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WATER HYACINTHS AND ALLIGATOR WEEDS FOR FINAL FILTRATION OF SEWAGE

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16. ABSTRACT

The potential of water hyacinths (Eichhornia crassipes) (Mart.) Solms and alligator weeds (Alternanthera philoxerides) (Mart.) Griesb. as secondary and tertiary filtration systems for domestic sewage was demonstrated. These two vascular aquatic plants reduced the suspended solids, total Kjeldahl nitrogen, total phosphorus, BOD_5, and total organic carbon levels in domestic sewage from 60 percent to 98 percent within a two week period. These plants grown in domestic sewage were also free of toxic levels of trace heavy metals.

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INTRODUCTION

A serious problem presently facing the United States and other industrial countries is the development of practical and economical means of removing nutrients and trace toxic chemicals from industrial and domestic waste prior to their discharge into rivers and streams. In some areas, sewage and toxic chemical pollution has increased to such an extent that the waters have become unsuitable for recreation, fishing, domestic consumption, and other related uses. This problem is further complicated by population growth and an ever-increasing demand for clean water for domestic and industrial uses.

The possible use of vascular aquatic plants to remove nutrients and toxic chemicals from domestic and industrial waste effluents has been investigated (1, 2, 3, 4, 5, 6, 7).

Water hyacinths and alligator weeds have received recent attention because of their pollution removal potential when utilized as a biological filtration system under controlled conditions in sewage treatment lagoons. These species of vascular aquatic plants are some of the most attractive candidates for lagoon use because of the ease of harvesting the free-floating plants; the high bio-mass productivity; and the potential economic benefits achievable through the sale of desirable products to offset lagoon operating costs. Potential products are food, methane gas, and fertilizers (9, 10, 11, 12, 13).

MATERIALS AND METHODS

Water hyacinths (*Eichhornia crassipes*) (Mart.) Solms, and alligator weeds (*Alternanthera philoxerides*) (Mart.) Griesb. were collected from nearby bayous and lagoons in Hancock and Pearl River Counties, Mississippi. Mature plants were selected for all experiments.

Fresh samples of influent and effluent sewage water from the wastewater lagoon at Bay St. Louis, Mississippi, were used in these experiments. Mature plants were placed in 4-1/2 liters of sewage water contained in five-liter glass cylinders and maintained in a well-lighted building at 25°C $\pm$ 5°C. Each experimental arrangement included one control free of plants. Volume losses due to evapotransportation were controlled by the addition of nitrogen/phosphate-free deionized, distilled water, as needed.

Before addition of plants to the fresh influent and effluent samples, analyses were performed including pH, total suspended solids (14), total phosphorus (15), total Kjeldahl nitrogen (16), BOD_5's (17), and total organic carbon (TOC). These analyses were repeated on samples exposed to plants and on the controls free of plants at 7-day and 14-day intervals.

Initial effluent samples were analyzed for trace heavy metals by atomic absorption. The analysis for mercury contamination was accomplished using a flameless atomic absorption technique (18).

One gram samples of plant roots from both water hyacinths and alligator weeds grown in the effluent for fourteen days were digested in 20 percent aqueous nitric acid. The digestion was followed by the addition of two milliliters of 30 percent hydrogen peroxide and dilution to one liter. These digested plant roots were analyzed for trace heavy metals by the same methods outlined for the effluent sewage water.

RESULTS AND DISCUSSION

Water hyacinths demonstrated the ability to rapidly remove nutrients and pollutants from domentic sewage waters as shown in Table 1. In both influent and effluent sewage samples, water hyacinths maintained the pH between 7.20 and 7.40 during fourteen-day exposure times; whereas, the pH of the influent sewage water control free of plants increased from 7.05 to 7.90, and the effluent control decreased slightly from 8.80 to 8.20 in the same fourteen-day exposure intervals. Analysis of the influent test containers after fourteen days exposure to water hyacinths demonstrated the following average reductions as compared to the control containers free of plants: total Kjeldahl nitrogen, 92 percent (control, 18); total phosphorus, 60 percent (control, 12); BOD_5, 97 percent (control, 61). The results of the analysis of the effluent test containers after fourteen days exposure to water hyacinths demonstrated the following average reductions in comparison to the reductions in the control containers free of plants: total suspended solids, 75 percent (control, 15); total Kjeldahl nitrogen, 75 percent (control, 15); total phosphorus, 87 percent (control, 11); BOD_5, 77 percent (control, 6); total organic carbon (TOC), 82 percent (control, increased 28 percent). The increase in total organic carbon in the control free of plants was due to heavy algae growth. In all effluent waste waters exposed to water hyacinths, there remained no visible evidence of algae growth after two weeks of plant exposure.

Alligator weeds also proved to be good filtering agents for nutrients and pollutants as demonstrated in Table 2. In influent waste water containing alligator weeds, the pH increased only slightly from 7.10 to 7.40 over a two-week interval, although the control free of plants increased from 7.10 to 8.25. The effluent waste water pH decreased from 8.9 to 7.2 when exposed to alligator weeds, while the control pH decreased from 8.9 to 8.35. Analysis of the influent test containers after fourteen days exposure to alligator weeds demonstrated the following average reductions as compared to the control containers free of plants: total Kjeldahl nitrogen, 98 percent (control, 31); total phosphorus, 71 percent (control, 30). The results of the analysis of the effluent test containers after fourteen days exposure to alligator weeds demonstrated the following average reductions in comparison to the reductions in the control containers free of plants: total suspended solids, 87 percent (control, 33); total Kjeldahl nitrogen, 83 percent (control, 12); total phosphorus, 59 percent (control, 21); BOD$_5$, 90 percent (control, 15). After fourteen days, the effluent waste water containing alligator weeds had no visible evidence of algae, although the control free of plants still supported heavy algae growth.

Analysis of the initial effluent waste water used in these studies for toxic trace metals showed the following concentrations: <0.008 ppm Pb, <0.001 ppm Cd, <0.01 ppm Cu, <0.02 ppm Ag, <0.05 ppm Ni, <0.08 ppm Zn, <0.001 ppm Hg, <0.01 ppm Sr, <0.007 ppm Co. The results of the analysis of the digested roots of water hyacinths grown for a period of two weeks in effluent sewage water were: 0.063 ppm Pb, <0.001 ppm Cd, <0.01 ppm Cu, <0.02 ppm Ag, <0.05 ppm Ni, 0.58 ppm Zn, <0.001 ppm Hg, <0.01 ppm Sr, <0.007 ppm Co. Analysis of acid-digested alligator weed roots grown in effluent sewage water for two weeks contained the following trace heavy metal concentrations: 0.035 ppm Pb, <0.001 ppm Cd, 0.16 ppm Cu, <0.02 ppm Ag, <0.05 ppm Ni, 0.84 ppm Zn, <0.001 ppm Hg, <0.01 ppm Sr, <0.007 ppm Co.

Both water hyacinths and alligator weeds demonstrated their abilities to rapidly remove nutrients and pollutants from domestic sewage waste. Within a period of two weeks under static laboratory conditions, these vascular aquatic plants demonstrated their potential as secondary and tertiary filtration systems capable of producing clean water from sewage lagoon effluent. The plants grown in sewage from the Bay St. Louis lagoon were also free of toxic levels of trace heavy metals after a two-week growth period. Therefore, this harvested plant material, relatively high in protein and mineral content, is an excellent candidate for feed and/or food products (19).

Table 1. Experimental Analysis of Influent and Effluent Sewage Waste Water Containing Water Hyacinths and Corresponding Controls Free of Plants

ANALYSIS		INFLUENT Container No. 1	INFLUENT Container No. 2	INFLUENT Container No. 3 (Control)	EFFLUENT Container No. 1	EFFLUENT Container No. 2	EFFLUENT Container No. 3 (Control)
pH	Initial	7.05	7.05	7.05	8.80	8.80	8.80
	7-Day	7.30	7.40	7.75	7.30	7.40	8.90
	14-Day	7.30	7.40	7.90	7.20	7.20	8.20
Total Suspended Solids (ppm)	Initial	-	-	-	109.0	109.0	109.0
	7-Day	-	-	-	17.0	33.0	96.0
	14-Day	-	-	-	46.0	8.0	93.0
Total Kjeldahl Nitrogen (ppm)	Initial	16.1	16.1	16.1	1.76	1.76	1.76
	7-Day	-	1.35	13.2	0.55	0.32	1.53
	14-Day	<0.20	<0.20	8.36	<0.20	<0.20	1.50
Total Phosphorus (ppm)	Initial	5.60	5.60	5.60	4.50	4.50	4.50
	7-Day	1.25	3.25	4.90	0.57	0.57	4.01
	14-Day	0.75	3.00	4.25	<0.06	<0.06	3.38
BOD_5 (ppm)	Initial	72.0	72.0	72.0	21.6	21.6	21.6
	7-Day	2.60	1.90	28.0	5.16	4.9	20.3
	14-Day	-	-	-	3.90	3.10	12.5
Total Organic Carbon (ppm)	Initial	-	-	-	94	94	94
	7-Day	-	-	-	59	60	98
	14-Day	-	-	-	<6	<7	120
Dry Plant Weight (Grams)		14.6	6.1	Control Free of Plant	9.9	7.2	Control Free of Plant

Table 2. Experimental Analysis of Influent and Effluent Sewage Waste Water Containing Alligator Weeds and Corresponding Controls Free of Plants

ANALYSIS		INFLUENT				EFFLUENT				
		SAMPLE "A"		SAMPLE "B"		SAMPLE "A"		SAMPLE "B"		
		Container No. 1	Container No. 2 (Control)	Container No. 1	Container No. 2 (Control)	Container No. 1	Container No. 2 (Control)	Container No. 1	Container No. 2	Container No. 3 (Control)
pH	Initial	7.20	7.20	7.05	7.05	8.30	8.30	9.10	9.10	9.10
	7-Day	7.30	8.05	7.10	7.75	7.40	8.40	7.00	7.10	8.05
	14-Day	7.40	8.25	7.15	7.90	7.20	8.35	6.90	7.05	7.95
Total Suspended Solids (ppm)	Initial	-	-	-	-	104	104	109	109	109
	7-Day	-	-	-	-	6.6	65	2.0	10	46
	14-Day	-	-	-	-	1.6	42	46	10	73
Total Kjeldahl Nitrogen (ppm)	-Initial	12.5	12.5	16.1	16.1	1.45	1.45	1.49	1.49	1.49
	7-Day	-	-	0.52	13.2	0.59	1.37	0.82	0.30	1.27
	14-Day	0.32	10.7	0.23	8.36	0.35	1.25	<0.20	<0.20	1.36
Total Phosphorus (ppm)	Initial	4.90	4.90	5.60	5.60	5.50	5.50	4.20	4.20	4.20
	7-Day	2.50	4.25	2.75	4.90	3.00	4.50	2.20	2.60	3.75
	14-Day	1.10	3.20	2.00	4.25	2.10	3.25	2.10	1.50	4.50
BOD_5 (ppm)	Initial	38.0	38.0	72.0	72.0	19.8	19.8	21.6	21.6	21.6
	7-Day	3.25	9.50	5.30	28.0	2.00	20.7	3.50	9.80	15.0
	14-Day	-	-	-	-	1.00	17.3	2.40	3.10	18.0
Dry Plant Weight (Grams)		25.8	Control Free of Plant	39.2	Control Free of Plant	24.1	Control Free of Plant	36.5	28.2	Control Free of Plant

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APPROVAL

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The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense of Atomic Energy Commission programs has been made by the NSTL Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

for B. C. Wolverton

HENRY F. AUTER
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