Ogoya, Ishikawa, Japan is the site of an abandoned copper mine which continues to contaminate a small nearby stream. Acidic (pH 4), sulfur-rich, metal-laden water (rich in Cu and Zn) is released from drainage pipes at several points along the embankments. There is a marked difference in benthic flora based on water quality characteristics. Since the mine was opened, fish have not been found at the study site or for a significant distance, in its receiving waters. Several nearby tributaries, however, have greater biodiversity with healthy fish populations.

Field and laboratory observations and analyses were carried out on water, aquatic moss, and sediments from the stream. At the first drainage point, moss appears as a thick benthic layer which continues downstream for more than 30 meters. Although it flourishes near drainage points, a marked absence of moss was observed in areas upstream. A line separates areas affected by acid mine drainage (AMD) and carpeted with green moss, from areas with relatively clean water but bare stream beds. Water quality (pH, EC, ORP and DO) between the areas is vastly different, indicating minimal mixing between discharged and receiving waters. This difference also strongly suggests that the AMD conditions are important to the moss’s vitality.

Drainage water and moss were taken from the site and kept in an aerated aquarium for two months. Analyses were performed on samples both from the site and from the end of the aquarium experiment. X-ray fluorescence analyses indicated the presence of heavy metals, including Cu and Zn, both in the water and in the moss samples. Moss samples were also high in Fe. Optical microscope and SEM observations revealed the presence of abundant and varied diatoms, and various other microorganisms, often in close association with the moss. Some sections of the moss show signs of cell specialization, with patches of cells possibly used for mineral storage, while some diatoms seem to collect Fe and Cu within their sheaths.

Metal content was particularly high in the moss, perhaps suggesting the preferential uptake of metals by the acid tolerant plants and its associated microbial community. Furthermore, the close correlation between the moss’s presence and particular water conditions (including the presence of Cu/ Zn) could indicate that it is in fact an acid-tolerant metalophile. When coupled with the accompanying decrease of copper in the aquarium water, this possibly indicates potential for their use in phytoremediation. The moss and its associated microbial community could possibly hold keys to the sustainable, natural remediation of copper mine drainage.

Fig. 1: SEM micrographs of naturally dried moss (A), with associated clay minerals (B) and diatoms (C) from the end of the aquarium experiment. EDX analyses showed elevated copper and iron levels in each of these materials.

References