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The Efficiency of Cleaning Agents at Different Temperatures in Soil Washing Process for Arsenic Contamination

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ABSTRACT

The use of heavy metals especially arsenic, lead, cadmium and mercury has led to extensive contamination of soils worldwide. Arsenic, however, is mostly noted because of its carcinogenic and mutagenic characteristics occurred due to the agricultural and industrial activities and the invasion of domestic and industrial wastewater into the soil environment. In this research, the removal efficiency of arsenic by use of soil washing process was assessed and diverse cleaning agents and also temperatures were applied. Water, Ethylene Diaminetetraacetic Acid (EDTA), Sodium Dodecyl Sulphate (SDS) and a mixture of EDTA and SDS were chosen as the agents to treat the contaminated samples. Regarding the analysis results, it could be observed that efficacy of water, EDTA, SDS, and the mixture solution of SDS and EDTA at 20˚C is 20.82, 45.21, 37.93, and 79.48%, respectively. These results were determined as 24.75, 52.34, 40.83, and 79.48% for treated samples at 50˚C, correspondingly. Consequently, the efficiency of soil washing solutions in the removal of arsenic (at 20˚C and 50˚C) is specified as: "Mixture of EDTA and SDS" > "EDTA" > "SDS" > "Water". Additionally, the investigation of the results showed that by increasing the temperature, the effectiveness of soil washing process would be enhanced.

KEYWORDS:

Arsenic, Soil Washing, Cleaning Agents, Temperature

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1- Introduction

Soil contaminated with heavy metals, such as arsenic (As), lead, chromium, copper, zinc, mercury and cadmium, are commonly found in many parts of the world as the result of rapid industrialization, increased urbanization, modern agricultural practices and inappropriate waste disposal methods [1, 2]. In 2011, the priority list of CERCLA's considered hazardous substances was published that arsenic was placed at the first row of the table [3]. Arsenic is not removed from the environment and is present naturally in soil and minerals, but its state could be changed. This heavy metal could enter the air and after landing on the ground, penetrate the soil and groundwater through runoff and leaching. Exposure to arsenic has been linked to a variety of cancers, cardiovascular disease, diabetes, and anemia, as well as having reproductive, developmental, immunological, and neurological effects [4]. As a consequence, the need for soil remediation is growing and the development of low-cost, efficient and environmentally friendly remediation technologies has become a key research issue [5]. Soil washing is an ex situ process that cleans contaminated soil through separating highly contaminated fine fractions from the clean coarse material and transferring them into a liquid stream. This method employs physical and/or chemical procedures to extract metals contaminants from soils. Today, various chemical agents (e.g., surfactants and chelating acids) are applied to increase the efficiency and decrease the time of the process [6, 7]. In this research, the arsenic removal by use of EDTA, SDS, and mixture of EDTA-SDS was investigated and the influence of temperature on the efficacy of soil washing using the reagents was explored.

2- Methodology

The soil sample was collected from the subsoil layer of unpolluted area (30-45cm) located in the south of Tehran. The sample was air-dried at room temperature and then screened through No.10 sieve to remove the fractions. For subsequent use in experiments, the soil sample was homogenized and stored in a plastic container. The physical and chemical characteristics of the soil consisting of classification, moisture content, soil pH, and plastic index were identified according to ASTM methods.

Five samples, each consisting of 35 g, were collected from the As-spiked soil (1 kg) earlier prepared and to measure the prior As (arsenic) concentration with Atomic Absorption spectrophotometer (AAS). For washing process, eight samples (20 g) were subsequently placed in the capped glass bottles (250 mL) which were earlier prewashed with water. Next, 200mL of the washing solutions were added to each 6 containers and the bottles were put on the shaker to carry out the washing process for 4 hr. After that period, each sample was passed through the sieve No.200 and then filtered using a filter paper to remove the precipitates. Since filtering process would take a long time, a vacuum pump and an evacuated flask were applied to enhance the speed of separating operation. The liquid phase was then sent to AAS for the analyses process. To evaluate the influence of temperature on As removal efficiency, samples were placed in the oven at 50˚C and other samples were kept at 20˚C (the temperature of the laboratory).

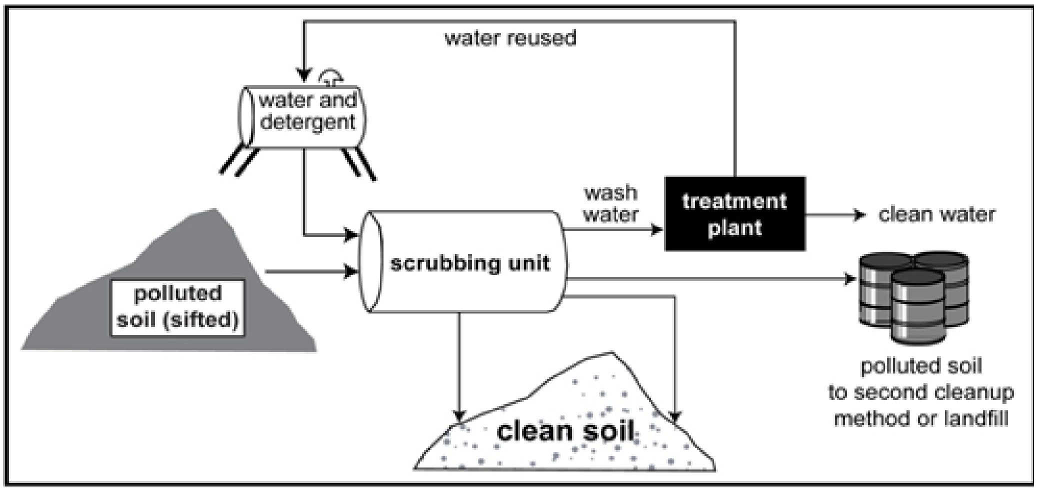

Figure 1. Schematic process of soil washing

3- Results

Soil washing was identified as an appropriate technique for the soil consisting of mostly coarse fractions (the soil containing 50 -70 % of the sand) and is not cost- effective for the soil comprised more than 30 – 50 % of fine particles. According to the characteristics of the soil sample collected from the south of Tehran, the proportions of sand and fine particles (clay and silt) were 53.05 % and 15.43 %, respectively. In addition, regarding the plastic limit of 21.1 % and moisture content of 10.4 %, it could be concluded that the soil has a slight potential swelling. Hence, based on the above data, soil washing is a proper method for treatment of the contaminated samples in this study.

The results showed that the As removal efficiency using the reagents decreased in the order of "Mixture of EDTA and SDS" > "EDTA" > "SDS" > "Water" at temperature of 20 and 50˚C. The removal efficiency of arsenic at two aforementioned temperatures were measured to be 20.82, and 24.75% for water, 45.21, and 52.34% for EDTA, 37.93, and 40.83% for SDS, and 74.18, and 79.48% for mixture of EDTA-SDS, respectively.

4- Conclusions

Regarding the physico-chemical properties of the soil consisting of sand (53.05 %), silt and clay (15.43 %), plastic limit (21.1 %), and moisture content (10.4 %) with low swelling potential, it was explained that soil washing was an appropriate technique for remediation of the contaminated soil samples. The analysis results represent that the As extraction considerably improved by the mixture of EDTA and SDS. On the other hand, mixture of EDTA and SDS illustrated more efficiency in comparison with water, EDTA and SDS. Moreover, in this research, the rise in temperature from 20 to 50˚C increased removal of arsenic. Thus, the elevated temperature could be considered as an effective factor on the rejection of arsenic from the contaminated soil.

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