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Department of Horticultural Science
University of Minnesota, St.Paul, MN

Sediment Dredging and Macrophyte Harvest as Lake Restoration Techniques

Jeremy Klein

INTRODUCTION

Eutrophication is the natural aging process for lakes and reservoirs. This aging process involves an increase in nutrient richness in the water body, as well as increased sediment thickness. This sediment filling will promote the transition from lake to wetland by creating a shallower basin. Lakes are generally classifies into one of three categories; oligotrophic, mesotrophic, or eutrophic (Owens and Chiras 1990). Oligotrophic lakes are clear, cold lakes with low nutrients and few macrophytes. these lakes have phophorus concentrations less than 1 microgram per liter (Klapper 1991). Mesotrophic lakes are intermediate while eutrophic lakes are characterized by high nutrient levels, turbid water, and large macrophyte populations (Owen and Chiras 1990). Phosphorus concentrations can be as high as 1 milligram per liter in eutrophic lakes (Klapper 1991). Considering one gram of phosphorus can produce one hundred grams of algal biomass it is clear that eutrophic lakes contain large algal populations.

Cultural eutrophication, which is the acceleration of the natural aging process through human inputs, is a major problem facing lakes around the world (Ryding and Rast 1989). Cultural eutrophication can lead to contaminated drinking water supplies, massive fish kills, increased bacterial counts, and several other ecological and social effects. Eutrophication can impact drinking water supplies in a variety of ways. Rapid changes in the dominant algal species can be harmful because it is not what the treatment plant is set-up to handle (Klapper 1991). Some of these new species can even be toxic. Bacteria also become a problem in water supplies and can cause taste and odor problems (Klapper 1991). Fish kills can occur by a lack of oxygen, elevated ammonia concentrations, or by the occurrence of hydrogen sulfide in the water column (Klapper 1991). In many situations the occurrence of large algal blooms coincide with large bacterial counts. This bacterial dissimulation and algal growth can lead to the release of carbonic acid into the water (Klapper 1991).

Lake restorations are usually attempted to improve water quality or to improve aesthetic and recreational needs (Gangstad 1982). This review focuses on restoration by the removal of phosphorus. In most cases phosphorus is the limiting nutrient for aquatic systems, when phosphorus is plentiful growth can increase exponentially. Phosphorus can be found in the water column when external inputs such as waste water are entering the water body. This phosphorus can be removed by treating incoming water to remove the phosphorus. Phosphorus is also found in high concentrations in lake sediments and vegetation. When the sediment concentrations are the problem these sediments sealed through chemical application or removed by dredging. When aquatic vegetation is the concern herbicides or harvest are the options. Dredging and macrophyte harvest differ from other restoration approaches in that these techniques involve physical removal of material from the water body.

DREDGING

The methods of dredging used in lakes were originally designed for dredging harbors. Many of these methods have since been scaled down for use in smaller lakes and reservoirs. Dredging can accomplish several goals: removal of toxic substances, macrophyte removal, phosphorus removal, and contour alteration for navigational purposes (Cooke et al. 1986). Dredging can control phosphorus levels by removing the portion that is contained in the sediments. Lake Ontario sediments have been found to contribute phosphorus levels equal to ten percent of the lake's external loading (Bannerman et al. 1975). Studies have shown that some bodies of water can have up to sixty-six percents of their total phosphorus loading from sediment input (Cooke et al. 1986). Bodies of water where sediment phosphorus loading is a major contributor to the total phosphorus load are good candidates for restoration through dredging. The sediment phosphorus loading occurs when the phosphorus held in the sediment is disturbed and redistributed into the water column. Disturbance can be caused seasonal changes in stratification or by wind action in shallower bodies of water.

There are three main types of dredging implements. The dredge types are grab bucket, hydraulic, and pneumatic. Grab bucket dredges are cranes with large buckets that are clam-like in design (Klapper 1991). Once the bucket is lowered into the sediment, the bucket is closed and the load is either directly dropped on shore or onto a barge. These dredges can be operated from shore or placed on a barge to operate off-shore. Often times the dredging area will be surrounded by a silt curtain to contain the disturbed sediments in the working area and prevent excess turbidity in the rest of the water body. Advantages to this style is that dredges are able to work in confined areas and are relatively inexpensive (Klapper 1991). Disadvantages include high turbidity levels (Nakai 1978), uneven bottom contour, and inefficiency of the dropping, lifting, and unloading process.

Hydraulic dredges used in inland lakes are usually made up of a cutterhead with a hydraulic pipeline (Cooke et al. 1986). Main components of the dredge include the hull, cutterboom, cutterhead, pump, and spuds. The hull supports the entire unit and is engineered to sustain constant vibration (Cooke et al. 1986). The cutterboom determines the workable depth of the dredge and supports the cutterhead and suction pipe. The cutterhead is the piece that performs the actual excavating. Cutterheads can be of varying design but all are built to loosen the sediments. The sediments are then pumped through the suction pipe and disposed of on shore or into barges. Many controls are needed along the pipeline to prevent reflux and other conditions if the pump fails (Inada 1979). The spuds can be though of as the dredge's legs. The spuds are located at the rear corners and walk the dredge forward as the sediments are removed (Cooke et al. 1986). This type of dredge is better at reducing turbidity when operated correctly. Improper use of the equipment can result in excessively high levels of turbidity (Cooke et al. 1986). Sustar (1979) concluded that the amount of sediment disturbance is related to the sediment type. Even a well run dredge can cause high turbidity levels when the sediments are high in clay.

Pneumatic dredges are similar to hydraulic dredges but use hydrostatic pressure to force the sediment into the suction head. The sediments are then pumped through the pipe and deposited (Cooke et al. 1986). The advantage of these dredges is that they are able to bring up sediments that have solids contents of up to seventy percent (Cooke et al. 1986). By removing such high solid contents the dredge is more efficient and extracted sediments do not contain unnecessary water.

Peterson (1977) examined several dredging projects. Many of the projects are poorly documented and lack follow up evaluations. In Trout Lake, Florida three hectares of a forty-one hectare lake were dredged down to a sand base. The result of this experimental restoration was that benthic fauna diversity increased in the dredged areas. Long Lake, Michigan was dredged to improve fish habitat. The average depth was increased from three fourths of a meter to two meters, and bass average length increased by about five centimeters. Lake Trummen, Sweden was dredged to reduce phosphorus in the lake. After dredging the lake no longer showed periods of phosphorus concentrations near 1 milligram per liter, but held steady around 0.2 milligrams per liter.

Dredging is also used after an external nutrient source has been diverted or treated. The dredging is required to remove the phosphorus that accumulated within the lake prior to treatment. The main advantage that dredging has over other techniques is that it does not introduce foreign substances into the water body. The main disadvantage is that the extracted sediments have to be put somewhere, and treatment of these deposit sites is still under investigation (Calhoun 1978).

MACROPHYTE HARVEST

The idea behind macrophyte harvest as a restoration technique is that it will reduce the internal productivity of the water body and remove phosphorus that is stored in the plant by removing the plant. Herbicide use can also reduce the internal productivity, however, the plants remain in the water and can contribute to the phosphorus load when they breakdown. Harvesting is also done for social and recreational reasons, most people think of all aquatic vegetation as weeds and do not want the vegetation in their lake.

All harvesters are generally based on designs by Wisconsin researchers (Cooke et al. 1986). The units are paddle wheel propelled and have a large frame extending down into the water ahead of the bow. This frame is made up of vertical sickles on the sides and a sickle across the bottom connecting the two sides. A conveyer belt extends up from this frame to the boat and carries the cut macrophytes to the surface where they are collected (Cooke et al. 1986).

By harvesting macrophyte biomass less phosphorus holding material is present in the water body. The amounts of phosphorus removed by harvesting macrophytes is considerably less than the phosphorus amounts held in sediments. Harvest and subsequent nutrient dynamics has been studied by Neel et al. (1973). The study lake was receiving municipal waste water through a river inlet. In this lake the bulk of the phosphorus load is in the water column with significantly lower levels in the sediment. Neel et al. (1973) concluded that harvesting had virtually no effect on phosphorus levels and calculated that removal has to be greater than the annual external input. This suggests that if the external input is removed that macrophyte harvest could reduce phosphorus levels in the lake. Repeated harvesting can reduce the macrophyte growth and can have a carryover affect that could be more cost effective than herbicide usage (Cooke et al.

1986). This may be desirable in recreational areas where there is a risk of people coming in contact with herbicides. The main advantage of macrophyte harvest is that it is a highly visible technique that provides instant results. The main disadvantage is that the process does not remove a significant amount of phosphorus from the system.

DISCUSSION

Dredging and macrophyte harvest are two restoration techniques that have relatively little negative impact on the water system since no foreign substances are being introduced into the system. However, these techniques can only be successful in certain situations. The Neel et al. (1973) study would have been more informative if the inflow of municipal waste water had been stopped prior to the macrophyte harvesting. With the inflow stopped the phosphorus would not have been held in the water column and harvest might have been worth while. In a culturally eutrophied body once the nutrient source is removed macrophyte harvest or dredging could be used to reduce the internal phosphorus load of the eutrophied system.

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