Phytoremediation for Treatment of Eutrophic Lake

Helen Roselene and Paneerselvam

[1]HOD Environmental Science, Dept of Environmental Science Mount Carmel college, Bangalore e-mail helenroselene@yahoo.co.in)
[2]Research Coordinator, Vinayaka Mission University, Salem

ABSTRACT

Bangalore city does not have any perennial river .It is dependent on river Cauvery which is about 140 km away to provide water to its residents Pumping water is an expensive business as the population of Bangalore increases the demand for water to increases .My present study is on heavily polluted lake the BELLANDUR LAKE and Phytoremediation for treatment of eutrophic lake. The lake is located at a latitude 12° - 45' -0"and longitude 77° - 40' - 0". The total catchment area of the lake is 110.94 Sq miles. The annual rainfall of the catchment area is 32 inches. It has a submerged area of 915.00 acres. The tank remains full throughout the year since it receives sewage water of about 100 MLD from Bangalore city in addition to its own supply of water of rainfall from its own catchment's area.

Study has shown that lake water is highly eutrophicated has DO less than 1.6mg/L, high phosphate 10.4mg/L to9.2mg/L,. Surprisingly nitrate levels are below the permissible limit(7.6 mg/L is the maximum).

Eutrophication of lentic water bodies is a problem of increasing environmental and ecological concerns is particularly serious when there is no perennial river.

Phytoremediation for treatment of eutrophic lake was taken up using Vetiver and Cana which were grown in small basins and allowed to float using bamboo for the removal of N and P containing eutrophic lake water in the basin for a week .The total phosphorous and nitrate removed were recorded .The proposed research taken is to transform the natural lake into a waste water treatment plant using Phytoremediation .This technique plays an important role since the phyto Biofilm (Vetiver and Cana)introduced near the inlet point where the incompletely treated sewage water is discharged by treating the polluted water and giving aesthetic beauty to the otherwise eutrophic lake.

INTRODUCTION

Water is a prime natural resource, a basic human need and a precious national asset. Planning development and management of water resources need to be governed by national perspectives. Bangalore city does not have any perennial river .It is dependent on river Cauvery which is about 140 km away to provide water to its residents pumping water is an expensive business as the population of Bangalore

increases the demand for water to increases. Leading to dependency on ground water which is recharged by lakes .My present study is on heavily polluted lake the BELLANDUR LAKE which is an old[about 130 yrs] major tank in varthur of Bangalore south taluk which is located at latitude 12° - 45' -0"and longitude. 77° - 40' - 0". The total catchment area of the lake is 110.94 Sq miles. The annual rainfall of the catchment area is 32 inches. It has a submerged area of 915.00 acres. The tank remains full throughout the year since it receives sewage water of about 160^{100} MLD from Bangalore city in addition to its own supply of water of rainfall from its own catchment area.

Bellandur Lake is also under serious threat due to damaging land use practice in the catchments area. The lake choking with weeds, silting and encroached from all sides is shrinking in size with deterioration in its quality and loss of its

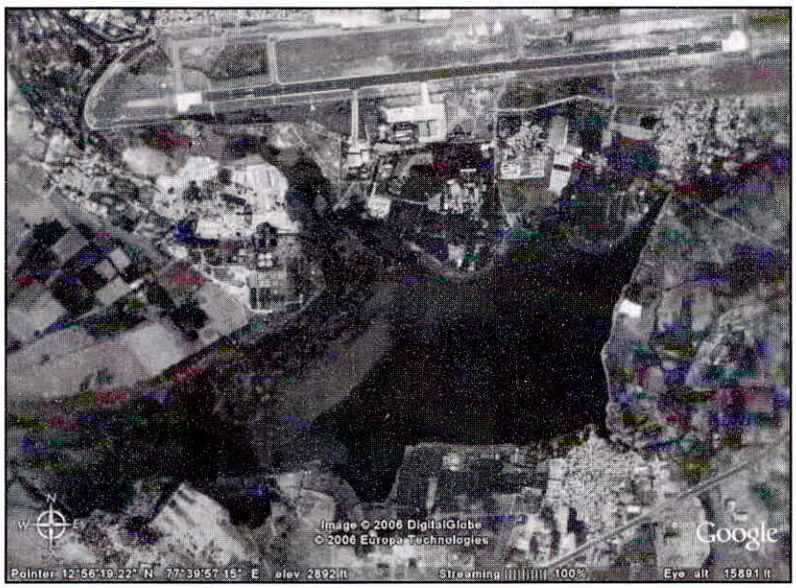


Fig 1: Eutrophic lake-Bellandur Lake (Google image)

varied flora, fauna and other resources. The 950 acre lake is a health hazard now as most of the pollutants are slowly leaching into the ground water table the crisis is enhanced since there is no other source of water except the ground water. Currently two main methods of treating wastewater can be practiced Engineering and Biological are used to prevent pollutants or contaminants from entering a body of water. Remediation measures work through the removal of contaminants already present in the water, a process also known as 'water purification'. Three kinds of wastewater are known to contaminate water (containing waste products), polluted water (containing heavy metals, pesticide residues and other hazardous materials), and eutrophicated water (containing plant nutrients, especially N and PO4). This paper discusses how vetiver and canna can control the water quality through simple methods, using low-cost technology

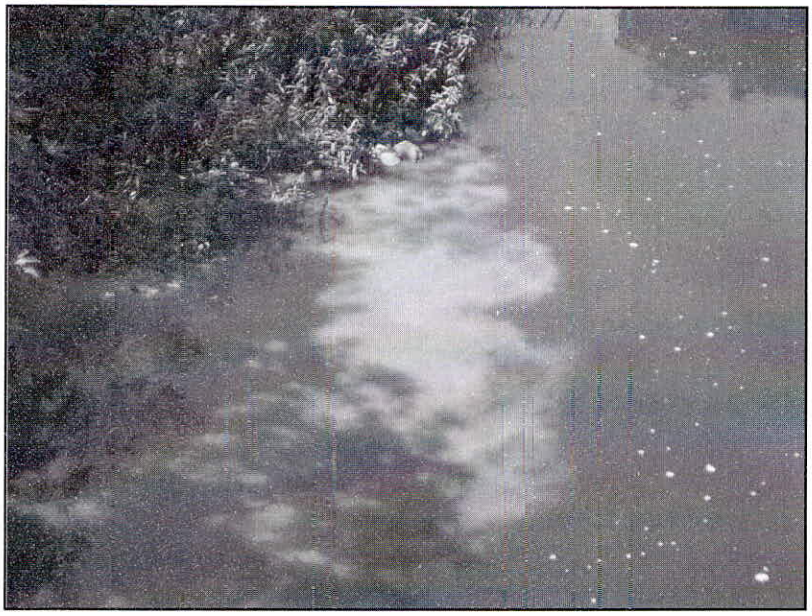


Fig. 2 : Lake getting polluted from effluent

Vetiver (Chrysopogon zizanioides) is a perennial grass of the Poaceae family, native to India. The name comes from Tamil. In western and northern India, it is popularly known as khus or vetiver oil . Vetiver can grow up to 1.5 meters high and form clumps as wide. The stems are tall and the leaves are long, thin, and rather rigid; the flowers are brownish purple. Unlike most grasses, which form horizontally spreading mat-like root systems, vetiver's roots grow downward, 2–4 meters in depth.

This makes vetiver an excellent stabilizing hedge for stream banks, terraces, and rice paddies. The close growing culms also help to block the runoff of surface water. Because vetiver propagates itself by small offsets instead of underground stolons, it is noninvasive and can easily be controlled by cultivation of the soil at the boundary of the hedge.

Vetiver is mainly cultivated for the fragrant essential oil distilled from its roots. Worldwide production is estimated at about 250 tons per annum (Lavania). Due to its excellent fixative properties, vetiver is used widely in high end perfumes. It is contained in 90% of all western perfumes (Lavania).The oil is amber brown and rather thick. The odor of vetiver oil is described as deep, sweet, woody, smoky, earthy, amber, balsam. The best quality oil is obtained from roots that are 18 to 24 months old. The roots are dug up and cleaned then dried. Before the distillation, the roots are chopped and soaked in water.

Vetiver is an important tropical grass used widely for environmental protection, flavours and Fragrances, handicrafts etc in different parts of the world. Since vetiver has

a strong root system and is perennial in nature, it has been considered widely for conservation of soil against erosion of top soil in various parts of the world. Also, vetiver has been a candidate plant for Phytoremediation of polluted soils. Vetiver oil obtained after steam distillation of its roots is unique oil and has no synthetic substitute. Vetiver oil is a perfume by itself and it is an indispensable product in several flavours and fragrances appreciated widely through out the world. Vetiver being a multipurpose crop is also used for making mats, handicrafts and such utility items besides being used to cover roofs of dwellings in tropical parts of the world. Vetiver has many medicinal uses such as it is carminative, stimulant, diaphoretic, refrigerant, for lumbago, rheumatism, sprains etc. South India is traditionally known for the cultivation of Vetiveria zizianoides in different states. This is different from the wildly grown khus of north India. It is believed that more than 3000 ha of vetiver are under cultivation for extraction of vetiver oil in south India. The use of vetiver for environmental protection and for extraction of roots for its oil for other economic products is seen as a contradiction. Environmental protection should go hand-in-hand.

Vetiver has Stiff and erect stems that can stand up to high velocity flows and increase detention time. Thick growth forming living porous barrier that acts as a very effective filter trapping both fine and coarse sediments, as well as sediment-bound contaminants (e.g. heavy metals and some pesticide residues). Deep, dense and penetrating root system that can reduce and prevent deep drainage, and improve bed stability and nutrient uptake. Finely structured and massive root system, which provides an environment that, stimulates microbiological processes in the rhizosphere. It's unique physiological Features. Highly tolerant to adverse climatic conditions such as frost, heat wave, drought, flood, and inundation. Highly tolerant to adverse edaphic conditions such as high soil acidity and alkalinity; saline, Sodic, and magnesic conditions; and aluminum and manganese toxicities. Highly tolerant to elevated levels of heavy metals such as arsenic, cadmium, copper, chromium, lead, mercury, nickel, selenium, and zinc. vetiver hedgerows are effective in removing excess nitrates and phosphates that may be in the runoff water, and there is some evidence that vetiver will remove excess pesticides as well. Thus, vetiver hedgerows have a dual function of increasing groundwater levels and improving its quality

Canna indica (also known as saka siri, Indian shots) is a species of the Canna genus, belonging to the family Cannaceae, a native of the Caribbean and tropical Americas that is also widely cultivated as a garden plant. It is a perennial growing from 0.5m to 2.5m, depending on the variety. The leaf bases clasp the stem and each overlaps the next one above. The seeds ripen in October. The flowers are hermaphrodite. Each flower is about 3 in (8 cm) across, and the showy part is not made up of petals, but a modified style and three modified stamens, all of which look like petals. Only one of the petal-like stamens bears pollen. The petal-like style is in the center of the flower. The real petals are fused and form a tube at the base of the flower. Canna has rhizomes (underground

stems) that constantly give rise to additional shoots. The seeds are small, globular, black pellets, hard and heavy enough to sink in water. They resemble shotgun pellets giving rise to the plant's common name of Indian Shot.This plant species is Tested for Use In Constructed Wetlands for Wastewater Treatment plants as emergent plant(Donald A. Hammer, Bruce E. Hammer – 1989)

NEED FOR THE STUDY

Due to increasing population and rapid process of urbanization and industrialization, the demand for fresh water is increasing every year. In the mean while, the available fresh water source is being polluted by the discharge of untreated or partially treated sewage effluents Bangalore has become a concrete jungle and municipal waste discharges are indiscriminately let out into the lake. Though there are established sewage treatment plants in the Koromangala and Chellagata valley regions its 163 MLD (Ramakrishna and Yadhav Kumar 2001), which is partially treated. Its discharge is entering the lake.

The city of Bangalore does not have any perennial river. Bangalore has an estimated metropolitan population of 6.5million, making it India's third largest city and fifth largest metropolitian area which is dependent on the River Cauvery which is about 140 Km away and the water has to be lifted to about 500m high since it is at higher altitude. The proposed research taken is to transform the natural lake into a waste water treatment plant using Phytoremediation at inlet feeders.

OBJECTIVE OF THE RESEARCH

- To generate baseline data of physico chemical dynamics of Bellandur lake.
- To identify algae and characterize the bio indicator organism for the lake.
- To study the up take of the key elements responsible for water eutrophication and their removal of by vetiver in a most cost-effective and environmentally friendly method
- To study the up take of the key elements responsible for water eutrophication and their removal of by Cana in a most cost-effective and environmentally friendly method and aesthetically appealing

REVIEW OF LITERATURE

Eutrophicated water is one which is rich in mineral and organic nutrients that promote a proliferation of aquatic plants, especially blue-green algae consuming nearly all the oxygen, especially during warm weather, choking the fish, and often causes the extinction of other organisms. The characteristic of eutrophicated water is the promotion of algal growth due to the presence of high amounts of N and PO4. Depending on the origin, it can be classified into domestic, agricultural, and industrial eutrophicated water.

Phytoremediation consists of four different plant-based technologies each having a different mechanism of action for the remediation of metal-polluted soil, sediment, or water. These include: rhizofiltration, which involves the use of plants to clean various aquatic environments; phytostabilization, where plants are used to stabilize rather than clean contaminated soil; phytovolatilization, which involves the use of plants to extract certain metals from soil and then release them into the atmosphere through volatilization; and phytoextraction, where plants absorb metals from soil and translocate them to the harvestable shoots where they accumulate. Although plants show some ability to reduce the hazards of organic pollutants (Cunningham et al. 1995; Gordon et al. 1997; Carman et al. 1998), the greatest progress in phytoremediation has been made with metals (Salt et al. 1995a; Blaylock and Huang, 2000). Phytoremediative technologies which are soil-focused are suitable for large areas that have been contaminated with low to moderate levels of contaminants. Sites which are heavily contaminated cannot be cleaned through phytoremediative means because the harsh conditions will not support plant growth. The depth of soil which can be cleaned or stabilized is restricted to the root zone of the plants being used. Depending on the plant, this depth can range from a few inches to several meters (Schnoor et al. 1995). Phytoremediation should be viewed as a long-term remediation solution because many cropping cycles may be needed over several years to reduce metals to acceptable regulatory levels. This new remediation technology is competitive, and may be superior to existing conventional technologies at sites where phytoremediation is applicable.

Australia, vetiver was used very successfully as an integral part of a water purification program in removing waste products from septic tank effluent. With intensive farming adjacent to these water bodies, the quantities of N and P are bound to increase. Removal of these elements can be achieved by: (i) planting vetiver on the edges of the streams or in the shallow parts of the lakes where usually high concentrations of soluble N and P occurred, and (ii) growing vetiver hydroponically on floating platforms which could be moved to the worse affected parts of the lake or pond. The advantages of the platform method is that vetiver tops can be harvested easily for stock feed or mulch, and vetiver roots can also be removed for essential oil production (Truong and Baker 1998). Research in China has shown that the vetiver system can be used to remove high soluble N and P concentrations in eutrophicated river water (Zheng et al. 1997). It was found that vetiver can reduce soluble P up to 99% after three weeks and 74% of soluble N after five weeks. The authors were of the opinion that the vetiver system has the potential of removing up to 102 tons of N and 54 tons of P/yr/ha. From another experiment in China, it was found that vetiver, which was grown along the edges of the streams, or in the shallow parts of the lakes to first filter off the chemicals, and then grown hydroponically in water along banks, can effectively remove N and P. And, the water became more transparent after treatment (Xia et al. 1998; Zheng et al. 1998). These Chinese researchers and workers indicated that vetiver could remove dissolved nutrients, and reduced algal growth within two days under experimental conditions. Thus, vetiver can be used very effectively to control algal growth in water infested with blue-green algae.

According to Shuiping Cheng,et,al.The phytoremediation of triazophos (O, O-diethyl-O-(1-phenyl-1, 2, 4-triazole-3-base) sulfur phosphate, TAP) by Canna indica. In a hydroponic system was studied. After 21 d of exposure, the removal kinetic constant (K) of TAP was 0.0229-0.0339 d(-1) and the removal percentage of TAP was 41-55% The contribution of plant to the remediation of TAP was 74% and C. indica played the most important role in the hydroponic system. C. indica, which showed the potential of phytoremediation of TAP, and is commonly used in constructed wetland, so the technique of phytoremediation of TAP from contaminated water can be developed with the combination of constructed wetland.

METHODOLOGY

For major physico chemical analysis listed below were followed (APHA 1998,Burman. et al, 1996)

Physical

- pH Electrometric method
- Turbidity, NTU Turbidity meter
- Water temperature,°C Mercury thermometer
- EC, m S/cm conductivity meter method

Chemical

- DO, mg/L Winkler's iodometricmethod
- BOD&COD
- Phophates, mg/L Spectrophotometricmethod
- Nitrates, mg/L Spectrophotometricmethod

Phyto remediation study

Take 1 Lt. distilled water and 100 ml of the stock and place the plant species with a support for a concentration of 1ml contains 10 mg /l (for both and vetiver &Canna species,for preparing the stock refer APHA 1998)

DISCUSSION

Presence of algae such as Spirulina, Diatoms, Microcystis, Oscillatoria, Chlorella, Anhistrodesmus, scendesmus indicates that the quality of water an indicator of organic pollution or sewage contamination.

The water quality shows that the conductivity is very high (more than 300 us/ cm) which could be attributed to high level of ions present. The turbidity is also very high (more than 5 NTU).the total solid is also very high (except in August).The dissolved oxygen is almost Nil, the water shows high BOD and high COD all attributed to their high

Table 1 : Physico –Chemical analysis of Bellandur Lake

	MONTHS ?	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
PARAMETERS	STANDARD							
	VALUES ?							
TEMPERATURE		29ºC	27ºC	30ºC	24ºC	23ºC	20ºC	21ºC
pH	6.5 -8.5	7.02	7.72	7.15	8.5	7.6	7.3	7
CONDUCTIVITY	300	840	991	866	713	684	738	946
TURBIDITY	5 NTU	13	11	34	12.2	23	18	12.2
TOTAL SOLIDS	500 mg/L	400	560	688	663	722	580	542
DO	0.5 mg/L	0.5	0.2	1.6	0	0	0	0
BOD	30 mg/L	28	200	239	280	326	378	400
COD	250 mg/L	140	600	525	630	710	760	780
PHOSPHATE	0.1 mg/L	8	10.4	7.1	9.3	8.5	6.4	9.2
NITRATE	45 mg/L	4.5	7.6	1.02	3	4.8	1.2	1.4

organic content. The phosphate content reveals that the lake is highly eutrophicated though nitrate level is low the nitrogen may be present as ammonical nitrogen.

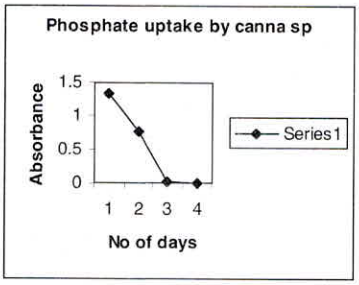
The tank is functioning as a carbon and nitrate removal system. Major untreated sewage influx is removed by the bio diversity of the lake. Three major sinks namely bacterial, algal, dominated by Microcystis in summer and before winter and in winter it is dominated by Chlorella ,followed by Euglenohyceae member .The third sink is the macrophyte Water Hyacinth ,followed by Alligator weed (Alternanthera philoxeroides).Phytoremediation could be viewed as a long-term remediation solution this new remediation technology is competitive, and may be superior to existing conventional technologies at sites its low cost and free from maintenance adds to its application.

Vetiver is a perennial This makes vetiver an excellent stabilizing hedge for stream banks, terraces, and rice paddies. The close growing culms also help to block the runoff of surface water.

Since vetiver has a strong root system and is perennial in nature, it has been considered widely for conservation of soil against erosion of top soil in various parts of the world. Also, vetiver has been a candidate plant for Phytoremediation of polluted soils.

Introduction of Canna brings back the aesthetic beauty to the lake which other wise looks disastrous and unappealing Vetiver and Canna is highly recommended for Phytoremediation since they are not edible and could be used for other aesthetic

no of days	1	3	5	7
Absorbance	1.34	0.757	0.032	0
Conc in ug	500	250	4	0



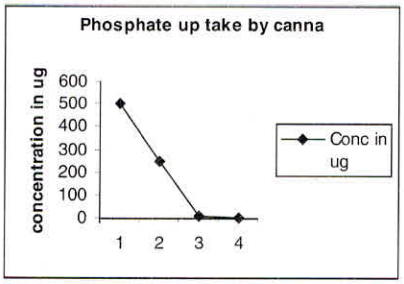
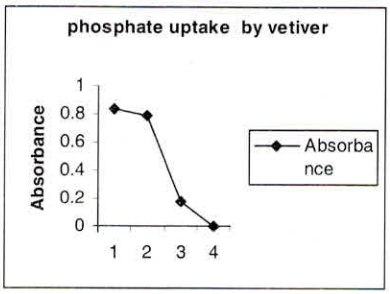


Fig. 3 : Phosphate uptake by Canna sp

no of days	1	3	5	7
Absorbance	0.831	0.787	0.18	0.002
Conc in ug	300	280	70	0



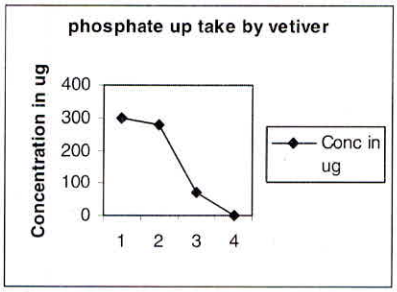
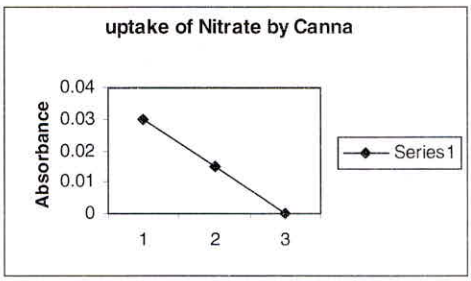


Figure 4 : Phosphate uptake by vetiver

no of days	1	2	3	7
Absorbance	0.030	0.015	0.002	0
Conc in ug	270	135	0.002	0



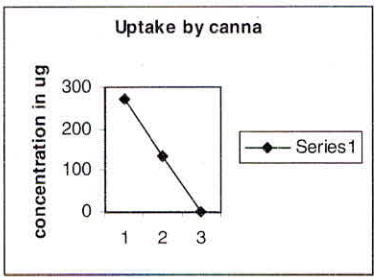
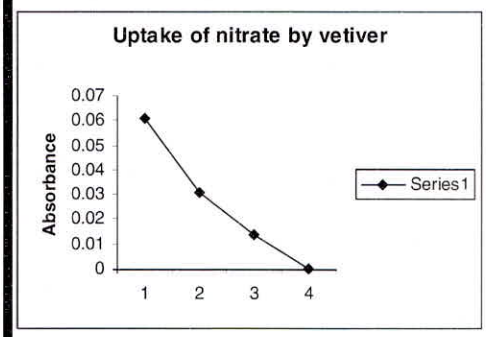


Fig. 5: Uptake Of Nitrate By Canna

no of days	1	2	3	7
Absorbance	0.061	0.031	0.014	0
Conc in ug	560	280	0	0



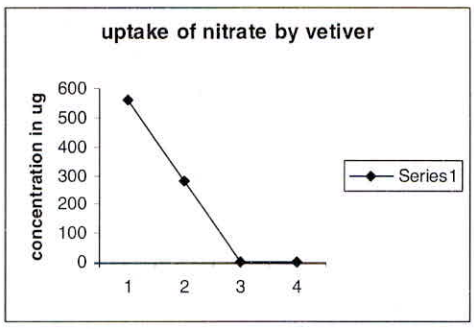


Fig. 6 : Uptake of nitrate by vetiver

properties. The harvested Vetiver being a multipurpose crop can be used for making mats, handicrafts and such utility items besides being used to cover roofs of dwellings in tropical parts of the world the oil which is extracted by distillation only(at specific temperature only khus oil distils out).The khus oil produced will be free from impurities hence the complex entry of the non biodegradable heavy metals would not enter the food chain. The intial amount of phosphate taken was 10 mg /l .After the uptake of phosphate by vetiver 300 ug of phosphate was left in the residual water. On 5 day it is reduced to 70 ug and by the 7 day all the phosphate is removed the intial amount of phosphate taken was 10 mg /l. After the uptake of phosphate by Canna. The uptake of phosphate by canna 500 ug of phosphate was left in the residual water. On 3 day it is reduced to 250 ug and by the 7 day all the phosphate is removed. The initial amount of nitrate taken was 10 mg /l .After the uptake of nitrate by vetiver 560 ug of nitrate was left in the residual water. On 3 day it is reduced to 280 ug and by the 3 day all the nitrate is removed The initial amount of nitrate taken was 10 mg /l. After the uptake of nitrate by canna 270 ug was left in the residual water. On 3 day it is reduced to 135 ug and by the 3 day all the nitrate is removed.

FUTURE SCOPE OF THE STUDY

1. The research carried out enables the lake development authority to adapt these species in bioremediation of eutrophicated lake and maintain its fragile survival.
2. The research carried out would enable the potential for advanced engineered biological system for large scale bioremediation of pollutants. If successfully studied in Ex- Situ condition this technique could be applied in other areas of treatment of industrial effluents.
3. Further heavy metals uptake could be studied

REFERENCES

1. APHA, 1998. Standard methods for the examination of waters and wastewaters. APHAAWWA-WEF, Washington, DC
2. Buurman P., B. Van Langer and E.J. Velthrost, 1996. Manual for soil and water analysis. Backhuys Publishers, Leiden, The Netherlands.
3. Blaylock, and Huang, Phytoextraction of metals. Phytoremediation of toxic metals: using plants to clean-up the environment. New York, John Wiley & Sons, Inc., 2000, p. 53-70.
4. Carman, . Crossman, T.L and Gatliff, e.g. Phytoremediation of no. 2 fuel oil-contaminated soil. journal of soil contamination, 1998, vol. 7, p. 455-466.
5. Cunningham, S.D; Berti, W.R and Huang, J.W. Phytoremediation of contaminated soils. trends in biotechnology, 1995, vol. 13, no. 9, p. 393-397
6. Donald A. Hammer, Bruce E. Hammer - 1989 - Technology & Engineering Constructed Wetlands for Wastewater Treatment plants;

7. Gordon, M.; Choe, N.; Duffy, J.; Euan, G.; Heilman, Phytoremediation of soil and water contaminants. washington, ,American chemical society, 1997, p. 177-185.
8. Shuiping Cheng, Jin Xiao, Huiping Xiao, Liping Zhang, Zhenbin Wu. Technical note Phytoremediation of triazophos by canna indica Linn. in a hydroponics system.
9. Ward M.H. et al. (1996) Drinking water nitrate and the risk of non-Hodgkin'sLymphoma. Epidemiol. 7:465.
10. Ramakrishna ,2001 Analysis Report- Bellandur Tank. In Water quality Monitoring of lakes in and around Bangalore City, Karnataka State Pollution control Board
11. Salt, D.E.;and et.al Phytoremediation: a novel strategy for the removal of toxic metals from the environment using plants. biotechnology, 1995a, vol. 13, p. 468-474.
12. Schnoor,Phytostabilization of metals using hybrid poplar trees. Phytoremediation of toxic metals: using plants to clean-up the environment. new york, john wiley & sons, inc., 2000, p. 133- 150.
13. Shuaibu.O.A Usman Kenneth.A. Yongabi 2002 Phytoaccumulation Of Selected Heavy Metals In Nymphaea Lotus (Waterlilly) From Polluted Stream In Bauchi And A Proposed Integrated System Use Shuiping Cheng, Jin Xiao, Huiping Xiao, Liping Zhang, Zhenbin Wu Technical note phytoremediation of triazophos Canna Indica by Linn. in a hydroponic system. The Chinese Academy of Sciences, Wuhan, PR China
15. Venkataraman.R ,2006 Urban Wastewater-A Renewable resource for Non-Potable water needs. EAB seminar on Urban waste management 2006,National Institute of Advanced Studies, Bangalores
16. www.karnataka.com/tourism/bangalore/facts.shtml