

NASA TECHNICAL MEMORANDUM

TM-X-72729
OCTOBER, 1975

WATER HYACINTHS FOR UPGRADING SEWAGE LAGOONS TO MEET ADVANCED WASTEWATER TREATMENT STANDARDS: PART I

By B. C. Wolverton
R. C. McDonald

(NASA-TM-X-72729) WATER HYACINTHS FOR
UPGRADING SEWAGE LAGOONS TO MEET ADVANCED
WASTEWATER TREATMENT STANDARDS, PART I
(NASA) 9 p HC \$3.25 CSCL 06C

N76-10697

Unclas
G3/51 03061

**NASA
NATIONAL SPACE TECHNOLOGY LABORATORIES
BAY ST. LOUIS, MISSISSIPPI 39520**



1. REPORT NO. TM-X-72729	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.	
4. TITLE AND SUBTITLE Water Hyacinths for Upgrading Sewage Lagoons to Meet Advanced Wastewater Treatment Standards: Part I		5. REPORT DATE October, 1975	
		6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S) B. C. Wolverton and R. C. McDonald		8. PERFORMING ORGANIZATION REPORT NO.	
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Space Technology Laboratories Bay St. Louis, Mississippi 39520		10. WORK UNIT NO.	
		11. CONTRACT OR GRANT NO.	
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, D. C. 20546		13. TYPE OF REPORT & PERIOD COVERED Technical Memorandum	
		14. SPONSORING AGENCY CODE	
15. SUPPLEMENTARY NOTES Interim program test results, NASA, Office of Applications sponsored program - (RTOP 644-02-02) Vascular Aquatic Plants for Pollution Control and Sources of Energy and Food.			
16. ABSTRACT Water hyacinths, (<i>Eichhornia crassipes</i>) (Mart.) Solms, have demonstrated the ability to function as an efficient and inexpensive final filtration system in a secondary domestic sewage lagoon during a three month test period. These plants reduced the suspended solids, biochemical oxygen demanding substances, and other chemical parameters to levels below the standards set by the state pollution control agency. The water hyacinth-covered secondary lagoon utilized in this experiment had a surface area of 0.28 hectare (0.70 acre) with a total capacity of 6.8 million liters (1.5 million gallons), receiving an inflow of 522,100 liters (115,000 gallons) per day from a 1.1 hectare (3.8 acre) aerated primary sewage lagoon. These conditions allowed a retention time of 14 to 21 days depending on the water hyacinth evapotranspiration rates. The desired purity of final sewage effluent can be controlled by the water hyacinth surface area, harvest rate, and the retention time.			
17. KEY WORDS Water hyacinths Sewage Tertiary filtration Wastewater		18. DISTRIBUTION STATEMENT <i>B.C. Wolverton</i> Unclassified - Unlimited	
19. SECURITY CLASSIF. (of this report) Unclassified	20. SECURITY CLASSIF. (of this page) Unclassified	21. NO. OF PAGES 9	22. PRICE

WATER HYACINTHS FOR UPGRADING SEWAGE LAGOONS TO MEET ADVANCED WASTEWATER TREATMENT STANDARDS: PART I

INTRODUCTION

Although effluent from the typical sewage lagoon is an improvement over the untreated influent, this nutrient rich discharge is still frequently high in suspended solids and biochemical oxygen demanding substances. As a result of more stringent requirements being placed by regulatory agencies on sewage effluent entering rivers, streams, and estuarine areas, microbiological treatment alone is not adequate. Since the effluent from a typical sewage treatment plant is also rich in chemical nutrients, the replacement of lagoons with expensive conventional sewage treatment plants would not likely solve the additional treatment requirements. The simplest and most economical means of accomplishing final filtration to remove nutrients, heavy metals, and other chemicals from domestic wastewaters appears to be the utilization of vascular aquatic plants as demonstrated by Wolverton et al. 1, 2, 3, 4, 5, 6, 7, 8, 9

Water hyacinths, (*Eichhornia crassipes*) (Mart.) Solms, were used in this field study because they have demonstrated the most promise in laboratory studies in removing nutrients and chemicals from static water systems. This plant has also demonstrated the ability to produce phenomenal quantities of biomass when grown in a warm, nutrient enriched environment. This easily harvested plant possesses levels of minerals and protein which make it a good candidate for a new southern crop to be utilized in producing animal feed, organic fertilizer, and soil conditioner, or methane gas and inorganic fertilizer from the microbial anaerobic fermentation of water hyacinths. This aquatic plant is also a candidate for use in northern climates when used in conjunction with hydroelectric power generating plants. Thermal discharges from the condenser cooling water could conceivably be mixed with sewage pumped into large lagoons near power generating facilities and water hyacinths grown year-round in this warm, nutrient enriched water. This concept could possibly supply an additional bonus as a radioactive safety filter where the thermally polluted water comes from nuclear power plants. These facilities normally produce larger quantities of hot water than conventional power plants along with the added risk of contaminating the aquatic environment with radioactive

elements such as plutonium, strontium, cesium, etc. as a result of reactor disruption or leakage from unforeseen disasters.

MATERIALS AND METHODS

The system evaluated in this field study is a secondary domestic sewage lagoon located at Orange Grove residential development in north Gulfport, Mississippi. This secondary lagoon receives domestic sewage effluent from a 1.1 hectare (3.8 acre) aerated primary sewage lagoon with a two week average retention time. It has a .23 hectare (0.7 acre) surface area and contains a total volume of 6.8 million liters (1.5 million gallons). The average flow rate into this secondary system is 522,100 liters (115,000 gallons) per day, resulting in an average retention time of approximately three weeks.

Background data was obtained on biweekly grab samples for two months before the system was completely covered with water hyacinths, (Eichhornia crassipes) (Mart.) Solms. Biweekly grab samples were continued after saturation with water hyacinths, along with samples from a control lagoon free of water hyacinths. Grab sample data correlated well with monthly 24-hour composite samples obtained with an ISCO Water Sampler Model 1392.

The following analyses were performed on all samples: pH, total kjeldahl nitrogen (10), total phosphorus (11), biochemical oxygen demand (BOD₅) (12), fecal coliform (MPN) (13), suspended solids (14), dissolved solids (15), and total organic carbon (TOC) (16). Dissolved oxygen concentrations and temperature were obtained directly in the field with a YSI Model 54 Oxygen Meter.

The effluent was also monitored for any contamination by toxic heavy metals using atomic absorption or flame emission with an IL Model 253 spectrometer.

RESULTS AND DISCUSSION

The preliminary results of the field test using water hyacinths, (Eichhornia crassipes) (Mart.) Solms, as a final filtration system in a secondary domestic sewage lagoon has shown great promise in reducing suspended solids, BOD₅ and other parameters to levels below the standards set by the Environmental Protection Agency and state pollution control agencies. Monthly averages of this preliminary data are presented in Table 1 along with state pollution control standards.

Suspended solids which are mainly due to algae were reduced in the water hyacinth lagoon by 74 percent during the month of July, 63 percent for August, and 80 percent for September. The water hyacinth covered lagoon also reduced the biochemical oxygen demand of the sewage entering this lagoon during these critical summer months to levels below the established state standards. Total kjeldahl nitrogen levels averaging 3 mg/l entering the water hyacinth lagoon were reduced to averages of 1.2 mg/l in the final effluent with a nitrogen reduction of approximately 60 percent. The average total phosphorus entering the water hyacinth lagoon was 5.5 mg/l with a maximum phosphorus removal of 26 percent for the first five weeks. Phosphorus reduction rates after this period of time suggests that plants should be harvested at five week intervals for maximum phosphorus removal.

The pH was maintained at 6.5 for the effluent from the water hyacinth lagoon. The average influent pH was 7.7. The fecal coliform count was reduced from an average of 121,000 MPN/100 ml for the influent to an average of 40,000 MPN/100 ml effluent. However, no definite correlation of the effect of water hyacinths on fecal coliform over the normal effect on fecal coliform in a lagoon without these plants has been established during this brief test period. As expected the dissolved oxygen level dropped from 5.9 mg/l in the influent wastewater to 2.0 mg/l in the wastewater leaving the lagoon. However this lower dissolved oxygen concentration produced no adverse effects such as an increase in undesirable odors. Upon natural reaeration from mixing action of the wastewaters leaving the Orange Grove sewage system, the dissolved oxygen level was brought back up to between 5 and 6 mg/l, which is adequate to meet the pollution control permit requirements.

As shown in Table 2, many elements essential to both plants and animals were found in this secondary sewage lagoon. No toxic levels of heavy metals were detected by atomic absorption or flame emission in either the influent or the effluent sewage wastewater.

CONCLUSIONS

Based on data presented in this preliminary report, cities located in the tropical and subtropical regions of the world should be able to utilize water hyacinths as a final filtration system for reducing the levels of polluting substances in domestic sewage to levels which comply with advanced wastewater treatment standards.

Water hyacinths have demonstrated the ability to absorb organics, nutrients, and other chemical elements from sewage waste in the process of

producing large quantities of plant material. This biomass when grown in enriched sewage waste free of toxic heavy metals can be harvested and possibly processed into valuable high protein food and feed products, organic fertilizer and soil conditioner, methane gas and inorganic fertilizer or other products as presently being demonstrated by NASA and university scientists.

The volume of water hyacinths required depends upon the amount of sewage to be processed and the desired purity of the final wastewater required by the local effluent quality criteria. For complete or near complete removal of phosphorus from typical domestic sewage from a city or community of 5,000 people would require approximately ten acres of water hyacinth surface area, but complete removal of phosphorus is usually not required or even desirable. Therefore much smaller systems could be utilized to meet present and future wastewater effluent standards.

Table 1. Orange Grove Sewage Lagoon Preliminary Field Test Data

	Total Suspended Solids, mg/l		Total Dissolved Solids, mg/l		Biochemical Oxygen Demand (BOD ₅), mg/l		Total Kjeldahl Nitrogen, mg/l		Total Phosphorus, mg/l		Total Organic Carbon, mg/l		pH		Dissolved Oxygen, mg/l		Temperature °C		Total Coliform MPN/100 ml	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
State Effluent Quality Criteria	N/A	30	N/A	N/A	N/A	15	N/A	6	N/A	N/A	N/A	N/A	N/A	6.0 to 7.8	N/A	3.0	N/A	N/A	N/A	200*
Data After the Addition of Water Hyacinth																				
1. Monthly Average July, 1975	26	9	286	261	23	7	2.23	1.43	5.44	4.43	31	22	7.8	6.5	5.8	1.8	27	26	138,000**	51,300**
2. Monthly Average August, 1975	35	13	294	276	26	5	2.47	1.17	5.24	4.79	24	18	7.4	6.6	6.0	2.0	27	26	128,000**	17,000**
3. Monthly Average September, 1975	43	6	187	145	22	7	4.44	1.07	5.47	3.73	24	15	7.2	6.7	5.5	2.2	22	23	64,000**	13,000**
Data for Water Hyacinth-Free Control Lagoon																				
1. Monthly Average July, 1975	77	60	370	340	18	43	4.70	4.50	7.30	7.26	36	26	7.0	7.0	3.5	6.0	27	27	Neg*	Neg*
2. Monthly Average August, 1975	33	32	254	420	-	-	6.17	6.40	5.48	5.49	23	31	7.0	7.1	5.5	4.8	27	28	Neg*	Neg*
3. Monthly Average September, 1975	48	44	180	240	27	30	4.52	4.45	4.44	4.60	20	32	6.8	7.0	5.0	8.0	26	27	Neg*	Neg*

* After chlorination
** Before chlorination

Table 2. Metal Analysis of Orange Grove Sewage Lagoon

Metals	Influent, ppm	Effluent, ppm
Aluminum	0.41	0.25
Boron	2.22	2.00
Cadmium	< 0.001	< 0.001
Calcium	1.30	1.26
Chromium	< 0.001	< 0.001
Cobalt	< 0.01	< 0.01
Copper	< 0.001	< 0.001
Iron	0.33	0.23
Lead	< 0.008	< 0.008
Magnesium	0.788	0.829
Manganese	< 0.001	< 0.001
Mercury	< 0.001	< 0.001
Nickel	< 0.005	< 0.005
Potassium	4.71	4.41
Silver	< 0.001	< 0.001
Sodium	41.67	40.19
Zinc	0.038	0.007

REFERENCES

1. Wolverton, B. C. and R. C. McDonald, 1975. "Water Hyacinths and Alligator Weeds for Removal of Silver, Cobalt, and Strontium from Polluted Waters". NASA Technical Memorandum TM-X-72727.
2. Wolverton, B. C., R. M. Barlow, and R. C. McDonald, 1975. "Application of Vascular Aquatic Plants for Pollution Removal, Energy, and Food Production in Biological Systems". NASA Technical Memorandum TM-X-72726.
3. Wolverton, B. C., R. C. McDonald, and J. Gordon, 1975. "Bio-Conversion of Water Hyacinths into Methane Gas: Part I. NASA Technical Memorandum TM-X-72725.
4. Wolverton, B. C. and R. C. McDonald, 1975. "Water Hyacinths and Alligator Weeds for Final Filtration of Sewage". NASA Technical Memorandum TM-X-72724.
5. Wolverton, B. C. and R. C. McDonald, 1975. "Water Hyacinths and Alligator Weeds for Removal of Lead and Mercury from Polluted Waters". NASA Technical Memorandum TM-X-72723.
6. Wolverton, B. C., 1975. "Water Hyacinths for Removal of Phenols from Polluted Waters". NASA Technical Memorandum TM-X-72722.
7. Wolverton, B. C., 1975. "Water Hyacinths for Removal of Cadmium and Nickel from Polluted Waters". NASA Technical Memorandum TM-X-72721.
8. Rogers, H. H. and D. E. Davis, 1972. "Nutrient Removal by Water Hyacinths", Weed Sc. 20:423-427.
9. Haller, W. T. and D. I. Sutton, 1973. "Effect of pH and High Phosphorus Concentrations on Growth of Water Hyacinth", Hya. Control J. 11:59-61.
10. Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, p. 175.
11. Ibid, p. 249.

REFERENCES (CONT'D)

12. Standard Methods for the Examination of Water and Wastewater,
13th Edition, p. 489, Method 219 (1971).
13. *Ibid*, p. 669.
14. Methods for Chemical Analysis of Water and Wastes, U.S. Environmental
Protection Agency, p. 266.
15. *Ibid*, p. 266.
16. *Ibid*, p. 236.

APPROVAL

WATER HYACINTHS FOR UPGRADING SEWAGE LAGOONS
TO MEET ADVANCED WASTEWATER TREATMENT STANDARDS:
PART I

By B. C. Wolverton
R. C. McDonald

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or 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.


Henry F. Auter
Director, Applications Engineering
National Space Technology Laboratories