COLLEGE OF AGRICULTURE & LIFE SCIENCES
Cooperative Extension

az1698 April 2016

The Gold King Mine Spill: Can it Impact Water Users below Lake Powell Reservoir and Yuma Farmers?

Janick F. Artiola, Karletta Chief, Paloma Beamer, Sarah T. Wilkinson, Raina M. Maier, Channah Rock, and Charles Sanchez

Introduction

On Wednesday August 5, 2015, during an EPA mine site investigation of the Gold King Mine near Silverton, CO, heavy equipment caused an unexpected release of acid mine drainage trapped inside a mine tunnel (Fig. 1). Approximately 3 million gallons of acid mine drainage went into Cement Creek that flows into the Animas River. A sample of the water was analyzed and found to contain several heavy metals such as lead, arsenic, and cadmium. The spill turned the normally clear waters of the Animas river to a murky, yellow color flowing down into the San Juan River, where they mixed with its muddy waters that ultimately flow into Lake Powell. Therefore, the spill had the potential to reach the lower part of the Colorado River and the Yuma valley farming community in Arizona.

Why was the Water Yellow?

When the ore in the mine tunnels is exposed to water and air, acid is generated and metals from the rock seep into the water. This creates a thick, metal-filled mixture called "acid mine drainage." Acid mine drainage is usually a rusty red to orange color due to the presence of soluble iron. When acid mine drainage is mixed with fresh water, it becomes less acidic, which changes the chemistry of the metals. The soluble iron in the acid mine drainage precipitates turning the water yellow. Old-time miners referred to this as "yellow boy."

The yellow color of the water indicates the presence of iron but not the presence of other metals such as lead or cadmium.

What was in the Water and how Big was the Spill?

The contaminated water contained various metals and salts. In highest concentration were oxides of iron and aluminum, calcium, magnesium and sodium salts commonly found in soils and sediments. In addition, the spill contained potentially toxic metals such as zinc, copper, manganese, lead, arsenic, mercury, and cadmium. Together these metals and salts totaled about 190 tons of solids. These solids were mixed in about three million gallons of water or 9.3 acre-feet, the amount in 250 swimming pools, or 9 football fields spread out one foot deep.

Figure 1. The mining tunnel from which the spill occurred (USEPA, 2015).

Who may be Impacted by the Spill?

Besides Colorado and Utah, the states of New Mexico, Arizona, Nevada, and California were potentially impacted by the Gold King Mine spill (Fig. 2). The users of the Colorado River water entering Lake Powell include 12 tribes who have water rights or adjacent lands to the Colorado River.

As the river flows south towards Nevada at Lake Mead and Hoover Dam it continues south through several dams until it

Figure 2. The Colorado River System. Red dot shows location of spill. (Adapted from:Rand.org 2015)

reaches Mexico after passing Imperial Dam. Before it reaches Mexico the Colorado River flow has several water diversions: The Central Arizona Project, the Colorado River Aqueduct, and the All-American Canal. These diversions are for domestic use for major cities including: Las Vegas, NV; Phoenix, AZ; and Tucson, AZ; and for agricultural use as far south as Yuma, AZ.

The Gold King Mine spill occurred in the Upper Colorado River Basin, where water flows through six U.S. states and into Mexico. Colorado River water is used by or flows near 12 Native American tribes within this area.

Was the Spill Diluted?

Yes, river water diluted the spill after it entered the Animas river and beyond. River flow data from the US Geologic Survey indicates that on the day of the spill, the Animas River at Durango was flowing at 1,414 acre-feet per day. Since most of the spill took place in less than 24 hours, the 9.3 acre-feet of contaminated waters were mixed with the river's water and diluted 150 times within 24 hours. On the same day, the San Juan River at Four Corners was flowing at 5,177 acre-feet per day, diluting the spill roughly 600 times. At Lee's Ferry, AZ, the Colorado River flows on average at about 14 million acre-feet/year (Graf, 1997). So, 9.3 acre-feet of water would have been diluted 4,000 times in the Colorado River.

An estimated 190 tons of sediments, mostly iron and aluminum oxides along with lesser amounts of potentially toxic metals entered the Colorado River. About 44.4 million tons of sediment produced by river bed erosion arrive at Glen Canyon Dam each year (Andrews, 1990; Weisheit, 2003). If all the spilled sediment from the Gold King Mine reached Glen Canyon Dam, it would be diluted 640 times in one day by the 121,000 tons of erosion sediment that enter the lake each day.

The chances of significant exposure to toxic metals resulting directly from the spill in the lower Colorado region downstream from Lake Powell are negligible, since it is likely that any contaminated sediments that entered Lake Powell are trapped there.

What are the Potential Impacts of the Spill to Water Users?

Colorado River water is used to irrigate agricultural lands in Yuma. Under some conditions, metals can accumulate beyond safe levels in vegetables and grains. There are several potential sources of metals, including the soil itself, fertilizers, dust, and irrigation water. The Colorado River water typically contains metals, including lead cadmium, arsenic, and uranium (Table 1), and these are the same metals that were also found in the spilled mine waste water.

Four pounds of cadmium and 2.5 tons of lead were released in this spill. Cadmium, lead and other metals that can accumulate in soils may be taken up by vegetables and grains. Using Colorado River daily flow volumes of water and sediments, we estimated that levels of cadmium, arsenic and other metals from the spill (except iron, aluminum and lead) in water would be non-detectable or below the USEPA drinking water standard (Table 1) after mixing with one day of Colorado River flow. Further dilution will occur as the spill reaches the Lake Powell reservoir.

Ultimately, any sediments with metals that reach the Lake Powell reservoir will be mixed and buried with many tons of river sediments that enter the reservoir each day. The reservoir is an immense storage of sediments in itself and will buffer/trap/bury/dilute beyond detection any metals of concern and any sediments from the spill.

However, since a lot of lead was released, there was a chance that lead would be detectable in the sediments suspended in the river for at least the first few days of the spill, see next section. It is important to point out that the majority of the 190 tons of sediments were made up of iron and aluminum oxides and that lead and other metals are very insoluble in water at neutral pH and can be trapped in the iron and aluminum oxides that made up most of the spilled sediments.

Table 1. Concentrations of four metals in Colorado River water diverted at Imperial Dam prior to the spill. (Sanchez, unpublished data collected before the spill)

Metal	Range (µg/L)*	Mean (µg/L)	NPDWS (µg/L)**
Lead	bdl-0.66	0.17	15
Cadmium	bdl-0.07	0.05	5
Arsenic	1.7-4.1	3.1	10
Uranium	1.2-5.2	3.6	30

bdl = Below Detection Limits
**National Primary Drinking Water Standards (USEPA)

Table 1 shows the range and mean concentrations of typical measured metals in the Colorado River (where it is diverted at Imperial Dam into the All-American Canal, the Gila River, and the Yuma Project aqueduct) and compares it to the USEPA National Primary Drinking Water Standards (NPSDWS). Note that the mean values are about 3-100 times lower than the USEPA NPSDWs for these four metals.

What is known about the Water Quality After the Spill?

An Arizona Department of Environmental Quality (ADEQ) News Release of August 17th summarized the results of water quality samples collected by ADEQ and the Utah DEQ at multiple locations along 100 miles of the San Juan River, over various dates since the spill as follows:

" …water quality conditions in the San Juan River upstream of Lake Powell are generally consistent with pre-spill conditions. "Based on what we're seeing with the water flowing into Lake Powell, we don't expect there to be noticeable change in water quality in Arizona,"…"

Note that water quality monitoring data collected by these two agencies and four other state and federal agencies showed elevated levels of lead at some locations along the San Juan River for up to one month after the spill. For more information on sampling data, see the Arizona Geological Survey interactive map of the samples collected and results at the Gold Mine Spill Response website: http://maps.azgs.az.gov/gold-king-mine-spill/ (AZGS, 2015). Presently, the Animas, San Juan, and upper Colorado Rivers show normal levels (below US EPA National Primary Drinking Water Standards) of lead and other metals (AZGS, 2015).

What if Crops Are Irrigated with Sediments Containing Metals?

All soils contain small amounts of naturally occurring metals, including lead and cadmium. Soils in Arizona have a high pH (alkaline), which helps trap heavy metals, reducing the chances of being taken up by plants. Contaminated sediments are also filtered by the soil and trapped, making them less likely to release their metals.

Can Domestic Animals Drink Water from the Colorado River?

Yes. When possible, water fed to animals should be clear and sediment-free. If water is cloudy, it should be filtered or allowed to rest until sediments settle.

Basic Precautions When Using Any Surface Water Source for Drinking

- Do not drink colored, murky water or water with a distinct metallic/rust taste.
- Water taken directly from the river, or from nearby shallow riverbed wells, should be filtered through fine particle filters (backpacking filters or other commercially available in-line filters) to remove any suspended sediments from the water. *Note that other treatments such as disinfection may be required before consuming surface water.*

Summary

There is evidence that the Gold Mine Spill impacted the water quality of the Animas River and portions of the San Juan River, and that some contaminants such as lead remained elevated (above drinking water standards) for about one month after the spill. The impact on water quality in the below the Lake Powell reservoir and the Yuma area as a result of this particular event was not measured and may not be measurable in the near future.

Presently, there is no evidence that the spill changed the irrigation water quality of the Colorado River downstream from Lake Powell. However, ongoing water monitoring of the Colorado River water quality may change this evaluation.

Links of Interest

USEPA. 2015. Gold King Mine Incident Report http://epaosc.org/site/site_profile.aspx?site_id=11082

US EPS. 2015. Emergency Response to August 2015 Release from Gold King Mine: http://www2.epa.gov/goldkingmine

AZGS. 2015. Gold Mine Spill Response website: http://maps.azgs.az.gov/gold-king-mine-spill/

References

Andrews, E.D. 1990. The Colorado River: A perspective from Less Ferry, Arizona. Pages 304-310 in Surface-Water Hydrology. The Geology of North America, Vol, O-1. Special Publication. Boulder (CO): Geological Society of America.

Graf, J.B. 1997. The Colorado River in Grand Canyon: How fast does it flow? USGS Fact Sheet FS-168-97. December 1997. http://pubs.usgs.gov/fs/FS-168-97/pdf/fs-168-97.pdf

Rand.org. 2015. Adapting to a Changing Colorado River. http://www.rand.org/jie/projects/colorado-river-basin/interactive-brief.html

Weisheit, J. 2003. A Colorado River sediment inventory. The Confluence. The Journal of Colorado Plateau River Guides. Number 27, December 2003. http://www.riversimulator.org/Resources/Hydrology/AcoloradoRiverSedimentInventoryWeisheit2003.pdf

Superfund Research Program
The University of Arizona

COLLEGE OF AGRICULTURE & LIFE SCIENCES
Cooperative Extension

The University of Arizona
College of Agriculture and Life Sciences
Tucson, Arizona 85721

Janick F. Artiola
Associate Professor and Water Quality Specialist, Department of Soil, Water & Environmental Science

Karletta Chief
Hydrology & Tribal Extension Specialist, Department of Soil, Water & Environmental Science

Sarah Wilkinson
Research Translation Coordinator, Superfund Research Program

Paloma Beamer
Associate Professor, Mel and Enid Zuckerman College of Public Health and Center for Indigenous Environmental Health Research

Raina M. Maier
Director, Superfund Research Program and Department of Soil, Water & Environmental Science

Channah Rock
Associate Professor and Water Quality Specialist. Department of Soil, Water & Environmental Science

Charles Sanchez
Professor and Agronomy and Food Production Specialist. Department of Soil, Water & Environmental Science

Contact :
Janick F. Artiola
jartiola@email.arizona.edu

This information has been reviewed by University faculty.
extension.arizona.edu/pubs/az1698-2016.pdf

Other titles from Arizona Cooperative Extension can be found at:
extension.arizona.edu/pubs

Any products, services or organizations that are mentioned, shown or indirectly implied in this publication do not imply endorsement by The University of Arizona.

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Jeffrey C. Silvertooth, Associate Dean & Director, Extension & Economic Development, College of Agriculture Life Sciences, The University of Arizona.

The University of Arizona is an equal opportunity, affirmative action institution. The University does not discriminate on the basis of race, color, religion, sex, national origin, age, disability, veteran status, or sexual orientation in its programs and activities.