Choose Your Poison

Metal Contamination or Climate Change

With the advent of the green energy transition, there has been an increased need for clean energy technologies, which are greatly mineral intensive. Moreover, the European Union has increased its targets for mineral self-sufficiency sixfold by 2050 (IEA 2022; SGU 2022). The most needed metals in high volumes are copper, nickel, zinc, and lithium (IEA 2022), all of which are highly prevalent in the Swedish bedrock (SGU 2022). As such, Sweden's mining industry will play an important role during this transition. While metal mining is critical to the Swedish economy and the ongoing energy transition, the industry has incontestable environmental costs that are a global concern.

Direct environmental impacts of metal mining include the transport of toxic metal contaminants (i.e., arsenic, lead, mercury) through wet and dry deposition, the oxidization of metal waste (acid mine drainage), loss of biodiversity, and sediment build-up in nearby waterbodies. In aquatic ecosystems, these environmental impacts have compounding effects. For example, aquatic biodiversity loss inhibits important ecosystem functions, and acid mine drainage makes metal ions more water soluble, and greatly reduces water quality (Hogsden & Harding 2012). Some of these direct impacts, such as acid mine drainage, have been documented to persist for over a century (Fischer et al. 2020). The indirect impacts of mining are, however, much less understood. For example, physical changes in lake morphology due to increased mining-derived sediment build-up may have indirect, yet persisting, ecological effects that could influence overall toxicity. Thus, how these indirect changes reshape lake habitats and subsequently influence biological activity and communities is largely unknown.

Despite the clear and toxic environmental impacts, the metal ore mined in Sweden today has only a fraction of the carbon footprint and environmental impact than that of foreign-mined metal ore (SveMin n.d.). This is attributable to Sweden's robust and strong current environmental legislation, the Environmental Code 1999. Prior to the introduction of this Code, hundreds of mines operated and closed without stringent environmental regulations and without any obligation to remediate the mine sites (Naturvårdsverket 2019). Many, if not most, of these closed and abandoned mine sites, are unmonitored and may be a huge environmental hazard, because they may be continuously leaching metals and wreaking havoc on surrounding ecosystems.

Current monitoring efforts are carried out by the respective mining company and the state, usually the country administrative board. These efforts are responsible for limiting the spread of metal contaminants and ensuring the preservation of the environment. With regards to lakes specifically, modern-day monitoring efforts may be inadequately diagnosing the ecological status of metal-impacted lakes. Not only do monitoring efforts today neglect the indirect impacts of metal mining, they also predominantly use indices that were designed to measure the impact of acidification (acidic pollution) and eutrophication (nutrient pollution), and not specifically metal pollution. Therefore, before the mining renaissance in northern Sweden commences, monitoring efforts must be sufficiently sensitive to detect both the direct and indirect environmental impacts in Swedish lakes. This is especially true of the northernmost Swedish lakes that are already vulnerable to arctic amplification and climate change.

This doctoral thesis aims to first disentangle how metal mining in northern Sweden indirectly impacts lake ecosystems. The study will investigate the link between how the direct and indirect impacts of metal mining jointly influence lake biological activity. The outcome of these results will be used to capture the effects of metal distribution on a temporal gradient and to develop tailored monitoring methods that provide a combined insight into the biological, terrestrial, physiological, and metal compartments. The study is carried out by Maria Camila Urrea (doctoral student) under the supervision of Åsa Berglund (associate professor).

REFERENCES

Fischer, S., Rosqvist, G., Chalov, S.R. & Jarsjö J. (2020). "Landscape dynamics in the context of mining and climate change in the Arctic," *Sustainability*, 12:4; doi: 10.3390/su12041394.

Hogsden, K.L & Harding, J.S. (2012). "Consequences of acid mine drainage for the structure and function of benthic stream communities. A review," *Freshwater Science*, 31:1, pp. 108–120; doi: 10.1899/11-091.1.

IEA = International Energy Agency (2022). The Role of Critical Minerals in Clean Energy Transitions. Executive Summary; www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary; accessed on 2 May 2023.

Naturvårdsverket (2019). Nationell avfallsplan för Sverige. Del 2. Åtgärdsprogram ['Swedish national plan for wastage. Part 2. Action plan']; www.naturvardsverket.se/4a437e/globalassets/media/publikationer-pdf/6700/978-91-620-6790-8.pdf; accessed on 2 May 2023.

SGU = Sveriges geologiska undersökning (2022). Statistik över den svenska gruvindustrin 2021 ['Statistics of the Swedish mining industry 2021'; https://resource.sgu.se/dokument/publikation/pp/pp202202rapport/pp2022-2-rapport.pdf; accessed on 2 May 2023.

SveMin = Föreningen för gruvor, mineral- och metallproducenter i Sverige (n.d.). Climate; www.svemin.se/en/our-positions/climate/; accessed on 2 May 2023.

Maria Camila Urrea
Dept. of Ecology and Environmental Science
Umeå University
Sweden
maria.camila.urrea@umu.se