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Column study to access bioretention cell filter mixtures for urban stormwater management

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Abstract
The study examined several options for material mixtures in bioretention cells to keep water cleaner and cut down on pollution into urban storm sewers.

Keywords
Conservation practices, Soils and agronomy, Water quality quantity and management

Disciplines
Agronomy and Crop Sciences | Natural Resources and Conservation | Soil Science | Water Resource Management

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Q If iron fillings are mixed with soil media in bioretention cells, will they retain phosphorus without hindering plant growth?

A Iron fillings are inappropriate for bioretention cell media because they leach out as particulates, cement the soil, and reduce plant growth. Iron fillings did not significantly retain phosphorus.

ECOLOGY

Background

Bioretention cells (biocells) are used in urban stormwater systems as an initial treatment for water quality volume or first flush of pollutants. Biocells reduce urban runoff and retain nutrients, bacteria and metals, thus reducing their loss to storm sewers. In addition to stormwater treatment, they also provide aesthetic appeal and habitat for desirable pollinating insects and wildlife.

An area that receives runoff from an upslope area or roof is directed toward the biocell. The cell contains a modified or engineered soil mix of compost, sand, sorbents and /or soil. Beneath the mix is an aggregate storage area containing a perforated tile drain that is usually connected to a stormwater sewer pipe discharging into a local waterway. Bioretention cells are used for larger drainage areas such as parking lots at commercial or retail locations, schools or churches.

Modified soil mixtures are used to balance the requirement to filter and remove pollutants with the need to sustain plant growth at an affordable cost. The purpose of this study was to compare modified mixtures that could reduce leaching of phosphorus and nitrate while maintaining plant growth. The study compared compost with sand and/or soil mixed with iron filings. Iron oxides will absorb phosphorus and elemental iron has been suggested as an amendment to bioretention cells.

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Budget:
$ 2,063 for year one

Approach and methods

A variety of materials were used for the modified soil mixtures. The compost used was derived from urban leaf-grass yard material. (No tests were done for herbicide content.) The Dubuque soil was taken from the subsoil of a park. All the rest of the soils were taken from urban "fill" areas. Approximate soil series for each site were Downs for Iowa City, Monona for Council Bluffs, Fayette for Dubuque, and Killduff with some Kenyon mixed in for Davenport. The approximate soil series are based on latitude-longitude in web soil survey. Since the areas were disturbed, nearby soil may been mixed with soil native at these sites.

The goal was to collect a mixture in the columns that was approximately 1/3 sand. All

Plant growing in one of the columns..

mixtures were on a volume basis and were mixed with sand before combining with compost and iron filings. The soil-sand mixtures were combined with 3 percent iron filings and 32 percent compost. The compost treatment had only compost. The sand mix had 78 percent sand, 19 percent compost, and 3 percent iron filings.

Mixtures were packed layer-by-layer into PVC columns 6" wide and 39" long. Aquarium gravel was packed at the bottom of the column to facilitate drainage out of the drain hole at the bottom. Saturated and unsaturated infiltration of tap water was measured in the columns, and the first and final effluents were collected to determine nitrate and total phosphorus in the leachate. The columns were planted with Buffalo grass, Blue grama grass and purple coneflower in July 2013, and harvested in September. During growth, a weak fertilizer solution was used to water the plants and simulate nutrient additions from runoff. The total nutrients added were 1.7 mg phosphorus and 12.6 mg nitrogen per column. Then the saturated and unsaturated infiltrations were repeated, and first flush and final effluent were collected for nutrient analysis.

Results and discussion

The saturated infiltration rate before planting was more rapid for sand and compost, even greater than the maximum recommended rate of 4 in h-1. Infiltration after harvest was much slower than before planting, even for the compost and sand treatments. The iron may have plugged pores in the soil and sand treatments. It is not clear why compost would have slower infiltration after harvest, but the soil did become somewhat water repellent. All the columns with iron filings appeared cemented after harvest, and the core samples were difficult to take. Researchers could not use the incremental sampler at all (0-10, 10-20 cm). Plants grew best in the 100 percent compost treatment.

The drinking water standard for nitrate is 10 ppm, but column effluent levels were higher for the compost, Iowa City and Council Bluff treatments. Effluent concentrations before planting were confounded by interactions of iron with nitrate, which resulted in low detection of nitrate for some treatments. This could be the difficulty in detecting nitrate, if present, or the iron could reduce nitrate within the column. The iron was supposed to absorb the phosphorus, not interfere with nitrate. Notably, only the compost treatment resulted in high nitrate effluent levels after harvest.

Soil from Iowa City and Council Bluffs had lower native iron before adding iron filings, and the lowest P in effluent, but had higher nitrate amounts in effluent. Soil from Dubuque and Davenport had higher native iron and highest P in effluent with low measured nitrate in effluent.

To quantify the possible iron interaction with the nitrate effluent, a color scale was assigned to the effluent samples, in which darker effluent had a higher color number. Both organic material and iron contributed to the darker effluent. Excluding effluent from the compost treatment, there was a trend toward lower nitrate concentrations

Suspended iron in the effluent.

for darker effluent, at least before planting. Before planting, treatments with lower measured nitrate levels showed higher total phosphorus levels. The iron may have co-leached with phosphorus as particulates since a darker color was associated with higher total phosphorus in the effluent.

Conclusions

Iron filings are not recommended as an amendment for bioretention cells, though they may be fine in a filter bed where no plants are grown. The iron may exit the bioretention cell as suspended material in the effluent, and the iron remaining in the cell can cement the material and reduce infiltration rates. Soil naturally high in iron or aluminum oxides would be a better amendment than iron filings, especially for soils registering lower pH levels. Further studies will examine dolomite limestone as a possible amendment to sorb phosphorus at higher pH levels. Pure compost provided good media for plant growth, but resulted in excess leaching of nitrate and phosphorus. The compost had four times as much total nitrogen and three to four times as much extracted phosphate as the soil mixtures, so the higher nutrient load in the compost resulted in higher nutrient load in the effluent.

Leveraged funds

No additional funds were leveraged by this project.

For more information, contact:
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