Abstract

Two types of X-ray fluorescence (XRF) spectrometers were deployed on site to analyse stream and lake surface waters as well as lake sediment chemistry. Water and sediment samples were collected downstream of the abandoned Aldermac VMS mine, 15 km west of Rouyn-Noranda, Quebec. The goals of the study are to identify the spatial and temporal extent of metal contamination as a result of decades of acid mine drainage from the Aldermac site and to evaluate and compare rapid data collection in the field by XRF with laboratory-based inductively coupled plasma mass spectrometry (ICP-MS) for Cu, Zn and Mn.

Water chemistry was determined by a Bruker S2 PICOFOX total reflection X-ray fluorescence (TXRF) spectrometer from filtered and acidified samples spiked with Ga as an internal standard. The instrument demonstrated high accuracy for the certified reference material (CRM), TMDA-51.3. Data obtained for Cu, Zn and Mn concentrations were within acceptable limits of the certified values. Analytical results by ICP-MS of lake and stream samples showed excellent correlation (r² > 0.99) with field analysis by TXRF for the three metals. Lake sediment geochemistry was determined by a handheld Olympus Innov-X Delta Premium DP-4000 X-ray fluorescence spectrometer. Sample preparation in the field included drying and reducing samples to a powder. High accuracy of analytical results was obtained using CRM LKSD-1 for Cu, Zn and Mn. Comparison of Cu, Zn and Mn concentrations determined by handheld XRF with ICP-MS analyses of aqua-regia and four-acid digestions of sediment samples also yielded excellent correlations ($r^2 > 0.98$

Results suggest that TXRF analysis of surface waters and handheld XRF analysis of lake sediments provide practical and accurate diagnostic tools for rapid field analysis of Cu, Zn and Mn concentrations. Overnight results allowed quick testing of scientific hypotheses (e.g., contaminant flowpaths, locations of potential control sites) without waiting for laboratory results (e.g., by ICP). Rapid data acquisition also provided guidance for and optimization of daily sampling strategies during field work. Rapid field-based analytical results from XRF spectrometry have the potential to provide efficiencies for environmental risk assessments conducted by industrial project proponents and environmental consultants

Introduction

The Lac Dasserat study aims to establish scientific evidence for best practices of geoscience tools for environmental risk assessment downstream of contaminated mine sites: these include surface water and bottom sediment surveys. The former Aldermac Mine in northwestern Quebec, 15 km west of Rouyn-Noranda, exploited a group of massive sulphide lenses from 1932-1943 that produced Cu, Zn, Au and Ag and left behind acid mine drainage contamination to the watershed downstream, including Lac Dasserat. The Aldermac site was one of the most environmentally problematic abandoned mines in the Abitibi-Témiscamingue region for which a provincially-led environmental restoration program was initiated. Two X-ray fluorescence spectroscopic methods were deployed in surface waters and aquatic sediments downstream of the site to explore their potential application in environmental risk assessment. The contamination gradient within the watershed is well depicted by the pH distribution in surface waters (Fig. 1) and iron staining proximal to the Aldermac site (Fig.

Methodology

Sampling protocol

Water

- Lake water samples were collected 0.5 m below the surface and 0.5 m above the sediment-water interface with Kemmerer® water sampler (Fig. 3A).
- Stream water samples were collected within the active part the stream channel.
- Samples were filtered on-site using 0.45 μm Sterivex®-HV filters into 60 ml HDPE bottles (Fig. 3B,C).
- Water samples were preserved with 0.4% nitric acid (ultra trace grade) at camp.

Sediment

- Surface lake sediment samples (~10 cm depth) were collected with a Ponar® grab sampler (Fig. 4A). The samples were homogenized on site and sub-sampled into 500 ml wide mouth HDPE bottles (Fig. 4B).
- Surface stream sediment samples were collected within the active part of the stream channel.

Sample preparation

TXRF

- 1 ml aliquot of acidified water was spiked to 1 ppm Ga.
- 10µl of sample were transferred onto an acrylic disk using a polypropylene pipette tip (Fig. 5B).
- The disk was heated at 65°C on a hot plate until dry (Fig. 5C).
- Two additional 10 μ l aliquots were placed on the disk.

pXRF

- Approximately 15 g of wet sediment were placed in an antistatic weighing dish.
- The samples were dried overnight at 40°C in a convection
- The samples were reduced to a powder using an agate mortar and pestle, transferred to a 4 dram vial, and covered with a 4 μ m Prolene® film (Fig. 6B).





Figure 4. A) Collection of lake sediment using a Ponar® grab sampler B) Bulk sediment sample in collection bag



Figure 5. A) S2 Picofox setup at the field camp. B) Mount of sample on acrylic disk using a pipette. C) Layout during sample preparation



igure 6. A) Innov-X Delta Premium DP-4000 used for the study. B Lake sediment samples at different stages of preparation for pXRF



AN EXAMPLE FOM THE LAC DASSERAT STUDY, QUEBEC



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