

Geo-EnvironMeet 2025

GSP 358

Innovative Developments toward Sustainability

Selected Papers from Geo-EnvironMeet 2025
Louisville, Kentucky • March 2–5, 2025

EDITED BY

Arvin Farid, Ph.D., P.E.
Krishna Reddy, Ph.D., P.E., D.GE
Nazli Yesiller, Ph.D.

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The Geo-Institute
of the American Society of Civil Engineers

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Preface

The Geotechnical Special Publication (GSP) presented here compiles papers from GeoenvironMeet 2025, the ASCE Geo-Institute's Geoenvironmental Engineering conference, held from March 2–5, 2025. This event marks nearly four decades since the inaugural geoenvironmental specialty conference. Held every six to eight years, it serves as a vital platform for addressing current issues in our field. The theme of the 2025 conference, "Sustainability and Resilience of the Geoenvironment in Facing a Changing Climate," underscores our commitment to tackling pressing challenges. GeoenvironMeet 2025 drew a diverse audience of geoenvironmental professionals, fostering invaluable exchanges amidst the backdrop of unprecedented industry challenges. While the conference featured numerous discussions and networking opportunities, this publication offers a focused selection of papers centered on Innovative Developments toward Sustainability. The topics include innovative sustainable developments in geotechnology, geo-energy, and biogeotechnics, among others, reflecting ongoing and emerging developments in the field. The rigorous review process adhered to ASCE GSP standards, with each of the submitted manuscripts evaluated by two or more independent peer reviewers. We extend our heartfelt gratitude to the session chairs and reviewers whose dedication ensured the success of both the conference and these proceedings. It is our hope that this compilation serves as a valuable resource for the geoenvironmental engineering community in the years ahead.

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Fungal-Mycelium Biocover: A Novel Biogeotechnology for Improving Soil Resistance to Water and Wind Erosion

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ABSTRACT

Soil erosion by water and wind poses serious threats to land resources, infrastructure, and human health. This study investigates the potential of fungal mycelium as a biocover to protect soil from erosion. Due to global warming, climate change, and human activities, land-related hazards, such as soil erosion, dust storms, and desertification, have increased in frequency and intensity. These hazards affect agricultural lands, coastal zones, fire-affected areas, and geotechnical structures, such as slopes and embankments. Planting trees and vegetation is a natural way to prevent desertification, reduce soil erosion, and sequester carbon, but it takes a long time (1–3 years) to establish. Considering the rapid rate of soil loss due to climate change, there is a need to develop alternative soil stabilization techniques that are eco-friendly, cost-effective, and supportive of vegetation growth and establishment. This study presents a novel biogeotechnology that uses living microfibers (fungal mycelia) as a soft engineering method to stabilize soil surface and minimize soil loss. Experiments were conducted on fungal-treated Ottawa 20/30 and F60 silica sands to evaluate their resistance to water and wind erosion, respectively. Sand slopes were inoculated with spore suspension of *Pleurotus ostreatus* fungus and grown for 7-, 10-, and 14-day periods. The slopes were exposed to simulated rainfall events, and the soil loss and runoff were measured. The Portable In Situ Wind Erosion Laboratory (PI-SWERL) was used to test the wind erosion resistance of another set of fungal-treated and untreated F60 silica sand. Results show that the fungal-mycelium treatment of loose cohesionless sand reduced soil loss (to less than 5%) compared to untreated samples. The threshold friction velocity (indicating resistance to dust entrainment) of treated sands was significantly higher than that of untreated sand due to the mycelia biocover formed after a growth period of 7 days. The results demonstrate the feasibility of engineered living systems such as fungal-mycelium growth to serve as a fast, cost-effective, eco-friendly, and soft-engineering alternative for mitigating unsustainable soil loss.

INTRODUCTION

Soil erosion poses significant threats to food security, land resources, earthen geotechnical infrastructure, ecosystem functionality, and human well-being. Middleton and Thomas (1997) reported that 87% of land degradation in arid regions was due to wind and water erosion. The global average rate of soil erosion by water increased from 25 Gt/year in 2015 to 44 Gt/year (2.4

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ton/ha/yr.) in 2020 and projections suggest it could rise to 65 Gt/year by 2050 if no substantial interventions are implemented (FAO and ITPS, 2015; von Jeetze et al., 2023; Wuepper et al., 2020). Similarly, Global dust emission rates, estimated to range between 0.5 and 3.32 Gt/year (Ginoux et al., 2012; Shao et al., 2011) are particularly severe in dryland areas, which comprise 41% of Earth's surface (Middleton and Thomas, 1997; Ravi et al., 2010). These rates of soil loss substantially exceed the natural rate of soil formation, underscoring the need for ambitious and effective conservation measures. von Jeetze et al. (2023) suggests that global climate action and the implementation of sustainable soil protection strategies could reverse soil loss rates by 16 Gt/year compared to the *status quo*.

Conventional soil protection strategies employed by engineers involve the use of chemical binders such as Portland cement concrete, organic and inorganic soil stabilizers, and various proprietary erosion control products (soil covers) like rolled mats, blankets, geotextiles or hydraulically applied mulches. Dust mitigation interventions include the use of portable water, salt solutions, surfactants, and innovative nature-inspired approaches like enzyme-induced precipitation of calcium chloride crusts (Hamdan and Kavazanjian, 2016; Woolley et al., 2020) and engineered biocrusts (Ayuso et al., 2020; Fick et al., 2020). Hybrid biostabilization strategies that combine environmentally friendly approaches are also being considered (Patil et al., 2023). Given the drawbacks of current erosion mitigation practices—such as the use of portable water, hazardous chemicals, salts, high application and maintenance costs, energy demands, and associated carbon emissions—it is crucial to develop alternative soil stabilization techniques that are sustainable, eco-friendly, cost-effective, durable, and supportive of vegetation growth..

This study evaluates the effectiveness of a nature-based engineered living system using fungal mycelium to enhance soil resistance to wind and water erosion. Mycelium, the vegetative part of filamentous fungi, forms extensive 3D networks of natural fibers at the micron scale in soils (Figure 1a), altering the hydraulic and mechanical properties of the soil. These networks, through the secretion of extracellular polysaccharides, bind soil particles together, enhancing the formation of water-stable aggregates and altering the surface wettability of soil grains. Previous research has demonstrated that mycelium can improve soil strength (Lim et al., 2020), induce water repellency in sands (Salifu and El Mountassir, 2021; Zhang et al., 2020; Fig. 1b), delay infiltration and reduce hydraulic conductivity (Park et al., 2023; Salifu et al., 2022), and potentially contribute to soil erosion resistance (El Mountassir et al., 2021). The influence of engineered mycelium growth on soil erodibility under simulated rainfall and wind is yet to be explored. This study aims to determine the effects of mycelium treatment on the stability and erosion resistance of sand slopes subjected to intermittent simulated rainfall and induced wind.

MATERIALS AND METHODS

Soil. Ottawa 20/30 sand, poorly graded (SP), with a Coefficient of Curvature (C_c) of 1.01, a Coefficient of Uniformity (C_u) of 1.20, and a Specific Gravity (G_s) of 2.65, was used for the water erosion test. The F60 silica sand (SP, C_c = 1.73; C_u = 0.95, G_s = 2.65) which is more prone to dust formation, was used for the wind erosion test. These sands were selected instead of natural soils to eliminate extraneous variables and to represent non-cohesive soils that are highly susceptible to erosion by water and wind. The sands were amended with lignocellulosic fibers (woodchips) sourced from JRF Rotteinmaeir, Germany, which provided a substrate for the mycelium growth. An optimized sand-to-lignocellulose ratio of 1:0.02 was adopted, based on the findings of previous studies (Salifu, 2019).

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