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EFFECT OF ANAEROBIOSIS ON FILTER MEDIA POLLUTANT RETENTION

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ABSTRACT

This paper presents the results of experiments conducted to determine if four potential filter media (sand, activated carbon, peat moss, and compost) could retain previously-trapped pollutants even under anaerobic conditions. The results indicated that permanent retention of heavy metals may occur even in an anaerobic environment. However, retention of nutrients may not occur under these conditions.

RESEARCH BACKGROUND AND DESCRIPTION

One of the primary problems with downflow filtration of stormwater runoff is the clogging of the filter prior to the medium's exhaustion of the chemical capacity. Upflow filtration using a siphon control may improve the life of the filters. However, for upflow filtration with siphon control for entering water, it would be expected that only the top of the filter would be exposed to air (unlike a gravity filter where the top and bottom are potentially exposed to air between storms), and an anaerobic environment could develop. The purpose of this series of tests was to determine if filter media were able to retain trapped pollutants even if the filter developed an anaerobic environment, either throughout the filter or only in sections of the filter, between storm events. A full description of the tests and results can be found in Clark (2000).

For this set of tests, four media were used: activated carbon, peat moss, compost, and sand. These media were selected because they provided the best overall results during the preliminary work – with sand being used as a comparison to traditional filter material. The media were exposed to a concentrated solution – spiked tap water (10 mg/L of lead, copper, zinc, iron, nitrate, phosphate, and ammonia) – for several hours. The water was then filtered through a 0.45-μm membrane filter. The amount of material sorbed onto the media was calculated using the pre- and post-sorption water concentrations (a blank sample was evaluated in a similar manner, except with no media, so that the effects of sorption onto the exposure containers would be accounted for in the data analysis). After rinsing with a buffered distilled water to remove any loosely bound material and to replace any concentrated pore water, the media were exposed to pre-settled stormwater runoff (from Star Lake, a stormwater detention pond, in Hoover, Alabama) for a period of several weeks. One sample of each medium was maintained in an aerobic environment where aeration stones were used to keep the lake water saturated in oxygen. The other sample of each medium was exposed to the Star Lake water while in sealed BOD bottles, where the naturally-occurring matter/organisms in the water would consume the oxygen and create an anaerobic environment. No seeding was done to encourage more rapid development of anaerobic conditions.

At the end of the exposure time, the dissolved oxygen (DO) concentration and the oxidation-reduction potential (ORP) of each aerobic and anaerobic sample were taken. Then the samples were filtered through a 0.45-μm gel membrane filter, and the filtrates were analyzed for the ammonia, nitrate, total nitrogen, phosphate, total phosphorus, and the following metals (calcium, magnesium, iron, copper, lead and zinc.

RESULTS

For all three forms of nitrogen measured in this experiment (see Figures 1 and 2, total nitrogen not shown), pollutant retention was equal to or greater under aerobic exposure conditions than under anaerobic exposure conditions. For ammonia, the compost released ammonia during the initial sorption. When exposed to aerobic conditions, additional release did not occur. Additional release/leaching did occur, however, when the compost was exposed to anaerobic conditions. Previously sorbed ammonia was released from the peat moss when the water went anaerobic. Peat moss also released previously-adsorbed nitrate when the exposure water went anaerobic. Within experimental error, no other media were shown to release nitrate when exposed to anaerobic conditions. The behavior of all media for total nitrogen reflected the behavior seen for nitrate (Figure 2).

Phosphorus retention (phosphate: Figure 3; total phosphorus: not shown) on carbon, peat, and sand was excellent under both aerobic and anaerobic exposure conditions, indicating that the phosphate that is sorbed on the media will tend to remain on the media, and, if the sorption capacity is not full, additional phosphorus may be sorbed to the media during the long-term exposure. For compost, retention was better and/or leaching was lesser when the media are held under aerobic conditions.

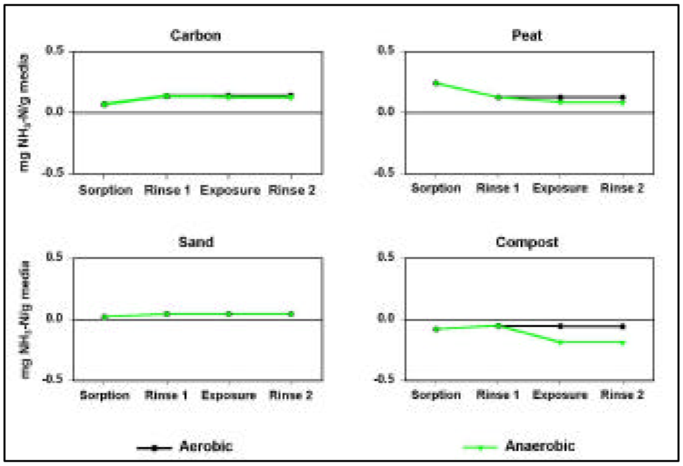

Figure 1. Behavior of ammonia-nitrogen under aerobic and anaerobic conditions.

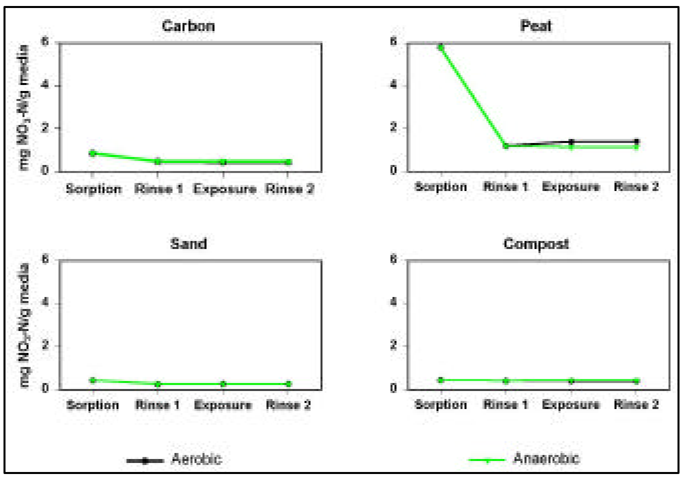

Figure 2. Behavior of nitrate-nitrogen under aerobic and anaerobic conditions.

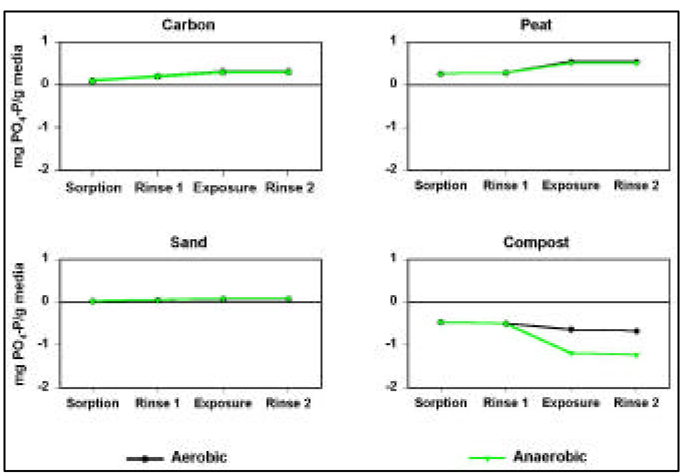

Figure 3. Behavior of phosphate under aerobic and anaerobic conditions.

The results for the heavy metals are shown in Figures 4, 5, 6, and 7 (copper, iron, lead, and zinc, respectively). As expected, once the metals were adsorbed onto the media, only negligible removal occurred during rinsing and exposure, except for the iron-compost combination. For copper, lead, and zinc, the sorption onto the peat and compost appeared to be permanent, likely due to the formation of complexes with the organic compounds on the surface of these materials. Retention by the sand and the carbon also appears to be permanent under the conditions of this experiment. Iron (Figure 5) was adsorbed to all four media. However, when the initial sorption pH is closer to neutral (as in these experiments), the bonding between the compost and the iron was not as strong, and pollutant release occurred during anaerobic conditions. When the test was repeated with a lower initial sorption pH, pollutant release was not seen for any of the metals under either aerobic or anaerobic conditions.

Calcium and magnesium (data not shown) were leached from the compost and peat media (loss greater than total amount sorbed), likely due to competition between these ions and the other ions in solution (especially the heavy metals) for sorption sites on these media. The leaching is significantly greater under anaerobic conditions, where a reducing environment has been developed. Minimal sorption of calcium and magnesium was seen on the carbon and the sand.

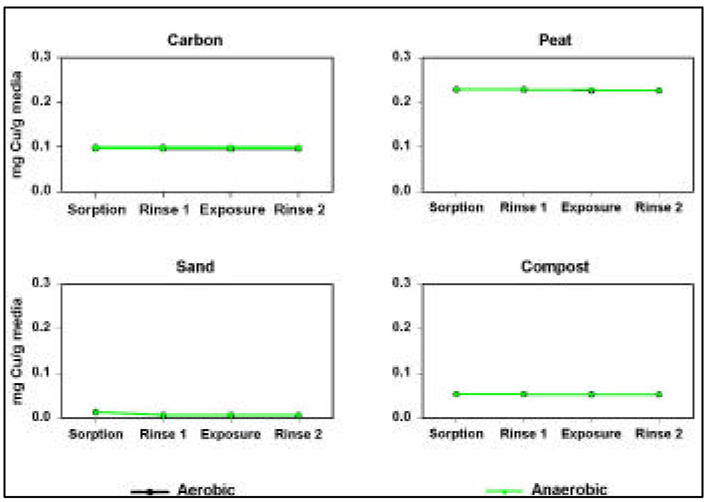

Figure 4. Behavior of copper under aerobic and anaerobic conditions.

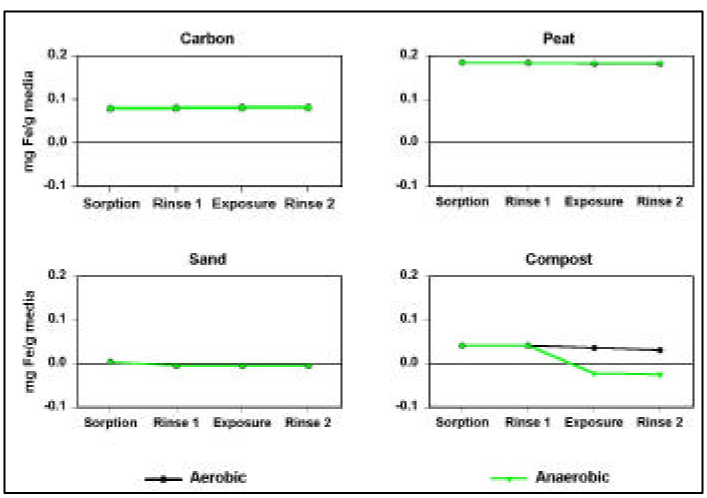

Figure 5. Behavior of iron under aerobic and anaerobic conditions.

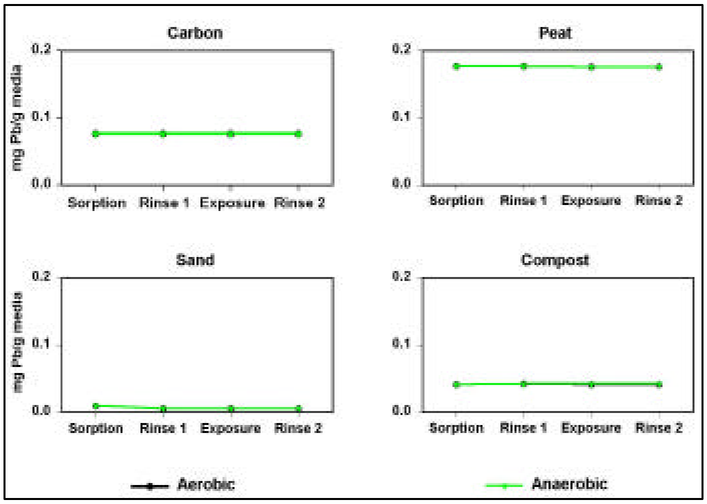

Figure 6. Behavior of lead under aerobic and anaerobic conditions.

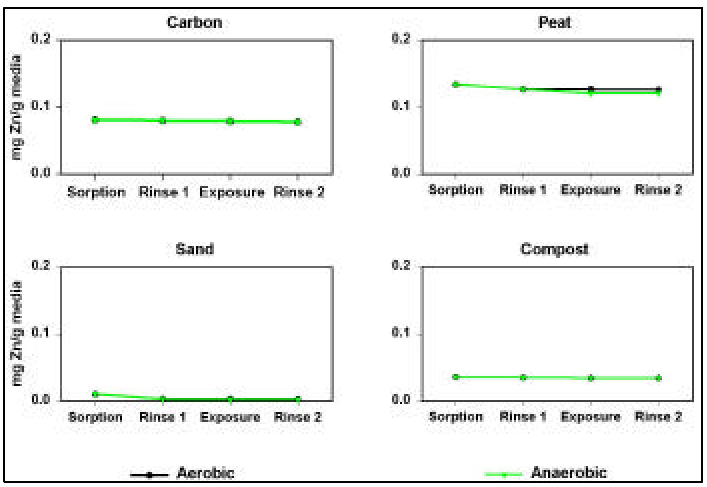

Figure 7. Behavior of zinc under aerobic and anaerobic conditions.

CONCLUSIONS

These results indicate that permanent retention by the filter media for the heavy metals may occur even when the filter goes anaerobic. However, retention of the nutrients may not occur under anaerobic conditions. This indicates that in situations where nutrient release will cause problems for the receiving water, the filter needs to stay aerobic. Therefore, upflow filtration may not be a suitable stormwater treatment technology for those sites. The permanent retention of the heavy metals indicates that upflow filtration may be feasible for sites where the primary stormwater pollutants are metals, such as scrap metal recyclers and junkyards. This project is part of the WERF Project 97-IRM-2, *Innovative Metals Removal Techniques for Urban Stormwater.*

REFERENCE

Clark, S. (2000). *Urban Stormwater Filtration: Optimization of Design Parameters and a Pilot-Scale Evaluation*. Ph.D. Dissertation. University of Alabama at Birmingham, Birmingham, Alabama. 450 pages.