Title: Solid and Dissolved Phase Aluminum in Storm Water Runoff on the Pajarito Plateau, Poster, Individual Permit for Storm Water, NPDES Permit No. NM0030759

Author(s): Cuthbertson, Daria Veenis, Steven J.

Intended for: Public

Purpose: This poster was prepared for the 13th Annual Student Symposium at Los Alamos National Laboratory (LANL) held in July 2013. The symposium is a showcase for the work of students at the Laboratory. The poster was prepared by a student who provides support to the Individual Permit (IP) project. It will be available on LANL’s IP public website.
Solid Dissolved Phase Aluminum in Storm Water Runoff on the Pajarito Plateau: What Size Fraction is Protective to Aquatic Ecosystems on the Pajarito Plateau?

Introduction

Aluminum is the most abundant metal and the third most abundant element found in the earth’s crust after oxygen and silicon. It is never found free in nature and is found in most rocks, primary in stable silicate minerals such as feldspars and phyllosilicates. Aluminum enters environmental media naturally through the weathering of rocks and minerals. In these forms aluminum is bound strongly and is not toxic to aquatic organisms. However, aluminum hydroxide and oxyhydroxides are somewhat toxic to aquatic organisms. This form of aluminum is common when acid mine drainage is treated and neutralized but is rarely present in a typical environment. Storm water samples collected on the Pajarito Plateau contain measurable aluminum concentrations. The New Mexico aquatic life quality criteria for aluminum are now based on total recoverable aluminum in a sample that has been filtered to remove the non-mineral phases. This investigation was sponsored by the New Mexico Environment Department (NMED) because total recoverable procedures using centrifugal samples will likely measure significant concentrations and particulate mineral phase forms of aluminum that are not toxic; yet the typical “dissolved” metal fraction might exclude some amorphous or colloidal aluminum fractions that can be toxic. The Environmental Protection Agency (EPA) states that “if total recoverable metal is used for the purpose of specifying water quality standards, the lower bound of particulate metal and lower bioavailability or water metals as they are discharged may result in an overly conservative water quality standard. The use of dissolved metal in water quality standards gives a more accurate result in the water column. However, total recoverable measurements in ambient water have value, if these measurements of criteria on a total recoverable basis are an indication that metal bioavailability could be a stress to the ecosystem, particularly in locations other than the water column (e.g., in the sediments).”

The purpose of this study is to aid the determination of appropriate filter pore size needed to partition the non-mineral phases of aluminum from the potentially toxic forms of aluminum. This partitioning will be evaluated by comparing the results using varying filter pore sizes.

Dissolved phase aluminum is then defined by the partitioning criteria that allow for the determination of toxic “dissolved” aluminum.

Purpose

The purpose of this study is to explore what membrane size is appropriate for pre-filtering surface water when analyzing total recoverable aluminum concentrations. Typically water quality criteria for metals consider the dissolved phase as the most toxic phase to aquatic organisms (EPA 1994). Dissolved metals are generally defined as the fraction that passes through a 0.45-µm filter. Using two different metal concentrations, the majority of the fraction of the samples were used to evaluate the effectiveness of using different filter pore sizes to determine the recovery of dissolved aluminum.

Background

Los Alamos, New Mexico, has a seasonal climate with an average rainfall of about 10 in. per year. Over 90% of the area is dominated by ponderosa pine stands at elevations that transition to Pinon-Juniper woodlands as elevation decreases. The Pajarito Plateau is a 15-square mile area of uplift by west-east-oriented normal faults. The majority of the canyon streams are ephemeral streams. These streams flow briefly in response to precipitation that occurs in the surrounding area or stream runoff from higher elevations. Parental sources are present in the banks of the Jemez Mountains and supply baseflow to the upper reaches of some canyons, but the volume of flow is insufficient to maintain surface flows across the Los Alamos National Laboratory (LANL) facility. Significant precipitation events can result in high velocity flows that are capable of transporting aluminum and other metals in the stream flow and sediments.

Methodology

Sample locations are identified using stream age and precipitation data to identify potential flow locations. Samples will be collected in canyons streams chosen for high flow potential and high bedrock influent. Table 3 lists four sample sites. Automated Global Water Samplers (GLS007J-2) will be installed at the identified locations. Samples intakes and actuators will be placed in the stream channel. Stream flow will be ake the sampler to collect up to two filter samples. Precipitator will be monitored daily. Samples will be injected after precipitation events include possible stream flow to the sample.

Solid phase identification will aid in the determination of toxicity. Identification of aluminum solid phases will be performed using nuclear magnetic resonance (NMR) and quantitative x-ray diffraction techniques (QXRD). NMR identifies atoms and molecules within the mineral structure. XRD techniques is useful to identify crystalline and non-crystalline materials. Both crystalline and non-crystalline materials can be identified with this technique. XRD techniques will also be used to identify the mineralogy of the sediments. The mineralogy of the sediments is crucial to identifying the solid phase aluminum. Solid material collected on flat filters of size fractions 0.2, 0.45, 1, and 5 µm will be dried, collected, and archived. Aluminum hydrous oxides are thought to form in the smaller size fraction so we will focus on the less than 5 µm material. Selected samples will be chosen and submitted for both QXRD and NMR analysis to compare and verify results.

Water passing through filter sizes 0.2 through 10 µm will be analyzed for aluminum at a LANL contract laboratory. Selected samples will be screened at the Earth and Environmental Sciences (EES) geochemistry analytical facility for fast turnaround results. Capsule 100 mm will be used to produce sufficient water for analysis and toxicity testing. Water for aluminum analysis will be preserved and archived. Water for toxicity testing will be stored in the refrigerator until delivery to the toxicity laboratory.

Solid Phase Analysis:
The following table shows the solid phase analysis of the samples.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Solid Phase</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aluminum Hydrous Oxides</td>
<td>50%</td>
</tr>
<tr>
<td>2</td>
<td>Aluminum Silicate</td>
<td>30%</td>
</tr>
<tr>
<td>3</td>
<td>Other Minerals</td>
<td>20%</td>
</tr>
</tbody>
</table>

References:


