Archives of Polish Fisheries	Vol. 1	Fasc. 2	161 - 166	1993

MODEL STUDIES ON A RECIRCULATION SYSTEM WITH A ROTATING BIOLOGICAL FILTER FOR FISH FATTENING

PART I - PRELIMINARY MODEL STUDIES ON THE ROTATING DRUM FILTER

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A b s t r a c t. A new rotatory biological filter was worked out and constructed on the basis of available literature. Studies on its effectiveness were made in a model recirculation system with a stock of silver and common carp. Some difficulties were noted as to the initiation of the phase II of nitrification. They resulted in a dangerous increase of nitrite content (maximal nitrite content reached 0.63 mg N-NO_2 per dm^3). Amount of suspended organic matter reached 30 mg/l.

Key words: FISH REARING, WATER PURIFICATION, RECIRCULATION SYSTEM, ROTATORY BIOLOGICAL FILTER

INTRODUCTION

Rotating biological filters have been used since a number of years to purify water in the recirculation systems used for fish rearing (Parker 1981, Miller and Libley 1983, Knosche 1984, Kruner and Rosenthal 1987). Disk filters, such as of „Stahlermatic" type, are most frequently used; their rotor rotates with the speed of from 2 to 6 rot./min (Parker 1981, Miller and Libley 1983) and is formed of a set of disks attached to a shaft at about 2 cm intervals. Rotors of this type are characterized by some advantages (simple construction, low hydraulic resistance) but their relative surface is rather small, so if a given efficiency is to be achieved their size must be quite considerable (Hirayama 1966, Speece 1973, Liao and Mayo 1972).

The aim of the studies was to check the efficiency for fish fattening system of a model biological filter with a drum rotor filled with PCV moulders. The rotor under study was characterized by an almost double effective surface compared to a disk rotor of the same size.

MATERIAL AND METHODS

Studies were carried out in a model recirculation system (Fig. 1) of the following parameters:

water volume in two rearing tanks - 1.4 m^3

water volume in the sedimentation tank - 1.3 m^3

water volume in the upper retention tank - 0.4 m^3

The rotating biological filter was characterized by the following parametrs:

volume of the filter chamber - 0.46 m^3

rotor dimentions: diameter - 0.6 m, length - 1.0 m

effective surface - 46.76 m^2

rotation speed - 3 rot./min

drive - an electric motor 0.18 kW with a planetar reductor and a transmitter with a transmission belt.

The rotor was of a drum shape; it was made of polyethylene net with 5 mm mesh size, extended over a rack of steel wire. Interior of the drum was filled with moulders consisting of an elastic drainage PCV pipe of 50 mm in diameter cut into 100 mm pieces.

The recirculation system was used to rear fry of silver and common carp. Initially the fish were fed with carp pellets at the rate of 3% of the stock weight daily. The food was given in 4 portions each day. Water temperature ranged from 22 to 25°C throughout the experiment.

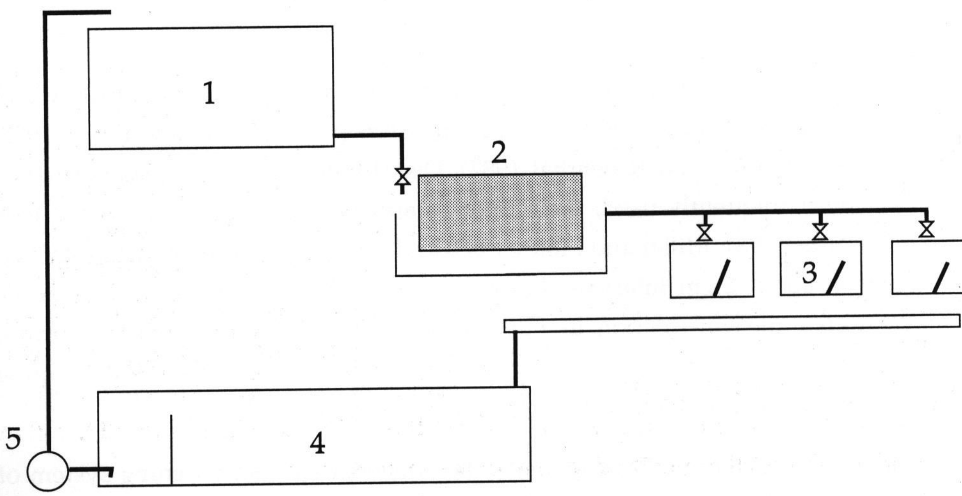

Fig. 1. Description of the recirculation system used for fish fattening. 1 - upper retention tank, 2 - rotating biological filter, 3 - motoreductor, 4 - rearing tanks, 5 - sedimentation tank, 6 - water pump

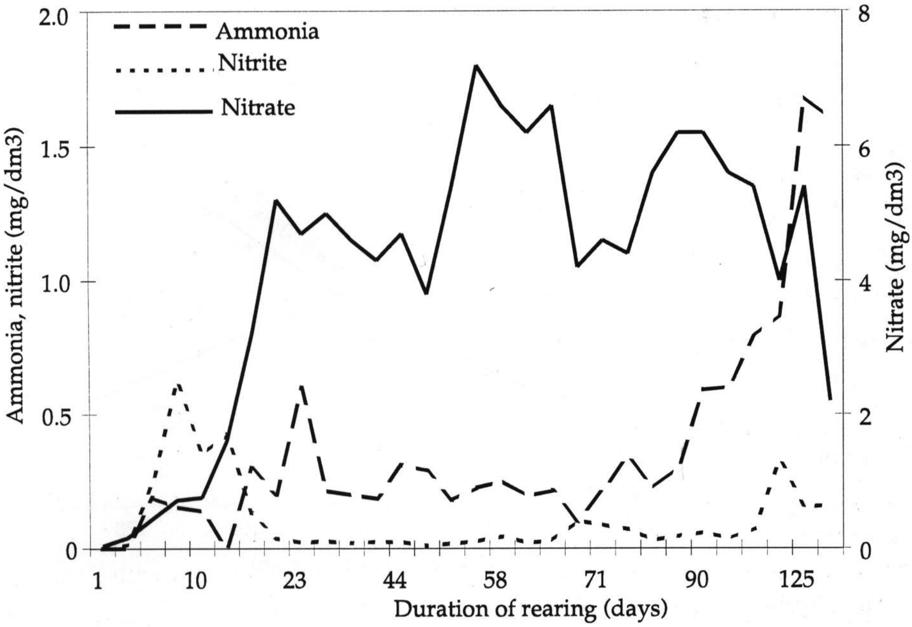

Fig. 2. Changes in ammonia, nitrite and nitrate concentration in the recirculation system

Twice a week determinations were performed of the amount of dissolved oxygen, ammonia, nitrates and nitrites in water, as well as of the pH value. The analyses were performed with the standard methods (Hermanowicz 1976).

RESULTS AND DISCUSSION

The experimental fish fattening was initiated using the fry of silver carp of average weight 4.13 g/ind. Total initial weight of the fish stock was 4.6 kg. After 70 days the stock weight increased to 7.6 kg and then the second rearing tank of the model recirculation system was stocked with carp fry of average individual weight 527.14 g, at the rate of 28 individuals. On 106th day the system broke down, so that 70% of silver carp died and the stock weight decreased from 36.68 kg to 25.07 kg. By the end of the experiment weight of the fish stock in the system amounted to 30.09 kg.

Rate of water flow in the system was changed so as to ensure that oxygen content in water outflowing from the fish rearing tanks did not decrease below 5 mg/l (Alabaster 1982). The flow rate was: 14 l/min till the 12th day, 25 l/min till the 70th day, and 45 l/min till the 135th day (end of the experiment).

Nitrification process started practically since the first days of the experiment. This was reflected in an increase of nitrate and nitrite content (Fig. 2). It should be underlined that nitrification effectiveness in the first phase (oxygenation of ammonia

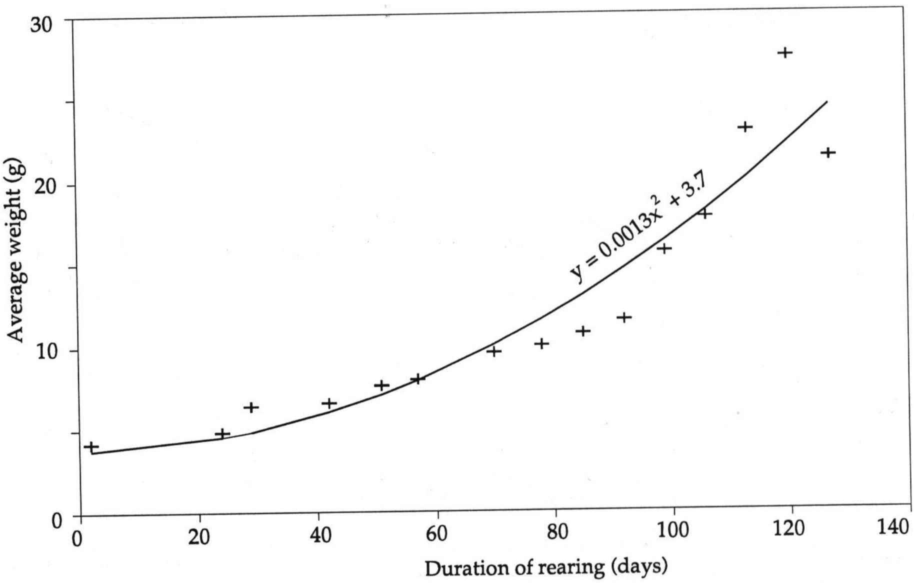

Fig. 3. Rate of growth in average weight of silver carp fry

to nitrites) increased more rapidly than in the second phase (oxygenation of nitrites to nitrates). As a result, nitrite content increased too rapidly, reaching 0.63 mg/l after 10 days. Later on nitrite content decreased rapidly while nitrates increased (Fig. 2). At that time ammonia concentration showed an increasing trend (Fig. 2) though within the range permissible for the fish (Alabaster 1982). Ammonia and nitrite content increased rapidly on the 110th day of the experiment, while nitrate content decreased. This was most probably caused by the mentioned braking down of the recirculation system during which the filter was not working for about two days. Adaptation of the filter to new working conditions lasted for about two weeks. Afterwards nitrite content decreased and the increase of ammonia content was inhibited.

In course of the fish rearing content of nitrites reached the level twice higher than the one accepted as dangerous for fish (Spotte 1973). This happened twice:

- in the initial phase of rearing (filter development)
- after breaking of the system of water recirculation (adaptation of the filter to new working conditions). No fish losses were observed in the first case. In the second case the losses were probably caused by a synergic effect of decreased oxygen content and increased content of ammonia and nitrites (Downing and Merkens 1955). This is supported by the fact that the content of nitrites was lower than in the period of filter development while maximal content of ammonia (1.68 mg/l) at pH 6.0 - 6.5 and water temperature 22 - 25°C was at a level permissible for fish (Trussel 1972, Alabaster 1982).

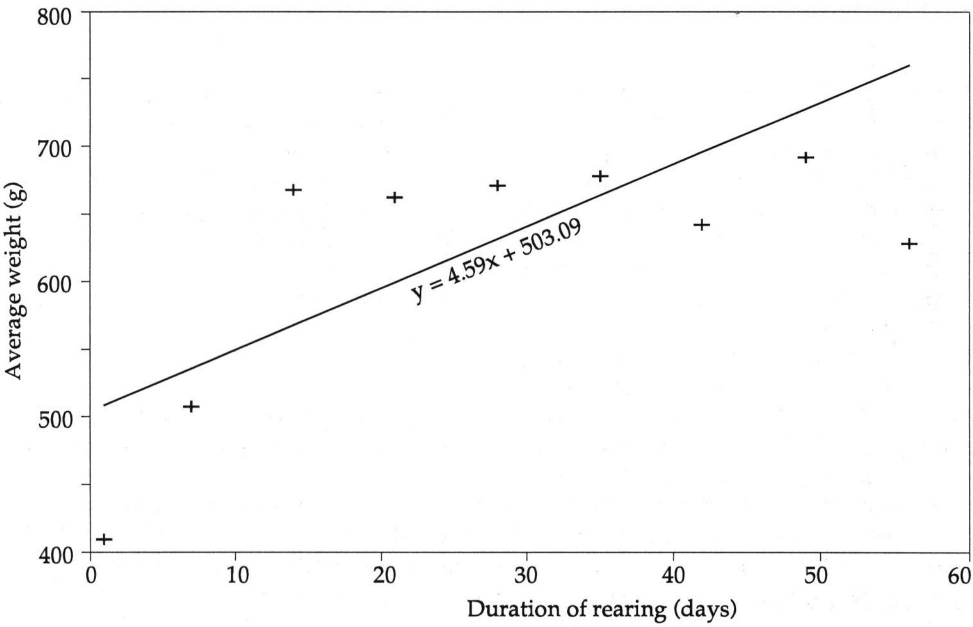

Fig. 4. Rate of growth in average weight of carp fry

Satisfactory environmental conditions were also reflected in the rate of growth of silver (Fig. 3) and common carp fry (Fig. 4). Regression of the growth curve for silver carp shows that when common carp was stocked into the second tank the growth rate of silver carp increased considerably. This was due to an increase of organic suspension, mostly in form of fragments of the biological film which floated in water as there was no mechanical filtration. Determinations performed by the end of the experiment showed that suspended matter content exceeded 30 mg/l. This matter was used as a valuable food by silver carp. As a result there was no decrease in growth rate of this fish when daily food portion was lowered to 1.5% of the stock weight since 110th day of the experiment. Suspended matter favoured the growth of silver carp but it was considered as unsatisfactory since it constituted an additional load on the system (mineralization process). Such amounts of suspended matter would be quite dangerous if salmonids were to be reared in the system (Alabaster 1982).

Summing up the results it may be stated that the rotatory filter used in the experiment can be introduced in the recirculation systems for fish fattening on condition that excess of suspended matter shall be somehow removed, and that effective filter surface shall be increased. The latter should increase effectiveness of the nitrification process.

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STRESZCZENIE

BADANIA MODELOWE SYSTEMU RECYRKULACYJNEGO DO TUCZU RYB Z OBROTOWYM FILTREM BIOLOGICZNYM.

CZĘŚĆ I. WSTĘPNE BADANIA MODELOWE ZŁOŻA BĘBNOWEGO

Na podstawie analizy dostępnej literatury zaprojektowano i skonstruowano biologiczny filtr obrotowy. Badanie efektywności filtru przeprowadzono w modelowym obiegu zamkniętym. Początkową obsadę stanowił narybek tołpygi białej w ilości 4.6 kg. Po 70 dniach podchowu dodatkowo obieg zamknięty obciążono karpiem(28 szt. o średniej masie 527 g.).

W trakcie eksperymentu prowadzono ścisłą kontrolę podstawowych parametrów środowiska wodnego, a minowicie oznaczano ilość tlenu rozpuszczonego, amoniak, azotyny i azotany, a także wartość pH. Na podstawie krzywych zmian koncentracji amoniaku, azotynów i azotanów stwierdzono, że nitryfikacja rozpoczęła się w pierwszych dniach od rozpoczęcia eksperymentu. Wystąpiły natomiast trudności z uruchomieniem drugiej fazy nitryfikacji. Spowodowało to niebezpieczny wzrost ilości azotynów (maksymalna odnotowana koncentracja azotynów wyniosła 0.63 mg N-NO_2/l). Obserwowano wzrost ilości zawiesiny trudno opadającej, której ilość wahała się od 25 do 30 mg/l.

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