Comparative Study of Wastewater Lagoon with and without Water Hyacinth

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A 3-year study was conducted on an existing, one-cell, facultative sewage lagoon having a total surface area of 3.6 ha and receiving a BOD₅ loading rate of 44 kg/ha/d (40 lb/a/d). The comparative experimental periods ran from July through November for 3 consecutive years. During the first period, water hyacinths completely covered the lagoon. The water hyacinth coverage was reduced to 33% of the total surface area the second year. The lagoon, free of all vascular aquatic plants the third year, was monitored for comparative purposes. The most significant improvement overall in the effluent quality occurred when water hyacinths covered the entire lagoon. During this period the effluent BOD₅ and TSS were 23 and 6 mg/l, respectively. Without water hyacinths, the effluent BOD₅ and TSS were 52 and 77 mg/l, respectively. The effluent total organic carbon concentration with water hyacinths averaged 40 mg/l, and without water hyacinths, 72 mg/l. A discussion of the results from this 3-year study is presented in this paper along with associated problems that were observed when water hyacinths were introduced into the lagoon and altered its behavior from that of a normal facultative lagoon.

In recent years all wastewater treatment systems have come under more critical examination and more stringent discharge requirements. Consequently, a large percentage of communities, especially those with wastewater treatment lagoons, have been required to upgrade their existing facilities. One new method that has been the focus of several recent research projects involves the use of vascular aquatic plants as the principal biological filtration agent. Water hyacinth (Eichhornia crassipes), in particular, has received much attention because of its hardiness and high productivity, especially when grown in domestic sewage lagoons. This floating, aquatic plant has an extensive root system that allows the plant to absorb nutrients directly from the water. In favorable climates and nutrient-enriched waters, this plant can grow to over 1 m in height above the water surface. Since this plant reproduces mainly by vegetative means, it can continuously produce offspring and new plant material following partial harvesting without the need of restocking. Pieterse (1978) recently wrote a comprehensive review of the available literature on the water hyacinth.

Steward (1970) and Boyd (1970) suggested that the water hyacinth was an excellent candidate for large nutrient removal systems based on theoretical projections from observed plant nutrient content, and Westlake’s (1963) estimated potential hyacinth productivity of 150 mt/ha/yr. Wolverton and McDonald (1978) later projected an annual productivity of 154 mt/ha from growth rate studies at the lagoon investigated in this report. Projections of this nature were further substantiated in actual nutrient removal studies. In one such study Sheffield (1967) found that his laboratory-scale system, which consisted of a water hyacinth pond...
followed by air stripping and coagulation and receiving 8.0 l/day of treated wastewater, could reduce the $\text{o-PO}_4^{-3}$-P to 0.7 mg/l, the $\text{NO}_3^-$-N to 0.2 mg/l, and the $\text{NH}_4^+$-N to 0.1 mg/l. The results from a study by Rogers and Davis (1972), using water hyacinths in both static and flowing systems, when interpreted with the productivity results of Penfound and Earle (1948), indicated that a 1-a water hyacinth treatment system could remove the daily nitrogen and phosphorus wastes of 800 people. Field tests by Dunigan et al. (1975) indicated that the water hyacinth was more effective in removing $\text{NH}_4^+$-N than $\text{NO}_3^-$-N. Ornes and Sutton (1975) conducted phosphorus removal experiments using water hyacinths and static sewage effluent. A maximum uptake of 5.50 $\mu$g P/g (dry weight) of plant material was observed from wastewater containing 1.1 mg P/l. Promising results pertaining to the nutrient removal ability of the water hyacinth from treated sewage effluent were also obtained by Cornwell et al. (1977).

More recently water hyacinths have been used to upgrade full size domestic sewage lagoons. In a study, Dinges (1978) used the water hyacinth as a final treatment system to upgrade the effluent from a large system consisting of an activated sludge plant and two aerated basins operating in parallel followed by three stabilization ponds. The 5-day biochemical oxygen demand (BOD$_5$) loading in the water hyacinth experimental pond was varied from 42.1 to 86.8 kg/ha/d. Throughout the experiment, the BOD$_5$ and total suspended solids (TSS) of the effluent averaged less than 10 mg/l each. The total nitrogen concentration was reduced to less than 5 mg/l.

For the past 5 years the National Aeronautics and Space Administration (NASA) at the National Space Technology Laboratories (NSTL) in south Mississippi has sponsored research on the use of the water hyacinth in wastewater treatment and the production of biomass for food, feed, fertilizer, and energy. A review was recently written by Wolverton and McDonald (1979a) on NASA’s vascular aquatic plant program. One study (Wolverton and McDonald, 1976) involved introducing water hyacinth into a facultative pond which received the discharge from 2, series aerated lagoons. The pond was used in a polishing mode to upgrade the water quality, especially in terms of lowering suspended solids concentration, in order to meet permit requirements. In this experiment the yearly mean TSS and BOD$_5$ were each reduced to 14 mg/l each. In another study, water hyacinth was introduced into a 1-cell, facultative waste treatment pond (Wolverton and McDonald, 1979b). With water hyacinths, the mean total suspended solids in the effluent were reduced to 10 mg/l due to the virtual elimination of algae. The BOD$_5$ was reduced by an average of 94% to a mean of 5.4 mg/l prior to discharge.

The 3-year study presented in this paper is a continuation of NASA’s efforts at NSTL to develop a data base sufficiently extensive to make it possible to predict with confidence the impact of the introduction of water hyacinth on an existing, full-scale domestic sewage lagoon. During the first summer of the study reported herein, the sewage lagoon was totally covered with water hyacinths; during the second summer, the lagoon was partially covered with these plants; and during the third consecutive summer, the lagoon was free of water hyacinth and all other vascular aquatic plants. Year-round growth of the water hyacinth could not be maintained since the system was completely open and some freezing occurs during the winter.