PRELIMINARY INVESTIGATIONS OF CHEMICAL SOIL AND WATER RELATIONSHIPS AND LIME TREATMENT OF SOFT WATER IN GEORGIA FARM PONDS *

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ABSTRACT

A general classification of pond waters according to hydrogen ion and total hardness of calcium and magnesium is correlated with the major soil regions in the state. Specific correlation between Piedmont soils and Coastal Plain soils are apparent.

Limited data is available on lime treatment of soft waters and relationships to fertilization programs. Pond bottom soil analysis before and after liming exhibit beneficial nutrient releases following treatment, and water concentrations of calcium and magnesium and hydrogen ion are presented before and after lime treatment.

The efficiency of fertilization programs have been improved following lime treatment and amounts of fertilizer required for optimum results reduced. Pending additional study and results, liming may be a necessary constituent in fertilization programs of ponds within certain soil areas of Georgia.

INTRODUCTION

Observations of Georgia pond fertilization has demonstrated widely varying results in plankton production under apparently identical conditions. Some ponds consistently produce better plankton blooms with less fertilizer than other ponds, and some ponds fail to produce good blooms even with heavier than average fertilization. Many factors are necessarily related to fertilization success, among these are watershed fertility, climatic conditions, physical characteristics of the pond, and certain biological considerations sometimes associated with plankton organisms. It is further impractical to recommend a fertilizer analysis for individual ponds, even though water conditions may indicate a wide range of nutrient concentration. Generally, an approved analysis fertilizer, either 8-8-2 or 20-20-5 has produced desired results in Georgia ponds. Blooms of short duration and poor fertilization colors in many ponds each year has indicated the need for additional information on fertilization practices.

Past research has proposed various factors as indices of water productivity. Limiting factors generally attributed to be of significance include phosphorus, nitrogen, hydrogen ion and total alkalinity. Chemical analysis alone presents but a brief picture of actual conditions that are present in natural waters, and chemical data by itself is but a component of the overall picture and should be treated as such. The importance attributed to water hardness and total alkalinity, however, may be of particular significance in Georgia, since the entire state would be classed as a naturally occurring soft water area by comparative standards. Random chemical analysis throughout the state substantiate these findings except in the limestone areas of the state.

Carbon dioxide and calcium are essential to plant life. Although changes readily occur in hydrogen ion and carbon dioxide concentrations, such shifts can generally be attributed to the degree of photosynthetic activity. For this reason, hydrogen ion concentration as a single measurement is of little value in water chemistry studies. When correlated with total hardness of calcium and magnesium, hydrogen ion measurements are more indicative of existing conditions.

Agriculturists generally acknowledge that treatment of acid soils is necessary for complete utilization of fertilizer substances. This lime treatment provides a buffer effect and raises pH to a level where more desirable plant growth is achieved. The presence of calcium and magnesium carbonates and monocarbonates serves to function both for direct utilization in plant systems and as a buffer for more favorable release of nutrients through hydrogen ion adjustments. Comparable conditions appear to be present in Georgia ponds. A series

* This work was undertaken with Federal Aid to Fish Restoration funds under Dingell-Johnson Project F-6-R-4, Evaluation of Pond Management Practices.

of ponds has been encountered by the authors during the past several years that failed to produce any results from continued fertilization. Investigation indicated slightly acid conditions and only traces of soluable salts of calcium and magnesium and their bicarbonates. Lime treatment of these areas brought subsequent increases in hardness, raised hydrogen ion concentration, and brought about heavy plankton blooms not encountered prior to lime treatment. These results provided the basis for the investigation which follows.

METHODS

Hardness of water is due to the soluable salts of calcium and magnesium. Temporary hardness is due to calcium and magnesium bicarbonate and permanent hardness is due to soluable calcium and magnesium salts of inorganic acids. The sum of Temporary hardness and permanent hardness is equal to total hardness, which is the measurement utilized throughout this study. Total hardness determinations were found to be of more overall value than total alkalinity (temporary hardness) primarily because of hydrogen ion effects on bicarbonate to carbonate shifts and total hardness determinations also includes the carbonates of magnesium. Total hardness was determined by the Diehl, Goetz and Hatch method as the most accurate, rapid, and best designed field technique. The procedure involves titration of sodium ethylenediamine-tetraacetate with Erichrome black T indicator using a 50 cc. sample of pond water buffered to pH of 9-10. Hydrogen ion was determined colorimetrically with the Taylor pH Comparator and later, with the Beckman portable glass electrode. A wide range of pH was encountered varying with the degree of photosynthetic activity.

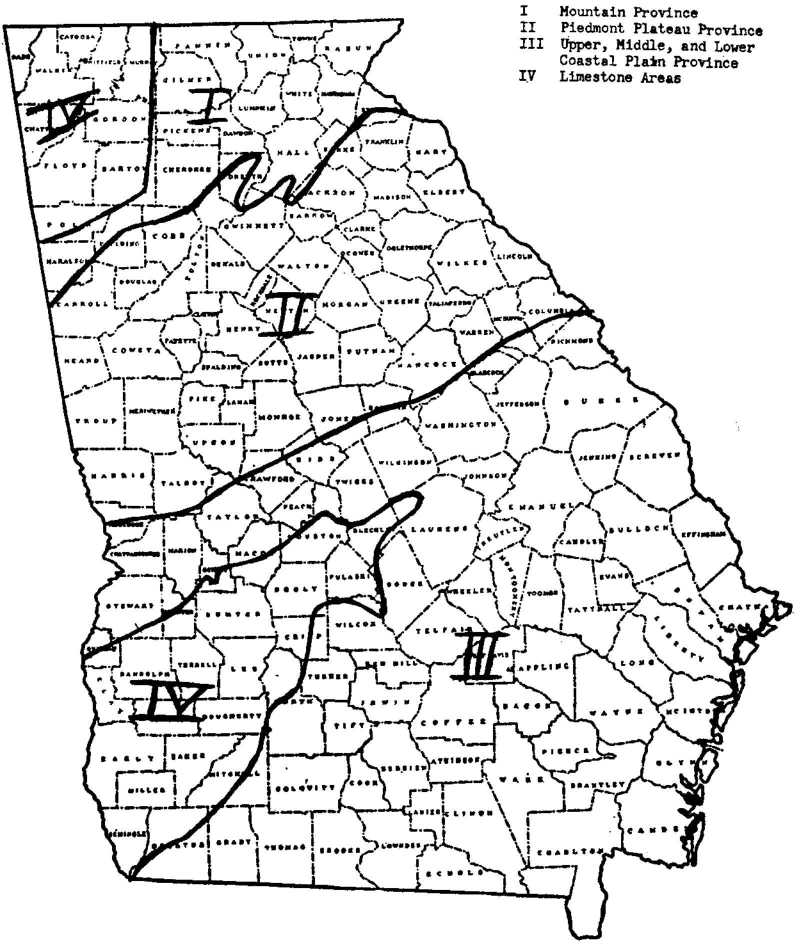
Water samples were collected at random and analyses made in the field during routine investigations of farm pond management studies. The data has been collected year around during the past three years and catalogued for future reference. Nearly 500 chemical analyses of total hardness and hydrogen ion are available along with substantiating complete chemical analysis and soil test data in some cases.

WATER CLASSIFICATION BASED ON SOIL TYPE

From the following map, figure 1, it can generally be seen the state is divided into two main soil association areas, Piedmont or red clay soil and the sandy soils of the Coastal Plain provinces. Considerable variation in total hardness is found within the same general soil type. The average total hardness range for ponds within Piedmont type soils is higher than that of ponds in the Coastal Plains. Calcium and magnesium deficiencies of total hardness are found, however, in both soil types. Total hardness range of ponds in Piedmont soils regularly vary from 20-40 p.p.m. total hardness of calcium and magnesium compared to a general range of 10-30 p.p.m. in Coastal Plains soils. Calculated averages for the soil types show 26 p.p.m. for Piedmont soil and 17 p.p.m. for Coastal Plain soils. The limestone belt within area IV of the map proves the general exception to these figures since within this area the highest total water hardness is found ranging in some cases as high as 100 p.p.m. Geologically this area is formed from Ocala Limestone, with sands, limestone, sandstone, and gravel soils predominant. As a general classification, it does hold true that the southern section of the state is generally within the soft water area although lime treatment for maximum fertilization results has been found necessary within both general areas.

LIME TREATMENT OF SOFT WATER PONDS

Random checks of pond problems associated with the pond management evaluation project, has revealed a number of ponds that failed to produce plankton color following fertilization. In most cases, these ponds were found to be slightly acid with very low or no detectable amount of total hardness present. These same ponds when treated with lime or basic slag, did emphatically respond to fertilization when the pH was raised and total hardness increased. Table I summarizes the results of this lime treatment and indicates type of treatment involved. In all cases fertilization was successfully and definitely improved following treatment. Amounts of material were varied but the general increases in total hardness and pH remain fairly consistent. The amount of basic slag or agricultural limestone was varied to determine the



minimum amount for best results. Since an optimum range for best fertilization results appears to be between 15-40 p.p.m., treatment of 500 to 1,000 pounds per acre have proved satisfactory. Very little increase is noted with larger amounts of material, probably due to soluability. It may be, however, that treatments of 1,000-5,000 pounds per acre will last longer and require less frequent treatments. The Mathis pond listed in Table I received a treatment of 1,500 pounds per acre in 1956 and has maintained good levels of calcium and magnesium this year. The McGhee pond which received 600 pounds in 1956 shows a decrease in total hardness in 1957 to further substantiate this hypothesis.

Increases in pH and total hardness were detected chemically within a week following treatment, although maximum fertilization results generally require 3-4 weeks following treatment. The McKenney pond was the best example of improved fertilization results. During the spring and summer of 1955, 2,800 pounds of 8-8-2 were applied per acre in the fertilization program. In 1956, 600 pounds of basic slag was applied to the pond, and 2,200 pounds of 8-8-2 per acre were needed for fertilization. An additional 1,000 pounds of basic slag was added in November of 1956 with excellent results the next spring, since during the summer of 1957 only 400 pounds of 8-8-2 per acre have been necessary to maintain optimum plankton color at the time of this writing.

TABLE I

EFFECTS OF LIME TREATMENTS IN EXPERIMENTAL PONDS

Pond	*Analysis Before Treatment* *pH*	*TH*	*Date Treatment*	*Amount Per Acre (Lbs.)*	*Date Analysis after Treatment*	*Results* *pH*	*TH*	*Fertilization*
Speer	4.5	0	3-10-56	1,000	5- 1-56	6.5	10	Fair
Ike	7.0	10	10- 8-55	5,500	5- 1-56	8.0	35	Fair
					6-22-56	8.4	40	Excellent
Kelley	6.5	10	3- 9-56	200	6-22-56	8.0	20	Excellent
Mathis	7.6	5	2-10-56	250	4-29-56	7.2	10	Good
			4-10-56	1,250	5-16-56	8.2	20	Excellent
					6-22-56	8.2	30	Excellent
					6-15-57	8.4	40	Excellent
McKenney	6.8	5	3- 4-56	300*	4-20-56	7.3	10	Fair
			5- 1-56	300*	5-25-56	7.6	15	Fair
			11- 7-56	1,000*	3-15-57	8.4	40	Excellent
					7- 6-57	8.8	40	Excellent
McGhee	7.0	0	5-18-56	200*	5-20-56	8.0	0	Poor
			5-23-56	200*	5-30-56	8.0	30	Fair
			5-28-56	200*	6- 8-56	8.0	35	Good
					6-30-56	8.4	45	Good
					7- 7-57	8.5	20	Fair
Watson	6.2	0	6- 5-56	3,300	6- 8-56	7.0	20	Fair
					6-15-56	7.6	45	Good
					6-19-56	7.5	45	Good
					6-27-56	8.4	100	Excellent
					8-26-57	8.8	30	Good
Doster	5.0	0	1- 3-56	200	2- 7-56	6.5	20	....
			4- 2-56	400	4-17-56	6.5	30	Fair
			4-18-56	1,000	4-23-56	7.6	45	Good
					5-11-56	8.0	50	Excellent
					4-10-57	8.0	40	Excellent
Smison	6.8	5	4-15-57	1,500*	5-17-57	8.8	40	Excellent
					7-18-57	8.9	40	Excellent
Edwards	6.3	10	8-..-57	1,000	3-19-57	6.8	20	....
					7- 1-57	8.9	20	Excellent
Hendley	6.5	5	..-..-..	1,000*	5- 7-57	8.9	25	Excellent
					8-14-57	8.9	20	Excellent
Le Hardy	6.8	5	Summer '56	6,000	4-22-57	8.5	25	Good
Eager	6.8	5	6- 7-57	500	7- 1-57	8.1	15	Good
					8-14-57	9.1	15	Excellent
Eager, W. G.	7.5	5	5-16-57	1,000*	6-18-57	8.5	15	Excellent
Langdale No. 1	5.5	5	7-27-57	500*	8-14-57	6.8	15	....
No. 4	6.1	15	7-27-57	500*	8-14-57	7.5	15	....
No. 5	4.9	5	7-27-57	500*	8-14-57	7.1	15	....
Jones	6.1	5	6-14-57	500*	7- 3-57	9.2	25	Excellent
					8-15-57	9.1	25	Excellent
Veasey	6.8	5	6-10-57	500	7,16,57	8.5	25	Good
					8-15-57	9.1	25	Good
Dorminey	6.3	10	2- 1-57	500*	6- 1-57	7.5	15	Fair
					8-15-57	8.9	15	Excellent
Corbin and Duggin No. 5	5.5	..	9- 1-56	500	11-15-56	8.3	35	Fair
					3-20-57	8.5	35	Fair
					4- 4-57	7.7	35	Fair
No. 6	5.6	..	9- 1-56	300	11-15-56	6.8	15	....
					3-20-56	6.7	25	....
No. 7	5.5	..	9- 1-56	200	11-15-56	6.8	15	....
					3-20-57	6.7	35	....

TH—Total Hardness. *—Basic Slag.

Analysis of bottom soils before and after treatment exhibits a nutrient release presumably due to changes in hydrogen ion. Data is presented in Table II for comparisons of bottom soil before and after lime treatment.

TABLE II

BOTTOM SOIL ANALYSIS BEFORE AND AFTER LIME TREATMENT AS POUNDS PER ACRE

Pond	Amount Lbs. Per Acre	Before Treatment pH	P_2O_5	K_2O	CaO	After Treatment pH	P_2O_5	K_2O	CaO
McGhee	600	6.3	31	60	675	6.7	76	60	1,120
Watson	3,300	5.6	72	66	990	5.9	200	60	2,000
McKenney	1,600	6.0	78	68	1,350	6.9	200	64	2,400

* Basic Slag.

It is immediately apparent that concentrations of available phosphorus was more than doubled following lime treatment. Apparently phosphorus is liberated through a stimulated release of phosphate from organic phosphorus in the pond bottom, and through displacement of insoluable phosphorus compounds. The latter may be through anion exchange between phosphate and introduced hydroxide radicals. Anion exchanges in soils often concerns phosphate absorbed to clay minerals. The clay bottoms of most artificial impoundments suggests that considerable nutrients could be released by this anion displacement. The release of nutrients through organic decompositions, stimulated by alkalization, probably accounts for most of the nutrient increase indicated above. Decomposition by microorganisms is inhibited under acid conditions found in agricultural soils. Since our bottom soil analyses have indicated a comparable acid condition, bacterial decomposition is unquestionably hampered in the pond bottom. Neutralization by liming should account for an increased rate of decomposition and a subsequent release of nutrients. This increase of previously unavailable nutrients was shown in the ponds that received lime treatment during the winter months. In early March, the McKenney pond developed a dark plankton color before any fertilizer was added, probably brought about by the release of nutrients applied the season before but not utilized.

Calcium oxide was also subsequently increased through direct addition of lime. Potassium concentrations were relatively unaffected, however, lime does not greatly influence the availability of potassium in row crop production, and apparently the pond bottom reaction is similar.

CONCLUSIONS

Although this investigation is preliminary and additional time is needed to fully evaluate the data, certain factors seem to be definitely established.

1. Georgia Piedmont soils have a higher average total hardness than Coastal Plains soils.
2. Plankton blooms were induced and emphatically improved in 22 problem ponds with initial applications of lime or basic slag.
3. Optimum range of total hardness for best fertilization results is 15-40 p.p.m. Lime applied at the rate of 500 pounds to 1,000 pounds per acre was sufficient in most ponds to alleviate acid conditions and induce plankton blooms. Heavier applications of lime may prove necessary for adequate fertilization of several years duration.
4. Lime treatment adds calcium compounds directly to the water and also effects a release of nutrient material, primarily phosphate, from bottom soil. This reaction appears to be a chemical replacement of relatively insoluable phosphorus compounds that tie up phosphate under acid conditions.
5. Pending additional study and results, liming is a necessary constituent in successful fertilization of ponds with low total hardness and acid conditions.

Question: What time of year was the lime applied?

Answer: Different times. Winter seems to be best time to apply.

Question: What is the best result of applying lime only?

Answer: Not known, but lime alone is not a complete fertilizer and would not supply the need for elements other than calcium.

Question: Why do you set the optimum total hardness level at 15-40 p.p.m.?
Answer: Water could be made too alkaline. It was not meant to imply that this figure was the upper limit.
Question: How long will the effects of the lime persist?
Answer: Not definitely established. At a rate of 3,000 pounds per acre the effect extended into the second year after treatment.
Question: Would continued liming be harmful?
Answer: Yes, might render phosphorus unavailable.
Question: Have you worked with water having 100-200 p.p.m. total hardness?
Answer: No. There is no water this hard in Georgia.
Question: Have you used lime to clear turbid waters?
Answer: No.

INFLUENCE OF FISHING PRESSURE ON BASS FISHING SUCCESS

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INTRODUCTION

The implication of most literature dealing with the influence of fishing pressure on bass fishing success has been that bass populations can withstand unlimited fishing pressure without undue duress. Results emerging from recommendations from these findings such as abandonment of closed seasons and removal of size restrictions have proven satisfactory in almost every instance. In Virginia studies, total harvest, rate of catch, bass reproduction and growth rates, remained essentially the same following the adoption of year-round fishing. At the same time, little or no increase in total fishing pressure was noted.

However, the author's experience in fishing privately owned ponds and other waters closed to the general public indicated that the rate of catch in restricted waters was far better than from most public waters. Likewise, creel, tagging, and population sampling data obtained in conjunction with previous Dingell-Johnson projects suggested that bass harvests were more extensive than commonly recognized. These observations led to the preparation of this paper dealing with the influence of fishing pressure on bass fishing success.

Thanks are due to fisheries biologists N. R. Bowman and D. L. Shumate, Jr., for field assistance in collecting data, G. W. Buller, Chief of the Fish Division for his valuable guidance and assistance, and I. T. Quinn, Executive Director of the Commission of Game and Inland Fisheries for making the study possible.

DESCRIPTION OF STUDY AREAS AND CREEL CENSUS METHODS

Complete creel census data including estimates of total harvest and fishing pressure was obtained from five public and two private ponds. In addition tag return data was obtained from three of these smaller public ponds, Douthat Lake, Carvin Cove Reservoir, and Fairystone Lake. Creel and tagging data were also available from three larger bodies of water, Back Bay, Claytor Lake and South Holston Reservoir. Pertinent descriptive information concerning these waters is presented in Table I.

The smaller ponds ranged between 60 and 650 acres in size. They were distributed generally over the state and were considered representative of average fishing ponds. Fertility levels were uniformly low and none of the ponds were fertilized or otherwise managed. Fish populations in all but one newly created pond, Lake Burton, would be considered mature. The remainder of the ponds were over 15 years of age. One of the public ponds, Airfield Pond, and both private ponds were abandoned grist mills that date back over 200 years. Largemouth bass, bluegill, and black crappie comprised the principle sport fish species. Chain pickerel were also present in three of the public ponds and in both private ponds. All contained substantial populations of suckers and bullheads.