Comparative study of waste water treatment by plants and algae

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Abstract : With the increase in the number of the sugar mills it has resulted in bulk generation of high strength waste water. The sugar mill waste water has a relatively clear appearance. However after stagnation even for some time, the waste water turns black and starts emitting foul odor. Discharge of untreated waste water can result in depletion of the dissolved oxygen of the water body hence making it unfit for fish and other aquatic species.

The aim of this paper is to seek and imply an efficient and cost effective waste water treatment for the high strength sugar mill effluent. A pilot scale algal pond, with volume of 16 litres , 25 cm in depth along with some aquatic plant species like myriophyllum, salvinia and ludwigia were taken for the treatment of sugar mill effluent. The objective of the paper is to carry a comparative study to investigate the enhanced removal efficiency of unconventional plants and algae and as a post treatment. The influent and the effluent were analyzed for pH, TS, BOD_5, COD, TKN and TP after a period of 10 days after the commencement of the experiment. The results showed that ponds with aquatic plants were superior to those with algae. Specifically the system with Salvinia showed the best pollutant removal efficiency for sugar mill waste water as a post treatment

1. Introduction

Maharashtra is the largest producer of sugar in India and per capita consumption of sugar in India is approximately 134 Kg per annum. There are about 400 operating sugar mills in states of Uttar Praadesh, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. Sugar Mills consume about 1500-2000 litres of water and generate 1000 litres of waste water for per ton of cane crushed. The effluent mainly consists of floor washing waste water and condensate water. Algal and aquatic ponds are accounted as one of the processes for waste water recovery and recycling. The principle removal mechanisms are based on physical sedimentation and bacterial metabolic activity as in conventional activated sludge process and trickling filters.

2. Methodology

As discussed the mentioned plant species and algaes were planted in plastic tubs, each having a volume of 16 litres and depth of 24 cm. Aquatic plants are so chosen which have a tendency to grow superficially in the tub containing waste water from a sugar mill.

The detention time provided for each waste water sample is 10 days. At the end of 10 days the treated waste water is tested with various parameters including 5-day Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Solids (TS), Total Kjeldhal Nitrogen (TKN) and Total Phosphorus (TP).

3. Plant Species used

Salvinia, a genus in the family Salviniaceae, is a floating fern named in honor of Anton Maria Salvini, a 17th-century Italian scientist. Watermoss is a common name for *Salvinia*.[1] The genus was published in 1754 by Jean-François Séguier, in his description of the plants found round Verona, *Plantae Veronenses*. Twelve species are recognized, at least three of which (*S. molesta*, *S. herzogii*, and *S. minima*) are believed to be hybrids, in part because their sporangia are found to be empty. *Salvinia* is related to the other water ferns, including the mosquito fern *Azolla*. Recent sources include both *Azolla* and *Salvinia* in Salviniaceae, although each genus was formerly given its own family. *Salvinia*, like the other ferns in order Salviniales are heterosporous, producing spores of differing sizes. However, leaf development in *Salvinia* is unique. The upper side of the floating leaf, which appears to face the stem axis, is morphologically abaxial.[3]From a human point of view, when their growth is robust the plants pose a particular hindrance on certain lakes, having choked off much of the water in Lake Bistineau near Doyline in Webster Parish, Louisiana. Other problems affected a second Webster Parish site, Caney Lakes Recreation Area.

Myriophyllum (**watermilfoil**) is a genus of about 69 species of freshwater aquatic plants, with a cosmopolitan distribution. The center of diversity for *Myriophyllum* is Australia with 43 recognized species (37 endemic).[1][2] Its name comes from Latinized Greek, "myrio" meaning "ten thousand", or figuratively "too many to count", and "phyllum" meaning "leaf".These submersed aquatic plants are perhaps most commonly recognized for having elongate stems with air canals and whorled leaves that are finely, pinnately divided, but there are many exceptions. For example, the North American species *M. tenellum* has alternately arranged scale like leaves, while many Australian species have small alternate or opposite leaves that lack dissection. The plants are usually heterophyllous, leaves above the water are often stiffer and smaller than the submerged leaves on the same plant and can lack dissection. Plants are monoecious or dioecious, the flowers are small, 4(2)-parted and usually borne in emergent leaf axils. The 'female' flowers usually lack petals. The fruit is a schizocarp that splits into four (two) nutlets at maturity. The fruits and leaves can be an important food source for waterfowl, which are thought to be an important source of seed and clonal dispersal.

Ludwigia adscendens, with common name **water primrose**, is a species of flowering plant in the evening primrose family. Its native distribution is unclear. It is now a common weed of rice paddies in Asia and occurs also in Australia and Africa, but may have originated in South America. This plant is a perennial floating herb with white spongy buoys, and can float on water surface as well as creep over the surface of wetlands. The plant has simple leaves with elliptic blades, which are 0.4–7 cm long and 0.7–3 cm wide. Its petioles are 0.5–1.0 cm short. Its cream flowers emerge singly at axils, and each has 5 sepals, 5 petals, and 10 stamens.

4. Inlet Parameters-

In order to assess the removal efficiencies of various plants and algae the effluent sample was collected from a sugar industry.

Parameter	Range
pH	5.2-6.5
Color	Reddish Yellow
Total suspended solid (TSS) mg/l	760-800
Volatile suspended solid (VSS) mg/l	173-2190
Chemical Oxygen Demand (COD) mg/l	1000-4340
Bio chemical oxygen demand (BOD) mg/l	350-2750
Phosphorous mg/l	1.3-2.5
Total kjeldhal nitrogen (mg/l)	15-40

5. Results and Discussion

Parameter	Dilution	Influent	Effluent							
			Myriophyllum	%R	Salvinia	%R	Ludwigia	%R	Algae	%R
pH	100	5.3	5.41	-	5.95	-	6.08	-	5.23	-
	75	6.6	5.58	-	7.24	-	6.31	-	6.30	-
	50	7.1	7.44	-	7.66	-	7.36	-	7.10	-
	25	7.5	7.72	-	7.90	-	7.60	-	7.30	-
BOD	100	496.62	407.72	17.9	149.97	69.80	233.10	53	446.96	10
	75	354.50	272.61	23.1	90.043	74.60	124	65.2	305.9	13.7
	50	280.73	192.02	31.60	49.68	82.30	86.18	69.3	230.19	18
	25	172.50	106.40	38.3	19.147	88.9	47.61	72.4	135.7	21.3
COD	100	1096.3	807.9	26.3	416.59	62.7	574.4	47.6	962.5	12.2
	75	986.7	612.7	37.9	277.2	71.9	431.1	56.3	827.8	16.1
	50	915.1	536.6	41.4	163.8	82.1	301.0	67.1	723.8	20.9
	25	859.6	417	45.2	31.8	96.3	233.1	73	639.5	25.6
TOTAL SOLIDS	100	1.58	1.23	22.1	0.37	76.3	0.53	66.2	1.57	4.6
	75	0.76	0.17	17.2	0.28	62.4	0.29	61.3	0.79	-
	50	0.46	0.42	7.1	0.20	54.7	0.19	58.4	0.45	2.1
	25	0.28	0.27	4.1	0.13	51.3	0.12	54.2	0.30	-
TOTAL PHOSPHORUS	100	1.3	0.86	33.8	0.52	59.8	0.53	59.1	0.61	52.9
	75	1.1	0.69	37.2	0.39	64.4	0.41	62.8	0.49	54.8
	50	1	0.58	41.7	0.30	69.1	0.45	54.2	0.39	60.1
	25	0.9	0.49	45.1	0.24	73.6	0.41	53.9	0.32	64.2
TKN	100	15.12	7.35	51.4	6.94	54.1	3.26	78.4	6.47	57.2
	75	11.2	4.77	57.4	4.51	59.7	3.21	71.3	6.10	45.45
	50	10.08	6.85	61.8	3.69	63.4	3.66	63.7	6.0	40.4
	25	8.96	2.94	67.2	2.7	69.8	3.91	56.4	5.98	33.33

The removal efficiencies of the various parameters by using the different plants and algae is mentioned below-

6. Phosphorus Removal

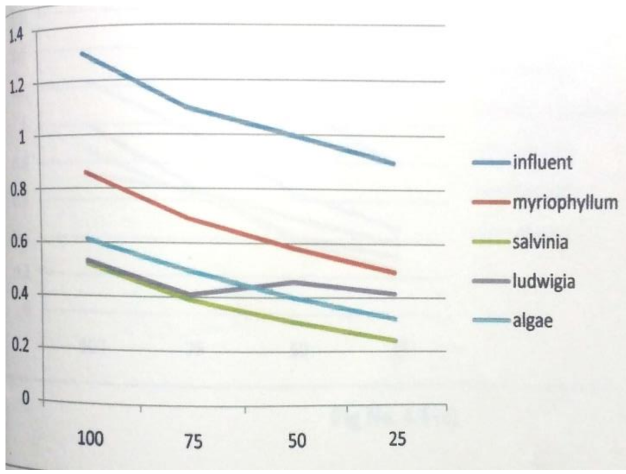

Fig: Total Phosphorus removal from experimental setup.

The decay of plant biomass can reduce the removal efficiency. For phosphorus removal, the Ludwigia showed higher efficiency then Myriophyllum, Salvinia and algae units. The Phosphorus present in waste water is up taken by the plants for their growth, especially by Ludwigia.

7. Total Solids Removal

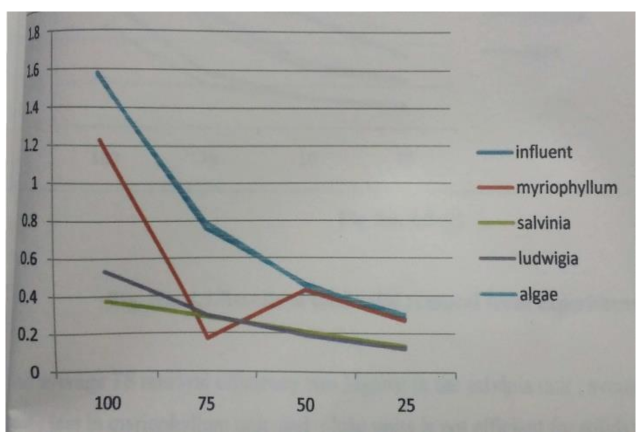

Fig: Total Solids removal from the setup.

The Total Solids removal efficiency was highest in the Salvinia unit, average for Ludwigia unit, less in myrophyllum unit and algae unit is not efficient for solids removal. Adsorption of TS by submerged roots of plants in Salvinia and Ludwigia unit could increase the TS removal efficiency in comparison to the others.

8. Chemical Oxygen Demand Removal

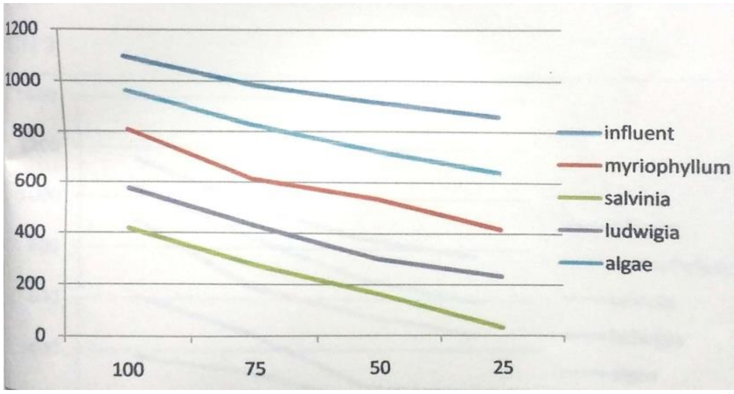

Fig: COD removal from experimental setup.

The COD standard for irrigation as per CPCB is 250mg/L. Among all the plants and algae only Salvinia and ludwigia units could meet this regulation. The stems and leaves of aquatic plants provide a good habitat for bacteria to assimilate the colloidal/soluble BOD remaining in waste water.

9. Biochemical Oxygen Demand Removal

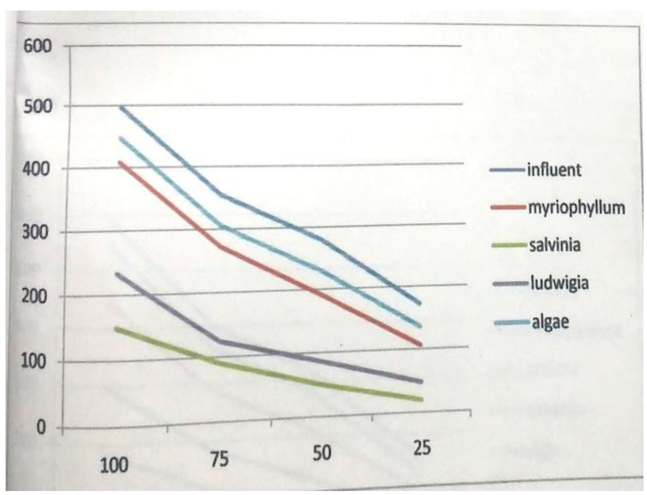

Fig: BOD removal from experimental setup.

The BOD standard for irrigation as per CPCB is 100mg/L. Among all the plants and algae only Salvinia and ludwigia units could meet this regulation. The stems and leaves of aquatic plants provide a good habitat for bacteria to assimilate the colloidal/soluble BOD remaining in waste water.

10. Total Kjhekdal Nitrogen Removal

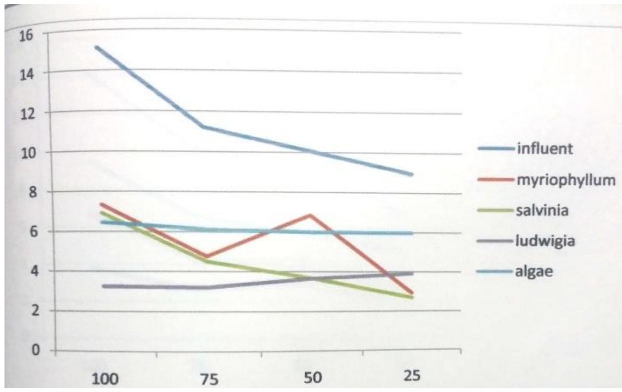

Fig: TKN removal from experimental setup.

Nutrients, especially nitrogen and phosphorus, have been recognized as the pollutants that contribute to eutrophication I lakes and slowly flowing water bodies. Even though there was low nitrogen concentration, high amount of eutrophication is observed in the effluent of the sugar industry.

11. Conclusion

Based on the results presented, the system m with Salvinia showed the best removal efficiency for the pollutant removal in the sugar industry waste water as a post treatment, while the algae unit was troubled with high pH in the effluent and under suspicion with SS removal.

Hence it is concluded that algae and Myriophyllum are not suitable for sugar industry effluent. However constructed ponds with aquatic plants and algae can result on higher efficiency and more advantage then a system with single specie of plant.

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