A Non-Toxic Lake Management Program

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ABSTRACT

Aeration and chemical precipitants act together to restore lakes to low nutrient levels. A non-toxic lake management program consists of monitoring physical and chemical parameters of a lake to determine first the need for aeration; second, the need for and proper time to apply mineral precipitants; and third, continuing adequacy or correction of the two adjuncts.

INTRODUCTION

Compounds of calcium, fluorine, magnesium, iron, zinc, and aluminum are known precipitants of plant nutrients, especially of phosphates and iron (2). While bacterial acids, carbon dioxide (CO_2), and manganese in the water redissolve these minerals back into the water (1), aeration removes or renders the mineral-dissolving factors ineffective. Adequate aeration coupled with mineral precipitation compounds can restore lake quality to low levels of available nutrients.

In addition to nutrient removal, aeration aids the oxidation and aerobic digestion of bottom organic ooze, and reduces loss of fish due to low oxygen levels.

By monitoring the physical and chemical parameters of a lake, determinations can be made as to required quantity and time of application of both precipitants and aeration.

LAKE TREATMENT METHODS

In a lake restoration program, the first step is to test the lake for its physical and chemical properties. To determine aeration required, depth of bottom muck or peat must be known along with the bottom topography. Coliform bacteria indicate influx of sewage to be counteracted.

An important nutrient for aquatic plants is CO_2 and could be increased if inadequate aeration is introduced. This would be caused by introducing oxygen to bottom muck without adequately moving the bottom water to the surface to have the CO_2 that is generated by aerobic digestion blown off by the wind. Carbon dioxide also may act on precipitated tri-calcium phosphate to form the more soluble mono- and di-calcium phosphates (4).

Hydrogen sulfide, ammonia, manganese, iron, nitrate, and nitrite, biological oxygen demand (BOD), pH, and turbidity are all important measures of anaerobic decomposition and organic and inorganic matter present due to inadequate aeration. Manganese may release phosphate (PO_4) from an insoluble bond with iron, freeing these nutrients for plant assimilation (3).

Dissolved oxygen (DO) and ortho and meta phosphate can be misleading parameters unless organically bound phosphate and algae and weed content are considered. A lake with overabundant nuisance weeds and algae may be very high in surface DO during the day and may be in great need of aeration during the night. Respiration of the vegetation during the night or extended cloudy weather may seriously deplete the available dissolved oxygen. Likewise, near-zero available phosphates can exist in either a fairly clean low nutrient lake or one filled with flora, having absorbed all available phosphate.

The aerator used in the present study[1] was designed to use nature to restore water quality. It is not economical to attempt to aerate a water body by diffusing air into it with a machine, when wind on the surface is providing up to thousands of horsepower. The total concept in the aerator used was to move as much water from the bottom

[1]Manufactured by Clean-Flo Laboratories, Inc., Hopkins, Minnesota.

to the surface as economically as possible, and then let the wind oxygenate the water and allow diffusion of unwanted gasses to the atmosphere. It is desirable to create a current along the bottom towards the aerator, and then straight up to the surface to prevent carbon dioxide from diffusing up through the entire water body to the surface and acting as a plant nutrient.

For this purpose a diffuser element having a porous ceramic plate was chosen to produce the smallest possible bubbles in the greatest possible quantity. Air pressure must be adequate to move the bubbles away from the diffuser and into the water before they have time to coalesce. Excessive air pressure will create turbulence, and interfere with laminar flow. By concentrating the water flow over a small diffuser area, high water current drags the bubbles quickly up in a laminar column.

Using this principle, about 3,000 gpm was observed, rising to the surface from a diffuser 6 ft deep with a 0.33-hp compressor. This same unit produced about 12,000 gpm at 12 ft depth. A 0.5-hp unit placed at 85 ft depth produced about 40,000 gpm transfer. Such massive transfer cannot be obtained economically by other mechanical means, but only by the combination of increasing the buoyancy of the bottom water, and by providing maximum air-to-water surface contact. No clogging of the diffuser has ever been experienced.

The amount of aeration required is estimated by considering the depth and organic content of muck, the bottom contour, surface acreage and shape, and the amount of nutrients and contaminants discussed above. Knowing the abilities and characteristics of the aeration system to be used, the system is installed and ammonia, pH, iron, CO_2, and manganese monitored. When CO_2 reaches a low enough level, say 5 ppm and pH is over 8.0, the phosphate precipitant may be added. If CO_2 increases and does not decrease after a reasonable time, additional aeration is indicated.

Precipitant level is determined approximately by organic muck, manganese, iron, and total phosphorous contents remaining after carbon dioxide has reached a minimum level. Manganese will not effect the calcium phosphate precipitation, but its removal will help available iron to remove phosphate.

While this program appears on the surface to be ideal for restoring quality, it should be noted that there are many unknowns, and as we continue to gain information, we may find that the solution is not so simple.

TEST RESULTS

A soluble, non-toxic calcium-based product,[2] has been tested in over 25 lakes in Minnesota[3] and eight in Florida. Generally, 5 to 30 ppm was added, and phosphate removal ranged from 70 to 100%. Our testing has all been confined to the use of the Clean-Flo chemical and aerator.

[2]Clean-Flo Lake Cleanser(TM), Manufactured by Clean-Flo Laboratories, Inc., Hopkins, Minnesota.

[3]Laing, R. L. 1972. Phosphate Reduction in Long Lake (T35, R24), Isanti County, Minnesota using Clean-Flo Lake Cleanser. Booklet, Clean-Flo Laboratories, Inc., Hopkins, Minnesota.

Aeration alone at Wilson & Company, Inc., a meat processing firm, reduced phosphorus effluent from 14 to 5 ppm in 3 weeks time. In the same time, BOD was reduced from an average of 41 to an average of 21.[4] This was accomplished using a 0.5 hp aerator in each of a 5, 15, and 20-acre, waste treatment aerating lagoon. In spite of this apparent improvement, effluent suspended solids have not significantly decreased. This is probably because of an alga bloom, because phosphate is still so high.

On March 29, 1973, at "Trout-Aire," a trout fishery at Forest Lake, Minnesota 15,000 1 to 2-lb rainbow trout (*Salmo gairdneri* R) were dying in a 0.5-acre, 10-ft average depth spring-fed pond.

The pond had a several foot layer of organic muck at the bottom, and an algae and weed (Curled Pondweed, *Potamogeton crispus* L.) problem. Orthophosphate content was zero. The pond had a 10-hp surface aerator operating continuously. The 0.33-hp aerator, a diffuser type, was installed beside the surface aerator. Within 15 minutes the trout revived, and after 0.5 hr they thrashed the surface for food. Carbon dioxide was 20 ppm, pH 8.7, and color 20 APHA platinum-cobalt units. Surface DO read 13 ppm while bottom DO was zero. Total hardness was 344 ppm and total alkalinity 378 ppm. After the aerator had been installed for 1 week, 20 ppm Clean-Flo Lake Cleanser was added. In 2 weeks, all sign of muck was gone, revealing a clean sand bottom and very healthy fish. The water was clear, and the weeds were receding. The concentration of CO_2 had been reduced to 7.5 ppm, pH to 8.2, and color to 7.

Tests on Peavey Pond, a 6.5-acre lake at Wayzata, Minnesota, 90 ft deep, are not complete, but data taken to date are shown in Table 1. This lake was a sewage settling pond for many years, and has a deep deposit of sludge, with a minimum of 5 ft of muck on the shoreline. A 0.5-hp aerator was installed at a 10-ft depth 150 ft from shore on 10 May, 1973. This was found to be inadequate due to increase of CO_2. On 3 June, a second 0.5-hp unit was installed at the bottom, center, and CO_2 decreased. Due to the high phosphate content, it was felt necessary to add a preliminary dose of 10 ppm precipitant even before CO_2 was fully reduced. Because of the high CO_2, phosphate did not decrease until the precipitant was added. Water quality will now be monitored and adjusted as described above as the parameters stabilize.

It can be seen that in just 2 months, from 3 June to 2 August, the pond is on the road to recovery with phosphate, CO_2, nitrate-nitrite, iron, manganese and hydrogen sulfide reduced significantly. Green algae are still abundant, since available phosphate is much greater than that required for a luxuriant bloom. These tests were made at approximately 1 p.m. at center surface on a sunny day about 25 ft from the diffuser. Single samples were taken.

DISCUSSION

Earlier, the term "adequate aeration" was used. Inadequate aeration could result in excessive generation of

[4]Mershon, C. E. 1973. Personal correspondence.

TABLE 1. AERATION AND ADDITION OF 10 PPM SOLUBLE CALCIUM COMPOUND TO AN ABANDONED SEWAGE SETTLING POND 6.5 ACRES IN SURFACE AREA AND 90 FT. DEEP.[a]

Measurement	Initial	After 24 days of aeration	37 days after installing 2nd aerator	4 days after adding chemical	81 days from start	84 days from start
DO at 9 ft (ppm)	6	—	—	4	1.2	—
DO at surface (ppm)	13	5	—	23	13	6
Secchi disk (in)	36	18	54	23	24	30
CO_2 (ppm)	12	55	10	8	10	1
Ammonia Nitrogen (ppm)	0.2	—	—	2.4	2.0	0.6
Hydrogen Sulfide (ppm)	0.07	—	—	0.02	0.0	—
Iron (ppm)	—	1.2	0.8	0.5	0.2	0.25
Manganese (ppm)	—	0.5	0.4	0.6	0.0	0.0
Ortho Phosphate (ppm)	—	12	13	7	5.5	3.3
Total Phosphate (ppm)	—	13	—	9	6.0	5.0
Nitrate-Nitrite (N) (ppm)	—	0.2	—	0.04	0.13	0.05
pH	—	7.1	8.0	8.7	8.4	8.5
Total hardness (ppm)	—	—	—	308	—	274
Total Alkalinity (ppm)	—	240	—	274	—	257
Phenolphtalein alkalinity (ppm)	—	0	—	51	—	34
Calcium hardness (ppm)	—	—	—	171	154	154
Magnesium hardness (ppm)	—	—	—	137	—	7
Color(APHA platinum- cobalt units)	30	—	—	75	—	45
Odor	offensive	offensive	faint	nil	nil	nil
Coliforms, Total (MPN/100ml)	0	—	—	—	—	—

[a]Where values are not shown, the water was not tested for that parameter at that particular time.

CO_2 without adequate removal or a mixed aerobic/anaerobic system in which the aeration provides accelerated bacterial action by mixing; anaerobic digestion produces abundant plant nutrients while aerobic digestion provides carbon dioxide. This results in excesive algae or weed growth.

The total lake management program is now in progress in several locations, and by this time next year, more complete data should be available. While our program utilizes especially adapted products, the same program could be geared to other products with equal success, especially when more is known about the various interactions.

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