

# **Reclamation Under the Looking Glass; New England Programs and Regulations**

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Biosolids and paper mill sludge (short paper fiber) represent a large portion of the organic waste stream in northern New England. For over a decade, both materials have been used in northern New England as the organic matter component in manufactured topsoils. The use of uncomposted biosolids and short paper fiber in manufactured topsoils represents of technologically simple means of recycling these materials, while providing high organic matter content soils that are effective at resisting erosion. Manufactured topsoils containing short paper fiber and biosolids have been used extensively in northern New England for establishing vegetation in disturbed areas, such as spent gravel pits, as well as being used for the vegetative layer on landfill capping projects. While the use of manufactured topsoils has successfully eliminated the need for transporting hundreds of thousands of cubic yards of stripped topsoil to disturbed areas, increasing regulatory requirements, especially in New Hampshire, have provided several challenges to the development of topsoil recipes and the implementation of operationally practical topsoil manufacturing programs.

## ***Topsoil Components***

Short paper fiber is a by-product of the papermaking process which consists primarily of the wood fibers that are too short to bond to make the paper. Short paper fiber also contains lime, clay and the microbial biomass generated during the treatment of process water. Because short paper fiber originates from wood, it is a good source of organic matter. Additionally, the cohesion of the wood fibers in short paper fiber provide for the erosion-resistance qualities of the manufactured topsoil, and the high water holding capacity of short paper fiber allows the manufactured topsoil to retain moisture for grass growth even in periods of low rainfall.

In general, short paper fiber has a low nutrient content and a high carbon to nitrogen ratio (C:N). The high C:N of most short paper fiber allows for high application rates in manufactured topsoils without creating nitrate leaching concerns that often drive application rates with more nitrogen-rich organic residuals. Consequently, short paper fiber is often the primary organic matter component in manufactured topsoils. In some cases, though, short paper fiber used as a soil amendment without supplemental fertilization can result in nitrogen immobilization in soils, resulting in reduced yields due to nitrogen deficiencies.

Biosolids have proven to be an ideal supplement to short paper in manufactured topsoils. Biosolids not only provide nitrogen in a slow-release form that can counteract nitrogen immobilization, they also provide other macro-nutrients, such as phosphorous, and micro-nutrients that typically occur at very low concentrations in the short paper fiber. Additionally, biosolids can help to quickly establish a microbial community in the otherwise sterile mix of short paper fiber and sand.

## ***Adjusting C:N and Total Nitrogen Loading***

Blending ratios of short paper fiber, sand and nutrient sources (including biosolids) in manufactured topsoils were originally determined by trial and error. In the 1980s operators of topsoil manufacturing programs were aware of the potential for nitrogen immobilization, but good data on target C:N ratios for the organic matter components of manufactured topsoils was lacking. More recent research directly related to manufactured topsoils, along with information gathered from composting research, has indicated that a target C:N between 25:1 and 35:1 in the organic matter component of topsoils is likely to provide a balance between nitrogen

immobilization in soil and leaching of nitrate-nitrogen mineralized in excess of crop uptake and soil microbial needs.

As nitrogen management gained more attention in land application programs, regulators in New Hampshire became concerned that adjusting C:N ratio alone may not provide adequate protection from excessive nitrogen leaching. When applying biosolids at agronomic rates to grow silage corn in northern New England, the nitrogen need of the crop is approximately 150#N/acre per season. In the case of biosolids with 20% of its nitrogen in the inorganic form and with the remainder in the organic form, the nitrogen loading rate would be approximately 290# total Kjeldahl nitrogen (TKN)/acre. Manufactured topsoils typically have a mix ratio close to 1 part organic residuals to 1 part mineral base material on a volumetric basis. In the case of a manufactured topsoil with a C:N of 25:1 placed in a 12" lift over a disturbed area, nitrogen loadings can be as high as 5000# TKN/acre. Although providing a C:N of 25:1 in the organic residual components of the topsoil may reduce the rate at which nitrogen is mineralized, regulators were concerned that the relatively high loading of potentially mineralizable nitrogen could result in large pulses of organic nitrogen being mineralized and leaching to groundwater as nitrate nitrogen. As an example, if only 5% of the 5000# TKN/acre described above were mineralized during the first year after application, 250# nitrogen per acre would become available. University of New Hampshire Cooperative Extension's nitrogen recommendation for grass seedings, by comparison, is 60# per acre.

As a result of concerns over nitrate leaching, regulators in New Hampshire have taken the conservative approach of requiring an adjusted 30 - 35:1 C:N in the organic matter component of manufactured topsoils and limiting the nitrogen loading to 2500# TKN/acre.

#### ***VOC Testing and Materials Management***

While much of the historical focus of the chemical quality of organic residuals has been related to trace metal concentrations, regulators in several New England states have initiated several testing programs, and in some cases, numerical limits for organic compounds that occur in biosolids and short paper fiber. Testing in New Hampshire has indicated the potential for certain volatile organic compounds (VOCs) to be found at detectable levels in biosolids and short paper fiber. Of most concern to regulators, some compounds, most notably acetone and methyl ethyl ketone (MEK), appear to be generated within stockpiles of short paper fiber.

Acetone and MEK are volatile organic compounds that are both naturally occurring and commercially produced for industrial purposes. MEK is a natural product made by some trees and commonly found in some fruits and vegetables. It has been qualitatively identified as a volatile constituent in raw chicken breast muscle, milk, roasted filberts, cheese and other food products. Acetone is found in many of the same foods as MEK. MEK and acetone are also produced commercially and used as solvents. MEK is used in paints, glues and other finishes. Acetone is used to make other chemicals that make plastics, fibers and drugs.

In organic matter substrates under certain environmental conditions, such as anaerobiosis, MEK and acetone can be generated as a result of microbial activity. In the case of short paper fiber, neither acetone nor MEK is used extensively in the paper-making process, and testing of material directly off of de-watering presses at paper mills indicate that initial concentrations in short paper fiber are quite low, if at all detectable. In large stockpiles of short paper fiber that are in the field for extended periods of time, however, analyses demonstrating higher levels of these two VOCs suggest that they are being created as a by-product of anaerobic decomposition.

While both of the compounds are naturally occurring, and while exposure to potential receptors of these compounds from topsoil manufacturing activities is likely to be minimal, the potential for these leachable VOCs to contaminate groundwater has pushed New Hampshire regulators to require further testing and stricter management practices when using short paper fiber in manufactured topsoils. With information suggesting that VOCs may be generated within stockpiles of short paper fiber, and without organic compound numerical limits specific to organic

residuals recycling programs in hand, the New Hampshire Department of Environmental Services (NH DES) has begun applying soil standards from their Contaminated Sites Risk Characterization and Management Policy (RCMP) to topsoil manufacturing and biosolids recycling programs.

New organic compound standards in New Hampshire require testing of biosolids and short paper fiber for VOCs prior to processing the manufactured topsoils. Additionally, the final topsoil product must be tested prior to placement, and it must be demonstrated that the topsoil meets the RCMP standards for VOCs. Current management practices required by the NH DES to eliminate the potential for generation and subsequent leaching of VOCs include maximum stockpile periods (generally less than 30 days), maximum stockpile sizes (generally less than 1000 cubic yards for both the topsoil components and the finished topsoil), and the implementation of groundwater monitoring programs at reclamation sites.

### ***Enteric Virus Testing***

Class B biosolids are often used in New England as the source of macro and micro-nutrients in manufactured topsoils. Pathogen populations in Class B biosolids are not completely eradicated, but with the use of site restrictions, the EPA has determined that Class B land application is safe relative to potential pathogen transfer to human or other animal receptors. While the safety of Class B biosolids land application is well documented, recent testimony at a biosolids public hearing by a New England microbiology professor unfamiliar with land application practices, has resulted in additional pathogen testing requirements for reclamation sites in New Hampshire. The microbiologist suggested that enteric viruses may exist in Class B biosolids and that these viruses are small enough to travel through topsoil and into groundwater. Again, not having what they considered to be adequate information to counter this charge, the NH DES has required Class B biosolids used at reclamation sites to meet Class A criteria for enteric viruses (less than 4 MPN/gram). The NH DES reasoning in applying this regulation to reclamation sites is that the biosolids application rates may be higher in reclamation than in agricultural land application programs, and that reclamation sites typically have more coarse topsoils and subsoils than agricultural sites. Interestingly, testing of Class B biosolids to comply with this regulation has indicated that most Class B biosolids (especially those that are lime-stabilized) meet the Class A enteric virus standard.

### ***Summary***

Manufactured topsoils containing biosolids and short paper fiber have successfully revegetated hundreds of acres of disturbed land in northern New England. The manufactured topsoils have proven superior, both in terms of erosion resistance and long-term soil fertility, to native topsoils. Additionally, topsoil manufacturing programs have provided an environmentally sound recycling solution for the solids generated in New England municipal and paper mill wastewater treatment plants, and reduced the need for stripping topsoil from agricultural land to revegetate disturbed lands.

The evolution of the New England topsoil manufacturing programs in a period of increased regulatory scrutiny and public concern over land application issues has involved several adjustments to recipe development, analytical requirements and management practices. While early programs simply required trace metal testing of the topsoil components, and adjustment of the C:N ratio to minimize nitrate leaching, current programs include organic compound testing requirements and limits, maximum total nitrogen loading, enteric virus concentration standards and stockpiling requirements designed to reduce microbial activity within stockpiles. New requirements have increased the costs of manufacturing topsoil for disturbed land reclamation, and have effectively increased the minimum site size for which reclamation using manufactured topsoils is economically feasible. Overall the use of manufactured topsoils to reclaim disturbed land in New England remains a promising opportunity to create a self-sustaining soil ecosystem on lands that would otherwise remain barren. Additionally, the new testing required in some New England states has provided a valuable database on the environmental quality of topsoil manufacturing programs.