Application of electrokinetic in controlling heavy metals migration in sand: A feasibility study

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Abstract - Uncontrolled migration of heavy metals from human activities in the subsurface can lead to the degradation of environmental quality and potential use of soil and groundwater. This paper studies the feasibility of using electrokinetics in controlling the migration of heavy metals in sand. Copper and iron (initial concentration of 100 mgL^{-1}) are the target heavy metals in this study as they are the most commonly found heavy metals from human activities such as mining and land filling. The performance of electrokinetic in controlling the migration of these heavy metals is tested in a sand tank at combination of water velocity and electrical gradient of 1.3 cm h^{-1}, 0.5 V cm^{-1} and 0.88 cm h^{-1}, 1 V cm^{-1}, respectively. The formation of gas at electrodes, scouring on carbon anode and corrosion of crocodile clips during experiment (0.88 cm h^{-1}, 1 V cm^{-1}) showed the occurrence of electrokinetics. Further studies need to be conducted to optimize the operating conditions for effective application of electrokinetic in controlling heavy metals migration in sand.

***Keywords*:** Electrokinetic, heavy metals, sand tank experiment, carbon electrode

I. INTRODUCTION

MIGRATION of heavy metals in ground can cause problem such as pollution of groundwater resources and contamination of soil. The presence of heavy metal in groundwater can affect the quality of water resources such as drinking and irrigation water. Improper disposal of mine waste at an open pit copper mine led to the leaching of copper discharge into groundwater resources at the Mamut Basin, Sabah making the groundwater unsuitable for daily consumption [1]. Various techniques for controlling the migration of heavy metals in groundwater have been developed, such as in-situ bioremediation and phytoremediation, which incur low cost and maintenance as it depends on the natural up take of heavy metals in soil and groundwater [2,3]. Nevertheless, these techniques typically have slow reaction rate, susceptible to ground conditions, may produce toxic by-products in oxygen deficient conditions and only applicable for shallow depths within the reach of the roots [4]. Thus, there is a need for more effective and rapid technique to control the contamination of heavy metals in groundwater such as electrokinetic.

Electrokinetic is a technology which utilizes electric (direct) current to control the migration of contaminated compound in ground such as radionuclide, heavy metals, certain organic compounds and mixed inorganic species [5]. It is effective in controlling the migration of heavy metals in soil by applying direct current though the electrodes installed in ground. The electrical gradient facilitates the electromigration of the ionic species, cations (heavy metals such as copper and iron) to cathode and anions (such as sulphate and nitrate) to anode [6,7]. Various electrokinetic configurations had been developed such as (i) using cation-selective membrane placed in front of cathode, (ii) using porous surfactant-coated ceramic anode casings, (iii) Lasagna™ process, (iv) Electro-Klean™ process, (v) electrokinetic bioremediation, (vi) electrochemical geooxidation, (vii) electrochemical ion exchange, and (viii) Electrosorb™ [7]. Its advantages over other techniques are (i) faster groundwater remediation than bioremediation [4], (ii) controllable application throughout the process [5], (iii) simple in-situ installation without much excavation required, and (iv) can be applied in both saturated and partially saturated soil conditions, thus not directly affected by groundwater level fluctuation [7]. There are four main mechanisms in electrokinetic which are electrolysis, electrophoresis, electroosmosis, and electromigration which will be discussed in the following section.

Despite the advantages, the performance of electrokinetic can be affected by the initial concentration of contaminant, mobility of contaminant, hydrogeology characteristics, and current and voltage applied [8]. Most previous research focused on the application of electrokinetics on saturated fine-grained soils, while limited studies were conducted on soil with greater hydraulic conductivity such as sandy soil. Mattson and Lindgren [9] showed that electrokinetics can be applied for unsaturated sandy soil through laboratory experiments. The study investigated the effect of the initial and final concentration

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