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Legacy of Coal Mining: Trace Element Contamination in Soils from Billefjord, Svalbard

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A b s t r a c t

Although trace elements naturally occur in the environment, their concentrations increase significantly as a result of anthropogenic activities such as mining and the combustion of fossil fuels. The introduction of these elements can disrupt ecosystem functioning, especially in sensitive Arctic regions. Svalbard, which has long been exploited for coal, mineral, and hydrocarbon extraction, is particularly vulnerable to such disturbances. Soils serve as long-term sinks for both local contamination and atmospheric deposition, making them effective indicators of environmental pollution. In this context, Billefjorden, and in particular Petuniabukta, where the Adam Mickiewicz Polar Station is located, serves as an ideal natural laboratory due to historical impact of intensive coal mining, especially in the area of the former Soviet mining town of Pyramiden. To assess the spatial extent and intensity of trace element contamination, soil samples were collected from three locations representing a gradient of anthropogenic pressure: Pyramiden, a heavily impacted former mining town; Elsa Valley, a site with moderate exposure; and Ebba Valley, a relatively undisturbed area. For this, concentrations of elements typically associated with mining activities —including Pb, Cd, Cu, Zn, Co, Ni, Cr, As, Sb, Te, Bi, and Mo—were analyzed using inductively coupled plasma mass spectrometry (ICP MS). Results show that in Pyramiden, concentrations of Ni, Cu, Zn, and Te were significantly higher than in Ebba Valley, while values in Elsa Valley were intermediate and did not differ significantly from either Pyramiden or Ebba. Concentrations of Pb, As, and Sb were significantly higher in Pyramiden compared to both other locations, suggesting local sources of contamination. Interestingly, Cd concentration was higher in Elsa Valley than in Ebba Valley, which may indicate transport or secondary sources of pollution. Co, Mo, and Cr showed no significant differences between locations, suggesting a geogenic origin or uniform geochemical background. It is also worth noting that despite clear signs of anthropogenic activity in the Pyramiden area, the soils in this region were partially imported from

Russia. This may imply a different geochemical background and affect local environmental conditions. These preliminary results contribute to a better understanding of pollution gradients in Arctic soils and provide valuable reference data for monitoring environmental changes in regions affected by both historical and ongoing human activity.

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