution of lakes. Lake Floor sediments play a significant role as a trap and offer a surface for sediment deposition (Vijayaraj R

and HemaAchyuthan, 2016). They act as natural regulator for biological processes in the lakes. The primary source of Organic matter and Total Organic Carbon in lake sediments is often considered to be derived from the particulate detritus of plants and only a small percentage is from animals and other sources (Meyers P.A., 2003).Sediment in lakes acts as a storage pool and an archive of nutrients and can reveal the history of eutrophication (Clarke et al. 2006).

### OBJECTIVES

The objectives of the study were to:

- 1) Findout the diversity of Macrophytes in Varthur and Bellandur Lakes of Bangalore
- 2) To determine the Carbon and Nitrogen content of Macrophytes and sediments along with nutrient of water and
- 3) To findout the bioremediation potential of macrophytes

### MATERIALS AND METHODS

**Study area:** Bangalore city, Karnataka, India is located between 12°39' 13°18' N and 77°22' - 77°52' E. Bangalore (Figure 2) city has a large number of lakes, ponds and marshy wetlands, which ensures a high level of ground water table and pleasant climate. Bangalore has no natural lakes but large numbers of manmade lakes that were built for various hydrological purposes and to meet the needs of drinking water and irrigation. Totally there were 262 lakes in the Bangalore city. The current studies on the temporal analysis of wetlands indicated a 79% decline in Greater Bangalore due to rapid and unplanned urbanization and expansion (Ramachandra T.V and Bharath H.A, 2016). The study was carried out during April 2016.The selected lakes chosen for the study period falls in the KormangalaChallghatta valley, Varthur lake series (figure 1).

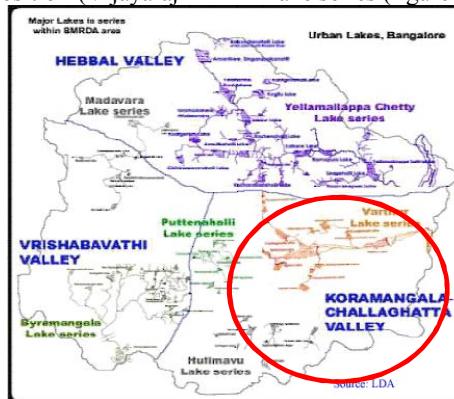
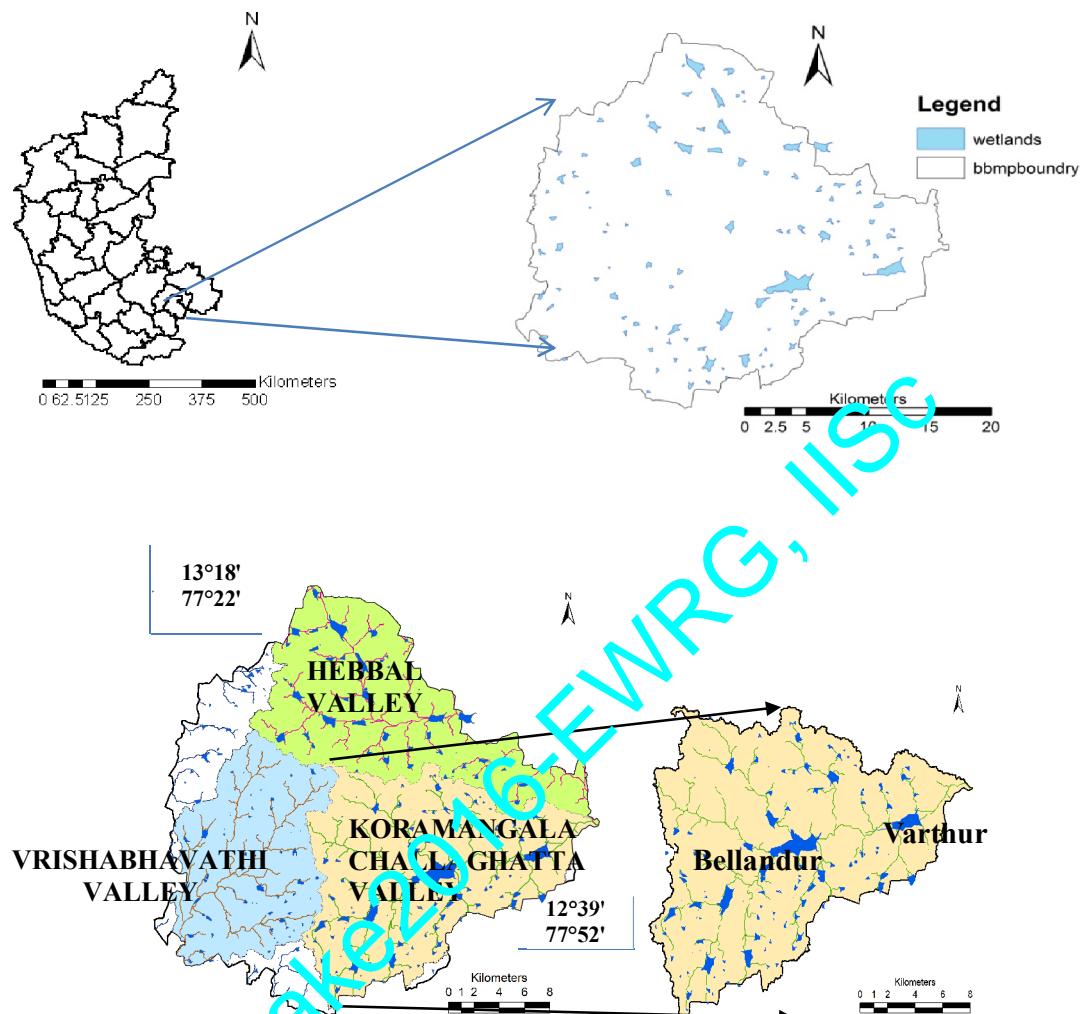


Figure 1: Major valleys and lake series of Bangalore



**Figure 2: Study area**

**Sampling:** Macrophytes, water and sediment samples were collected from inlet to outlet following transect method (100 m) (figure 3&4). Three to five samples were collected in each transect. Random sampling method was used for collection of macrophytes. *Eichhornia crassipes* and *Alternanthera philoxeroides* were the dominant species of macrophytes. Collected macrophytes were stored in polythene bags after species identification using taxonomic literatures (C.D.K. Cook, 1996 and Ramaswamy and Razi, 1973). Surface sediments (0 to 30 cm) were collected from the same sites where macrophytes were collected. Water samples were collected in 1lt acid washed bottles and carried out to lab for further analysis.

**Water quality:** Water samples were filtered and analysed for nutrients (nitrate and phosphate) following methods of APHA.

**Carbon and nitrogen analysis in macrophytes and sediment:** Collected Macrophytes were washed to eliminate sediments and epiphytes and separated into species. Above ground and below ground parts were then separated and oven dried at 60° C for 2-3 days until constant weight. It is then powdered using mixer/grinder and sieved to get fine powders. The replicates of each sample were used for nutrient analysis. The samples were analyzed for C, H and N using TRUE SPEC CHN Analyzer. Sediments were air dried and sieved to remove coarse debris. Samples were powdered using a mortar and sieved to get fine powders. Nutrient analyses were done according to procedure mentioned same as for macrophytes.

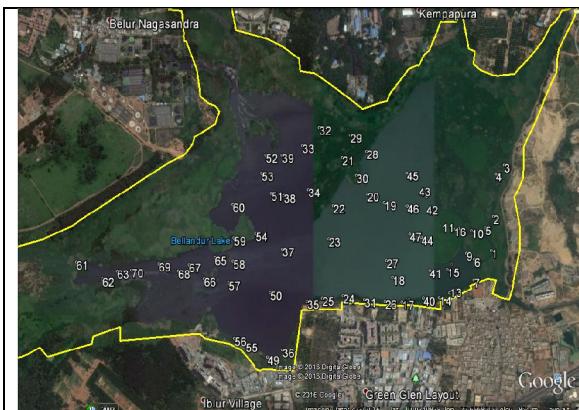


Figure 3: Sampling locations in Bellandur lake



Figure 4: Sampling locations in Varthur lake

## RESULTS AND DISCUSSION

**Diversity of Macrophytes in Lakes:** 13 species (5 free floating and 8 emergent) were recorded in the studied lakes (Figure 11). Varthur had higher species than Bellandur. The lakes were found to be dominated by non-native and invasive macrophytes like *Eichornia crassipes* (floating macrophyte) and *Alternanthera philoxeroides* (an emergent macrophyte). The diversity of macrophytes is shown in Table 1.

**Variation of Nitrate and Phosphate in water samples:** Phosphate and nitrate concentrations of studied lakes ranged between 0.54 to 2.65 mg/l and 0.23 to 0.35 mg/l respectively. The variations of nitrates and phosphates were given in Figure 5 and 6. The nutrients in water was higher in the inlets and shorelines of the lake where there was entry of untreated sewage. The middle and outlet regions of the lake had lower nitrate and phosphate compared to the inlet. In the shallow areas of the both lakes, the concentration of nutrients was generally higher than in their respective deeper parts.

**Total Nitrogen and Carbon in Sediment:** The Carbon values of Bellandur sediment ranged from 1.2 % (B25) to 29.2% (B49). The highest C content (>20%) was seen along the shorelines and inlets of the lake where the depth was varying from 0.5 to 1.5 m. The lowest C in sediment was seen, where the depth was above 2 m and mostly in towards the middle region of the lake. Nitrogen values were ranging from 0.11 % (B25) to 1.84 % (B60). Nitrogen also followed the same trend as Carbon. The values were higher in inlets and shorelines where untreated sewage was entering into the lake. The carbon values for sediment of Varthur ranged from 1.58 % (V44) to 21.1% (V12). The high C values were observed where depth was 0.25 to 1m and in the Northwest and

northeast shoreline side of the lake. On the other hand lower C values were observed where depth was greater than 1m (middle) and outlets of the lake. N values varied from 0.05% (V27) to 1.37% (V12). The trend of variation was same as Carbon.

**Carbon / Nitrogen ratio:** This ratio is an important factor determining how easily bacteria are able to decompose an organic material. This ratio can be used to help identify the origin of the organic matter in sediments. C/N ratios in lake sediments the composition of organic matter in the system (Nakai, 1986; Hassan et al., 1997, Mahapatra et al., 2011). C/N ratios of 5-8 indicate unaltered algal organic matter, whereas C/N ratios of 25-35 indicate fresh land-derived organic matter. In case of macrophytes it is about 39.4. Organisms that decompose organic matter use carbon as a source of energy and nitrogen for building cell structure. They need more carbon than nitrogen. If there is too much carbon, decomposition slows when the nitrogen is used up and some organisms die. Other organisms form new cell material using their stored nitrogen. In the process more carbon is burned. Thus the amount of carbon is reduced while nitrogen is recycled. Decomposition takes longer. Earlier studies suggest that a C/N ratio of 20:1 or 30:1 is better than a 10:1 ratio for various wastewater treatment such as poultry waste, cow manure, and coffee waste (DeRenzo, 1977; Sathianathan, 1975; Boopathy & Mariappan, 1984). The C:N ratio ranged from 10.97 (B26, middle) to 26.68 (B67,inlet) in Bellandur lake and was ranging from 4.26 (V44 middle) to 56.38 (V27, outlet) in Varthur lake. In Bellandur C:N was higher in the inlet region. But in varthur it was higher in deeper region of lake. Similar pattern was observed by earlier studies(Mahapatra et al, 2011).

**Total Nitrogen and Carbon in Macrophyte (Water hyacinth) samples:** The Shoot Carbon content in water hyacinth from different sites was ranging from 32.4% to 37.6% in Bellandur Lake (figure 9). B2 had higher C content and B22 had lowest. Mean content for shoots of water hyacinth was 33.62%. The N content in water hyacinth shoot ranged from 2.8% to 4.2% with B69 highest and B43 lowest (figure 9). The average value of N in Water hyacinth shoot was 3.24%. In Varthur, the Shoot

Carbon content in water hyacinth from different sites was ranging from 32.54% to 37.5% (figure 10). V2 (Inlet) had higher C content and V15 had lowest. Mean C content for shoots of water hyacinth was 34.2%. The N content in water hyacinth shoot ranged from 2.6% to 4.3% with V7 highest and V12 (Northeast shoreline) lowest (figure 10). The average value of N in Water hyacinth shoot was 2.98%.

Species	Life form	Family	Varthur	Bellandur
<i>Eichhornia crassipes</i>	Free floating	Pontederiaceae	+	+
<i>Alternanthera philoxeroides</i>	Emergent	Amaranthaceae	+	+
<i>Colocasia esculenta</i>	Emergent	Araceae	+	+
<i>Typha angustata</i>	Emergent	Typhaceae	+	+
<i>Lemna gibba</i>	Free floating	Araceae	+	+
<i>Lemna minor</i>	Free floating	Araceae	+	+
<i>Wolffia sp</i>	Free floating	Araceae	+	
<i>Paspalum sp</i>	Emergent	Poaceae	+	+
<i>Ipomea sp</i>	Emergent	Convolvulaceae		+
<i>Polygonum glabrum</i>	Emergent	Polygonaceae		+
<i>Cyperus sp</i>	Emergent	Cyperaceae	+	+
<i>Ludwigia perennis</i>	Emergent	Onagraceae	+	
<i>Pistia stratiotes</i>	Free floating	Araliaceae	+	

Table 1: Diversity of Macrophytes in studied lakes

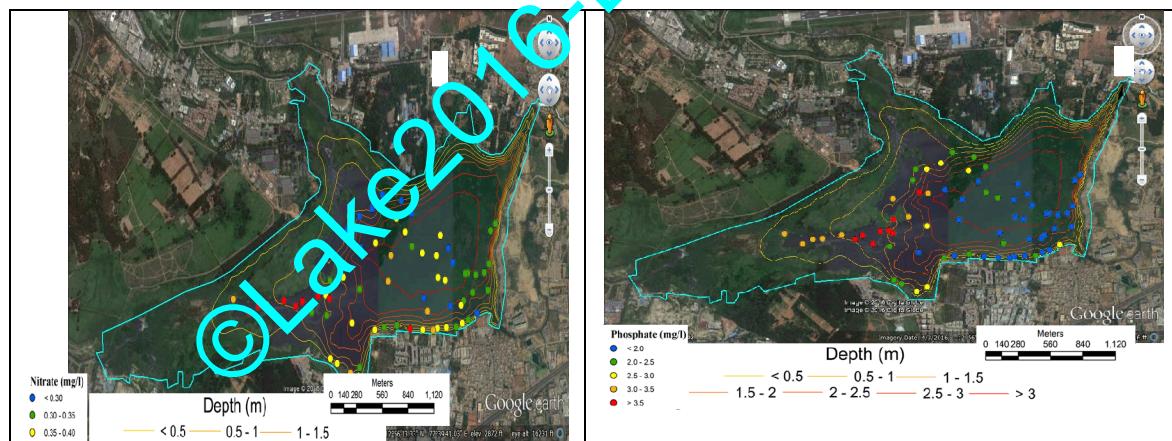


Figure 5: Variation of nitrate and Phosphate along the Bellandur Lake

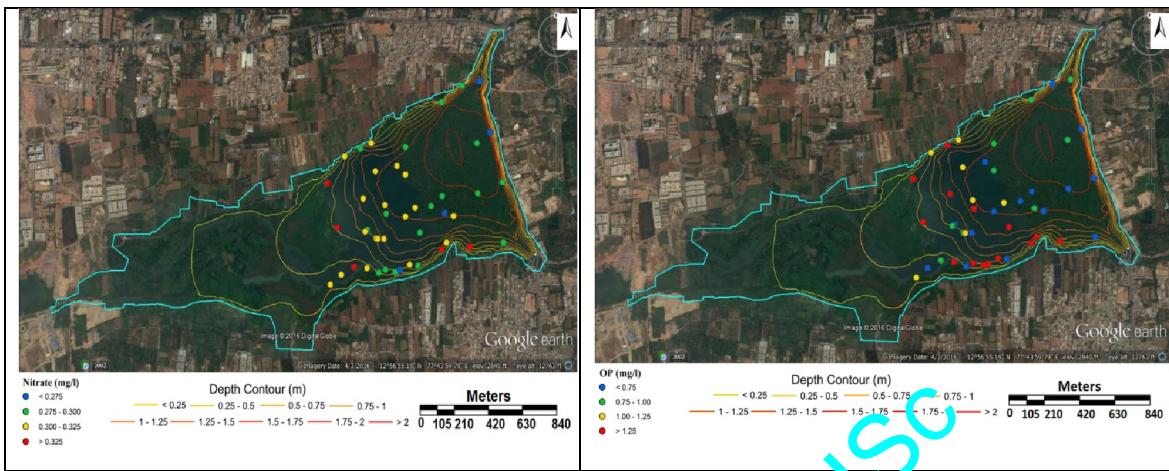


Figure 6: Variation of nitrate and Phosphate along the Varthur Lake

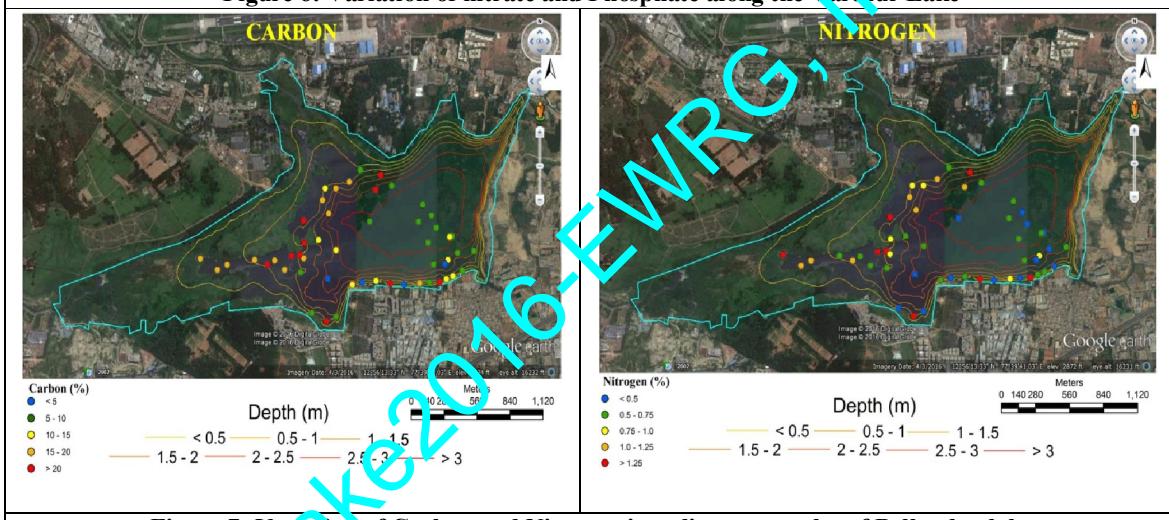


Figure 7: Variation of Carbon and Nitrogen in sediment samples of Bellandur lake

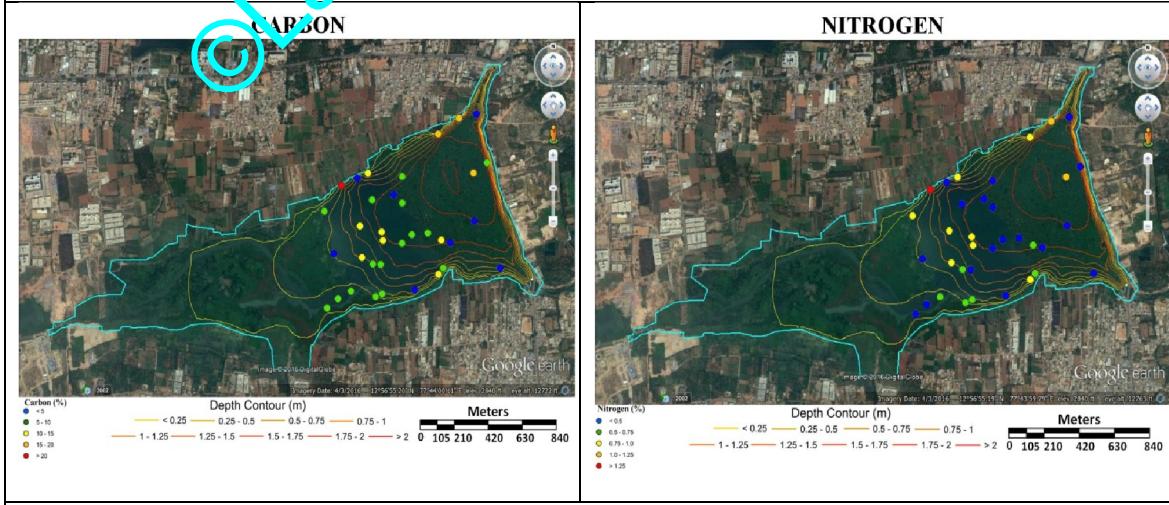
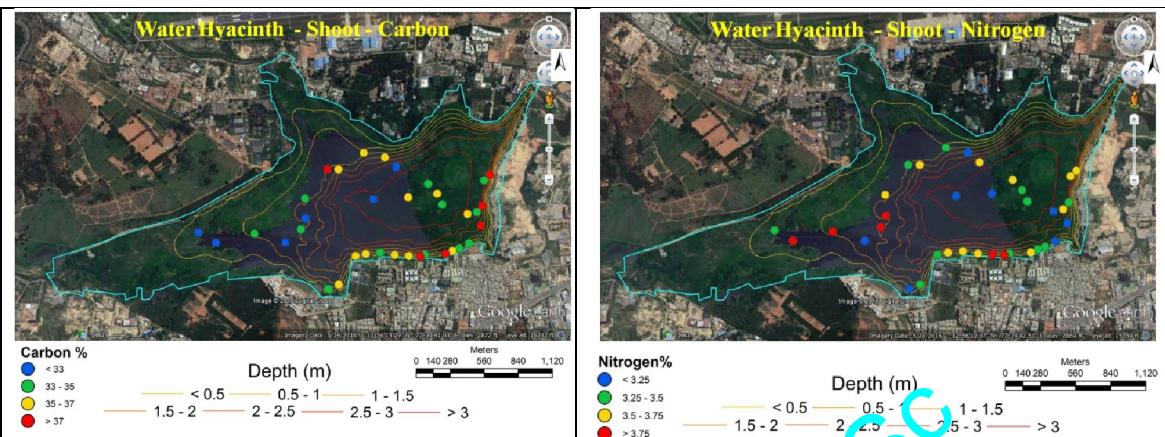
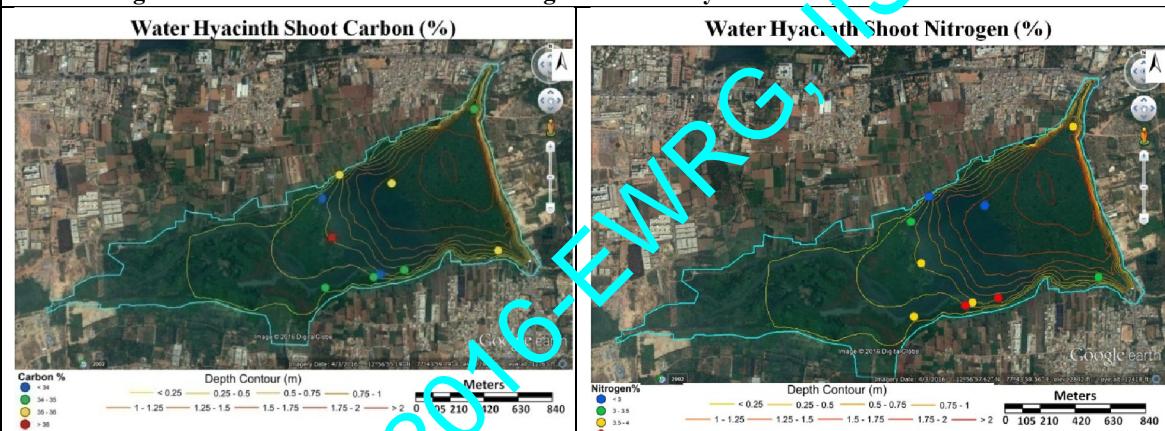


Figure 8: Variation of Carbon and Nitrogen in sediment samples of Varthur lake



**Figure 9: Variation of Carbon and Nitrogen in Water hyacinth samples of Bellandur lake**



**Figure 10: Variation of Carbon and Nitrogen in Water hyacinth samples of Varthur lake**





**Figure 11: Macrophytes found in the lakes**

### CONCLUSION

Tirtheen species of macrophytes were recorded during the study period and were dominated by non-native and invasive macrophytes like *Eichhornia crassipes* (floating macrophyte) and *Alternanthera philoxeroides* (an emergent macrophyte that had out-competed the other submerged species). The Nitrates and Phosphates in the water were higher in the inlets and shorelines where untreated sewage entry was there. The Carbon and Nitrogen in sediments and macrophytes samples also followed the same trend as nutrient in water. This study emphasizes the bioremediation potential of macrophytes. The Carbon and Nitrogen content of macrophytes were also higher in the sites where sediment and water nutrient content was higher.

### REFERENCES

- 1) APHA (1998). Standard methods for the examination of water and wastewater, 20th edition, Clesceri, L.S. Greenberg, A.E. and Eaton, A.D. (Eds.), American Public Health Association, Washington, DC.
- 2) Boopathy, R., & Mariappan M. (1984). Environmental factors affecting methane production, *Bioenergy Renew.* 29–32.
- 3) Clarke A, Weckstrom K, Conley D, Anderson NJ, Adser F, Andren E, De Jonge V, Ellegaard M, Juggins S, Kauppila P (2006) Longterm trends in eutrophication and nutrients in the coastal zone. *Limnology Oceanography* 51:385–397.
- 4) Cook, C.D.K. (1996). Aquatic Plant Book. 278 pp. The Hague. SPB Academic Publishing/Backhuys Publishers.
- 5) DeRenzo D.J. (1977). Energy from the conversion of waste materials. Noyes Data Co, NJ. 178–191.
- 6) DurgaMadhabMahapatra, Chanakya H.N., Ramachandra. T.V. (2011). Role of macrophytes in a sewage fed urban lake. *Institute of Integrative Omics and Applied Biotechnology Journal (IIOABJ)*, Vol. 2, Issue 8, pp.
- 7) DurgaMadhabMahapatra, Chanakya H.N., Ramachandra. T.V. (2011). C:N ratio of sediments in a sewage fed Urban lake, *International Journal of Geology* 3(5):86-92.
- 8) Gersberg, R.M., Elkins, B.V., Lyon, S.R., and Goldman, C.R. (1986). Role of aquatic plants in wastewater treatment by artificial wetlands. *Water Resources* 20: 363–368.
- 9) Hassan, K. M., Swinehart, J. B. and Spalding, R. F.: (1997). 'Evidence for Holocene environmental change from C/N ratio, and  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values in Swan Lake sediments, Western Sand Hills, Nebraska, *Journal of Paleolimnology* 18:121-130.
- 10) Koorosh.J, M. Sadanand, Yamakanamardi, K. Altaff, (2009). Abundance of copepods from three contrasting lakes of Mysore city. India, *J. Aquatic Biol.*, 23, 26-29.
- 11) Miller, R.R. (1996). Phytoremediation, 11pp. Pittsburgh, PA. Ground-Water Remediation Technologies Analysis Center.
- 12) Nakai, N. (1986). 'Paleoenvironmental features of Lake Biwa deduced from carbon isotope compositions and organic C/N ratios of the upper 800 m samples of 1400 m cored column', *Proceedings of Japan Academy* 62, Ser. B, 279–282.
- 13) Peverly, J.H. (1985). Element accumulation and release by macrophytes in a wetland stream. *Journal of Environmental Quality* 14: 137–143.
- 14) Rai, U.N., Sinha, S., Tripathi, R.D., and Chandra, P. (1995). Wastewater treatability potential of some aquatic macrophytes: removal of heavy metals. *Ecological Engineering* 5: 5–12.
- 15) Ramachandra, T. V., Ahalya, N. & Payne, M. (2003). Status of Varthurlake: opportunities for restoration and sustainable management. Technical report 102. Centre for Ecological Sciences, Indian Institute of Science, Bangalore.
- 16) Ramachandra, T. V., & Kumar, U. (2008). Wetlands of Greater Bangalore, India: automatic delineation through pattern classifiers. *Electronic Green Journal*, 1(26).
- 17) Ramachandra, T. V., & Solanki, M. (2007). Ecological assessment of lentic water bodies of Bangalore. The Ministry of Science and Technology.
- 18) Ramachandra T.V and Bharath H.A. ( 2016). Bangalore's reality: towards unlivable status with unplanned urban trajectory *Current Science* (Guest editorial), 110(12): 2207-2208.
- 19) Ramaswamy, S. V., & Razi, B. A. (1973). Flora of Bangalore district. Mysore: University Press.
- 20) Reddy, K.R., D'Angelo, E.M., and DeBusk, T.A. (1989). Oxygen transport through aquatic macrophytes: the role in wastewater treatment. *Journal of Environmental Quality* 19: 261–267.
- 21) Sathianathan, M.A. (1975). Biogas achievements and challenges. Association of voluntary agencies for rural development, New Delhi: 4–42.
- 22) U.S. Environmental Protection Agency. (1998). A Citizen's Guide to Phytoremediation. 6 pp. Report No. EPA 542-F-98-011. Washington, D.C. Office of Solid Waste and Emergency Response.