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Treatment of Vellalore municipal sewage water using aquatic weeds

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Abstract
The circular economy is the concept in which products materials (and raw materials) should remain in the economy for as long as possible and waste should be treated as secondary raw materials that can be recycled to process and reuse. The treatment of water is very essential to reduce the pollution load. Vellalore municipal sewage is treated using aquatic weeds *Ceratophyllum demersum* and *Pistia stratiotes*. The various parameters has been analysed.

Keywords: *Ceratophyllum demersum*, *Pistia stratiotes*, Vellalore municipal, aquatic weeds

Introduction

The waste waters from the industries and domestic areas affect the water quality by colouring agents, high organic content, widely varying pH, presence of heavy metals and other pollutants. The low dissolved oxygen concentrations which are characteristic of many polluted waters increase the toxicity to the living organisms like fishes.

These effluents and run-off from fields which comprise of chemicals of versatile nature, exert their toxic effects on aquatic animals by depleting the dissolved oxygen, altering the pH, salinity, carbon dioxide content and thereby directly or indirectly affecting the life cycle as well as the metabolic activity of the aquatic animals and plants at the biochemical level. Biological methods of treatments, especially using macrophytic plants is simple, safer and cost effective. It can be used at any time at any season. It is an economically viable technology. The use of adsorbents like activated carbon is also a simple mechanism, cost effective and efficient in the removal of certain pollutants.

Sen and Mondal (1990) [13] indicated that the aquatic plant, *Salvinia natans L*. was found to be very useful in the removal of copper (II) from waste water. Tripathi and Chandra (1991) [14] reported on the influence of metal chelators, EDTA, salicylic acid and pH on the accumulation of chromium by *Spirodela polyrhiza* under laboratory conditions.

Mandi (1994) [12] reported on the capacities of two vascular aquatic plants, *E. crassipes* and *L. gibba* in the purification of waste water in Marrakesh, Morocco. Studies on management of Lead (II) contaminated industrial waste water by *Pistia stratiotes* was studied by Ghosh *et al*., (2003) [11].

Materials and Method

Characteristics of Study Area

The Sanganur canal, an open drainage in Coimbatore has its origin from the Western Ghats, namely, Kuridimalai Hills and flows from west to east and enters Coimbatore city limit at Coimbatore-Mettupalayam Road and flows for about 10km within the city. It is a major open drainage system which has intricate linkage with storm water supply, domestic sewage and industrial effluent disposal (forming municipal sewage). Sewage and sullage from adjoining areas, flow in this drain and finally confluences with Singanallur pond and Noyyal River at the upstream of Checkdam at Vellalore.

Vellalore municipal sewage

Fig 1: Sampling station of Sanganur canal

Treatment using aquatic weeds

Aquatic weeds selected for the study were *Ceratophyllum demersum* and *Pistia stratiotes*. Plants of equal size from each group were used for the experiment. Municipal sewage water sample was taken in seven plastic troughs (7 litre capacity), weighed quantity of two types of aquatic plants were introduced separately to each tub containing Vellalore municipal sewage water. One tub containing the same municipal sewage water without the plants, served as control. All the troughs were kept exposed to sunlight for 48, 72 and 96 hour and the plants were removed after these periods of treatment and the parameters were analysed in the control and the plant treated waters.

Results and Discussion

Removal of Pollution Load in Different Hours of Treatment

The Vellalore municipal sewage water after subjected to various treatments for 48, 72 and 96 hours with the selected aquatic weeds (*C.demersum* and *P.Stratiotes*), showed a very good reduction of pollution parameters.

pH

pH of the municipal sewage sample showed little alteration with treatments after 48 and 72 hours. In the 96 hours duration treatment, with *P.stratiotes* and *C.demersum* showed an increase in pH from 7.74 to 8.00, 8.05 and 8.16 respectively.

EC

Among the different treatments 96 hours treatment showed better reduction rate. Maximum reduction of EC was observed in *C.demersum* (3.39 mmhos/cm -2.20 mmhos/cm) followed by *P.stratiotes* (2.50 mmhos/cm).

Total solids

Though significant reduction in the level of total solids was observed in all the treatments 96 hours duration treatment showed better effect. Minimum reduction was brought about by *C. demersum* and *P. stratiotes* (8000.00mgl^{-1} to 2000.00 mgl^{-1}).

Total dissolved solids

Among the three treatments 96 hours treatment showed better effect. The treatments with *C. demersum* and *P.stratiotes* (5333.3 mgl^{-1} to 666.67 mgl^{-1}) showed maximum reduction.

Biological oxygen demand

Different hours of treatment with various materials showed BOD reduction. BOD removal was better achieved during 96 hours treatment. The aquatic weeds *P. stratiotes* and *C. demersum* reduced the BOD of municipal sewage water from the initial level of 123.33 mgl^{-1} to 20.00 mgl^{-1} and 35.00 mgl^{-1}.

Chemical oxygen demand

Better impact on COD removal was in 96 hours treatment with various materials. Treatments with *P. stratiotes* and *C. demersum* reduced COD from 277.33 mgl^{-1} to 146.67 mgl^{-1} and 157.33 mgl-1 respectively.

The relationship between BOD –COD during treatments

Analysis of correlation co-efficient indicated a low degree of positive correlation between BOD and COD in all the treatments.

Sulphate

Among the treatments 96 hours treatment showed better reduction effect on sulphate. Maximum reduction in sulphate level was observed in treatment with *C. demersum* and *P. stratiotes* (40.00 mgl^{-1} to 5.00 mgl^{-1}).

Phosphate

The 96 hours treatment showed phosphate reduction with better effect. The aquatic weeds *P.stratiotes* and *C. demersum* reduced the level of phosphate of the municipal sewage water from the initial level of 9.47 mgl^{-1} to 3.73 mgl^{-1} and 5.03 mgl^{-1} respectively.

Table 1: Variation between treatment group in reduction of pollution load in 48 hours

Treatment	pH	EC	TS	TDS	BOD	COD	Sulphate	Phosphate
R-Raw municipal sewage water	7.74	3.39	8000.00	5333.33	123.33	277.33	40.00	9.47
T_1– *C.demersum*	8.35	2.50	4000.00	2000.00	38.33	173.33	8.33	5.23
T_2– *P. stratiotes*	8.34	2.80	2666.67	1333.33	30.00	157.33	10.00	4.07
SEd	0.01	0.03	674.77	801.49	3.90	6.13	2.11	0.08
CD (0.05)	0.01	0.07	1447.40	1719.21	8.38	13.15	4.53	0.17
CD (0.01)	0.02	0.09	2008.83	2386.07	11.60	18.25	6.29	0.24
F-ratio	5113.29**	323.316**	27.92**	9.325**	114.76**	360.53**	69.60**	1187.03**

Table 2: Variation Between Treatment Group in Reduction of Pollution Load in 72 Hours

Treatment	pH	EC	TS	TDS	BOD	COD	Sulphate	Phosphate
R-Raw municipal sewage water	7.74	3.39	8000.00	5333.33	123.33	277.33	40.00	9.47
T_1– *C.demersum*	8.21	2.30	4000.00	2000.00	36.67	165.33	6.67	5.17
T_2– *P. stratiotes*	8.23	2.70	2000.00	1333.33	23.33	149.33	6.67	3.93
SEd	0.01	0.03	674.77	801.49	3.90	6.13	2.11	0.08
CD (0.05)	0.01	0.07	1447.40	1719.21	8.38	13.15	4.53	0.17
CD (0.01)	0.02	0.09	2008.83	2386.07	11.60	18.25	6.29	0.24
F-ratio	5113.29**	323.316**	27.92**	9.325**	114.76**	360.53**	69.60**	1187.03**

Table 3: Variation Between Treatment Group in Reduction of Pollution Load in 96 Hours

Treatment	pH	EC	TS	TDS	BOD	COD	Sulphate	Phosphate
R-Raw municipal sewage water	7.74	3.39	8000.00	5333.33	123.33	277.33	40.00	9.47
T_1– *C.demersum*	8.16	2.20	2000.00	666.67	35.00	157.33	5.00	5.03
T_2– *P. stratiotes*	8.05	2.50	2000.00	666.67	20.00	146.67	5.00	3.73
SEd	0.01	0.03	674.77	801.49	3.90	6.13	2.11	0.08
CD (0.05)	0.01	0.07	1447.40	1719.21	8.38	13.15	4.53	0.17
CD (0.01)	0.02	0.09	2008.83	2386.07	11.60	18.25	6.29	0.24
F-ratio	5113.29**	323.316**	27.92**	9.325**	114.76**	360.53**	69.60**	1187.03**

All values are in mgl-1 except pH and EC in mmhos/cm.
SEd – Standard deviation
CD – Critical Difference
** Significant at 1% level.

Treatment of Vellalore Municipal Sewage water by using aquatic weeds

The physico-chemical, biological and heavy metal monitoring of the municipal sewage water revealed the high level of pollution of Vellalore municipal sewage water.

The bioaccumulation of heavy metals altered biochemical responses, hitopathological studies revealed the damages caused in the systems of fishes. Consumption of such fishes by human beings will certainly cause health risks. This points need for the treatment of the municipal sewage water before it is utilized for agriculture or fish culture.

Vellalore municipal sewage water is being utilized for irrigation purpose. The plants absorb pollutants and heavy metals and store in the edible parts. Through food chain these pollutants reach human body resulting in biomagnifications and related health hazards. So Vellalore municipal sewage water was selected for treatment studies. Treatments methods are cost involved. Generally in industries people do not opt for costly treatment procedures. So it is better to employ low cost treatment techniques like use of biological agents, adsorbents and simple chemical method which will be effective and can be adopted at any stage.

The aquatic weeds, *C. demersum*, *P. stratiotes* are found to be the economically viable choices for municipal sewage water treatment for the removal of EC, BOD, sulphate and phosphate.

Suvarna and Charya (1995) have observed a gradual change in the pH from neutral to alkalinity with the increase in the incubation time in pistia grown medium which may be attributed to the release of free ions from the plant to the medium. Similar increase in pH has been recorded during treatment with *P. stratiotes* and *C. demersum*.

Maximum reduction in EC was achieved by *C. demersum* in 96 hours treatment. Similarly Mishra *et al*., (1991) [2] have obtained a reduction in EC in the treatment of waste water using water hyacinth.

Murugesan *et al*., (1996c) [5] have achieved 89 per cent of total dissolved solids reduction by *P. stratiotes*, 77 per cent by *Trapha*, 82 per cent by *Salvinia molesta*. Similar results were observed in the present study wherein 75 per cent, 75 per cent and 87.50 per cent of total dissolved solids was removed from municipal sewage water treated with *P. stratiotes*, 62.50 per cent, 62.50 per cent and 87.50 per cent by *C. demersum* during 48, 72 and 96 hours treatment. Removal of solids by plants is probably due to the root system which favour sedimentation of solid particles both on the bottom of the container as well as by trapping in the root hairs.

BOD removal was found to be effective by plants as in the present study 83.78 per cent removal was achieved in 96 hours treatments with *P. stratiotes*. Similarly Zhenbin *et al*., (1993) [10] have achieved 85.57 per cent of BOD reduction in municipal waste water treated with *Eichhornia spirodela*, *Pistia* and *Alternanthera*. Murugesan *et al*., (1996a) [4] have reported 71 per cent BOD reduction by *Trapha* and 67 per cent BOD by *pistia*, 80 per cent by *E. crassipes* and 92 per cent reduction of BOD from rubber factory effluent in seven days.

The aquatic weeds used for BOD removal seems to function as fixed film reactors with the submerged plant structures act as a substrate for bacteria. Some aquatic plants can transport atmospheric oxygen from the foliage into the root (De Busk, 1987). Oxygen not required for root respiration may diffuse into the waste water and be utilized by bacteria for the oxidation of BOD. This statement agrees with the present finding with regard to the efficiency of *P. stratiotes* which effects 75.68 per cent, 81.08 per cent and 83.78 per cent removal of BOD during 48, 72 and 96 hours treatment. 68.92 per cent, 70.27 per cent and 71.62 per cent removal of BOD by *C. demersum* from municipal sewage water during 48, 72 and 96 hours respectively.

According to Sinha and Sinha (1969) [9] aquatic plants have been reported to be effective in controlling the growth of algae in lagoons and purification of waste water by their cellular enzyme system accomplishing oxidation without oxygen by removal of hydrogen. This higher rate of oxidation might be one of the reasons for reduction of BOD values in waste waters.

Sulphates and phosphates have been effectively removed by plants during treatment for 48, 72 and 96 hours and it was found 87.5 per cent removal of sulphate through the treatment with *C. demersum* and *P. stratiotes* and 60.61 per cent removal of phosphate was achieved through P. stratiotes treatment in 96 hours. Murugesan *et al*., (1996a) [4] have observed a higher percentage of removal of sulphur from rubber factory effluent by various aquatic weeds such as *E.crassipes* (78 per cent), *Trapha* (74 per cent), *Pistia* (89 per cent) and *Salvinia* (83 per cent).

Zhenbin *et al*., (1993) [10] have observed a minimum of 15.8 per cent reduction of the total phosphate from waste water treated with *Eichhornia*, *Spirodela*, *Pistia* and *Alternanthera*.

Pescod (1994) [8] has indicated that *C. demersum* a submerged macrophyte is very efficient in removing phosphorous upto 96 per cent.

Ceratophyllum may also play an important role in stabilizing and maintaining a clear water state at high phosphate concentration (Mjelde and Faafeng, 1997) [3].

The higher removal efficiency of nutrients (sulphate, phosphate) could be attributed to the ultimate utilization of the nutrients by the aquatic plants for their growth (Mohan *et al*., 1988) [6]. Chapol Kumar Roy *et al*., (2018) [15] studied the characterization and treatment of textile wastewater by aquatic plants (Macrophytes) and Algae.

Aquatic Weeds used for the Study

C. demersum *P. stratiotes* Treatment with aquatic weeds

Fig 2: R- Raw waste water, **T1**- 48 hrs with *C.demersum*, **T2** – 72 hrs with *C.demersum*, **T3** – 96 hrs with *C. demersum*, **T4** – 48 hrs with *P.stratiotes*, **T5** – 72 hrs with *P. stratiotes*, **T6** – 96 hrs with *P. stratiotes*

Table 4: Pollution Load Removal Efficiency in Percentage by Biological Treatments and Impact Of Time Duration

Parameters	**Percentage efficiency of biological treatment**					
	C. demersum			***P. stratiotes***		
	48 hrs	**72 hrs**	**96 hrs**	**48 hrs**	**72 hrs**	**96 hrs**
pH	7.88↑	6.07↑	5.43↑	7.75↑	6.33↑	4.01↑
EC	26.25↓	32.15↓	35.10↓	17.40↓	20.35↓	26.25↓
TS	50.00↓	50.00↓	75.00↓	66.67↓	75.00↓	75.00↓
TDS	62.50↓	62.50↓	87.50↓	75.00↓	75.00↓	87.50↓
BOD	68.92↓	70.27↓	71.62↓	75.68↓	81.08↓	83.78↓
COD	37.50↓	40.39↓	43.27↓	43.27↓	46.15↓	47.11↓
Sulphate	79.18↓	83.33↓	87.50↓	75.00↓	83.33↓	87.50↓
Phosphate	44.77↓	45.41↓	46.88↓	57.02↓	58.50↓	60.61↓

All the values are in percentage
↑ denotes increase
↓ denotes decrease

Conclusion

Among the treatments maximum reduction of BOD, sulphate and phosphate was achieved by the biological method. It is proved to be effective in removing the parameters.

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