Aquatic Vegetation and Water Pollution Control Public Health Implications

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Abstract: Results obtained from pilot studies and the operation of a plant scale treatment facility located at the Williamson Creek Wastewater Treatment Plant at Austin, Texas, demonstrate that culture of the water hyacinth *Eichhornia crassipes* in shallow earthen basins is effective in the removal of algae, fecal coliform bacteria and deleterious impurities from wastewater stabilization pond effluent. Stabilization ponds followed by hyacinth culture constitute an economical, low energy treatment system which reduces significantly those potential health hazards associated with wastewaters. Harvested hyacinths represent a useful product which could be converted into compost, or used directly as a soil amendment. (Am. J. Public Health 68:1202-1205, 1978.)

Public health protection is the foremost reason for treating wastewaters, irrespective of aesthetics and the economic liability of polluted waters. Many Texas streams and reservoirs serve as sources of domestic raw water supply and are used for body contact recreation. Some smaller watercourses would normally be dry were it not for the introduction of used waters, and the major portion of the base flows of two rivers—the Trinity and San Antonio—consists of treated wastewaters. Wastewaters must be reclaimed to a level of quality appropriate for additional beneficial use.

Secondary treatment of wastewater involves microbial degradation and transformation of organic materials into biomass. The biomass, precipitated minerals, and debris (sludge) can be separated from water. Above 90 per cent of the organic content of raw wastewaters may be removed, but some organic matter and abundant nutrients pass through a secondary treatment plant. Secondary effluent may also contain infectious biological agents, toxic compounds, and mutagenic or carcinogenic synthetic organics. Significant advances in treatment effectiveness of such processes cannot be anticipated due to inherent environmental and biological limitations.

Secondary treatment will not suffice in the future to afford adequate protection to the public waters of Texas as the population expands with corresponding increased demands upon the limited fresh water resources. Advanced wastewater treatment has already been mandated in certain cases where effluents discharge to sensitive bodies of water.

Chemical-physical technology is available for cleaning water to almost any degree of desired purity. Application of such technology, however, is expensive and energy intensive. Controlled culture of selected species of aquatic vegetation in specially designed shallow basins has been shown to be an alternative method of advanced treatment.[1-5] Only a few facilities of this type are in use and much remains to be learned concerning system application, design and management procedures.

The Division of Wastewater Technology and Surveillance, in cooperation with the City of Austin, is evaluating the use of controlled culture of water hyacinth *Eichhornia crassipes*, a tropical plant, for improving stabilization pond effluent quality at the municipal Williamson Creek Wastewater Treatment Plant. Some results of pilot studies* conducted in two phases during 1975–1976 are presented in Tables 1 and 2.[6-8] A plant scale experimental hyacinth culture basin was placed into operation in October 1977 (See Figure 1).

Pond effluent was selected as input to the experimental facilities because stabilization pond treatment is considered to be superior to that of other secondary processes in reducing potential health hazards associated with wastewaters. It is generally known that significant reduction in fecal coliform bacteria occurs in ponds. Only limited data are available relative to the decrease to be expected in virus content of waters passing through pond systems.[9-11] Pond treatment is ef-

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*Operational details and diagram are available on request to the author.

TABLE 1—Pilot Studies—Indicated Mean Reductions in Wastewater Quality Parameters Affected by Hyacinth Treatment

	First Study Phase June 1975–February 1976			Second Study Phase May 1976–August 1976		
	Influent	Effluent	% Reduction	Influent	Effluent	% Reduction
BOD_5, mg/1	22.6	5.2	77	46.5	5.7	87
TSS, mg/1	43.3	7.0	84	117	7.5	93
COD, mg/1	84	40	52	184	51	72
MBAS, mg/1	0.17	0.03	82	0.13	0.04	66
Fecal Coliform Bacteria/100 ml	2895	31	98	27423	363	98

fective for the removal of cysts of parasitic protozoa and the cysts and eggs of parasitic worms.[12] Toxicity of certain chemical compounds is diminished during extended storage and heavy metals precipitate out of solution.[13]

Facilities and Operation

The Williamson Creek Wastewater Treatment Plant consists of an aerated basin equipped with a surface aerator, a clarifier, and three stabilization ponds. The plant was designed to treat 757 m^3/d (.2 mgd) of wastewater. Sludge is returned to the aerated basin, with excess sludge and clarified effluent being discharged to the ponds. The ponds are about 1.2ha (3 ac) each in size and are operated in series at a depth of about 2.4m (8 ft). Actual depths are less due to sludge accumulation. The last stabilization pond was drained, cleaned, and converted into a hyacinth culture basin. A crushed stone barrier approximately 2.4m (8 ft) in height and 9 × 9m (30 ft × 30 ft) in size was constructed at the lower end of the basin to prevent escape of the plants and to create a clear outlet zone. Influent is admitted to the basin from the second stabilization pond by an adjustable gate. A water depth of .9m (3 ft) is maintained in the hyacinth culture basin. System effluent is transferred to a nearby 18.2ha (45 ac) stabilization pond by an electrically driven pump rated at 31.5 l/sec (500 gpm). Flow to the wastewater treatment plant varies between 1325 (.35 mgd) and 1445 m^3/d (.38 mgd). A somewhat lesser amount of water passes through the hyacinth basin due to seepage and evaporation losses.

Influent-effluent samples are collected weekly by city personnel and analyzed in the Austin Wastewater Laboratory according to accepted procedures. Samples for the determination of fecal coliform bacteria content are collected weekly by the author and delivered to the Health Department Bacteriology Laboratory. Selected data obtained during the period of October 1977–March 1978 are summarized in Table 3. It is estimated that the system is hydraulically loaded to less than one-half of its capacity.

TABLE 2—Pilot Studies—Contaminant Accumulation by Hyacinths and Contaminants in Basin Sediment

	Means, mg/kg (dry weight)	
	Hyacinths (Stems and Leaves)	Sediment (Plant Debris)
As	2.63	8.4
Ag	—	3.3
Cr	8.96	170
Cu	8.3	52
Fe	470	13000
Hg	0.18	0.47
Mg	4300	6100
Mn	153	260
Ni	9.7	164
Pb	6.5	16
Zn	24	490
PCB*	39.6	—
Chloride	63533	—
Nitrogen-Kjel.	1900	25000
Phosphorus-P	7821	5200
Potassium	65133	—
Sodium	1490	—

*Micrograms

Discussion

A floating hyacinth mat contributes to environmental stability and affords suitable habitat for a variety of primitive and higher organisms. The plants grow to a height of .9m (3 ft) and their extensive roots are from 10–50cm (4in–20in) in length. Some pollutants entering a culture basin undergo microbial degradation and enter the atmosphere as gases, while others as accumulated by the plants or are deposited in the sediment. Hyacinth treatment is especially effective in the reduction of suspended particulates. Obviously, periodic removal of biomass and benthal debris is required to maintain maximum system efficiency.

Hyacinths are hardy and vegetative reproduction is rapid. A mature standing crop of hyacinths results in the production of about 3,000 g/m^2 (dry weight) of biomass, having an ash (mineral) content of near 20 per cent. Soluble substances are absorbed by hyacinths rather indiscriminately.

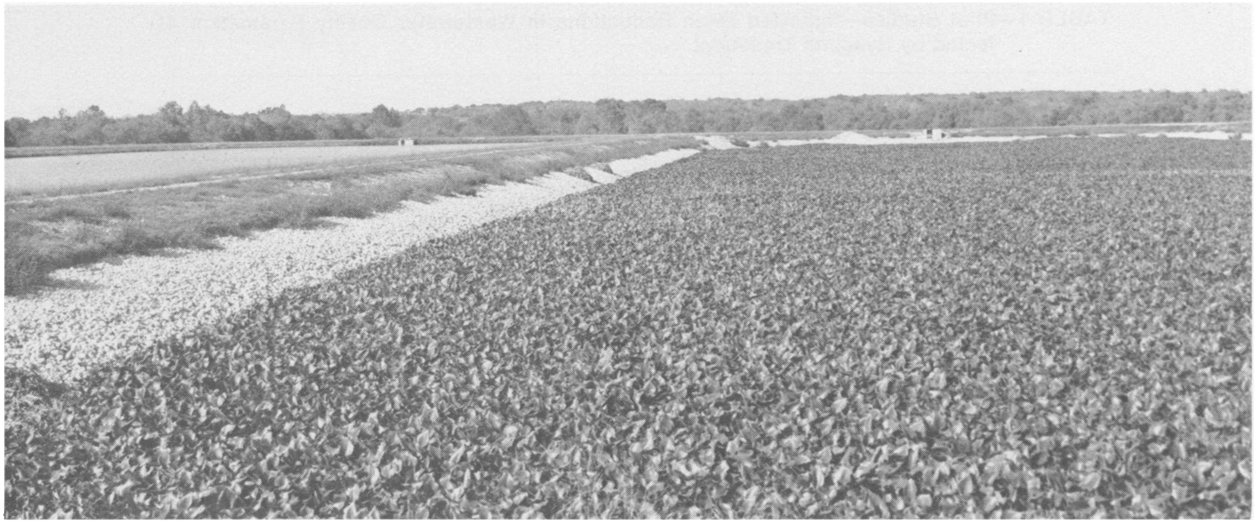

FIGURE 1—Three Acre Hyacinth Culture Basin Being Used to Treat Wastewaters from A Population of Over 3,500 People

As might be expected, they exhibit luxury uptake of mineral nutrients, but also accumulate materials without nutritive value, including phytotoxic heavy metals, polychlorinated biphenyls (PCBs), and pesticides. Mosquito fish *Gambusia* and predatory insects serve to control mosquito production in culture basins.

The hyacinth is unique and perhaps unequaled as a candidate species for cleansing contaminated waters. Hyacinths will not grow in brackish waters and are cold sensitive. Continual production in open basins is possible only in those areas where frosts are uncommon. Elsewhere, seasonal culture would be indicated with retention of wastewaters being required during the winter.

Hyacinths may be employed for upgrading stabilization pond effluent for a period of from 9 to 10 months in Austin. Stems and leaves are frozen down to the water surface with the onset of freezing weather in mid-November. Almost a total kill of hyacinths usually occurs in late winter. Plants were killed in February 1978 when the air temperature was 5° C (23° F). Normally, a culture basin would be drained, allowed to dry, and cleaned prior to effluent quality deterioration. The experimental culture basin, however, was kept in operation and the decaying vegetation allowed to remain. The basin was stocked with an estimated 50,000 small plants ($4.5m^3$) (6 cu yd) in late March and an equivalent amount added in April to speed system recovery.

Hyacinth culture basins following stabilization ponds could be used for the treatment of wastewater on a continuous basis in sub-tropical and tropical climates. Two or more culture units would be required to permit alternate operation. Year-round hyacinth culture in a temperate climate would depend upon the feasibility of providing basins with protective translucent covers and maintenance of water temperatures of 10° C (50° F) or more.

Construction costs of culture basins would be comparable to those of conventional stabilization ponds. It would be premature to present an economic evaluation of covering basins until such time as basin design criteria are developed to attain maximum system efficiency. Operational costs of hyacinth treatment facilities would be quite low as little external energy would be needed and, aside from restocking and removal of basin debris, minimal maintenance would be necessary.

Controlled hyacinth culture may prove to be useful for a number of other beneficial purposes, including the pretreatment of domestic water supply sources. The hyacinth is the most productive macrophyte known, except perhaps for sugarcane. It has been suggested that, utilizing enriched wastewaters, extensive areas could be devoted to growing hyacinths for livestock feed or for methane generation.[3, 14] Water quality enhancement obtained by such proposed large scale operations would be incidental to biomass production.

Small communities using hyacinths solely for wastewater treatment would have several options for the use or disposal of basin debris. The material removed could be landfilled, plowed under for soil amendment of agricultural land, or composted for use in parks and nurseries.

TABLE 3—Plant Scale Study—Indicated Mean Reductions in Wastewater Quality Parameters Obtained during the Period from October 1977–March 1978, at the Williamson Creek Experimental Hyacinth Treatment System

	Population Served—3,500+		
	Influent	Effluent	% Reduction
BOD_5, mg/1	46.2	11.3	75.5
TSS, mg/1	40.5	8.2	79.7
Fecal Coliform/100 ml	6143*	445	92.8

*One test result of 6 × 10^6 organisms not used in calculation of mean

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