SHORT ABSTRACT

Thermal backfill is essential for underground crude oil pipelines, crude oil storage tanks, and geo-energy storage units. The major function of such backfills is to prohibit heat migration from the source as well as sub-structural stability. Often the thermal characteristics of locally available soils are not adequate for thermal backfill applications. Hence, it is required to modify the native soil by amending it with appropriate materials that possess suitable thermal characteristics and provide enhanced sub-structural stability. Biochar is a low thermal conductive, highly chemically stable, and eco-friendly material and has the potential to mitigate heat loss and may increase soil strength. However, the thermal characteristics of soil-biochar composite (SBC) in the compacted condition in view of applying it as thermal backfill material have largely been unaddressed in literature. Therefore, this study aims to explore the possibility of biochar-based soil composite as thermal backfill material. In the current study, two types of locally available soil and three types of biochar (hardwood biochar, water hyacinth biochar, and sugarcane bagasse biochar) are used to investigate the applicability of SBC as thermal backfills. The experimental results revealed that the SBC has lower thermal conductivity and volumetric heat capacity compared to bare soil under dry, wet, and near-saturation conditions. However, the UCS of soil also reduces with biochar amendment, which depends upon soil type and particle size fractions. To overcome this, a biopolymer-based stabilization technique is used to make it a high-strength sustainable biochar-biopolymer-based composite thermal backfill that is capable of providing efficient thermal insulation and strength. The findings of this study establish the synergistic attributes of biopolymer and biochar amendment for developing a high-strength and low thermal-conductive soil composite. A bench-scale study on the thermal insulation efficiency of SBC and soil-biochar-biopolymer composite (SBPC) in terms of heat transfer was conducted to facilitate field-scale applications. The SBC and SBPC exhibit lower temperatures than bare soil at all radial distances. The temperature difference between bare soil and SBC varies from 4 to 20 °C. A pyrolysis temperature of 400ºC is determined to be a suitable temperature regardless of the feedstock type because of the least energy consumption, considerable yield, required thermal characteristics, and carbon stability for the design period. The finding from the current study unravels the potential of biochar-based thermal backfill to restrict heat transfer from energy storage facilities.