"Let the Green, Save Green"

Urban Soil Restoration: Helping Communities Meet Stormwater Management Requirements

We have hundreds of years of experience in making "Dirt" –
It's time we start re-making "Soils" on a landscape level, quickly –
C. Hegberg

Figure 1- Grass Farmers Social Gathering (Source Unknown)

It's no secret: Americans take their lawns seriously - kind of a green love affair. In America, lawns are the largest agricultural crop at approximately 40 million acres and growing (Figure 1). Where I reside, the Chesapeake Bay watershed has nearly 3.8 million acres of lawns and turf or a staggering 9.5 percent of the total watershed land area (CSN, 2009). Of that area, an incredible 75% is dedicated to lawns producing enough lawn clippings to equal to 272 million bushels of corn consuming 215 million pounds of nitrogen fertilizer, 1.9 million acre/feet of water and over 57 million gallons of gasoline. This is a tremendous amount of time and money to steward our little patch of green. The latest estimates conducted by the Chesapeake Stormwater Network estimated that in the Chesapeake Bay watershed, we have 6.8 million "Grass Farmers," volunteering the equivalent of approximately 61,000 full-time jobs and spending nearly $5 billion per year. I am sure many of you reading this article can attest that your community and watershed is likely no different.

Yet with all this investment, our beloved compacted patch of green generates a significant amount of polluted runoff. Whether a new development or an older one, if the soils were not restored or protected during construction, they will not repair themselves. All too often, it is believed that soils are capable of repairing themselves through time and by vegetative root growth; however, studies in both urban and agricultural environments have demonstrated that this is not occurring and that some form of physical intervention is necessary (Pitt et al., 2008; Brown and Hunt, 2010) (Figure 2). Without this physical intervention, most lawns do not currently provide significant water infiltration, retention, pollutant removal, carbon sequestration or localized cooling because most have ceased to function as intended (Figure 3).

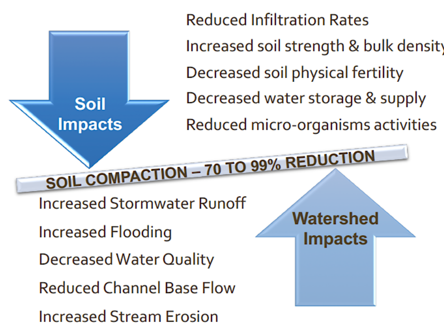

Figure 2 - Watershed Impacts from Soil Compaction

Figure 3 - Subsoils and Sod Installation in New Development (Source: Dr. Stu Schwartz)

For many communities, the use of Green Infrastructure (GI) is a new approach to managing urban stormwater runoff volumes and quality. GI manages stormwater runoff by using natural ecosystems and/or engineered systems that mimic natural systems. GI is designed to mimic natural hydrologic runoff characteristics (groundwater recharge and surface flow) as closely as possible while simultaneously maximizing disconnected impervious areas. It has been envisioned by the regulatory community that much of the disconnection to reduce runoff and nutrients would be accomplished using small-scale, nonstructural stormwater Best Management Practices (BMPs).

For many communities throughout the nation, the latest Federal and State stormwater and water quality programs have become major operations and a significant additional tax burden. For many older communities that are already dealing with crumbling and aging infrastructure, the additional cost of meeting new and unfinanced stormwater treatment regulations is quite significant. The potential economic impact and financial cost for implementation, operation and maintenance has not been lost on businesses, the public, and many levels of government.

While GI offers many benefits, retrofitting existing urban infrastructure is still a complex and expensive endeavor. Most municipalities own very little land and what they do own is often not located where it is needed for stormwater treatment. Older, well-established communities have limited spaces to install many of the traditional GI BMPs on a scale to make significant impacts on runoff volumes necessary to see any measurable improvements within a drainage basin. Land acquisition, utility conflicts, lack of or inferior drainage infrastructure networks and high design, construction and maintenance costs are ultimately borne by the citizens via stormwater taxes or fees. Additionally, many communities commonly overlook or underestimate the long-term inflationary maintenance costs that must be accepted by the citizens after installation is completed. The continued maintenance aspect is not a small or inexpensive component by any measure and only grows as more GIs are installed. This is a generational cost that must be fully considered. While still cheaper than traditional stormwater management, the cost per impervious acre treated can escalate quickly.

As most available GI space is privately held, there is an opening for this energetic group of “Grass Farmers” to come to the rescue. A golden opportunity exists for local citizens to help their communities by offering up their lawns and turf as a new GI asset. Many of our built-out communities contain a tremendous amount of green real estate that is available for infiltration, retention, and filtration. Rather than capture all stormwater in new treatment systems, existing greenways and open space (which may consist of turf areas, filter strips, reforestation areas and tree plantings, meadows, grass swales, and ditches) can be restored and enhanced. Basically, every business and citizen that participates in “Grass Farming” can be a player. By doing so, they can help reduce the many constraints previously mentioned, and the overall number of more complex GI systems, thus lessening the long-term financial burdens on a community.

But wait there is more! In 2012, I was part of a research partnership with the University of Delaware, to study ways to redevelop healthy functioning (physical, chemical, and biological) soil using biochar. For those not familiar with biochar, it is a charcoal-like material formed by “cooking” waste organic matter, (wood, green waste, poultry litter, etc.) in an oxygen-free environment. Every community has green waste which to work with. Even better is biochar does not decompose as compost lasting hundreds to thousands of years. Yet the addition of a small amount of high-quality compost has been found to promote soil microbial development and the enhancement of micropore development (Figure 4).

Figure 4 - Mycelium/Biochar Attraction in Compost (Source: Pacific Biochar)

Since the re-discovery of Terra Preta (“Dark Earth”) soils of the Amazon basin in 2001, there has been an explosion of scientific, peer-reviewed research conducted throughout the world. This ever-growing research has connected biochar with many beneficial outcomes such as soil restoration, water management and quality improvements, remediation, and carbon sequestration. An additional exciting aspect of biochar is its carbon-negative benefit when used as a soil amendment whereby ~1 ton of biochar is equal to ~ 3 tons of CO_2e.

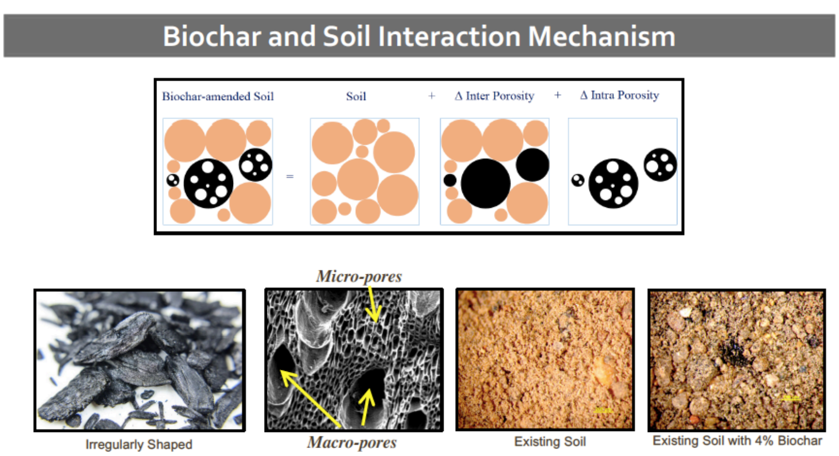

Figure 5 - Biochar and Soil Interaction Mechanism

As part of the biochar research for the restoration of urban soils and stormwater management, our research team found that amending the study site’s soils with biochar resulted in an average reduction of stormwater runoff volume and peak flow rate by 88 percent and 84 percent, respectively, while capturing 100 percent of the runoff from 85 percent of all the storms during a nearly 2 year period. It was also documented that soil water holding capacity increased by nearly 30 percent. In addition, it was found that the amended soils were cooler in the summer and warmer in the winter than the unamended soils.

Diving deeper into these exciting results, the study demonstrated that the increased water infiltration and retention in biochar-amended soil is attributed to two key functions. First, the biochar's ***intra***-porosity (micro-pores and macro-pores) provided the ability of soils to increase their water holding capacity with much of the plant available water held in the biochar's macro-pore space (Figure 5). Secondly, the ***inter***-porosity, the spaces between the irregularly shaped biochar and the soil particles, helped to modify the soils' bulk density and the creation of micro and macro soil tubes (Figure 5). This significantly influenced the formation of soil aggregation by chemical and microbial processes further enhancing infiltration activities while improving pollutant removal similar to a carbon filter. These two processes helped to create the ultimate long-lasting soil sponge. Lastly, the economics look quite attractive as compared to other similar types of GI practices. A cost analysis comparing biochar amendment to 23 other GI practices indicated that biochar is less expensive than 20 other practices – up to 10 times less, requiring less space for each impervious acre treated.

Currently efforts are ongoing to convert a quarter-acre of existing turf to a pollinator meadow, amending the top 12 inches of soils with biochar to capturing runoff from a 5-acre drainage area, 3 acres of which are impervious. There is strong evidence from the previous field-research that soil regeneration techniques with biochar will greatly enhance existing GI practices, as well as open up opportunities for areas previously not considered available for stormwater management such as lawns and turf areas. Addressing large-scale water volume reduction using this approach may prove to be a "silver bullet" to help solve problems associated with limited space, cost, and implementation speed of stormwater projects. Today, it is possible to accelerate soil evolution processes by creating "Terra Preta" (dark earth)-like soils through implementing broad-scale soil restoration methods combined with innovative techniques such as biochar soil amendments, subsoiling and/or pneumatic sub-soilers and soil probiotics on a large-scale landscape level.

Figure 6 - Terra Aeration Tracker Pneumatic Soil Decompaction (Source: Terra Aeration)

Based on the research results, implementation using a broadscale soil restoration methods would significantly change the hydrodynamics of a watershed by improving infiltration, water retention, pollutant removal and carbon sequestration. It is possible that stormwater permit requirements could be met using this method thereby considerably reducing design, installation and operation and maintenance costs, both present and future. While these new programs nationwide are complex and expensive, there is nothing preventing the use of soil restoration techniques or the use of biochar as an amendment or in combination with other amendments or GI practices. Soil restoration is or should be considered an acceptable practice for these programs. If your community doesn't have ordinances or guidance allowing for urban soil restoration as an acceptable GI practice for new developments and especially for existing older green spaces, work should begin to develop them. This approach is very much the low hanging fruit that should be picked. Remember, there are tens of millions of "Grass Farmers" likely willing and ready to participate in serving their communities by offering up their turfy areas – for a better turfy area.

Charles Hegberg
chegberg@live.com

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