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TechLink Research Summary #3301

LEED® Green Building Credits Using Filtrexx® Organic BMPs

The Leadership in Energy and Environmental Design (LEED) program created and administered by the US Green Building Council (USGBC) is a point accrual and rating system that promotes and certifies environmentally sustainable building projects to create a national standard, through third party verification, in order to increase the value of green buildings in the marketplace. During the site and building design phase of construction a project team of developers, builders, architects, and consultants determine what level of LEED certification they plan to achieve by predicting how many LEED credits they plan to accrue based on material selection and design. Ultimately, the USGBC audits the finished project to determine what the project team was able to accomplish and how many LEED credits the project is awarded. In some cases, the higher the level of certification the greater the value in the market place. LEED Certified buildings generally are less expensive to operate and maintain and have been directly correlated to greater worker productivity, attendance, and well being. Increasingly, municipal and federal government agencies are requiring new construction projects for their agencies to be LEED Certified.

LEED Version 4 is the most current version of the green building and rating system, and **LEED Building Design and Construction for New Construction** is the most widely used program in which Filtrexx products and practices can be readily adopted and used to help a project team accrue credits toward LEED Certification.

Categories under the LEED BD+C rating program include the following; categories in bold are areas where Filtrexx products and practices may be used.

1. **Sustainable Sites**
2. **Water Efficiency**
3. Energy and Atmosphere
4. **Materials and Resources**
5. Indoor Environmental Quality
6. Innovation and Design Process

SUSTAINABLE SITES (SS)

This category is divided into 26 potential credits, although compost BMPs can contribute to a maximum of 8 credits.

Site Development - Protect or Restore Habitat (2 Credits): awards two credits for the preservation or restoration of site wildlife habitat. If the site has been previously developed the plan must restore native habitat to 30% of the site area. Compost products have been widely used for land and ecosystem restoration projects. Compost uniquely restores above and below ground biodiversity and habitat which is essential to plant community health and ecosystem function and sustainability.

Open Space (1 Credit): awards a credit for creating 30% of the site as outdoor space and 25% of this needs to be vegetated. Compost applications have been widely used for vegetation establishment and sustainability.

Rainwater Management (2-3 Credits): awards credits for implementing low impact development (LID) and green infrastructure practices to manage and treat runoff from 95% (2 credits) -98% (3 credits) of the average annual runoff event. For most of the US this is 1.0 to 1.5 inches. Compost has been used widely in LID and green infrastructure practices, including green roofs, bioretention, and bioswale applications.

Heat Island Reduction (2 Credits): awards two credits if the vegetated non-roof and roof area is equal or greater than the total paved and roof area. Compost has been used widely in both green roof and site landscape applications.

WATER EFFICIENCY (WE)

This category is divided into 10 potential credits, with a maximum of 8 credits in which compost products/practices may contribute.

Outdoor Water Use: Reduce 50-100% (1-2 Credits): awards credits for reducing irrigation from potable water supplies by 50% (1 credit) to 100% (2 credits). 100% reduction in irrigation is not required until after a 2 year establishment phase. Compost has a high water holding capacity and has been shown to reduce irrigation requirements with a variety of plant materials and crops.

Indoor Water Use: Reduce 25-50% (1-6 Credits): awards credits for reducing potable water use in building toilet systems or by reduction of wastewater discharge through on-site treatment. Compost has been widely used as a substrate combined with plant materials in water biofiltration systems and constructed wetlands used to treat wastewater, increase infiltration, adsorb/bind pollutants, and recharge aquifers and ground water systems. Composting toilet systems have also been utilized to reduce potable water use to attain this credit. This section awards a credit for each 5% increase in water use reduction starting at 25%, up to 50%.

MATERIALS AND RESOURCES (MR)

This category is divided into 14 sub-categories, with a maximum of 6 possible credits using compost products.

Building Product Disclosure/Optimization - environmental product declarations (1 Credit): awards a credit if products are documented to provide environmental benefits, including: reduce green house gas emissions, reduce nutrients in water bodies, and conserve non-renewable energy. Compost has been widely documented to reduce carbon footprint through methane avoidance and carbon sequestration; reduce nutrients through runoff reduction and biofiltration; and reduce energy use through transport reduction due to local availability and non-virgin materials use due to recycled content attributes. Note: >25% of the total value of permanent building materials must meet this requirement in order for credit award. Product extracted/manufactured/sold 100 miles from building site awarded 200% value.

Building Product Disclosure/Optimization - sourcing of raw materials (1-2 Credits): awards credits for: A. Environmentally Responsible Material/Extraction/Manufacturing/Land Use Reporting (1 credit); B. Leadership Extraction Practice: Bio-Based or Recycled Content (1 credit). Compost is typically made of organic (bio-based) materials, manufactured (recycled), and used (land applied) all within a 100 mile radius. Note: >25% of the total value of permanent building materials must meet this requirement in order for credit award. Product extracted/manufactured/sold 100 miles from building site awarded 200% value.

Building Product Disclosure/Optimization - material ingredients (1 Credit): awards a credit if 99% of material/product ingredients (by weight) can be certified to cause no health/safety issues through entire supply chain. Compost is typically made of all natural, organic materials that pose no health and safety threat throughout the supply chain from cradle to end use. Note: >25% of the total value of permanent building materials must meet this requirement in order for credit award. Product extracted/manufactured/sold 100 miles from building site awarded 200% value.

Construction & Demolition Waste Management (1-2 Credits): awards credits for diversion of construction and demolition (C&D) waste from landfills. Diverting 50% of C&D waste with 3 source separated waste streams (1 credit), or 75% of C&D waste with 4 source separated waste streams (2 credits). Some of these materials may be composted on-site or diverted to commercial composting operations.

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*Information provided that is specific to Filtrexx products/compost has not been reviewed by the USGBC and will need to be evaluated by a LEED Accredited Professional™ on a per project basis.

For more information on LEED® and how Filtrexx BMPs may be used in attaining additional credits contact: Britt Faucette, Ph.D., CPESC, Research Director/Ecologist, Filtrexx International, ph: 404-687-8393, email: brittf@filtrexx.com

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TechLink Research Summary #3302

A Comparison of Performance & Test Methods of Filtrexx® SiltSoxx™ Sediment Control vs. Silt Fence

Due to recent NPDES Phase II enforcement, evaluating the effectiveness and performance level of sediment control devices has never been more important. As states' begin to revise their erosion and sediment control manuals to reflect new information on best management practices, many are requiring that erosion and sediment control practices meet a minimum performance standard. Slope protection practices (single net straw blanket, compost erosion control blanket) normally use Cover (C) Factors (from the RUSLE) to compare and evaluate the effectiveness between these practices and products. Channel protection practices (turf reinforcement mat, rip rap, Filtrexx® Channel Protection, Bank Stabilization) normally use shear stress values to compare and evaluate the effectiveness between these practices and products. Although there is no standard test method to compare and evaluate between sediment control devices (silt fence, straw bale, straw wattle, Filtrexx® Sediment Control), generally the accepted analysis is sediment removal efficiency.

In a study evaluating the sediment trapping efficiency of silt fence, Wishowski et al, observed that as sediment particle sizes decrease, trapping efficiency declines, meaning clay and silt sediment is less effectively trapped using silt fence (1998). Barrett et al (1998) adds that most studies reporting sediment removal efficiencies for silt fence are overstated since many have used a disproportionately large fraction of sand particles with relatively low sediment-laden concentrations of stormwater runoff. Sand settles easily during ponding, therefore increasing removal efficiency. They observed 92% of the total suspended solids were clay and silt and were an order of magnitude smaller than the openings in the silt fence fabric due to very low settling velocities are normally not removed by sedimentation (Barrett et al, 1998). Barrett et al (1995) concluded that effective sediment trapping efficiency of silt fence is a result of increased ponding behind the silt fence, while a similar study by Kouwen (1990) concluded that excessive ponding is largely due to eroded sediment clogging the fabric of the silt fence. Barret et al (1998) further concluded that sediment removal efficiency by silt fence was not attributable to the filtration by the fabric but due to duration of runoff detention behind the silt fence. Some suspended solids are never removed by silt fence

Many environmental parameters can influence sediment removal efficiency (assuming prpoer installation), including: slope degree; flow rate of runoff (or rainfall intensity); sediment concentration of runoff; percent of gravel, sand, silt, clay in runoff; and duration of runoff (or rainfall) event. For example, a test method that uses a slow flow rate, on a 5% slope, with a low concentration of sediment in the runoff, where the sediment is predominantly sand, with a runoff duration of 10 minutes is probably going to produce results that make the sediment control device appear to function extremely well, by exhibiting a high sediment removal efficiency. Below is a summation of selected test methods used in performance evaluation of selected sediment control devices.

TEST METHODS

ASTM D-5141 - *Standard Test Method for Determining Filtering Efficiency and Flow Rate of a Geotextile for Silt Fence Application Using Site Specific Soil (2004).* This test method uses a 12:1 slope (8%) , a 12 in silt fence, runoff sediment concentration of 2890 mg/l of site specific soil (many tests have been conducted using predominantly sand, i.e. large sediment particles), using 50 liters of runoff, in plots 48 in long by 34 in wide, silt fence is pre-wet using 50 L of clean water.

Soil Control Lab - *Standard Test Method for Sediment and Chemical Removal of FilterMedia™ Used in Filtrexx FilterSoxx™.* This test method and results from this test method have been reviewed and published in the 2006 International Erosion Control Association (IECA) Annual Proceedings, Long Beach, CA. This test method uses a 3:1 slope, an 8 in Filtrexx® Sediment Control, runoff sediment concentration of 3000 mg/l of 33% sand and 67% silt, using 50 liters of runoff, in plots 4 ft long by 12 in wide, Filtrexx® Sediment Control is pre-wet using 50 L of clean water (Faucette & Tyler, 2006).

USDA ARS Environmental Quality Lab - *Evaluation of Compost Filter Socks in Sediment and Nutrient Reduction from Runoff.* This test method and results from this test method have been submitted for presentation and publication in the 2006 American Society of Agricultural Engineers (ASAE) Annual International Meeting, Portland, OR. This test method uses a 10:1, an 8 in Filtrexx® Sediment Control & 24 in silt fence, simulated rainfall (3 in/hr for 30 min) which produces a runoff sediment concentration of 100,000 mg/l of silt loam, in plots 44 in long by 14 in wide, compacted soil is pre-wet prior to rainfall (Sadeghi et al, 2006).

University of Georgia Institute of Ecology - *Evaluation of Storm Water from Compost and Conventional Erosion Control Practices in Construction Activities.* This test method and results from this test method followed methods developed by the USDA National Soil Erosion Research Lab Water Erosion Prediction Project (WEPP) and have been reviewed and published by the University of Georgia Graduate School and the Journal of Soil and Water Conservation (Faucette et al, 2005). This test method uses a 10:1 slope, 12 in high by 24 in wide compost filter berm & 36 in silt fence, simulated rainfall (3.2 in/hr for 60 min) which produced an avgerage runoff sediment load of 32,000 g, in plots 3 ft wide by 16 ft long, on a compacted sandy clay loam subsoil.

Table 1: Sediment Removal Efficiencies for Various Sediment Control Devices.

Sediment Control Device	**Sediment Removal/Reduction Efficiency**	**Reference**
Silt Fence	3% turbidity	Horner, 1990
Silt Fence	0% turbidity	Barrett et al, 1998
Silt Fence	0-20% clay	US EPA, 1993
Silt Fence	50% silt	US EPA, 1993
Silt Fence	80+ % sand	US EPA, 1993
Filtrexx® Sediment Control	98% total solids	Faucette & Tyler, 2006
Filtrexx® Sediment Control	70% suspended solids	Faucette & Tyler, 2006
Filtrexx® Sediment Control	55% turbidity	Faucette & Tyler, 2006
Silt Fence	67% suspended solids	Sadeghi et al, 2006
Silt Fence	52% turbidity	Sadeghi et al, 2006
Filtrexx® Sediment Control	90% total solids	Sadeghi et al, 2006
Filtrexx® Sediment Control	78% suspended solids	Sadeghi et al, 2006
Filtrexx® Sediment Control	63% turbidity	Sadeghi et al, 2006
Filtrexx® FilterMediatm w/ Flocullent Agent	97% suspended solids	Sadeghi et al, 2006
Filtrexx® FilterMediatm w/ Flocullent Agent	94% turbidity	Sadeghi et al, 2006
Filtrexx® FilterMediatm w/Silt Stop	97% suspended solids	Sadeghi et al, 2006
Filtrexx® FilterMediatm w/Silt Stop	98% turbidity	Sadeghi et al, 2006
Filter Berm vs Silt Fence	65% less total solids	Faucette et al, 2005
Filter Berm vs Silt Fence	91% less total solids	Demars & Long, 2000
Filter Berm vs Straw Bale	92% less total solids	Demars & Long, 2000
Filter Berm vs Silt Fence	72% less total solids	Ettlin & Stewart, 1993
Filter Berm vs Silt Fence	91% less suspended solids	Ettlin & Steart, 1993

TechLink Research Summary #3303

C Factors for Compost and Rolled Erosion Control Blankets

The C Factor or Cover Factor is one of 6 factors used in the Universal Soil Loss Equation (USLE), the Revised Universal Soil Loss Equation (RUSLE) or the latest version, RUSLE2. The C Factor indicates how an erosion control practice, erosion control product, or conservation plan will affect average annual soil loss. The Universal Soil Loss Equation was originally developed in 1965 by the USDA to help predict or estimate water soil erosion using site, soil, rainfall, and management factors. The RUSLE (currently the most widely used of the three) and RUSLE2 have revised the USLE to include water soil erosion from sites beyond agriculture, including construction activities. All equations use the same factors (it is the sub-factors and supporting database that have been revised) to predict soil loss:

$A = r\,k\,l\,s\,c\,p$

Where A equals predicted soil loss (mass/area) of interill (sheet flow) and rill (small gullies where interill deposits flow) erosion from detachment (rainfall impact) and transport (runoff flow) on hill slopes up to the point of a concentrated flow area (channels); r is the erosivity factor for a given region (range = 8 to 700), which is based on historic rainfall rate/intensity averages; k is the soil erodibility factor, which is based on soil characteristics including texture, structure, organic matter content, permeability, and runoff potential; l is the length of the slope; s is the steepness of the slope; c is the cover management factor; and p is the support practice factor, which is attributable to practices that slow runoff such as terraces and slope interruption devices or cause sediment deposition such as silt fence or FilterSoxxtm. Currently, product manufacturers have not tried to determine P Factors for their products for use with the RUSLE, however, this is not the case for C Factors.

The C Factor in the USLE only allowed for types of agricultural management practices (such as cover cropping), in RUSLE one can input a specific C Factor for a particular erosion control tool or product, such as hydraulic mulch or a single net straw mat (usually determined through product testing and reported by the manufacturer not the USDA or RUSLE modelers). In RUSLE2 one can no longer input a specific C Factor but is required to input characteristics (sub-factors for determining the C Factor) of the erosion control practice, tool, or product. This creates less potential bias from manufacturer testing and reporting, particularly since there is no standard test method for determining C Factors for erosion control products. RUSLE2 sub-factor inputs used to determine C Factors are: percent canopy coverage of soil, percent contact with soil surface, surface roughness, amount of cover applied (tons/ac) - which is used to determine thickness of blanket, decomposition rate of materials (how long will it last), and historic soil disturbance/tillage.

Although determining C Factors can be complicated, the erosion control industry (not USDA or RUSLE modelers) has greatly simplified the process to quickly and inexpensively evaluate their erosion control products so equation users (designers, engineers, architects) can readily and easily insert specific product C Factors into RUSLE. To do this, product manufacturers (and/or their third party testing labs) only determine the soil loss ratio of the specific erosion control product relative to a bare soil under the same test conditions. Therefore, the soil loss ratio is the total amount or mass of soil lost to water erosion from the erosion control product test plot area relative to a bare soil under the same soil type, rainfall, and slope conditions. The inverted soil loss ratio is the percent soil loss from the erosion control product relative to the bare soil (example: a straw blanket reduces soil loss by 80%, its soil loss ratio is 0.20, or reported as C Factor by most erosion control blanket manufacturers).

The Erosion Control Technology Council (ECTC) has approved this simplified method for determining and reporting C Factors. It includes a standard test slope of 3:1 (h:v), minimum test plot size of 8 ft w by 40 ft long, on six inches of compacted soil (testing sand, silt, and clay soils separately), with a designed storm of 2 in/hr for 20 min, 4 in/hr for 20 min, and 6 in/hr for 20 min for a total of 60 minutes or until catastrophic failure occurs (ECTC, 2003). In addition to the characteristics of the erosion control blanket that is being tested, a C Factor (or soil loss ratio) can be greatly influenced by: slope degree, slope length, rainfall intensity, duration of storm, soil texture, and soil organic content.

Product/Practice (reference)	C Factor	Influencing Factors
Hydraulic mulch + synthetic or fiber netting (ECTC, 2004)*	<0.10	5:1 slope; ECTC test method
Netless rolled erosion control blanket (bound by polymers or chemical adhesion) (ECTC, 2004)*	<0.10	4:1 slope; ECTC test method
Single net erosion control blanket (natural materials woven/mechanically bound) (ECTC, 2004)*	<0.15	3:1 slope; ECTC test method
Double net erosion control blanket (natural materials woven/mechanical bound between 2 layers) (ECTC, 2004)*	<0.20	2:1 slope; ECTC test method
Erosion control blanket/open weave textile (slow degrading, continuous weave double net ECB) (ECTC, 2004)*	<0.25	1.5:1 slope; ECTC test method
Turf reinforcement mat (permanent/nondegradable, 3- dimensional thickness, used in concentrated flows) (ECTC, 2004)*	None (usually tested for shear stress)	0.5:1 slope; ECTC test method
Straw blanket (Demars & Long, 1998) *	0.08	2:1 slope; natural rainfall (max. 1.6/24 hr); 10 ft x 35 ft test plot; on silty sand;
Straw blanket w/pam (Faucette, unpub)*	0.19	10:1 slope; 4 in/hr 1hr rainfall; 3 ft x 16 ft test plot; clay subsoil; 2 in blanket
Mulch blanket (Demars & Long, 1998)*	0.075	2:1 slope; natural rainfall (max. 1.6/24 hr); 10 ft x 35 ft test plot; on silty sand; 3 in blanket
Mulch Fines (Faucette et al, 2004)*	0.16	10:1 slope; 3.2 in/hr 1 hr rainfall; 3 ft x 3 ft test plot; clay subsoil; 1.5 in blanket
Mulch Overs (Faucette et al, 2004)*	0.11	10:1 slope; 3.2 in/hr 1 hr rainfall; 3 ft x 3 ft test plot; clay subsoil; 1.5 in blanket
Wood chips @ 7 tons/ac (GA SWCC, 2000)*	0.08	
Wood chips @ 12 tons/ac (GA SWCC, 2000)*	0.05	
Wood chips @ 25 tons/ac (GA SWCC, 2000)*	0.02	
Compost blanket (Demars, 1998)*	0.05	2:1 slope; natural rainfall (max. 1.6/24 hr); 10 ft x 35 ft test plot; on silt sand; 3 in blanket
Compost Blanket (Demars et al, 2000)*	0.02	2:1 slope; natural rainfall, 10 ft x 35 ft test plot; on silty sand; 3 in blanket
Compost Blanket (Faucette et al, 2005)*	0.01	10:1 slope; 3.2 in/hr 1 hr rainfall; 3 ft x 16 ft test plot; clay subsoil; 1.5 in blanket
Compost Overs (Faucette, unpub)*	0.01	10:1 slope; 4 in/hr 1hr rainfall; 3 ft x 16 ft test plot; clay subsoil; 1.5 in blanket
Compost Fines (Faucette, unpub)*	0.065	10:1 slope; 4 in/hr 1hr rainfall; 3 ft x 16 ft test plot; clay subsoil; 1.5 in blanket
Compost Fines w/ biopolymer (Faucette, unpub)*	0.03	10:1 slope; 4 in/hr 1hr rainfall; 3 ft x 16 ft test plot; clay subsoil; 1.5 in blanket
Forest duff layer (GA SWCC, 2000)*	0.001-0.0001	

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TechLink Research Summary #3304

Flow Through Rate, Design Height, and Design Capacity of SiltSoxx™ and Silt Fence

Silt fence performance for sediment control in construction activities has been widely evaluated (Wyant, 1981; Fisher and Jarret, 1984; USEPA, 1993; Barrett et al, 1998; Britton et al, 2000). Geosynthetic silt fences, when installed correctly, function as temporary runoff detention storage areas (Robichaud et al, 2001), designed to increase ponding depth (Goldman et al, 1986) to allow suspended particulates to settle out of storm runoff before discharging the runoff down slope of the sediment barrier. Barrett et al (1995) concluded that effective sediment trapping efficiency of silt fence is a result of increased ponding behind the silt fence, while a study by Kouwen (1990) concluded that excessive ponding is largely due to eroded sediment clogging the fabric of the silt fence. Barret et al (1998) further concluded that sediment removal efficiency by silt fence was not attributable to the filtration by the fabric but due to length of runoff detention time behind the silt fence.

While this design may function well under relatively small runoff events, if ponding becomes excessive the silt fence may fail due to overtopping. In response, the design height of silt fence has steadily increased from 18 (46 cm) to 24 (61 cm) to 36 inches (91 cm) over recent years. However, the force created by the increase in head and the prolonged detention of storm runoff, may predispose silt fence to failure in field applications. Wyant (1981) and the USEPA (2005) recommend that silt fence have a minimum sediment-laden flow rate of 0.3 gal/ft2/min (12.5 L/m2/min). Sedimentladen runoff concentrations appropriate for testing silt fence according to ASTM D 5141 are approximately 2900 mg L-1 (2900 ppm) (Barrett et al, 1995).

Filtrexx Soxx™ (SiltSoxx™, InletSoxx™, DitchChexx™) are three dimensional filters and are designed to allow water to flow through at higher rates than silt fence. The larger, three dimensional construction of these sediment filters allow the filter itself to trap suspended solids from runoff reducing the need to pond water to allow settling to occur. Less ponding and lower head pressure will reduce the propensity for failure from blowout and over topping in the field. Additionally, if sediment removal efficiency is a result of the performance of the filter, instead of its ability to pond water, then the design height and capacity for these new sediment control devices should be based on flow through rate not ponding rate.

Research Results

Research conducted by the University of Georgia and published in the Journal of Soil and Water Conservation (Faucette et al, 2005) showed that under simulated rainfall, runoff flow rates (prior to vegetation) from compost filter berms were 21% greater than silt fence, and total sediment loads were 35% less, on a 10% slope of compacted sandy clay loam in 48 ft2 field plots. Research conducted at the USDA ARS Environmental Quality Lab in Beltsville, MD and submitted for presentation and publication in the 2006 American Society of Agricultural Engineers Annual International Conference in Portland, OR (Sadeghi et al, 2006) found that flow through rates of 8 in Filtrexx Filter Soxx were on average 50% greater than 24 in silt fence, on a 10% slope of compacted sandy loam soil under a simulated rainfall of 3 in/hr for 30 min duration. Research conducted by the Ohio State University Department of Food, Agricultural and Biological Engineering Department and accepted for presentation and publication in the 2006 American Society of Agricultural Engineers Annual International Conference in Portland, OR (Keener et al, 2006) found the following results. On a 10% slope, using a sediment- laden runoff concentration of 10,000 mg/l of silt and clay (no sand) for 30 minutes, average flow rates were 50% greater for SiltSoxx relative to silt fence, and ponding height was 75% greater behind a 24 in silt fence vs 12 in SiltSoxx. At flow rates less than 5 gpm/linear ft an 8 in SiltSoxx had the same design capacity (failure due to overtopping) as a 24" silt fence, a 12 in SiltSoxx had a greater design capacity (failure due to overtopping) than 36 in silt fence. At flow rates greater than 5 gpm/linear ft a 12 in SiltSoxx had an equal design capacity as a 36 in silt fence, and an 18 in SiltSoxx had a greater design capacity than 36 in silt fence. Results from this research have been used by Ohio State University to create a comparative and interactive, MS Excel based, design capacity prediction model for sediment control using silt fence and Filtrexx SiltSoxx.

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TechLink Research Summary #3305

Determining Runoff Curve Numbers for Filtrexx® Slope Protection

Runoff curve numbers are often used in design applications to predict or estimate potential storm water runoff flow from a designated post construction area or watershed. A runoff curve number (CN) is the number assigned, between 1 and 100, to the runoff potential of a hydrologic soil-cover complex (Soil Conservation Service USDA, 1972). A hydrologic soil cover complex (and its assigned CN) is determined by the hydrologic soil group (A, B, C, or D), the land use (fallow, row crop, pasture, forest, etc), land treatment class (straight row, contour, terrace), the hydrologic condition of the soil (poor, fair, good), and the soil moisture content. The hydrologic condition of the soil is a subjective measure and the hydrologic soil group has been predetermined for every soil classification in the US (where A represents a low runoff potential soil and D represents a high runoff potential soil). For example, an impervious surface, like pavement, is 99, a wooded area with sandy soil is 46, and a surface that produces no runoff under any circumstance is 1. Today runoff curve numbers are usually estimated based on published book values and databases. Curve numbers for Filtrexx® Slope protection can be estimated with sufficient site and soil information based on these published book values. When determining runoff curve numbers, Filtrexx® Slope Protection can have a significant effect on storm water runoff potential and should be considered in the assignment of the correct CN. Additionally, if a low CN is the desired characteristic, particularly in Low Impact Development (LID) or Leadership in Energy and Environmental Design (LEED) projects, sensitive watershed environments, sediment and/or stormwater management pond catchment basins, or where storm water utilities are levied, inclusion of Filtrexx® Storm Water Blanket should be seriously considered.

Rationale

Filtrexx® Slope protection has been shown to significantly reduce storm water runoff, so much that they may be considered a runoff reduction tool as much as an erosion control tool. The humus fraction of compost (15-35% of the carbon originally used to make the compost or 60-80% of the stable organic matter content of the finished compost) is known to hold up to 5 times its weight in water (Brady and Weil, 1996).

Research at the University of Georgia (Faucette et al, 2005) and at Iowa State University (Persyn et al, 2004) have shown that Filtrexx® Slope protection used on hill slopes can significantly reduce runoff volumes during rain events.

Research at the University of Georgia showed that a 1.5 in thick Slope protection on a 10:1 slope, under a simulated rainfall of 3.1 in/hr for 60 min (50 yr return), could delay runoff commencement by up to one hour relative to bare soil conditions and by 45 minutes relative to a hydroseeded treated soil on a cecil sandy clay loam (hydrologic class B). Filtrexx® Slope protection reduced cumulative stormwater runoff over 1 year by 65% relative to a bare soil and 50% relative to a hydroseeded soil, and reduced stormwater volume during a single large storm event by as much as 96%. Similarly, Filtrexx® Slope protection reduced peak runoff rates by an average of 36% (and as much 67%) relative to bare soil and 27% relative to hydroseeded soil, over 1 yr duration. In a follow up study at the same site, under 2 simulated rainfall events of 4 in/hr for 60 min (100 yr return), Slope protection reduced total runoff by an average of 60% and retained an average of 80% of the total runoff applied.

Research from Iowa State University reported that a 2 in compost blanket on a 3:1 slope, under simulated rainfall of 4 in/hr for 60 min (100+ yr return), could delay runoff commencement by 50 min relative to a 6 in topsoil blanket or disk-tilled soil. Filtrexx® Slope protection reduced runoff rate by 79% relative a bare disked-tilled soil and 71% relative to a 6 in topsoil blanket (Persyn, 2004).

Research performed by the University of Texas-Austin, for the Federal Highway Administration and the US DOT, found that erosion control compost blankets 3 in thick on a clay soil and a 3:1 slope could reduce peak runoff rates 10 fold under a simulated rainfall of 3.45 in/hr for 3 hr duration (5 yr return) (Kirchhoff et al, 2003).

Research conducted at Texas A&M, for the TX Commission of Environmental Quality, using 2 inch compost blankets on a 3:1 slope of clayey soil, under a simulated rainfall of of 3.6 in/hr for 60 min (25 yr return), found that prior to vegetation establishment the compost blankets reduced runoff by 35% (and as much as 67%) relative to soils receiving commercial fertilizer, prior to vegetation establishment (Mukhtar et al, 2004).

In similar studies, Agassi et al (1998) found that compost mulches percolated twice as much water as a bare soil under rainfall simulation; Meyer et al (2001) found that incorporating compost at 40 Mg ha-1 to gravely clay loam and gravely sandy loam soils on 10 to 16% slopes can reduce runoff by 77% under a simulated rainfall of 4 in/hr for 30 minutes (100+ yr return), while the percent of runoff from rainfall was reduced from an average of 36% to 6%.

Runoff Curve Number for Slope Protection

Runoff curve numbers can be determined if rainfall and runoff volumes are known (Georgia Storm Water Management Manual, 2001). Using results from Faucette et al (2005) where three storms produced 10 inches of rainfall, and compost blankets (from yard debris) generated 2.6 in of runoff; and Pitts (1994) equation for determining runoff curve numbers when rainfall and runoff volumes known, where:

$$CN = 1000/[10 + 5(P) +10(Q) - 10(Q2 + 1.25QP)1/2]$$

CN = runoff curve number
P = rainfall volume (in.)
Q = runoff volume (in.)

$CN = 43$

NOTE: this CN is representative of the site and soil conditions at the research site. Runoff CNs assigned to soils that are predominantly sand, silt, not severely compacted, or belong to hydrologic soil group A will have a significantly lower CN. For accurate curve numbers that reflect your site and soil conditions, please consult the SCS National Engineering Handbook for Hydrology, a similar reference, or Dr. Britt Faucette at Filtrexx.

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TechLink Research Summary #3306

Filtrexx®, Compost, Low Impact Development, and Design Considerations for Storm Water Management

What is LID?

Low Impact Development (LID) is a comprehensive land planning and engineering design approach with the goal of maintaining and enhancing the pre-development hydrologic regime of post-development, urban and developing watersheds. LID is a storm water management design approach that seeks to provide on-site management using a variety of distributed landscape features and engineering devices that, 1) reduce stormwater runoff, 2) slow down runoff, 3) enhance infiltration, 4) filter runoff pollutants, and 5) capture stormwater. LID uses a hybrid of engineering - technical design to meet specific runoff management targets (peak flow, volume, water quality), and architectural - functional design for aesthetics and increased value and design principles (LID Center Inc, 2005).

Low Impact Development recognizes that impervious surfaces in a watershed or site relative to natural systems, 1) generate runoff more quickly, 2) generate greater runoff volume, and 3) carry more pollutants in runoff to receiving water bodies. For example, in a natural watershed, average runoff is 10% of the total precipitation volume; with 10-20% impervious surface area it increases to 20%; 35-50% impervious surface area increases to 30% runoff; 75% + impervious surface increases to 55% runoff (Tourbier and Westmacott, 1981). Watersheds with greater than 10% impervious surface area have been directly correlated to impaired stream water quality, and watersheds with greater than 25% impervious surface have been correlated to long term stream water quality impairment. As an example, an average single family home site in high density residential subdivision has a 25 to 60% impervious surface area.

Who uses LID?

LID can be used to address a wide range of wet weather flow issues, including Combined Sewer Overflows (CSOs), National Pollutant Discharge Elimination System (NPDES) Stormwater Phase II permits, Total Maximum Daily Load (TMDL) permits, Nonpoint Source Program goals, and other Water Quality Standards (LID Center Inc, 2005). Local permitting agencies can use LID as a model in revising local zoning and subdivision regulations in favor of more cost-effective, ecologically sound development practices. Developers can achieve greater project success and cost savings through the intelligent use of LID, and designers can apply these techniques for innovative, educational, and more aesthetically pleasing sites (LID Center Inc, 2005).

LID Design Objectives

By focusing on prevention and reduction of storm water runoff rather than control and treatment, LID manages runoff at the source, as it is being generated and before it reaches large concentrated flows. The hydrological goal of LID design is to mimic natural systems to achieve natural (or predevelopment) levels of: landscape surface water storage, infiltration, filtration, runoff velocity, interception, evapotransporation, and thermal control. Principle LID design objectives include - storm water quantity management under all conditions (volume, peak runoff rate, frequency, duration); water quality control under all conditions (pollution prevention); aesthetics; safety; and low cost (design, construction, maintenance). To achieve these objectives, the key LID design strategies are to - minimize land disturbance, maximize roughness along water flow paths (Manning's n value) to maintain or reduce flow velocity, maximize infiltration rate, maximize retention, disperse runoff flow - maintain sheet flow/discourage concentrated flows, filter water above and below ground, minimize slope angles, disconnect impervious surfaces, and connect pervious and natural surfaces.

LID Integrated Management Practices

LID Integrated Manangement Practices (IMPs) are designed to reduce the hydrograph, or maintain predevelopment and/or natural hydrograph conditions, and to reduce pollutant loads in storm water. LID Integrated Management Practices include bioretention cells, rain gardens, vegetated filter strips, filtration cells, bioretention swales, grassed swales, dry wells, level spreaders, infiltration trenches, engineered soils, soil amendments, green roofs, permeable pavement, rain barrels, and cisterns. Specifications are written using AASHTO and or ASTM criteria wherever possible. Standards, specifications, and design drawings for bioretention cells, bioretention swales, permeable pavement blocks, and soil amendments can be found at www.lowimpactdevelopment.org/resources.htm. An interactive, web-based LID IMP design tool can be accessed at www.lid-stormwater.net/intro/background.htm. Other design resources include *Low Impact Development Design Strategies - An Integrated Design Approach* at www.epa.gov and the USEPA LID Homepage at www.epa.gov/nps/lid.

Table 1: Site Characteristics and LID Design Strategies

	Minimize Disturbance	Maximize Roughness	Maximize Infiltration	Maximize Retention	Filter Runoff	Minimize Slopes
Runoff Peak Flow Rate	↓	↓	↓	↓		↓
Runoff Volume	↓	↓	↓	↓	↓	↓
Time of Concentration	↑	↑	↑	↑		↑
Infiltration Rate	↑	↑	↑	↑	↑	
Pollutant Loading	↓	↓	↓	↓	↓	

Recreated from Low Impact Development Design Strategies - An Integrated Design Approach (Prince George's County, MD, 1999)

HOW DOES FILTREXX AND COMPOST FIT INTO LID & STORM WATER DESIGN?

Design Tools, Prediction Models, Equations, Values, and Coefficients

USDA NRCS TR55/TR20, Rational Method, US Army Corp of Engineers HEC-1, USEPA Storm Water Management Model, and the US EPA Hydrologic Simulation Program - FORTRAN are storm water prediction models commonly used for land development and watersheds designed for various aspects of storm water discharge, water quantity and quality relationships, rainfall-runoff relationships, hydrologic-hydraulic characteristics, pollutant wash-off and transport, sediment yield, runoff flow rates, runoff volume, and potential affects on stream and river flows (Prince George's County, MD, 1999).

Hydrologic abstractions (initial), runoff coefficients, runoff curve numbers, peak runoff rates, runoff volumes, and unit hydrographs for compost blankets have been developed and can be used in selected storm water/runoff prediction models.

Ia = hydrologic abstraction (initial) - is the amount of precipitation absorbed by a landscape before initiation of runoff (influenced by antecedent soil moisture, vegetation density/cover, soil/surface roughness, soil type [organic content, bulk density, aggregation]). It is a storage volume capacity, and is correlated to infiltration rate, which consequently declines over the storm duration as the landscape reaches saturation. Runoff volume can also be correlated to abstraction, since the greater the initial abstraction the lower the runoff volume.

In a study conducted by the University of Georgia, initial abstractions for compost blankets, relative to bare soil, at the time of installation, on average were 51% greater and after one year were 65% greater (Faucette et al, 2005). Based on three 1 hr/50 yr (3.1 in/hr for 1 hr) storm events, initial abstractions averaged 2.5 in (78%) and were as high as 3.2 in (96%), and runoff commencement was delayed by an average of 20 min and as much as 1 hour. In a follow up study, using two designed 1 hr/100 yr return (4 in/hr for 1 hr) storms, compost blankets held an average of 80% of the 132 gallons of rainfall applied, increased the time to runoff initiation by a factor of 6, and reduced runoff volume (Vr) by 60%.

In a similar study, Iowa State University reported that a 2 in compost blanket on a 3:1 slope, under simulated rainfall of 1 hr/100 yr return (4 in/hr for 1 hr), delayed runoff commencement by 50 min relative to a 6 inch topsoil blanket and a disk-tilled soil (Persyn et al, 2004).

Research conducted at Texas A&M, for the TX Commission of Environmental Quality, using 2 in compost blankets on a 3:1 slope of clayey soil, under a simulated rainfall of 3.6 in/hr for 1 hr (25 yr return), found that prior to vegetation establishment the compost blankets reduced runoff volume by 35% relative to soils receiving commercial fertilizer, prior to vegetation establishment (Mukhtar et al, 2004).

Tc = time of concentration - is the time it takes for a raindrop to travel from its point of surface contact to a predetermined or designated outflow

Q = the peak runoff flow rate. A high Tc and a low Q are preferred, and generally lead to greater infiltration, lower erosivity, and lower sediment and pollutant loads.

In the same study conducted by the University of Georgia, over one year, peak runoff rates for soils treated with compost blankets were reduced by 36% relative to bare soil and 27% relative to hydroseeded soil. In the same follow up study compost blankets without vegetation reduced peak runoff rates by 34% and with vegetation by 51%.

In the same Iowa State University study compost erosion control blankets reduced runoff rate by 79% relative to bare disked-tilled soil and 71% relative to a 6 in topsoil blanket.

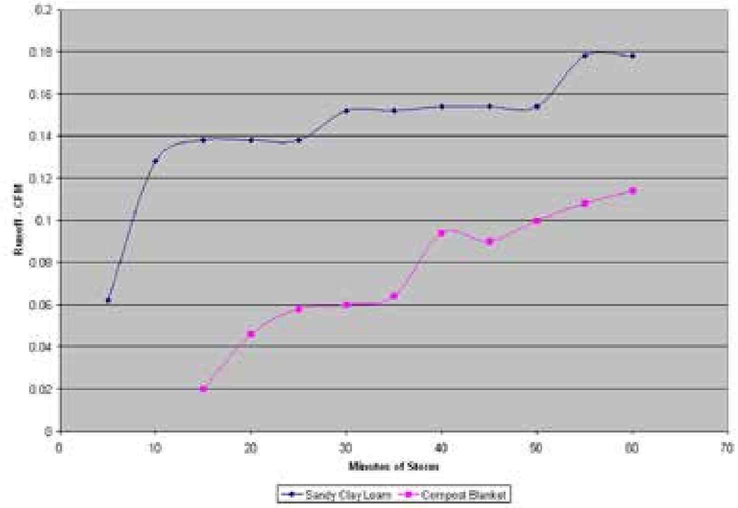
Research performed by the University of Texas-Austin, for the Federal Highway Administration and the US DOT, found that 3 in compost blankets applied to a clay soil on a 3:1 slope reduced peak runoff rates 10 fold under a 3.45 in/hr simulated rainstorm for a 3 hr duration (Kirchhoff et al, 2003).

CN = runoff curve number - is the number assigned to a watershed or surface area based on its tendency to shed water (1-99). Compost Blankets = 43. See Determining Runoff Curve Numbers for Compost Erosion Control Blankets.

C = runoff coefficient, in the Rational Formula (see below), is the ratio of runoff to rainfall. For example, C = 1, or 100% of the rainfall volume in a designated area or watershed becomes runoff. Impervious services (e.g. asphalt, concrete, roof) have a runoff coefficient of 0.95, undisturbed forests have a runoff coefficient of 0.15, lawns are 0.1 to 0.35 (depending on soil type and slope), pasture is 0.1 to 0.3, graded and unvegetated soil are 0.3 (sandy) to 0.6 (clay), gravel is 0.5, downtown areas are 0.95, neighborhoods are 0.7, single family homes are 0.5, and apartment areas have a C of 0.7 (Georgia Stormwater Management Manual, 2001). Compost blankets have a runoff coefficient of 0.05 to 0.35 (depending on soil type underneath).

Rational Formula
Where: Q = C x i x A

Q = peak runoff rate (cubic feet/sec)
C = runoff coefficient
i = rainfall intensity (in/hr)
A = area of watershed/drainage area (acres)



Unit Hydrographs

A hydrograph allows you to visually compare runoff rate of soil/vegetation complexes and/or management practices, over the duration (time) of a storm. Above is a single event hydrograph for a compost blanket and a sandy clay loam without vegetation. This is based on a constant 4 in/hr storm for a 1 hour duration (1 hr 50 yr return for this site), on a 10% slope. Generally, the slower the runoff rate and the longer the elapsed time to peak flow conditions, the more effective the storm water management practice.

LID Practices and their Benefits using Filtrexx and Compost

Runoff Filtration Practices - vegetated filter strips, bioretention ponds
Benefit: high pollutant removal efficiency (FilterSoxxTM - phosphorus, metals, suspended solids, turbidity, total solids); reduction in discharge volume of runoff to reduce pollutant loads to receiving waters (compost blankets, Filtrexx® Filtration system).

Soil Amendments (compost is listed) - used specifically to improve water retention and infiltration, increase soil aeration, reduce soil erodibility, reduce soil compaction, increase slope stabilization, and enhance vegetation establishment.
Benefit: reduced storm water conveyance and management costs; reduced area required for capture ponds; smaller ponds = less capital and maintenance cost; smaller footprint = more land for other use (e.g. development, income generation, green space, recreation, habitat conservation). Reduced storm water volume discharge = lower storm water utility fees paid to municipality. Less pollutant loading = benefit to water quality and TMDL list water bodies, and lower treatment costs.

Green Roof (compost as growing media) - used to increase hydrologic abstraction, reduce peak runoff rates, buffer temperature.
Benefit: reduced storm water discharge, lower storm water utilities, and energy savings.

Conclusions

Chemical adsorption of nutrient and metal pollutants by compost + runoff reduction from high hydrologic abstraction and water absorption of compost + removal efficiency due to settling in designed detention or filtration area = compost is ideal for bioretention ponds, rain gardens, sediment detention ponds, and storm water treatment and management ponds. For more information on design considerations and criteria using Filtrexx products and practices consult the Filtrexx® Design Manual.

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TechLink Research Summary #3307

Removal and Degradation of Petroleum Hydrocarbons from Stormwater with Compost

Independent laboratory testing with compost based Filtrexx® FilterMedia™ at the Soil Control Lab in Watsonville, CA has shown that this material can remove petroleum hydrocarbons (as motor oil) from simulated runoff at consistently high percentage rates. Out of 32 independent tests with motor oil concentrations in water between 100 and 1700 mg L-1, compost based filter media removed an average of 87% of the motor oil concentration in stormwater, while 20 of the 32 composts removed greater than 95% of the motor oil concentration in the simulated stormwater runoff.

While compost FilterMedia™ has shown promise to remove petroleum hydrocarbons from stormwater, thereby reducing it's migration to and pollution of ground and surface waters, what is the eventual fate of this pollutant within the compost media?

A benefit of compost is that it can naturally provide, 1) a high diversity of microorganisms including hydrocarbon degrading microorganisms and, 2) an optimum environment for them to thrive. Hydrocarbon degrading microorganisms require an environmental habitat that has a sufficient and preferably sustainable (slow release) source of nutrients (mostly N and P), water, air, mild ambient temperature, and a moderate pH - compost provides a habitat that supplies each of these environmental factors. At optimum levels these environmental factors provide the energy and metabolic resources that create a widely diverse group of beneficial microorganisms that will suddenly reproduce on a very rapid scale. While these degrader microorganisms increase their populations they also work rapidly and effectively to degrade petroleum hydrocarbons, for food (from carbon) to sustain their growth pattern. Additionally, it is often the humus content of compost (6 times higher in mature compost than typical soils) that catalyzes the degradation process of organic compounds/contaminants (Stevenson, 1994 and USEPA, 1998).

Under optimum environmental conditions petroleum concentrations in soil were shown to reduce from 196 to 10 mg kg-1 and from 2109 to 195 mg kg-1 over a one year period (Mohn, 2001). Thomassin-Lacroix et al (2002) found that under favorable environmental conditions diesel fuel was degraded from 2.9 to 0.5 mg g-1 in 65 days, and at a rate of 90 g per gram of soil per day for 14 days. Poultry litter and degrader bacteria degraded 67 - 78% of hydrocarbons in gasoline contaminated soil in 60 days (Rahman et al, 2002). Additionally soils contaminated with oil and treated with nutrients found that slow release nutrient sources produced higher bacteria community structures and higher degradation rates (in the form of CO2 evolution) compared to liquid nutrient sources (Roling et al, 2004). Petroleum contaminated soils amended with compost exhibited degradation rates of 375 mg kg-1/day compared to only 40 mg kg-1/day without compost (Stegmann et al, 1991 and Hupe et al, 1996). At the rate exhibited by the compost amended soil, typical petroleum hydrocarbon contaminated soils (normal range is between 5,000 to 20,000 mg kg-1) would be completely degraded in 14 to 60 days (USEPA, 1998). According to the USEPA (1998) compost has been shown to degrade the following contaminants under controlled conditions and/or in field research programs: petroleum hydrocarbons (gasoline, diesel fuel, jet fuel, oil, grease), polynuclear aromatic hydrocarbons (wood preservatives, refinery wastes, coal gasification wastes), pesticides (herbicides and insecticides), and explosives (TNT, RDX, nitrocellulose).

What is the specific fate of the hydrocarbons after they were degraded by microorganisms (the mass balance for the degraded carbon)?

In an experiment by Hupe et al (1996), 59% was converted to CO2, 4% was volatilized, 4% was converted into the biomass of the microorganisms, 8% was extractable (in its original form), and 24% was bound to residue. The fraction that bonds with the residue often is incorporated into the core structure of the humic materials, making it relatively bio-unavailable for decades and even centuries (Stevenson, 1994 and USEPA, 1998).

Bacteria and Fungi are the primary agents for degradation of organic contaminants in soil (Alexander, 1994), and increasing the diversity, population, and community structure can accelerate the degradation of the contaminants

(Cole et al, 1994). Microbial diversity and population density is greatly increased by the addition of compost compared to fertile, productive soils; therefore, bioremediation takes far less time with compost than under natural conditions (Cole et al, 1994 and USEPA, 1998). Normal bacteria populations in fertile soils are approximately 26 million/gram of dry soil, while in compost bacteria populations are approximately 417 million/gram of dry compost. Similarly, fungi populations in fertile soils are approximately 28 thousand/gram dry soil and 155 thousand/gram for dry compost (Cole, 1976 and Cole et al, 1994). Additionally, microbial activity in mature compost can be nearly 40 times greater in compost than in soil (USEPA, 1998). It is no surprise that hydrocarbon degrading microorganisms are often isolated from compost and used to inoculate bioremediation projects (Civilini et al, 1996 and Castaldi et al, 1995).

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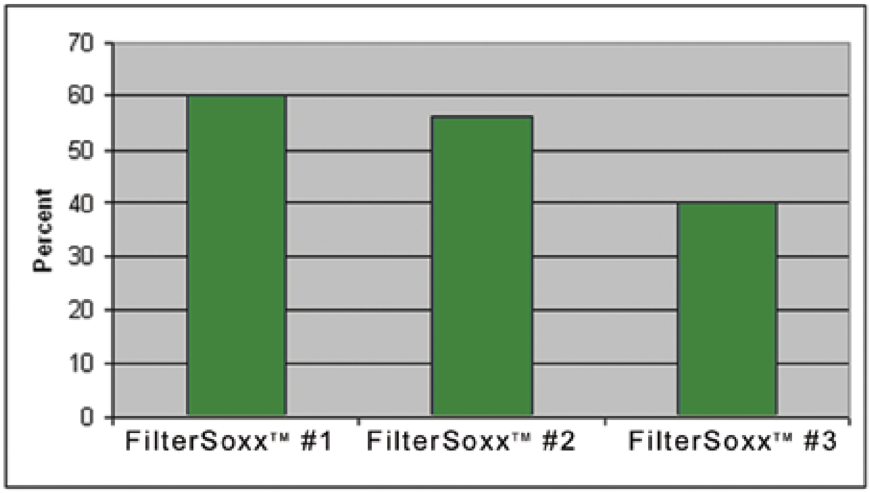
TechLink Research Summary #3308

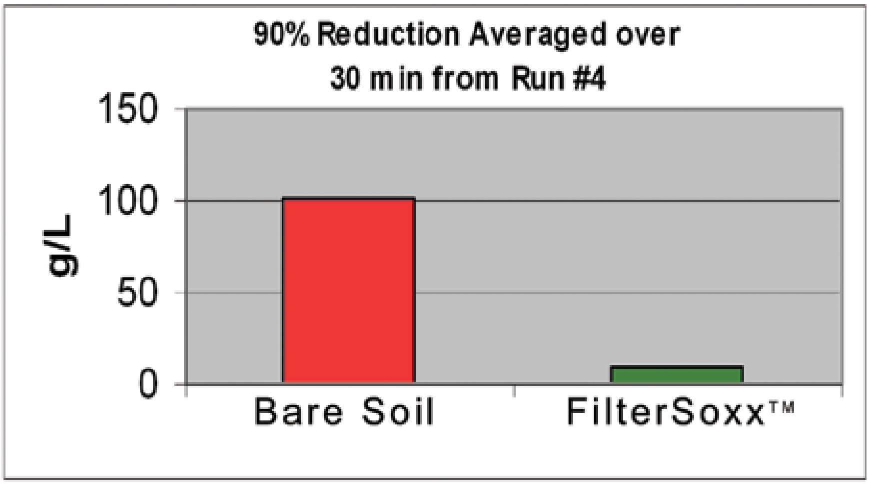
USDA ARS Research Summary: Filtrexx® FilterSoxx™ vs Silt Fence

Research results based on three replicates per treatment on a 5:1 slope, pre-wet compacted silty loam soil, 3.1 in/hr simulated rainfall intensity for 30 min., with average runoff sediment concentrations of 100,000 mg L-1. Research conducted at the US Department of Agriculture - Agricultural Research Service, Environmental Quality Lab, Beltsville, MD.

Note: ASTM 5141 - Standard Test Method for Determining Filtering Efficiency and Flow Rate of a Geotextile for Silt Fence Application Using Site Specific Soil uses a 12:1 slope, a 12 in silt fence, and simulated runoff sediment concentration of 2890 mg L-1.



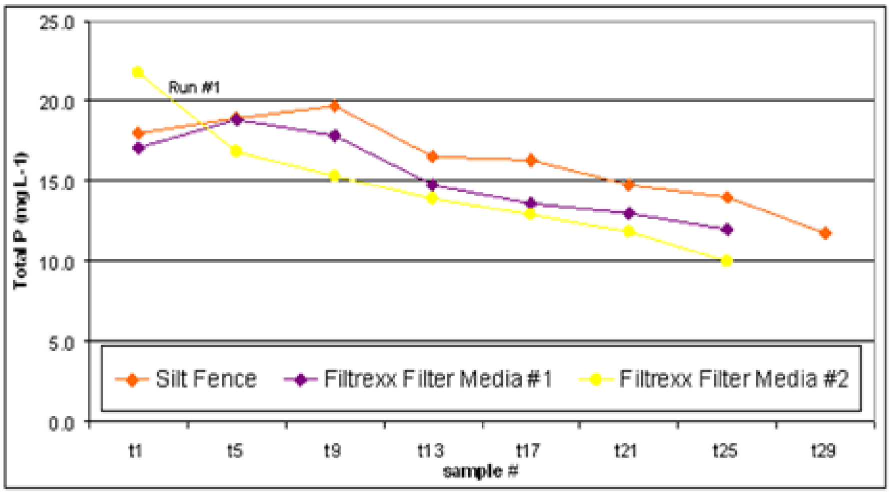
1) 50% Greater Flow Through Rate: 8 in FilterSoxx™ vs 24 in silt fence



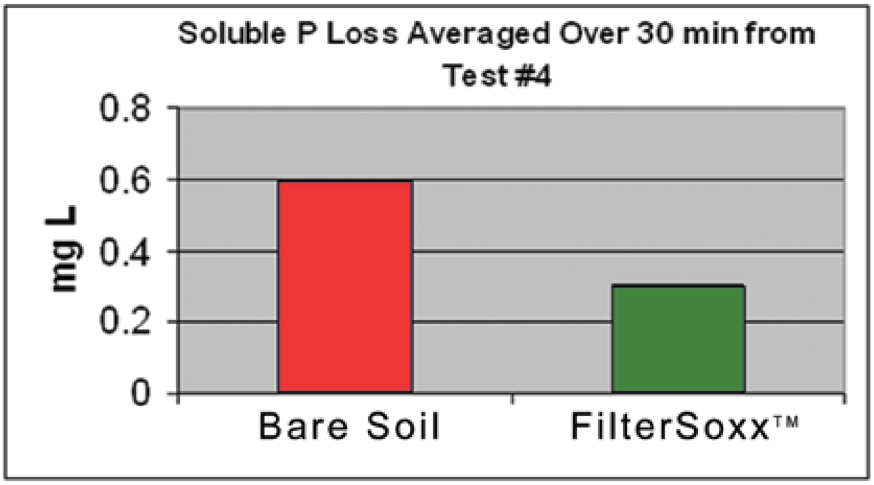
2) 90% Reduction of Total Solids

Treatment	TSS	Turbidity
Silt Fence	67	52
FilterSoxx™	78	63
FilterSoxx™ & PAM 12	91	79
FilterSoxx™ & SiltStop	97	98
FilterSoxx™ & BioFloxx™	97	94

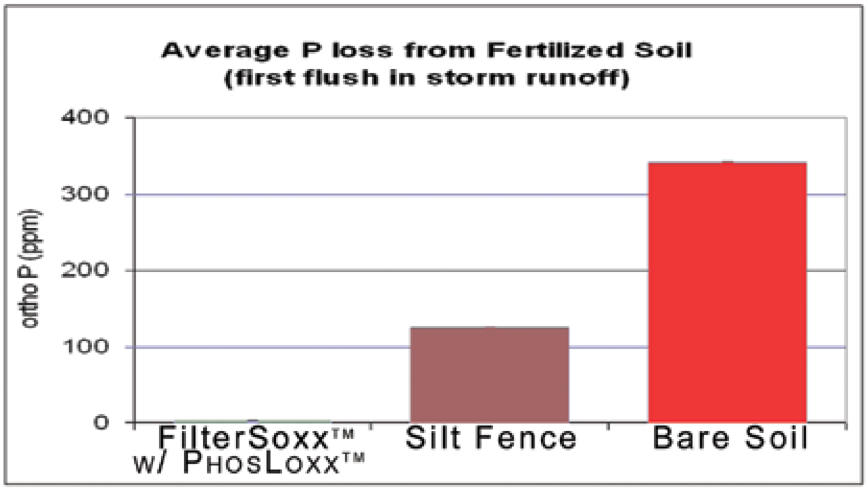
3) Percent Reduction of TSS (mg L-1) & Turbidity (NTU) of silt fence, FilterSoxx™ , FilterSoxx™ + Flocculent agent



4) Total Phosphorus from FilterSoxx™ vs silt fence



5) Soluble P from FilterSoxx™ 50% less than untreated soil



6) 99% Soluble P Reduction in Stormwater w/ FilterSoxx™ + Nutrient agent. NPK 25-27-5 fertilizer applied at 150 lbs/ac equivalent

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TechLink Research Summary #3309

Humus Content and Quality of Compost Materials

Humus is the stable organic fraction of soil, compost, or any growing media. Humus is the term used for a collection of complex organic compounds that have been decomposed and synthesized by microorganisms to a stable level - or are resistant to further decay or decomposition (Brady and Weil, 1996). Humus is generally dark brown in color, colloidal in nature, and mostly organic carbon - as most nutrients have been mineralized and subsequently made available to plants by microbial decomposition. The benefit of this humus fraction is its ability to increase the physical structure and stability of the soil, to hold nutrients and make them available to plants, to hold water (5 times its weight) and to make it available for plants, and to adsorb pollutants in the soil and water matrix (Brady and Weil, 1996).

Composting is often referred to as an accelerated humification process. Approximately 15 to 35% of the carbon originally used to make compost ends up as humus and approximately 60 to 80% of the stable organic matter content in compost or soil is in the form of a humic substance.

Humic substances are made of humins + humic acids + fulvic acids, while the remaining non-humic fraction, 20 to 40%, is still considered humus and of great benefit to nutrient availability for plants and to aggregate stability (which increases water infiltration, percolation and holding capacity; increases soil biology and reduces soil erosion) of soil particles. Humic substances can be extremely stable with a half life ranging from decades to centuries (Brady and Weil, 1996). Humic acid and fulvic acid is known to enhance seed germination, root establishment and root elongation; however, scientific tests of commercially available humate products have not shown any benefit to plant growth (Brady and Weil, 1996). It is the naturally produced humus fraction of compost that is generally considered to be its most beneficial and valuable component.

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TechLink Research Summary #3310

How Important Is Particle Size in Specifications for Filtrexx® Slope Protection?

Filtrexx® Slope protection used for slope stabilization and vegetation establishment have been evaluated in research and field demonstration projects more widely than compost used for sediment control (Ettlin and Stewart, 1993; Demars and Long, 1998; Glanville et al, 2001; Kirchhoff et al, 2003; Mukhtar et al, 2004; Faucette et al, 2004; Faucette et al, 2005). While specifications for compost blankets have been accepted and published by the Texas Department of Transportation (TX DOT), the American Association of State Highway Transportation Officials (AASHTO), the US Environmental Protection Agency (USEPA), Indiana Department of Natural Resources (IN DNR), Coalition of Northeast Governors/Connecticut Department of Transportation (CONEG), and many other public agencies, no research has been conducted to evaluate the most critical section of the specifications, the particle size distribution of the compost used to make the erosion control blanket. Of the 23 compost blanket treatments evaluated by Demars and Long (1998), Glanville et al (2001), Kirchhoff et al (2003) and Faucette et al (2004, 2005) none met any of the particle size specifications for Filtrexx® Slope protection. Mukhtar et al (2004) reported that TX DOT specifications were followed, however, particle size distribution was not determined.

Table 1: Particle size specifications for compost erosion control blankets

Specifying Agency	% Pass 2 in	% Pass 1 in	% Pass ¾ in	% Pass ¼
TX DOT*	95	65	65 (5/8 in)	50 (3/8 in)
AASHTO	100 (3 in)	90-100	65-100	0-75
US EPA	100 (3 in)	90-100	65-100	0-75
IN DNR	100	99	90	0-90
CONEG	100	100	100	70 (1/2 in), 50 (1/12 in)

** 1:1 blend of compost and untreated wood chips (termed Erosion Control Compost)*

In Filtrexx® Slope protection larger particles (overs or blended mulch) are the primary material that prevents soil loss, while the small particles (compost fines) are the primary material that prevents runoff. Large particles prevent splash erosion and soil dislodgement by reducing the energy of raindrop impact, additionally, they reduce sediment transport in overland runoff by reducing runoff rates due to their size and weight. The small particles in compost can hold a significant amount of moisture (from rainfall), which likely increases infiltration and evaporation, additionally, it is the small particles that provide the nutrients and structure for plants (and their roots) to establish and maintain a healthy cover (which is generally the end goal of erosion control). It is also likely that any benefit of increased soil quality (over time) will result mainly from the small particles in the Filtrexx® Slope protection (and biota in the soil and compost).

Table 2: Particle size distribution of compost and soil loss from erosion control blanket

Treatment	Soil Loss (g)	Suspended solids (g)	Turbidity (NTU)	Particle size % passing		
				1 in	1/2 in	1/4 in
Compost 1	46	25	36	99	64	30
Compost 2*	62	29	60	99	85	67
Compost 3*	100	31	87	99	89	76
Compost 4**	196	136	288	99	99	95

**Did not meet TX DOT specification for erosion control compost particle size distribution.*
***Did not meet TX DOT, USEPA, IN DNR, or CONEG specification for erosion control blanket particle size distribution*

Research conducted in 2005 at the University of Georgia Institute of Ecology Field Test Site, in Athens, GA, evaluated the influence of particle size distribution of compost used as an erosion control blanket. Four 2 in thick compost blankets, with different particle size distributions, were tested on a 10% slope, on a compacted sandy clay loam subsoil, under 4 in/hr for 60 minutes of simulated rainfall, on plots 3 ft wide by 16 ft long. Test methods and analysis followed methods developed by the USDA National Soil Erosion Research Lab Water Erosion Prediction Project (WEPP) and those published by Faucette et al (2005) in the Journal of Soil and Water Conservation.

Based on this research total soil loss can 4 times as high, suspended solids can be 5 times as high, and turbidity can be 8 times as high if particle size specifications are not followed. Additionally, depending on which specification is followed (TX DOT, AASHTO, US EPA, IN DNR), total soil loss and turbidity can be twice as high from one compost specification relative to
another.

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TechLink Research Summary #3311

Design Height, Flow Through Rate and Slope Spacing of Filtrexx® SiltSoxx™ and Silt Fence

Design for slope spacing between runoff control, slope interruption, or sediment control devices is dependant on three broad parameters: site and soil characteristics (e.g. slope angle, surface roughness, initial abstraction/water absorption, cover or erosion control practice), rainfall characteristics (designated storm intensity and duration or total rainfall and duration for a specified return period, e.g. 24 hr 25 yr return), and control device characteristics (flow through rate or flow restriction, and design or effective height) - assuming that sediment and/or pollutant removal efficiency of the device is effective and acceptable. The maximum slope spacing between control devices is determined by the point at which overtopping of runoff occurs from a given watershed area under a given rain storm (e.g. a predetermined or standard set of soil, site, and rainfall characteristics), as the sediment control function is no longer at an optimum performance level.

To determine maximum slope length (or maximum spacing between control devices) once soil, site, and rainfall characteristics are known (i.e. environmental conditions are constant), the two variables become the height of the design tool and the runoff flow through rate of the control device, assuming sediment removal rates are similar - greater sediment removal rates which result in greater sediment accumulation behind the device, ultimately reduces the effective height of the control device, which will then cause runoff to overtop the device more quickly.
Design and Effective Height

Design height of silt fence and Filtrexx® SiltSoxx™ is different from the effective height used to control runoff and sediment once installed and subject to field conditions. While silt fence is available in 18, 24, 30, and 36 in design heights, the amount of fabric trenched into the ground is generally 8 (GA SWCC, G DOT, KY EP&SC, VA DCR) to 12 in (Iowa SUDAS, Iowa DNR, MN DOT, OH DOT, SC DOT, NC DENR), and once a constant head of water pressure (from surface runoff) is applied to the silt fence it sags between an average of 3 in (24 in silt fence) and 6 in (36 in silt fence) (Keener et al, 2006). Wire or fence reinforced silt fence only sags about 3 in (for 36 in silt fence). Therefore the effective height of a 24 in silt fence is 13 in; the effective height of a 36 in silt fence is 18 to 22 in; and the effective height of wire reinforced silt fence is 21 to 25 in.

Filtrexx® SiltSoxx™ is available in 8, 12, 18, 24, and 32 in design diameters and once installed and a constant head of water pressure is applied (from surface runoff) they sag (or bow) between 1 in (8 in) and 5 in (24 in). Therefore the effective height of a 12 in sock is 10 in and an 18 in sock is 15 in.

Flow Through Rate of Silt Fence

Flow through rate for silt fence has been reported between 0.3 gal/ft2/min to 100 gal/ft2/min. The USEPA (2005), Virginia Highway and Transportation Research Council (VHTRC) and Virginia E&SC Field Manual (VDCR, 1995) and a study by Wyant (1981), used to create ASTM D-5141 Standard Test Method for Determining Filtering Efficiency and Flow Rate of a Geotextile for Silt Fence Application Using Site Specific Soil, all report a flow through rate of 0.3 gal/ft2/min using sediment laden water (2890 mg L-1) & 10 gal/ft2/min using clean water with no sediment concentration.

ASTM D-5141 uses a 12 in silt fence, a 12:1 slope, runoff sediment concentration of 2890 mg L-1, 50 liters of total runoff volume, in boxes 48 in long (slope length) by 34 in wide (length of filter), and the silt fence is pre-wet using 50 L of clean water.

The Minnesota DOT (2000) reports a flow through rate for silt fence at 100 gal/ft2/min and use ASTM D-4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity. This standard test method uses a 2 in diameter cut section of filter fabric placed at the base of a vertical column. The rate in which 50 mL of clear water (no sediment) flows vertically through the column (and fabric) is determined, and mathematically corrected to represent one square foot of silt fence filter fabric. This test method and the one below (GDT-87) report the flow of water per area of filter fabric (ft2) NOT per area of land (ft2). ASTM D-4491 should not be used to estimate flow through rates under field conditions and therefore should not be used in design spacing specifications.

The Georgia DOT (G DOT, 2006) and Georgia Erosion and Sediment Control Manual (GA SWCC, 2000) report flow through rates for silt fence at 25 gal/ft2/min for Class A and B silt fence and 70 gal/ft2/min for Class C, although the openings in the filter fabric are the same (determined by AOS - apparent opening size ASTM D-4751). The G DOT uses its own test method, GDT-87 (G DOT, 2006), for determining the flow through rate of silt fence. It is nearly the same as ASTM D-4491 except it uses a 4 in diameter cut section of silt fence. To calculate flow through rate GDT-87 uses the formula,

Q = 983/T
Where: Q = flow through rate, T = seconds to drain 50 mL

Flow Through Rate of Filtrexx® SiltSoxx™

Standard test methods for determining flow through rates and the values reported for flow through rates for silt fence are extremely variable. Because of this variability and because the standard test methods were developed specifically for geotextile filter fabric it is more beneficial to evaluate flow through rates for Filtrexx® Sediment control (or any sediment control device) in a side-by-side comparison with silt fence, under the same set of test conditions - until a new standard test method is developed to accommodate all runoff and sediment control devices. Without a standard test method that can accommodate tubular devices and silt fence it is impossible to compare and evaluate these devices except under a side-by-side experiment (preferably conducted by a non-biased third party, using multiple replicates and an experimental design and method easily replicable for others). Additionally, it is important to test these control devices, 1) using sediment-laden runoff conditions that represent real field conditions - as this effects flow through the filter especially over time, 2) with horizontal runoff flows (not vertical) applied to the effective length (not area) of a control device. This is important because the pressure created from horizontal flow on a device is different from vertical flow, and horizontal flow rarely makes contact with the entire surface area of the control device, as it is usually concentrated (not dissipated) to a specific area. Research results conducted by the USDA ARS and The Ohio State University using these criteria are discussed below.

Table 1: Time to overflow at three flow rates* for silt fence and Filtrexx® SiltSoxx™

	Flow Rate		
Sediment Control Device	**1 gpm/linear ft**	**5 gpm/linear ft**	**7.5 gpm/linear ft**
36 in silt fence	6.5 hrs	2 hrs	45 min
30 in silt fence	5 hrs	1.5 hrs	30 min
24 in silt fence	3.5 hrs	1 hr	20 min
18 in Filtrexx® SiltSoxx™	11.5 hrs	4 hrs	1 hr
12 in Filtrexx® SiltSoxx™	7.5 hrs	2.5 hrs	30 min
8 in Filtrexx® SiltSoxx™	5 hrs	1.5 hrs	10 min

** Sheet flow runoff with 10,000 mg L-1 of suspended solids consisting only of silt and clay.*

The USDA Agricultural Research Service (Sadeghi et al, 2006) has reported that flow through rates for Filtrexx® Sediment control is 50% greater than silt fence. The USDA ARS test method uses a 5:1 slope, an 8 in Filtrexx® Sediment control, a 24 in silt fence, a simulated rainfall intensity and duration of 3 in/hr for 30 min - which produces a runoff sediment concentration of 100,000 mg L-1 of silt loam, in soil boxes 44 in long (slope length) by 14 in wide (length of filter). Soil is compacted and pre-wet prior to rainfall.

The Ohio State University (Keener et al, 2006) test method uses 17% and 37% slopes, runoff flow rates of 1.5, 2, 2.5, and 7.5 gal/linear ft/min, and runoff sediment concentration of 10,000 mg L-1 of only clay and silt, in flumes 8 ft long by 2 ft wide.

The Ohio State University has also reported that flow through rates for Filtrexx® Sediment control is 50% greater, relative to silt fence, and ponding depth behind the silt fence can be as much as 75% greater. At an actual flow rate of 7.5 gal/linear ft/min a 24 in silt fence overtopped after 20 min, while a 12 in Filtrexx® Sediment control did not overtop until 30 min (see Table 1). However, if sediment was excluded from the runoff (i.e. clean water), flow through rates for the silt fence were 25% greater than the Filtrexx® Sediment control; which shows that to determine representative flow through rates sediment must be added to the runoff or results can be extremely inaccurate (if the purpose is to simulate or predict field conditions). Accurate flow-through results are critical in determining slope spacing/length for sediment and runoff control devices.

Because flow through rates using runoff with sediment reduce overtime as sediment begins to accumulate behind (or inside) the filter (restricting flow), determining slope length and distance between control devices must accommodate for this real world fact - flow through rates are not constant nor do they reach a steady state (whereas with clean water a constant steady state can be achieved). To account for sediment accumulation and its affect on flow restriction over time the following formula was developed by engineers at The Ohio State University to model ponding depth behind a sediment/runoff control device.

$$df = A(qf)t + B(qf)$$

Where:
df = *pond depth (in)*
qf = *sediment-laden flow rate (gal/linear ft/min)*
t = *time (min)*
$A(qf)$ = *rate of increase in depth as a function of runoff flow rate (sediment-laden) and suspended solids concentration of runoff (in/min)*
$B(qf)$ = *initial pond depth behind filter before sediment clogging occurs (in)*

Based on results from the research at The Ohio State University and this formula the following calculations were developed to estimate time to overflow a silt fence and a SiltSoxx™.

Silt Fence: $t = df - (1.1932qf + 1.2993)/0.0132\, qf + 0.029$

Filtrexx® Sediment control: $t = df - (0.8282\mathrm{exp}0.2564qf)/0.014\mathrm{exp}\ 0.3132qf$

Slope Length and Control Device Spacing

Spacing between control devices and/or the maximum allowable slope for a particular control device is generally determined based on design height (although it should be based on effective height) and the accurate flow through rate of the device. Because reported flow through rates of silt fence are widely variable (0.3 to 100 gal/ft2/min), allowable slope length and device spacing specifications in state erosion and sediment control (E&SC) manuals vary widely. Table 2 compares slope spacing specifications from selected state E&SC manuals.

Table 2: Spacing length (ft) specifications on slopes for 36 in silt fence in selected E&SC manuals*

Slope %	Iowa DNR	GA SWCC	G DOT	Iowa SUDAS	KY TC	Penn DOT / PA DEP**	USEPA/ VADCR	OH DOT/ OH EPA	SC DOT	NC DENR
<2	150	100	100	100	ND	1000	1000	220	100	100
2 to 5	ND***	75	50	100	ND	500	ND	110	100	75
5 to 10	100	50	50	100	125-200	300	ND	110	100	50
10 to 20	60	25	50	60	125-200	250	ND	110	100	25
25	50	15	50	50	100-150	150	ND	55	100	15
33	40	15	50	40	ND	90	ND	55	100	15
50	ND	15	50	ND	75-125	50	ND	55	100	15
>50	ND	15	50	ND	50-100	ND	ND	ND	100	15

** Iowa DOT - Iowa Department of Natural Resources/Construction Site Erosion Control Manual; GA SWCC - Manual for Erosion and Sediment Control in Georgia/Georgia Soil and Water Conservation Commission; G DOT - Georgia Department of Transportation; Iowa SUDAS - Iowa Statewide Urban Design and Specifications Manual; KY TC - Erosion Prevention and Sediment Control Field Guide/Kentucky Transportation Cabinet; Penn DOT/PA DEP - Pennsylvania Department of Transportation & PA Department of Environmental Protection E&SPC Manual; USEPA - United Sates Environmental Protection Agency/VADCR - Virginal Erosion and Sediment Control Field Manual/Virginia Department of Conservation; OH DOT/OH EPA - Ohio Department of Transportation/Ohio Environmental Protection Agency; SC DOT - South Carolina Department of Transportation, NC DENR - North Carolina Department of Environment and Natural Resources. ** Silt fence with wire reinforcement. ***ND - No data available.*

Design Tool Created by The Ohio State University

An MS Excel™ based interactive design prediction model was created by engineers at The Ohio State University so designers determining runoff/sediment control device spacing on slopes can easily determine this based on real site and rainfall conditions. The design tool allows the user to choose the appropriate design height/diameter control device and to compare the performance of each effective height/diameter for silt fence and Filtrexx® Sediment control. Site and rainfall input parameters that the user can manipulate include: total rainfall (in)/duration (hrs), rainfall intensity (in/hr)/duration (hr), area of watershed (ac) or slope width (ft) and length (ft), percent slope, potential runoff reduction (%) for soil/vegetation/erosion control/management practices, effective length of filter used to drain watershed area, diameter of Filtrexx® Sediment control, and height of silt fence. The output tells the user whether the silt fence and/or Filtrexx® Sediment control will fail based on the input parameters and how long (hrs) it took or will take for each control device to overflow. The design tool was built based on the flume research, ponding formula, and calculations described above for silt fence and Filtrexx® Sediment control, coupled with equations for site and rainfall/runoff characteristics described below in Figure 1. A copy of the design tool created by The Ohio State University can be obtained from Filtrexx International.

The equations for runoff are:

$Q = [I\ W\ L \cos(s)\ 7.48 / (60 * 12)] = 0.01039\ I\ W\ L \cos(s)$

$Q = 0.01039\ I\ W\ L \cos(s)$

$q_f = Q/W$

where:

Q_f = flow rate to filter, gpm

I = rainfall intensity, in/hr

W = width, i.e. length of filter, feet

L = length of slope, feet

s = angle of slope, degrees

d_f = depth of water at the filter measured   to slope, inches

q_f = flow rate to filter, gpm/f

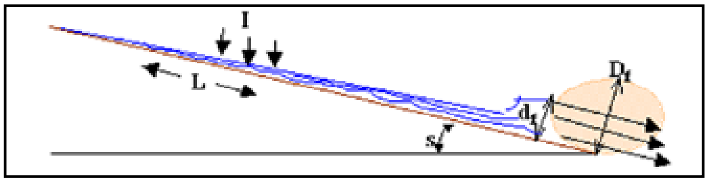

Figure 1. Diagram representation of control structure in operation and listing of variables used to calculate water runoff rates from a slope.

Conclusion

Filtrexx has provided adequate data to show that responsible and effective design criteria are available for the use of our products in situations where we specify them. In addition, we have shown that there are several reasonable questions about existing responsible and effective design criteria from currently accepted tools like silt fence. We simply ask that the specifications for Filtrexx product uses are adopted in full, without alteration, unless a). More research about similar products (tubes, socks) has been conducted to show that our results are invalid or b). Calculations prove this research presented is inaccurate.

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TechLink Research Summary #3312

Is Filtrexx® Slope Protection Really an Erosion Control Blanket?

Webster's dictionary defines a blanket as a covering layer. Filtrexx® Slope protection is typically used to stabilize soil on slopes with the goal of preventing soil erosion from occurring due to soil particle dislodgement resulting from splash erosion and from soil transport due to sheet runoff.

By blanketing the soil, Filtrexx® Slope protection protects the soil surface by preventing soil particle dislodgement created by the impact of rain drops, the first stage of water soil erosion. Tightly woven mats do this by intercepting these raindrops prior to contacting the soil. The larger particles used in Filtrexx® Slope protection provide the same function, just as a layer of mulch in a forest would provide.

Once the soil underneath Filtrexx® Slope protection has reached its water holding capacity during storm conditions, runoff begins. Unlike conventional erosion control blankets, Filtrexx® Slope protection holds a much higher quantity of water, therefore delaying and in some cases preventing runoff from occurring (Faucette et al, 2005). This is a function of the humus content and smaller particles in the Slope protection. Once runoff conditions occur, therefore entering the second stage of water soil erosion, Filtrexx® Slope protections is designed to reduce the rate of runoff flow over the soil surface by interrupting its flow and dispersing its energy over the slope. If the runoff flow rate is slowed, the runoff will have a reduced erosivity potential, therefore reducing the likelihood of interrill soil erosion and soil transport. Filtrexx® Slope protection has been shown to significantly reduce runoff rates, delay the time until peak runoff rates occur, and reduce overall runoff volume on slopes (Faucette et al, 2005).

Perhaps the most important function of Filtrexx® Slope protection is to protect soil surfaces prior to vegetation establishment and to quantifiably reduce soil erosion and transport from slopped areas. Research at the University of Georgia has shown that over two storm events, with rates and intensities over 3 in/hr for one hour duration, compost Filtrexx® Slope protections reduces soil loss on slopes by 99% and have a C factor of 0.008, the cover factor in the equation commonly used to predict soil loss by the RUSLE computer model software (Faucette et al., 2005).

Many erosion control professionals are beginning to prefer compost Filtrexx® Slope protection over rolled erosion control blankets, because they can improve soil structure and overall soil quality (Faucette et al., 2004) which leads to sustained and permanent vegetation growth. Additionally, they tend to increase vegetation establishment while suppressing weed growth (Richard et al., 2002; Faucette et al., 2004), which is the principle goal of permanent erosion control tools. In a recent study in the Journal of Soil and Water Conservation, researchers at the US Department of Energy's Savannah River Site found that rolled erosion control blankets captured an average 1.26 snakes per roll with a 75% kill rate, and concluded that the synthetic netting was likely harmful to other wildlife as well, including endangered species (Barton and Kinkead, 2005). Additionally, leachate from aspen excelsior has been shown to be toxic to aquatic organisms, and therefore should not be used near surface waters (Taylor et al., 1996). Whether the issue is ecosystem health, erosion control, soil quality, water quality, storm water reduction, vegetation establishment, or permanent vegetation, compost Filtrexx® Slope protections increasingly are the Filtrexx® Slope protection of choice by erosion control professionals and environmental managers.

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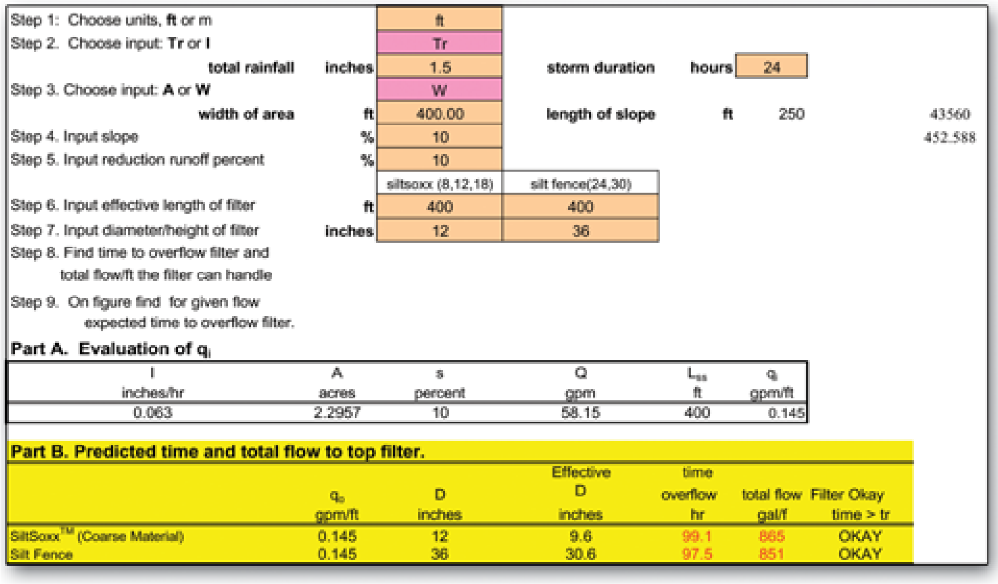
TechLink Research Summary #3313

Design for Sediment Control Structures: Filtrexx® SiltSoxx™ & Silt Fence

An MS Excel™ based interactive design capacity prediction model was created by engineers at The Ohio State University so designers working with runoff/sediment control devices can easily determine the following design considerations based on real site and rainfall conditions: slope spacing between sediment/runoff control devices, maximum allowable slope length or watershed area draining to a sediment/runoff control device, time until sediment/runoff control device will overflow, runoff rate required to overflow sediment/runoff control device, and effective height of the sediment/runoff control device after field installation and under field conditions. The design tool allows the user to choose the appropriate design height/diameter control device and to compare the performance of each effective height/diameter for silt fence and Filtrexx® Sediment control. Site and rainfall input parameters that the user can manipulate include: total rainfall (in)/duration (hrs), rainfall intensity (in/hr)/duration (hr), area of watershed (ac) or slope width (ft) and length (ft), percent slope, potential runoff reduction (%) for soil/vegetation/erosion control/management practices, effective length of filter used to drain watershed area, diameter of Filtrexx® Sediment control, and height of silt fence. The output tells the user whether the silt fence and/or Filtrexx® Sediment control will fail based on the input parameters and how long (hrs) it will take for each control device to overflow.



Step 1: Choose units, ft or m			ft			
Step 2. Choose input: Tr or I			Tr			
	total rainfall	inches	1.5	storm duration	hours	24
Step 3. Choose input: A or W			W			
	width of area	ft	400.00	length of slope	ft	250
Step 4. Input slope		%	10			
Step 5. Input reduction runoff percent		%	10			
			siltsoxx (8,12,18)	silt fence(24,30)		
Step 6. Input effective length of filter		ft	400	400		
Step 7. Input diameter/height of filter		inches	12	36		

43560
452.588

Step 8. Find time to overflow filter and
total flow/ft the filter can handle

Step 9. On figure find for given flow
expected time to overflow filter.

Part A. Evaluation of q_i

I inches/hr	A acres	s percent	Q gpm	L_{ss} ft	q_i gpm/ft
0.063	2.2957	10	58.15	400	0.145

Part B. Predicted time and total flow to top filter.

	q_o gpm/ft	D inches	Effective D inches	time overflow hr	total flow gal/f	Filter Okay time > tr
SiltSoxx™ (Coarse Material)	0.145	12	9.6	99.1	865	OKAY
Silt Fence	0.145	36	30.6	97.5	851	OKAY

The design tool is based on research results, the ponding formula and calculations described below for silt fence and Filtrexx® Sediment control, and the equation for site and rainfall/runoff characteristics described below in Figure 1. A copy of the research and/or design tool completed by The Ohio State University can be obtained from Filtrexx International.

Table 1: Time to overflow at three flow rates* for silt fence and Filtrexx® SiltSoxx™

Sediment Control Device	Flow Rate 1 gpm/linear ft	 5 gpm/linear ft	 7.5 gpm/linear ft
36 in silt fence	6.5 hrs	2 hrs	45 min
30 in silt fence	5 hrs	1.5 hrs	30 min
24 in silt fence	3.5 hrs	1 hr	20 min
18 in Filtrexx® SiltSoxx™	11.5 hrs	4 hrs	1 hr
12 in Filtrexx® SiltSoxx™	7.5 hrs	2.5 hrs	30 min
8 in Filtrexx® SiltSoxx™	5 hrs	1.5 hrs	10 min

** Sheet flow runoff with 10,000 mg L-1 of suspended solids consisting only of silt and clay.*

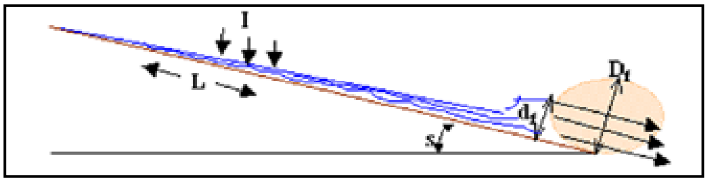


Figure 1. Diagram representation of control structure in operation and listing of variables used to calculate water runoff rates from a slope.

Formulas:

Formula to determine ponding depth behind sediment/runoff control device:
$df = A(qf)t + B(qf)$

Where:
df = pond depth (in)
qf = sediment-laden flow rate (gal/linear ft/min)
t = time (min)
A(qf) = rate of increase in depth as a function of runoff flow rate (sediment-laden) and suspended solids concentration of runoff (in/min)
B(qf) = initial pond depth behind filter before sediment clogging occurs (in)

Based on results from the research at Ohio State University and this formula the following calculations were developed to estimate time to overflow a silt fence and a Silt Soxx.

Silt Fence: $t = df - (1.1932qf + 1.2993)/0.0132\,qf + 0.029$
Filtrexx® Sediment control: $t = df - (0.8282\exp 0.2564qf)/0.014\exp 0.3132qf$

The equations for runoff are:
$Q = [I\,W\,L\cos(s)\,7.48/(60 * 12)] = 0.01039\,I\,W\,L\cos(s)$
$Q = 0.01039\,I\,W\,L\cos(s)$
$qf = Q/W$

Where:
Qf = flow rate to filter, gpm
I = rainfall intensity, in/hr
W = width, i.e. length of filter, feet
L = length of slope, feet
s = angle of slope, degrees
df = depth of water at the filter measured to slope, inches
qf = flow rate to filter, gpm/f

Runoff Reduction Coefficient:
The runoff reduction coefficient was incorporated into the equation for predicting runoff using the following relationship:
$qf = (100 - RC)/100 * Q/W$
where:
qf = flow rate to Filtrexx® Sediment control (gpm/ft)
Q = flow rate to Filtrexx® Sediment control (gpm)
W = width, i.e. length of sediment control filter (ft)
RC = runoff reduction coefficient (percent)

RC accounts for loss of water volume (mass) due to the effects of absorption by ground cover and/or infiltration as it moves down the watershed to the sediment control structure. Past research has shown values ranging from 0 for concrete to as much as 60% for some compost blankets and mulches.

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TechLink Research Summary #3314

Sediment Storage Capacity of Filtrexx® Sediment Control vs Silt Fence

Sediment storage capacity is the maximum volume of sediment that a sediment control device (SCD) can accumulate either behind the device (upslope) and/or within the filter itself. While silt fence only has the ability to accumulate and store sediment behind the filter fabric, tubular devices, such as compost FilterSoxxtm have the ability to accumulate and store sediment behind the filter and within the matrix of the filter.

Assuming that environmental conditions (soil type, slope degree and length, rainfall-runoff characteristics, erosion control practice) are equal or held constant, there are four variables that can affect the sediment storage capacity of a SCD: 1) the height of the device, 2) the void space or air space within the device, 3) filtering or sediment removal efficiency of the device, and, 4) the maintenance specification for allowable sediment accumulation upslope of the device.

Design and Effective Height

Design height of silt fence and Sediment control is different from the effective height that actually controls runoff and sediment once installed and subject to field conditions. While silt fence is available in 18, 24, 30, and 36 in design heights, the amount of fabric trenched into the ground is generally 8 in (GA SWCC, G DOT, KY EP&SC, VA DCR) to 12 in (Iowa SUDAS, Iowa DNR, MN DOT, NC DENR, SC DOT, OH DOT, PA DEP), and once a constant head of water pressure (from surface runoff) is applied horizontally from the ground to the top of the silt fence it sags between an average of 3 in (24 in silt fence) and 6 in (36 in silt fence) (Keener et al, 2006). Wire or fence reinforced silt fence only sags about 3 in (for 36 in silt fence). Therefore the effective height of a 24 in silt fence is 13 in; the effective height of a 36 in silt fence is 18 to 22 in; and the effective height of wire reinforced silt fence is 21 to 25 in.

Table 1: Total sediment storage capacity (sediment storage within + sediment storage behind) at 0% slope, per linear ft of silt fence and Sediment control

SCD	Design Height (in)	Effective Height (in)	Maximum Sediment Storage Height (in)	Sediment Storage Length (upslope) (in)	Sediment Storage within + behind SCD (in3)	Total Sediment Storage Capacity (in3)
Silt Fence	24	13	6.5	6.5	0 + 254	254
Silt Fence	36	20	10	10	0 + 600	600
Silt Fence	36 reinforced	23	11.5	11.5	0 + 794	794
SiltSoxx	8	6.5	3.25	3.25	111 + 63	174
SiltSoxx	12	9.5	4.75	4.75	261 + 135	369
SiltSoxx	18	14.5	7.25	7.25	542 + 315	857
SiltSoxx	24	19	9.5	9.5	1089 + 542	1631

Sediment control is available in 8, 12, 18, 24, and 32 in design diameters. Once installed and a constant head of water pressure is applied (from surface runoff) they sag (or bow) between 1.5 in (8 in), 2.5 in (12 in), 3.5 in (18 in) and 5 in (24 in). Sediment control is generally not trenched into the soil. Therefore the effective height of a 12 in sock is 10 in and an 18 in sock is 15 in. When determining sediment storage capacity of a SCD the effective height should be used, not the design height.

Void Space within SCDs

An average 8 in Sediment control contains 1/60 or 0.017 cubic yards (793 cubic inches) of compost filter media per linear ft., a 12 in Sediment control contains 1/25 or 0.04 cubic yards (1866 cubic inches) of compost FilterMediatm per linear ft, an 18 in Sediment control contains 1/12 or 0.083 cubic yards (3872 cubic inches) of compost FilterMediatm per linear ft, and a 24 in Sediment control contains 1/6 or 0.167 cubic yards (7792 cubic inches) of compost FilterMediatm per linear ft. Based on laboratory testing of field filled Filtrexx Certified FilterMediaTM, analyzed at the Soil Control Lab in Watsonville, CA., the average volumetric void space, or air space, of compost FilterMediaTM once inserted and installed with a FilterSoxxtm is 20%. This air space is created due to the heterogeneous mixture and placement of specified material particle sizes (and shape variation) of the compost FilterMediaTM that are inserted into the FilterSoxxTM. The void space created within the Sediment control is air space that can accumulate and store sediment as it moves into the filter (compost FilterMediaTM occupies the area within the Sediment control that is not free air space). A silt fence has no quantifiable void space in which to accumulate and store sediment, therefore, sediment storage for silt fence is exclusively behind (upslope) the filter fabric.

Filtering Efficiency and Maintenance for Sediment Accumulation

Based on research conducted by the USDA ARS (Sadeghi et al, 2006) and The Ohio State University (Keener et al, 2006) sediment removal efficiencies for silt fence and Sediment control are similar, therefore the rate at which they accumulate sediment is assumed to be equal for this exercise.

Maintenance requirements for sediment accumulation behind SCDs according to state erosion and sediment control manuals (GA SWCC, 2000; KY EP&SC, 2005; SC DOT, 2005; WS DOT, 2005) and manufacturers' specifications usually call for removal (of the sediment) once accumulation has reached 1/3 to ½ the height of the SCD.

Sediment Storage Capacity

To determine sediment storage capacity we will make the following assumptions: filtering efficiency of sediment for silt fence and Sediment control are equal; the maximum allowable height of sediment accumulation behind the SCD is ½ of the effective height; and the horizontal length (in) of accumulated sediment behind (i.e. upslope) the SCD will be equivalent to the sediment accumulation height (in); the slope of the land area above the SCD is 0% (or no more than 10%). State and manufacturer specifications for SCDs often recommend the device be installed at least 5 ft from the toe of the slope to allow for maximum sediment storage behind the device. Total sediment storage capacity (volumetric) is determined by the following formula:

$Sc = (Hs \times Ls \times 12)(0.5) + I$

Where:
Sc = total sediment storage capacity per linear ft of SCD (cubic inches)
Hs = maximum allowable sediment storage height (in)
Ls = horizontal length of sediment accumulated upslope of SCD (in)
12 = in per linear ft
I = maximum sediment storage within the SCD per linear ft (cubic inches)

And:
$I = (v/l)(0.2)(0.7)(46{,}656)$

Where:
v = volume of compost (cubic yards)
l = length of sock per cubic yard of compost (linear ft)
0.2 = void space within a linear ft of compost FilterSoxxtm (%)
0.7 = safety factor, whereas sediment may fill up to 70% of the air space within a tubular SCD
46,656 = conversion to cubic inches from 1 cubic yard

References Cited

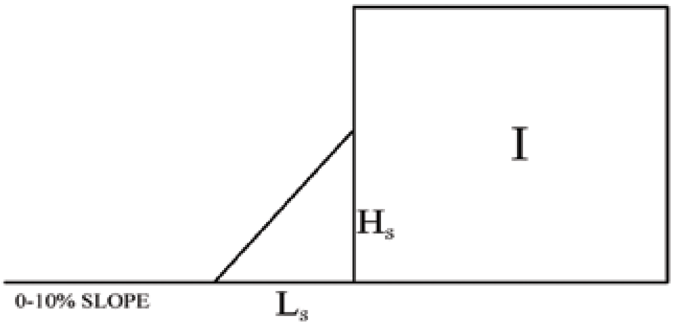

Figure 1: Diagram of sediment control device and variables used to calculate sediment storage capacity

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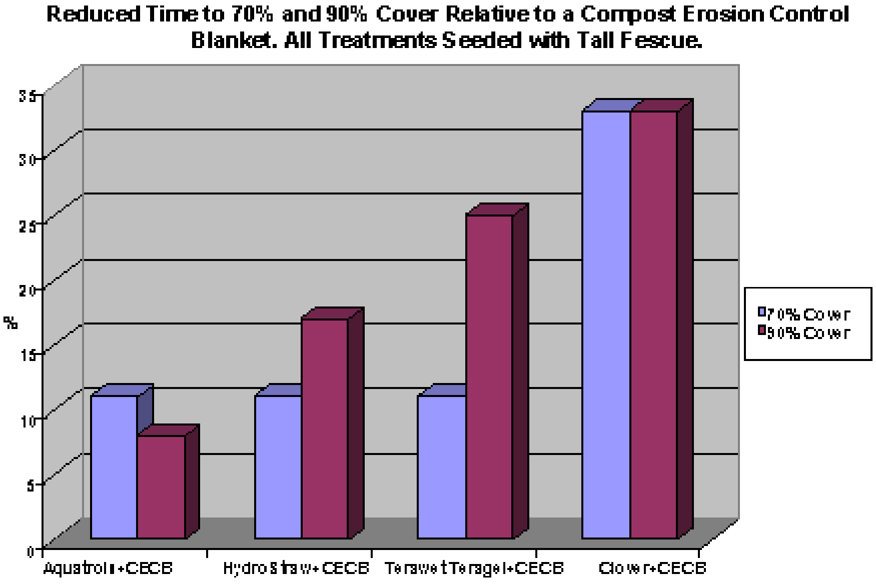
TechLink Research Summary #3315

Vegetation Enhancement for Filtrexx® Slope Protection

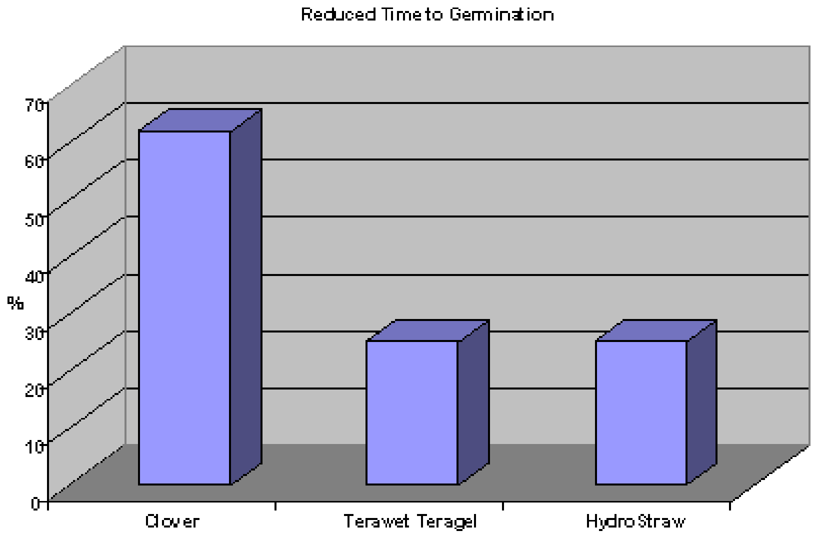
Construction and land disturbing activities where topsoil is cleared of vegetation are particularly subject to accelerated soil erosion. These areas often create a significant challenge to vegetation establishment for erosion control due to reduced soil quality and fertility. Arguably the best way to reduce runoff and stabilize soil is to establish permanent vegetation as quickly as possible. According to Brady and Weil (1996) densely grassed areas are nearly equal to forest ecosystems in preventing soil loss, which is why grasses are typically specified for soil stabilization for land disturbing activities (GA SWCC, 2002). Vegetation with dense foliage and cover can intercept between 5% and 40% of the total rainfall, thereby preventing it from contacting the soil surface and reducing splash erosion and runoff potential (Brady and Weil, 1996). Typically, construction sites must achieve a 70% uniform vegetative cover to pass post-construction close out requirements (Kentucky Erosion Prevention and Sediment Control Field Guide, 2005).

Although Filtrexx® Slope protection has been used effectively for permanent slope stabilization and vegetation establishment, this vegetation establishment practice can be challenging to keep moist in a drought prone summer season as well as arid and semi-arid regions. The dark color of the Filtrexx® Slope protection may contribute to increased evaporation during hot and dry conditions. Although Slope protection is high in organic matter and humus content, which are known to have high water holding capacities, a Filtrexx Support Practice™ that could further increase water holding capacity and water plant availability during peak hot and dry seasons may increase the survival and establishment potential of seeding applications, as well as potentially reduce irrigation requirements - particularly during the critical stage of plant establishment.

The following Filtrexx Support Practices™ can be added to Filtrexx® Slope protection to decrease the time to seed germination and time to 70% and 90% uniform vegetation cover, and above ground biomass of the mature vegetation. These Support Practices may also be used with any Filtrexx BMP where Filtrexx® GrowingMedia™ is specified, including Filtrexx® Temporary seeding, Storm water blankets, Runoff diversion, Channel protection, Bank stabilization, Engineered soils, Filter strips, Severe slope stabilization, and Vegetated retaining wall systems. The addition of one or a combination of these Support Practices™ can be critical if: 1. Rapid stabilization and/or vegetation establishment is important; 2. Contract and/or construction close-out phase is rapidly approaching or requires immediate completion; 3. A lush and healthy vegetation cover is important for aesthetics, stabilization, or sustainable erosion control.



*Evaluations performed at The University of Georgia Plant Pathology Greenhouse Complex. For the complete study see Vegetation Growth Evaluation with Compost, Mulch, and Support Practice™ Additives in the Appendix of the Filtrexx Design Manual.



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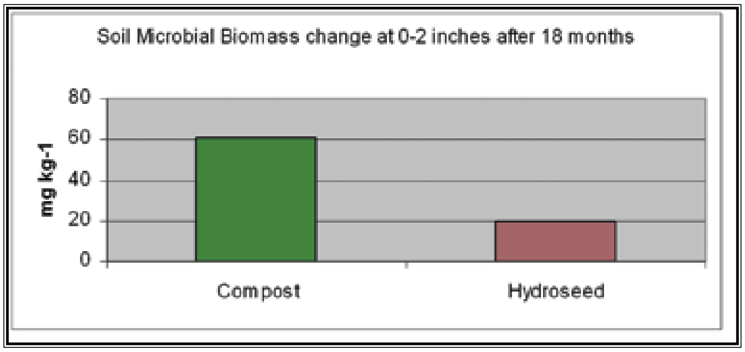
TechLink Research Summary #3316

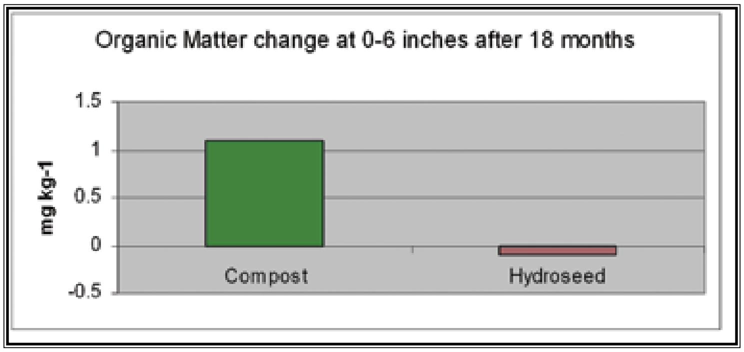
Soil Quality: A Comparison of Filtrexx® Slope Protection vs Hydroseed Applications

Change in Soil Microbes and Organic Matter

The application of the Filtrexx® Slope protection increased soil microbial biomass over 3x that of hydroseed at a depth of 0-2 inches after 18 Months.

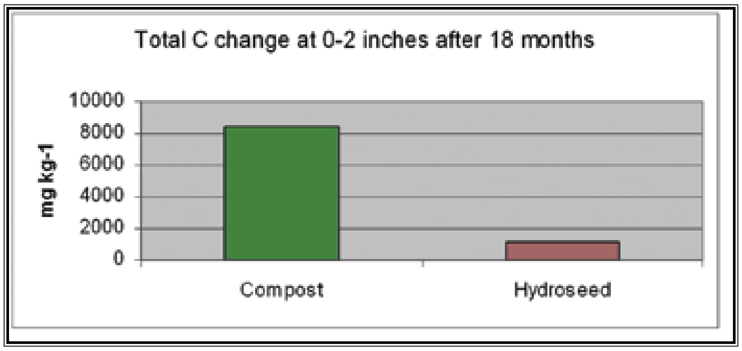


The application of Filtrexx® Slope protection increased soil organic matter by 0.1% while hydroseed applications showed a net loss in soil organic matter at a soil depth of 0 to 6 inches. Increasing soil organic matter is critical to improving soil structure and fertility, ensuring long-term healthy vegetation, and reducing runoff and erosion.

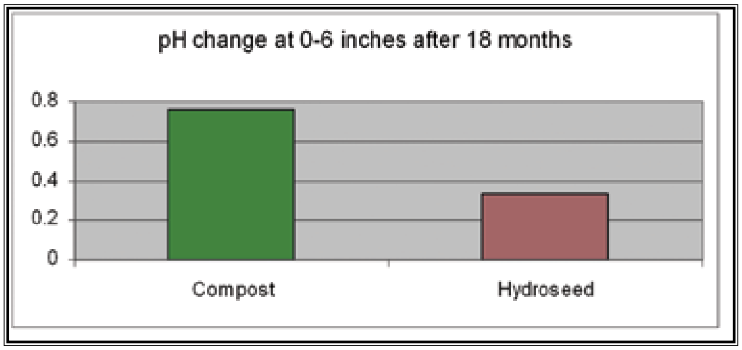


Change in Soil Carbon and pH

The application of Filtrexx® Slope protection increased soil carbon over 7x that of hydroseed over an 18 month period at a soil depth of 0 to 2 inches. Returning carbon to soil increases soil quality and reduces greenhouse gas emissions.

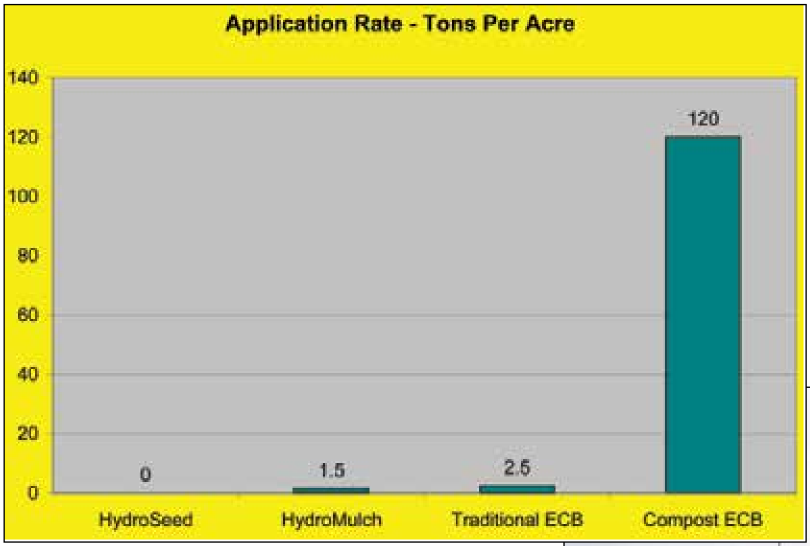


The application of Filtrexx® Slope protection increased soil pH (originally 4.7) over 2x that of hydroseed over 18 months - even though hydroseeding includes lime. Buffering soil pH to near neutral levels (6.0 - 7.0) can increase beneficial soil biota and availability of nutrients.



Summarized From: Faucette, L. Britt, Carl F. Jordan, L. Mark Risse, Miguel L. Cabrera, David C. Coleman, and Larry T. West. 2006. Vegetation and soil quality effects from hydroseed and compost blankets used for erosion control in construction activities. Journal of Soil and Water Conservation. 61:6:355-362.

Filtrexx® Slope protection significantly increased soil microbial carbon, relative to bare soil between 6 months and 18 months after applications. Similarly, Fraser et al. (1988) reported that organic amendments increased soil microbial biomass and total organic C. This gives evidence that unincorporated Slope protection may increase soil quality relative to erosion control measures that do not add organic matter to the soil. Soil microorganisms can increase nutrient cycling, increase nutrient availability to plants, improve soil structure through aggregate stability (Sylvia et al., 1999), increase overall soil biodiversity (Wardle, 2002), and degrade petroleum hydrocarbons (Alexander, 1994) commonly spilled during construction activities.



In addition to the differences in soil microbial carbon near the soil surface, the control showed a net loss of total carbon over the 18-month study period, whereas, all of the treatments showed a net increase. This is similar to Fraser et al (1988) findings, where increases in soil total organic C paralleled increases in soil microbial biomass. Furthermore, at 0 to 15 cm (0-6 in) soil depths, organic matter in the hydroseed and bare soil plots had net losses over the 18 month sampling period whereas, the Filtrexx® Slope protection all showed a net increase. Similarly, Sommerfeldt and Chang (1985) reported an increase in soil organic matter from 0-15 cm in a clay loam soil with addition of organic amendments. These slight differences may be the result of organic matter and C from the Filtrexx® Slope protection slowly being incorporated into the soil via microbial migration from the soil surface into the soil profile (Wardle, 2002). Soil quality improvements resulting from an erosion control application is a step forward to sustainably managing vegetation, storm water, and soil erosion.

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TechLink Research Summary #3317

Performance of Sediment Control Barriers on Construction Sites

Want to know which new sediment control barrier removes more sediment? Trying to decide which type of technology works better for removing suspended solids? Need to choose a sediment control barrier for your construction site or storm water pollution prevention plan where suspended solids may be an issue?

Silt Fence Failure: Accumulated sediment released in a mass failure

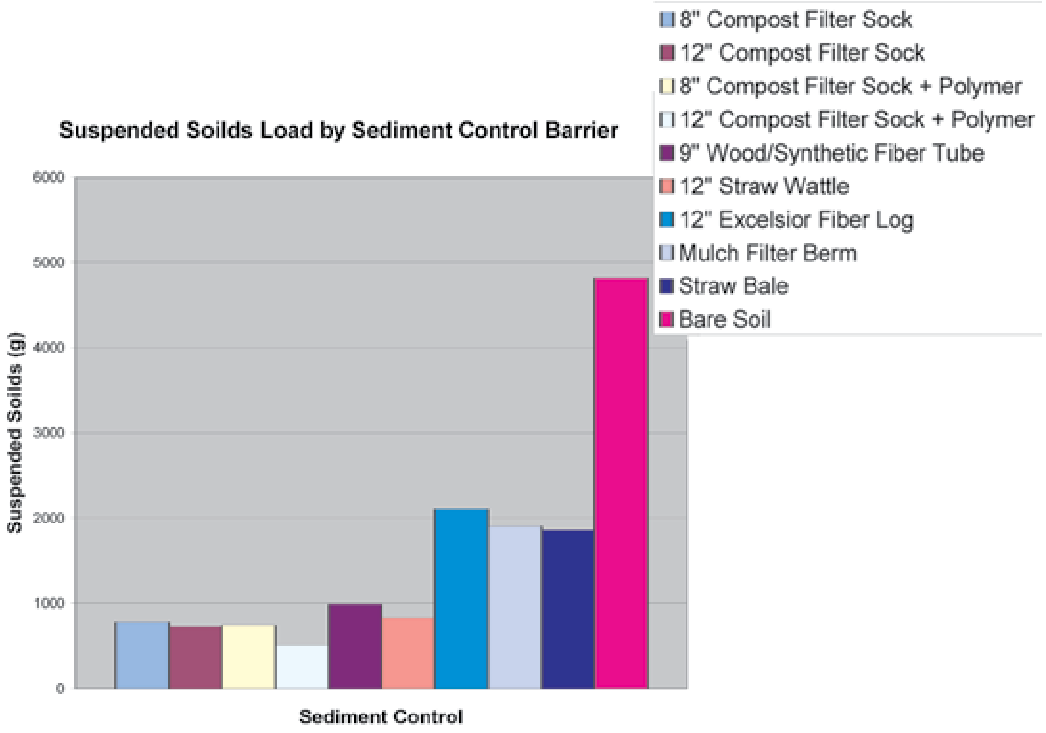
It is estimated that the national cost to society due to sedimentation of eroded soil is over $17 billion per year. As states begin to revise their erosion and sediment control and/or storm water management manuals to reflect new information and technology on best management practices (BMPs), many are requiring that erosion and sediment control practices meet a minimum performance standard. However, there is very little performance data in the research literature, despite a call for this information by environmental regulators and design professionals and the approval and inclusion of these new BMPs into state manuals. As an example, the effect from failing BMPs may generate a domino effect when accumulated sediment rinses out from behind a device after initial accumulation. This sudden surge of sediment previously held by the device has profound negative impacts on the environment and is rarely calculated. Additionally, 303d listed receiving waters/ watersheds under TMDL designation for sediment may require better performing sediment control management practices.

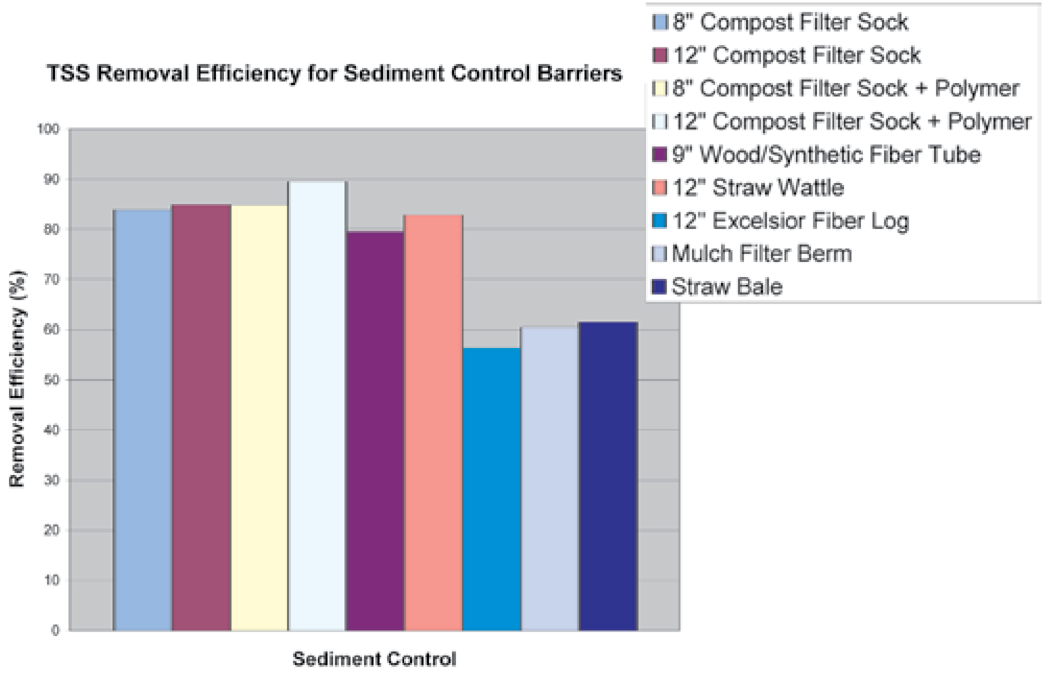
"Our Soxx™ Don't Fall Down": Accumulated sediment doesn't release; no mass failure

Rainfall simulation (Norton Rainfall Simulator with 4 variable speed V-jet oscillating nozzles obtained from the USDA ARS National Soil Erosion Research Lab) was used to produce a standard storm intensity of 12.5 cm (5.0 in) h-1 for a duration of 3 hrs and total rainfall of 37.5 cm (15.0 in). This is greater than the 1-hour storm event for a 100-year return and similar to a 24-hr 10-yr return for North Georgia. Site soil was classified as an eroded Pacolet Clay Loam to Sandy Clay Loam and has a soil erodibility factor (K value) of approximately 0.36. The testing area was cleared of vegetation and graded to a 10% slope exposing the subsoil (B horizon) to simulate construction site conditions without soil stabilization or erosion control best management practices.

Nine sediment control barriers were installed across the entire base-width of individual test plots. The control (bare soil) received no sediment control barrier. All treatments and the control were replicated in triplicate for a total of 30 test plots. Runoff sampling procedures and calculation methods followed procedures used for the Water Erosion Prediction Project (WEPP) developed by the USDA National Soil Erosion Research Lab. Total suspended solids were determined following methodology outlined by the US EPA.

Runoff total suspended solids load and removal efficiencies were evaluated for all sediment control treatments. The mean TSS load for bare soil for the 3 hr rainfall-runoff event 4819.2 g. Runoff suspended solids accounted for 70% of the total solids in the runoff. Typically, suspended solids are more difficult to remove from storm water runoff than the non-suspended solids fraction. Historically, sediment ponds and traps have been used to remove fine suspended solids instead of sediment control barriers such as silt fence. Mean TSS concentrations from the sediment control barriers ranged from 718.3 to 2264.0 mg/l, and TSS loads ranged from 506.4 to 2106.0 g. Removal efficiency for TSS load ranged from 56.3 to 89.5%. The following figures depict TSS loads and removal efficiencies for each of the sediment control barriers.


Suspended Soilds Load by Sediment Control Barrier


TSS Removal Efficiency for Sediment Control Barriers

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TechLink Research Summary #3318

A Comparison of Filtrexx® Slope Protection vs. Hydroseed Applications

Summarized From: Faucette, L. Britt, Carl F. Jordan, L. Mark Risse, Miguel L. Cabrera, David C. Coleman, and Larry T. West. 2006. Vegetation and soil quality effects from hydroseed and compost blankets used for erosion control in construction activities. Journal of Soil and Water Conservation. 61:6:355-362.

The objective of this study was to compare the vegetation establishment and long term growth characteristics of Filtrexx® Slope protection and hydromulch used in erosion control and slope stabilization applications.

Vegetative grass and weed growth analysis for each field plot was performed at 3 months and 12 months. Analysis included the percentage of total vegetative (grass + weeds) cover, total number of weed plants and different species, and above ground biomass of the vegetation. Grass and weed biomass analysis was only conducted at the end of the study.

Percent vegetative cover was measured using a one meter (3.3 ft) wide by 4.8 m (16 ft) long grid with string lines set 10 cm (4 in) apart on all sides. Vegetation was counted only if it was found directly under each intersect. A total of 480 intersects per plot were used in the calculation to obtain the percent cover.

Weeds (defined as any species other than Bermuda grass) may help control soil erosion but they are also regarded as a nuisance and undesirable in field applications. The total number of different weed species and the total number of weed plants were counted for each plot at three months and twelve months. Total number of weed species and number of plants were low enough at three months to manually count and identify for the plot as a whole. At twelve months, a grid measuring 9.3 dm2 (1 ft2) was randomly placed once in each third of each field plot to sub-sample number of weed species, number of weeds and percent cover of weeds (i.e. excluding Bermuda grass). The sub-samples were averaged to obtain a composite for each plot. Composite samples for biomass analysis were harvested using a 9.3 dm2 (1 ft2) sampling area replicated three times, once in each third of each plot. Vegetation was clipped and harvested at the soil surface. Harvested biomass was sorted into weed biomass and Bermuda grass biomass, and then oven dried separately. Biomass was calculated as dry weight divided by the area. The addition of the weed biomass and Bermuda grass biomass were used to calculate the total biomass.

Percent cover

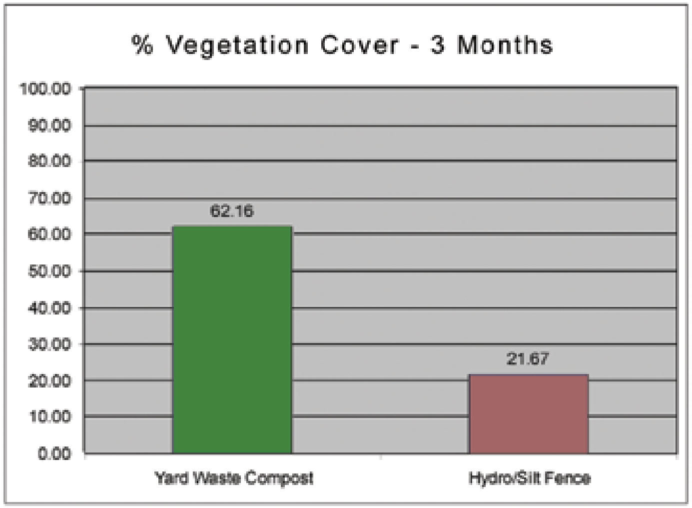
Although the control was not seeded, there was no statistical difference between the control and the hydroseed treatments; however, the Filtrexx® Slope protection treatments had significantly more vegetation cover than the hydroseed treatments. The compost treatments averaged 2.75 times more vegetation cover than the hydroseed treatments. Prior to plant establishment, it was likely that a greater proportion of seed washed down the slope during rain events in the hydroseed treatments, relative to the Filtrexx® Slope protection, as runoff volume and rate were higher in the hydroseed treated plots (Faucette et al., 2005). Percent cover results for all treatments at three months were lower than expected due to drought conditions over the 3-month time period (90.7 mm of rain). The greater percent cover observed on the compost treatments was likely due in part to their ability to hold more moisture (or restrict evaporation) than the hydroseed. This can be critical to plant growth during periods of drought, as experienced during the three months leading up to the first vegetation analysis.

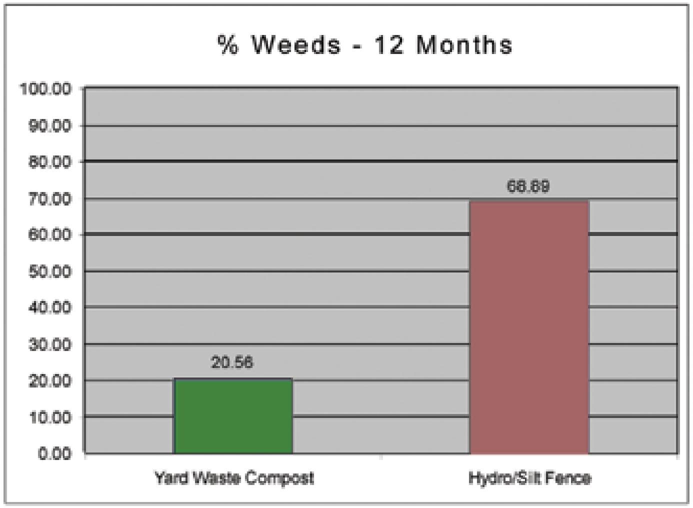
Above Ground Biomass

Above ground biomass samples were harvested in May of 2003, 12-months after the test plots were seeded. Although there were no differences between treatments for biomass of Bermuda grass, weed biomass was significantly higher in the hydroseed treatments relative to the compost treatments and the control. Similarly, Richard et al. (2002) reported that seeded Filtrexx® Slope protectionhad significantly less weed biomass than seeded topsoil or bare soil although the biomass of planted species was the same. The slow establishment of the bermuda grass on hydroseeded plots, relative to the compost plots, may have enabled more weeds to establish and proliferate. Additionally, the 1.5 in Slope protection acted as a mulch layer, physically suppressing and therefore preventing potential weed seeds in the soil from emerging through the compost. This provides evidence that Slope protection may suppress weed growth, relative to hydroseed.

Mineral N can have a positive affect on weed growth and proliferation, and although not directly tested in this study, it may partly explain why the hydroseed plots had significantly more weed growth than the bare soil.

On construction sites where disturbed soils are prone to erosion and vegetation establishment is required, compost applications will provide a greater vegetation cover and less invasive weed growth, relative to hydroseeding. These results indicate that Filtrexx® Slope protection may provide better erosion control in slope stabilization applications where vegetation establishment is required for post construction areas. Additionally, if exotic or invasive weeds are a concern, Slope protection should be considered instead hydroseeding.





After a period of 3 months, yard waste compost produced nearly 3 times the vegetation than hydroseeding and silt fence

After 12 months, Yard Waste Compost had 70% less weeds than hydroseed and silt fence.

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TechLink Research Summary #3320

Stormwater Runoff, Infiltration and Erosion: Filtrexx® Slope Protection vs Hydroseed Applications

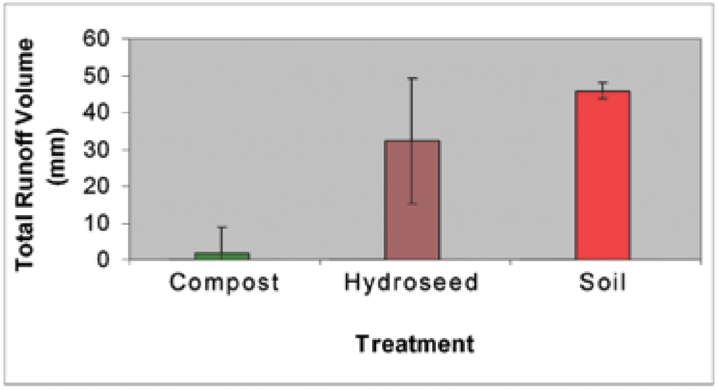
Summarized From: Faucette, L. Britt, Carl F. Jordan, L. Mark Risse, Miguel L. Cabrera, David C. Coleman, and Larry T. West. 2006. Vegetation and soil quality effects from hydroseed and compost blankets used for erosion control in construction activities. Journal of Soil and Water Conservation. 61:6:355-362.

Storm Water Runoff, Infiltration, and Erosion

The objective of this study was to evaluate the storm water characteristics and soil loss from Filtrexx® Slope protection and hydroseed applications to soils disturbed by construction activities. The soil was classified as an eroded Pacolet Sandy Clay Loam. The testing area was cleared of vegetation and uniformly graded to a 10% slope with a grading blade mounted skid steer, exposing a semi-compacted (from the skid steer) subsoil (Bt horizon) to simulate construction site conditions on 48 m2 test plots. Each treatment, excluding the control, was seeded during treatment application with a 1:1 mix of hulled and unhulled Common Bermuda (Cynodon dactylon) grass seed as specified for erosion control by the Georgia Department of Transportation. Three simulated storm events were conducted over 1 yr. A Norton Rainfall Simulator with 4 variable speed V-jet oscillating nozzles was used to simulate rain events within an intensity of 7.75 cm (3.1 in) h-1 for 1 hr duration - equivalent to a 50-year return.

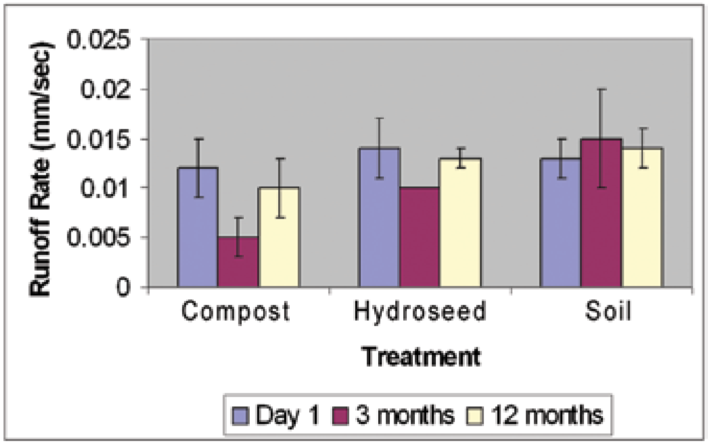
Under a rainfall simulation of 3.1 inches/hr for one hour duration, hydroseed produced over 16x more stormwater runoff than the compost blanket after 3 months. More runoff often means more soil erosion.

Total Runoff Volume - 3 Months



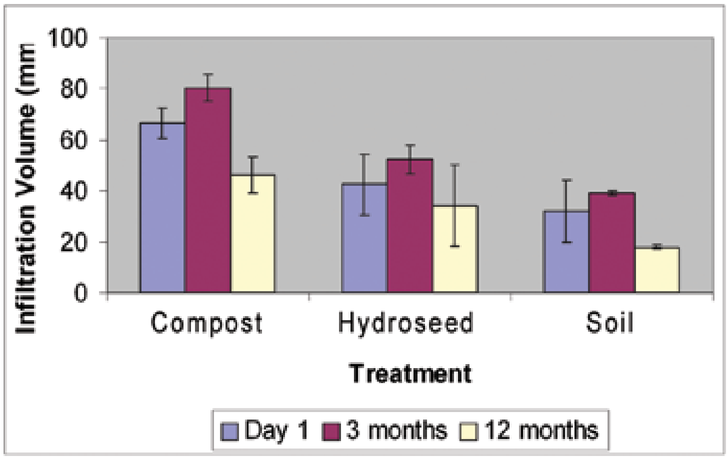
Under the same rainfall intensity and duration throughout a 12 month period, the compost blanket showed reduced runoff rates compared to hydroseed for all storm events. Lower runoff rates are less erosive to soil surfaces.

Peak Runoff Rate

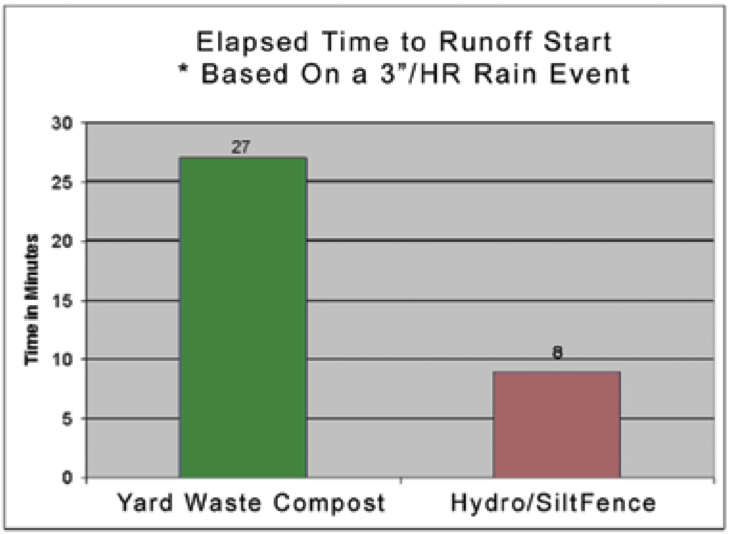


Infiltration Volume

Under the same rainfall intensity and duration averaged over a 12 month period, the compost blanket infiltrated 33% more rainwater than hydroseeding. Greater infiltration means less runoff.



Compost Performs 3x Better than Hydroseed



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TechLink Research Summary #3321

Nutrient Runoff: A Comparison of Filtrexx® Slope Protection vs Hydroseed Applications

Summarized From: Faucette, L. Britt, Carl F. Jordan, L. Mark Risse, Miguel L. Cabrera, David C. Coleman, and Larry T. West. 2006. Vegetation and soil quality effects from hydroseed and compost blankets used for erosion control in construction activities. Journal of Soil and Water Conservation. 61:6:355-362.

Nutrient Runoff

The objective of this study was to evaluate the water quality impact from Filtrexx® Slope protection and hydroseed applications to soils disturbed by construction activities. The soil was classified as an eroded Pacolet Sandy Clay Loam. The testing area was cleared of vegetation and uniformly graded to a 10% slope with a grading blade mounted skid steer, exposing a semi-compacted (from the skid steer) subsoil (Bt horizon) to simulate construction site conditions on 48 m2 test plots. Each treatment, excluding the control, was seeded during treatment application with a 1:1 mix of hulled and unhulled Common Bermuda (Cynodon dactylon) grass seed as specified for erosion control by the Georgia Department of Transportation. Three simulated storm events were conducted over 1 yr. A Norton Rainfall Simulator with 4 variable speed V-jet oscillating nozzles was used to simulate rain events within an intensity of 7.75 cm (3.1 in) h-1 for 1 hr duration - equivalent to a 50-year return.

Because hydroseed is applied with inorganic N and soluble P it is more likely that these nutrients will be lost to storm runoff and consequently are in forms more available to aquatic plants which leads algae growth, eutrophication, and impaired water quality.

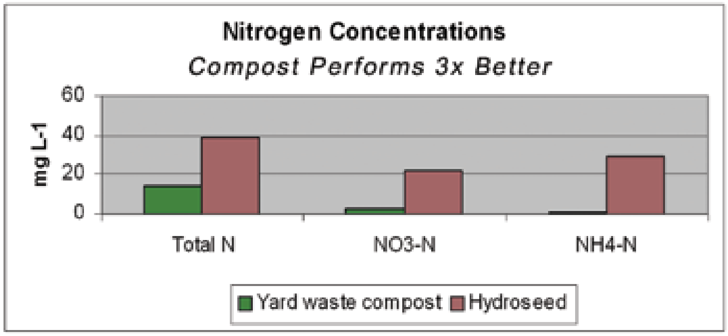
Nitrate-N loading to water bodies can also be toxic to aquatic and terrestrial animals, including humans. Mass loading of total P and dissolved P from hydroseed was significantly greater than Filtrexx® Slope protection. The potential for high losses of P from hydroseeding applications needs to be addressed by the policy and regulatory community, particularly since it is one of the most ubiquitous erosion control/vegetation establishment best management practices (BMPs) in the United States. Erosion control materials high in nutrients, particularly nutrients in soluble and inorganic forms, increase the risk of nutrients entering water bodies; although, because compost can significantly reduce runoff and nutrients are in organic form, nutrient loads are often lower from these BMPs relative to stabilization and vegetation establishment practices. This may be of particular concern where erosion control/ vegetation establishment is needed near surface waters, storm inlets, storm channels/ditches, wetlands, or TMDL listed watershed/water bodies.

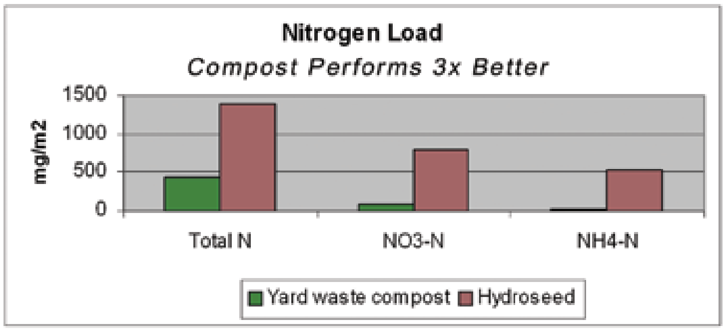
Nitrogen Concentrations and Loads

Total nitrogen runoff concentration of the compost blanket was approximately 1/3 that of hydroseed.

Nitrate-N concentration in the compost blanket runoff was less than 1/8 that of hydroseed.
[Note: the US EPA limit for drinking water is 10 mg/L.]

Total N load (concentration x runoff volume) from the compost blanket was approximately 1/3 that of hydroseed; nitrate-N load from the compost blanket was approximately 1/9 that of hydroseed and ammonium-N load from the compost blanket was approximately 1/20 that of hydroseed.

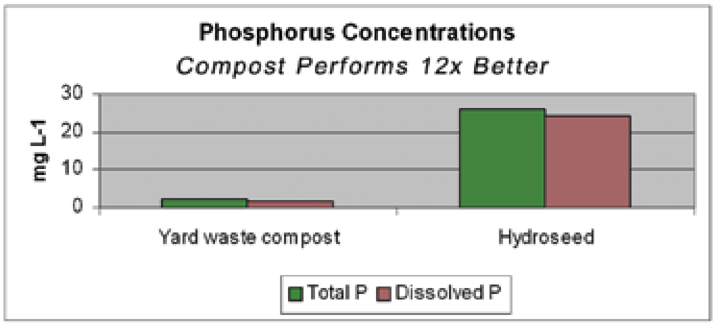


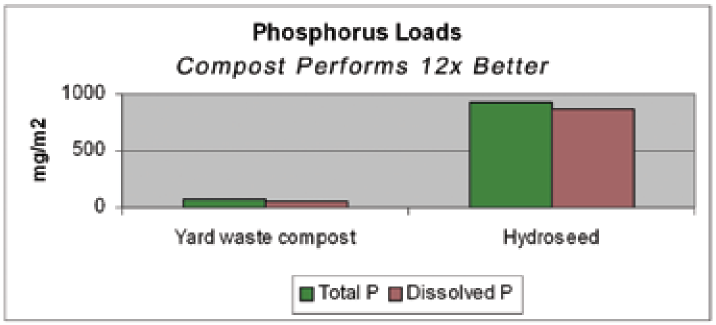


Phosphorus Concentrations and Loads

Total phosphorus runoff concentration of the compost blanket was less than 1/12 that of hydroseed for both total and dissolved phosphorus.

Phosphorus loads (concentration x runoff volume) in the runoff from the compost blanket plots were less than 1/12 that of hydroseed for both total and dissolved phosphorus. Phosphorus loading is a major source of eutrophication and one of the leading causes of water quality impairment.





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TechLink Research Summary #3322

Phosphorous Reduction Using Compost

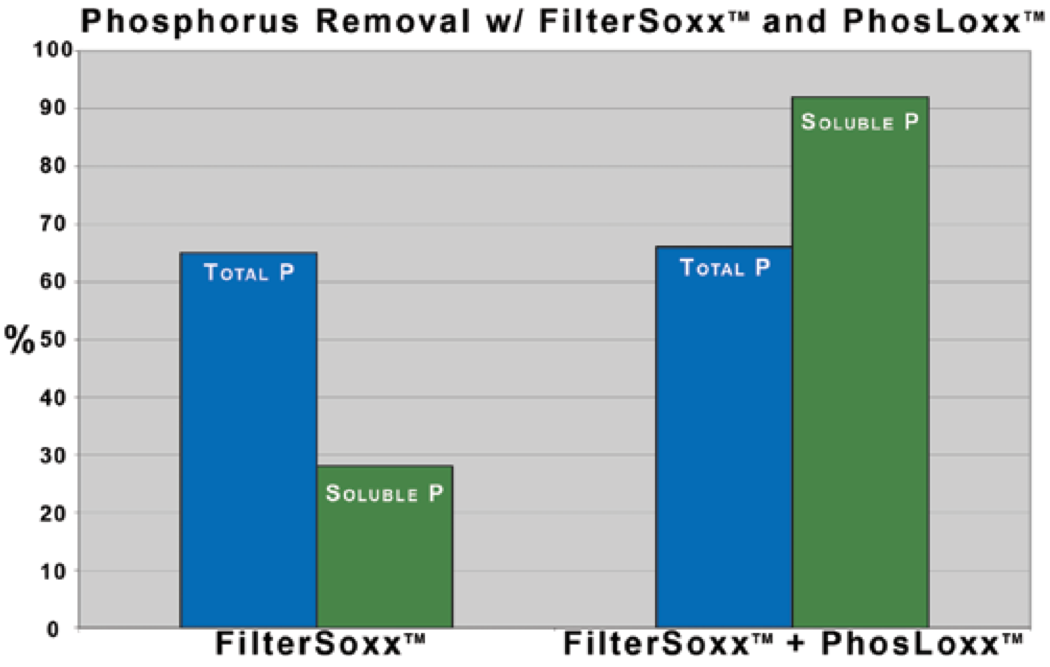
Phosphorus (P) is an essential nutrient to plants in land based ecosystems. While P is essential to terrestrial plant growth it is often a pollutant in fresh water ecosystems. As this nutrient is typically the 'limiting nutrient' to plant growth in fresh water systems (such as nitrogen is to plants on land based ecosystems) a small amount of P loading to a water body can elicit a rapid growth response by algae. Although P is not toxic to humans or aquatic organisms, once algae blooms occur in an aquatic ecosystem, the microbial decomposition of the algae causes aquatic microbes to utilize a higher percentage of the dissolved oxygen in water, thereby causing fish and other aquatic organisms to suffocate and ultimately die, often in large numbers. This process is called eutrophication.

Additionally, algae growth can blanket the surface of a water body, thereby reducing sunlight penetration through the water, resulting in reduction of photosynthesis to aquatic plants under the surface. These aquatic plants are often habitat and/or food source for other aquatic organisms in the food web and without them can lead to mortality of certain aquatic organisms or even whole trophic levels.

Phosphorus enters surface waters typically through non-point source storm water runoff. It is either attached to sediment particles (particulate or sediment-P) or free-floating in the runoff water solution (dissolved or soluble-P). Sediment-P runoff is typically higher where soils are disturbed, such as construction sites, while soluble-P is higher where land surfaces have been recently fertilized or where storm water volumes are high due to prevalent impervious surfaces in the watershed - such as parking lots, highways, and roof tops.

Reducing P loads from runoff can be done by source reduction, reducing runoff volume (through infiltration or containment practices such as bioretention, engineered soils, and green roofs), or filtration (by physical means for sediment-P and chemical means for soluble-P).

Total phosphorus concentration limits generally applied to wastewater treatment plant discharges are 5 mg L-1 (5 ppm) and typical storm water runoff concentration is approximately 0.4 mg L-1 (0.4 ppm). The critical concentration of total P (sediment-P + soluble P) in streams at which eutrophication is triggered is 0.10 mg L-1 (0.10 ppm), and 0.03 mg L-1 (0.03 ppm) for soluble P (Brady and Weil, 1996). Soluble P entering surface water is of particular concern because it is often bio-available to aquatic plants for immediate uptake, leading to increased risk of eutrophication, while sediment-P is not readily available for plant uptake (but can become available over time). Total annual loss of nitrogen, phosphorus and potassium due to soil erosion in the US is estimated to be over 38 million Mg (42 million tons). It is estimated that the annual cost to society for on-site loss of soil and nutrients due to soil erosion is over $27 billion per year (Brady and Weil, 1996).



Total maximum daily load (TMDL) - Section 303(d) of the US Clean Water Act, 'listed streams' for phosphorus have become increasingly common in recent years as over 5600 water bodies have been labeled as nutrient impaired and over 3500 have been approved as TMDL listed water bodies for nutrients since 1995 (US EPA, 2007). While erosion and sediment control BMPs may reduce sediment-P, they do little to reduce soluble-P in storm runoff. Additionally, when soil becomes detached and in contact with water, sediment-P can quickly become desorbed, thereby transforming into soluble-P (Westermann et al. 2001). In order to improve receiving water quality, and in particular to meet TMDL requirements for phosphorus, BMPs should be developed to reduce soluble-P loading to streams. Soluble-P is more reactive, or bioavailable, relative to sediment-P to aquatic plants; therefore, it is more likely to cause algae blooms and eutrophic conditions contributing to the degradation of our nation's surface waters.

Filtrexx Phosphorus Solutions

FilterSoxx™:

Filtrexx® FilterSoxx™ provide a physical means to filter P from storm water, while Filtrexx® Nutrient agent adds a chemical binding component by flocculating soluble P ions in water. According to the USDA Agricultural Research Service (USDA ARS), standard Filtrexx® FilterSoxx™ remove 65% of total P and 27% of soluble P from storm water runoff on disturbed or bare soils. By adding Filtrexx® Nutrient agent, the removal efficiency of soluble P increases to 92%. Experimental conditions included runoff-sediment concentrations of 60,000 mg/L, runoff total P concentration of 82 mg/L, soluble P concentration of 37 mg/L, a 10% slope, exposed to 30 minutes of simulated rainfall at 3.4 in/hr (8.5 cm/hr) (Sadeghi, 2006). Filtrexx® FilterSoxx™ utilizing Filtrexx® FilterMedia™ include: Filtrexx® Sediment control, Inlet protection, Check dams, Concrete washouts, Filtration systems, Sediment traps, and Slope interruption.

Filtrexx® Slope protection & Storm Water Blankets:

Filtrexx® Slope protection and Storm water blankets reduce P loading through runoff volume reduction and because plant nutrients are in organic form - a form less mobile under storm runoff conditions relative to fertilizers typically used in traditional seeding and hydromulching applications. According to the University of Georgia (UGA) Filtrexx® Slope protection and Storm water blankets can reduce total P and soluble P loading in runoff by over 80% relative to hydroseed and hydromulch applications used in seeding and vegetation establishment (Faucette et al, 2005). See Filtrexx TechLink #3321 for more information on how these technologies reduce nutrient loading in storm water runoff.

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SUSTAINABLE TECHNOLOGIES

TechLink Research Summary #3323

Hydraulic Performance & Design for Channel Lining and Stream Bank Stabilization Using Low Impact Development Design Strategies

The Texas Transportation Institute (TTI) of Texas A&M University recently tested Filtrexx® Channel protection and Bank stabilization products for hydraulic performance as flexible channel liners under open channel flow conditions using ASTM Standard Test Method D-6460. The test is designed to determine the maximum hydraulic shear stress (lbs/ft2 or kg/m2) which flexible vegetated channel liners can withstand prior to an average ½ in (1.25 cm) of soil loss across the channel bed area. This soil loss threshold represents the point at which the planted seed bed within the channel has eroded and can no longer support vegetation establishment. Channel liner products are exposed to successional shear stress pressures of 2 lbs/ft2 (10 kg/m2), 4 lbs/ft2 (20 kg/m2), 6 lbs/ft2 (29 kg/m2), 8 lbs/ft2(39 kg/m2), 10 lbs/ft2 (49 kg/m2), and 12 lbs/ft2 (59 kg/m2) to determine product failure points on a 10% channel slope. Soil loss thresholds determined by TTI are 350 lbs/100 ft2 (17.1 kg/m2), 500 lbs/100 ft2 (24.4 kg/m2), 620 lbs/100 ft2 (30.2 kg/m2), 800 lbs/100 ft2 (39.0 kg/m2), 1180 lbs/100 ft2 (57.5 kg/m2), and 1200 lbs/100 ft2 (58.5 kg/m2) for each of the 6 shear stress test values, respectively. Of 60 flexible channel liner products tested and reported by TTI and the Texas Department of Transportation (TX DOT), only 7 other products have been rated for the maximum shear stress category reported by TTI of 12 lbs/ft2 (59 kg/m2).

Table 1. Testing Parameters and Results from Performance Testing by TTI.

Filtrexx Material	Vegetation type	Shear stress	Velocity	Flow rate	Water depth	Soil loss-limit	Soil loss-Filtrexx
SafetySoxx™ with MFPP LockDown™ Netting wrap	Triple rye	2 lbs/ft2 (10 kg/m2)	3.1 ft/sec (0.9 m/sec)	93 cfm (2.6 m3/min)	4 in (10 cm)	350 lbs/100 ft2 (17.1 kg/m2)	97 lbs/100 ft2 (4.7 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Triple rye	4 lbs/ft2 (20 kg/m2)	8.7 ft/sec (2.7 m/sec)	522 cfm (14.8 m3/ min)	8 in (20 cm)	500 lbs/100 ft2 (24.4 kg/m2)	183 lbs/100 ft2 (8.9 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Triple rye	6 lbs/ft2 (29 kg/m2)	11.75 ft/sec (3.6 m/sec)	1013 cfm (28.7 m3/ min)	11.5 in (29 cm	620 lbs/100 ft2 (30.2 kg/m2)	259 lbs/100 ft2 (12.6 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Triple rye	8 lbs/ft2 (39 kg/m2)	12.95 ft/sec (3.9 m/sec)	1506 cfm (42.6 m3/min)	15.5 in (39 cm)	800 lbs/100 ft2 (39.0 kg/m2)	476 lbs/100 ft2 (23.2 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Common Bermuda+ Green Sprangletop	2 lbs/ft2 (10 kg/m2)	3.1 ft/sec (0.9 m/sec)	93 cfm (2.6 m3/ min)	4 in (10 cm)	350 lbs/100 ft2 (17.1 kg/m2)	1 lbs/100 ft2 (0.5 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Common Bermuda+ Green Sprangletop	4 lbs/ft2 (20 kg/m2)	8.7 ft/sec (2.7 m/sec)	522 cfm (14.8 m3/min)	8 in (20 cm)	500 lbs/100 ft2 (24.4 kg/m2)	55 lbs/100 ft2 (2.7 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Common Bermuda+ Green Sprangletop	6 lbs/ft2 (29 kg/m2)	11.75 ft/sec (3.6 m/sec)	1013 cfm (28.7 m3/ min)	11.5 in (29 cm)	620 lbs/100 ft2 (30.2 kg/m2)	127 lbs/100 ft2 (6.2 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Common Bermuda+ Green Sprangletop	8 lbs/ft2 (39 kg/m2)	12.95 ft/sec (3.9 m/sec)	1506 cfm (42.6 m3/ min)	15.5 in (39 cm)	800 lbs/100 ft2 (39.0 kg/m2)	177 lbs/100 ft2 (8.6 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Common Bermuda+ Green Sprangletop	10 lbs/ft2 (49 kg/m2)	13.85 ft/sec (4.2 m/sec)	1974 cfm (55.9 m3/ min)	19 in (48 cm)	1180 lbs/100 ft2 (57.5 kg/m2)	231 lbs/100 ft2 (11.2 kg/m2) **PASS**
SafetySoxx™ with MFPP LockDown™ Netting wrap	Common Bermuda+ Green Sprangletop	12 lbs/ft2 (59 kg/m2)	14.45 ft/sec (4.4 m/sec)	2493 cfm (70.6 m3/ min)	23 in (58 cm)	1200 lbs/100 ft2 (58.5 kg/m2)	267 lbs/100 ft2 (12.9 kg/m2) **PASS**

**Based on 10% Slope, and Unit Weight of Water = 62.4 lbs (28.3 kg)*

What is hydraulic shear stress?

Shear stress is the tractive or frictional force exerted by moving water across a plane or channel bed, or in this case a channel liner. In design considerations for channels and streams banks shear stress is recommended over flow velocity principally because it accounts for depth of flow, slope angle, and water weight variables that contribute to the pressure exerted on the channel bed, bank, or liner. In a straight channel, the channel bed experiences more shear stress than the banks, therefore, in this standard test method the channel liner is only installed on the channel bed with the understanding that if it can withstand the tractive force along the bed it can withstand the force along the walls. It is important to note that this test method is not designed to determine failure of the channel liner from dislodgement, rupture, or destruction (although these occurrences would certainly result in a product failure under this particular test method), but to determine the point at which vegetation can no longer be established due to excessive erosion of the seed bed underneath or within the channel liner. Unlike some flexible channel liners, the Filtrexx system encapsulates the growing media and the root structure of the vegetation, thereby preventing erosion of the seed bed and root zone, which ensures stability and sustainability of the vegetation. Designers can use the maximum shear stress value to determine if a particular product is designed to withstand potential shear forces that may be exerted in a given channel, ditch, conveyance system, or stream bank. As an alternative, some designers may use the maximum hydraulic velocity value to rate the performance capacity of a given channel liner or bank stabilization management practice, although this is not recommended. Table 1 describes the testing parameters and results from performance testing conducted and reported by the Texas Transportation Institute at Texas A&M University and the Texas Department of Transportation.

What is Manning's equation and Manning's n roughness coefficient?

Manning's equation is commonly used to analyze and simulate water flows in open channel systems and culverts. Manning's roughness coefficient (n) is the value given to a material surface used to convey water, or where water is transported via sheet flow or concentrated flow. Typically the lower the Manning's n coefficient the smoother the material surface. For example, PVC pipe has a Manning's n of 0.01 and clay tile has a Manning's n of 0.014, while a densely wooded floodplain has a Manning's n of 0.15 (LMNO, 2000). Additionally, the rougher the surface, typically the greater the propensity to slow water flow, increase infiltration, and reduce erosion. Rougher surfaces are part of Low Impact Development (LID) design strategies and also tend to Mimic Nature™. Contained in Table 2 are Manning's n roughness coefficients for non-vegetated and vegetated Filtrexx® Channel protection and Bank stabilization products. Note that the roughness coefficient value is more a function of the vegetation type, establishment phase, and density rather than the Filtrexx® Channel protection or Bank stabilization product alone.

Table 2. Manning's n Roughness Coefficients for Filtrexx® Channel Protection and Bank Stabilization

Vegetated Characteristic of Soxx™	**Manning's n (roughness coefficient)**
No Vegetation	0.022
Grass Only	0.035
Grass + Live Stakes (young or sparse)	0.05
Grass + Live Stakes (mature or dense)	0.075

References

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SUSTAINABLE TECHNOLOGIES

TechLink Research Summary #3324

Filtrexx International's Carbon Reduction and Climate Change Mitigation Efforts

Global climate change has been linked to increased emissions of carbon-based gases, such as carbon dioxide and methane, that result from combustion of carbon-based fossil fuels, deforestation, and emissions from landfills, feedlots, and rice paddies. Global climate change has the potential to have catastrophic affects on local climate patterns and natural resources and is predicted to significantly increase sea levels, storm intensities, flooding, and drought conditions; as well as significantly alter wildlife habitat, agricultural planting zones, major ocean currents, biodiversity, and even whole ecosystems.

While the affects of climate change may be difficult to reverse, there are ways to potentially slow and mitigate climate change through reduction in carbon gas emissions and carbon sequestration. Additionally, innovative products and management practices can be employed to reduce the harmful effects to the global environment created by climate change.

Reduction of Carbon Emissions

Landfills are the leading source of methane in the United States. Methane is 20-25 times more concentrated than carbon dioxide as a greenhouse gas. Methane from landfills is principally generated from the organic fraction of waste materials that are deposited into our nation's landfills. While capture of methane emissions for energy conversion and combustion are classified as practices that reduce methane emissions and qualify for carbon credit trading scenarios, Filtrexx International partners with private and municipal landfills and composting operations to prevent organic waste from reaching landfills. Once diverted, the organic waste is naturally bio-converted to compost, a process that does not generate methane as a byproduct, thereby preventing (rather than treating) the generation of methane from the leading source in the United States.

Filtrexx International is the leading user of composted organic waste materials in the United States, using over 2,000,000 yds3/yr (1,000,000 tons/yr) of compost, equating to approximately 4,000,000 yds3/yr (4,000,000 tons/yr) of organic waste diverted from national and international landfills. How much methane gas is prevented by diverting this organic waste? One ton of organic waste generates approximately 196 yd3 of landfill gas, which is approximately 63% methane (124 yd3 or 64 kg of methane [some estimates are as high as 170 kg]) (Sakai, 2007). Therefore, 4,000,000 tons/yr of organic waste diverted from landfills prevents approximately 256,000 tons/yr of methane from entering the atmosphere. Once converted to the global warming potential in carbon dioxide equivalents this accounts to approximately 5,120,000 tons of CO2e/yr.

Carbon Sequestration

Carbon sequestration is the act of removing carbon dioxide from the atmosphere and storing the carbon in carbon sinks, such as oceans, plants and other organisms that use photosynthesis to convert carbon from the atmosphere into biomass. Forest ecosystems and permanent grasslands are prime examples of terrestrial carbon sinks that sequester carbon. Filtrexx International, through its erosion control, land reclamation, vegetation establishment and ecosystem enhancement programs, is responsible for approximately 7,500 acre/yr of permanent grass seeding using compost based technologies. The carbon sequestration rate for permanent grassing for the Western US = 0.4 tons/ac/yr of CO2; and for the Eastern and Midwestern US = 1.0 tons/ac/yr of CO2 (Chicago Climate Exchange, 2008). Ten percent (750 ac/yr) of Filtrexx International's application of permanent grass seeding is applied in the Western US, 90% (6,750 ac/yr) of permanent grass seeding applications are in the Midwest and Eastern US. Total carbon sequestered per year (tons/yr CO2) = 300 ton/yr in the Western US + 6,750 tons/yr in the Midwest and Eastern US, which equates to 7,050 tons of CO2e/yr.

In addition to the carbon sequestered through permanent grass plantings, Filtrexx International applies approximately 1,000,000 tons/yr of compost to terrestrial ecosystems and landscapes around the world through over 20 different environmental management practices and green products. These products are typically left on and in the soil, and are generally converted to stable soil carbon. Compost is typically 12.5% carbon (wet basis). This equates to approximately 125,000 tons of C/yr.

Environmental Management Under Global Climate Change

Filtrexx International's compost based products and management practices have been researched, developed, and utilized in applications to: 1) reduce the effects of increased storm water quantity and localized flooding through collection and infiltration technologies; 2) limit the effects of increased pollutant transport, decreased storm water quality, and degraded surface water quality through storm water volume reduction, filtration, and vegetation establishment and sustainability technologies; 3) protect and restore wildlife habitat and biodiversity through soil and plant ecosystem reclamation and sustainability applications; 4) reduce urban heat island effects, thereby reducing energy demand; 5) reduce transportation to end users, thereby reducing petroleum use and carbon dioxide emissions; 6) increase use of locally available materials and resources, thereby reducing energy demand from extraction and transportation; 7) increase use of bio-based materials, thereby reducing petroleum and other non-renewable resource use and demand; 8) protect against failure of levees and sand dunes, thereby preventing severe flooding; 9) improve crop and plant survivability during drought periods through increased water holding capacity; and 10) reduce water and irrigation demand during periods of mandated water conservation, prolonged drought, and drought prone regions.

Conclusion

The extent to which global climate change will affect society, economics, resources, culture, and our shared environment is widely debated and ultimately unknown. Filtrexx International recognizes that climate change is a reality and is doing its part to reduce carbon emissions, sequester carbon from the atmosphere, and provide green products and services that will mitigate the negative effects of climate change while also strengthening the sustainability, functionality, and resiliency of our ecosystems, the natural resources they provide, and the natural capital in which we all depend.

Filtrexx International is committed to reducing its overall carbon footprint towards a corporate goal of total carbon neutrality, as well as continually creating innovative new products and management practices to mitigate the negative effects of climate change on the environment across the globe. Filtrexx International is employing these technologies and applying its corporate goal in the United States, Canada, Japan, Australia, New Zealand, and the European Union.

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TechLink Research Summary #3325

Removal of Urban and Post-Construction Storm Water Pollutants with Filtrexx® Treatment Train™

Did you think Filtrexx® Sediment control was only used for sediment control on construction sites? Although Sediment control is most commonly used for this application, scientific evidence is showing that the benefit to using Filtrexx® FilterMedia™ filled Sediment control goes far beyond simple sediment control. Recent research is showing that this eco-friendly technology has the ability to filter soluble pollutants typically found in storm water flows originating from urban and suburban post-construction surfaces, such as roadways, parking lots, and roof tops (Faucette and Tyler, 2006; Faucette et al., 2006). The humus fraction of FilterMedia™ has the ability to chemically adsorb free ions, such as soluble phosphorus (P) and ammonium nitrogen (N) (Brady and Weil, 1996). The USDA ARS (Sadhegi et al., 2006) recently reported removal efficiencies for FilterSoxx™ between 14 and 28% for soluble P, and between 1 and 17% for nitrite-nitrate N. Faucette and Tyler (2006) also reported minor removal concentrations between 1 and 7 mg L-1 for nitrate-N and total P, and motor oil removal efficiencies between 85 and 99% when initial runoff concentrations of motor oil ranged between 1,000 and 10,000 mg L-1.

In 1998, the US EPA national water quality assessment stated 35% of streams were found to be severely impaired while nearly 75% of the US population lives within 10 miles of an impaired water body (US EPA, 2007). In response, as part of the 1972 Clean Water Act the US EPA has frequently listed streams for Total Maximum Daily Load (TMDL) designation for specific pollutants. Since 1995, pathogens (5081 listed), metals (5054 listed), and nutrients (3511 listed) have been the three most frequently cited TMDL water impairing pollutants, respectively; and additionally are the number one (8913 cases), fourth (6473 cases) and fifth (5625 cases) leading causes of impaired water quality (US EPA, 2007). Non-point sources of thse pollutants are generally the most difficult to control. Source examples include storm runoff from impervious services such as parking lots, roadways, and rooftops in urban and suburban areas. In disturbed soils, where soils are prone to detachment and transport (such as on construction sites), these pollutants are often attached to sediment; however, sediment bound pollutants can quickly become desorbed, therefore transforming into soluble pollutant forms (Westermann et al., 2001). Where sedimentation is minimal due to effective erosion control and/or stabilized post-construction surfaces, soluble pollutants can be more than 80% of the total pollutant load (Berg and Carter, 1980). Consequently, soluble pollutants are often more reactive, or bioavailable, to aquatic organisms, than sediment-bound pollutants. In order to protect and improve receiving water quality, particularly around soils where fertilizers have been applied for vegetation establishment, around impervious surfaces that typically transport metals, hydrocarbons, and harmful bacteria in storm water, and where water bodies have been designated to meet TMDL requirements, BMPs need to reduce soluble pollutant loading.

The objective of this study was to conduct individual experiments to evaluate the removal efficiency potential of typical urban and post-construction storm water pollutants using Filtrexx® Sediment control with specific material additives (Filtrexx® Treatment Train™). Specific storm water pollutants to be evaluated included: bacteria (total coliform, E. coli), heavy metals (copper, cadmium, chromium, nickel, lead, zinc), nitrogen (ammonium-N and nitrate-N), fine sediments (clay and silt), and petroleum hydrocarbons (PHC) (motor oil, gasoline, and diesel fuel).

Materials and Methods: Experimental Design

Research conducted collaboratively with the USDA-Agricultural Research Service (USDA-ARS) in Beltsville, MD, was performed to quantify the effectiveness of Filtrexx® Treatment Train™ products on the removal of common urban and suburban storm water pollutants. Filtrexx Sediment Control with Treatment Train™ additives were installed on a Hatbro silt loam soil at the base of 10% slope and exposed to rainfall-runoff conditions for 30 minutes at 3.5 in/hr, with the exception of the PHC experiment which utilized a 1 in (2.5 cm) concrete veneer on top of the soil surface to simulate an urban watershed surface. Soil chamber boxes 1 ft (0.3 m) wide by 3 ft (0.9 m) long were used to establish the effective rainfall-runoff treatment area and to contain the soil (and concrete veneer for the PHC experiment), Filtrexx Sediment control, and pollutant additions. All experiments included a control (bare soil or concrete), Filtrexx Sediment Control with various Treatment Train™ additives added to the Sediment control to target a specific pollutant. All treatments, including controls (bare soil or concrete) were conducted in triplicate. All runoff was collected in successive 1 L Nalgene bottles and used to determine total runoff, runoff rate, and to create hydrographs (with the exception of the PHC experiment). These runoff samples were used for analysis of identified pollutants. Unless otherwise stated, each respective sample pollutant concentration was determined and multipled by sample volume to determine average load in runoff. Loads were used to determine removal efficiency values using results from the control versus the treatment. For the PHC experiment, per replicate, all runoff was collected in separate 5 gal (19 L) buckets to determine total volume. Sub-samples were taken separately for each of the three PHCs (1 L for motor oil and diesel fuel, 40 mL for gasoline), in special amber and sealed bottles/viles to prevent transformation (degradation or volatilization). PHC bottles were supplied, and analysis was conducted by Test America Labs, Inc. Loads for each PHC were used to determine total runoff volume measured in the buckets.

Application and Analysis of Pollutants

Per experiment, the soil or concrete surfaces were loaded with specific pollutants prior to rainfall-runoff simulations. The experiment evaluating potential bacteria removal utilized fresh cow manure collected on USDA-ARS grounds and applied at 45 tons/acre (4.4 lbs) equivalent to test plots, the recommended USDA-NRCS nitrogen application rate requirement for pasture grasses. Runoff samples were analyzed for total coliform bacteria (Escherichia, Klebsiella, Enterobacter, and Citrobacter) and E. coli using Colilert. Cells were incubated at 37 C for 24 hrs prior to numeration of positive total coliform and E. coli colonies. Positive cell counts were correlated to table values for most probable number (MPN) concentrations in runoff.

The experiment to evaluate potential nitrogen removal applied 180 lbs N/acre (204 kg/ha) of 34-0-0 mineral nitrogen fertilizer (17.8 g fertilizer or 6.05 g of N). Runoff samples for ammonium-N (method #12-107-06-2-A) and nitrite/nitrate-N (method # 12-107-04-1-B) were filtered (0.45 micron) and analyzed by flow injection analysis on a Lachat Quikchem. Sample concentrations were multiplied by runoff volume to determine loads. Loads from the control were compared to each treatment to determine removal efficiencies.

The experiment to evaluate metals applied 500 mL of a prepared solution containing soluble Cu, Cd, Cr, Fe, Ni, Pb, and Zn to each surface yielding the following pre-application mass (concentration): Cu: 7.32 mg (14.6 mg/L), Cd: 7.92 mg (15.8 mg/L), Cr: 6.74 mg (13.5 mg/L), Ni: 8.07 mg (16.1 mg/L), Pb: 6.03 mg (12.1 mg/L), Zn: 6.55 mg (13.1 mg/L). These metals were chosen because they have been identified as the most common metal pollutants effecting urban storm water quality. Metals extractions were performed using 1% nitric acid in a deionized water solution (water extractable metals) and analysis was performed using inductively coupled plasma optical emission spectrometry (ICP) and atomic absorption spectroscopy (AA). Soil metals mass was determined by sampled and analyzed soil concentrations multiplied by the mass of soil eroded from the surface of each plot. Total metals removal efficiencies were determined by metals transported to treatment relative to metals collected in runoff; however, sediment and water metals removal efficiencies were determined using bare soil relative to treatment runoff results.

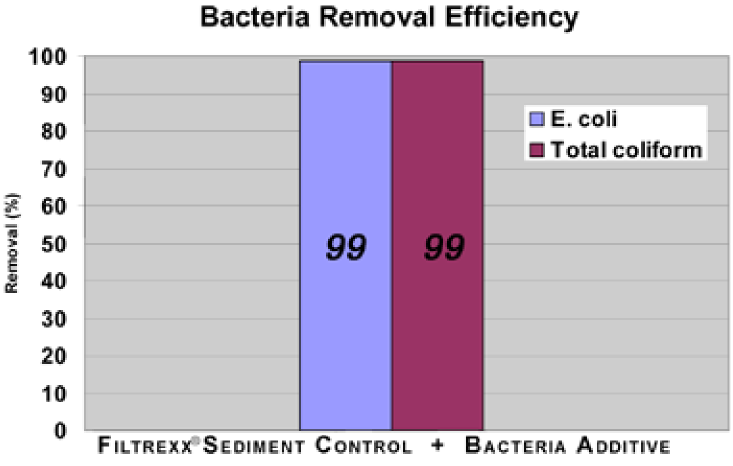
The experiment to evaluate clay (particle sizes <0.002 mm) and silt (particle sizes 0.002-0.05 mm) removal used the total sediment eroded from the soil test plots. Particle size distribution analysis of the runoff sediment was performed on a Horiba (Model LA-920) laser scattering particle size distribution analyzer using sonic dispersion of particles and light diffraction to determine particle diameters and frequency range. Samples were centrifuged prior to analysis. Particles <0.002 mm are identified as clay sediment, particles 0.002-0.05 mm are identified as silt sediment, no particles greater than this range were found in the sediment (i.e. sand sediment).

The experiment to evaluate PHC removal applied 100 mL each of motor oil, diesel fuel, and gasoline to the concrete surface at the top of the slope. Analysis for diesel fuel and gasoline in runoff used EPA Method 8015B for concentration determination of nonhalogenated volatile organic compounds and semivolatile organic compounds for diesel range of organics (DRO) and gasoline range of organics (GRO) using gas chromatography. Analysis for motor oil in runoff used EPA Method 1664A, hexane extractable material (HEM), oil and grease, by gravimetric measurement. Removal efficiencies for PHC's were determined and reported.

Results and Discussion

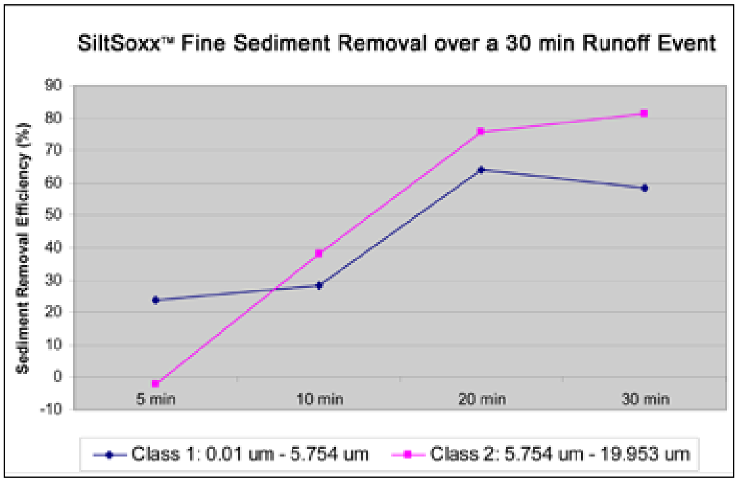
Bacteria

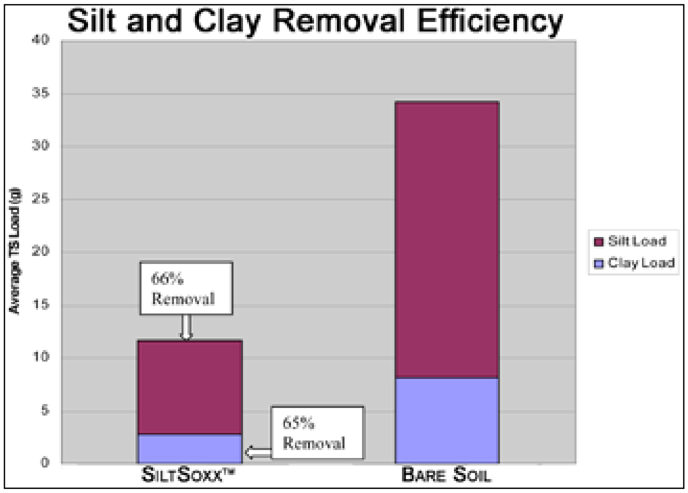
Average runoff bacteria MPN from bare soil for total coliform were 2.02X108/100 mL, and for E. coli was 1.72X108/100 mL. Removal efficiency for total coliforms and E. coli when Filtrexx® Bacteria agent is added to the Sediment control was 99%.



Clay & Silt

Average total sediment load generated from the bare soil was 34 g (8.2 tons/ac), with 24% classified as clay sediment and 76% classified as silt sediment. Results show a 65% and 66% removal efficiancy for clay and silt particulates, respectively. Additionally, results show that removal efficiency for Class 1 (0.01-5.75 µm) sediment particulates is 60%, and for Class 2 (5.75-19.95 µm) sediment particulates is 80%. These sediment fractions are typically responsible for the majority of suspended solids and turbidity found in surface waters negatively affected by storm water.





Heavy Metals

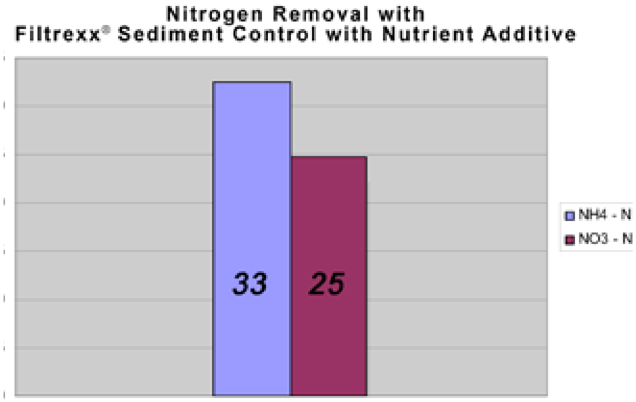
Filtrexx® Sediment Control with Heavy Metals Agent removed all 6 metals used in this experiment, and was effective at removing metals in solution in the runoff as well as metals attached to sediment particulates. FIltrexx® Sediment control with Heavy metal agent added showed a removal efficiency of 47 to 73% for all metals. Removal efficiency of metals in solution for all 6 metals ranged from 29-79%

		METALS (water extractable)					
Treatment	**Parameters (mg)**	**Cd**	**Cr**	**Cu**	**Ni**	**Pb**	**Zn**
Filtrexx® Sediment Control + Heavy Metal Agent	Applied	7.915	6.740	7.320	8.070	6.025	6.545
	Soil Surface	0.004	0.019	6.491	0.144	0.154	2.028
	Total	7.919	6.759	13.811	8.214	6.179	8.573
	Transported to Sediment Control	0.812	0.490	1.640	1.056	0.937	1.669
	Runoff Water	0.210	0.221	0.383	0.301	0.144	0.621
	Removal Efficiency*	72	29	70	69	79	57
	Runoff Sediment	0.014	0.039	0.122	0.029	0.105	0.161
	Removal Efficiency*	77	78	45	63	61	47
	Total Runoff	0.224	0.260	0.505	0.330	0.249	0.782
	Removal Efficiency (%)	73	47	70	69	73	53

**Relative to Bare Soil w/out Treatment;*
Note: Cd concentrations in untreated runoff (0.07 mg/L) were above surface water quality limits (0.02 mg/L);
Note: Cu concentrations in soils (75-135 mg/kg) were above common range max (100 mg/kg).

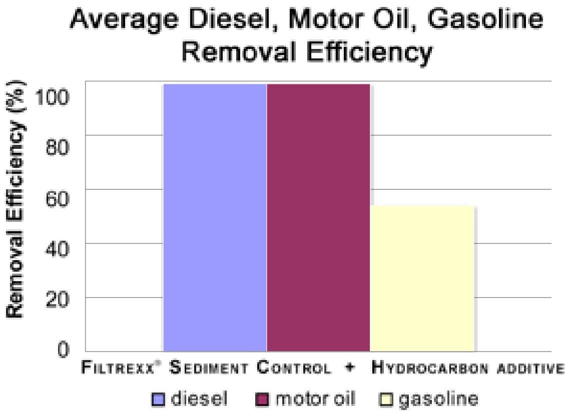
Nitrogen

Runoff nitrogen load from the bare soil was 72 and 86 mg of ammonium-N (NH4-N) and nitrate-N (NO3-N), respectively. The Filtrexx® Sediment Control + Filtrexx® Nutrient agent removed 33% of runoff NH4-N and 25% of NO3-N.



Petroleum Hydrocarbons

Runoff loads from the control for diesel fuel, motor oil, and gasoline were 77,440mg; 20,820mg; and 1070mg, respectively; while runoff concentrations were 5400 mg/L, 1410 mg/L, and 74 mg/L, respectively. Removal efficiency by the Filtrexx® Sediment Control with Hydrocarbon Agent for diesel fuel, motor oil, and gasoline in storm runoff was 99%, 99% and 54% respectively.



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TechLink Research Summary #3326

Field Testing of Filtrexx® Filtration System for Urban Stormwater Quality Retrofits with City of Chattanooga, TN

Figure 1. Map of Chattanooga's service vehicle parking and processing facility (City Wide Services, CWS). The arrow depicts the storm water outfall location, CWS Outfall #2, where the Filtrexx® Filtration system was installed to filter urban storm water pollutants.

According to the USEPA, sediment, oil, grease, nutrients, bacteria, and heavy metals are some of the typical pollutants found in urban and suburban stormwater runoff originating from parking lots, roadways, lawns and gardens, pet waste, and roof shingles (USEPA, 2003). These pollutants are carried into streams, rivers, and lakes causing severe degradation of drinking and recreational water supplies as well as the water quality necessary to support aquatic life. Several bench scale experiments have been conducted to quantify the performance of Filtrexx® FilterSoxx™ on the removal of these common urban and suburban stormwater pollutants, including fine sediments (clay and silt), petroleum hydrocarbons (PHC), phosphorus (P), nitrogen (N), bacteria (total coliform, E. coli), and heavy metals (copper, cadmium, chromium, nickel, lead, zinc). These experiments indicated considerable removal efficiencies by Filtrexx® FilterSoxx™: 65 and 66% for clay and silt particulates, respectively; 84, 99, and 43% for motor oil, diesel fuel, and gasoline, respectively; between 14 and 28% for soluble phosphorus (P); 15% for ammonium nitrogen (N); 71 and 73% for total coliforms and E. coli, respectively; and between 37 and 71% for heavy metals.

Figure 2. Filtrexx® Filtration system was installed April 20th, 2007, to evaluate their performance on chemical oxygen demand (COD), total suspended solids (TSS), and oil and grease in the storm water effluent from CWS Outfall #2.

However, field scale testing of Low Impact Development (LID) Integrated Management Practices (IMP), such as Filtrexx® FilterSoxx™, is necessary to augment and validate these bench scale research studies. In April 2007, the City of Chattanooga, TN, implemented field scale testing of FilterSoxx™ using a Filtrexx® Filtration system as a LID IMP to evaluate their performance in urban runoff pollution filtration applications. The City's Water Quality Program has been monitoring the practicality and performance of retrofitting existing stormwater systems by installing a Filtrexx® Filtration system across a stormwater outfall draining 5.5 acres of the City's service vehicle parking and processing facility (Figures 1 and 2). Quarterly stormwater quality sampling and analysis is currently being conducted by the City of Chattanooga's Water Quality Program and is scheduled to be conducted annually in perpetuity according to their NPDES storm water permit. Stormwater pollutants analyzed include: total suspended solids (TSS), oil and grease, chemical oxygen demand (COD), ammonium-N (NH4-N), organic-N, total kjeldahl-N (TKN), metals (arsenic, beryllium, cadmium, chromium, copper, lead, nickel, zinc), hardness, and specific organic pollutants.

Figure 3. COD and TSS concentrations before (pre-retrofit, 2nd quarter) and after (post-retrofit, 3rd and 4th quarter) Filtrexx® Filtration system installation.

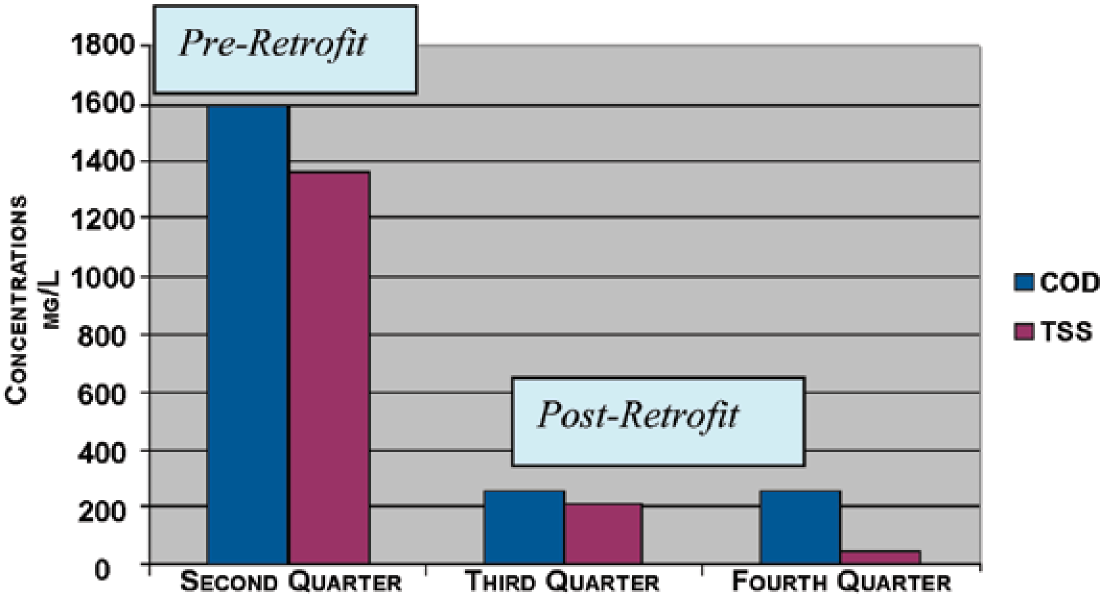

Table 1. Analytical results of COD, TSS, and oil and grease in effluent from CWS Outfall #2 before retrofit and after retrofit with Filtrexx® Filtration system.

Analysis	**2-1-2007 (Pre-retrofit)**	**6-8-2007**	**8-30-2007**	**12-13-2007**	**% Reduction**
Chemical Oxygen Demand (COD)	1600 mg/L	259 mg/L	255 mg/L	125 mg/L	92
Total Suspended Solids (TSS)	1370 mg/L	208 mg/L	38.7 mg/L	18.7 mg/L	99
Oil & Grease	107 mg/L	27.3 mg/L	N/A	N/A	74

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USEPA. 2003. Protecting Water Quality from Urban Runoff. http://www.epa.gov/owow/nps/toolbox/other/epa_nps_urban_facts.pdf. Accessed on April 1st, 2008.

Acknowledgements
Special thanks to Mo Minkara, City of Chattanooga, for helping to coordinate this project and supplying analytical results for water quality, and to Earthscapes of Chattanooga, TN for supplying materials and installation.

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TechLink Research Summary #3327

Performance & Design of Filtrexx® Slope Protection at Various Depths & Slope Grades vs Common Slope Stabilization Practices

Filtrexx® Slope protection has been widely used for erosion control and slope stabilization applications and published research has quantified their effectiveness (Persyn et al, 2004; Mukhtar et al, 2004; Faucette et al, 2005, Faucette et al, 2006, Faucette et al, 2007). Although standard specifications have been developed and utilized for years, principally based on this body of research, no research has directly quantified: 1) how Filtrexx® Slope protection performs relative to other slope stabilization practices, such as rolled erosion control blankets (RECBs), polyachrylamides (PAMs), and tackifiers; 2) the performance of various Slope protection thicknesses; 3) the effect of slope steepness on compost blanket performance. No research has been published evaluating Filtrexx® Slope protection on slopes greater than 3:1, and nearly all research has used a compost blanket thickness of approximately 2 inches or greater. Published research has already shown that Filtrexx® Slope protection performs better than topsoil (Persyn et al, 2004), hydromulch (Faucette et al, 2005) and straw mulch (Faucette et al, 2007); however, comparison to higher end erosion control products and technologies has not been conducted.

Erosion Control Practice	Soil loss @ 2 in/hr 20 min (0.67 in)			Soil loss @ 4 in/hr 40 min (2.0 in)			Soil loss @ 6 in/hr 60 min (4.0 in)		
	lbs	t/ac	% reduction	lbs	t/ac	% reduction	lbs	t/ac	% reduction
Bare soil	84	61	NA	563	137	NA	1507	171	NA
CECB™ 2.0 in	0.18	0.02	99.8	187	46	66.8	424	48	71.9
CECB™ 1.0 in	0.73	0.09	99.1	219	53	61.1	468	53	68.9
CECB™ 0.5 in	40	29	52.1	394	96	30.1	638	72	57.7
Single-net straw	44	31	48.8	348	84	38.3	893	101	40.8
Single-net excelsior fiber	24	18	70.2	224	55	60.1	585	66	61.1
Double-net straw	31	23	62.7	255	62	54.7	664	76	56.0
Double-net coconut fiber	0.44	0.05	99.5	149	36	73.5	621	71	58.8
Tackifier	17	12	79.9	246	60	56.2	886	101	41.2
PAM	59	43	29.9	603	146	-6.8	1390	158	7.7
CECB™ 2.0 in + LockDown™ Netting	0.04	0.005	99.9	121	29	78.6	465	53	69.1
CECB™ 1.0 in + LockDown™ Netting	0.13	0.02	99.8	182	44	67.7	443	50	70.6
CECB™ 0.5 in + LockDown™ Netting	1.6	0.2	98.1	262	64	53.5	834	95	44.7
CECB™ 0.5 in + PAM	2.9	0.4	96.7	484	118	14.1	1254	142	16.8
CECB™ 1.0 in + Single-net excelsior fiber	0.37	0.05	99.6	7	0.9	98.7	14	1.7	99.1

Table 1: Cumulative soil loss and soil loss reduction (%) for each erosion control practice relative to bare soil (control), at 2:1 slope, after each 20-minute rainfall intensity increment (total rainfall accumulation).

CECB™ Thickness (in)	Slope Angle (H:V)	Soil loss @ 2 in/hr 20 min (0.67 in)			Soil loss @ 4 in/hr 40 min (2.0 in)			Soil loss @ 6 in/hr 60 min (4.0 in)		
		lbs	t/ac	% reduction	lbs	t/ac	% reduction	lbs	t/ac	% reduction
Bare soil	2:1	84	61	NA	563	137	NA	1507	171	NA
2.0	2:1	0.18	0.02	99.8	187	46	66.8	424	48	71.9
1.0	2:1	0.73	0.9	99.1	219	53	61.1	468	53	68.9
0.5	2:1	40	29	52.1	394	96	30.1	638	72	57.7
Bare soil	3:1	75	55	NA	541	132	NA	1267	144	NA
2.0	3:1	0.75	0.09	99.0	108	26	80.1	308	35	75.7
1.0	3:1	2	0.25	97.4	74	18	86.4	629	72	50.4
0.5	3:1	7	0.9	90.0	384	94	29.1	881	100	30.5
Bare soil	4:1	101	72	NA	447	108	NA	972	110	NA
2.0	4:1	0.04	0.005	100.0	38	9	91.4	169	19	82.6
1.0	4:1	3	0.37	96.8	172	42	61.4	527	60	45.9
0.5	4:1	2	0.25	98.2	230	56	48.4	603	68	38.0

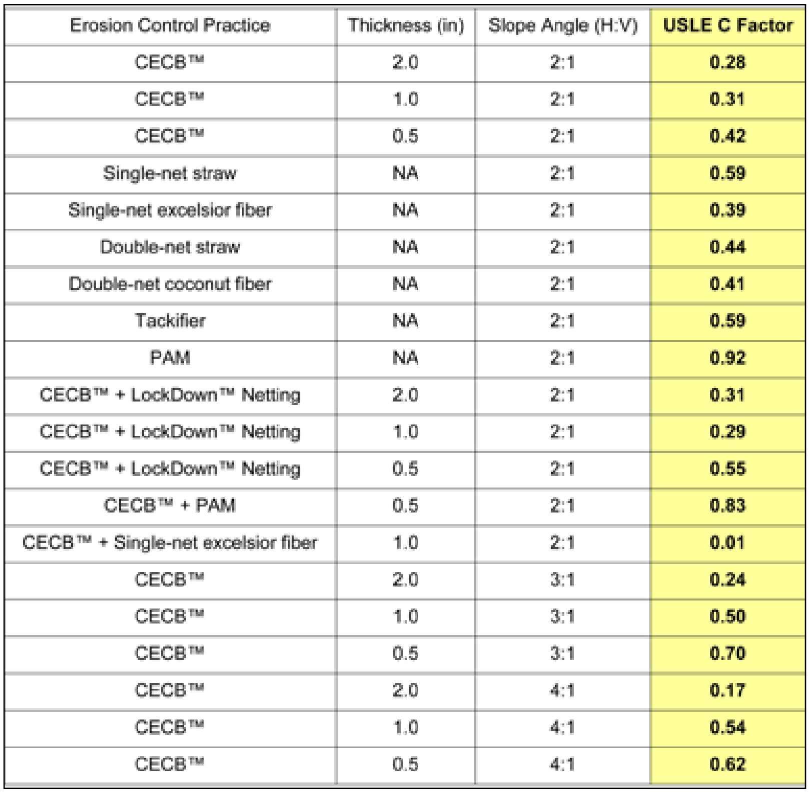
Table 2: Cumulative soil loss and soil loss reduction (%) for each Slope protection thickness relative to bare soil (control), by slope angle, after each 20-minute rainfall intensity increment (total rainfall accumulation).

Using ASTM D-6459, Standard Test Method for Determination of Erosion Control Blanket (ECB) Performance in Protecting Hillslopes from Rainfall Induced Erosion, on slope angles ranging from 4:1 to 2:1, 20 different erosion control best management practices (BMP) were compared for their performance and design parameters at San Diego State University's Soil Erosion Research Laboratory (SDSU SERL). Using a

Norton Ladder Rainfall Simulator designed and supplied by the US Department of Agriculture National Soil Erosion Research Laboratory (USDA-ARS NSERL), ASTM specified design storm intensities and durations were applied to each of the erosion control products. The ASTM D-6459 design storm is as follows: 2 in/hr for 20 min, followed by 4 in/hr for 20, followed by 6 in/hr for 20 min, for a total of 60 minutes duration. Each erosion control product was tested in triplicate to obtain statistical averages.

DESIGN CRITERIA

Development of USLE (and RUSLE and RUSLE2) cover management factors (C factors) for erosion control BMPs can assist site planners and designers in predicting and estimating soil loss, which can affect the size and design of other site BMPs such as sediment barriers, traps, ponds or basins; and can assist designers in choosing the optimum performing BMP for their site plan. Cover management factors for all BMP treatments tested are listed in Table 3. The cover management factor for the control (bare soil) is 1.0. The USLE is represented as:

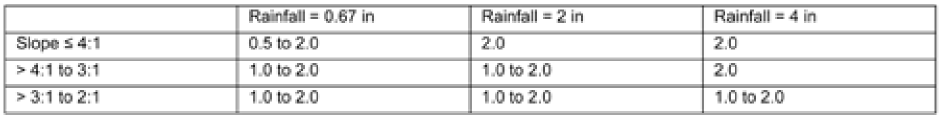


Erosion Control Practice	Thickness (in)	Slope Angle (H:V)	**USLE C Factor**
CECB™	2.0	2:1	**0.28**
CECB™	1.0	2:1	**0.31**
CECB™	0.5	2:1	**0.42**
Single-net straw	NA	2:1	**0.59**
Single-net excelsior fiber	NA	2:1	**0.39**
Double-net straw	NA	2:1	**0.44**
Double-net coconut fiber	NA	2:1	**0.41**
Tackifier	NA	2:1	**0.59**
PAM	NA	2:1	**0.92**
CECB™ + LockDown™ Netting	2.0	2:1	**0.31**
CECB™ + LockDown™ Netting	1.0	2:1	**0.29**
CECB™ + LockDown™ Netting	0.5	2:1	**0.55**
CECB™ + PAM	0.5	2:1	**0.83**
CECB™ + Single-net excelsior fiber	1.0	2:1	**0.01**
CECB™	2.0	3:1	**0.24**
CECB™	1.0	3:1	**0.50**
CECB™	0.5	3:1	**0.70**
CECB™	2.0	4:1	**0.17**
CECB™	1.0	4:1	**0.54**
CECB™	0.5	4:1	**0.62**

Table 3: Cover management factors for erosion control BMPs using ASTM D-6459 after 60 minutes cumulative rainfall.

A = r x k x ls x c x p

Where:
A = soil loss rate (tons/ac/yr)
r = rainfall erosivity factor
k = soil erodibility factor
ls = slope length and steepness factor
c = cover management (erosion control) practice factor
p = support practice factor



	Rainfall = 0.67 in	Rainfall = 2 in	Rainfall = 4 in
Slope ≤ 4:1	0.5 to 2.0	2.0	2.0
> 4:1 to 3:1	1.0 to 2.0	1.0 to 2.0	2.0
> 3:1 to 2:1	1.0 to 2.0	1.0 to 2.0	1.0 to 2.0

Table 4: Recommended Slope protection thickness (in) based on slope angle (H:V) and rainfall accumulation in a 24 hr period.

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Faucette, L. Britt, J. Governo, C.F. Jordan, B. G Lockaby, H. F. Carino, and R. Governo. 2007. Erosion control and storm water quality from straw with pam, mulch, and compost blankets of varying particle sizes. Journal of Soil and Water Conservation. 62:6: 404-413.

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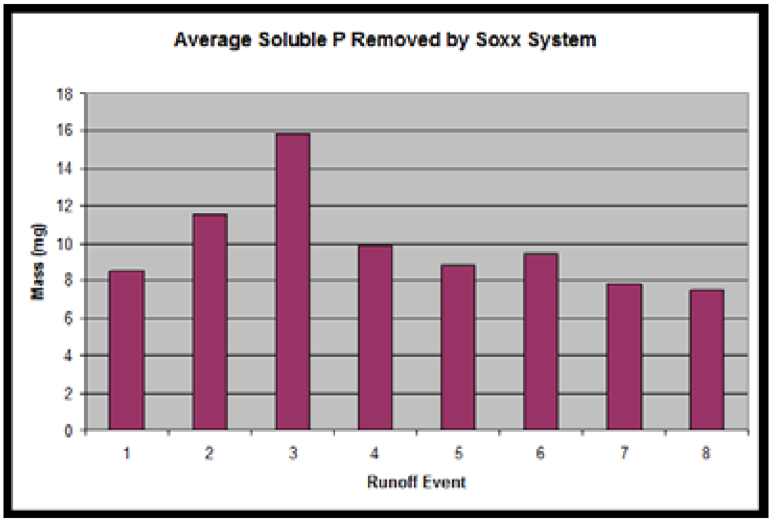
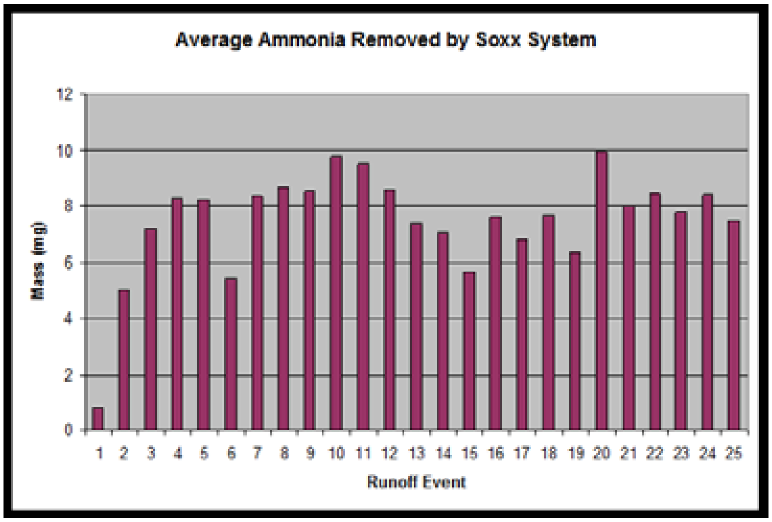
Persyn, R. T. Glanville, T. Richard, J. Laflen, and P. Dixon. 2004. Environmental effects to applying composted organics to new highway embankments, Part 1: Interrill runoff and erosion. Transactions of the American Society of Agricultural Engineers. 47:2:463-469.

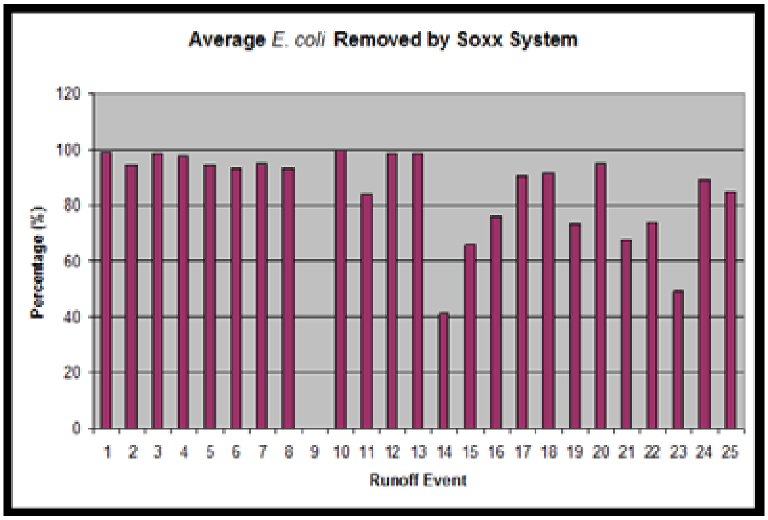
TechLink Research Summary #3328

Performance Capacity of Filtrexx® Treatment Train™ Products in Urban Runoff Applications

Urban storm water runoff poses a substantial threat to receiving surface waters. According to the US Environmental Protection Agency's (USEPA) national water quality assessment, 35% of US streams are severely impaired and 75% of the population lives within 10 miles of an impaired surface water (USEPA 2007). In accordance with Section 303(d) of the Clean Water Act, the USEPA designates specific stream segments for Total Maximum Daily Load (TMDL) development for particular pollutants. Between 1995 and 2007, bacterial pathogens and nutrients have been leading causes of TMDL designations, with 5081 and 3511 listings, respectively. These pollutants are the number one (8,913 cases) and fifth (5,625 cases) leading causes of impaired water quality in the US (USEPA 2007). Urban storm water runoff is one of the leading sources of these pollutants. Green infrastructure, low impact development, green building ordinances, NPDES storm water permit compliance, and TMDL implementation strategies have become national priorities. However, designers need more sustainable, low cost solutions to meet these goals and guidelines. The purpose of the study was to determine the storm water pollutant removal efficiency and longevity of FilterSoxx™ with a natural Filtrexx® Treatment Train™ Product (FTTP) added to the FilterSoxx™ system. Urban storm water pollutants evaluated included: ammonium-nitrogen, nitrate-nitrogen, oil, soluble phosphorus, and E. coli bacteria. The FTTP was exposed to pollutant concentrations representative of urban storm water runoff, for up to 25 runoff events.





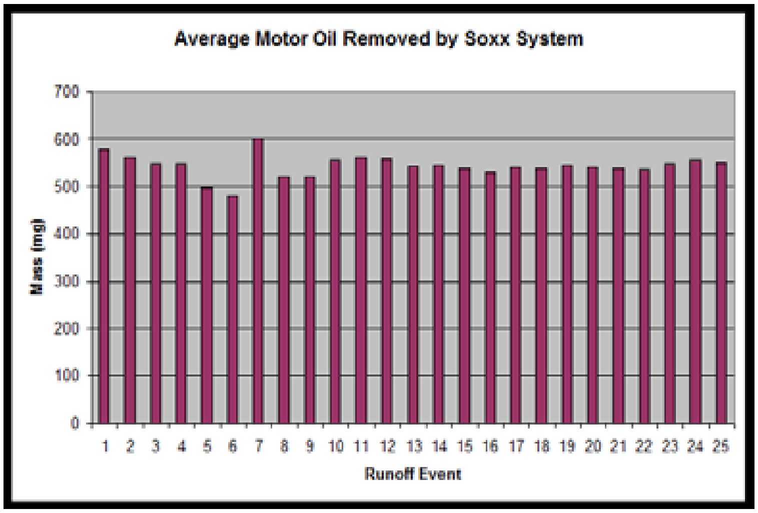


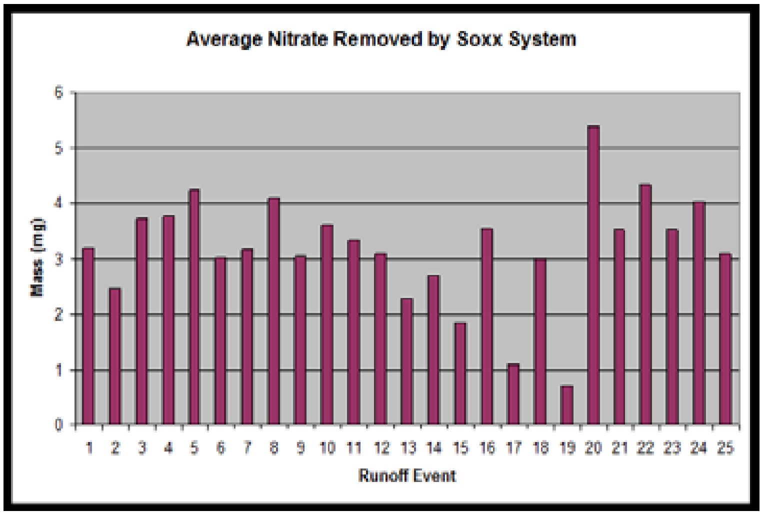
Summary of Results

For soluble phosphorus, the FilterSoxx-Treatment Train System (FS-TT) removed a total of 72 mg/linear ft over 8 runoff events, or an average of 34%; 54% of ammonium-N over 25 runoff events, or 162 mg/linear ft, and only 11% of nitrate-N, or 69 mg/linear ft. The FS-TT removed 99% of oil over 25 runoff events, or a total load of 11,662 mg/linear ft; and 85% of E. coli and a total load of 9.52 CFUs x 107/linear ft over the same number of storm events. These load capacities can be used to determine the annual load removal efficiencies for site specific applications where total pollutant load exposure from a drainage or watershed area (e.g parking lot or field) has been determined. For example, if a 1 acre asphalt parking lot generates 10,000 mg of ammonium-N on an annual basis, approximately 63 ft of FS-TT would be needed to treat the ammonium-N coming from the parking lot.

Based on these results it is clear this technology can be used to remove a variety of storm water pollutants and perform at a high level over multiple storm events, thereby improving storm water quality and potential receiving surface waters over a long period of time.

Once the product's filtering capacity is reached it can be easily removed, returned to a composting facility for recycling, and replaced with a new one. Furthermore, for oil and bacteria this technology may be used in more challenging applications where load exposure is much greater, such as oil spills and runoff from animal feeding operations. Additionally, this technology should be useful in other green infrastructure applications, such as bioretention systems and bioswales.





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TechLink Research Summary #3329

Navigating the New World of Biodegradable and Compostable Plastics

Are you confused about the terms biodegradable, photodegradable, compostable, oxo-biodegradable, or even plain old degradable? Welcome to the new world of biodegradable materials.

Whether you are a compost manufacturer, compost end-user, or designer, you are affected by these terms and it is important to understand the inherent differences in these types of materials and what the industry recognizes. As part of the developing industry around biodegradable products and materials, new ASTM standards and definitions have recently been developed to categorize these materials.

ASTM Standards

ASTM D883-08: defines various types of plastics and common terms that are to be utilized in all other ASTM standards.

ASTM D5338: test method that establishes rate and extent of biodegradation (carbon transformation to carbon dioxide), using inoculation from commercial compost piles. Standardized parameters are defined in ASTM D6400.

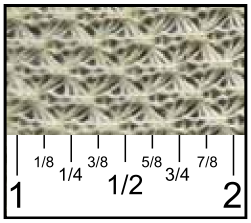
ASTM D6400: specification for reporting and labeling based on ASTM D5338, which includes rate of biodegradation and disintegration within a commercial composting environment, and any deleterious effect on composting process or compost product quality due to inclusion. This standard provides guidelines for the required commercial composting environment, including temperature, air, and humidity controls for a period of 180 days; acceptable metals content limits established at 50% of CFR 503 standards, and phytotoxicity limits.

ASTM D6868: specification for biodegradable coatings used in paper and plastic materials typically used in biodegradable packaging and fiber-based bagasse products. The requirements are identical to those of ASTM D6400.

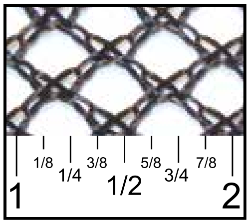
ASTM D7081: specification for non-floating biodegradable plastics explicitly designed for, and used in marine environment applications.

Filtrexx Products

All Filtrexx products utilize compost or recycled organics as a component of the final product. Most Filtrexx mesh netting materials classify as photogradable. Filtrexx also offers a compostable (which also meets definition for biodegradable) and an oxo-biodegradable mesh netting material. Filtrexx® BioSoxx™ is made from 100% cotton fiber, and should readily breakdown in any commercial composting operation within 180 days, thereby meeting standards set forth in ASTM D5338 and ASTM D6400. If left in the field this product will also easily biodegrade in 3 to 6 months, leaving little or no residues.



BioSoxx™
Material: Cotton
Mesh Opening: 1/8″
Strength: n/d
Longevity: up to 12 mo.



5mil HDPE
Material: Oxobiodegradable
Mesh Opening: 3/8″
Strength: 26 psi; 23% @1000 hrs
Longevity: 6 – 12 mo

Filtrexx Biodegradable High Density Polyethylene (HDPE) netting is classified as oxo-biodegradable, which will biodegrade if left in the environment but not as rapid as the Filtrexx® BioSoxx™. This product is typically used when biodegradability is desired, but longevity is also a functional concern.

Currently, there is no ASTM standard for oxo-biodegradable materials and products. There are no specifications for the generic term 'biodegradable'. However, 10 years of experience from field applications with over 50,000 projects at Filtrexx International has shown that HDPE and HDPP will weaken and lose integrity in 12-18 months, depending on UV exposure. For instance, hot sunny climates like Phoenix, Arizona show the products do not last as long as cloudy, colder climates in Cleveland, Ohio. For this reason, longevity and estimated functional times are listed in the Filtrexx design manual so engineers can select the appropriate product for the proper use.

Filtrexx oxo-biodegradable HDPE

For applications where Filtrexx® Soxx™ are permanentley vegetated, the canopy shields the Soxx from destructive UV exposure, which will also make the Soxx invisible. This permanent UV protection ensures long term structural integrity to Soxx and is an important design consideration for any long term, vegetative application.

Souces: Biodegradable Products Institute (BPI), ASTM

Definitions

Degradable: material will change in structure or properties under certain environmental conditions resulting in fragmentation and loss of performance or properties.

Photodegradable: material will degrade into smaller pieces or molecules when exposed to sunlight, ultraviolet light, or infrared radiation.

Biodegradable: material will break down over an unspecified time period and may or may not leave toxic residues.

Oxo-biodegradable: material will biodegrade over a longer period of time by oxidation and biodegradation processes due to an added ingredient that increases rate of breakdown (2-3 years; some studies show much longer time periods), and may leave fragmentations; typically used with plastics. These materials will fragment much more quickly than traditional plastics. However, these fragments will remain in the environment for years.

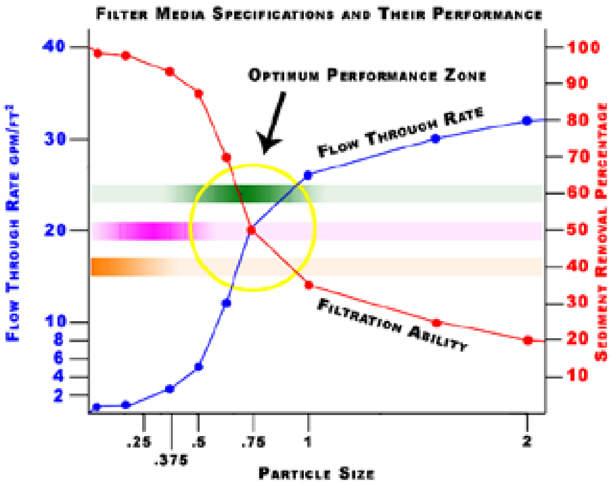
Compostable: material will break down into natural components with no toxic or visual residues within the time span attributed to compost manufacture in a commercial composting operation or environment (approximately 6 months).

Polylactic Acid (PLA): PLA is used to make bioplastic materials and is biodegradable, typically derived from cane sugar or glucose; it is an alternative to polypropylene and polyethylene plastic materials.

TechLink Research Summary #3330

Alternative FilterMedia™ for Filtrexx® FilterSoxx™ Applications

Filtrexx® FilterSoxx™ are used for a wide variety of sediment control, stormwater filtration, and biofiltration applications. Compost filtration media has historically been the only form of Filtrexx approved filter media; however, new research has shown that non-composted, organic materials may be used in targeted environmental applications. Applications where only sediment removal and hydraulic flow-through conditions need to be achieved may use an alternative organic filter media. Acceptable alternatives include: untreated and non-painted wood pallets, land clearing debris, or tree chips. Research conducted by Filtrexx International has shown that these organic materials will perform as well as compost filter media for sediment control and hydraulic characteristics when Guidelines A through E (listed below) are met. Alternative filter media is not recommended for pollutant removal (other than sediment), bioremediation, or vegetation applications, as these types of organic filter media may reduce the performance of the FilterSoxx™ for these specific applications.



Research conducted by USDA-ARS (Faucette et al, 2006) and the Soil Control Lab, Inc. (Faucette et al, 2006a), have reported strong relationships between hydraulic flow through rate of Alternative FilterMedia™ and sediment removal efficiency. Typically the higher the hydraulic flow through rate the lower the sediment removal efficiency. Both studies reported that larger particle size distributions of FilterMedia™ typically exhibit higher hydraulic flow through rates and lower sediment removal efficiencies.

Organic materials used for Filtrexx FilterMedia™ shall be weed free and derived from a clean, separated source of organic matter. The organic materials shall be free of any refuse, contaminants or other materials toxic to plant growth, animals, or humans. Non-organic products will not be accepted.

Alternative Media Guidelines
A. pH – 5.0-8.0 in accordance with TMECC 04.11-A, "Electrometric pH Determinations for Compost"

B. Particle size – 99% passing a 2 in (50mm) sieve and a maximum of 40% passing a 3/8 in (9.5mm) sieve, in accordance with TMECC 02.02-B, "Sample Sieving for Aggregate Size Classification". (Note- In the field, product commonly is between ½ in [12.5mm] and 2 in [50mm] particle size.)

C. Moisture content of less than 60% in accordance with standardized test methods for moisture determination.

D. Material shall be relatively free (<1% by dry weight) of inert or foreign man made materials.

E. A sample shall be submitted to the Engineer for approval prior to being used and must comply with all local, state and federal regulations.

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TechLink Research Summary #3331

Installation Effects on Performance of Sediment Control Barriers

The number one reason why any best management practice (BMP) fails in the field is due to improper installation. BMPs such as straw bales and silt fence are losing favor with regulatory agencies and design professionals due to high incidence of failure, often due to improper installation of these sediment control barriers. Filtrexx® SiltSoxx™ offer an alternative that is easy to install and can be accompanied by a Trained and Certified Filtrexx® Installer. Research and field evidence is showing that SiltSoxx™ have a much lower incidence of field failure, and even when the BMP does fail (nothing works 100% of the time), the failure is minimal relative to the catastrophic failures exhibited by silt fence failure.

Research was conducted at San Diego State University's (SDSU) Soil Erosion Research Laboratory to evaluate the performance of SiltSoxx™, silt fence, and straw wattles under various installation scenarios. Sediment control barriers were installed at the base of the slope and exposed to experimental conditions using a modified ASTM 6459 standard test method typically used for erosion control blankets. The sediment control barriers were installed on a loamy sand soil at the base of a 3:1 slope with an exposed soil and drainage of area of 2 meters wide by 8 meters long. The design storm utilized for this research project used a Norton Ladder Rainfall Simulator developed by the USDA ARS National Soil Erosion Research Laboratory and was programmed for an intensity and duration of 2 in (5 cm)/20 minutes followed by 4 in (10 cm)/30 minutes. Average peak runoff rate exposed to the sediment control barriers was 28.4 liters/min, average runoff volume was 986 liters, average sediment concentration was 460,000 mg/L, and average sediment load was 385 kg. Experimental runs were conducted in triplicate to obtain statistical means.

The sediment control barriers were installed correctly, according to specification, and incorrectly, subjectively determined to represent typical field installation. SiltSoxx™ were installed according to Filtrexx® standard specifications (including prepared surface, staking, and backfill) and were also installed on the soil surface without surface preparation, staking, and backfill (incorrect installation). Silt fence was installed correctly, according to staking, trenching, and backfill compaction specifications; and incorrectly, using staking, minimal trenching, and backfilling. Straw wattles were installed correctly, according to staking and trenching specifications; and incorrectly, with staking and without trenching.

According to this study by SDSU the SiltSoxx™ performs better than silt fence and straw wattles in both correctly and incorrectly installed applications. This means that whether installed by a certified professional or by an untrained contractor the Filtrexx® SiltSoxx™ will perform better than other products in this market category, which means less regulatory issues, cleaner construction sites, and most importantly cleaner water.

Table 1. Average sediment load (kg) and sediment removal efficiency (%) for each sediment control barrier at both levels of installation.

Treatment	Sediment Load	Removal Efficiency
SiltSoxx™ installed correctly	87 kg	77%
SiltSoxx™ installed incorrectly	254 kg	34%
Silt fence installed correctly	109 kg	72%
Silt fence installed incorrectly	254 kg	31%
Straw wattle installed correctly	159 kg	59%
Straw wattle installed incorrectly	268 kg	30%

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TechLink Research Summary #3332

Sediment Removal Performance of Filtrexx® SiltSoxx™ and Rock Bags in Inlet Protection Applications

Sedimentation rates from construction sites are typically 10 to 20 times greater than from agricultural operations, and 1000 to 2000 times greater than forestlands (US EPA 2005). In a short period of time, sedimentation from a construction activity can exceed decades of natural sedimentation that causes physical, chemical, and biological harm to our nation's water system (US EPA 2005).

Filtrexx® SiltSoxx™ are often used as storm inlet protection devices used to filter sediment from runoff prior to entry into the storm drain system. Sediment and soluble pollutants are filtered from runoff water as it passes through the organic structure. As water temporarily ponds behind the inlet protection, this allows deposition of suspended solids. Pre-cut and prefilled SiltSoxx™ for inlet protection also allow for quick and easy installation.

Filtrexx® SiltSoxx™ for Inlet Protection

Typical rock bag installation for inlet protection

While many other products are available for use as inlet protection devices, rock bags are another common management practice specified and installed around many construction sites across the United States in addition to SiltSoxx™. Although these practices are widely used, there has been very little evaluation (or test methodology developed to evaluate) of these management practices. Rock aggregate is commonly used because it does not impede the flow of storm water runoff, and is believed to remove some pollutants prior to entry into the storm drain.

Inlet protection devices should not restrict the primary goal of managing storm water in these areas – rapid removal of storm runoff from streets to reduce hazards to vehicular traffic. An inlet protection device that removes sediment and does not impede or divert runoff into the storm inlet shall be considered a superior product/practice. Additionally, these practices should be able to remove all types of sediment, including sand, silt, and clay.

Objectives

- Evaluate the total suspended solids (TSS) and turbidity reduction efficiency of clay loam and silt loam sediment-laden runoff using a SiltSoxx™
- Evaluate the TSS and turbidity reduction efficiency when filter sand is added to a SiltSoxx™
- Evaluate the TSS and turbidity reduction efficiency of coarse Filtrexx® FilterMedia™, fine FilterMedia™, rock, and a blend of fine FilterMedia™ and rock.

Materials and Methods

To test for filtration efficacy, compost filter medium were subjected to a laboratory scale storm runoff event, meant to simulate the conditions of storm water passing through an 8 in diameter SiltSoxx™. To achieve this, a tilt table was designed and produced (by Soil Control Lab of Watsonville, CA) to test the device. The tilt table used was 4 ft in length where water flows from one end of the table, through the filter medium, and out the other end of the table, where runoff water samples can be taken. In this study the slope was maintained at a ratio of 3:1. The runoff distributors were connected to a 57 L open-top water tank, equipped with a pump-enabled siphon tube. For the duration of this study, 2 gal/min/linear ft of runoff was pumped through the runoff distribution system.

Test Procedure

After the sample FilterMedia™ was assembled, City of Watsonville, CA tap water was run down the tilt table and through the FilterMedia™ for 10 min. Then the runoff distributors supplied a pollutant-laden storm water runoff containing a predetermined amount of sand, silt, and clay. After 10 min of running the pollutant-laden water through the FilterMedia™, the inflow and outflow runoff were sampled and tested for sediment constituents.

Analysis

The inflow and the outflow of the pollutant-laden runoff water were analyzed for the following sediment constituents using these test methods:

- Total solids (ASTM D3977-97C)
- Suspended solids (SM 2540 D)
- Total suspended solids (ASTM D3977-97C)
- Turbidity (SM 2130 B)

Full descriptions of US EPA test methodologies can be found in the Methods for Chemical Analysis of Water and Wastes (US EPA, 1983). Sediment removal efficiency was determined from runoff water for TSS and turbidity. Maximum flow through rate was also calculated for the FilterMedia™.

Treatments

A clay loam soil from Athens, GA, and a silt loam soil from Watsonville, CA were used to create sediment-laden runoff at 1400 mg/l to evaluate the sediment removal efficiency of a typical clay and typical silt sediment. Sand was added to the compost FilterMedia™ to test for potential increase in sediment removal efficiency to tighten up pore space. The sand used was 50% #20 and 50% #30. Sediment-laden runoff was prepared using a Cecil clay loam soil from Athens, GA at 1400 mg/l. Two separate tests were performed. Test #1: sand was blended with compost at 6% on a v/v basis (1 cup/gal; 350 g/gal; 134 lbs/cubic yard); Test #2: sand was blended with compost at 25% on a v/v basis (2 pints/gal; 1400 g/gal; 535 lbs/cubic yard). A coarse FilterMedia™ (>1 in), a fine FilterMedia™ (< ¾ in), rock aggregate, and fine FilterMedia™ + rock (blended by volume 1:1) were tested as storm inlet protection FilterMedia™.

Sediment removal efficiency (%)
of two sediment types for SiltSoxx™

	TSS Removal	Turbidity Reduction
Silt loam (1400 mg/l)	33	25
Clay loam (1400 mg/l)	64	26

Clay loam sediment removal efficiency (%)
for SiltSoxx™ with sand filtration addition

	TSS Removal	Turbidity Reduction
No sand added to sock (control)	64	26
Sand mixed in sock at 6% (v/v)	71	53
Sand mixed in sock at 25% (v/v)	82	65

Sediment removal efficiency (%) and maximum
flow through rate (gpm/lin. ft) of various inlet filters

	TS	TSS	Turbidity	Flow Rate
Coarse FilterMedia™	77	25	1	>50
Fine FilterMedia™	99	63	38	5
Fine FilterMedia™ + rock (1:1)	98	46	17	8
Rock	16	-14	-10	>50

Conclusions

Based on the experimental design and conditions presented in this study, SiltSoxx™ exhibited higher removal efficiencies for clay loam relative to silt loam sediments. If filter sand is added to the FilterMedia™, removal efficiency of fine sediments increases. Furthermore, increasing the inclusion rates of filter sand will increase the removal efficiency of fine sediments from storm runoff. By reducing the particle size of the FilterMedia™, TSS and turbidity were greatly reduced. Blending rock with fine FilterMedia™ decreased sediment removal efficiency, but increased the hydraulic flow through rate; while rock media alone exhibited a very high flow through rate it contributed fine sediments to the runoff and removed a small fraction of large sediments. Based on this analysis the fine FilterMedia™ is the best option for sediment removal, the coarse FilterMedia™ is the best option for high flow situations, and rock does a poor job in removing sediments and is likely to contribute sediments if not prewashed.

References Cited

US EPA, 1983. Methods for chemical analysis of water and wastes, EPA-600/4 4-79-020. United States Environmental Protection Agency, Cincinnati, Ohio.

US EPA 2005. Storm Water Phase II Final Rule: Small Construction Program Overview. Office of Water 4203. Fact Sheet 3.0. EPA 833-F-00-013.

TechLink Research Summary #3333

Performance of Seven Sediment Control Barriers Under Large-Scale Testing

Performance of sediment control barriers is of increasing concern to designers, regulators, and contractors. Whether staying in compliance with state and federal permits, protecting sensitive water bodies, or simply demanding high-performing practices on job sites, knowing how sediment control barriers perform and compare to one another has become of critical importance. In order to evaluate the sediment control performance between various sediment control barriers, these practices must be subject to the same standardized testing procedure or evaluated in controlled side-by-side testing. This testing project does both.

OBJECTIVES

The primary objective of this study was to evaluate the performance of the following sediment control barriers: 9-in Filtrexx® SiltSoxx™, 12-in Filtrexx® SiltSoxx™, 12-in Compost Tube, 9-in Straw Wattle, 20-in Straw Wattle, 9.5-in Tire Chip Filled Wattle, and 10-in Triangular Silt Dike. The secondary objective of this study was to determine any sediment removal performance differences between compost filter socks meeting all federal/state specifications (Filtrexx® SiltSoxx™) versus those that do not comply (Compost Tube). It has been hypothesized that compost filter socks/tubes containing predominantly fine particle-size filler material (> 50% passing 3/8-in) and/or a containment system with mesh apertures smaller than 1/8-in do not allow adequate hydraulic flow through, and thereby overtop faster, leading to increased sediment loss; or the increased hydraulic pressure behind the barrier leads to undermining and even greater loss of sediment. These same characteristics may also have a similar effect on performance of wattle/tube devices using filler material other than compost filter media.

MATERIALS & METHODS

The large-scale testing reported herein was performed in accordance with ASTM WI 11340 modified as necessary to accommodate the selected products, on 3:1 slopes using sandy clay test plots measuring 27-ft long x 8-ft wide. Simulated rainfall was produced by "rain trees" arranged around the perimeter of each test slope. Each rain tree had four sprinkler heads atop a 15-ft riser pipe. The rainfall system was calibrated prior to testing to determine the number of sprinkler heads and associated pressure settings necessary to achieve target rainfall intensities and drop sizes. The target rainfall intensities were 2, 4, and 6-in/hr and were applied in sequence for 20 minutes each. Three replicate test slopes with the perimeter sediment control barriers (SCBs) installed at the bottom were tested. The sediment retention provided by the product tested was obtained by comparing the protected slope results to control (bare soil) results.

The initial slope soil veneer was 12-in thick and was placed and compacted on the slope prior to each run. Compaction was verified to be 90% (± 3%) of Proctor standard density using ASTM D2937 (drive cylinder method). Subsequently, the test slopes underwent a "standard" preparation procedure prior to each slope test. First, any rills or depressions resulting from previous testing were filled in with test soil and subject to heavy compaction. The entire test plot was then tilled to a depth not less than four inches. The test slope was then raked to create a slope that was smooth both side-to-side and top-to-bottom. Finally, a steel drum roller was rolled down-and-up the slope three times proceeding from one side of the plot to the other. The submitted erosion control product was then installed using the technique acceptable to/ recommended by the manufacturer. For this testing, sediment control barriers were installed on the slope as follows:

1. Compost Socks/Tubes installed with wood stakes @ 2-ft centers.
2. Straw Wattles installed with wood stakes @ 2-ft centers.
3. Erosion Eel installed with 5-ft Steel T-Posts (downstream) @ 2-ft centers.
4. Triangular Silt Dike installed with apron in upslope anchor trench and 6-in staples through the apron.


Fig. 1: Test Plot Set-Up Prior to Treatment Installation.

Immediately prior to testing, rain gauges were placed at the quarter points (i.e. 6.75, 13.5, 20.25-ft) on the slope. The slope was then exposed to sequential 20-minute rainfalls having target intensities of 2, 4, and 6 inches per hour. All runoff was collected during the testing. Additionally, periodic sediment concentration grab samples were taken and runoff rate measurements were made. Between rainfall intensities, the rainfall was stopped and rainfall depth was recorded from the six rain gauges, valves are adjusted to facilitate the subsequent rainfall intensity, and empty collection vessels were positioned to collect subsequent runoff. After allowing for sediments to settle, water was decanted from the collected runoff. The remaining sediments were collected and dried to determine total soil loss.

The Practice Management (P) Factor from the Revised Universal Soil Loss Equation (RUSLE) of the USDA-ARS Agricultural Handbook 703 was the reported performance measure for slopes determined from this testing. The A-Factor, R-Factor, and P-Factor reported herein are related through RUSLE by the following relationship:

$A = R \times K \times LS \times C \times P$

where:

A = the computed soil loss in tons per acre (measured/calculated from test);
R = the rainfall erosion index (measured/calculated from test);
K = the erodibility of the soil (calculated from control tests);
LS = the topographic factor (2.02 for 8 x 27 ft slope);
C = the cover factor = (1.0 for all test slopes); and
P = the practice factor = ratio of treated slope sediment loss (via the sum of sediment moving through, over, or under a SCB) to control slope sediment loss (via sediment without SCB).

Note: P = 1.0 for the control slope.

Total sediment loss and the associated rainfall depth measured during the testing are the principle data used to determine the P-Factor. The P-Factor thus calculated is the reported performance value. This facilitates product-to-product comparison of test results at a common point of the storm event.

RESULTS

Results from measured design criteria and performance testing are reported in Table 1 for each individual sediment control barrier. Performance test results are based on means for all three tested replications.

Table 1: Design Characteristics and Performance of Sediment Control Barriers.

Sediment Control Barrier (SCB)	Design Dia/ Height (in)	Density/Weight (lbs/linear ft)	Undermined‡/ Overtopped (min)	Sediment Loss (tons/acre)	P Factor	Removal Efficiency (%)
Filtrexx® SiltSoxx™	8	10.4	28	2.6	0.18	82
Filtrexx® SiltSoxx™	12	25	NA	0.4	0.03	97
Straw Wattle	9	2.2	43‡	2.8	0.21	79
Straw wattle	20	2.7	33‡	4.1	0.30	70
Off-spec compost sock	12	14.7	26	4.6	0.34	66
Tire-chip wattle	9.5	16.6	23‡	4.4	0.31	69
Triangular Silt Dike	10	0.5	34	0.9	0.07	93
Bare soil (control)	NA	NA	NA	14.5	1.0	0

SUMMARY & CONCLUSIONS

The main objective of this study was to evaluate the sediment control performance of seven different sediment control barriers under a standardized testing procedure. Based on the testing methods described above, the sediment control barrier characteristics that most affected sediment removal performance included staking, degree of level surface, and particle size of filler media. All sediment barriers experienced overtopping for all replicates due to the amount of runoff and sediment generated under this test method. Overtopping increased at low points in the sediment control barrier, due to depressions from staking or uneven fill material. Because of this phenomenon, practices with extremely level surfaces are able to maintain sheet flow during overtopping (rather than localized concentrated flow) thereby reducing sediment loads flowing over the practice. Those practices that utilize finer particle-size materials for filler media (straw wattles, off-spec compost tube) appeared to overtop or undermine faster, due to the increased rate of runoff accumulation (ponding) and/or hydraulic pressure behind the barrier. Additionally, these sediment control barriers were most likely to undermine, thereby releasing the most sediment. It should be noted that overtopping typically releases much less sediment, relative to undermining, as the former still allows sediment deposition and filtration to continue, while the latter often results in mass failure if left unchecked.

In sum, those practices that could convey runoff through the barrier while preventing undermining were the best performing practices – these included both SiltSoxx™ and Triangular Silt Dike. It should be noted that the tire-chip wattle has both high density and apparent high hydraulic-flow through rate characteristics, but because the practice cannot be staked (secured to the ground), this practice experienced more undermining than any other.

The secondary objective of this study was to evaluate any sediment control performance difference between compost filter socks adhering to federal and state specifications versus those that do not meet these specifications. While the quantitative difference between these two practices is quite substantial, it is interesting to note that the 8-in SiltSoxx™ performed better than the 12-in off-spec compost tube, generating 43% less tons/acre of sediment, underscoring the importance of specification compliance in the performance of these practices. Furthermore, although the 8-in SiltSoxx™ was the smallest diameter sediment control barrier, it performed better than any other tubular sediment control barrier in the study. And finally, likely due to the combination of high density, high hydraulic flow through, staking ability, and filtration, the 12-in SiltSoxx™ did not undermine, resulting in 91% less tons/acre of sediment relative to the off-spec compost tube, and earning the highest sediment removal efficiency and designation of best performing sediment control barrier in this study.

Fig. 2-6: Testing Photos from TRI Environmental

Fig. 2: 12" SiltSoxx™
(97% Removal Efficiency)

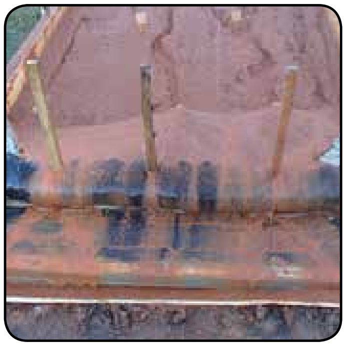

Fig. 3: 12" Off-Spec Compost Sock
(66% Removal Efficiency)

Fig. 4: 9.5" Tire-Chip Wattle
(69% Removal Efficiency)

Fig. 5: 10" Triangular Silt Dike
(93% Removal Efficiency)

Fig. 6: 20" Straw Wattle
(70% Removal Efficiency)

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Ecosystem Service Benefits of Filtrexx® Compost-Based Sustainable Management Practices (SMPs)

TechLink Research Summary #3335

Filtrexx Living Walls are Sustainable Management Practices

Filtrexx International is committed to creating high performance environmentally sustainable products, not just for their intended applications, but across the entire supply chain from cradle to end use. At Filtrexx International we are moving beyond the concept of *best* management practices (BMPs), and have introduced the idea of a truly *sustainable* management practice (SMP). This is not just a short-term commitment, it is part of our company mission statement.

As part of our mission we strive to protect and restore natural capital, in order to maximize the ecosystem services and benefits they provide all of us. *Natural Capital* is the stock material within the environment which provide free ecosystem services that maintain our economic, environmental, and human health (examples: forests, biodiversity, and *organic matter*). *Ecosystem Services* include soil erosion control, storm water prevention and filtration, maintenance of natural cycles (water, carbon, nutrients), waste reduction, and climate regulation (regional and global). As an example, one tree (natural capital) can evapo-transpire 2.5 million gallons of water over its lifetime, regulating the water cycle and climate (ecosystem services). According to Economist Robert Costanza (1997), ecosystem services have a global economic value of $33 trillion/year. Ecologist Carl Jordan (1998) adds, the closer we manage landscapes to their natural design the more we save on energy, inputs, hard infrastructure, and financial expenditure...*working with nature* takes advantage of services that are both free and efficient.

Filtrexx products are well known for their storm water quality benefits through natural biofiltration mechanisms, and now we would like to introduce you to why Filtrexx is leading the industry in sustainability and maximizing the benefits of ecosystem services provided by Filtrexx SMPs.

FilterMedia™ Compost for SiltSoxx™

GrowingMedia™ Compost for GroSoxx®

Water Absorption, Conservation, & Treatment

With approximately 50% organic matter, a high porosity, and high relative surface area, compost has the ability to absorb significant volumes of water. Data extrapolated from published University research shows that each linear ft of 12 inch diameter Soxx (which equates to 1 square foot of Living Wall) with GrowingMedia compost can absorb up to **4 gallons** of water (Faucette et al, 2005; Faucette et al 2007).

This information may be used to determine the potential volume of rainfall absorption and resulting storm water runoff reduction, or the volume of captured storm water that can be treated or used as irrigation if applied to the Filtrexx Compost-Based SMP. Each of these scenarios could be extremely beneficial in drought prone or water restricted areas, or where green infrastructure or green building programs have been implemented.

Recycled Organics

Recycling organic wastes by diverting these materials from landfills helps to preserve landfill space, prevents pollution from landfill leachate, and reduces carbon intensive greenhouse gases. The amount of organics recycled/diverted from the landfill per linear ft of 12 inch diameter SiltSoxx with FilterMedia compost = **80 lbs** organics diverted from the landfill, while 1 linear ft of 12 inch diameter GroSoxx with GrowingMedia compost = **160 lbs** organics diverted from the landfill.

Carbon Footprint Reduction

Filtrexx Compost-Based SMPs can have a significant impact on a project or site's carbon footprint. There are four key ways in which our products can significantly lower carbon footprint.

1. *Methane Avoidance:* this is the process in which methane gas is prevented from forming due to organic materials being recycled/diverted from the landfill through composting. Methane gas is 25 times more concentrated in carbon than carbon dioxide (e.g. 25 carbon dioxide equivalents or 25 CO_2e). For each linear ft of 12 inch GroSoxx with GrowingMedia compost we prevent **280 lbs** of CO_2e from going into the atmosphere, for SiltSoxx with FilterMedia compost we prevent **140 lbs** of CO2e (Sakai, 2007).

2. *Carbon Sequestration by Permanent Vegetation:* this is the process of taking CO_2 out of the atmosphere when permanent/perennial vegetation is established in our system (not temporary vegetation). If the project is in the Eastern US the carbon removed from the atmosphere is **0.05 lbs**/linear ft of 12 in vegetated GroSoxx, and if it's in the Western US it is **0.02 lbs**/linear ft of 12 in vegetated GroSoxx (Chicago Climate Exchange, 2008).

3. *Carbon Sequestration by Storing Carbon in the Soil:* this is the process of using the stable carbon in compost, returning it to the soil, and creating a carbon sink (rather than source) as long term soil carbon. When compost is returned to the soil, part of the carbon in compost is

considered active and part is considered passive. The scientific community is currently debating which parts should be considered as long term soil carbon contributing to carbon sequestration. Using only the passive carbon fraction (where there is greater scientific consensus) each linear ft of 12 inch GroSoxx will sequester **27 lbs** of CO_2 (California Environmental Protection Agency, 2011).

4. Transportation Reduction: when we source, manufacture, and utilize compost-based products locally we prevent carbon dioxide emissions due to reduction of transportation in shipping and freight. Many of our competitors source, manufacture, and ship their products from oversees or across the US. The US Green Building Council's LEED Rating and Certification Program also awards credits for choosing products that meet this transportation and CO_2 reduction profile. For each trucking mile reduced we prevent **4.0 lbs** of CO_2 from entering into the atmosphere (US Environmental Protection Agency, 2010). For every **4.7 tons** of CO_2 we prevent or remove from the atmosphere it is the equivalent of removing one mid-size car from the road for one year (US Environmental Protection Agency, 2014).

Transportation Reduction
To determine CO_2 reduction from transportation, you will need to determine the number of truckloads of SiltSoxx/GroSoxx and comparative product to be used, and the distance from the site of manufacture to project site location for both products.

Where:
A = (B-C) x 4.2 - (D-E) x 4.2

A = CO_2 reduced (lbs)
B = Competitor product truckloads (#)
C = Competitor product distance from manufacture to project site (mi)
D = Filtrexx product truckloads (#)
E = Filtrexx product distance from site of manufacture to project site (mi)

NOTE: SiltSoxx values should be used for all applications that use FilterMedia compost; GroSoxx values should be used for all applications that use GrowingMedia compost.

Sustainable Management Practices Quick Reference Guide

Water Absorption/Conservation (max, per rainfall event)
5 in GroSoxx = 0.6 gal/ft
8 in GroSoxx = 1.7 gal/ft
12 in GroSoxx = 4 gal/ft
18 in GroSoxx = 8 gal/ft
24 in GroSoxx = 16 gal/ft

Recycled Organics Diverted
5 in SiltSoxx = 12 lbs/ft
8 in SiltSoxx = 33 lbs/ft
12 in SiltSoxx = 80 lbs/ft
18 in SiltSoxx = 160 lbs/ft
24 in SiltSoxx = 320 lbs/ft

5 in GroSoxx = 25 lbs/ft
8 in GroSoxx = 67 lbs/ft
12 in GroSoxx = 160 lbs/ft
18 in GroSoxx = 320 lbs/ft
24 in GroSoxx = 640 lbs/ft

Carbon Footprint
1. Methane Avoidance
5 in SiltSoxx = 22 lbs CO_2e/ft
8 in SiltSoxx = 59 lbs CO_2e/ft
12 in SiltSoxx = 140 lbs CO_2e/ft
18 in SiltSoxx = 280 lbs CO_2e/ft
24 in SiltSoxx = 560 lbs CO_2e/ft

5 in GroSoxx = 44 lbs CO_2e/ft
8 in GroSoxx = 118 lbs CO_2e/ft
12 in GroSoxx = 280 lbs CO_2e/ft
18 in GroSoxx = 560 lbs CO_2e/ft
24 in GroSoxx = 1120 lbs CO_2e/ft

2. Carbon Sequestered in Vegetation; Western/Eastern US
5 in GroSoxx = 0.003/0.007 lbs CO_2e/ft
8 in GroSoxx = 0.008/0.02 lbs CO_2e/ft
12 in GroSoxx = 0.02/0.05 lbs CO_2e/ft
18 in GroSoxx = 0.04/0.1 lbs CO_2e/ft
24 in GroSoxx = 0.08/0.2 lbs CO_2e/ft

3. Carbon Sequestered in Soil
5 in SiltSoxx = 4 lbs CO_2e/ft
8 in SiltSoxx = 11 lbs CO_2e/ft
12 in SiltSoxx = 27 lbs CO_2e/ft
18 in SiltSoxx = 54 lbs CO_2e/ft
24 in SiltSoxx = 108 lbs CO_2e/ft

5 in GroSoxx = 4 lbs CO_2e/ft
8 in GroSoxx = 11 lbs CO_2e/ft
12 in GroSoxx = 27 lbs CO_2e/ft
18 in GroSoxx = 54 lbs CO_2e/ft
24 in GroSoxx = 108 lbs CO_2e/ft

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TechLink Research Summary #3336

Understanding and Identifying Compost Filter Media used in Compost Filter Socks

What is Compost?

Compost is the product resulting from the controlled aerobic, microbiological decomposition process of organic materials that have undergone mesophillic and thermophillic temperature phases, that sanitize and stabilize the recycled organic materials to the point that it is beneficial to plant growth. Compost bears little physical resemblance to the raw material from which it originated. Compost is a carbon and biologically based source of organic matter that has the unique ability to improve the chemical, physical, and biological characteristics of soils or growing media. It contains plant nutrients but is typically not characterized as a fertilizer (US Composting Council 2008; Risse and Faucette, 2000).

Most federal and state agencies require compost to meet the 40 Code of the Federal Register (CFR), Part 503, Appendix B, Process to Further Reduce Pathogens (PFRP) to ensure safe use. This states that compost must undergo either the in-vessel composting method or the static aerated pile composting method, and maintain temperatures over 131 degrees F for 3 consecutive days; or use the windrow composting method and maintain temperatures over 131 degrees F for 15 consecutive days with a minimum of 5 turnings of the windrow.

How is Compost Produced?

Compost is produced through the controlled activity of aerobic (oxygen- requiring) microorganisms. These microbes require oxygen, moisture, and food in order to grow and multiply. When these factors are maintained at optimal levels, the natural decomposition process is greatly accelerated. The microbes generate heat, water vapor, and carbon dioxide as they transform raw organic materials (waste) into a stable soil conditioner (compost). Active composting is typically characterized by a high-temperature phase (thermophilic) that sanitizes the product by killing weed seeds, plant and human pathogens, and allows a high rate of decomposition; followed by a lower-temperature phase (mesophilic) that allows the product to stabilize while still decomposing at a lower rate. Compost can be produced from many "feedstocks" (the raw organic materials, such as leaves, manures or food scraps). State and federal regulations exist to ensure that only safe and environmentally beneficial composts are marketed.

Why use Compost?

Organic materials that have undergone the composting process typically exhibit many benefits including, but not limited to: weed seed destruction, plant and human pathogen destruction, degradation of toxic materials, methane gas prevention, neutral pH suitable for plant growth, carbon to nitrogen ratio suitable for plant growth, stabilization of nutrients, stabilization of carbon, carbon sequestration, beneficial microorganisms, sorption of pollutants in soil and/or water, biofiltration of pollutants in runoff, soil erosion control, plant disease suppression, water absorption, and water conservation.

What is Compost Filter Media?

Compost filter media is organic material that has undergone the composting process and has had the small particles removed through a screening process. The large particles, often termed "overs", are the material used and described as compost filter media. This screening process is required to meet applicable federal and state particle size distribution specifications, typically 99% < 2 inch, 60 > 3/8 inch (although this may vary slightly from state to state).

Federal and State Specification Requirements

At the current time 6 federal agencies and most state environmental protection agencies and/or state departments of transportation have a standard specification or required guidelines for compost filter media applications. While these vary substantially in their level of detail and requirements, most include parameters for 40 CFR Part 503 PFRP compliance, and content ranges or threshold levels for heavy metals, pH, organic matter, moisture, soluble salt, biological stability, maturity, human made physical inerts, toxic materials, particle size distribution, pathogens, and physical appearance (Archuleta and Faucette, 2011).

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