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Opinion

Grand Challenges of the 21st Century Warranting A Shift in Geoenvironmental Engineering

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Opinion

Soil is a naturally three-phase, complex, and dynamic medium, containing solid particles, water, and air. Added to the three are organic carbon, minerals, living organisms, and nowadays contaminants. As with everything else in life, for every action, there is a reaction, making interactions among soil and the surrounding environment reciprocal. For example, soils play a vital role in the health of fauna and flora, as well as the global cycles of water, nutrients, and carbon. Flora and fauna also play a role in soil protection against erosion. Soil and its flora and fauna are impacted by the climate and can also reciprocally impact the climate.

Soil also plays a crucial role in food production for the ever-growing human population. Events such as floods and wildfires can lead to the loss of nutrient-rich topsoil, in turn, impacting food production. In addition, as vegetation can help sequester carbon, natural hazards such as wildfires not only turn the carbon sequestered within tree trunks into smoke, increasing greenhouse gases (GHG), but they can also reduce the vegetarian available for future carbon sequestration, exponentially increasing GHG, exacerbating climate change. The soil environment also retains groundwater, which is not only a source of drinking water, but also interacts with surface water, and is even beneficial in water treatment. Soil also holds other resources, such as fossil fuels, construction materials, and rare minerals, making them the subject of excess mining. At the same time and during this process, not only is the soil environment excessively altered, but it is also polluted through the process. Major examples are soil contamination by mine tailing and construction/demolition waste. The soil environment also serves as the eventual destination of waste (e.g., municipal waste) housing landfills. As seen through the above-mentioned examples, all these events and factors are deeply connected, complex, and dynamic.

On the other hand, the changing climate has exacerbated extreme climatic events from heat waves and droughts to snowstorms and hurricanes, turning them into conditions and natural hazards beyond what the current infrastructure (e.g., seawalls and levees) and environment (permafrost) can tolerate. The accelerated change in the climate has widened the spatial and temporal scale of these hazards deteriorating the entire environment, including air, surface- and groundwater, and soil. The resulting impacts alter the physical, chemical, and biological properties of the environment. In the case of soil, floods and wildfires lead to the loss of nutrients, alteration of acidity or alkalinity, and hydrophobicity of soil, in turn, resulting in the loss of vegetation, and, in turn, increased run-off and soil erosion. Not only these known impacts are not fully understood, but these also are unforeseen impacts. Understanding is the first necessary step to find ways for mitigation of impacts and restoration of soil to its original condition. Moreover, with the tremendous growth in the population and the resulting increase in waste and contamination, the changing climate and resulting post-hazard waste, the growth in the need for resources, sustainability and resiliency have become the focus of attention for all government agencies, and thus academicians and industry. Responding to all of this requires a holistic approach. Thus, long gone is the time that individual disciplines could address challenges. Research by inter- or multidisciplinary teams has been helpful but has run its course. The grand challenges of the 21st century require a convergent scientific and engineering approach to both problems and solutions by teams with members that are each transdisciplinary, so they can understand and communicate with each other.

On the other hand, in the past, engineers used natural resources to innovate and solve problems. A geotechnical/geoenvironmental example is the use of cement or lime to treat expansive soils. With the growth in waste generation, relatively more sustainable approaches were invented such as the reuse and recycling of waste in construction. An example is the use of fly ash in concrete construction. Other examples of sustainable solutions for the higher need for energy and resources are energy geo-storage, the use of geothermal energy, nuclear energy, and the extraction of gas hydrates. These solutions have extended beyond the natural conditions (e.g., temperature, pressure) within the soil environment. In the case of nuclear energy, the use of deep repositories requires knowledge of the soil behavior under extreme conditions. In the case of using the ground as a source or sink of energy for buildings' heating, ventilation, and air conditioning (HVAC), the raised or lowered temperature impacts the soil properties and bearing capacity of energy piles [1].

The grand challenges of today's world are larger in magnitude and run across wider spatial and temporal scales. Hence, like the convergent research approach, solutions need to be not only holistic but multifold, i.e., multiple problems need to be solved at once. A multifold approach is mixing two problematic or waste materials to create an engineered product. An example is the use of food-processing waste to treat expansive soils [2]. However, to examine innovative multifold sustainable solutions like this, physical, chemical, and biological processes need to be simultaneously considered. Not only do the geotechnical (mechanical strength) properties need to be analyzed, but geoenvironmental, economical (life cycle, cost, benefits), and social aspects of the design and build of this engineered product need to be analyzed convergently. In this example, the unused lime and calcium carbonate within the waste and the available pozzolanic properties can reduce the swelling potential of the clay, and the lower permeability of clay can immobilize the leachate of contaminants within the food-processing waste. However, unforeseen issues may arise (e.g., the high organic content of the food-processing waste can impact the behavior).

Hence, not only does the current state of the disciplinary scientific approach need to be expanded into a transdisciplinary convergent approach, but at times, the single disciplinary governing equations currently popular within each discipline require rethinking. Unlike some scientists who have pursued relatively more unifying and comprehensive governing equations (the most prominent examples are Maxwell's equation governing electromagnetic wave propagation or the pursuit of a unified theory by physicists), engineers simplify problems and only consider one physics or limited scales to find a more applied governing equation. An example is the consideration of only electrostatic forces governing properties for fine-grained soils and gravity-induced friction for coarse-grained particles. These two need to be merged to better understand the behavior of soils (containing both fine and coarse grains) contaminated with a mix of substances that are miscible, immiscible, or even ones like per- and poly-fluoroalkyl substances, PFAS, with more complex molecular structures and, in turn, fate and transport.

References

1. Farid A, Zimmerman DP (2023) Variations in the Capacity of Driven Energy Piles in Clay. In: Yukselen AY, Reddy KR, Agnihotri AK (eds) Sustainable Earth and Beyond. EGRWSE 2022. Lecture Notes in Civil Engineering. Springer, Singapore, pp. 370.
2. Kelly N, Farid A (2023) Soil-Stabilizing Potential of using Food Industry Byproducts. Proceedings of ASCE GeoCongress.