Use of Aquatic Plant (Water Hyacinth) in Wastewater Treatment

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Abstract

Pollution of water is a major environmental problem and most conventional remediation approaches do not provide acceptable solution to pollution problem. The use of special plants for environmental clean-up is an emerging technology called phytoremediation. This paper is an attempt to study the phytoremediation efficiency of water hyacinth (*Eichhornia crassipes*). A natural wastewater treatment system using water hyacinth was studied with five different wastewaters such as wastewaters from mohinga, candied papaya, chilli sauce, soya-bean sauce, and noodle manufacture in Yangon. Wastewaters were subjected to water hyacinth treatment unit in the laboratory for one month. Samples were withdrawn weekly and the common pollutional parameters such as pH, TSS, TDS, COD, and BOD_5 were monitored. The culturing of water hyacinths in the treatment system reduced TSS (up to 96%), TDS (up to 81%), COD (up to 98%) BOD_5 (up to 98%) and the pH of the sample changed towards neutral. The effect of water hyacinth has resulted in significant decrease in turbidity and due to which the removal of flocs and reduction in organic matters in water have been observed. The applicability of water hyacinth system was gauged based on comparative study with plain sedimentation. Contamination is removed from polluted waters as a result of combination of biological, chemical, and physical factors. Use of water hyacinths for wastewater treatment has been demonstrated to be highly efficient and inexpensive.

Keywords : industrial wastewater, phytoremediation, water hyacinth system, organic matter, efficient and inexpensive

Introduction

Water is our most important industrial raw material. All industries which involved liquid processing operation produce liquid wastes. The conventional treatment system like activated sludge process and trickling filters require energy input for treatment of wastewater. Moreover, in rural areas it is very difficult to practice such treatment process due to economic and space concern. Also skilled labors are required to operate such treatment plants. Hence it is required to find economical and efficient substitute for such treatment plants which should be eco-friendly. Water hyacinth *(Eichhornia crassipes)*, free-floating aquatic plant which is called "beida" in Myanmar, is being used for wastewater treatment. They utilize atmospheric oxygen and carbon dioxide. Almost all the remainder of their sustenance must be obtained from the soluble nutrients in the waters in which they are growing.

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Water hyacinths can reduce the level of algae, suspended solids, dissolved impurities and nutrients and produce a high quality effluent. Hyacinth can also reduce BOD, COD and phenol levels of water by direct uptake. It can also absorb toxic chemicals.

Water hyacinth is an aquatic vascular plant with rounded, upright and shiny green leaves and lavender flowers similar to orchids. Growth of water hyacinth is primary dependent on ability of plant to use solar energy, nutrient composition of water, cultural methods and environmental factors. Optimal water pH for growth of this aquatic plant is neutral but it can tolerate pH values from 4 to 10. This is very important fact because it points that water hyacinth can be used for treatment of different types of wastewater. Optimal water temperature for growth is 28-30ºC. Temperatures above 33ºC inhibit further growth.

Water hyacinth is fast growing perennial aquatic macrophyte with great reproduction potential. It is a member of pickerelweed family. This tropical plant spread throughout the world in late 19^{th} and early 20^{th} century. Today, it is well-known for its reproduction potential and as a plant that can double its population in only twelve days. Water hyacinth is also known for its ability to grow in severe polluted waters. Just like all other biological processes, growth of water hyacinth depends on various ecological factors. The qualities of water and air temperatures are considered as main limiting factors for regular plant development and growth.

It can be adopted in rural areas where conventional treatment methods cannot be used due to economic and space concern. It is an eco-friendly type of system and can be proved as a beneficial substitute for conventional treatment method. The objective of the study is to measure its efficiency parameters like TSS, TDS, COD and BOD_5 removal and compare it with plain sedimentation.

Materials and Methods

About 1kg of water hyacinth plants were spread evenly on the surface of about 20 liters of wastewater sample, contained in a glass tank (45cm × 30cm × 35cm). These plants that decayed were periodically replaced – in this case once a week – with a new batch of plants. About 200 ml of wastewater samples were withdrawn weekly and the parameters such as pH, total suspended solids (TSS), total dissolved solids (TDS), chemical oxygen demand (COD) and biochemical oxygen demand (BOD_5) values were examined according to the "Standard methods for the examination of water and wastewater" for water quality characterization and their results recorded in Tables 1 to 6.

Results and Discussion

Improvement of water quality through the use of water hyacinth system is presented in Tables.

At the end of the detention time of 28 days, the changes in pH value were found to be from 3.7 to 7.4 for mohinga, from 5.5 to 7.5 for candied papaya, from 6.2 to 7.5 for chilli sauce, from 8.1 to 7.1 for soya-bean sauce and from 9.2 to 8.6 for noodle wastewater. These data show that all the pH values change towards neutral. It can be explained as follows. Atmospheric oxygen enters stomata of the hyacinth stems and leaves and transported down into the roots. Masses of primitive organisms cling to the roots, and higher organisms feed upon the attached biota and organic detritus. A shallow surface layer of the water remains aerobic while the benthal waters are anaerobic, providing conditions favorable for nitrification and denitrification. Thus, the waters tend to remain near neutral.

With a detention time of 28 days, reductions in TSS were 95.59% for mohinga, 86.87% for candied papaya, 82.36% for chilli sauce, 81.66% for soya-bean sauce and 93.99% for noodle wastewaters. In the stilled waters particulate matters tend to settle to the bottom, so the amount of TSS decreases. A complex community of organisms in a hyacinth culture basin performed reduction, oxidation and consumption processes. Removal of TSS is fostered by physicochemical and biological factors related to the habitat provided.

The removal of TDS at the end of 28 days for candied papaya, chilli sauce, soya-bean sauce, mohinga and noodle wastewaters were found to be 53.23%, 33.68%, 33.83%, 80.93% and 74.70% respectively. It can be seen from these data that the removal of TDS was generally less than TSS for all wastewaters. It seems that the volume of water from the tank decreased due to loss of water through transpiration by hyacinth leaves, and hence a simultaneous increment of TDS concentration occurred in the tank. Moreover, withering plants decrease in uptake of soluble materials. Plant uptake of soluble materials from the water is restricted to the period of active growth.

Water hyacinth system has advantage over plain sedimentation in inducing purification within a relatively short period. This can be seen in the Tables.

Removal of 81% of TSS in mohinga and 71% of TSS in nooddle were achieved in one week by water hyacinth systems whereas the same amount of removal for these wastes took 2 weeks in plain sedimentation. In candied papaya 75% of TSS was removed in 2 weeks whereas in plain sedimentation it took 4 weeks.

Removal of TDS (ie 74% in mohinga, 24% in candied papaya, 16% in soya-bean sauce and 62% in noodle) were achieved in one week by water hyacinth system whereas the same amount of removal took 3 weeks for candied papaya and soya-bean sauce and 4 weeks for mohinga and noodle in plain sedimentation.

Between 70–82% of COD and BOD_5 were removed in one week for candied papaya, chilli sauce and soya-bean sauce in water hyacinth system whereas the same amount of removal took 4 weeks for candied papaya and soya-bean sauce and 3 weeks for chilli sauce in plain sedimentation. Similar results were also noted for mohinga and noodle (i.e 2 weeks for mohinga and 4 weeks for noodle).

In figures it can be seen clearly that the percentage removal of TSS, TDS, COD and BOD_5 increase with increase in detention time.

Table 1. Pollutional characteristics of wastewaters from cottage food industries in Yangon

Wastewater	pH	Acidity as $CaCO_3$(mg/L)	Alkalinity as $CaCO_3$(mg/L)	Nitrogen (mg/L)	Phosphorus (mg/L)
Mohinga	3.7	1400	-	308	245
Candied papaya	5.5	4800	200	710	220
Chilli sauce	6.2	400	600	325	165
Soya-bean sauce	8.1	300	1000	510	70
Noodle	9.2	-	1800	624	120

Table 2. Comparison of water hyacinth system to plain sedimentation in terms of change in pH

Detention time, day	pH									
	Mohinga		Candied papaya		Chilli sauce		Soya-bean sauce		Noodle	
	PS	WH	PS	WH	PS	WH	PS	WH	PS	WH
0	3.7	3.7	5.5	5.5	6.2	6.2	8.1	8.1	9.2	9.2
7	3.2	4.0	5.2	5.4	7.0	7.1	7.5	7.6	9.0	8.8
14	4.0	4.3	5.4	5.5	7.0	7.3	7.2	7.4	8.8	8.7
21	6.7	6.5	6.8	6.9	7.2	7.4	7.3	7.3	8.6	8.6
28	7.0	7.4	7.2	7.5	7.3	7.5	7.4	7.1	8.4	8.6

PS = Plain sedimentation

WH = Water hyacinth

Table 3. Reduction of total suspended solids by water hyacinth system in comparison with plain sedimentation

Detention time, day	Total suspended solids remaining, %									
	Mohinga		Candied papaya		Chilli sauce		Soya-bean sauce		Noodle	
	PS	WH	PS	WH	PS	WH	PS	WH	PS	WH
0	100	100	100	100	100	100	100	100	100	100
7	42.1	19.17	80.03	69.66	55.09	55.09	69.97	62.52	48.34	28.34
14	16.01	11.34	53.28	25.44	29.99	37.33	50.66	41.30	26.01	14.68
21	9.76	7.00	32.37	17.22	19.05	26.90	36.46	28.51	15.01	9.51
28	5.96	4.41	30.20	13.13	14.55	17.64	23.67	18.34	8.34	6.01

PS = Plain sedimentation

WH = Water hyacinth

Table 4. Reduction of total dissolved solids by water hyacinth system in comparison with plain sedimentation

Detention time, day	Total dissolved solids remaining, %									
	Mohinga		Candied papaya		Chilli sauce		Soya-bean sauce		Noodle	
	PS	WH	PS	WH	PS	WH	PS	WH	PS	WH
0	100	100	100	100	100	100	100	100	100	100
7	55.62	25.88	80.0	75.59	73.85	74.23	94.54	84.37	65.25	38.26
14	29.99	21.24	78.09	57.65	56.28	69.99	86.86	77.52	48.76	27.50
21	26.79	19.25	76.17	51.88	52.23	68.44	84.05	70.21	41.26	26.13
28	26.79	19.07	72.46	46.77	51.84	66.32	77.92	66.17	37.5	25.30

PS = Plain sedimentation

WH = Water hyacinth

Table 5. Reduction of COD by water hyacinth system in comparison with plain sedimentation

Detention time, day	COD remaining, %									
	Mohinga		Candied papaya		Chilli sauce		Soya-bean sauce		Noodle	
	PS	WH	PS	WH	PS	WH	PS	WH	PS	WH
0	100	100	100	100	100	100	100	100	100	100
7	90.67	79.51	75.83	29.68	43.48	25.14	50.45	23.86	55.07	3.62
14	56.00	39.70	50.00	13.70	30.43	18.21	35.91	12.73	33.96	12.88
21	48.76	24.66	34.08	6.71	25.27	14.81	32.27	8.86	22.03	4.95
28	45.49	22.37	29.73	2.42	22.42	12.23	28.41	6.82	14.15	1.93

PS = Plain sedimentation

WH = Water hyacinth

Table 6. Reduction of BOD_5 by water hyacinth system in comparison with plainsedimentation

Detention time, day	BOD_5remaining, %									
	Mohinga		Candied papaya		Chilli sauce		Soya-bean sauce		Noodle	
	PS	WH	PS	WH	PS	WH	PS	WH	PS	WH
0	100	100	100	100	100	100	100	100	100	100
7	93.36	82.13	78.42	27.85	47.43	28.75	51.89	18.15	59.80	43.34
14	59.65	41.96	53.32	11.78	33.91	20.69	37.73	11.04	30.02	14.37
21	48.41	24.70	35.54	5.30	28.87	17.10	32.45	8.57	25.75	5.76
28	43.24	21.13	29.83	1.76	26.78	14.62	26.69	6.92	17.00	2.38

PS = Plain sedimentation

WH = Water hyacinth

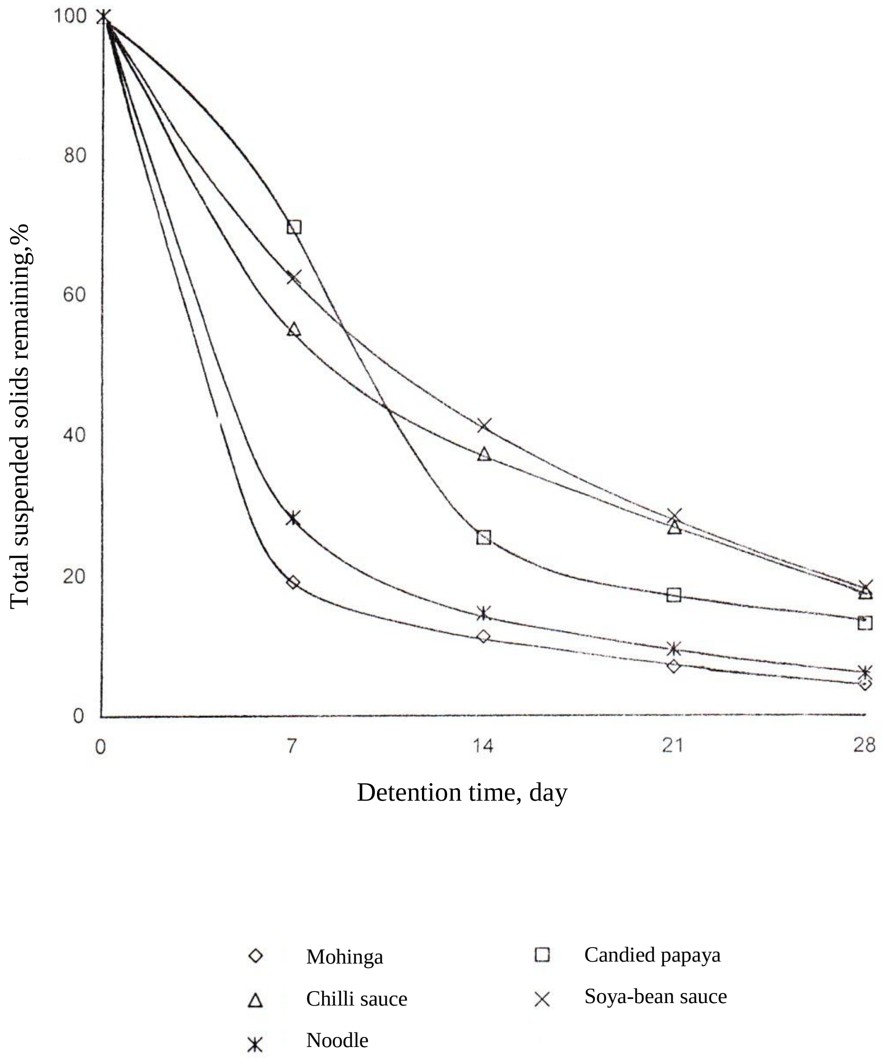

Fig 1. Effect of water hyacinth system on reduction of total suspended solids for various types of wastewater

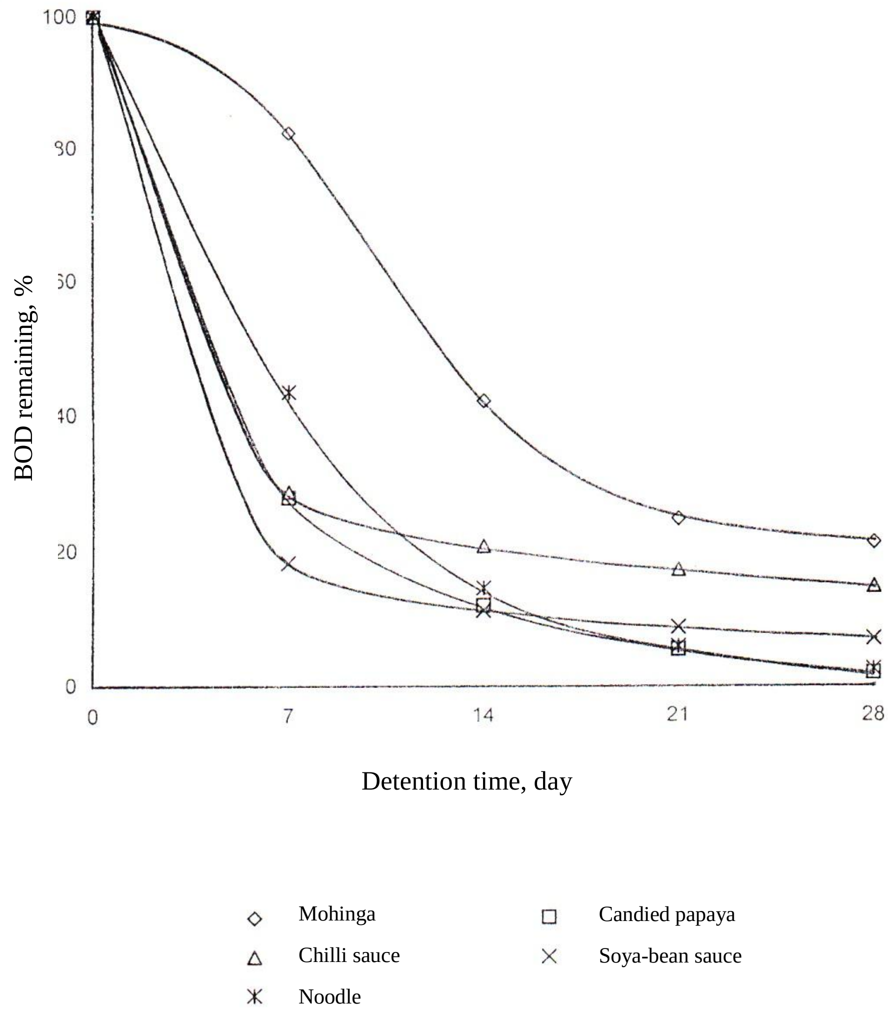

Fig 2. Effect of water hyacinth system on reduction of BOD_5 for various types of wastewater

Conclusion

From this laboratory investigation, water hyacinth system was found to be effective for all wastewater samples. Design and construction cost of water hyacinth systems are simple and comparatively low and economical to operate in plant scale. Water hyacinth is highly suitable for tropical wet and dry climate. Myanmar has good climatic conditions for water hyacinth to grow well. If the wastewater flow is high, then a series or parallel set-up of water hyacinth can be done. If adequate land is available, water hyacinth system is suitable to treat industrial wastewater.

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