X. STUDIES ON THE PHOSPHORUS CONTENT OF CERTAIN OKLAHOMA WATERS, AND NOTES ON THE DEVELOPMENT OF ARTIFICIAL PONDS

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Muddy water and absence of vegetation are two conditions which are usually found in the artificial ponds and lakes in the central and western parts of Oklahoma. Game fish do not grow and reproduce satisfactorily when the water is turbid, and vegetation is always limited under such conditions. Consequently the problem of determining what can be done to make conditions more favorable for the propagation and development of desirable fish needs to be investigated.

Recent studies on the soils of Oklahoma indicate that a marked deficiency in total and available phosphorus occurs in many soils; and since phosphorus is essential for the growth of plants, it might be possible that vegetation both macroscopic and microscopic could be restricted because of lack of this important plant food. Wiebe, working for the United States Bureau of Fisheries at Fairport, Iowa, reported that when the aquatic vegetation was making a rapid growth, the inorganic phosphorus in the ponds would frequently decrease to a very low content.

Juday, Birge, Kemmerer, and Robinson (2) studied eighty-eight lakes in northern Wisconsin and found only small amounts of inorganic phosphorus present in the water.

The amount of soluble inorganic phosphorus which has been reported from different sources varies from a minimum of .003 part per million in certain Wisconsin lakes to .253 part per million in certain Ordivician waters in Kentucky.

Samples of water taken during the season of 1930 from ponds and lakes located near Stillwater, Oklahoma, gave the following results:

Name of pond	Location in miles from Stillwater, Oklahoma	PHOSPHORUS CONTENT IN PARTS PER MILLION				
		May 29	June 1	June 24	July 10	Nov. 26
Chandler Pond	2 N.; 1 E.	----	----	.020	.590*	.001
Davis Lake	2 N.; ½ W.	.060	----	.005	.690*	.000
Lake Park (west)	3½ W.; 1 S.	.000	.660*	.100	.060	.002
Yost Lake	3 E.; 6 N.	.007	----	.005	.030	.003
Yost Lake Fish Hatchery	3 E.; 6 N.	.015	----	----	----	.001

*Fertilized with superphosphate; average of duplicate samples taken from different sides.

The solubility of tricalcium phosphate in distilled water in term of phosphorus is about one and one-half parts per million. A saturated condition has never occurred in any of the waters studied. Cameron and Bell (1) show that an increase in the alkalinity of the solution results in a decrease in the solubility of phosphorus, especially in the presence of increasing amounts of calcium bicarbonate.

The reaction of lake waters examined during spring and summer was about pH 7.4 to 7.6. Eleven out of thirteen water samples taken from different ponds and lakes on November 25 had a pH of 8.0 to 8.5, and in all instances except one, the phosphorus content was very low. In eight cases the amount was .001 part per million or less.

The growth of vegetation in these ponds was quite variable and could not be correlated with a lack or an abundance of soluble phosphorus. In one pond containing an abundant growth of plants (algae and myriophyllum) no phosphorus was present in water in midsummer, apparently due to the absorption of that element by the growing plants, since earlier tests indicated an abundant supply. Other ponds having a good supply of soluble phosphorus contained practically no vegetation. In most cases the waters were turbid in spring and early summer, and considerable decrease in turbility occurred toward mid-summer.

Further studies on the easily soluble phosphorus, total nitrogen, and reaction of the soil on the bottoms of these ponds and lakes were made in order to determine whether or not any of these factors could be correlated with vegetative development.

The results were as follows:

Name of lake or pond	Location in miles from Stillwater, Oklahoma	Easily* soluble phosphorus in percent	Total nitrogen in percent	Acidity of soil.	Growth of Vegetation
Boomer Reservoir	2 N.	.0016	.0870	Basic	Poor**
Chandler Pond (north)	2 N.; 1 E.	.0014	.0487	Basic	Poor
Chandler Pond (south)	2 N.; 1 E.	.0028	.0685	Slight	Fair
Experiment Station (west of A. H. Pond)	1½ W.; ½ N.	.0032	.0565	Basic	Poor
Experiment Station (S. W. of Horse Barn)	½ W.; ½ N.	.0020	.0747	Neutral	Fair**
Fish Hatchery at Power Plant in City		.0026	.1250	Basic	Excellent
Davis Lake	2 N.; ½ W.	.0028	.0550	Basic	Poor
Lake Park (S. W. Lake)	3½ W.; 1 S.	.0028	.0517	Neutral	Poor
Lake Park (East Lake)	3 W.; ¾ S.	.0008	.0385	Neutral	Poor
Yost Lake (at Bridge)	3¼ E.; 6 N.	.0070	.0182	Basic	None
Yost Pond (S. W. part of golf ground)	3 E.; 6 N.	.0048	.0885	Basic	----***
Yost Hatchery (west)	3 E.; 6 N.	.0022	.0885	Slight	Excellent
Yost Hatchery (near Club House)	3¼ E.; 6 N.	.0024	.0825	Slight	Excellent****

*N/5 sulfuric acid used, 1 part of soil to 10 parts of acid.
**Very turbid water.
***Not examined in mid-summer.
****Fertilized heavily in spring of 1930 with farm manure.

A study of the above table indicates that growth of vegetation is more closely associated with the nitrogen content of the soil which occurs on the lake bottom than with the easily soluble phosphorus in the soil, although both factors are essential for optimum growth and could be limiting factors under certain conditions. The easily soluble phosphorus of the soil has been increased by fertilization in the case of the South Chandler Pond and the southwest lake at Lake Park, as compared with North Chandler Pond and the east lake at Lake Park. No significant increase in vegetative development occurred this past year as a result of phosphorus fertilization, but the effect may be greater next season. Nitrogen fertilization of vegetation along the edges of some of these ponds resulted in a marked increase in vegetative development.

One of the reasons why vegetation is often scarce in new ponds may be due to the fact that no plants are introduced which are adapted to the new environment. Frequently introductions are made, and failure results because of an unfavorable soil condition. In the construction of many artificial ponds and lakes an area is selected where a dam will impound a considerable body of water, and frequently it is in a canyon or ravine. Often the banks of the new lake are relatively steep, and under such conditions the organic matter content of the soil is low. As the waves begin their action on the new shore line, the clay in the soil is churned into suspension, and settles very slowly because of the deflocculating effect of the sodium which occurs in many of the subsurface soils in the Great Plains area. The turbid condition of the water restricts the penetration of sunlight, and as a result the water plants which normally grow beneath the surface of the water do not develop. Consequently what might be a fisherman's paradise is only a red uninteresting mass of liquid surrounded by a muddy shore. Where vegetation once secures a good start, conditions gradually change, and the problem of establishing vegetation in new ponds appears to be closely associated with the nitrogen content of the soil on the lake bottom. The elimination of steep banks near the shore line is important in the rapid development of a new pond, because it decreases the tendency of the waves to carry clay particles into supension which add to the turbility of the water.

Under Oklahoma conditions where the shore line often recedes during periods of summer drought, a type of vegetation which will follow this shoreline and prevent the waves from stirring up the soil is essential. Bermuda grass is one of the best grasses for this purpose. After this is accomplished the water will clear sufficiently to allow the algae and other plants which grow beneath the surface of the water to develop and further protect the shore lines from the waves. Plants do not grow vigorously when the soil is not fertile; consequently, nitrogen fertilization is very important if an artificial pond or lake is to be developed rapidly. The best means of supplying nitrogen has not as yet been determined. Farm manures, cottonseed meal, or organic residues of any kind are sources of nitrogen which can be used. Whether or not commercial fertilizers such as ammonium sulfate can be used effectively cannot be answered at this time; although tests during the past year show that a very large increase in border vegetation of ponds has been secured as a result of spring applications of ammonium phosphate.

An economical problem is associated with such a process, and whether or not an individual can afford to assist nature in developing the vegetation in newly constructed ponds and lakes will govern the treatments to be given.

Colloidal clay can be removed from lake water by flocculating with lime, alum, or any other standard flocculating material; but the difficulty with water clarification is that the effect is only temporary where incoming water is always loaded with more clay, or where the waves are allowed to churn up a new supply from an unprotected shore line.

Five factors of importance need to be emphasized in developing artificial ponds or reservoirs in central and western Oklahoma, and they are as follows:

1. A water shed covered with grass or forest is most desirable.
2. A shoreline which is free from steep banks should be prepared so that vegetation can grow and protect the banks from waves.
3. Addition of fertilizer to poor soils is necessary so that a good growth of vegetation can be supported.
4. Introduction of adapted vegetation is usually required in order to secure a rapid development of aquatic plants, which have an important effect on the growth of fish, and also aid indirectly in clarifying the water.
5. The pond should be fenced so that livestock cannot trample the vegetation into the mud along the edges and destroy it.

References

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