

AN EVALUATION OF THE REMOVAL EFFICIENCY OF ZEBRA MUSSELS (*DREISSENA* SPP.) FROM RAW WATER BY PRIMAR FILTRATION CERAMIC FILTERS

INTRODUCTION

Approaches to control zebra mussel (*Dreissena* spp.) biofouling in raw water systems can be broadly categorized as either chemical, physical, or biological. No biological methodology has proven to be an effective deterrent to zebra mussel settlement. Many chemical methods, although proven effective, may be limited by present and/or future environmental regulations. Small water withdrawers, such as cottage owners, will probably not be able to obtain permits to inject a chemical, such as chlorine, at the intake to keep the intake-line mussel free. Backflushing with chemicals is also not permitted. An environmentally-benign, low maintenance alternative is to install, at the intake, a filter with uniform-sized small openings that would exclude the planktonic zebra mussel life forms commonly referred to as veligers.

On October 24, 1995, representatives from FERRO Corporation (FERRO), Primar Filtration, and Acres International Corporation (Acres) met to discuss the logistics and practicality of conducting a pilot-scale field based study to evaluate the biological effectiveness of the Primar Filtration ceramic filter manufactured by FERRO to exclude zebra mussels from a residential-sized water line. A proposal that included a proposed study plan was prepared by Acres and accepted by FERRO and Primar Filtration.

The ceramic filter assembly proposed for testing was constructed of ceramicly-bonded alumina particles that are shaped into a tube. The units proposed for testing were FERRO grades, FAO 100, FAO 70, and FAO 50. The tube size was 4 inches OD by 17 inches long.

METHODS

Tests were conducted on December 1 through 3, 1995 at the ENTERGY, Mississippi Power and Light Corporation's (MP&L's) Gerald Andrus Plant (GAP) located in Greenville, Mississippi. The site's raw water is withdrawn from Lake Ferguson, which is an opened oxbow lake contiguous with the Mississippi River. The site was selected based on Acres' familiarity with the facilities due to previously-conducted tests and prior years' zebra mussel monitoring programs, which indicated that a sufficient density of veligers would be available for testing at the site through mid-December.

A low-volume pump was used to draw raw water through the filter units at a rate of about 30.3 liters per minute (8 gpm). The filter unit was placed in a 124.9-liter (33-gallon) tank, and raw water was continuously supplied to the tank from a tap off of a raw service water line in the GAP intake building. Prior to the tests, the pump was turned on and the flow rate through the filter was determined by the bucket and stopwatch method. The filtered water was sampled by sieving it through a fine mesh plankton net for a predetermined period, so a minimum of 1 cubic meter (264.2 gallons) was sampled. Typically, after sampling was completed, the flow rate through the filter was again calculated to determine any filter clogging.

Sampling was generally accomplished using a 63-micron mesh plankton net to collect the filtrate. This mesh size is the standard used in zebra mussel monitoring and research work since it collects all shelled-form mussels, including the pediveliger/umbonal veliger forms that are capable of settling, and the D-form veligers that are immediate to the umbonal forms but are not capable of settlement. Some earlier embryonic forms and eggs can pass through the 63-micron mesh, however. A limited number of samples were collected using a 22-micron mesh plankton net to sample for the earlier embryonic forms and eggs. Control samples were collected each sampling day to determine the density of veligers in the raw test water available to be filtered.

To minimize the elapsed time between sample collection and analysis, an on-site biological laboratory was set up. Both wide-field dissecting microscopes (with cross-polarizing filters) and high power compound microscopes were available. Samples collected in the GAP intake house were immediately transferred to the laboratory for processing. Samples were aerated using an oil-free diaphragm pump to ensure that sufficient oxygen was available to the organisms and placed in an ambient temperature water bath. Samples were processed in the order that they were collected. Precautions were taken to prevent cross contamination of the samples, including use of dedicated equipment for treatment versus control samples and a rigorous inspection program.

For treatment samples (i.e., filtered samples) collected in the 63-micron mesh collection nets, the entire sample was examined under 40x magnification using cross-polarized filters. The 22-micron mesh collected samples were examined both under 40x magnification using cross-polarized filters and 120x to 140x using conventional light to screen for embryonic life forms and eggs. Viability of embryonic and shelled veliger life forms was based on direct observation (e.g., ciliar movement, gut rotation). Viability of any eggs found was based on either physical damage or size since eggs under 40 micron will not result in viable mussels.

RESULTS

A total of 12 treatment samples were collected over a three-day period, December 1 through 3, 1995. Over that same period, seven control samples were collected with 63-micron mesh nets and one with 22-micron mesh nets. The median densities of veligers collected in the 63-micron net control samples were:

- 164.2/m³ on December 1;
- 137.2/m³ on December 2; and
- 61.4/m³ on December 3 (Table 1).

The mean density of pre-adult zebra mussels collected in the 22-micron net control sample was 194.0/m³. This consisted of eggs (67.5/m³), embryonic life forms (67.5/m³), and shelled veligers (59.1/m³). The densities in both the 63-micron and 22-micron control samples were sufficient to evaluate the performance of the filter relative to zebra mussel removal efficiency.

Initially, a FAO 100 unit was tested and no veligers were collected in the filtered sample. Since there was no detectable clogging over the 38-minute, 1,180-liter sample, the filter was changed to a FAO 70 unit (Table 2).

Two treatment tests were conducted on the FAO 70 unit. No shelled veligers were present in the sample, however, many living rotifers were present. The rotifers present were within the size range that could include zebra mussel eggs and embryonic life stages, so it was decided to scale back to FAO 50 for subsequent evaluation.

Ten tests were conducted to determine the biological effectiveness of the FAO 50 filter, including two using 22-micron collection nets.

A total of 17,430 liters (4,605 gallons) of water was filtered over the course of the FAO 50 tests. No veligers were present in any of the evaluated samples. The FAO 50 unit effectively screened the rotifer species within the size range of zebra mussels, eggs, and embryonic forms. The presence of eggs, embryonic and shelled veligers, and zebra mussels in the 22-micron control sample provided evidence that they were effectively removed from the water stream by the FAO 50 filter.

CONCLUSIONS

Based on the results of this evaluation, the FAO 50 Primar Filtration ceramic filter will effectively exclude all settleable and shelled-form zebra mussel veligers from the water flow, under the given pumping rates. The number of tests and volume of water tested provide a significant confidence that the filter will remove all settleable veliger forms. Although there were no zebra mussel shelled veligers in the tests conducted on the FAO 100 and FAO 70 filters, too few test runs were conducted to conclude that those filters were 100 percent effective. Also, tests conducted on the FAO 50 filters using 22-micron collection nets indicated that they were also effective in excluding pre-shelled zebra mussel life forms (i.e., eggs and embryos).

TABLE 1

SUMMARY OF MEAN DENSITY OF ZEBRA MUSSEL VELIGERS
BY LIFE STAGE IN CONTROL SAMPLES COLLECTED
DURING PRIMAR FILTRATION CERAMIC FILTER TESTS
(63-MICRON MESH NET COLLECTIONS)

Date	Median Density (#/m ²) in Control			
	Embryonic	D-Form	Umbonal	Total
12-1-95	0.0	36.5	127.7	164.2
12-2-95	0.0	37.9	99.3	137.2
12-3-95	2.7	16.2	42.6	61.4

TABLE 2**SUMMARY OF TREATMENT SAMPLE ANALYSES
PRIMAR FILTRATION CERAMIC FILTER TESTS**

Sample No.	Sample Date	FERRO Grade	Collection Mesh (Micron)	Volume Filtered (Liters)	Veligers Present
01	12-1-95	FAO 100	63	1,180	0
02	12-2-95	FAO 70	63	1,890	0
03	12-2-95	FAO 70	63	3,250	0
04	12-2-95	FAO 50	63	2,570	0
05	12-2-95	FAO 50	63	1,170	0
06	12-2-95	FAO 50	63	1,840	0
07	12-3-95	FAO 50	22	1,910	0
08	12-3-95	FAO 50	22	1,940	0
09	12-3-95	FAO 50	63	2,410	0
10	12-3-95	FAO 50	63	1,950	0
11	12-3-95	FAO 50	63	1,710	0
12	12-3-95	FAO 50	63	1,930	0

Total flow (FAO 50 tests) = 17,430 liters (4,605 gallons).