Phosphorus Removal by Plant Harvesting on Lake Minnetonka

October 22, 2004

John M. Barten
Three Rivers Park District

Phosphorus Removal by Plant Harvesting on Lake Minnetonka

Introduction

In 1986, the exotic plant *Myriophyllum spicatum* (Eurasian watermilfoil) was discovered in Lake Minnetonka. The initial discovery of the plant was followed almost immediately by nuisance growth that impeded recreational boating in many areas of the lake. In response to these concerns, the Lake Minnetonka Conservation District initiated a plant harvesting program on the lake to minimize impacts to boating.

Annually, the LMCD program harvests between 400 and 1000 acres of the lake, and removes approximately 200 truckloads of plants. The annual removal of large quantities of plants from the lake has the potential to remove significant amounts of phosphorus from the lake and improve water quality. Previous studies, primarily in Wisconsin, found that aquatic plants are approximately 0.2 percent phosphorus by dry weight. Unfortunately, the dry weight of plant material removed from Lake Minnetonka was unknown, and it was thus very difficult to estimate the quantity of phosphorus removed from the lake. Estimates of phosphorus removal from the lake completed by the Minnehaha Creek Watershed District ranged from 2000 to 20,000 pounds annually.

In an effort to accurately quantify the actual removal of phosphorus from the lake, the LMCD initiated a study during the 2004-harvesting season. Representative truckloads of harvested plant material were weighed, the plants dried and then analyzed for phosphorus content. The study determined the ratio of dry to wet plant weight.

Project Objectives

The objective of the study project was to determine the quantity of phosphorus removed from Lake Minnetonka by the LMCD milfoil-harvesting program. A major component of the determination was to calculate the ratio of dry to wet plant weight in truckloads of material removed from the lake.

Methods

The mass of harvested plant material in a representative sample of truckloads was obtained by weighing two truckloads of material each week during the harvesting season. Trucks were weighed on a truck scale at a bituminous mixing facility near Lake Minnetonka. Prior to beginning the study, the truck was weighed empty with a full tank of fuel. The volume of fuel in the tank during each subsequent weighing was measured from the fuel guage. The fuel weight was then estimated assuming 7.1-lbs/ gallon for diesel fuel. Typically, the final load of the day was selected for sampling to maintain the operational efficiency of the harvesting program.

The weighed plant loads were transported to the Three Rivers Park District Gale Woods Park and dumped on a composting slab. Representative sub-samples were collected from the top, middle and bottom of each plant pile immediately after dumping, and mixed. The dominant plant species in each truckload were identified. The plant sample was placed in a plastic bag and weighed to determine the wet weight, transported back to the Park District laboratory and allowed to air dry. The air-dried material was then oven dried to a constant temperature of 105 C, and weighed.

Sub-samples of the oven dried plants were taken, ground up, and digested. The phosphorus concentration of the dried plant material was determined by the ascorbic acid method, (Standard Methods, 18th Edition). Duplicate analyses were performed on all collected samples.

Results and Discussion

Sample collection began on June 29, 2004. Two samples per week, one on Tuesday and one on Thursday, were collected for the following seven weeks. Typically, the final truck load of the day was weighed, and the plants delivered to Gale Woods Park. A total of 14 truckloads of plants were weighed and sampled.

There was considerable variability in the weight of plant material in the trucks. The plant loads ranged in weight from 6,200 to 14,118 pounds, with an average of 10,002 pounds/truck. Some of the variability was undoubtedly due to the load being the last of the day. Although the truck operator attempted to fill the truck completely, it was not possible to control the plant mass on each harvester at the end of the day. The time between unloading the final harvester load onto the truck and arrival at the weigh station was fairly consistent. Thus, water loss from the plants was also consistent for each harvester load.

The percent dry weight of the plant material ranged from 9.7 to 14.3 percent, with an average of 11.8 percent. This is similar to wet to dry weight ratios for aquatic plants reported by Burton, King and Ervin, 1979. Loads containing mainly EWM tended to be very similar in percent of wet to dry weight. Samples with significant amounts of coon tail, however, tended to have a lower wet to dry weight ratio, and samples with mainly niads's or pondweeds tended to have a higher percent of dry weight (Table 1).

Only 11 of the 14 samples were oven dried and analyzed for phosphorus concentration. Two of the samples developed a significant growth of a fungus during the air-drying process and were discarded. One sample, collected by staff from Gale Woods, was too large, and a stable oven-dried weight could not be obtained. This sample was also discarded.

The percent of phosphorus per gram of dry weight of 11 samples ranged from 0.11 to 0.41, with an average of 0.23 percent. The average is comparable to the value reported by Carpenter and Adams for EWM from Wisconsin lakes, and by Burton, King and Ervin, 1979. Differences in the percent of phosphorus in plant tissue (dry weight) are

also likely due to plant species differences. The two samples containing more than 50% coontail had an average phosphorus percent of 0.39% (dry weight). Conversely, samples containing mainly narrow leaf pondweed were 0.15 % phosphorus (dry weight).

Table 1. Plant Species Composition

Sample #	Date		(%) Plant Composition											
		Plants (lbs)	*MF*	*CT*	*NF*	*CH*	*PZ*	*EL*	*VA*	*PT*	*AG*	*ZD*	*PC*	*NL*
1	8/3/04	11608.75	80	20										
2	8/10/04	9923.75	95						5					
3	7/27/04	10917.5	>5	>5	60	30			5					
4	8/12/04	14117.5	40			10								50
5	7/22/04	7717.5	60	<5	30	<5							<5	
6	7/7/04	9381.25	5	90						<5		<5		
7	6/29/04	6200	99											
8	7/20/04	10195			80					5		15		
9	7/18/04	8340	30	50		10		5	5					
10	7/29/04	9220	60	25			5	5		5				
11	7/13/04	12395	80	5			10				5			

MF = Milfoil
AG = Algae
CT = Coontail
PZ = P. Zosteriformis
CH = Chara
EL = Elodea
VA = V. Americana
PT = Potamageton sp.
NF = N. Flexilis
ZD = Z. Dubia
PC = P. Crispus
NL = Narrow Leaf Pondweed

Table 2. Plant weight and percent phosphorus.

Sample	Date	Truck Weight	Fuel	Plant Weight (lbs.)	% Dry wt.	%P/ dry Weight	Lbs. P/truck load
1	8/3/04	27580	7/8	11609	10.3	0.161	1.930
2	8/10/04	25540	3/8	9924	10.4	0.218	2.250
3	7/27/04	26800	3/4	10918	14.0	0.195	2.980
4	8/12/04	30000	3/4	14118	14.	0.154	3.120
5	7/22/04	23600	3/4	7718	13.7	0.163	1.720
6	7/7/04	24820	1/8	9381	9.7	0.388	3.530
7	6/29/04	22260	Full	6200	10.0	0.228	1.410
8	7/20/04	25900	1/2	10195	13.1	0.285	3.810
9	7/18/04	24400	Full	8340	11.6	0.370	3.560
10	7/29/04	25280	Full	9220	12.6	0.117	1.330
11	7/13/04	28100	1/2	12395	10.1	0.273	3.420
Average				10002	11.8:1	0.232	2.642

The amount of phosphorus in an average truckload of plants harvested from Lake Minnetonka was calculated at 2.6 pounds. In 2004, 196 truckloads of plants were removed from the lake. Thus, approximately 510 pounds of phosphorus were removed from the lake by the harvesting program. The minimum and maximum pounds of phosphorus removed from the lake using the largest and smallest truckloads was calculated as 333 and 757 pounds/year respectively.

The Minnehaha Creek Watershed District estimates an annual phosphorus inflow to Lake Minnetonka of approximately 20,000 pounds. The harvesting program thus removes between 2 and 4 percent of the annual phosphorus load to the lake. The annual cost of the harvesting program is estimated at $104,000. The estimated removal cost of phosphorus with the harvesting program averages $204 per pound, significantly less than removal rates for most watershed BMPs. For instance, the estimated phosphorus removal cost of a street sweeping program is $300/ pound, and for many detention ponds is $1,000 per pound.

Although the harvesting program removes only three percent of the annual phosphorus load to Lake Minnetonka, the value of that removal can be viewed in terms of the difficulty of removal of phosphorus from stormwater. For instance, it would require the installation of 1500 rain gardens in the watershed to remove a comparable amount of

phosphorus. It would require the construction of a 4.5 acre-foot NURP pond treating stormwater runoff from approximately 700 acres of residential area to achieve a comparable phosphorus reduction. Viewed in this manner, the amount of phosphorus removed by the milfoil harvesting program is significant.

The effect of the phosphorus removal by the LMCD harvesting program on the water quality of Lake Minnetonka is more difficult to estimate. Previous studies have shown that, in the short term, removal of phosphorus through plant harvesting is not a viable water quality improvement technique. Generally, plants obtain phosphorus and other nutrients from lake sediments. Therefore, removal of plants does not necessarily remove phosphorus from the water column. However, the long term effect of annual plant removal on a large scale on water column phosphorus concentrations has not been determined. Theoretically, annual plant harvesting in the same area for an extended time period could mine phosphorus from the sediments and increase their ability to adsorb phosphorus from the water column. Future data from the ongoing monitoring program should be analyzed to determine if phosphorus reductions in bays with extensive harvesting are occurring.