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Laboratory Model Test for Heavy Metal-Contaminated Soil Remediation Using PVDs

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Laboratory remediation experiments were carried out through the use of Prefabricated Vertical Drains (PVDs) to remediate soil contaminated with heavy metals. In the ground with lower permeability, the extraction of contaminants and the transmission of fluids are difficult; thus, to improve the injection or extraction of surfactants and to overcome difficulties due to micro pores in the soil, PVDs were used. For band-type drains, experiments comparing the effectiveness of filters coated with reactive material with the effectiveness of uncoated filters were conducted, and for cylindrical-type drains, experiments comparing the effects of the injection of surfactants were carried out. The heavy metal contaminants used in the experiments were Cu, Pb, and Cd, and concentrations over time were measured to assess the remedial efficiency. In the experiments, the initial concentrations were determined in consideration of the Korean Soil Contamination Warning Standards. The results from the experiments showed that the removal rates for Cd and Cu were 40% while that for Pb was 35% in the case of extraction alone. In the case of extraction with the application of reactants, the removal rates for Cu and Cd were 60% while that for Pb was 55%. In the case using both the reactant coating and cleansing agent injection, the removal rates were 74%, 65%, and 58% for Cd, Cu, and Pb, respectively.

INTRODUCTION

The method for the remediation of contaminated ground should basically be determined according to in-situ conditions and the properties of the contaminants. Methods to remediate soils contaminated by heavy metals are classified into physiochemical treatment techniques (such as pump and treat, solidification and stabilization, and vitrification), phytoremediation techniques (such as land farming), and biological treatments. However, these techniques have disadvantages such as the long duration needed for remediation, high costs, and potential risk of secondary contamination from chemical agents applied, and in the case of the actual remediation of in-situ ground having lower hydraulic conductivity, the remedial efficiency may decline rapidly or even make it difficult to use a particular remedial approach. The transmission of fluids and extraction of contaminants from contaminated soils with high concentrations of heavy metals or harmful materials would be difficult, and the voids in soils of lower permeability, such as silt or clay, are typically very small, limiting the injection or extraction of surfactant or desorption agents. Thus, technical methods for the remediation of contaminated soils and construction techniques to perform the remediation of soils are required (Korean Ministry of Environment, 2009).

The adsorption capacity of Prefabricated Vertical Drains (PVDs) for contaminants was assessed by conducting adsorption experiments on reactive material coated on filters of the drains and by comparing the results of the experiments with the isotherm adsorption model. Regarding the remediation system with PVDs, the remedial efficiency was measured through cylindrical chamber experiments. The reactive material used in the experiments was a natural zeolite, and the contaminants were Cu, Pb, and Cd. The choice of three kinds of heavy metals was due to a contamination survey. Incheon was distributed in three heavy metal contaminated areas.

This study was conducted to determine basic data to be used for geotechnical remediation engineering by analyzing the characteristics of factors affecting the contaminated soils in the remediation process through the use of PVDs and by reviewing the removal effects obtained through laboratory experiments.

THEORETICAL BACKGROUND

Reactive Material for Adsorption of Soil Contaminants

In the ground, contaminants are contained in ground water, and reactive material is applied to remove such contaminants. The reactive material should have sufficient reactivity and be cheap enough to secure in abundance. It should also persist over an assigned duration for the removal reaction of the corresponding contaminant(s), and the permeability coefficient of the material should be equal to or above the coefficients of the adjacent aquifers so as not to disturb the flow of the ground water (De Wiest, 1965). Among those reactants, the zeolites can be classified into natural and synthetic ones that are currently employed as ion exchangers, dehydrating agents, and adsorbents for separation processes exploited for adsorption and separation properties. Generally, the cation exchange capacity of the zeolite is known to be 200-400 meq per 100 g (Dyer, 1995). In addition to possessing the best cation exchange capacity among commonly available minerals, the zeolite can selectively exchange cations, and depending on the types of minerals, it may reveal different selective exchanging properties (Bhattacharya and Venkobacher, 1984).

Remediation Technologies for Soil Contamination

Biological remediation methods include bioventing, land farming, and natural attenuation. Physiochemical remediation methods include the electrokinetic method, soil flushing, soil vapor extraction, and the solidification and stabilization method (Rowe, 1987).

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