Electrokinetic Technology Enhanced by Metal-reducing Bacteria for Remediation of Arsenic Contaminated Soils

Keun-Young Lee[1)] · Soon-Oh Kim[2)] · Kyoung-Woong Kim[1)*]

1. Introduction

From the inside and outside of the country, the geochemical study of arsenic(As) and the environmental concern for treatment technology have been performed more actively. In South Korea, the As contamination in soil environment has been mainly focused on tailings which are considered as one of the mining hazards.

Respiratory Fe and Mn reduction by metal-reducing bacteria is ubiquitous and, in many cases, dominant redox process in anoxic soils and sediments (Nealson and Saffarini, 1994). From now on, the activation of indigenous microorganisms caused by organic substrates not intended may affect that chemically stable form of toxic heavy metal, e.g. As, is dissolved and diffused throughout water system from soils, which is considered as the risk increment (Ahmann et al., 1997). In another viewpoint, an increase in As mobility by bacteria can be effectively employed in remediation of soil contaminated with As, on the pretext of bioleaching.

Previous studies on electrokinetic removal of As in soils have been limited up to now, because of the special characterisics of As. A variety of enhanced schemes have been developed and applied to achieve the process efficiency desired, such as electrolyte conditioning and chemical treatment of soil bed, but these also have some drawbacks for the efficient removal of As (Kim et al., 2005). The main objective of this study was the investigate the possibility of electrokinetic soil remediation enhanced by metal-reducing bacteria.

2. Methods and Results

As-contaminated tailing samples were collected from Songcheon abandoned mine area, which mine is well known as one of the most seriously contaminated sites by As and heavy metals in Korea. Total concentrations of As and other heavy metals after digested by aqua regia were determined. The contaminants and tailings were characterized geochemically and mineralogically by sequential extraction method and XRD & SEM-EDS analyses, respectively. The results of sequential extraction were showed that the labile fraction of As exists in the tailing sample, and the secondary minerals or phases formed as a result of oxidation or alteration of the primary minerals were observed. To verify the

Keywords : Arsenic(As), Tailings, Bioleaching, Electrokinetic soil remediation

1) Gwangju Institute of Science and Technology (kwkim@gist.ac.kr)
2) Gyeongsang National University (sokim@gnu.ac.kr)

major microorganisms to derive this phenomena, isolation and identification procedures were performed with 16s rDNA gene analysis, which showed these are species related with Fe(III)- and Mn(IV)-reducing bacteria (Nealson and Saffarini, 1994).

In the integrated method incorporating bioleaching and electrokinetics, the first set (control electrokinetics) of experiment was operated for 20days without any pretreatment, and the second set (bioleaching+electrokinetics) of experiment was operated for 12days after pretreatment by bioleaching, i.e., the same tailing was amended with carbon sources and allowed to incubate for 8 days.

Fig. 1 shows the directly opposite phase of As removal, the control and integrating experiments were mainly governed by the phenomena of electroosmosis and electromigration, respectively. Such a difference is caused by the degree of electroosmotic flow. The transported water volume in catholyte, which represents the electroosmotic effect, proved that the pretreatment of bioleaching reduced the electroosmosis. The electroosmotic velocity V_{eo} can be approximated by the Helmholtz-Smoluchowski equation (Shapiro and Probstein, 1993).

$$V_{eo} = -\varepsilon \zeta E / \mu$$

where E is the uniform electric field strength, μ is the viscosity of the liquid, ε is the permittivity of the liquid, and ζ is the uniform zeta potential of the surface corresponding to the surface charge. The bioleaching procedure decreased the initial soil pH, which can increase the zeta potential of soils. Also the biomass enhanced by the activation treatment exists the porewater and surface of soil particles, and it can affect the viscosity as well as the permittivity of electrolyte solution in electrokinetic procedure.

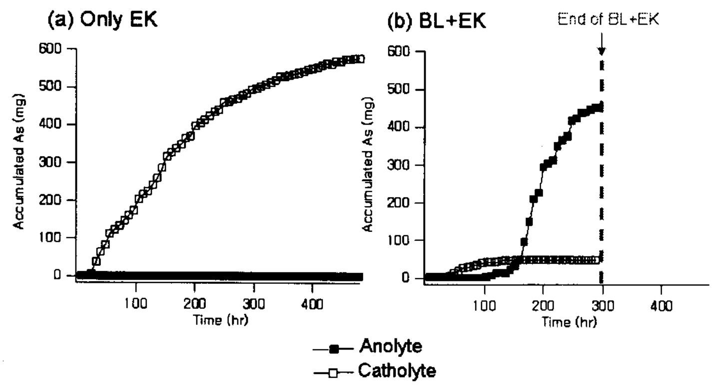

Fig. 1. Accumulated amount of As in the electrode compartments during experiments: (a) control electrokinetics and (b) electrokinetics pretreated by bioleaching

The result of control electrokinetic process showed finally 61.97% of removal efficiency, while the process integrating bioleaching and electrokinetics showed 75.62% (Fig. 2). This result indicates that the labile fraction of As (78.6%), extracted from step1 to step3 in the sequential extraction procedure, can be mostly removed by the integrated method.

3. Conclusion

This study demonstrated that the combination of microbial dissolution and electrokinetic removal of As can be considered an efficient technology, compared with each process applied individually.

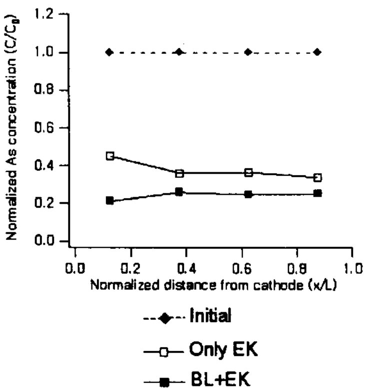

Fig. 2. Distribution of residual As concentrations within the soil bed after experiments: (C0: initial As concentration, C: final As concentrations, x: distance from cathode, L: length of soil bed)

4. References

(1) Nealson K.H. and Saffarini D. (1994) Iron and manganese in anaerbic respiration: Environmental significance, Physiology, and Regulation. *Annu. Rev. Microbiol.,* **48**, 331-343

(2) Ahmann D., Krumholz L.R., Hemond H.F., Lovley D.R. and Morel F.M.M. (1997) Microbial mobilization of arsenic from sediments of the Aberjona watershed. *Environ. Sci. technol.,* **31**, 2923-2930

(3) Kim, S.O., Kim, W.S., and Kim, K.W. (2005) Evaluation of electrokinetic remediation of arsenic contaminated soils. *Environ. Geochem. Hlth.,* **27**, 443-453

(4) Shapiro A.P., Probstein R.F. (1993) Removal of contaminants from saturated clay by electroosmosis. *Environ. Sci. Technol.,* **27**, 283-291

5. Acknowledgement

This work was supported by the Korea Science and Engineering Foundation(KOSEF) through the National Research Lab. Program funded by Ministry of Science and Technology (No. M10300000298-06J0000-29810), and also supported by the Korea Research Foundation Grant funded by the Korean Government (MOEHRD)" (KRF-2005-041-D00447).