METER
ENVIRONMENT

WHICH FACTORS MAKE RAIN GARDENS MORE EFFECTIVE?

Low Impact Development (LID) is an approach to development (or re-development) that mimics pre-development hydrology and uses ecological engineering to remove pollutants in stormwater and wastewater so it can be reused or replenish groundwater supplies. Examples of LID features include porous pavement, constructed wetlands, green roofs, and rain gardens. LID stormwater bioretention systems such as rain gardens have been proven to work, but are they designed as effectively as they could be? Dr. Amanda Cording (formerly at the University of Vermont) and her team wanted to understand which design factors would make rain gardens more resilient, increase phosphorus adsorption, and reduce nitrates.

WHAT'S HAPPENING INSIDE?

Scientists often evaluate LID design by quantifying how much stormwater the systems (cells) can divert from the sewer system. But Cording and her team wanted to understand what was happening inside the cell. They wondered which types of soil media and infrastructure would optimize a stormwater bioretention system's ability to improve water quality. She says, "We wanted to gather water quality information coming in and going out of the system. I designed inflow and outflow monitoring infrastructure to measure nutrient and sediment pollution." The system monitored pollution by sampling stormwater runoff from a paved road surface before and after it went through bioretention cells. Each cell was constructed with different features to test the influence of vegetation and soil media on pollutant removal capabilities.

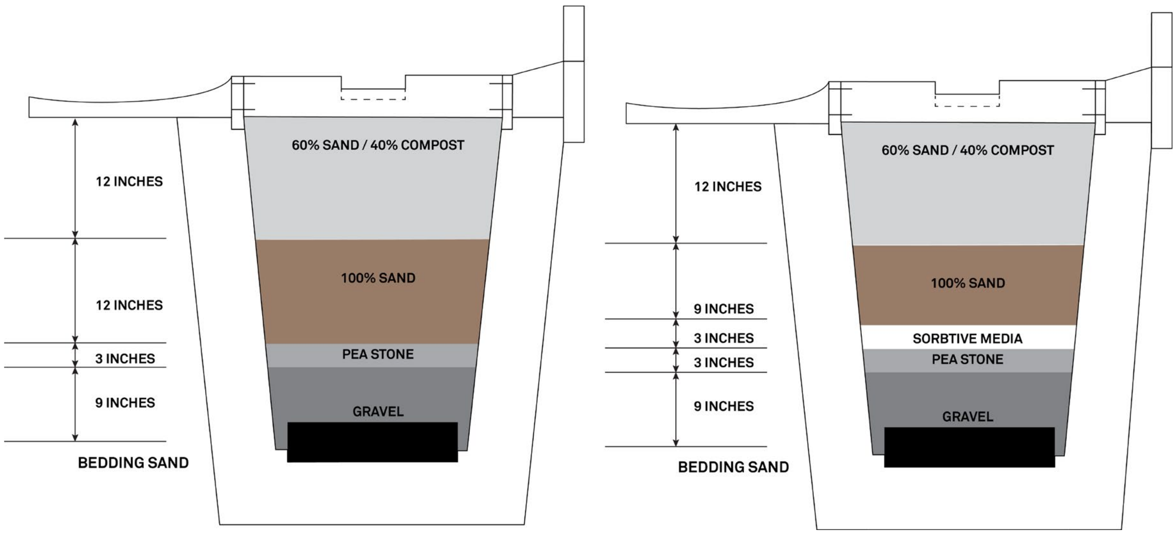

Figure 1. Bioretention cells at the newly constructed Bioretention Laboratory at the University of Vermont

METHODS USED

To understand what was happening within eight bioretention cells at the newly constructed Bioretention Laboratory at the University of Vermont, Dr. Cording and her team investigated the mechanisms influencing greenhouse gas emissions and nutrient transformations at various depths in engineered soil media. In addition to using her own monitoring infrastructure, Dr. Cording used METER soil moisture sensors to measure water content within the soil media. She says, "I was comparing different vegetation treatments while simulating increased precipitation due to climate change in the Northeast. I put the soil probes in at 5 cm and 61cm, one on top of the other. Then I looked at the way the EC and the volumetric water content (VWC) changed prior to a storm event, during a storm event, and after a storm event."

TEROS 12 volumetric water content and EC sensor

Cording says the EC and VWC sensors allowed them to get a general sense of what was happening inside the cell over time. She adds, “I used the data when I needed to know more of the story, such as how the conductivity at the surface compared to other depths so we could see if the nutrients in the soil were migrating, and how much was moving down. We were also able to use the soil moisture sensors to compare the VWC around the roots of different vegetation types. It provided a lot of insight into the dynamic world that exists below the soil surface.”

KEY FINDINGS

Cording says that some of her key findings were that the soil media and vegetation selection is absolutely crucial to the performance of these systems. Cording’s team looked at the root layering perspective in three dimensions and found that deep-rooted systems were found to have a much better ability to hold the soil in place and remove nutrients throughout the life cycle of the cell. The more surface area the roots covered, the more pollutants the cell would remove. She adds, “Cells with deep-rooted plants were found to be resilient during increased precipitation due to climate change, did well at retaining peak flow rates, and performed well at removing total suspended solids and nutrients predominantly associated with particulates.” Labile nutrients, Cording says, were a completely different story. She says the bioretention systems have to be specifically designed to remove those nutrients through sorption (P) and denitrification (N).

Compost, which is often used as an organic amendment in the soil media to help remove heavy metals and provide nutrients for the plants, was found to have a negative effect on water quality overall, due to the high pre-existing labile N and P content. She says, “It’s intuitive, but at the same time, a lot of these systems are designed based on bloom time and color, and not necessarily on the physical and chemical pollutant removal mechanisms at work.”

WHAT LIES AHEAD?

Cording also tested a proprietary bioengineered media in two of her cells which was designed to remove the phosphorous that causes algal blooms in the rivers and streams. She says, “It did a phenomenal job. There was very little phosphorous coming out compared to the traditionally-designed retention cells. Cording, who is now based in Honolulu and works for an ecological engineering company called EcoSolutions, is looking at how to use natural, highly-leached iron rich soils, to get a similar amount of phosphorous removal, and how bioretention can be designed with anoxic storage zones to remove nitrate via denitrification. She says, “These nutrients can be easily removed from stormwater with a little conscious design effort and a splash of chemistry.”

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