Wisconsin Conservation Department
Madison, Wisconsin 53701

FISH MANAGEMENT DIVISION

MANAGEMENT REPORT NO. 2

INVESTIGATIONS OF LIVE FISH TRANSPORTATION CHARCOAL FILTERS FOR THE REMOVAL OF METABOLITES

by
Paul Degurse
Fish Pathologist

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Introduction

Recent fish mortalities during live fish transport have prompted investigation and evaluation of methods and procedures used.

One system, that of recirculating water through a filter of crushed limestone and wood charcoal, has been reported by field personnel to be capable of improved efficiency in live fish transportation. However, when used during high temperatures, mortalities were encountered. Investigation of responsible factors of this system were then initiated.

Theory was held that the effectiveness of the filter recirculation system was related to efficient aeration and the removal of metabolic products through absorption on a filter. This theory was tested by experimentation with two units fabricated for general live fish transportation. Also during the course of this investigation changes were made in the filter system and an evaluation of activated carbon as an absorbent of ammonia from transportation tank water was attempted.

Procedure

Two transportation tanks with filters and pumps installed in such a way as to provide for recirculation of the total volume of water held in the tanks at the rate of 25-30 gallons per minute were used in this investigation. Water is picked up at the bottom of each of three compartments of these tanks and brought to jet returns which spray into the head space above the water level in the tanks. Between the pumps and the return jets is installed a filter of crushed limestone and wood charcoal. Water is passed with upward and cross sectional flow through this filter. In this report these tanks will be designated according to the place of fabrication as Wild Rose and Nevin. A more detailed description of each is given below.

The Wild Rose fish transportation tank is eight feet long, five feet wide and three feet deep. The capacity is 560 gallons. This tank is divided into three compartments with inside dimensions of 28 x 54 x 34 inches. The tank is fabricated from wood planking, 2 inch rough measurement. The inside is coated with a fiber glass finish. Two gasoline powered pumps of approximately 120 gallons per minute maximum delivery are used to circulate water. One pump is kept on standby during the operation of the system. Oxygen from a pressure cylinder is supplied to the intake side of the pump system. Pressures are monitored by a gauge installed between the pumps and the filter. The gauge for this line is installed in the truck cab. A pressure of 5 pounds per square inch is maintained in the supply line to the filter during the operation. The total flow with this pressure is approximately 30 gallons per minute. When fish are loaded, water volume is varied from 400 to 450 gallons. The total water volume is exchanged through the filter every 14 to 15 minutes during the operation.

The filter tank (Fig. 1) is made from sheet metal of ordinary steel. A three compartment basket fabricated from stainless steel perforated with 3/8-inch holes is held in place in the filter tank with gaskets and a bolted cover. The outer compartment of the basket is 3½ inches cross section and 30 inches high and is filled with charcoal 1/8 to 1-inch cross section particle measurement. The inner column 2 inches cross section is filled with 1/8-1/2-inch crushed limestone. A 2-inch diameter center column is left free of filter material. The water is supplied to the bottom of the filter tank and is removed at the top. Water flows upward and at cross section to the filter. With this arrangement a large surface area for filtration is provided, but a short contact time is the most likely since the flow may be across the upper limits of the filter.

The Nevin tank is fabricated from stainless steel sheet metal with double wall construction. The space between these walls is cork lined. Outside dimensions of this tank are: length - 10 feet, width - 4 feet and depth - 3 feet. It is also divided in three compartments each measuring 38 x 36 x 34 inches; total volume of this tank is approximately 700 gallons as normally used in fish transportation. The filter and pump arrangement and the dimensions are the same on this tank as on the Wild Rose tank.

On each tank the water is returned through jets to the head space above the water held during the operations. The Wild Rose tank is provided with jets made from 3/8 inside diameter tubing with quarter section fins installed to cause a relatively fine spray. The Nevin tank return jets are single spray jets of 3/32 inside diameter. Oxygen is provided to the flow streams at the outlet of the pump on this tank as contrasted with provisions for this at the intake side of the Wild Rose tank. This unit did not have provision for monitoring of oxygen pressure inside the truck cab. However, gauges were installed between the filter and the jet system. Attempts were made to maintain pressure at 10 to 15 pounds on these gauges.

Each tank was tested by loading light or heavy loads and fish observed for condition and reaction for varying periods of time. Records were kept on oxygen, carbon dioxide, temperature and free ammonium during the holding of fish in transport. Since these tests were run as preliminary evaluation of recirculation and filtration, oxygen was not used until it was obvious that the particular load could not be held without this supply.

For one trial the Nevin filter was replaced by a true column of activated charcoal, 12-inch diameter by 36 inches high. Fiber glass wool was used to hold the carbon in place in this filter. This filter was used in an upward flow in the system of the Nevin tank without changing this, other than the filter replacement.

The Nevin tank was loaded with 600 lbs. of rainbow trout, 10 per pound, for one trial. A load of 400 pounds of brood fish was used for the trial with activated charcoal. The Wild Rose tank was loaded with 1,300 pounds of rainbow trout at 8 per pound for the trial of this system. The Nevin filter had been used in transport of fish before these trials were run. The filter on the Wild Rose truck was made up with new filter material just prior to the trial.

Results

As may be seen in Table I, A, B, C, carbon dioxide and ammonia are not removed by either of the two filter systems as fabricated. Oxygen could not be maintained in the system even with comparatively light loads in the Nevin tank. Very rapid decline was shown with a relatively heavy load in the Wild Rose tank. The Wild Rose system demonstrated a very efficient method of introducing oxygen to the water supply. Here is the most apparent reason why this tank has been used successfully for large loads of fish as reported here and by field personnel.

Activated charcoal did not remove ammonia from the water under this system, but apparently some carbon dioxide was absorbed (Table B). None of the data supports the theory that more than particulate waste is removed by the filters tested. While it is apparent that no measurement of water conditions could be made before and after the filter stage, conditions of the water in the tank indicate no apparent value in this type filtration. Recirculation as such cannot maintain oxygen except in minimal loading, and it has the disadvantage of temperature rise even in comparatively mild air temperature ranges.

Laboratory studies run during this preliminary investigation indicate activated charcoal will not absorb ammonia with a contact time as short as that used in either of these filters. Laboratory tests of cation exchange resins demonstrate a very short contact time and may function in a true column of the size used on the Nevin tank with the same contact time.

All this investigation can be expected to yield is minimal information on the filter systems tested and some observations on the efficiency of recirculation for aeration. Data was negative on the filter - the filter didn't function. Recirculation is also of limited value. The demonstrated fish-to-water ratio for systems with oxygen under pressure and oxygen supplied directly to the water through stationary spargers was just as high as in recirculation systems.

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Chemical conditions of water in transportation of live trout, along with observed fish reactions. Time in hours.

A. Nevin tank with 600 lbs. rainbow 10/lb. (Light load)

Time (Hours)	NH_3^-	O_2	CO_2	pH	H_2O Temp. ^oF	Air Temp. ^oF	Fish Reaction
0	0.3	8.6	3.0	7.9	50	75	--
1	0.4	6.5	3.5	7.8	52	76	Normal
2	1.5	5.0	6.0	7.6	56	76	Distress*
3	2.5	6.5	10.0	7.5	57	78	Slight Distress
4	3.5	7.8	10.0	7.5	58	80	Normal
4.5	3.5	7.8	19.0	7.4	60	80	Normal

*Mortality: 2 fish. Oxygen supply turned on at the end of second hour. No delayed mortality after one week observations on fish held in raceway.

B. Nevin tank with activated charcoal, 400 lbs. brood fish 2 and 3 year old. (Average load)

Time (Hours)	NH_3^-	O_2	CO_2	pH	H_2O Temp. ^oF	Air Temp. ^oF	Fish Reaction
0	0.02	8.2	3.5	7.8	50	60	--
1	0.4	6.5	6.0	7.6	52	60	Normal
2	0.8	5.0	3.5	7.8	53	63	Normal
3	1.2	5.0	3.5	7.8	55	64	Distress*
4	1.5	6.8	3.5	7.8	58	65	Normal

*No mortality: Oxygen turned on at the end of 3rd hour. No delayed mortality.

Table I (cont.)

Chemical conditions of water in transportation of live trout, along with observed fish reactions. Time in hours.

C. Wild Rose tank 1,300 lbs. Rainbow at 8/lb. (Heavy load)

Time (Hours)	NH_3^-	O_2	CO_2	pH	H_2O Temp. ^oF	Air Temp. ^oF	Fish Reaction
0	.025	7.6	3.5	7.7	50	37	--
0.5	.001	7.4	2.5	7.9	50	37	Slight Distress
1.5	0.68	3.0	9.5	7.5	50	38	Distress Mortality 10*
2.5	2.30	7.1	19.0	7.4	48	34	Normal
3.5	3.20	8.2	19.0	7.4	49	34	Normal
4.0	3.20	8.4	20.0	7.4	49	34	Normal**

*Oxygen turned on at the end of 1½ hours of transport.

**Unloading revealed total of 30 fish lost in transport. This was from 10,400 fish. No delayed mortality after 9 days observation in raceways.

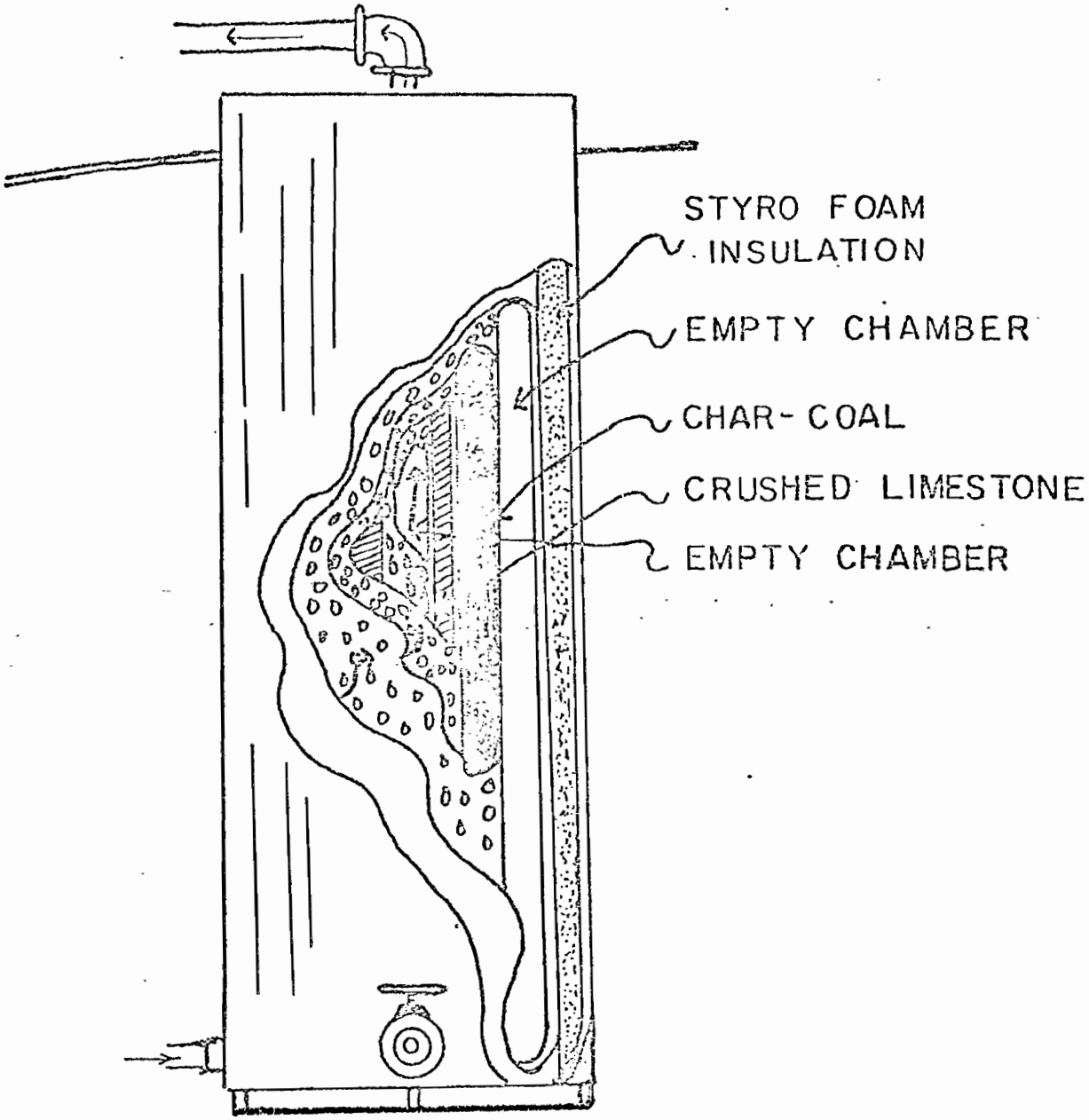

FIGURE NO. 1

Cross sectional drawing of the type of filter used on tanks.