ORGANIC BMPS USED FOR STORMWATER MANAGEMENT – Filter Media Test Results from Private Certification Program Yield Predictable Performance

Rod Tyler and Britt Faucette, Filtrexx International

**Introduction**

Soil erosion is considered the biggest contributor to nonpoint source pollution in the United States according to the federally mandated National Pollution Discharge Elimination System (NPDES) (US EPA, 1997). In 1987, amendments to the federal Clean Water Act mandated that construction sites must control storm water, erosion, and sediment originating from their site (US EPA, 2000). In 2003, the federally mandated NPDES Phase II went into effect extending the storm water management plan requirement to any land-disturbing activity over 0.4 ha (1 acre) (US EPA, 2000). These new regulations label development zones as "point sources" requiring better erosion control practices, new permitting programs, increased monitoring, and more site inspections by state and local officials. In addition, violators can also be held in noncompliance with the federal Clean Water Act can be fined up to $100,000 (USD) per day per violation (GA Soil and Water Conservation Commission, 2002).

Although soil loss rates from construction sites are 10-20 times that of agricultural lands (US EPA, 2000), much less research has been done in this area. Turbidity and concentration of suspended solids from storm runoff are the most commonly cited water quality impacts during and immediately following highway construction projects (Barrett et al., 1995). Construction and development projects, where topsoil is cleared of vegetation or moved, are particularly subject to erosion problems. These project zones often present a significant challenge in reestablishing vegetation to protect the soil due to reduced soil quality and fertility. In many cases the existing topsoil has been totally removed making the challenge even greater. In addition, heavy machinery and constant traffic compact the soil creating a "hard pan" that decreases infiltration, increases runoff, and prevents plant establishment and growth (Brady and Weil, 1996).

The most serious impacts of soil erosion occur once the sediment leaves the site and enters surface waters. When eroded sediment is transported from its site of origin to nearby surface waters it also carries fertilizers, pesticides, fuels and other contaminants and substances commonly spilled at construction sites that readily attach to soil particles (Risse & Faucette, 2001).

Surface water that is loaded with sediment can lead to reduced drainage capacity, increased flooding, decreased aquatic organism populations, decreased commercial and recreational fishing catches, clogged and damaged commercial and industrial irrigation systems, increased expenditures at water treatment plants to clean the water, and decreased recreational and aesthetic value of water resources (Risse and Faucette, 2001). In addition to sediment build up in US river systems, another 1.5 billion Mg of sediment are deposited in the nation's reservoirs annually (Brady and Weil, 1996). It is estimated that the national cost to society due to sedimentation of eroded soil is over $17 billion per year.

In the last ten years compost has been used for slope stabilization, erosion and sediment control, storm water filtration, and vegetative establishment applications (Tyler, 2001). Faucette (2004) showed that a compost system can reduce runoff, sediment and nutrient loss, and increase vegetation and soil quality parameters when compared to industry standard best management practices. Composted wood waste has been shown to increase water infiltration and water holding capacity by improving soil structure (Demars et al., 2000). Applications of composted municipal solid waste can provide efficient control of storm runoff by dissipating the impact of water droplets and reducing runoff flow velocity (Agassi, 1998). MSW compost has been shown to absorb approximately 85% of applied rainfall compared to 42% and 52% from control plots (Agassi, 1998). Runoff rates were found to be significantly lower on newly constructed highway embankments when using compost instead of topsoil (Glanville et al, 2001; Glanville et al, 2002).

Perhaps the biggest challenge to the widespread adoption of compost use in stormwater management applications is the extreme variability in quality *and* characteristics that exist in locally made products that do not consistently adhere to standards and specifications. Predictable and verifiable performance by compost products in stormwater management applications is only attainable if the compost products used consistently meet predetermined standards. Although recent development of state and federal specifications for compost use in erosion control have elevated performance and predictability, some private organizations have begun testing programs on a national basis to further improve upon these specifications. Particular attention has been given to the filtration capabilities of compost 'filter media' as differentiated from compost ‘growing media’. The objectives of testing programs have concentrated on flow through rate and sediment, nutrient, and hydrocarbon removal capabilities based on specific compost characteristics including, moisture, particle size distribution, and nutrient content. By testing a wide variety and sample size of compost products from around the country, trends and correlation results may provide greater performance predictability and efficacy of specific compost characteristics used in a multitude of stormwater management applications.

Stormwater management applications that compost products have shown consistent empirical success include perimeter control on construction sites, check dams in channels, channel protection, stormwater inlet and outlet protection, streambank stabilization, as a sediment pond alternative, slope stabilization, temporary and permanent vegetation establishment, flood control, green roof construction, stormwater gardens, bioretention ponds, and hydrocarbon filtration.

This report will present preliminary data from a compost ‘filter media’ testing program as well as progressive field applications that have used this technology in nearly 5000 projects in 45 US states, Japan, Canada, and New Zealand.

**Materials and Methods used in Testing Program**

In the Spring and Summer of 2004 thirteen compost products were sampled from eight commercial and municipal composting operations from around the United States. Each compost product was sampled and characterized for particle size distribution, bulk density, and water content and was tested specifically as a stormwater filtration and pollutant removal media. Compost products were placed on a 3:1 slope in an 8 inch diameter HDPE plastic Filtrexx™ Filter Soxx™ containment system with 3/8 inch diamond mesh openings.

**Sampling procedure and design**

The design of the tilt table and the testing protocol was developed by Frank Shields at Soil Control Lab, Inc. The test table involves a small tilt table design that allows FilterSoxx to be cradled by sideboards, allowing for a secure fit that prevents water from bypassing the product tested. The table has adjustable slope ratios from 4:1 to 1:1 that mimic slopes encountered in most land disturbing activities and most project sites within the construction industry. A water tank equipped with a pump enabled siphon tube are situated at the head (or top) of the slope and apply a predetermined pollutant concentrated 'runoff' for each treatment.

**Filtrexx FilterSoxx Test Procedure**

Step 1: The sample received is tested for particle size distribution, bulk density, moisture, and a packed void space.

Step 2: A sample of the material is packed into a Filtrexx FilterSoxx and pressed into the berm tester. Clear tap water is run through the filled FilterSoxx for ten min.

Step 3: Out flow is tested for soluble salts. Maximum flow is estimated based on water backed up behind the FilterSoxx and the flow adjusted accordingly.

Step 4: A prepared water containing nutrients, salts, sediment and sand is run through the FilterSoxx for ten min. Both inflow and out flow are then tested for the following concentrations:

1) Sand, suspended solids and turbidity
2) Nutrients including:
    a. Nitrogen series (NH4, NO3, total N, and organic N)
    b. Phosphate series including (reactive P, organic P, acid hydrolysable P, and total P)
    c. Potassium, Calcium, Magnesium and sulfate, copper, zinc, iron and manganese.
3) Total non-soluble carbon, pH, EC

Step 5: A sample of motor oil is dripped into the inflow for ten min.
The concentration of motor oil that passes through the FilterSoxx is determined.

Analytical tests for water quality are reported as concentration reduction and percent reduction from prepared runoff water.

**Analytical test methods**

Particle size distribution (TMECC 02.02 B sieve), Bulk density (SCL cylinder packed), Void Space(SCL – sand replacement), Soluble Salts (SM 2510 B EC meter), Ammonia-N (SM 4500-NH3 H auto phenate), Nitrate-N (SM 4500-NO3 C- IC), Total N (TMECC 4.02-D Leco), Organic N (Calculation), Reactive P (SM 4500-P –IC), Acid Hydrolysable P (SM 4500-P-ICP), Total P (EPA 3050/ EPA 6010 ICP), Organic P (calculated), Potassium, Calcium, Magnesium, Iron, Manganese, Copper, Zinc (EPA 3050 / EPA 6010 ICP), Non-soluble C (Leco), pH (SM 4500H+ B), Electrical Conductivity (SM 2510 B EC meter), and Motor oil (SM 5520 B partition gravimetric method).

**Preliminary Results from Testing Program**

Results from preliminary testing show a high variability in particle size distribution among the compost filter media products (Figure 1). Particle sizes less than ¼ in. have been grouped together. Maximum flow through rates varied greatly between compost products as well, ranging between 1 and 80 gallons per linear foot per minute (Figure 2). Silt fence typically has a flow through rate of 10 gallons per linear foot per minute for clean (no sediment) water. Moisture (water) content appears to have a direct negative correlation relationship with flow through rate (Figure 3). Particle size distribution of the filter media can also greatly influence flow through rates. While the majority of compost products performed exceptionally well at reducing total solids in storm runoff (excluding those with a high percentage of large particle sizes), total suspended solids and turbidity filtration were not as absolute but still quite good for most compost filter media products (Figure 4). Filter sock treatment 8 gives evidence that compost used as a filter media may contribute to water pollution if specifications are not followed. Motor oil removal from storm runoff by the compost filter media was near 100% for half of the compost products tested and near 50% or greater for all 13 products tested (Figure 5). Total nitrogen and total phosphorus reduction (or filtration) was highly variable between treatments, as it appears that some compost products can reduce N and/or P while others may contribute N and/or P to storm runoff. Continued testing will seek to evaluate which characteristics within the compost filter media contribute and/or remove nitrogen and phosphorus from storm water.

**Figure 1:** Particle size distribution of filter media with ¼ inch minus grouped.

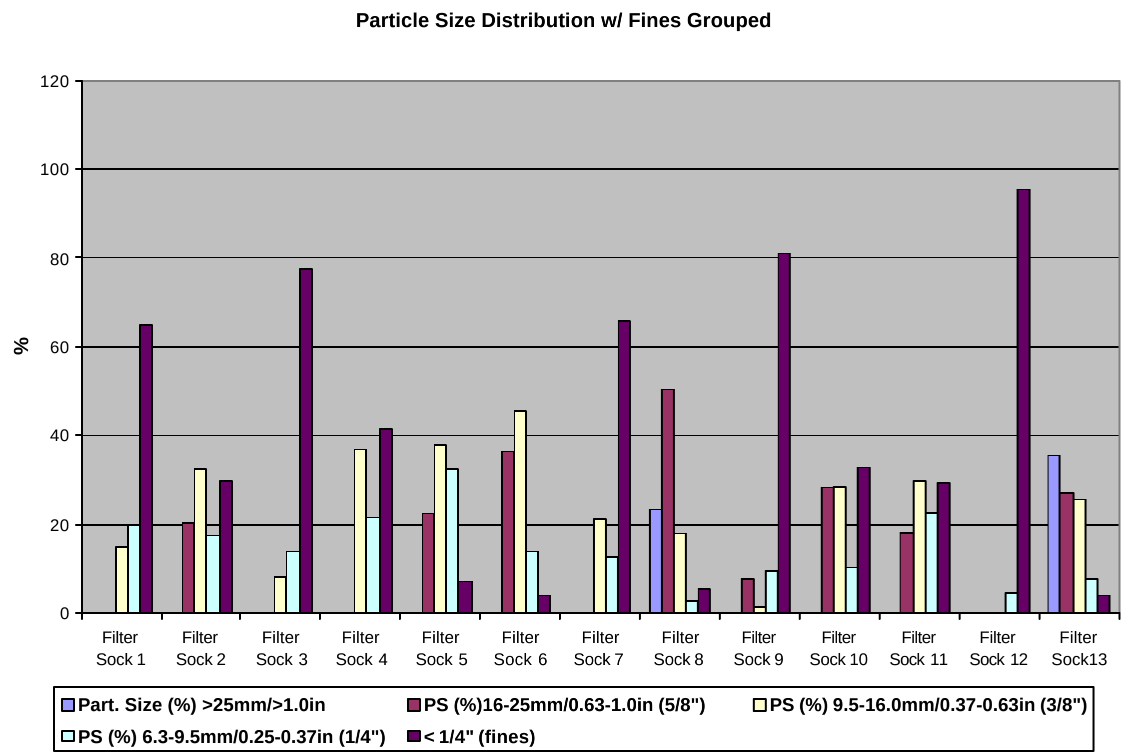


**Figure 2:** Maximum recorded flow through rate by filter media.

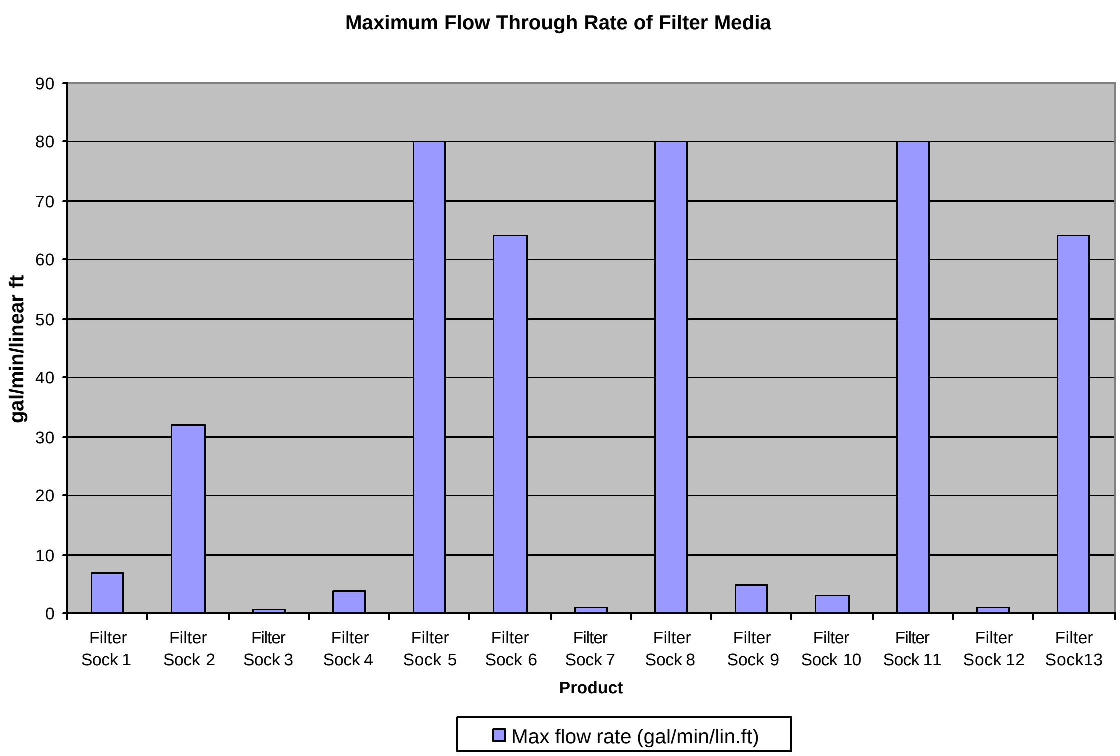


**Figure 3:** Maximum recorded flow through rate and moisture content of filter media.

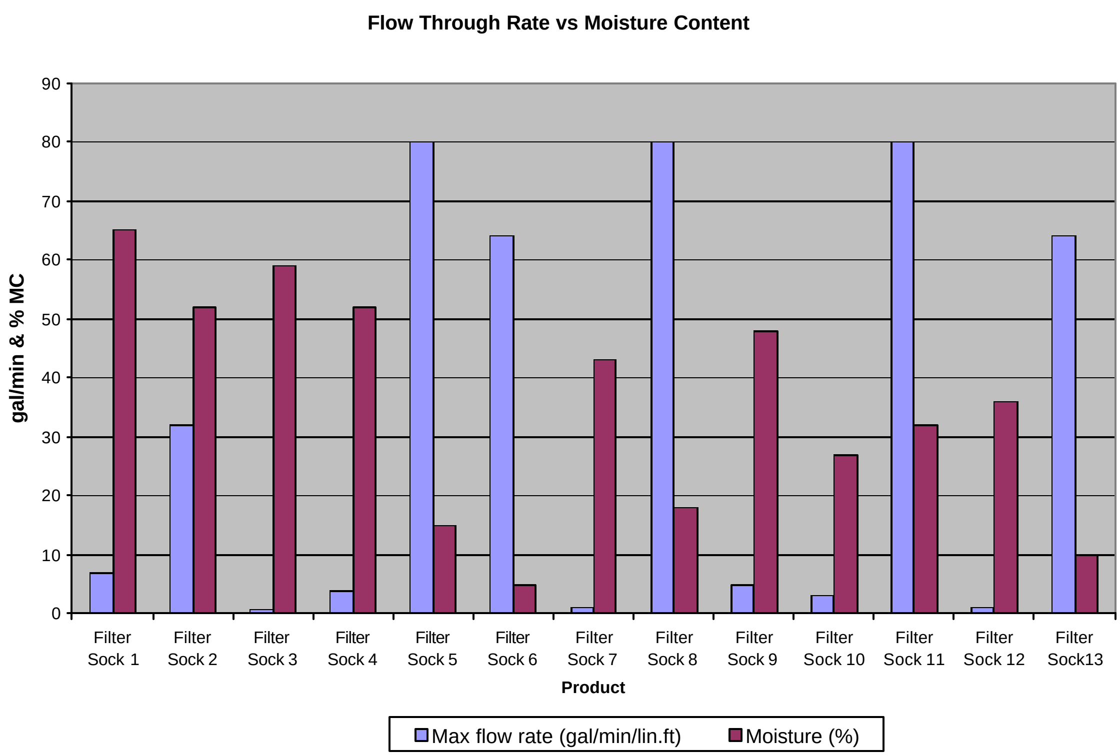


**Figure 4:** Percentage of total solids, total suspended solids and turbidity reduced by filter media.

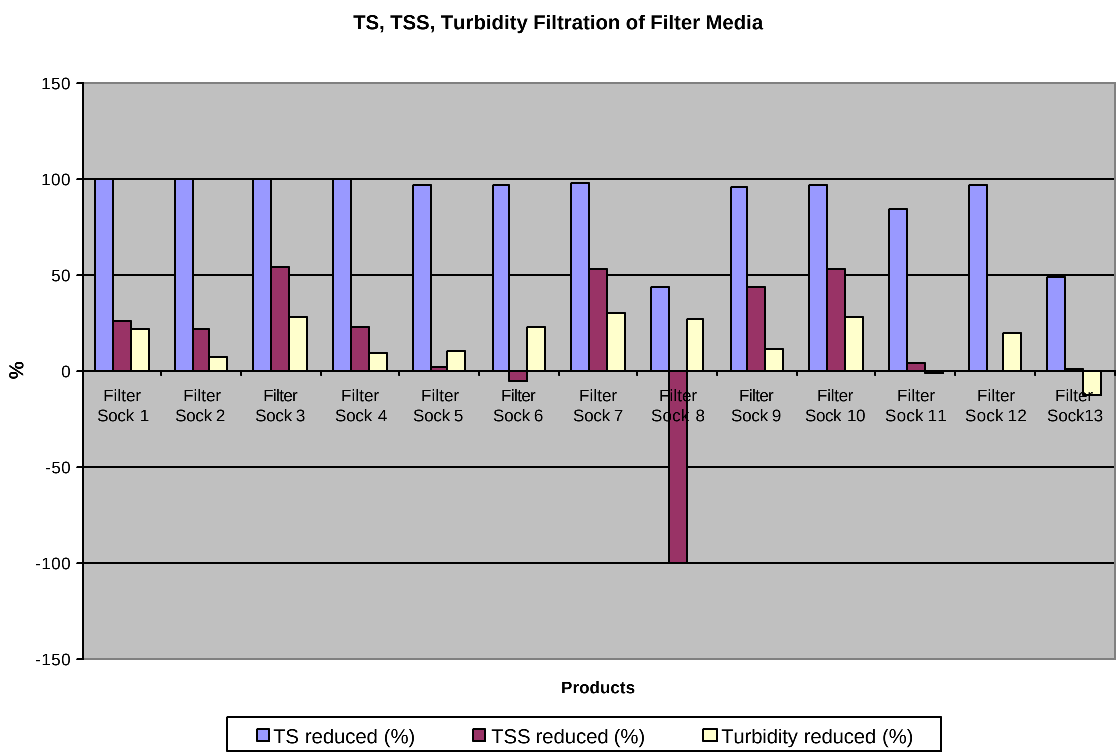
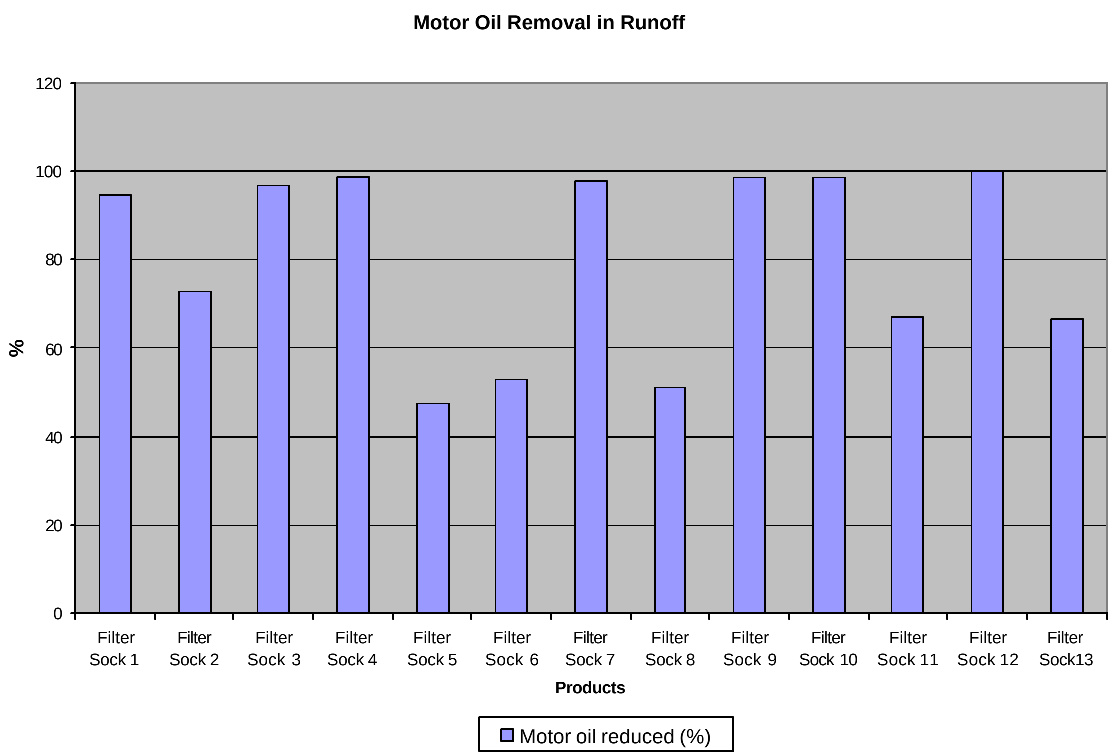


**Figure 5:** Percentage of motor oil removal from runoff by filter media.



**Correlations**

Preliminary correlation analysis among the thirteen treatments was conducted to predict statistical relationships ($r > 0.70$, alpha $< 0.05$) between the physical characteristics of the compost products and the removal of specific pollutants from storm water runoff and the flow through rate of the compost filter sock (Table 1). For selected variables r values near 0.70 are reported. While more samples will generate more accurate trends, preliminary results suggest that high water content of compost may increase motor oil removal and reduce flow rate through the compost sock. Additionally, a low bulk density may remove phosphorus and salts better than compost with a high bulk density.

Particle size distribution appeared to have a strong relationship with flow through rate and pollutant removal. Compost products with a high percentage of large particles often had high flow through rates but low solids and motor oil removal rates. Additionally, as the percentage of small particle sizes increases motor oil removal increases and flow rate decreases. A high percentage of fine particles may have a reduced ability to filter (or possibly lead to greater loss of) salts and reactive phosphorus but may reduce turbidity in runoff. Although not well correlated, compost products with high water contents tended to remove more solids from runoff and particle sizes between 5/8 inch and 1.0 inch had little effect on flow rate and solids removal.

**Table 1:** Results from preliminary correlation analysis.

| Independent Variable (compost product) | Response Variable (r value) |
|---|---|
| Water Content | Motor oil % reduced (0.74), Flow rate (-0.73) |
| Bulk Density | Total Reactive P mg reduced (-0.76), EC um reduced (-0.79), EC % reduced (-0.88) |
| Particle Size(%) >25mm/>1.0in | TS g reduced (-0.94), TS % reduced (-0.94) |
| Particle Size(%)16-25mm/0.63-1.0in | Flow rate (0.75), Motor oil % reduced (-0.79), TS g reduced (-0.66), TS % reduced (-0.66), TSS g reduced (-0.67), TSS % reduced (-0.70) |
| Particle Size(%) 9.5-16.0mm/0.37-0.63in | No variable was highly correlated |
| Particle Size(%) 6.3-9.5mm/0.25-0.37in | No variable was highly correlated |
| Particle Size(%) 4-6.3mm/0.16-0.25in | Motor oil % reduced (0.62), total solids g reduced (0.66), total solids % reduced (0.66), Flow rate (-0.61) |
| Particle Size(%) 2-4mm/0.079-0.16in | Motor oil % reduced (0.66), Flow rate (-0.64) |
| Particle Size(%) <2mm/<0.079in | Motor oil % reduced (0.78), EC um reduced (-0.73), EC % reduced (-0.77), Flow rate (-0.76), Total Reactive P mg reduced (-0.70), Turbidity NTUs reduced (0.60) |

**r > 0.70, alpha < 0.05, n = 13.**

## Field Application and Empirical Observations

Results from lab tests do not always predict what happens in the field. For example, flow rates of 10 gallons per minute are commonly reported for geotextiles (such as silt fence) in a lab testing. However, in the field, due to environmental conditions typical in construction activities, these flow through rates are rarely achieved. Consequently, installation designs for geotextiles must include increased heights to allow for higher volumes of ponded water.

Ponding and flow through rates are important design considerations when utilizing compost filter tools used for replacement of best management practices (BMPs) like geotextiles. In fact, when using a three dimensional storm water management tool like FilterSoxx, it is important to note they do not appear to clog with sediment as quickly as single dimensional tools like geotextiles. As such, subsequent rain events generating runoff are less likely to cause 'overtopping' or other failures because of the three dimensional nature of the FilterSoxx compost technology.

FilterSoxx used for perimeter control of sediment and storm water in construction activities drain runoff faster than sediment fence or geotextiles. In wet seasons and/or climates this may allow more work days per project per year due to quicker drying conditions relative to current industry standard practices.

In storm water pollution prevention plan (SWPPP) designs for construction activities, the height of the BMP is a key concern. If a geotextile or silt fence is 24 in., a FilterSoxx or filter berm must meet the same design. In reality, this is only necessary if documented flow through rates are similar. For many applications, compost tools may actually be designed shorter in height because of higher flow through rates and reduced likelihood of clogging. Increased storm water flow through rate (or the ability to handle greater volumes of storm water) coupled with equal to or better sediment removal rates make compost based BMPs a very attractive choice for SWPPP designers.

The number one reason for BMP failure in the field is poor installation. To prevent this, Filtrexx products are installed by a national network of Certified Installers utilizing Certified Filter Media. Predictably, failure rates in the field are less than other brand name products installed by generic installers. In addition, product specifications and design installation allow for less standing water and therefore less of a propensity that a gathering geometric force would cause failure, unlike silt fencing. In fact, most field professionals agree that the three dimensional design of compost filter tools is superior to single dimensional geotextile filtration devices.

**Conclusions and Future Directions**

Although results found in this preliminary study are encouraging, many questions still need to be answered. There are a number of feedstocks available for composting not yet analyzed, and we are still in the process of narrowing the best performers. Based on the performance compost products have demonstrated together with the frequent fines levied on construction activities utilizing standard BMPs, it seems that minimally, compost may offer less risk to contractors when applied and installed correctly. Risk is the leading element of concern for design professionals and property managers.

Price is also a leading concern, and on projects where enforcement and fines are less prevalent, price is likely the number one concern. As such, if compost products are not available locally, freight for import can quickly become a factor. However, in a marketplace of over 100 major U.S. cities, and supply naturally located near demand, our company has not found that our compost products are more expensive than the competition. This includes the total or 'true' cost of installation, maintenance, removal and disposal.

Since most states continue to compost very little of their organic waste/resources, it is obvious the erosion control and storm water management market can be a driving force for state and federal diversion strategies. Once the ecological benefit is factored into the 'true' cost of using BMP's for stormwater and erosion control, the least 'expensive' and 'best management practice' would surely be compost.

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