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9. ABSTRACT

This study evaluates small pond fish production in terms of dissolved oxygen levels, power requirements, and circulation potential for several mechanical aeration systems. Evaluation of catfish pond aeration systems has shown that daytime aeration by algae overshadows mechanical aeration and can reduce power requirements. The paddlewheel (modified oxidation ditch rotor) appears as the most reliable system. The power usage per lb. of fish is low enough to provide an economical production base. Paddlewheel tests have evolved a Level Raceway Concept which promises several advantages over the conventional earthen raceway. These include: a) lowering power requirements through lower lift requirements, b) eliminating field construction of water control drop structures, and c) continuing circulation after failure of one paddlewheel. Variations of the concept might include screening to separate the fish by sections and extending the number of pond units. Flow rates also could be diminished during daylight hours by reducing the number of operating paddlewheels. When the system could not be drained annually, a larger, unstocked pond connected in a series would improve water quality.

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Aeration, Water Quality, and Catfish Production

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ABSTRACT

EVALUATION of catfish pond aeration systems has shown that daytime aeration by algae overshadows mechanical aeration and can reduce power requirements. The paddlewheel (modified oxidation ditch rotor) appears as the most reliable system. Paddlewheel tests have evolved a Level Raceway Concept which promises several advantages over the conventional earthen raceway.

INTRODUCTION

Growth in the catfish industry from less than 100 acres of ponds in 1955 to over 40,000 acres in 1970 is indicative of the industry's potential. The production of one ton per acre per year through extensive culture versus the production of two-and-a-half tons per acre in intensive culture (Smitherman & Corley, 1971) indicates the effect aeration and circulation can have on fish in a large pond system. Furthermore, the small experimental pond production rate of 10 tons per acre in a 210-day experiment (Greene, 1971) indicates that intensive management of a closed loop water system has possibilities for further refinement.

In addition to higher production, intensive catfish culture has other attractive aspects. Feeding and harvesting operations can be simplified and more easily mechanized. The fish are more readily observable for disease control and growth rate. Predators and other unwanted large pond inhabitants are more easily eliminated. However, some aspects of intensive culture can be detrimental to profitable production. The problems of waste disposal and continuous good water quality are foremost; including the costs which aeration and circulation originate.

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A number of studies have been undertaken to improve water quality for intensive fish production. Loyacano (1970) presents an extensive review of early aeration work. Chu and Greene (1967) investigated biofilters for waste removal. Chesness (1971) made model studies of gravity flow aerators in catfish raceways, and more recently, (Chesness, 1973) evaluated the efficiency of a nozzle aerator. The study reported in this paper was undertaken to evaluate small pond fish production in terms of dissolved oxygen levels, power requirements and circulation potential for several mechanical aeration systems.

TREATMENTS AND PROCEDURES

For 2 years, 1971 and 1972, the studies have been conducted in rectangular concrete ponds 9 ft by 24 1/4 ft (1/200 acre water surface area) and 2 1/2 ft water depth. Water volume varied slightly from rainfall and evaporation but was maintained at about 4080 gal. All treatments were with three replications. All fish stocked each year came from the same common source and received uniform treatment for disease control prior to stocking. In 1971 the ponds were stocked with 100 catfish fingerlings 5 to 6 in. in size, and the test period lasted from July 2 to November 8. In 1972 the ponds were stocked with 100 lb of catfish (approximately the same number assigned to each pond) and the test period lasted from August 24 to November 2. Initial feeding rates were the same for all treatments each year. The fish were fed Purina Trout Chow* floating pellets at the rate of 3 percent of the body weight per day. Feeding in individual ponds was reduced or omitted for several days when those fish refused food or showed other signs of distress.

The aeration treatments investigated during the 2 years of experimentation can be grouped into five categories as follows:

1 Control – fish raised without mechanical aeration or circulation were included in the experiment only during the first year.

2 Biofilters – the biofilters were either gravel-filled boxes 4 ft in height positioned above the pond or a series of staggered splashboards with a similar total height. Water was continually pumped from the pond bottom and sprayed on top of the biofilters to allow a trickling gravity return flow to the pond. The rate of flow was maintained at 6 – 7 gal per min.

*Mention of trade names is for identification with no intended or implied endorsement.

FIG. 1 Paddlewheel in use for catfish pond aeration.

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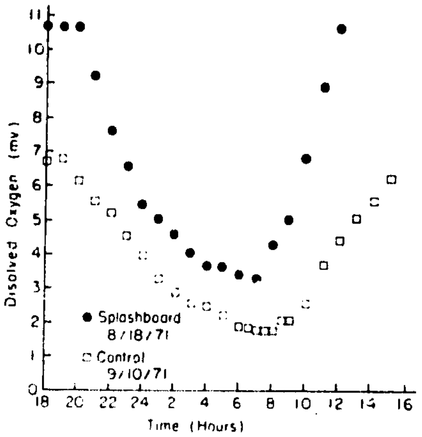

FIG. 2 Recording probe. Dissolved oxygen profile.

3 Surface Sprinkling – water was pumped from the pond bottom and sprinkled on the pond surface at the other end of the pool. Flow rate was similar to that of the biofilter treatment.

4 Venturi Air Injection – the discharge pipe of a submersible pump was equipped with an orifice plate to provide a venturi effect which induced air into the flow through tubes extending above the water surface. Flow rate for the submersible pump was about 30 gal per min.

5 Paddlewheel – a modification of the oxidation ditch rotor design tested by Knight (1965) was used to provide a splashing action and to provide circulation. A flow rate of about 500 gal per min was measured through the paddlewheel channel (Fig. 1). The paddlewheel was included only in the 1972 tests.

The use of water hyacinths for nutrient removal and the use of a second pond as a settling basin for solids were sub-treatments for the biofilter, surface sprinkling and venturi air injection treatments. The results are not reported separately since little difference was observed.

Separate water and electric power meters were installed for most of the treatments. Where individual pond installations were not feasible, instantaneous electric power readings were made and flow rate was based on a propeller meter traverse or manufacturer's data. Aeration measurements were made and recorded hourly with Chemtronic Oxygen Probes coupled to a 16-point millivolt recorder. The Chemtronic Probes were periodically checked against a YSI Model 54 Dissolved Oxygen Meter. In 1972 the YSI Meter was used to gain independent morning and evening readings of the dissolved oxygen status of various ponds.

RESULTS

Oxygen Levels

The recording oxygen probe readings showed a consistent diurnal pattern in 1971 as illustrated by Fig. 2. The diurnal pattern is the result of oxygen production by algae during daylight hours. The lowest reading occurred one or two hrs after sunrise revealing a time lag of the algae's photosynthetic oxygen production. Similarly, dissolved oxygen content did not start to drop until an hour or so after sunset. These findings, plus the normally high daytime values of dissolved oxygen allowed for subsequent operation of aeration equipment on an intermittent basis.

The 1972 oxygen level readings revealed additional interesting information. As shown in Fig. 3, the paddlewheel treatment consistently averaged higher oxygen levels than did the venturi treatment during the latter stages of the test. Most notable differences were observed at sunrise, i.e., the time for the

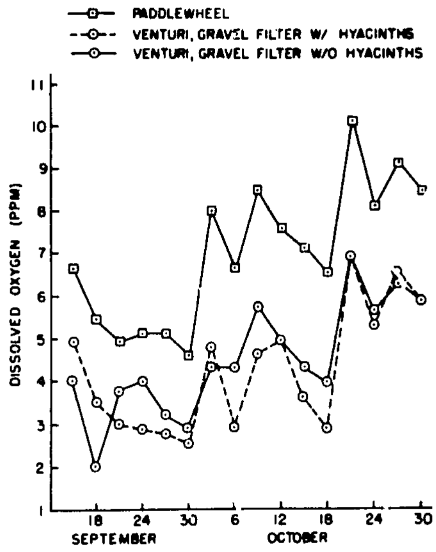

FIG. 3 Dissolved oxygen reading 3-day average at sunrise, 1972.

system's lowest oxygen levels.

The diurnal fluctuations in oxygen level were less for the paddlewheel as shown in the Fig. 4 comparison. In addition to maintaining a higher minimum level of dissolved oxygen, the wheel's aeration and circulation, during intermittent daytime operation, was apparently effective in preventing or reducing the level of supersaturation. For the most part agreement between the portable and recording oxygen probes was satisfactory. The variations that do exist may be a function of reading location rather than probe calibration differences.

Treatment Results

The summary of fish production, circulation and minimum power use (i.e., best replicate for a given treatment) is presented in Table 1. The range in values among the replications are presented in parenthesis beneath the aver-

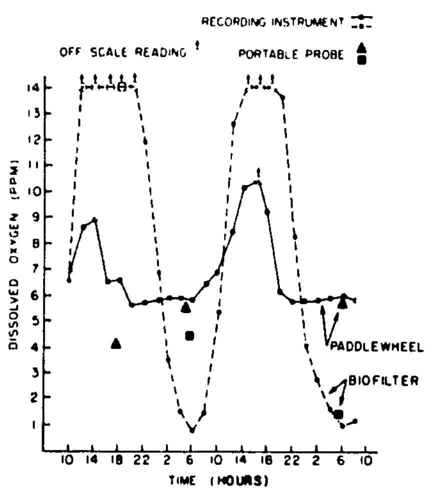

FIG. 4 Dissolved oxygen profiles, September 1972. Biofilter 9/16–9/18, paddlewheel 9/18–9/20.

TABLE 1. AERATION TREATMENT SUMMARY

Treatment and year		Circulation water change per day	Net gain, lb	Minimum power use kw-hr per lb
Control	1971	0	6 (2 – 9)	-----
Biofilter				
rock	1971	2.4	29 (28 – 31)	21.9
sp				
splash	1971	2.1	29 (25 – 33)	20.0
rock	1972	2.3	-35 (-95 – 34)	8.1
Surface sprinkling				
	1971	2.4	30 (29 – 31)	21.4
	1972	2.0	-21 (-98 – 25)	47.1
Venturi air injection	1971	10	33 (30 – 38)	41.2
	1972	10	1 (-91 – 70)	7.5
Paddlewheel	1972	110	40 (30 – 45)	4.7

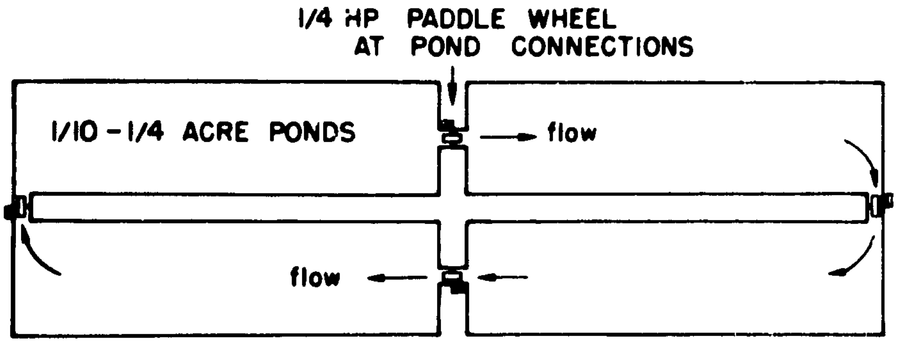

FIG. 5 The level raceway concept.

age values. Net gain is defined as the harvested weight minus the stocking weight of the fish. Fish kills occurring in 1972 are responsible for the negative net gain figures, i.e., the harvest weights were less than the stocked weights.

Aeration's potential for increasing production can be seen by comparing the control treatment's maximum net gain values with similar values from any of the aerated treatments. However, many of the aeration treatments show an alarming inconsistency which needs explanation and correction before other than research application would be appropriate. The paddlewheel, it should be noted, was the only treatment in 1972 that did not encounter a major fish kill.

Power use for the best pond of each treatment reflect differences in motor sizes as well as differences in maximum net gain. The submersible pumps were equipped with 1/2 hp motors, the biofilters and surface sprinkling had 1/3 hp motors and the paddlewheels required 1/4 hp.

SUMMARY AND CONCLUSIONS

On the basis of the production and power use findings, the paddlewheel treatment seems the most appropriate for consideration in a larger operation. The power usage per lb of fish is low enough to provide an economical production base. However some problems still exist regarding stocking rate and system management for any specific application.

Noting that a flow of 350 gal per min is recommended for earthen raceways with 10-ft bottom, 4-ft depth, and 1:1 side slopes (Chapman, et al. 1971) it seems reasonable to consider paddlewheels for a Level Raceway Concept as shown schematically in Fig. 5. Possible advantages of the Level Raceway Concept include: (a) lowering power requirements through lower lift requirements, (b) eliminating field construction of water control drop structures and (c) continuing circulation after failure of one paddlewheel. Variations of the concept might include screening to separate the fish by sections and extending the number of pond units beyond four as pictured. Flow rates could also be diminished during daylight hours by reducing the number of operating paddlewheels. Where the system could not be drained annually a larger unstocked pond connected in series would improve water quality.

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