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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 commercial potential. In most raceways, water is passed through the system once and subsequently discharged. These open systems are limited primarily by their water supply. The water discharged from these raceways is high in organic materials. Recirculation and biofiltration in raceways may offer increased efficiency of water utilization and environmental control.

Several indoor recirculating systems for the culture of channel catfish have been constructed at Memphis State University since August, 1970. The system (S-7) described here was designed to evaluate the effects of a high flow rate and a high filter to tank ratio on the carrying capacity of closed recirculating systems. In addition, attempts were made to determine the effectiveness of updraft and trickling filters containing various types of filter materials on the removal of waste products from the water.

This work was supported in part by an MSU Faculty Research Grant, OWRR Grant B-028-TENN, and through a cooperative research agreement with the Fish Farming Experimental Station, Stuttgart, Arkansas. Feed was provided by Ralston-Purina Company.

MATERIALS AND METHODS

Facilities.

The system consisted of a round 420-gallon fiberglass tank, a 220-gallon updraft filter, six 55-gallon trickling filters and one 400-gallon trickling filter (Fig. 1). Water was pumped from the tank through the updraft filter and then returned by gravity through the trickling filters into the tank. Plastic scraps were used as filter media in the updraft filter. Plastic scraps, oyster shells, coal slag, teflon rings and styrofoam packing material were used in the trickling filters. The total volume of the filter was 920 gallons resulting in a tank to filter ratio of 0.4 to 1. The total water volume of the system was 640 gallons, with all water passing through the filter every 10 min. The average flow rate was 55 gal/min. Fresh water (30 gal/day) was added to replace water lost by splashing and evaporation. Water was also added whenever the updraft filter was backwashed.

In early June, a foam stripper was installed to remove foam accumulation in the tank. In July, a 4-inch airlift pump was installed to provide mixing and oxygenation in the tank. Two agitators were also used to maintain adequate oxygen levels.

Growth.

Channel catfish were obtained from the Fish Farming Experimental Station, Stuttgart, Arkansas. Fish were held in the system 4 weeks prior to the initiation of the 142 day study (February 23 - July 14, 1973). A total of 650 fish averaging 60 g was stocked and sampled at monthly intervals. Lengths and weights of 50 individual fish were taken and the remaining fish were weighed in lots of 50.

Fish were fed Catfish Cage Chow at a rate of 3% total weight per day based on the previous weighing. Fish were fed twice a day, and feeding rates were adjusted when fish did not eat the feed readily. Any excess food was removed to reduce loading of the filter. Food conversion (wt fed/wt gained) and condition factors (Carlander, 1969) were calculated each month.

Water Quality.

Ammonia nitrogen and dissolved oxygen determinations were taken periodically at various locations in the system. Nesslerization in accordance with Standard Methods (APHA, 1971) was used for ammonia nitrogen determinations. A YSI oxygen meter was used for dissolved oxygen determinations. Temperature was recorded daily. Alkalinity, pH, total hardness, and CO2 determinations were made in July on a weekly basis using a DR-EL Hach kit (Hach Chemical Co., Ames, Iowa).

RESULTS

During the 142 day study a net gain of 318 lb was obtained, with a standing crop of 405 lb at a density of 7.2 lb/ft^3 (Table 1). Survival during the study was more than 99%. Fish gained weight throughout the study with greatest gains in April and May. In early July, fish were feeding poorly and apparently the carrying capacity of the system had been reached.

Food conversion for the 142 day growing period was 1.75 and ranged from 1.06 in April to 2.60 in June. Condition factors increased during the experiment, except in July when fish reduced their feeding activity.

The filter system was effective in removing ammonia. The highest level recorded was 2.7 ppm ammonia nitrogen on May 31. A decrease in nitrogen levels was observed as water passed through the filter (Fig. 2). Backwashing of the updraft filter was ineffective. Virtually no solids were removed from the system, but were broken down in the filter. The plastic scraps, oyster shells, and styrofoam packing material were all effective as filter substrate. The oyster shells served as a substrate for bacterial growth and as a source of calcium carbonate buffer. Solids accumulated in the slag and completely blocked water passage. The slag was replaced with teflon rings.

Dissolved oxygen levels decreased as water passed through the updraft filter. As water passed through the trickling filters oxygen levels increased. In early June, dissolved oxygen fell below 3 ppm in the tank. Two agitators were added. In late June, a dissolved oxygen stratification was observed, with a decrease of 1 ppm in dissolved oxygen from the top to the bottom in the tank. A 4-inch airlift pump was added and dissolved oxygen increased to above 5 ppm.

In July, alkalinity ranged from 28 - 35 ppm; total hardness ranged from 122-203 ppm, and pH was approximately 7.0.

DISCUSSION

Growth was relatively good throughout most of the experiment. The poor growth obtained during the first month of the investigation was probably a result of low temperatures. The system was located in a poorly insulated room and temperatures fluctuated from 63 F to 79 F in February and March.

The density of 7.2 lb/ft^3 represents the greatest density obtained in any of our recirculating systems at Memphis State. Andrews et al. (1971) obtained densities from 1.3 to 3.3 lb/ft^3, depending on exchange rate, in a flow through raceway. Stickney, Murai and Gibbons (1972) obtained slow growth and high mortality in tanks with densities of 1.5 lb/ft^3 in a flow through raceway. Piper (1970) reported densities ranging from 3.9 to 5.7 lb/ft^3 in a system in which water was exchanged 50 times/h. The above densities were obtained in flow through reported densities ranging from 3.9 to 5.7lb/ft^3 for trout raised in a series of troughs. Buss et al. (1970) obtained densities of trout up to 34 lb/ft^3 in a system in which water was exchanged 50 times/h. The above densities were obtained in flow through systems with various exchange rates. Although stocking densities affected production more than exchange rates, Allen (1973) found exchange rates of 1.5 h or less yielded good growth, but rates of 2 h or higher depressed production.

As the carrying capacity of this system was reached, growth rates began to decline and condition factors decreased. Food conversion was higher during the last 2 months of this research. The limiting factor for this system was not satisfactorily determined. Oxygen availability and accumulation of metabolic products may limit the carrying capacity of a system (Haskell, 1955; Willoughby, 1968). Dissolved oxygen levels fell to 3.5 ppm in July. The installation of an airlift pump increased dissolved oxygen levels but fish continued to feed poorly. Ammonia levels were low throughout the experiment. However, nitrate nitrogen and CO2 levels had increased to above 50 ppm on July 12. These factors possibly limited the production of this system to the 7.2 lb/ft^3. Further modifications in system designs will probably result in higher capacities in recirculating systems.

SUMMARY AND CONCLUSIONS

Greater carrying capacities for the culture of channel catfish in closed recirculating systems can be obtained with high flow rates and filter to tank ratios. A density of 7.2 lb/ft^3 was obtained in a 142 day growing period. Both updraft and trickling filters were effective in reducing ammonia levels without the removal of any significant amount of solid materials from the system. Solid wastes quickly clogged filters containing coal slag, but plastic scraps, oyster shells, teflon rings and styrofoam packing material served effectively as filter media.

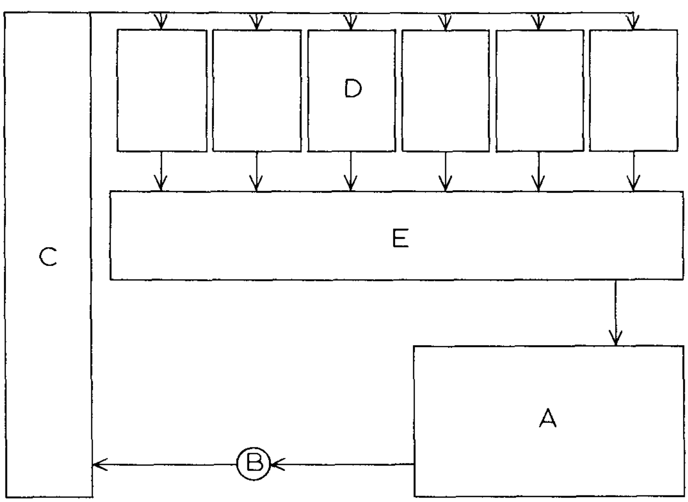

Figure 1. Diagram of recirculating raceway (MSU - S-7).
A-420 gallon tank
B-pump
C-220 gallon updraft filter
D-55 gallon trickling filter
E-400 gallon trickling filter

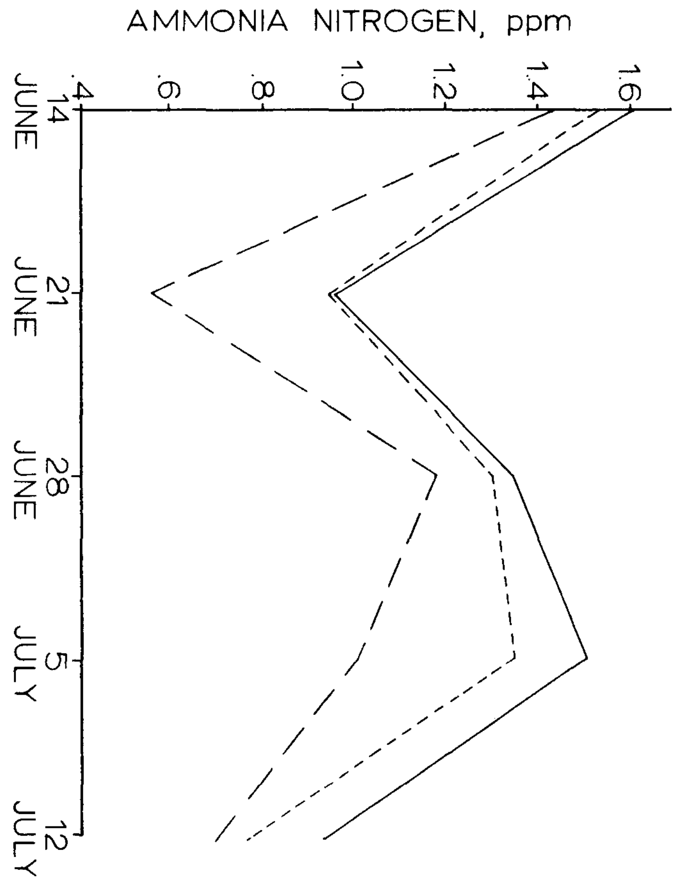

Figure 2. Ammonia nitrogen levels in a recirculating system. (June 14-July 12, 1973)

———— in tank
- - - - - top of updraft filter
— — — — out of trickling filters

Table 1. Growth of channel catfish in a recirculating system.

Sample date	Average weight (g)	Total weight (lbs)	lbs/ft^3	Food conversion	Condition factor
23 Feb	60.5	87	1.5	–	0.60
23 Mar	78.7	113	2.0	2.48	0.76
24 Apr	146.2	209	3.7	1.06	0.92
22 May	219.9	313	5.5	1.48	0.93
22 Jun	261.7	371	6.6	2.60	0.94
14 Jul	284.1	405	7.2	2.59	0.89

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FARM FISH PRODUCTION IN ARKANSAS DURING 1972

by

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ABSTRACT

Fish farming in Arkansas continues to be a major industry with 1972 returns exceeding $21 million. This indicates an overall increase in value of 23.5 percent since 1969. Acreage of intensively-farmed waters increased 15.7 percent since 1969. Data collected during this survey indicates that a peak in the industry was reached between 1969 and 1972 and that during the past year acreages devoted to fish production declined slightly. Personal interviews of fish farmers provided the most useful data in determining the total production. Acreage, production and dollar values are presented in categories of food fish, bait fish, fingerlings, and fee fishing. Specialized fish-rearing facilities and the production of uncommon types of fishes are discussed.

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