

# TREATMENT OF ARSENIC CONTAMINATED MINING WATER USING BIOFILMS

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Arsenic is a common trace-level constituent of gold-quartz vein deposits in mining regions. This toxic metalloid is often present in waste material, water and soil near gold mining areas. The discharge of mining drainage water containing arsenic contributes to its dispersion in the environment. The resulting contamination of surface waters, groundwater and sediments is a matter of great public concern due to the deleterious effects of arsenic on human health. In water, arsenic exists mostly as trivalent arsenite (As(III)) and pentavalent arsenate (As(V)), both forms being toxic to living organisms. Most of the existing treatment processes are effective only on As(V) which forms anionic complexes and is therefore more easily converted into solid waste, unlike As(III) which forms mobile neutral complexes. As a consequence, the removal of arsenic from water requires a preliminary oxidation step. The chemical oxidation of As(III) by O<sub>2</sub> is very slow (Jekel [1]), and the use of oxidant chemicals entails high operation costs (US-EPA [2]). This cost aspect could be overcome by using biological treatment with As(III)-oxidizing bacteria (Zouboulis and Katsoyiannis [3]). Arsenic oxidation capabilities of bacteria are known for a long time, since Green [4] isolated a bacteria belonging to *Achromobacter* in cattle dip in South Africa. Numerous studies reported isolation of heterotrophic and autotrophic bacteria able to oxidize arsenic (Philips and Taylor [5], Osborne and Ehrlich [6], Abdrashitova et al. [7], Battaglia-Brunet et al. [8]).

The present study deals with a mining water drainage resulting of the digging of an exploration gallery in a gold-arsenopyrite mineralization (cherts and quartz veins). Its flow-rate varies between 10 and 30 m<sup>3</sup> h<sup>-1</sup> and the arsenic concentration between 10 and 500 µg L<sup>-1</sup> for a pH close to 6.5. The water contains also high concentrations of iron (between 2 and 15 mg L<sup>-1</sup>). Both arsenic and iron concentrations are higher than the French quality standards (which are set to 100 µg L<sup>-1</sup> for arsenic and 3 mg L<sup>-1</sup> for iron in this kind of context), and thus, require a treatment to be removed from the effluent before discharging it in the environment. In the earlier part of the study, Battaglia-Brunet et al. [9] identified a biological As(III)-oxidizing activity in diverse micro-environments along the water stream, from the source to the discharge point. From those results, we investigated the possibilities of using this natural phenomenon for the removal of arsenic in a passive on-site treatment process based on three successive steps: (i) biological oxidation of As(III) by indigenous bacteria biofilm in a fixed-bed reactor filled with pozzolana, (ii) precipitation of iron in the form of hydroxides, (iii) adsorption of As(V) onto iron hydroxides (and/or co-precipitation of As(V) with iron).

Small-scale laboratory experiments showed that the indigenous bacterial population promoted As(III) and Fe(II) oxidation in conditions close to those of the site, i.e. temperature, water composition and oxygen availability. The immobilization of the bacteria on pozzolana by the development and the maintenance of a biofilm increased oxidation rates compared to natural conditions. These results were confirmed by long-term on site pilot-scale experiments. As and Fe removal was significant and their concentrations at the pilot outlet decreased under the discharge standards. The critical operation parameters determined in the study will be used to design a treatment unit based on the biological passive process described above.

- [1] M.R. Jekel, *Arsenic in Environment, part I: Cycling and Characterization*, Ed J.O. Nriagu, John Wiley & Sons **1994**, 119.
- [2] U.S. Environmental Protection Agency. *EPA/600/4-98/042* **1998**.
- [3] A.I. Zouboulis, I.A. Katsoyiannis, *Environmental International* **2005**, 31, 213.
- [4] H.H. Green, *South African Journal of Science* **1918**, 14, 465.
- [5] S.E. Philips, M.L. Taylor, *Applied and Environmental Microbiology* **1976**, 32, 392
- [6] F.H. Osborne, H.L. Ehrlich, *Journal of Applied Bacteriology* **1976**, 41, 295
- [7] S.A. Abdrashitova, B.N. Mynbaeva, A.N. Ilyaletdinov, *Mikrobiologiya*, **1981**, 50, 41
- [8] F. Battaglia-Brunet, C. Jouliau, F. Garrido, M.C. Dictor, D. Morin, K. Coupland, D.B. Johnson, K.B. Hallberg, P. Baranger, *Antony Van Leeuwenhoek International Journal* **2006**, 89 (1), 99.
- [9] F. Battaglia-Brunet, M.C. Dictor, F. Garrido, C. Crouzet, D. Morin, K. Dekeyser, M. Clarens, P. Baranger, *Geomicrobiology Journal* **2002**, 23, 201.