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9. ABSTRACT

A study to determine changes in pond bottom soil composition has been in progress at the Marion, Alabama National Fish Hatchery for more than ten years. This report gives the findings of analyses for calcium, phosphorus, potassium, pH, nitrogen, and organic carbon. Samples were taken periodically from the same locations with the last ones taken ten years after the initial flooding. During the period, pH generally changed from acid to neutral levels. Phosphorus increased in some ponds and decreased in others. One unfertilized pond supported a luxuriant growth of Najas sp. and Chara sp. even though no available phosphorus was measured in the soil sample. Organic nitrogen and carbon increased appreciably with nitrogen increasing at a greater rate. The carbon/nitrogen (C/N) ratio narrowed in 11 of 12 ponds.

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CHANGES IN POND BOTTOM SOILS DURING THE FIRST TEN YEARS OF USE[1]

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ABSTRACT

A study to determine changes in pond bottom soil composition has been in progress on the Marion, Alabama National Fish Hatchery for more than ten years. This report gives the findings of analyses for calcium, phosphorus, potassium, pH, nitrogen and organic carbon. Samples were taken periodically from the same locations with the last ones taken ten years after the initial flooding.

During the period, pH changed from acid to neutral levels generally. Phosphorus increased in some ponds and decreased in others. One pond which unfertilized supported a luxuriant growth of *Najas sp.* and *Chara sp.* even though no available phosphorus was measured in the soil sample.

Organic nitrogen and carbon increased appreciably with nitrogen increasing at a greater rate. The carbon/nitrogen (C/N) ratio became narrower in 11 of 12 ponds.

INTRODUCTION

Many fish culturists rearing fish in ponds have noted the diverse response adjacent pond units make to similar management methods. The experienced pond culturist expects diversity in yields, size range, survival percentage, vegetation composition and abundance, and other indices. Reasons for the diversity are not always understood and lack of time may preclude obtaining enough information to determine the cause of differences during a given production cycle. Influences including water quality, bottom soil compositon, autotrophic and heterotrophic organisms present and interaction between these influences combine to affect the production process.

[1]Prepared for presentation at a meeting of the Southern Division of the American Fisheries Society held in conjunction with the 27th Annual Meeting of the Southeastern Association of Game and Fish Commissioners, Hot Springs, Arkansas, October 21-24, 1973.

The role of the pond bottom has not been emphasized as much as that of the water in the functioning of this specialized aquatic ecosystem, although several investigators have given attention to it. Schaperclaus (1933) was one of the early pond culturists to stress the importance of the bottom mud in the production cycle of earthen ponds. Meehean (1935) and Meehean and Marzulli (1943) did some research relating to pond bottom soils. Mortimer and Hickling (1954) reviewed extensive European and Asiatic research on the importance of the pond bottom mud, while Hepher (1965) studied changed in pond bottom soils brought about by fertilization. Greene (1970) and Tackett (1971) reported on work done in Alabama and Arkansas during the late sixties.

A long-term study was begun at the Marion National Fish Hatchery in 1959 in an attempt to learn the effect of cultural practices on the chemical composition of the pond bottom soil. Procedural details are given in a preliminary report by Jones, Snow and Bryan (1970), along with findings resulting from the first five years of work. In brief, the study involved analysis of soil samples taken before new ponds were flooded and later after each draining, until five years had elapsed. Sampling was then scheduled to be done every five years. Included were 12 small earthen ponds ranging in size from 0.28 to 0.56 hectare. Records were kept on feeding and fertilization of the ponds and yields of fish were measured as each crop was removed. All of the ponds were used in the normal hatchery fish production operation for bass, bluegill, channel catfish or forage minnow production, with one exception. The one exception to the above was a warming pond or reservoir for the hatchery holding house water supply. All ponds were fertilized except the reservoir pond. The sampling procedure and method of processing and analyzing the samples is given in the first report on the study (Jones, et. al 1970). This paper gives the results of sampling five years after the first phase was ended.

MATERIALS AND METHODS

Beginning as the fish harvest was completed in the fall of 1970, the 12 ponds in the study were sampled in the same location and to the same depth (2.54 cm) as previously. The samples were air dried and held in the laboratory for varying periods of time until they could be reached for analysis. The soil was then passed through a burr mill for grinding to a particle size fine enough to pass through a No. 40 U.S. Standard sieve screen. Following grinding, the soil was divided, with part being sent to the Auburn University Soils Testing Laboratory for analysis as to pH, calcium, phosphorus, potassium, and magnesium. Another portion was sent to Dr. Claude Boyd of the Auburn University Department of Fisheries. Dr. Boyd analyzed the soil for organic carbon and nitrogen.

Station records were used to ascertain the amount of fertilizer applied to each pond in the study, as well as the amount of supplemental feed supplied and the yield of fish at each draining.

RESULTS AND DISCUSSION

Data on the anlyses for pH, calcium, magnesium and phosphorus are shown in Table 1, along with comparable data for the samples taken before and after the first 5 years of use. Table 2 gives the results of the organic carbon and nitrogen analyses and also gives the C:N ratio. Table 3 gives the pounds of fish removed during the period and also the amount of feed and fertilizer added to each pond during the 5-year period.

Changes in the compositon of the pond bottom soil as indicated by the samples taken were rather pronounced. In some instances these changes were a continuation of what had been observed in the earlier study (Jones, et. al 1970). For one or two parameters, there was a reversal of what appeared to be a well-defined trend during the first five years.

INORGANIC CONSTITUENTS

The trend toward increased levels of calcium, which was well documented during the first five years the ponds were in use, was reversed in several instances and slowed down in others. Analyses showed smaller amounts in samples taken in 1970 from 10 of the 12 ponds than were found in 1965. The amount was substantially higher in all instances, however, than was measured in the samples taken prior to the initial flooding.

In contrast to the calcium, pH was more alkaline in 10 of the ponds at the end of the second five-year period and more acid in two ponds. Generally pH seemed to have stabilized around a pH of 7.0.

Phosphorus increased in samples taken from seven of 12 ponds, but did not appear correlated with the amount of fertilizer added during the period. In the single pond receiving no fertilizer, the amount of phosphorus was zero, although the pond supported a moderate to heavy growth of *Chara sp.* and *Najas flexilis* each year.

There is a suggestion that soil type may be a factor in the amount of phosphorus occurring in the samples. In five of the eight ponds located on the lower, more silty area of the site, phosphorus declined. In one other instance the amount of increase was quite low, changing only 6 percent in five years. This took place in spite of addition of 24 kg. or more of P^2O^5 per year in four of the ponds.

Presence of abundant growth of submerged plants in the unfertilized pond along with a marked increase in organic carbon and nitrogen in the samples of bottom soil influenced us to analyze water flowing into and out of the reservoir pond for nitrogen and phosphorus. Water samples were negative for nitrogen (Hach procedure) but were positive for phosphate. Total phosphate was 0.08 ppm (0.05 ppm ortho) at the water inlet and 0.03 ppm (0.0 ppm ortho) at the outlet. Since the level of phosphorus in samples declined from 4.6 to 0.0 ppm in this pond during the study period it appears that much, if not all, of the plant growth was being made the second five yeras using phosphorus dissolved in the water supply.

Potassium was higher at the end of the second five years of use in 9 of the 12 pond samples. Levels were classified by the Soils Testing Laboratory as high in all instances. This is a result of a 4.0 ppm level of potassium in water from supply wells. The high level of potassium in the pond soil developed in spite of the fact that no potassium had been used in the fertilizer mix used since the ponds were placed in service.

ORGANIC CONSTITUENTS

As was expected, carbon increased substantially in samples from all ponds during the second five-year period since feed and fertilizer were used rather freely. A surprising development was that the highest rate of increase in carbon was in the unfertilized pond. A seventeenfold increase was measured there, with the next highest rate of increase being about fivefold. The lowest rate of increase was in a pond that produced the third highest poundage of fish on the fourth highest amount of total nitrogen.

Nitrogen can be a limiting factor in plant growth and is included in most fertilizer mixtures applied at Marion, either in organic or inorganic form. Also, six of the 12 ponds sampled received substantial amounts of supplemental feed ranging from a low of 799 kg. per ha. over the five-year period to a high of almost

1,930 kg. All except one also received varying amounts of organic and inorganic nitrogen directly as fertilizer. From all sources, nitrogen additions ranged from 41 to 136 kg. per ha. per pond.

The relationship between fertilization with nitrogen in food or fertilizer and percentage increase in total nitrogen content of soil samples was examined by means of Snedecor's linear regression technique (Snedecor, 1946). Even excluding the result in S-36, where no nitrogen was added, the analysis did not give an r-value remotely approaching significance at the five percent level. In all probability, interrelationships between enrichment, pounds and type of fish harvested, type and amount of plant material produced, frequency of draining, rate of water exchange, and bottom soil type, became too complex to permit simple cause-effect patterns to be revealed.

The marked increase in nitrogen in samples thaken from S-36, the unfertilized pond, was unexpected. To aid in explaining this, an analysis of the supply water was again performed after the data were being studied. The analysis did not indicate the presence of nitrogen as either NO^3 or NO^2. One might expect addition of 0.92-1.84 kg. per ha. annually in rainfall (Lyon and Buckman, 1943). The amount of increase noted is far in excess of this amount, however. It appears that the C/N ratio is too high for decay to contribute appreciable nitrogen. In fact, the slow decay of higher plants which had died and accumulated on the bottom may offer a possible explanation for the higher carbon and nitrogen values in this pond. Unfortunately, the data do not provide an unqualified answer to this question.

The carbon/nitrogen (C/N) ratio continued to decline, being lower after 10 years of use in 11 of the 12 ponds. Only in the unfertilized pond was the ratio higher than at the close of the first five-year sampling period. In all instances except the unfertilized pond, the fertilization plan being used was more than adequate for the quantity of fish removed in each crop.

SUMMARY

Results of the sampling of pond bottom soil ten years after the flooding of ponds for initial use revealed the following significant developments.

1. pH is becoming stabilized at neutrality.

2. After a large increase the first five years, calcium levels declined in some ponds and increased at a slower rate where decreased were not noted.

3. Phosphorus followed a pattern similar to calcium, increasing more slowly in some ponds the second five-year period, and decreasing drastically in the block of ponds where more silt was present.

4. Potassium continued to increase in most instances, with the rate varying from pond to pond. The greatest rate of increase was in the pond where a high rate of water flow was maintained.

5. A higher average organic carbon content was measured in the second sampling period than in the first. Six of the 12 ponds showed a greater percent increase at the end of the second five-year period than at the end of the first five. A favorable soil pH and added enrichment by feed and fertilizer are likely causes.

6. Nitrogen levles in the samples increased at a faster rate the second five-year period than during the first. As a consequence, C/N ratios continued to decline in 11 of the 12 ponds. Only in the unfertilized pond was the C/N ratio higher at the end of the second five-year period. Even here, the increase was small.

7. While changes in pond bottom soil constituents can be determined readily, causes for the changes appear to be complex, necessitating more observations on possible influencing factors than are maintained by a fish production station.

8. Variation between ponds suggests that each pond unit of a production station be sampled at intervals of 3-5 years to document chemical changes taking place in the pond bottom soil.

Table 1. Changes in chemical composition of bottom soil samples taken from warm-water ponds during use.

Pond No.	pH			Calcium[3]			Phosphorus[4]			Potassium[5]		
	Pre-flood	F+5[1]	F+10[2]	Pre-flood	F+5	F+10	Pre-flood	F+5	F+10	Pre-flood	F+5	F+10
S-1	5.7	7.0	6.6	1.200	3.115	1,824	1.9	9.0	24.0	98	151	174
S-2	7.0	7.6	7.2	1.120	3.880	1.592	3.3	12.5	30.0	94	145	123
S-3	6.6	7.0	7.2	1.280	2.580	1.736	3.7	32.0	35.0	118	135	110
S-4	4.8	6.4	6.9	384	2.560	1.644	4.4	16.0	28.0	53	123	178
S-17	4.9	5.9	6.4	387	2.760	1.820	8.7	17.5	36.0	53	116	108
S-18	5.0	4.8	6.4	260	1.320	1.429	4.4	6.0	14.5	52	90	109
S-19	5.1	6.2	7.0	644	2.400	2.324	4.8	28.0	1.5	83	126	160
S-20	5.4	6.2	7.3	670	1.880	2.602	5.4	14.0	0.5	104	108	154
S-35	5.3	7.0	7.2	576	3.840	2.108	4.6	10.0	4.0	58	123	163
S-36	5.1	7.3	7.3	386	8.400	1.948	4.6	0.5	0.0	41	99	160
S-37	5.2	6.6	7.2	336	1.440	1.556	1.7	17.0	2.0	36	71	94
S-38	5.6	7.1	7.2	568	2.382	1.564	4.6	32.0	34.0	50	94	130

[1]F+5 denotes date of initial flooding plus 5 years.

[2]F+10 denotes 10 years after first flooding.

[3]Av ppm Ca

[4]Av ppm P

[5]Av ppm K

Table 2. Changes in organic matter constituents of bottom soil samples taken from warm-water ponds during use.

Number	Carbon (gms/kg) Pre-flood	F+5[1]	F+10[2]	Nitrogen N (gms/kg) Pre-flood	F+5	F+10	C/N ratio Pre-flood	F+5	F+10
S-1	2.07	8.00	17.99	0.084	0.341	1.87	25	23	10
S-2	1.31	4.42	6.25	0.023	0.243	0.95	57	18	7
S-3	3.45	6.30	11.85	0.082	0.294	1.32	42	21	9
S-4	2.76	8.30	14.13	0.173	0.644	1.63	16	13	9
S-17	4.14	11.32	18.69	0.245	0.775	1.88	17	15	10
S-18	4.83	5.31	9.81	0.120	0.350	1.12	40	15	9
S-19	3.45	5.59	17.52	0.091	0.364	2.34	38	15	8
S-20	2.08	4.14	20.91	0.023	0.280	2.69	90	15	8
S-35	3.93	11.80	27.39	0.289	0.761	2.70	14	16	10
S-36	2.69	6.35	108.55	0.058	0.364	5.19	46	17	20
S-37	2.76	3.93	14.42	0.061	0.266	1.49	45	15	10
S-38	3.45	5.11	17.11	0.240	0.322	2.31	14	16	7

[1] F+5 denotes date of initial flooding plus 5 years

[2] F+10 denotes 10 years after date of first flooding

Table 3. Pond enrichment and fish removal during a five-year period.

Number	Inorganic N	Organic N	Feed	Total N	P_2O_5	Fish removed kg. per ha.
	Total kg. of enrichment added					
S-1	82	56	2,604 (145)[1]	284	139	758
S-2	79	64	2,531 (142)	227	97	621
S-3	66	12	3,659 (205)	283	85	449
S-4	75	40	39 (3)	119	136	304
S-17	2	53	3,768 (211)	265	82	1,556
S-18	52	43	328 (18)	113	155	81
S-19	88	22	1,678 (94)	[illegible]	124	99
S-20	72	67	275 (15)	155	175	168
S-35	73	53	1,600 (90)	216	138	102
S-36	0	0	0	0	0	0
S-37	90	47	65 (4)	141	141	199
S-38	85	42	177 (10)	137	172	142

[1]Figure in parenthesis is approximate N content assuming a 35 percent protein feed and a conversion factor of protein to N of 6.25.

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CULTURE OF CHANNEL CATFISH IN A HIGH FLOW RECIRCULATING SYSTEM

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ABSTRACT

An indoor recirculating system was designed to evaluate the effects of a high flow rate and a high filter to tank ratio on the carrying capacity of a closed system for channel catfish culture. Updraft and trickling filters with various filter media were evaluated. A net gain of 319 pounds, with a standing crop of 405 pounds at a density of 7.2 pounds per cubic foot, was obtained over a 142 day growing period.

INTRODUCTION

Fish production is limited by several factors, such as dissolved oxygen, temperature, disease and the build up of waste products. Although ponds normally support up to 2,000 lb/acre, Greene (1971) increased this carrying capacity to over 20,000 lb/acre by biofiltration and recirculation of the water. Andrews et al. (1971) indicated that intensive culture in raceways may have some