Experimental study on the performance of electrokinetic remediation of waste materials at different scales

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Abstract

In areas like ports, rivers, and waterways, sediment accumulation can impede safe navigation, affecting shipping activities. Due to their potential to contain organic and inorganic pollutants, dredged sediments are regulated by both national and international legislations. These materials, considered as waste and generating significant environmental risks, can be stored on managed areas onshore. Annually, about 600 million m³ of dredged sediments worldwide present a challenge and opportunity for reuse in sectors like construction and agriculture. In addition, industries generate large volumes of different waste materials like slags and fly ash, which include a potential reuse. Electrokinetic (EK) remediation is one among many treatment methods, where an electric field is applied to transport contaminants out of the material. This work, conducted at the LOMC laboratory at Le Havre-Normandie University, focuses on investigating the effect of electrokinetic processes on dredged sediments and slags characteristics at different scales. The study includes three parts: (1) examining the effect of material storage conditions (freeze-thaw, dry-wet) on the EK process, (2) investigating the EK efficiency on remediation of co-product material (slags) under different electrochemical conditions, (3) analyzing physico-chemical behavior of materials during upscaling of EK process, and (4) comparing the behavior of fluvial sediment and marine sediments under EKR process. The results lead to draw the following conclusions according to the above investigations: Storage conditions can affect the evolution of electrochemical parameters during EK process, and the key parameter is the pore water pH which lead to the high removal of Na (95%), Cl (100%), Ca (17%), and Mn (25%). In opposite, this parameter does not affect significantly organic matter content or participle size distribution. Only carbonates, including calcite, dolomite, and aragonite, were significantly affected by pH during EK process. The scale-up results show that applying 1V/cm in different scales led to temperature raise and variations in chemical behavior. So, in addition to other similarity parameters, the thermal similarity was challenging due to the increase of temperature in larger scales. Mixing fluvial sediment with slag increased electric current, resulting in higher removal of As (28%), Cu (32%), Zn (55%), and Cd (85%). The study provides a preliminary step for combining two waste materials (dredged sediments and an industrial co-product) for electrokinetic remediation purpose and subsequent valorisation in civil engineering applications, meeting environmental requirements and offering an economically viable solution for waste material management and recovery.