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Reduction of Soil Permeability Using Biological Method

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Abstract

An impermeable layer is one of the main parts of a landfill. One of the most common methods of constructing an impermeable layer is to use clay. If there is not a proper source close to the project site, preparing clay could be a major concern for civil engineers. One of the best options to provide required soil is to use the soil of the field. Usually the engineering properties of the soil need to be improved and in these projects the main property is permeability of soil. One of the novel methods that have been studied for improvement of the engineering properties of soils is the biological method. The method is actually a combination of biology and civil engineering, uses biological organisms. As a case study, this paper presents the use of this technique for permeability reduction of the soil base of the Shiraz landfill in Fars province, Iran. Bacillus Sphaericus with different values of optical density (O.D.) were used. The effects of curing time and bacterial O.D on the permeability of the soil have been studied. Soil permeability was measured using the falling head method. Tests showed that Bacillus sphaericus can decrease permeability of soil of Shiraz landfill significantly.

Keywords: Permeability of soil, Microbial calcite precipitation, Falling head test, Soil treatment.

1. INTRODUCTION

Engineering properties of soil in many parts of the world cannot meet the demands of the engineers. Considering the population growth, one of the most important thing is the need to find ways to improve the soil with a minimum consumption of resources and waste generation [1]. The demand for new, sustainable methods to improve soil continues to increase, with more than 40,000 soil improvement projects being performed per year at a total cost exceeding US$6 billion/year worldwide [2].The majority of these soil improvement techniques utilize mechanical energy and/or man-made materials, both of which required substantial energy for material production and/or installation [2].

Microbial-induced carbonate precipitation (MICP) has been the subject of research for several industrial applications. Several researchers have shown that MICP can be used to improve the mechanical properties of porous materials [3, 4, 5, 6, 7]This process involves hydrolysis of urea by bacteria containing the enzyme urease in the presence of dissolved calcium ions, resulting in calcium carbonate precipitation [3].

To make landfill floor impermeable, usually a layer of fine grain soil or polymeric coatings is used that imposes considerable costs. In order to reduce costs and take advantage of the existing soil, it is intended to study the use of a biological method to reduce permeability of Shiraz landfill soil and efficiency of this method will be investigated.

2. MATERIAL AND METHODS

The bacteria used for bacterial precipitation of calcium carbonate, due to the high activity in producing the calcium carbonate was B. sphaericus (PTCC 1487, Persian Type Culture Collection). B. sphaericus is unlike to cause human disease. No measurable health effects were seen in laboratory animals that were exposed to large concentrations of B. sphaericus by multiple routes of exposure. Cases involving human health effects following exposure to this organism are extremely rare. Mild eye and skin irritation may occur in humans following contact with B. sphaericus [8, 9].

Liquid culture media consisted of 3 g/L nutrient broth powder, 2.12 g/L NaHCO3, 20 g/L yeast extract and 10 g/L urea. Materials used for the medium is shown in Table 1.