Extraction of hazardous heavy metals in contaminated soil using DMSA and DMPS

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Heavy metals are not naturally eliminated by decomposition, are transported via ground water, aquifer, and soil particle, and affects chronic damage. Recently, the spreading of soil contamination with heavy metals is a major concern and emergency measures are needed in the world. Remediation of soil contaminations with heavy metals are used mainly soil washing or stabilization, solidification. Particularly, soil washing with chelating agents is effective for shorting remediation time and adequate for several types of soils. For example, using of EDTA, is a well-known chelating agent, has been reported extensively. However, traditional chelating reagents such as EDTA are recently reported low biodegradability and very persistent in the environment. Because the cleaned up soils are returned to their original site or are reused, remediation methods for soils have been needed for not only removing target contaminant but also no residual and no harm to the environment.

In the present, the candidates for soil washing agents that the request is satisfied are suggested DMSA and DMPS. DMSA (meso-2,3-dimercaptosuccinic acid) and DMPS (2-3-dimercaptopropane-1-sulfonate) are used mainly as an orally administered antidote for toxic heavy metal poisoning such as copper, lead, zinc and arsenic. The chemical structure has two vicinal tiol-group and these are bound with soft metals. These agents themselves and metal complex are water soluble in neutral pH, because these have carboxyl and sulfonyl groups. Moreover, these have high biodegradability. It was investigated the utilization of these agents such as soil washing agents by evaluating the extraction efficiency of target metal from contaminated soil and the elution of main component of soil during extraction.

In order to evaluate extraction efficiency, the batch method described below was conducted. Approximately 1g of contaminated soil and 20mL of extraction solution were added in a polyethylene centrifuge tube. The suspension was shaken for 2-24hr at room temperature (200rpm). The concentration of chelating agent and the pH of solution were prepared 4.5mM and neutral, respectively. The suspension was centrifuged at 8500rpm for 15min, and then the supernatant was filtrated through a 0.45um membrane filter. The filtrate was analyzed for the concentration of target metals and eluted soil component by means of ICP-AES. The extraction efficiency by citric acid, EDTA, EDDS ((S,S)-Ethylenediamine-N,N'-disuccinic acid), NTA were also compared.

Figure 1 shows the extraction efficiency (%) of target metals by each extraction solution. The soil used in this study was taken from riverside soil contaminated with wastewater from a mine. Major component of the soil was Al_2O_3:22, SiO_2: 56, Fe_2O_3: 7.6 (%). The grain size of the soil was 0.075-2.0mm. The content of total metal content obtained by aqua regia digestion was copper (140+-14), zinc (1192+-86) and lead (620+-32) ($mgkg^{-1}$). Then the sum of target heavy metals are approximately 23.4 $mmolkg^{-1}$ and the amount of chelae is approximately 3.8 times of that. In this condition, more than 60% of all of metals were extracted by EDTA. In the case of EDDS and NTA, more than 40 % of copper and zinc were extracted, although lead could not be extracted by them. On the other hand, DMSA and DMPS was lower extraction efficiency, 10-40%, than traditional chelates. DMPS was effective for all of metals, although the extraction efficiency of DMPS extracted half of that of EDTA. Figure 2 shows the amounts of eluted main component of soil during extraction. The amounts of eluted aluminum and iron by the traditional chelates were extremely high than that by DMSA and DMPS. It is thought that traditional chelates have low selectivity for target metals and dissolute soil composition.