LA-UR-13-25505

Approved for public release; distribution is unlimited.

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.

Los Alamos NATIONAL LABORATORY EST. 1943

Solid and Dissolved Phase Aluminum in Storm Water Runoff on the Pajarito Plateau

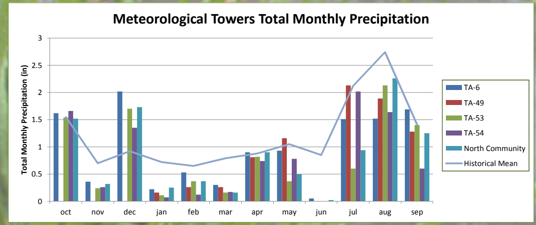
What Size Fraction is Protective to Aquatic Ecosystems on the Pajarito Plateau?

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, primarily in stable silicate mineral phases such as feldspars and phylosilicates. 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 ($Al(OH_3)$) is 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 water quality criteria for aluminum are now based on total recoverable aluminum in a sample that has been filtered to minimize the non-toxic mineral phases. This pre-filtration step was adopted by the New Mexico Environment Department (NMED) because total recoverable procedures using unfiltered samples will likely measure significant concentrations of larger 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 bioavailability of particulate metal and lower bioavailability of sorbed 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, in that exceedances of criteria on a total recoverable basis are an indication that metal loadings 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 in the determination of appropriate filter pore size needed to partition the non-toxic 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.

Stream gage and storm water sampling station E060.1, located in Pueblo Canyon below the grade control structure. Storm water runoff is collected by an ISCO automated sampler.

Figure 2 compares the monthly precipitation totals for 2012 to the historical mean for the Meteorological Towers at LANL. Most of the precipitation occurs during summer monsoons in the form of high-intensity rainfall.



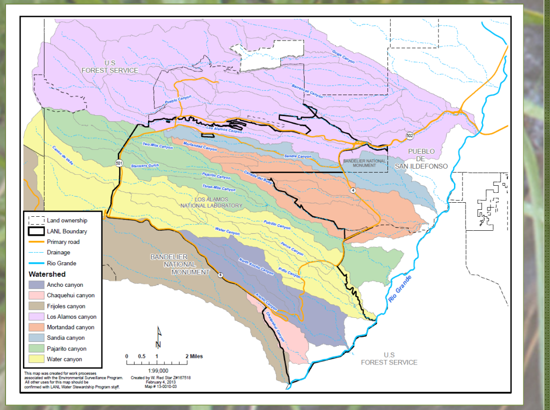


Table X. 2013 monitoring locations

Figure 1 shows the locations of watersheds, canyons and streams on LANL property. Elevation ranges from over 7100 ft. on the northern border near Los Alamos Canyon to 6000 ft. on the southern border of Chaquehui canyon. A network of 34 stream gages and 21 precipitation gages measure annual precipitation and stream flow on LANL property.

Pinon-juniper dotted canyons of the Pajarito Plateau

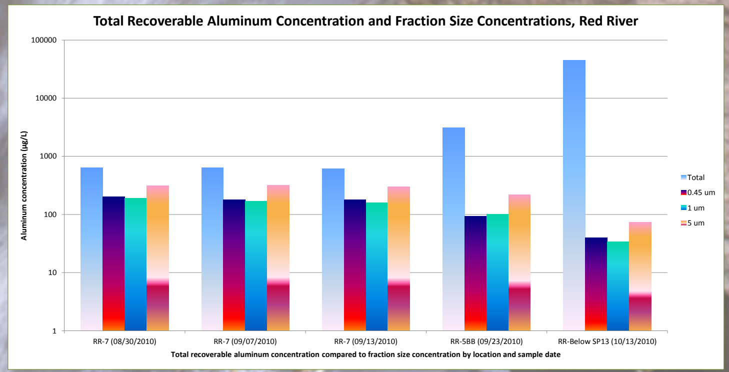
Background

Setting

Los Alamos, New Mexico, has a semiarid climate with an average rainfall of about 19 in. per year. Over 30% of the area is dominated by ponderosa pine stands at higher elevations that transition to Piñon-juniper woodlands as elevation decreases. The Pajarito Plateau is separated into finger mesas by west to-east-oriented canyons. The majority of the canyon streams are ephemeral streams. These streams flow briefly in response to precipitation that occurs in the surrounding area or snowmelt runoff from higher elevations. Perennial springs are present on the flanks of the Jemez Mountains and supply base flow 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.

NMED Study on the Rio Grande, NM and Chevron Mining Inc. study on the Red River, NM

Two studies have attempted to determine an appropriate filter size to exclude mineral bound aluminum silicates but allow the toxic semi-colloidal fraction to pass through a membrane; ARCADIS U.S., Inc. and GEI Consultants, Inc. for Chevron Mining Inc. (CMI) and the New Mexico Environment Department Surface Water Quality Bureau (NMED SWQB). The CMI study focused on water quality from three size fractions and toxicity testing, using samples collected from the Red River in New Mexico. The NMED SWQB collected and filtered water from the Rio Grande near the Buckman Direct Diversion intakes. In both the CMI and NMED SWQB studies, the samplers disturbed the river sediment to obtain turbid samples similar to sediment-laden storm water samples. In an August 2012 summary published by the NMED Surface Water Quality Bureau (SWQB), the study concluded that a filter pore size of 10 µm minimizes mineral-phase aluminum without restricting amorphous or colloidal phases. The CMI study concluded that a significant amount of the mineral-phase aluminum can be removed by coarse pre-filtration. The study recommended using a 5 µm filter for pre-filtration to remove 50 to 99 percent of the non-toxic aluminum associated with larger particulate matter. Both studies were conducted in perennial streams which are extremely rare on the Pajarito Plateau where the landscape is dominated by ephemeral flow in response to isolated precipitation events. In addition, both studies artificially introduced sediments into their water samples to increase turbidity before filtration. A more comprehensive and representative study should address naturally occurring storm water in an ephemeral drainage and focus on the naturally occurring dissolved, colloidal, and mineral bound solid phases entrained in the water column.



Reported results from the CMI Filtration Study, 2011.

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 1993). Dissolved metals are generally defined as the fraction that passes through a 0.45 µm filter. Using five different membrane sizes (0.2, 0.45, 1, 5, and 10 µm), storm water runoff samples will be filtered through flat filters to collect solid material and analyzed with quantitative x-ray diffraction focusing on the toxic mineral phases of aluminum. Second, storm water will be filtered through high capacity filters (0.2, 0.45, 1, 5, and 10 µm) and analyzed with induced coupled plasma mass spectrometry for aluminum concentrations. Third, aluminum toxicity tests will be performed using storm water runoff and the appropriate target organisms. Results from each test will be used to determine which filter size provides the appropriate protection for aquatic ecosystems on the Pajarito Plateau.

Storm water sampling in Sandia Canyon.

Methodology

Sample locations are identified using stream gage and precipitation data to identify potential flow locations. Samples will be collected in canyon streams chosen for high flow potential and high Bandelier Tuff influence. Table 1 lists four planned sites.

Automated Global Water Samplers (GL500-7-2) will be installed at the identified locations. Sampler intakes and actuators will be placed in the stream channel. Stream flow will activate the sampler to collect up to two four-liter samples. Precipitation will be monitored daily. Samplers will be inspected after precipitation events indicate possible stream flow to the sampler.

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 atomic and molecular relationships (composition) according to how they react to a high energy magnetic field. Both crystalline and non-crystalline materials can be identified with this technique. QXRD techniques is useful in identifying solid material with a coherent crystalline structure, amorphous phases are more difficult to identify.

Solid material collected on flat filters of size fractions 0.2, 0.45, 1, and 5 um will be dried collected, dried, and archived. Aluminum hydroxides colloids are thought to be present in the smaller size fraction so we will focus on the less that 5 um material. Select 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 um will be analyzed for aluminum at a LANL contract laboratory. Select samples will be screened at the Earth and Environmental Sciences (EES) geochemistry analytical facility for fast turn-around results. Capsule filters 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.

Daphnia magna (water flea)
This organism is used in bioassays to determine aquatic acute and chronic toxicity concentration standards.

Location	Landscape	Membrane Size (flat and capsule filters) (um) & field prep code					Water Quality	Toxicity Testing
		0.2 (0.2Fu)	0.45 (F)	1 (1Fu)	5 (5Fu)	10 (10Fu)		
E229.3	Bandelier Tuff	X	X	X	X	X	X	X
E240	Bandelier Tuff, Dacite	X	X	X	X	X	X	X
	Bandelier Tuff	X	X	X	X	X	X	X
Rendija	Bandelier Tuff	X	X	X	X	X	X	X
W Rock Lutheran Church	Bandelier Tuff; no Laboratory influences	X	X	X	X	X	X	X

Table 1: Proposed monitoring locations and sample plan. Sites were chosen for high flow potential and Bandelier Tuff influence.

References

ARCADIS U.S., Inc., & GEI Consultants, Inc. (2011). *Aluminum Sample Pre-Filtration Study of the Red River.* Questa: Chevron Mining Inc.

WQCC, N. (2000). *Environmental Protection Water Quality Standards for Interstate and Intrastate Surface Waters.* Santa Fe: NMED.

U.S. EPA. (2013). 40CF136 Guidelines Establishing Test Procedures for the Analysis of Pollutants. USA.

LA-UR-13-25505

Los Alamos NATIONAL LABORATORY