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Environmental Effects of Aquatic Disposal of Chopped Hydrilla

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ABSTRACT

Selected environmental effects of returning finely chopped hydrilla to the water immediately following mechanical harvesting (aquatic disposal) were examined in a field test conducted in hydrilla-infested Orange Lake, Florida. Dissolved oxygen (DO), temperature, and chlorophyll-a were compared between two harvested treatment plots, one with and one without aquatic disposal, and one non-harvested reference plot. Aquatic disposal resulted in an increase in chlorophyll-a concentration and a very minor decrease in dissolved oxygen. A test of the regrowth potential of chopped hydrilla showed that a very small portion of stem fragments (0.6%) could produce new growth.

Key words: mechanical harvesting, chlorophyll-a, dissolved oxygen, water quality, fragmentation.

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INTRODUCTION

Onland disposal of mechanically harvested aquatic plants usually constitutes the primary cost and time factors in mechanical control of aquatic plants. In an effort to alleviate this problem, a large mechanical harvester was developed (Limnos System, manufactured by Limnos Limited, Toronto, Canada), with an onboard chopper to facilitate a reduction in the volume of harvested material, thus requiring fewer trips to onland disposal sites.

During preliminary testing of this harvester (Smith 1984), it was observed that when chopped material was dropped directly back into the water behind the harvester, it quickly sank. This disposal practice, in comparison with onland disposal, doubled the cost-effectiveness of the overall operation. The importance of removing harvested plant material from the water, in order to prevent water quality degradation, reverse trends toward eutrophication, and prevent regrowth of fragments, has repeatedly been stressed (Hasler 1969, Livermore and Wunderlich 1969, Nichols 1974). However, no studies have been conducted to examine the actual environmental effects of not removing harvested material. Related situations which may

promulgate such effects include: decay of naturally senescing and herbicide-killed plants, and the decay of plants under benthic barriers. Research on these topics has shown that deoxygenation and nuisance algal blooms may occur under certain conditions (Daniel 1972, Boston and Perkins 1982, Landers 1982).

The current study was designed to examine the environmental feasibility of inlake disposal in conjunction with aquatic plant harvesting. Dissolved oxygen (DO), temperature, and chlorophyll-a were monitored in test plots in Orange Lake prior to and after hydrilla harvesting. Selected physical and chemical characteristics of the chopped plant material were analyzed, and the regrowth potential of the stem fragments were tested.

MATERIALS AND METHODS

The study was conducted in Orange Lake (Alachua Co., FL) (area = 5260 ha, average depth = 2.9 m). Three closely-placed (closest borders separated by 30 m) but nonadjoining 0.58 ha square plots were established within a large area of dense surface-matted hydrilla (*Hydrilla verticillata* (L.f.) Royle) at an approximately uniform depth (1.8 m). The plots were designated as the harvest (H), the disposal (D), and the reference (R) plots. Preharvest biomass sampling in each plot (n=16/plot), using a hydraulically operated aquatic plant sampler (Sabol 1984), indicated a standing crop of 99.8 g dry wt./sq.m. (standard error = 6.2 g) with no significant standing crop differences between plots.

On the morning of 20 July 1981 plots H and D were harvested to a depth of 1.5 m. Chopped plant material from plot H was disposed of on land, while that from plot D was immediately and uniformly deposited into the water. No harvesting operations were performed in plot R.

Daily water chemistry determinations were made in each plot from 9 July to 13 August, if weather permitted. Monitoring consisted of dawn and late afternoon temperature and DO determination (Hydrolab Surveyor 6-D) at depth increments of 0.25 m at each of 6 randomly-placed stations within each plot. Water samples for chlorophyll-a analysis were collected at a single depth of 0.5 m at 3 stations in each plot every other sampling morning. Samples were filtered and analyzed in accordance with the trichromatic procedure of Strickland and Parsons (1972).

Two-way analysis of variance was performed on areal oxygen content (g/sq.m, depth-integrated dissolved oxygen concentration) and chlorophyll-a concentration (μg/l) comparing plots and sampling days within daily sampling periods (dawn and afternoon) and treatment periods (before and after harvesting). Data sets used in this analysis consisted only of sampling periods in which all plots were sampled. Duncans multiple range tests were performed to discern plot differences. Mean dawn and afternoon temperature and DO profiles were computed for each plot and treatment period.

To document gross physical and chemical characteristics of chopped plant material, and to determine the potential for regrowth of stem fragments, samples of chopped plant material were collected from the harvester during operations in plot D. Physical determinations included mass density, number of stem fragments per unit weight (stem density), distribution of stem lengths, number of nodes per stem (nodal distribution), and buoyancy characteristics of the material. Mass density was estimated by measuring wet weights of 3 replicate samples of chopped material packed into 1-liter containers. Stem density, length, and nodal distributions were estimated by counting and measuring all stem fragments in a 105-g sample and extrapolating to per kilogram basis. Buoyancy characteristics were determined by placing a 27-g sample into a 1-m tall water-filled cylinder and making periodic observations on the number of stems remaining afloat over a 24-hour period.

Plant tissue was analyzed for total solids, ash-free dry weight, chemical oxygen demand, total organic carbon, total phosphorus, and total kjeldahl nitrogen. Analytical methods are listed in Table 1. Additional tests, not pre-

TABLE 1. CHEMICAL AND PHYSICAL CONSTITUENTS ANALYZED IN CHOPPED HYDRILLA SAMPLE. RESULTS ARE EXPRESSED IN DRY WEIGHT UNITS, EXCEPT FOR SOLIDS; STANDARD ERROR IS INDICATED IN PARENTHESIS.

COMPONENT	BULK COMPOSITION (S.E.)	METHOD
SOLIDS	5.74 (0.01) %	DRIED AT 70° C
ASH-FREE DRY WEIGHT	890(1) g/kg	LOSS ON IGNITION AT 550° C (APHA 1971)
CHEMICAL OXYGEN DEMAND	820 (4) g/kg	DICHROMIC ACID DIGESTION, TITRATION WITH FERROUS AMMONIUM SULFATE (APHA 1971)
TOTAL ORGANIC CARBON	404 g/kg	WET OXIDATION FOLLOWED BY INFRARED CO_2 ANALYSIS WITH OCEANOGRAPHIC INTERNATIONAL 524-C TOC ANALYZER (USEPA 1979)
TOTAL PHOSPHORUS	5.2 g/kg	PERSULFATE DIGESTION, COLORIMETRIC ORTHOPHOSPHATE DETERMINATION WITH ANTIMONY-PHOSPHOMOLYBDATE COMPLEX (USEPA 1979)
TOTAL KJELDAHL NITROGEN	35.9 g/kg	MICRO-DIGESTION WITH SELENIUM DIOXIDE AND PERCHLORIC ACID FOLLOWED BY COLORIMETIC DETERMINATION OF AMMONIA (USEPA 1979)

sented here, were conducted to estimate the portion of each of these constituents initially in soluble form.

The regrowth potential of the stem fragments was examined under field conditions. Aliquots (350 ml) of freshly chopped plant material were placed into each of 5 replicate chambers moored in the lake. Chambers consisted of 17-liter plastic buckets with plastic screen siding and tops, held in a mostly submersed position by an attached life ring; bottoms of each chamber contained 5 cm of heat sterilized (to kill any plant material within the sediment) Orange Lake sediment. Fragments were observed for 3 weeks, by which time all fragments either showed new growth (axillary branches) or had decomposed. The number of viable fragments in each chamber, and the length and number of nodes on the original portion of each fragment were counted and measured.

RESULTS AND DISCUSSION

The chopping process consolidated the harvested hydrilla to a mass density of 963 kg/cubic meter, almost that of water. This represents approximately a four-fold decrease in volume compared with unchopped hydrilla. Stem density was approximately 6200 fragments/kg with a median stem length of 6 mm (Figure 1). Leaf material sank immediately in the buoyancy test while most stem fragments initially floated. Within minutes, short fragments began losing buoyancy and sinking. After 24 hours only a few stems remained afloat; these consisted of relatively long fragments. Noticeable turbidity disappeared from the water in the cylinder within 3 hours.

Chemical composition of the chopped hydrilla (Table 1) was similar to that observed by others (Jewell 1971, Langland 1982). Only a small portion (10% or less) of each chemical constituent was initially in soluble form, except for total phosphorus, 21% of which was initially soluble (unpublished data).

The number of fragments exhibiting new growth in the regrowth chambers averaged 12 and ranged from 6 to 20. This corresponds to approximately 37 viable fragments/kg, or about 0.6% of the total number. From the nodal distribution of stems in freshly chopped material (Figure 1), the survival (based on regrowth) of fragments with 0 through 5 nodes was 0%, 2.2%, 2.9%, 28%, and 30%, respectively. These percentages are considerably less than those measured by Langland and Sutton (1980) in a another fragment survival test; differences in test conditions, particularly length of fragments tested, probably accounts for this difference. Longer fragments, which tended to have a relatively larger number of nodes, showed higher probability of regrowth, however,several fragments as short as 2 mm exhibited new growth.

The DO content of the test plots was similar before harvesting (Figure 2), with day-to-day variations far exceeding variations between plots. Harvesting appeared to have little effect on morning DO levels, however afternoon DO levels in harvested plots were much less than in the reference plot. Immediately following harvesting, an afternoon minimum was observed in plot D; comparable measurements were missed in plot H due to instrument malfunction.

Very minor, although statistically detectable ($p<.05$), DO differences occurred between test plots before harvesting (morning and afternoon) and in the morning following harvesting (Figure 3). Following harvesting, afternoon DO in harvested plots exhibited a large drop relative to plot R and relative to within plot DO prior to harvesting (Figures 3 and 4). Post harvesting afternoon DO differences between plots H and D were very minor but statistically de-

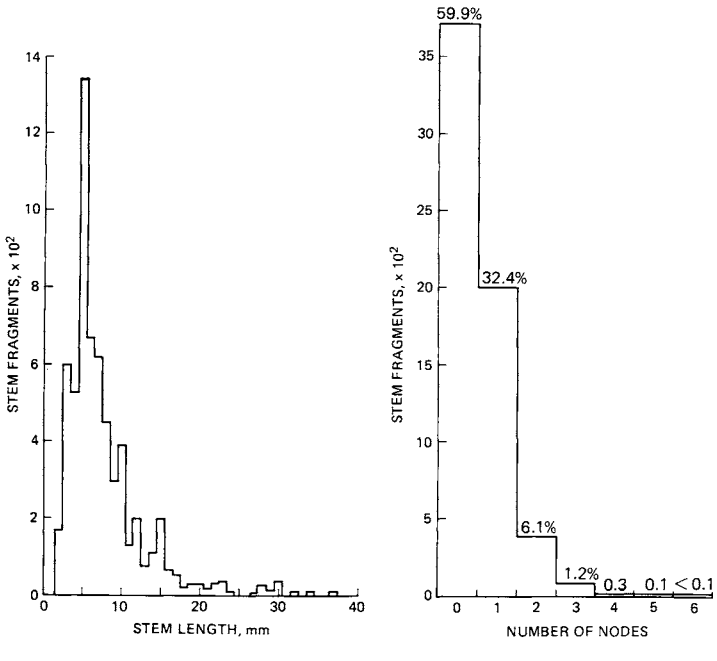

Figure 1. Distribution of lengths of stem fragments and the number of nodes per fragment per kilogram (wet weight) of chopped plant material.

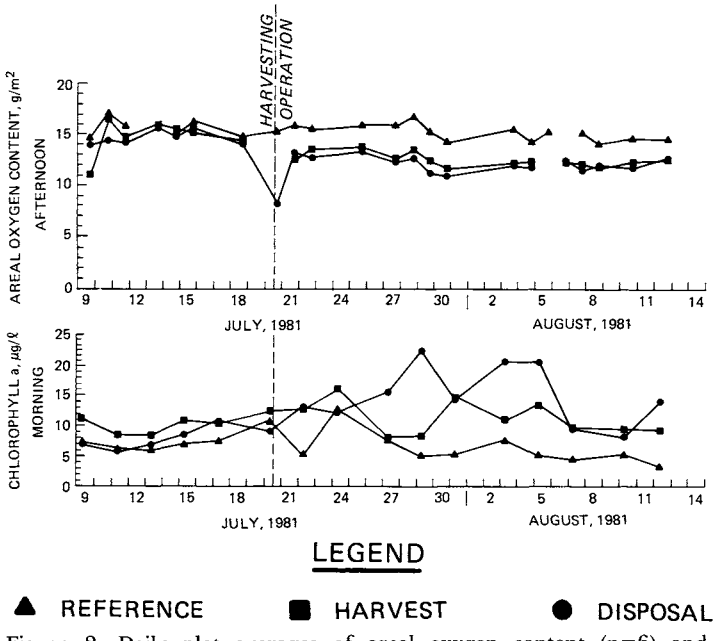

Figure 2. Daily plot averages of areal oxygen content (n=6) and chlorophyll-a contentration (n=3) for the 3 test plots over the test period.

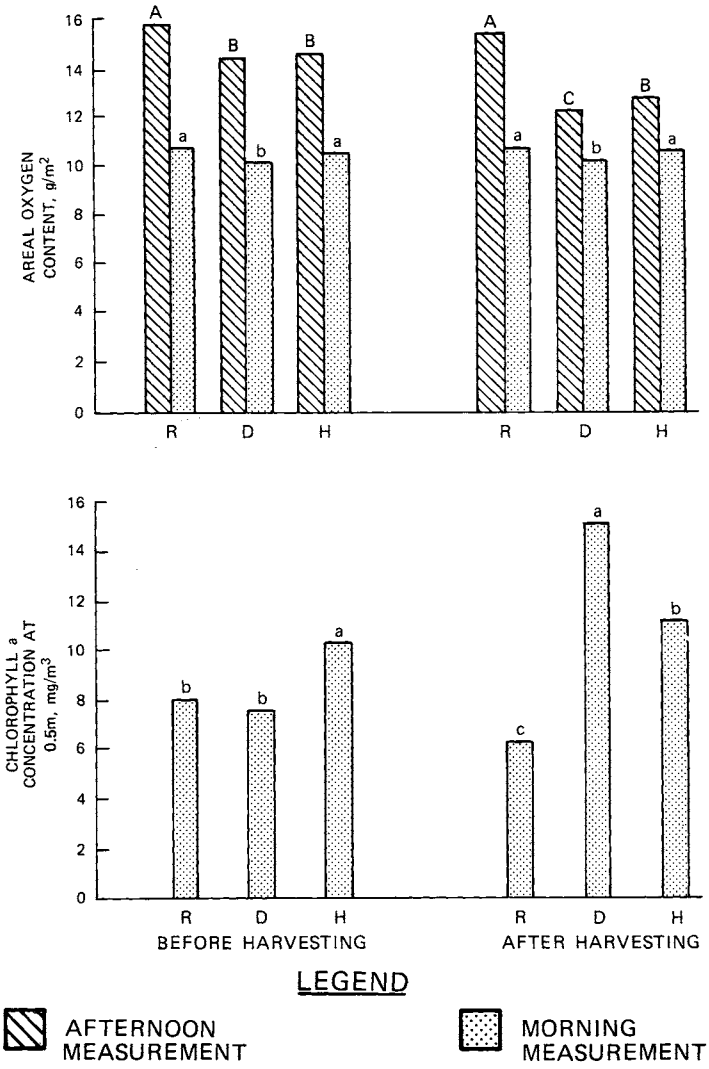

Figure 3. Analysis of variance of areal oxygen content and chlorophyll-a concentration. The three test plots are compared among themselves before and after harvesting by sampling period (morning and afternoon). Plots with the same letter are not significantly different ($p > 0.05$) (compare upper-case with upper-case, and lower-case with lower-case).

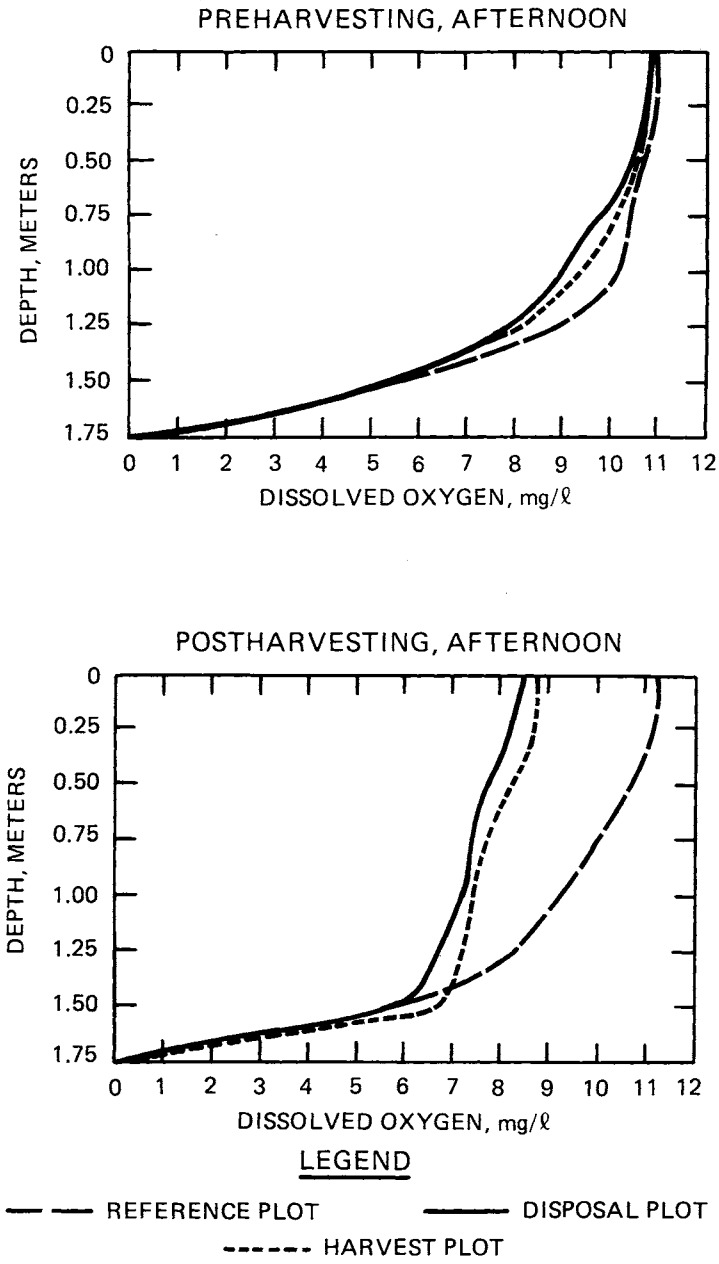

Figure 4. Average plot dissolved oxygen concentration profiles for the afternoon period before (n= 7 samplings of 6 stations each) and after (n= 14 samplings of 6 stations each) harvesting.

tectable ($p<.05$). Thermal profiles before harvesting showed isothermal conditions at dawn and pronounced stratification by late afternoon. Harvesting resulted in a very minor, although statistically detectable ($p<.05$) decrease in stratification.

Chlorophyll-a concentration varied greatly between plots and on a day-to-day basis (Figure 2). Plot differences were significant ($p<.05$) prior to and after harvesting (Figure 3). Comparing within plot concentrations between pre- and postharvesting periods, plot D concentration doubled following harvesting while plot H concentration increased slightly and plot R concentration decreased slightly.

The effects of aquatic disposal of chopped plant material on DO and temperature were negligible. The only appreciable effect was an apparent increase in chlorophyll-a concentration, which is taken to be indicative of algal density. The removal of hydrilla by harvesting (followed by either on-land or in-water disposal) exhibited a far greater effect on temperature, DO, and chlorophyll-a concentrations. This is of course expectable given the well documented effects of aquatic vegetation on water quality (Dale and Gillespie 1977, Edwards 1968, Fitzgerald 1969, Nichols 1973).

The organic loading due to the aquatic disposal, an estimated 45.5 mg oxygen demand/liter[2], resulted in a negligible depression in DO (Figure 2 and 3). This suggests that processes and factors which ameliorate DO depression are adequate for this loading level. These processes and

[2]Assume COD of dry material (404 g/ kg dry weight[dw]) represents potential oxygen demand,
loading = (99.8 g dw/sq.m)(820 g COD/kg dw)/(1.8 m depth)
= 45.5 g oxygen demand/cubic meter (=mg/l)

factors include: off site mixing, reaeration, and incomplete oxidation of plant material due to existence of a refractory component in the plant material, and settling of plant material from the aerobic portion of the water column. Insufficient data is available to determine the relative importance of each of the above, however, observations from the settling test and the observed near-bottom anoxic conditions would indicate that settling is an important factor.

It is not possible to draw widespread conclusions on water chemistry effects based on this single test. However, this test was conducted under operationally realistic conditions for small area harvesting. Given the high plant density harvested (high organic loading), it seems likely that the water quality effects observed may be as severe as are likely to result from this disposal practice for other commonly performed small area harvesting operations, such as cutting boat lanes.

The potential for spreading hydrilla by dispersal of viable fragments may be the most severe environmental effect of this disposal practice, particularly in open systems. This study shows that a small portion of the fragments are capable of regrowth although no attempt was made to track the actual fate of released fragments. Most fragments would probably probably sink in or near the harvested area, at least in non-flowing waters. However, the longer fragments, which have the greatest potential for regrowth, tend to float longer and therefore may drift to uninfested areas and regrow. This is not important in a completely infested waterbody such as Orange Lake, but it would be important in partially infested waterbodies.

A significantly greater degree of chopping would be required to eliminate the potential for fragment regrowth, given that the median length was 6mm and that some fragments as short as 2mm were observed to regrow. Such increased processing would likely increase the portion of organics and nutrients in soluble form and may result in greater water quality degradation.

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