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OPTIMIZATION OF POLLUTANT CONCENTRATION IN SEWAGE TREATMENT USING CONSTRUCTED WETLAND THROUGH PHYTOREMEDIATION

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Abstract: *Cana indica is a wide spread emergent aquatic weed. It generally grows on wastewater discharged areas like bogs, lakes, river pools and many. It is a promising emergent macrophytes for its sustainable use in wastewater treatment due to its rapid growth. This plant is a valuable biotic resource in waste water treatment due to its several properties by its plant-root system through Phytoremediation process.*

In the present investigation, Cana indica is used for the treatment of sewage to test its pollutant absorption capacity. Designed Angular Horizontal Sub-surface Flow method is used for treatment sewage collected from Solapur city for its recycling and reuse. The physico-chemical parameters of sewage samples were analyzed both before treatment and after the treatment and assessed for pollution load reduction efficiency. The sewage with different concentrations in the range of 10% to 100% was subjected to the phytoremediation treatment using Cana indica in designed treatment set up. The samples of sewage with different concentrations viz. 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% were tested for the treatment. It is observed that wastewater was dark blackish, obnoxious and found highly offensive odour in before treatment but after treatment with Cana indica in constructed wetland, it was found clear and odorless. Results reveal that pH range was changed from 6.76 to 7.26, maximum reduction of E.C was 33.51 % at 80%, TSS by 54.48%, TDS by 56.01%, TS by 55.22%, BOD by 73.77%, COD by 75.19%, NO_3 by 73.13%, PO_4 by 56.02% and SO_4 by 49.48% respectively after 96 hours (4 days) of Hydraulic Residence Time. The results reveal that root zone technology with up to 80% sewage concentration is useful for the maximum reduction in pollutant concentration of wastewater treatment. It is useful for reducing the surface and ground water pollution load.

Keywords: *Sewage Treatment, Cana indica, Angular Horizontal Subsurface Flow, Constructed Wetland, Phytoremediation.*

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1. INTRODUCTION:

Constructed wetlands are human engineered systems that utilize natural treatment processes to reduce the pollution levels in wastewater. The combination of soil, plants and microorganisms efficiently remove organic pollutants, nutrient concentrations and toxic contaminants in water using a variety of physical, biological and chemical processes. The energy that drivens all these processes is provided mainly by the sun. The research on the capacity of marsh plants in the reduction of organic pollutants and nutrients in aquatic systems started in the 1950's in Germany. Since then, various designs of constructed wetland have been developed. Thousands of facilities as an outcome of such investigation are currently in use in Europe, Australia and the United States. Recent years have seen the rapid proliferation of constructed wetland systems in Africa and Asia. There are two basic types of constructed wetlands, surface flow and subsurface flow. Surface flow wetlands are essentially shallow ponds planted with floating and emergent species of aquatic weeds. The water flow in these systems is observed almost entirely above the soil layer. The flow in subsurface flow in the wetlands occurs under the surface and within the soil planted with emergent aquatic plant species. Subsurface flow is either horizontal (the water moving parallel to the surface) or vertical (the influent is distributed across the surface). It percolates down the media and can be collected in a bottom layer. Subsurface wetlands are generally more efficient. These require less land area (Kuchta, and Sarana, 2008).

Major water bodies of all over the world are mostly polluted by the discharge of domestic sewage, trade effluents and industrial wastewater. But it is needed to be treated through low cost, an ecofriendly technology for sustainable future. The efforts can be made to treat the waste water using suitable aquatic weeds by using rootzone technology (Metcalf and Eddy, 1991; Chavan et al., 2009*a*). Such efforts have been made in the present investigation using *Cana indica* in constructed wetland.

Phytoremediation technology in the form of constructed wetland or natural water marsh is a nature's gift for control of water pollution and for sustaining livelihood. Wetlands, both natural and constructed are able to purify wastewater due to their ability to degrade, absorb or filter the pollutants and to take-up nutrients from the water or wastewater. Therefore, the use of constructed wetlands for wastewater treatment is becoming more and more popular. The wetlands are found across the country and around the world due to their diverse applications. The constructed wetland treatment systems can be established almost anywhere, including on lands with limited alternative uses (USEPA, 1988). They can often be an environmentally acceptable, cost-effective treatment options, particularly for small communities. The available water resources are adequate for the present community in some areas on the basis of natural average consumption but marginal in other areas such as arid, semi arid regions to meet their routine water needs. The wastewater from various sources can be efficiently treated by constructed wetlands and reused. There is vast literature available on this subject. Most of it has been devoted for the fulfillment of the gap that exists between the generalized approach and the local situations (Scierup et al., 1990; Schreijer et al., 1997; Newman et al., 1998; Dilshad et al., 2010). This gap provides a wide scope to undertake research to develop an efficient system and evolve and establish an effective procedure to fulfill the research gap between the literature information and localized need for adaptive aquatic weeds for the phytoremediation. The efforts have been made to contribute to fill up this gap with practical efforts in present work using *Cana indica*.

The root zone process is the natural remedy to the wastewater pollution problem. Wetland based technology is an ecofriendly, self–contained, artificially engineered constructed wetland ecosystem. In this process the wastewater is allowed to flow laterally through specially prepared impervious bed in which specific wetland plants are grown. The root zone process has been fully commercialized to treat industrial and domestic effluents by the use of specific aquatic macrophytes for the control of water pollution **(**Brix and Schierup, 1989; Dhote., 2007). One of the integrated components of this process is the need of adaptive and efficient aquatic weeds. The plants grow in the wastewater by absorbing nutrients at faster rate turning these weeds to a desirable productive use. The plants hold themselves in the interporous molecules of soil layer or support system through their roots and rhizomes. These form an intricate network of underground stem. The roots of these plants grow rapidly and provide air passages through the sludge. In turn, the sludge provides a host area for many biological communities to colonize, develop and continue to mineralize the sludge contents. It helps to optimize the microbiological, chemical and physical processes naturally occurring in the wetland (Bates and Hentages, 1976; Hammer, 1989).

The wastewater is made to flow horizontally along a seated path of porous bed reactor where oxygen is introduced biologically via helophytes. The porous bed material provides large surface area for the colonization or adsorption of bacteria which degrades organic load (Brix, 1994**)**. In the densely rooted bed, the activity of microorganisms increases in terms of both, quality and quantity. The large contact area between water and the bed particles allow eliminating nitrates and phosphates by both processes, absorption and chemical precipitation. The aerobic and anaerobic bacteria carry out active role in the reduction of COD and BOD of wastewater and help to reduce the extent of groundwater contamination. This technique is suitable for the sustainable wastewater and wastewater management. It may be preferred for recharging of groundwater **(**Rao and Mamatha, 2004; Vymazal, 2009).

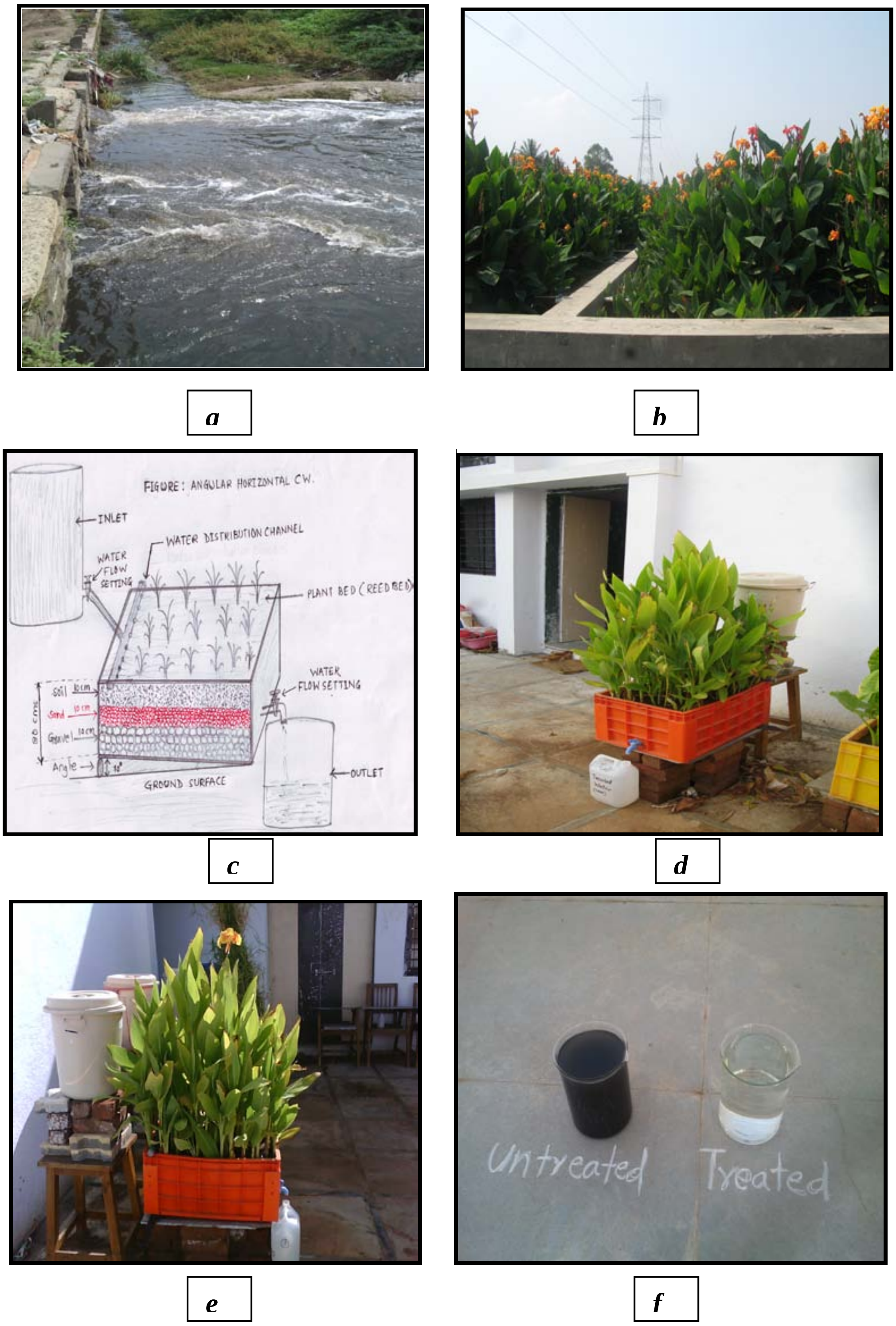
In India, almost all the water bodies ha been occupied with various types of macrophytes. These may be free floating, submerged and emergent (shoreline) plants are an integral part of the aquatic ecosystem and act as bio-filters. The conventional wastewater treatment process is inconvenient in the form of its operation and also very costly for its maintenance. Therefore, efforts are made by various researchers for the use of natural devices, which can be used as an eco-friendly and effective source of treatment. (Dhote et al., 2007; Chavan et al., 2012a, 2012b)

The present studies are aimed to investigate the phytotreatabilty potential of *Cana indica.* The investigations are carried out to determine the potentiality of *Cana indica* at different concentrations of pollutants for reducing the water pollution in the study region. Considering the abundant availability of *Cana indica* in Solapur region, this plant has been selected for the present study. This plant is locally adaptive, abundant, fast growing and easily available which made it easy to select for the present investigation. In this work, wastewater was treated in different concentrations of pollution load in Angular Horizontal Subsurface Flow (AHSSF) constructed wetland using *Cana indica*.

2. MATERIALS AND METHODS:

Experimental procedures followed in present investigation were similar to those described elsewhere (Chavan et al., 2009). *Cana indica*, the most prominently adaptive marshy plant was used for treatment of wastewater. It was transplanted in the designed wetland system in the Angular Horizontal Subsurface Flow process of constructed wetland. Grab samples of sewage for the treatment studies were collected from Shelgi nala (Pune naka) located near national highway no. 9 in Solapur city **(Figure 1a)**. These samples were treated using *Cana indica* by Phytoremediation technique after their pre-treatment characterization.

Figure 1: Showing a) Sewage Sampling location b) Cana indica Plants c) Design of Angular Horizontal Subsurface Constructed wetland d) Pilot plant e) Flowering in *Cana* indica f) Untreated and Treated sample of sewage.



a b c d e f

The selected plant *Cana indica* belongs to Kingdom–plantae, Order–Zingiberales, Family-Cannaceae, Genus–Canna and species-indica. This plant is commonly known as, 'Kardali' in the state of Maharashtra. This is a perennial herb with tuberous root stock and bears small but vivid red and yellow flowers. This plant is found almost everywhere constantly in blossom. This is an erect plant. The plant grows naturally in near open streams, along riverbanks and near houses. Flowering period of *Cana indica* is in mid autumn, early autumn, late summer and mid summer. The plant prefers a sheltered situation. It also grows well in direct sunlight, and prefers medium depth levels of water. *Cana indica* grows in the soils of varied range of pH ranging from a pH of 5 to 8.5. It is adapted to chalk, clay, clay loam, loam, loamy sand, peat, sandy clay, sandy clay loam and sandy loam soils. It has a clump forming growth form, and has an ultimate height of 2m / 6.6ft and spread of 0.5m / 1.6ft. It can take 4-5 years to reach its ultimate height. The leaves are green in spring or summer and green in autumn. They are oblanceolate in shape. It is used mostly in architectural, city courtyard garden, conservatory, container plant, flower border and bed and tropical effect. It gets propagated or is germinated by different techniques which include the germination through seed and rhizomes. The seed can be germinated by scarification-break down of seed casing **(Figure 1 b)**.

In the experimental set up three sets of buckets with different sizes and dimensions were used. The vertical buckets as holding tank (Inlet) were used to hold the waste water. The water storing capacity of tank was 35 liters each. The rectangular tub with test plant bed was used as experimental setup in each for preparing root zone bed of size 62 cm length and height 35 cm having suitable outlet. The vertical pipe was placed above the tub in an inverted 'T' shape for equal distribution of wastewater which was connected with the rubber pipe to the inlet of holding tank for each set. The length of plastic pipe was 40 cm and the holes were provided at the interval of 5 cm and equal flow was adjusted manually through them. Plastic cans were used for the collection of treated water and for flowing out from the root zone bed through the outlets. Inlet, Root zone tub and outlet were connected to each other with taps by tubes and plastic water pipes **(Figure 1c, d and e)**. Treated water samples were collected and analyzed in laboratory. The Angular Horizontal Subsurface Flow constructed wetland or root zone bed for each set was prepared as follows:

Three layers of support bed in constructed wetland were prepared with Pebbles, Sand and Garden soil. The big size pebbles comprising of 20 kg total weight were used for making bottom layer of 10 cm height followed by sharp and medium sized sand amounting total to 15 kg were added to form a middle layer of 10 cm height and small size, sieved 6 kg of soil to form upper layer of 10 cm height were used in construction of bed. The pebbles and sand materials were neatly washed with tap water and then arranged in different layers. Selective healthy, small, young, locally available plant saplings of *Cana indica* were transplanted which were arranged in rows & columns and covered by layers of small pebbles, sand and soil (Chavan et al 2012c).

The rectangular tub with plant bed was provided with 10^0 slope and kept in the slanting position. Flow rates were adjusted by using bucket and timer. Inlet flow and outlet flow of wastewater were adjusted to maintain Hydraulic Retention Time (HRT) of 4 days (96 hrs). Initially, plants in bed were acclimatized for two weeks prepared with suitable concentrations of sewage which were passed through root bed from time to time. As the time passed, the concentrations were increased such as 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% of sewage through plant treatment. Test samples before and after treatment were analyzed for selective parameters like pH, EC, TSS, TDS, TS, BOD, COD, NO3, PO4 and SO4 using standard method (APHA, 2005; Trivedi and Goel, 1986). The entire experiment was carried at room temperature under natural conditions outside the laboratory except the characterization. Finally, pollution reduction efficiency and treatment efficiency of the test plant were calculated.

3. RESULTS AND DISCUSSION:

Table 1: Treatment performance of wastewater (Before and After) in the Angular Horizontal Subsurface Flow Constructed Wetland using Cana indica after 4 days HRTs.

Concentration in %	Performance evaluating parameters (Before and After the treatment)																			
	pH		EC (µMohs/cm)		TSS (mg /L)		TDS (mg /L)		TS (mg /L)		BOD (mg /L)		COD (mg /L)		NO_3 (mg /L)		PO_4 (mg /L)		SO_4 (mg /L)	
	B*	A*	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
10	8.10	7.6	0.96	0.82	117	100	612	458	729	558	4.92	3.44	14.8	8.9	5.4	3.2	3.60	2.41	28	19.46
20	7.91	7.4	1.12	0.91	154	128	668	459	822	587	5.94	4.02	17.4	9.6	6.0	3.3	5.12	3.26	39	26.26
30	7.61	7.3	1.24	0.98	161	124	803	516	964	640	6.84	4.30	19.3	10.1	9.5	4.6	8.66	5.26	53	34.0
40	7.52	7.2	1.36	1.02	165	122	852	524	1017	646	7.27	4.34	21.8	10.3	11.7	5.2	9.86	5.63	66	39.0
50	7.47	7.12	1.47	1.07	163	116	964	548	1127	664	10.92	5.72	24.4	10.5	13.2	5.3	12.41	6.83	78	42.0
60	7.18	7.21	1.59	1.12	239	129	999	549	1238	678	12.31	6.11	27.7	10.9	17.0	6.1	14.66	7.56	84	46.0
70	6.9	7.29	1.71	1.19	258	130	1129	552	1387	682	22.08	8.60	36.9	11.2	19.6	6.3	16.83	7.76	89	47.0
80	6.87	7.26	1.82	1.21	290	132	1251	558	1541	690	37.4	9.81	51.6	12.8	21.4	6.4	17.92	7.88	94	48.0
90	6.81	7.24	1.94	1.32	345	205	1326	582	1671	787	46.02	14.60	92.8	28.4	24.6	6.7	18.81	8.92	97	49.0
100	6.76	7.26	2.56	1.81	394	232	1364	662	1758	894	51.44	19.09	118	41.4	26.8	7.2	21.60	10.63	107	57.0

**B means before treatment and A means after treatment*

Table 2: Percentage (%) reduction in various pollution parameters using Cana indica

Sewage Concentrations	Percentage (%) Reduction in various Parameters								
	E.C.	TSS	TDS	TS	BOD	COD	NO_3	PO_4	SO_4
10 %	14.58	14.52	25.16	23.45	30.08	39.86	40.74	33.05	30.05
20%	18.75	16.88	31.28	28.58	32.32	44.82	45.00	36.32	32.66
30%	20.96	22.98	35.74	33.19	37.13	47.66	49.47	39.26	35.84
40%	25.00	26.06	38.49	36.47	40.30	52.75	55.55	42.90	40.90
50%	27.21	28.83	43.15	41.08	47.61	56.96	59.48	44.96	46.15
60%	29.55	46.02	45.04	45.23	50.36	60.64	64.11	48.43	45.23
70%	30.40	49.61	51.10	50.82	61.05	69.64	70.00	53.90	47.19
80%	33.51	54.48	55.39	55.22	73.77	75.19	70.09	56.02	48.93
90%	31.95	40.57	56.10	52.90	68.27	69.39	72.76	52.57	49.48
100%	29.29	41.11	51.46	49.14	62.88	64.91	73.13	50.78	46.72

The constructed wetlands using phytoremediation process typically requires few months for the growth of vegetation, establishment of biofilm and sizable time for development of biodegradable colonies of microflora for pollution reduction (Billore et al., 1999). The plants with rhizomes and rhizospheres in the root zone treatment system play key role in treating the wastewater. The striking observations indicate that the deep roots and rhizomes create a large volume of active rhizospheres per unit treatment area. The important function of the plants in the bed of constructed wetland is to supply oxygen to the heterotrophic group of microorganisms in the rhizospheres. It also helps to increase the hydraulic conductivity of the soil. The roots and rhizomes leave horizontally through interconnected channels upon executing the role of decaying. According to Kickuth (1980) these microspores stabilize the hydraulic conductivity in the rhizosphere at a level equivalent to coarse sand within 2-3 years regardless of the soil environment.

The sewage collected was initially having turbid colour. It was full of dirt containing solids. The present experimental work focuses on the overall performance of *Cana indica* for the treatment of sewage. Water quality parameters studied such as pH, EC, TSS, TDS, TS, COD, BOD, COD, NO_3, PO_4, SO_4 reflected different treatment efficiencies at varied concentrations of sewage under the treatment in the constructed wetland.

The colour and odour were removed and hence treated samples were observed clear and odorless **(Figure 1f).** The pH values in before and after treatment sets were changed at different concentrations of treatment. In all sets of dilutions the results obtained were in near to the neutral range **(Table 1**) of pH. The pH before treatment in the set of 10 % concentration was 8.10 and after treatment it was 7.6. In 100% concentration it was 6.76 in before treatment and 7.26 after treatment. Vipat and his coworkers, 2008 reported the change in pH in decreasing mode in their field scale study of domestic wastewater using *Phragmites karka*. Dhote and his coworkers, 2009 also noticed the decreasing trend in pH in the lake water by using various aquatic macrophytes. The effluent standard enacted by Central Pollution Control Board, Ministry of Environment and Forest, India specified the pH of effluent to be in range between 6.5 and 7.5 which were achieved in all treatment sets in the present tests. The EC values were changed after treatment of domestic wastewater in various sets of concentrations. The EC before treatment in the set of 10% concentration was 0.96 µMohs/cm and after treatment it was decreased to 0.82 µMohs/cm. similar reduction trend in EC was noticed in 100% concentration. Before treatment the EC was 2.56µMohs/cm and after treatment it was 1.81µMohs/cm. In all these sets of dilution of wastewater, EC levels were reduced after treatment. The maximum reduction in E.C was observed in 80% concentration which was by 33.51%.

Solid contents such as TSS, TDS and TS estimated before and after the treatment reflected improvement in the quality of wastewater with phytoremediation. The TSS contents were 117 mg/L in 10% concentration before treatment and after treatment these were 100 mg/L.

Similar reduction was noticed in all concentrations including the 100% concentration. Before treatment TSS concentration was 394 mg/L and after treatment it was 232 mg /L in the set with 100% sewage concentration. The maximum reduction up to 54.48% in TSS was observed in 80% concentration. The TDS concentration was 612 mg/L in 10% concentration before treatment and was reduced to 458 mg/L after treatment. Similar reduction was noticed in 100% dilution. Before treatment TDS concentration was 1364 in 100% concentration and was reduced to 662 mg /L. The maximum reduction in TDS was observed in 90% concentration. It was by 56.01%. The TS concentration was 729 mg/L in 10% concentration before treatment and after treatment it was 558 mg/L. Similar reduction was noticed in 100% concentration with 1758 mg/L before treatment and 894 mg /L after treatment. The maximum reduction in TS was noticed in 80% concentration which was by 55.22%.

The BOD and COD are associated with settleable solids in wastewater which are in colloidal and soluble form. These are removed as the result of metabolic activities of microorganisms along with the physical and chemical interactions within the root zone (Vipat et al, 2008). The performance of phytoremediation treatment process in terms of reduction in BOD_5 is quite significantly consistent. BOD_5 removal efficiency is a function of Hydraulic Retention Time (HRT). The longer HRT increases the interaction within the aquatic plant system, which results in higher organic matter (Kanabkaew and Puetpaiboon, 2004) and can improve treatment efficiency further. The BOD is a function of aerobic or anaerobic decomposition, depending on the oxygen status at the deposition point (Zirschky, 1986). The BOD_5 were estimated in the samples before and after treatment. The treated wastewater collected from outlet was observed to have BOD_5 levels ranging between 3.44 mg/L to 19.09 mg /L. The BOD_5 before treatment in set of 10 % concentration was 4.92 mg/L and it was 3.44 mg/L after treatment. Likewise in 100% concentration the BOD_5 level observed 51.44 mg/L which was decreased to 19.09 mg/L. Highest BOD_5 reduction was observed up to 80% concentration and then reduction efficiency was decreased. The maximum BOD reduction found was by 73.77 % in the 80% concentration. The results are closer to the findings reported by Dhote and coworkers (2007). They reported 75% reduction in BOD at 80% and up to 71% reduction at 100% concentration of lake water. The COD values before treatment and after treatment varied in all sets of concentration. The COD before treatment in the set of 10% concentration was 14.8 mg/L and 8.9 mg/L before and after treatment respectively. In 100% concentration the COD was 118 mg/L and was decreased to 41.4 mg/L after treatment. The COD reductions were found in increasing order up to 80 % then in decreasing order. The maximum COD reduction up to 75.19 % was found in the 80% concentration.

Nitrates are commonly present in various forms in the wastewater and are important for plant growth. Removal of nitrogen conventionally takes place through several processes like plant uptake, ion exchange, ammonia (NH_3) volatilization, nitrification and denitrification (Gersberg et al, 1983; Chang-gyun et al, 2009; Vipat et al, 2008). Habrel and Perfler (1991) indicated the pathway of N-removal through the plant uptake as insignificant while Breen (1990) considered such plant uptake as a dominant mechanism for nitrogen removal. However NH_3 volatilization (Billore, et al, 1999), nitrification and denitrification (Brix, 1987, 1993; Kadlec and Knight, 1996) are considered to be key removal processes in wetland. Nitrates were estimated by Phenol Disulphonic Acid (PDA) method in the present investigation. The values of nitrates showed variable nature at various concentrations. Nitrates in treated effluent at outlet were observed in the range of 3.2 mg /L to 7.2 mg /L and the percentage reductions were in between 40.74 % to 73.13 %. Maximum reduction up to 73.13% was found in 100 % concentration of sewage. Similar reduction is reported by Billore and his coworkers (2002).

Phosphate is a main nutrient, significantly needed for the functioning of terrestrial as well as aquatic ecosystems. It is required for better plant growth and is a limiting key factor for vegetative productivity. Although, the introduction of trace amount of phosphorus into receiving waters can have negative effects on the structure and productivity of the aquatic ecosystem in the form of eutrophication (Kadlec and Wallace, 2008). The removal and recovery of phosphate from wastewaters is important to reduce eutrophication problem in the receiving water bodies. Conventional technologies for phosphorus removal have been investigated since 1950’s to overcome the problem of eutrophication. Investigations of P removal by wetland systems have been performed in the USA (Moshiri, 1993; Kadlec and Knight, 1996), and Denmark (Schierup et al., 1990), Norway (Zhu et al., 1997), Czech Republic (Vymazal, 1995) more recently in Netherlands (Schreijer et al., 1997) and in several countries in Europe. The phosphorus is found as phosphate in organic and inorganic matter in the wetlands, where free orthophosphate is utilized directly by algae and macrophytes (Vymazal, 2007). Recently, interest in the effective removal of phosphorus from wastewaters is growing with the constructed wetlands (Prochaska and Zouboulis, 2006; Hoffmann et al, 2011 and Bayansan 2011).

The phosphates removed in the treated wastewater at outlet of constructed wetland were observed in between 2.41 mg/L to 10.63 mg /L. Phosphate reduction increased up to 80% of sewage dilution then there was decrease in it. Maximum reduction up to 56.02 % was found in 80% sewage concentration. Ayaz and Akca, (2001) noticed similar reduction of phosphates in batch type system. Phosphorous can be removed in constructed wetlands by plant and microbial uptake in several ways including fragmentation, leaching, mineralization, sedimentation, adsorption and precipitation.

The observed levels of sulphate from outlet of treated wastewater ranged from 19.46 mg /L to 57.0 mg /L. The sulphate removal in the set of 10% sewage concentration was 30.05 % and in 100% sewage concentration it was 46.72 %. The highest sulphate removal efficiency was 49.48% found in the 90% sewage concentration. The overall results obtained from analysis of treated wastewater samples in present investigation indicated **(Table 2)** that the phytoremediation is more effective up to the sewage concentration of up to 80% and the characteristics of treated water signify that the treated water can be useful for agriculture, washing, gardening, planting or many more purposes.

4. CONCLUSION

Phytoremediation with the appropriate assortment of locally adaptive aquatic plant is an assured, more trust worthy and sustainable technology for better treatment of sewage in local environment. It is concluded that *Cana indica* is a suitable aquatic plant for sewage treatment. This is an adaptive plant in western region of India. It has considerable capacity of pollution reduction from the sewage and the capacity of generating treated water. The treatment efficiency increases with dilution. The treated water is apparently clear for common water uses. Such water is useful for gardening, washing, irrigation and general uses like cooling and floor washing and cleaning applications in both, household and industries.

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