Development of Phosphorus Filtering Systems for Environmental Protection

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Objectives:

1. *To test steel slag material for its dissolved P-reduction potential in both active and passive filtering systems.*
2. *To determine approximately how much runoff P from a mature bermudagrass site is due to natural causes (rainfall, soil, plant material) and how much can be attributed to synthetic fertilizer.*
3. *To identify standard expectations for use in evaluating phosphorous sorbing materials (PSMs).*

Previous research has clearly showed that sieved electric arc furnace steel slag (> 6.35 mm) is an effective medium in P removal structures designed to filter runoff P prior to reaching surface waters. However, the limited P sorption capacity of the sieved slag can limit the lifetime of such P removal structures. For example, the P removal structure shown in Figure 1 below (located at Stillwater Country Club) initially contained sieved >6.35 mm slag.

While this material was effective at removing 25% of the all dissolved P that flowed into it over a 6-8 month period, other PSMs tested in the laboratory showed a greater P sorption capacity. However, the problem with most PSMs is that they typically possess a low hydraulic conductivity. For a P removal structure to be successful it must not only possess material with high P sorption capacity, it must also be able to allow water to flow through it quickly (i.e. large hydraulic conductivity).

Therefore, the objectives were to test different sized slag fractions for hydraulic conductivity in the laboratory and choose the ideal sized fraction for further testing in the pilot scale pond filter and the landscape runoff P removal structure shown in Figure 1.

Laboratory Tests

Five different slag size fractions ranging from >0.5 mm up to non-sieved slag were tested for hydraulic conductivity, both in water and in a P solution. Materials are shown in Figure 2. All size fractions showed excellent hydraulic conductivity except for the non-sieved slag. In fact, other than the non-sieved slag, all size fractions possessed the same hydraulic conductivity of about 1 cm/

Figure 1. Phosphorus removal structure located at Stillwater Country Club. The unit treats runoff water at the outlet of a 150 acre watershed.

Figure 2. Various sized steel slag fractions tested for hydraulic conductivity. Picture on the right show the non-sieved slag after the test. Note the crusting and cementing of particles which resulted in a decrease in hydraulic conductivity.

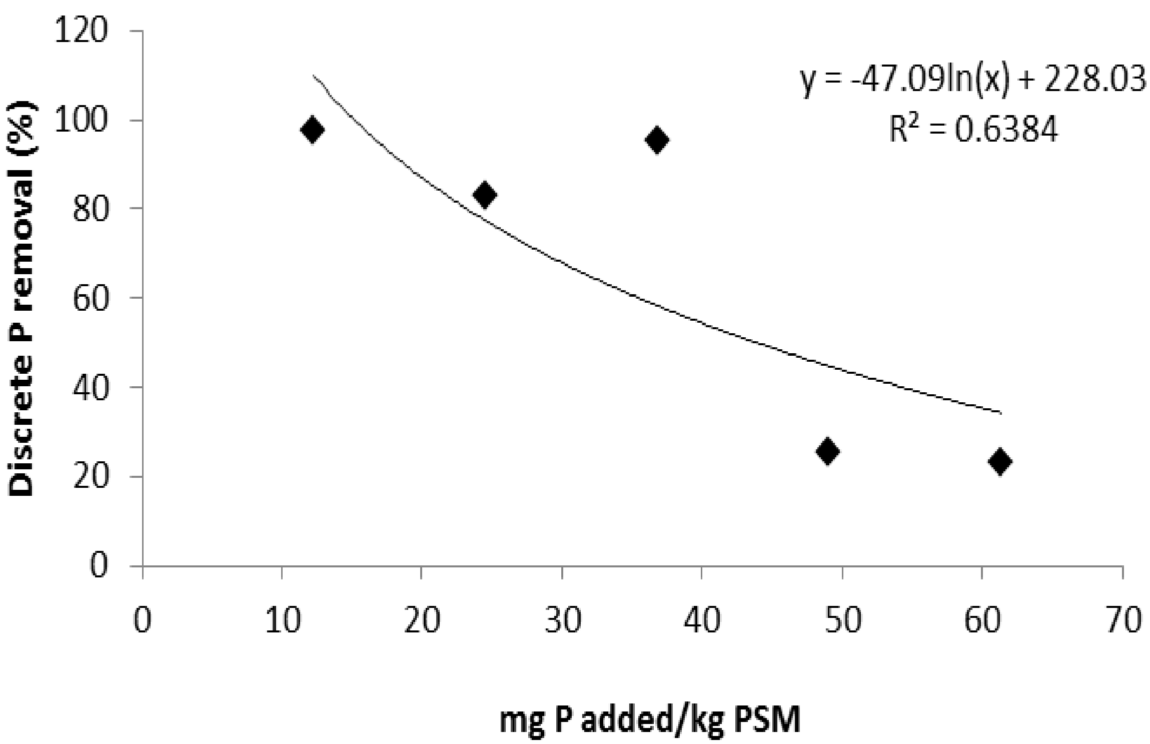

Figure 3. Discrete P removal by sieved >0.5 mm steel slag during a flow-through sorption test with an inflow P concentration of 0.5 mg P/L and a retention time of 10 minutes.

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Figure 4. Pilot scale P pond filter. Water from the pond is continuously pumped into the bed of PSMs contained in building. The filtered water drains back into the pond.

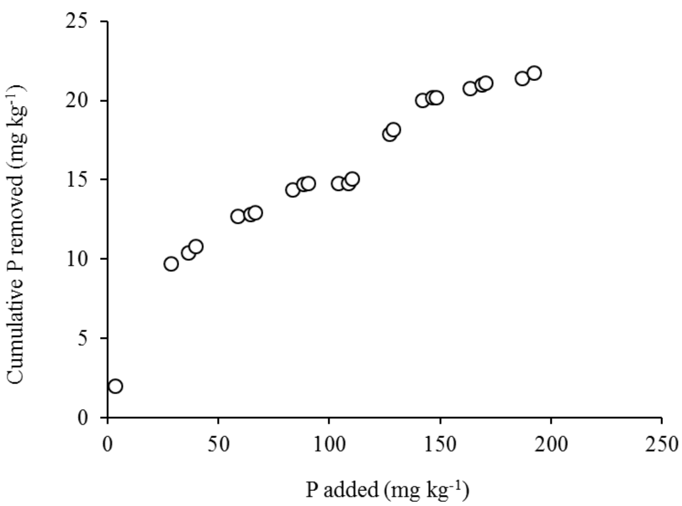

Figure 5. Cumulative P removed from the pilot scale pond filter using >0.5 mm sieved slag.

sec. The goal was to be able to identify the smallest size fraction that would not possess a limiting hydraulic conductivity.

Field Results

The sieved >0.5 mm slag fraction was then tested in the pilot–scale P filter shown below:

Results of the pilot scale test are shown in Figure 5. A non–sieved slag was also tested in the pond filter. There were two problems with the use of non–sieved slag. First, the material clogged up after less than one week of pumping water through it. Second, there was an appreciable amount of precipitated calcium phosphate mineral that flowed through the material and out with the drainage water. The source of this mineral is from precipitation reactions occurring between the slag and the high P inflow water. If this solid phase P is not prevented from leaving the filter, then the filter becomes effectively useless. A further engineered system would be required to achieve the physical containment of that precipitant that is currently escaping through the filter. For this reason, we do not recommend the use on non–sieved slag as a PSM.

Based on these results, sieved >0.5 mm slag was placed in the P removal structure shown in Figure 1. About 3 tons of the sieved material filled the 8 x 10 ft box approximately 9 inches deep. Material was placed in the structure in July, 2012, and has been continuously monitored.

Anticipated Results

The final report will include all results from the P removal structure filled with the >0.5 mm slag that is currently being monitored. Results of laboratory testing of acid mine drainage treatment residuals will also be included.

Summary Points

- P concentrations in runoff from fertilized plots over a 133 day period declined as the number of days after fertilizer application increased.
- P concentrations in runoff from plots that were not fertilized were significantly lower than from fertilized plots and were fairly consistent among runoff events
- Steel slag proved to be an effective filter of P runoff compared with a gravel control and removed an average of 26% of the P in the runoff from 14 runoff events.

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