

## Biopolymer Soil Stabilization — Innovation Description

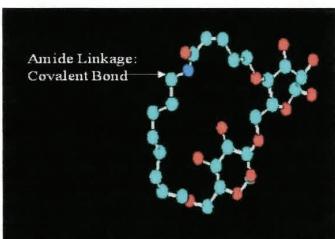
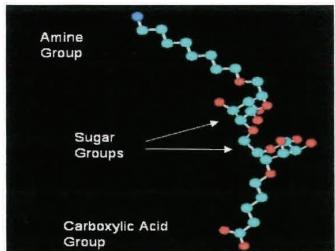
### **Innovation Description: Soil Stabilization using a Natural Organic Polymer**

**What the innovation is:** The innovation is the use of a natural, extracellular, organic polymer produced by *Rhizobium tropici* bacteria symbiotic with leguminous to stabilize soil and to replace petroleum-based polymers as soil amendments. The biopolymer is produced by stimulating the Rhizobium bacteria into hyper production of biopolymer material in a cell-free reactor as described in US Patent 7,824,569 (2010). This natural biopolymer can be used for rapid soil amendment. The natural functions of this biopolymer include surface adhesion of cells, water retention, and nutrient accumulation. It has been established that individual soil particles are linked together within the biopolymer matrix. This reduces particle mobility and results in decreased erodibility by wind or water. In addition, soil biopolymer promotes rapid seed germination, root development, and drought resistance of seedlings. The enhanced root development results in a higher rate of carbon sequestration, nitrogen fixation, and soil stability. A rapidly produced full cover of vegetation contributes to decreased soil erodibility.

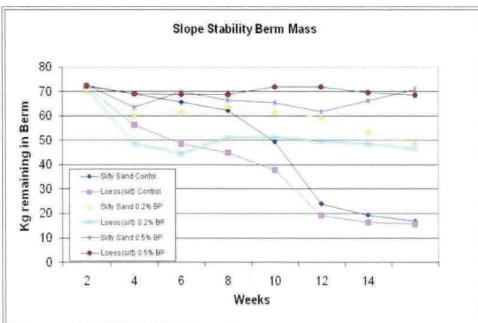
**Why it is innovative:** The innovation is the first method to stimulate naturally occurring *Rhizobium tropici* bacteria into hyper production of biopolymer material in an industrial production facility. Another innovation is the production of biopolymer material that as a soil amendment has the ability to increase seed germination, root growth, and water retention in soil adjacent to the plant root zone. Stimulation of the bacteria by producing a reactive (crosslinking) material (US Patent No.7,824,569, 2010) to produce large quantities of biopolymer in dedicated bioreactors provides sufficient availability of biopolymer for commercial applications such as slope stabilization and re-vegetation on highway and construction sites. Features of this innovation are: (1) the formation of a salt of the biopolymer that stops the cross-linking process, and (2) the capability to add the biopolymer to soil as either a wet or dry amendment.

**What it changed or replaced:** The natural biopolymer amendment replaces the numerous petroleum-based soil-stabilizing emulsions that are primarily copolymers of ethylene/vinyl acetate or are acrylic copolymers. Biologically produced polymers have unique benefits when compared to petrochemical-based polymers, such as (1) the reduction in the use of chemicals derived from petroleum, (2) complexity resulting from biosynthesis by bacteria providing a more diversified structure than the regularly recurring units in traditional plastics, (3) the stabilizing material is compatible and/or enhances growth of vegetation; this provides enhanced functionality, including post-application cross-linking, ease of derivatization for specific uses, and a long-lived, but ultimately biodegradable, material without the environmental concerns associated with synthetic polymers, and (4) the use of these natural, organic polymers acts as a carbon storehouse for readily biodegradable sugars that would otherwise be oxidized to carbon dioxide (CO<sub>2</sub>) and contribute to elevated greenhouse gasses in the atmosphere. The combination of laboratory, pilot-scale, and field demonstrations performed to date using the biopolymer as a soil stabilization amendment have demonstrated the addition to be a safe, effective, and cost-efficient mechanism for improving soil stability and reducing soil erosion and sediment transport.

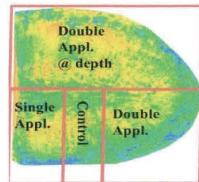
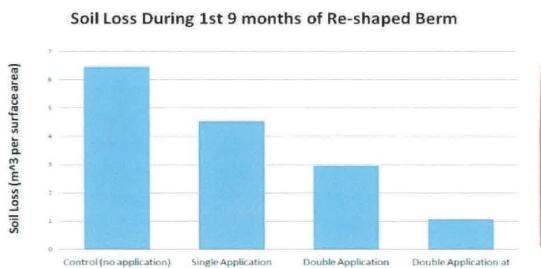
**Where/when it originated, has been used, and is expected to be used in the future.** Natural production process and isolation of the *R. tropici* biopolymer from the bacterial cells was initially studied from 2005 to 2007 as a basic research effort under the Army ERDC Military Engineering Program to mitigate the suspension of fugitive dust at airfields. Research quickly led to other potential applications. In laboratory studies, the biopolymer has been used to show reduced soil erosion by water and wind and increased germination and early growth of seedlings, particularly legumes and grasses. In 2010, a US Patent was awarded for the process of producing the stable salt of the biopolymer. Field studies (2009-2012) at Iowa Army Ammunition Plant were funded by the DoD Environmental Security Technology Certification Program (ESTCP). The ESTCP demonstrations collected cost as well as performance data for the new technology. Future studies will evaluate the biopolymer technology for the stabilization and re-vegetation of levees and for industrial site applications. The technology has been transferred via patent licensing agreements to 4 private sector companies for commercialization.

**Innovation Illustration: Soil Stabilization using a Natural Organic Polymer**

Intra-molecular amide linkages produce ringed, or bundled, biopolymer. Inter-molecular amide linking produces long chain high molecular weight biopolymer. These chemical characteristics make possible the physical binding of soil particles into the polymer matrix, increasing the soils resistance to erosion. The biopolymer also increases soil moisture/nutrient capacity enabling rapid seed germination and a degree of drought resistance, which also protects soil from erosion. The biopolymer is an all-natural, non-toxic, and non-petroleum-based product.



Addition of biopolymer showed significant reduction in soil loss using the Loess and Silty Sand soil types. Addition of biopolymer to soil results in a shift to larger soil particle sizes. This increases soil cohesion and compressive strength, resulting in decreased erosion of slopes, berms and levees.



Soil slippage in the control (untreated) area of a large sloped structure. The graph illustrates changes in soil volume and the differences in surface roughness between biopolymer treated and control areas of the berm.