

# Arsenic Leaching from the Tailings Area of Ylöjärvi Cu-W(-As) Mine, SW Finland

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## ABSTRACT

Mine tailings is the principle origin of the arsenic contamination in the surface waters and groundwater of the study area at the Ylöjärvi Cu-W(-As) mine in SW Finland. The Ylöjärvi mine, which was active from 1943-1966, is the only mine in Finland that produced arsenic concentrate, and the highest reported concentrations were from 6000 to 8000 mg/kg. However, it is worth noting that arsenic concentrate was recovered for only a few years, implying that most of the arsenic ended up in the tailings.

The mining activities left behind two tailings areas of 4 ha and 17 ha, two open pits and underground galleries. It is estimated that about 4 Mt of tailings and waste rock is stored in the area. Water from Lake Parosjärvi was used in processing the ore in a closed circulation, and in the first open pit as a clarification pool. As the mining works proceeded under the lake, it was dewatered. After closing the mine, the lake filled up again with water, and as a result, part of the smaller tailings area, the open pits and the underground galleries filled with tailings were flooded, leaving a lot of sulfides containing material subject to leaching of surface and groundwater. Reductive conditions prevail at the bottom of the lake, but two times a year seasonal temperature changes of the water mix the oxidative surface water with the deeper one, causing degradation and dissolution of the material. However, the main arsenic sources into the surface waters are the arsenic bearing sulfide minerals in the tailings areas. The main ore minerals, arsenopyrite (FeAsS), chalcopyrite (CuFeS<sub>2</sub>) and pyrrhotite (Fe<sub>1-x</sub>S), are associated with minor sulfides [pyrite (FeS<sub>2</sub>), sphalerite (ZnS), galena (PbS), cubanite (CuFe<sub>2</sub>S<sub>3</sub>) and molybdenite (MoS<sub>2</sub>)] (Himmi et al., 1979). These

minerals tend to weather and dissolve in contact with air and oxidizing rain water releasing arsenic and heavy metals into the environment. This process, formed by a series of complex geochemical and microbial reactions, is called acid mine drainage (AMD), and waters affected by it are characterized by high acidity and elevated concentrations of heavy metals and arsenic. According to Carlson et al. (2002), AMD spills in all directions from the bigger tailings area. The As concentrations range from less than 10 mg/l to 3500 µg/l in the spill points and up to 10 000 mg/l in the groundwater below the tailings (Carlson et al., 2002). Arsenic concentrations are elevated in the adjacent peat bog that receives groundwater from the tailings area. Additionally the nearby lakes and rivers are affected by the AMD (Parviainen et al., 2006, Bilaletdin et al., 2007). Commonly, the dissolved iron oxidizes and hydrolyzes in the spill points forming iron(III) precipitates goethite [FeO(OH)], schwertmannite [Fe<sub>16</sub>O<sub>16</sub>(OH)<sub>12</sub>(SO<sub>4</sub>)<sub>2</sub>] or jarosite [KFe<sub>3</sub>(SO<sub>4</sub>)<sub>2</sub>(OH)<sub>6</sub>] depending on the pH range (Kumpulainen et al., 2007). The iron precipitates retain arsenic and some heavy metals, diminishing their concentrations in surface waters. However, in the creek leading to the nearby Lake Parosjärvi the iron precipitates are not formed effectively enough because of a high flow rate.

Knowing the arsenic and heavy metal load in the surroundings of the Ylöjärvi tailings area, this research was undertaken to study the geochemical and mineralogical composition of the tailings and to predict the oxidation process of the primary sulfides and arsenides. Tailings samples are studied by reflected-light ore microscopy and scanning electron microscopy (SEM-EDS), and duplicate samples are subjected to a five step sequential extraction method. Combining these data gives

insight to the extent of tailings oxidation and to the natural attenuation capacity of secondary iron precipitates within the tailings i.e. the heavy metal load retained in them.

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