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Microbial Oxidation of As in As-Enriched Soil and Sediment

Ji-Min Yi[1]·Won-Kyong Ha[1]·Ju-Yong Kim[2]·Kyoung-Woong Kim[2]·Hyo-Taek Chon[3]·Jong-Un Lee[1*]

[1]*Department of Geosystem Engineering, Chonnam National University, Korea*
[2]*Department of Environmental Science and Engineering, Gwangju Institute of Science and Technology, Korea*
[3]*School of Civil, Urban and Geosystem Engineering, Seoul National University, Korea*
E-mail: jongun@chonnam.ac.kr

ABSTRACT

Currently As toxicity is an important issue of worldwide public health management. Through intensive studies on geochemical behaviour of As during the past two decades, the importance of microbial effects on the electrochemical speciation and cycling of As in subsurface environment was revealed. Bacterial reduction and oxidation between As(V) and As(III) are major mechanisms to mediate subsurface mobilization of As.

Arsenite(As(III))-oxidizing bacteria can be divided in two groups according to their physiological mechanisms of As oxidation. One group includes heterotrophic As(III)-oxidizers which require the presence of organic matter for growth. In this case, As(III) oxidation is considered to be a detoxification mechanism through which the bacteria reduce the toxicity of As(III). The other includes chemolithoautorophs which can gain energy for growth and maintenance from As(III) oxidation. Arsenite serves as a kind of energy source in this case. Recent laboratory and field researches on the effects of bacteria on As speciation have a tendency to focus on energy-deriving, chemolithoautotrophic As(III)-oxidizing bacteria. Such concern is attributed to specific capacity of these bacteria for acquiring energy to support growth by respiration of As(III) as an electron donor under aerobic conditions.

In this study, isolation and characterization of indigenous bacteria capable of oxidizing As(III) was conducted from both naturally and anthropogenically As-enriched geological materials. For the both geological materials, black shale soil in Dukpyung area and As contaminated sediments in the Dukeum mine area were chosen, respectively.

Chemolithoautotrophic growth of the bacteria which were isolated from the both areas was observed with As(III) as an electron donor, oxygen as an electron acceptor, and CO_2 as a carbon source. However, the rate of As(III) utilization and As(V) formation by the bacteria isolated from As-enriched soil in black shale area was too slow to make clear distinction between biological and chemical As(III) oxidation. In contrast, the rate of As(III) oxidation by the bacteria isolated from As-contaminated sediment showed a relatively remarkable increase when compared with chemical reaction under the experimental condition (Fig. 1). In this case, the concentration of biologically oxidized As(V) was about 48 mg/L. Such selectivity of As(III)-oxidizing bacteria from sediment was likely due to difference between the two geological materials. Arable soil was reported to have higher abundance of indigenous bacteria than undisturbed sediment; however, bacterial diversity in sediment was much greater than soil.

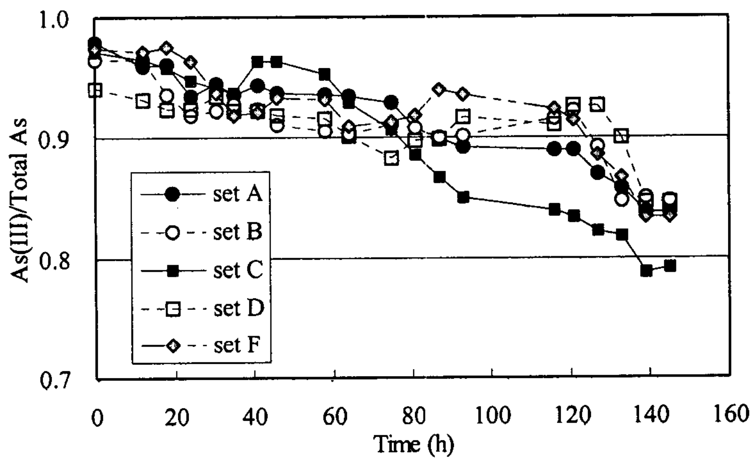

Fig. 1. The ratio As(III)/total As of the experimental sets A-D and F with time.
A: nonsterile soil, B: autoclaved soil, C: nonsterile sediment, D: autoclaved sediment, and F: abiotic control.

It may be worth further investigating the characteristics of indigenous bacteria isolated from the sediment in the Dukeum mine area to examine a potential of application to the effective As remedial processes in As-contaminated aquifer and subsurface.

Key words: arsenic, bacteria, oxidation, soil, sediment.