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Field Study on Application of Soil Washing System to Arsenic-Contaminated Site Adjacent to J. Refinery in Korea

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Abstract. Since 1995 when Korean Soil Protection Act was established, social concerns about soil contamination have been growing up as survey on contaminated soil and clarifying contamination sources were systematically carried out. Consequently, lots of researches on various soil remediation techniques are in progress and some remediation techniques have shown technical advancements by pilot projects. However, there are few success cases for remediation of domestic sites contaminated with heavy metals. Soil washing techniques, which could treat contaminated soils in a short period and are economically feasible, are widely used but remedial efficiency and cost fluctuate very significantly according to soil texture, especially proportion of fine soils which has a strong influence on contaminants concentration.

According to difference of the soil texture, this study applied remediation process based on particle-size separation technique into heavy metals, representatively arsenic, contaminated site adjacent to J. refinery in Korea in order to achieve an efficient and cost-effective remediation.

Keywords: heavy metal, arsenic, contaminated soil, soil washing, soil texture, particle-size separation

1. Introduction

Remediation techniques for heavy metals contaminated sites include containment, soil washing, permeable reactive wall, electrokinetic remediation, solidification/stabilization, phytoremediation, bioremediation. In these remediation techniques, soil washing process, which could treat contaminated soils in a short period and is economically feasible, is widely used[1,2,3)].

Soil washing techniques have features that remedial efficiency and operating cost fluctuate very significantly according to soil texture, especially proportion of fine soils which has a strong influence on contaminants concentration. Generally, a high proportion of fine soil makes the treatment efficiency low and increases the cost[4)].

As shown in Figure 1, the study area is the vicinity land of J. refinery stack located in Janghang, South Chungcheng Province, Korea. The site is contaminated with heavy metals, representatively arsenic, from surface to 1m below the surface vertically and to 1.5km radius from the refinery stack horizontally, and cause of the contamination is dust scattering from the stack. Especially, according to the land uses of the target area, it can be classified roughly into sandy soil which has a low proportion of fine soil particles and silty soil which has a high proportion of fine soil particles[5,6)].

Thus, this study applied different remediation process considering proportion of fine soils in order to achieve an efficient and cost-effective remediation.

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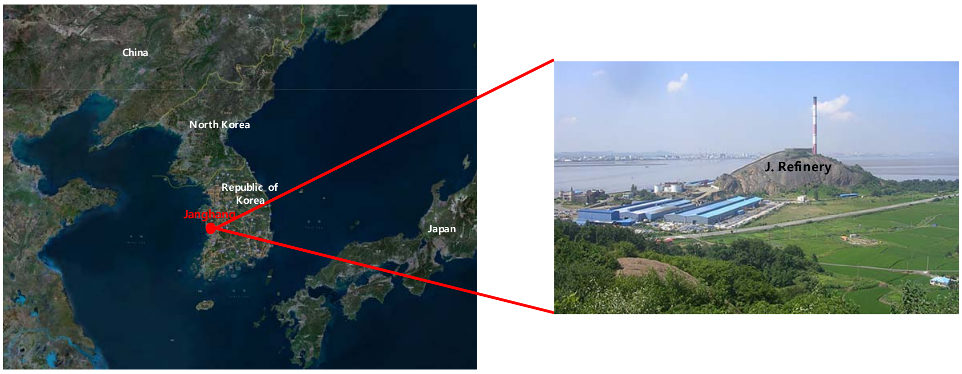

Fig. 1: Target area of this study; vicinity land of J. refinery stack

2. Materials and Methods

As shown in Figure 2, a soil washing plant with capacity of 3ton/hr was installed on the site to remediate the contaminated soils. The plant has been operated since October 2010.

The principles of soil washing are :

(i) Separation and removal of fine soils which have larger specific surface area. Contaminants are absorbed on the surface of soil grains, therefore, fine soils are carrying more contaminants, such as organic materials and heavy metals than coarse soils.

(ii) Pressurized water-jet removes the contaminants from the surfaces of soil grains.

Our soil washing system consists of five steps as follows. The first step is a crushing that feed contaminated soils mixed with water are unaggregated by a log washer. The second step is a screening that the unaggregated soils are divided into coarse soils like sand and gravel over 0.075 mm of particle-size and fine soils smaller than 0.075 mm of particle-size. The third step is a precise separation that the fine soils are subclassified according to cut-off particle-size in series connected multi-microcyclones. The fourth step is a clarification that highly contaminants-concentrated soil particles are flocculated and settled down. The final step is a dewatering that highly contaminants-concentrated soil sediments are dewatered by a horizontal vacuum belt filter (HVBF) and arsenic contaminated wash-water are cleaned up by activated carbon adsorption and then reused for zero-discharge of water.

Through the on-site operation of that soil washing plant, we evaluated treatment efficiencies of soil washing process and finally proposed a remrediation scenario according to soil texture.

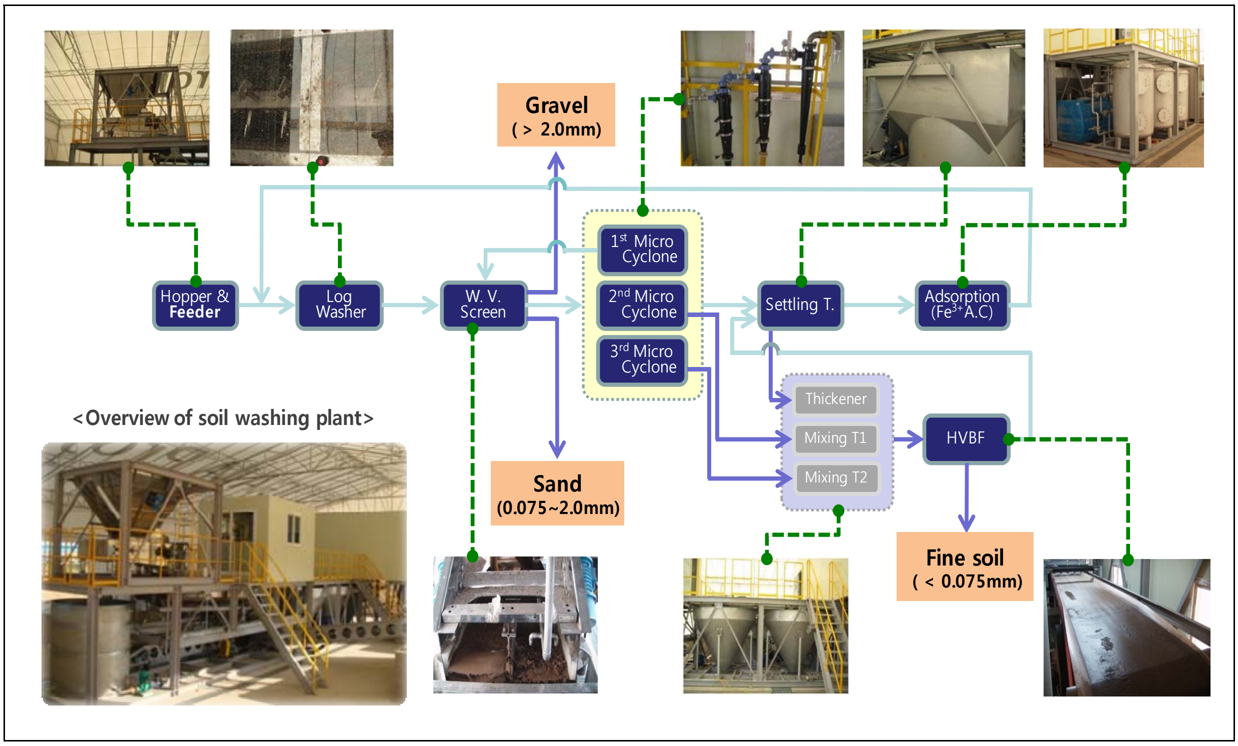

Fig. 2: Description of soil washing process and main facilities

3. Results and Discussions

In order to determine an efficient scope of application of the soil washing process, we carried out surveys on heavy metal contamination of the target area and evaluated the characteristics of the contamination. Figure 3 shows a variation of arsenic contaminated area by recent revision of Korean Soil Protection Act. An existing leaching method for estimating heavy metals concentration changed into aqua regia digestion method by the revision. There is a common trend that the contaminants are concentrated in depth 1 (surface to 0.3m below the surface vertically). After the legal revision, the volume of arsenic contaminated soil tends to increase.

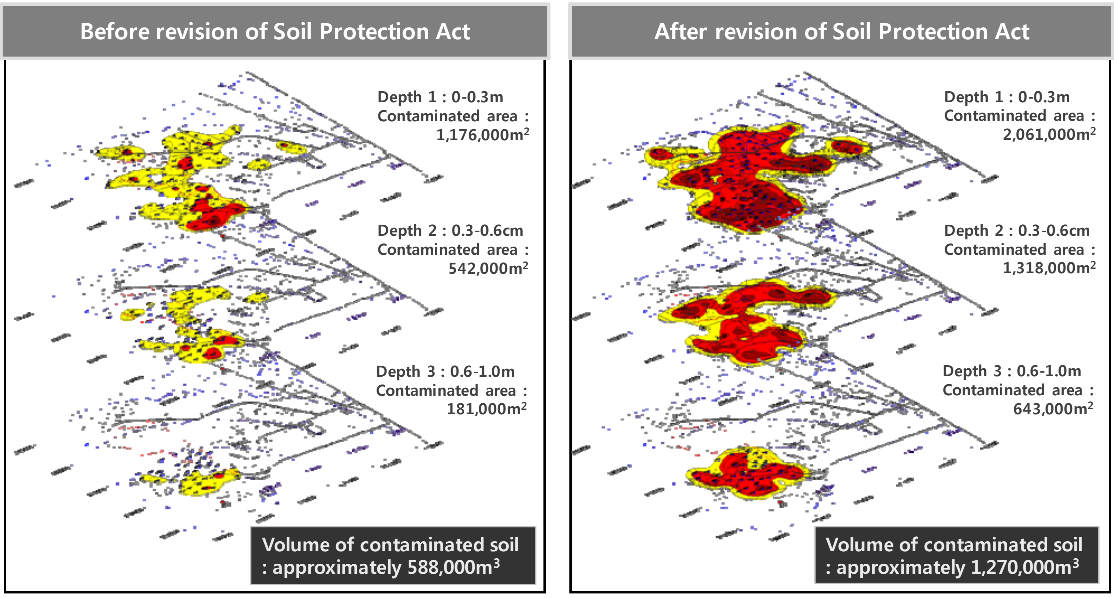

Fig. 3: Variation of arsenic contaminated area by revision of Korean Soil Protection Act

The results of soil washing for sandy soils were presented in Figure 4. Coarse soil particles like sand and gravel were dominant (over 85%) in the sandy soils but contaminants were concentrated in fine soil particles. The arsenic concentration of fine soils of 153.25mg/kg exceeded a legal standard of 25 mg/kg by Korean Soil Protection Act. The fine soils were precisely size-separated by a microcyclone as shown in the right graph of Figure 4. Soil particles which size is below 0.040 mm contained arsenic much more than soil particles which size is form 0.040 mm to 0.075 mm. Therefore, the soil particle-size below 0.040 mm could be an efficient range for additional treatment like waste treatment.

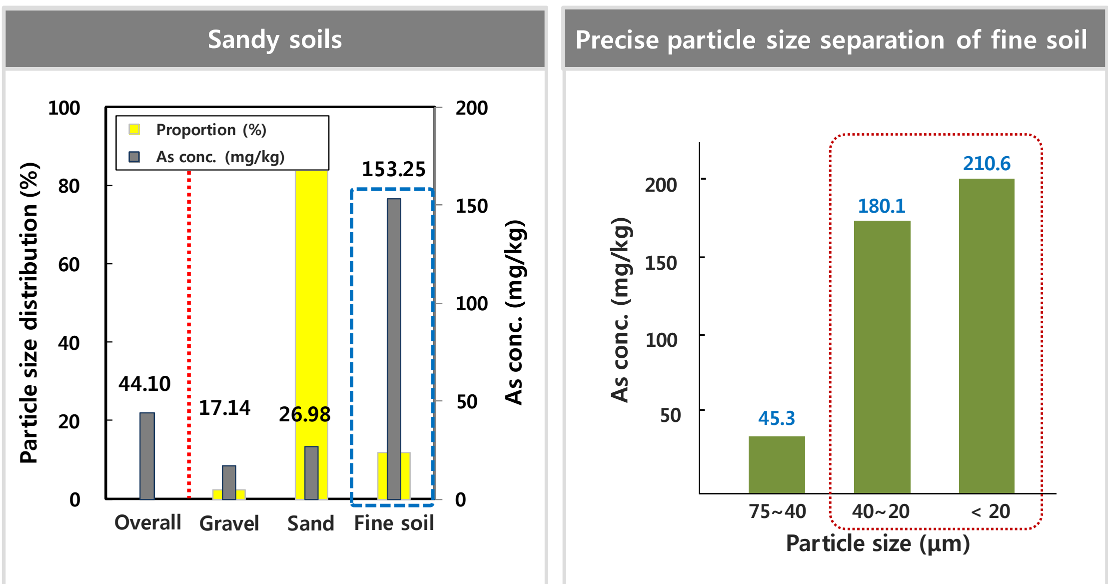

Fig. 4: Contamination distribution of sandy soils by particle-size separation

Figure 5 shows the results of soil washing for silty soils. In contrast to sandy soils, fine soil particles were dominant (over 86%) in the silty soils but contaminants were concentrated in coarse soil particles. The arsenic concentration of gravel and sand were 63.6 mg/kg and 53.9 mg/kg respectively. Fine soils separated from the silty soils met the soil arsenic standard of 25 mg/kg by Korean Soil Protection Act. For gravel and sand, acid extraction test was simply conducted to cleanup them. The arsenic removal efficiency by using 0.4N phosphoric acid was approximately 60% and the treated coarse soils of 23.3 mg/kg also met the legal standard.

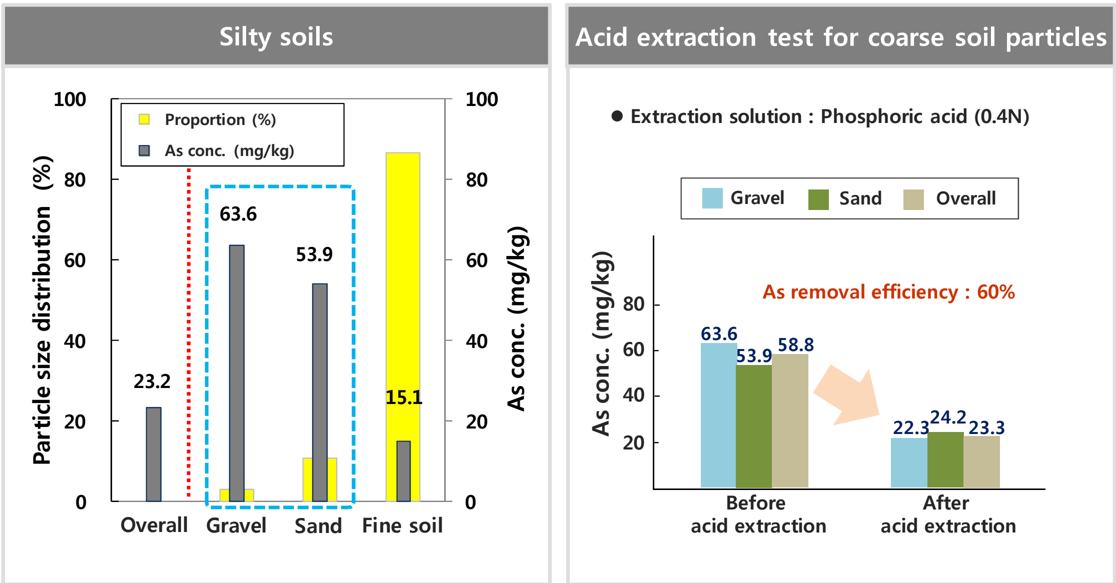

Fig. 5: Contamination distribution of silty soils by particle-size separation

Based upon different results of soil washing for sandy soils and silty soils, a remrediation scenario according to soil texture was proposed as shown in Figure 6. In this proposed scenario, soil particles, that are dominant in terms of soil particle-size distribution but relatively less contaminated, are separated. If the separated soils meet the legal arsenic standard, they would be reused as backfill soils or other purpose. Consequently, a quantity of highly arsenic contaminated soils to need advanced treatments could be significantly reduced. It contributes to reduce the term of remedial works and cost. In case of sandy soils, fine soil particles highly contaminated are precisely size-separated by multi-microcyclones and are then taken out for a waste treatment. In case of silty soils, coarse soil particles highly contaminated could meet easily the legal arsenic standard of 25 mg/kg by acid extraction treatment.

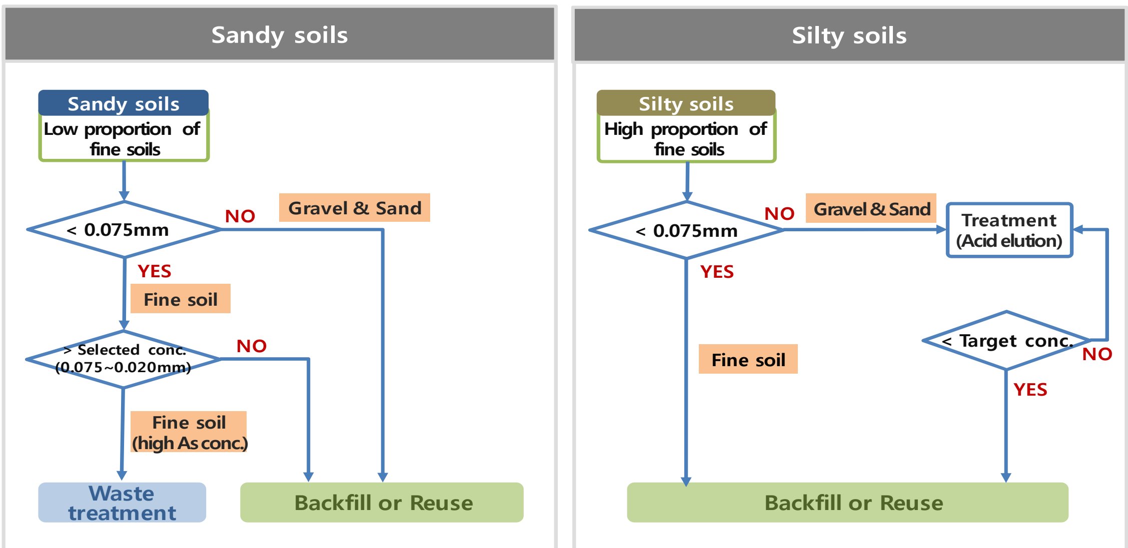

Fig. 6: Remediation process according to the soil texture

4. Conclusion

In this study, we carried out surveys on heavy metal contamination of the target area and evaluated the characteristics of the contamination in order to determine an efficient scope of application of the soil washing process. Based upon the results of this survey, a soil washing plant with capacity of 3ton/hr was installed and operated on the site to remediate the contaminated soils.

Though that operation of the soil washing plant, we proposed a remrediation scenario according to soil texture, especially proportion of fine soils which has a strong influence on contaminants concentration. The key of proposed soil washing process is that a quantity of highly contaminated soils to need advanced treatments could be reduced by concentrating them into a smaller volume using particle-size separation techniques. Finally, the soil washing process developed here will contribute to achieve an efficient and cost-effective soil remediation.

5. Acknowledgements

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