Heavy metals and hydroelectricity

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August 2014 GSA Today cover image: The northeastern shoreline of Lake Junín, Peru. The pristine water surface belies a high level of heavy metal contamination of surface sediments. Credit: Donald T. Rodbell

Hydraulic engineering is increasingly relied on for hydroelectricity generation. However, redirecting stream flow can yield unintended consequences. In the August 2014 issue of GSA Today, Donald Rodbell of Union College-Schenectady and coauthors from the U.S. and Peru document the wholesale contamination of the Lake Junín National Reserve by acid mine drainage from the Cerro de Pasco mining district.

According to the World Bank, about 60% of Peru's electricity is generated by hydropower, which during the dry season relies heavily on glacial meltwater to augment stream flow. The ongoing reduction in ice cover in Peru that began early in the twentieth century has reduced the aerial extent of glacial ice in some areas by nearly 30%. According to this GSA Today article, climate models project that warming will be pronounced in the highest elevation regions of the tropical Andes, and thus acceleration in ice loss is likely.

To maintain dry-season river discharge and energy generation for a growing Peruvian population, the hydropower industry in Peru has turned to hydraulic engineering, including dam construction. This study highlights an unintended consequence of early dam construction in the Cerro de Pasco region of the central Peruvian Andes, a region that has been a focal point of Peruvian mining operations for centuries.

The Cerro de Pasco mining district is among the most extensively worked mining districts in Peru. Pre-colonial mining there showed some of the earliest evidence of anthropogenic lead enrichment by aerosolic fallout in nearby lakes about 600 years ago. The first copper smelter was established there in 1906, and in 1931 the new and improved Cerro smelter held monopoly over the refining of all nonferrous metals in Peru.

In order to generate hydroelectricity for Cerro de Pasco's operations, the Upamayo Dam was constructed in 1932. The Upamayo Dam is located in the uppermost reach of the Río Mantaro, immediately downstream of the confluence between the Río San Juan, which drains southward from Cerro de Pasco, and the outflow of Lake Junín, the largest lake entirely within Peru.

The location of the Upamayo Dam and the small reservoir upstream from it has resulted in the discharge of Río San Juan waters, once destined for the Río Mantaro, directly into Lake Junín. Rodbell et al.'s GSA Today paper documents the impact of acid mine drainage from Cerro de Pasco into Lake Junín, which in 1974 was designated a Peruvian National Wildlife Reserve.

As a result of the drainage, the upper several decimeters of sediment in the lake now contain levels of lead and zinc that greatly exceed the U.S. Environmental Protection Agency limits for the lake basin. Today, more than 60,000 metric tons of copper, almost 900,000 metric tons of zinc, and almost 41,000 metric tons of lead are contained in the upper 50 cm of lake sediment—the zinc tonnage representing more than five years' worth of mining production at current rates.

Rodbell and colleagues write that among the biggest challenges that will face any attempt to mitigate the environmental disaster that has befallen Lake Junín are finding ways to stop the recycling of zinc from the lake bottom and the remobilization of all metals from the seasonally exposed and submerged deposits that are trapped behind the Upamayo Dam. Finally, they note that as future hydraulic engineering projects are developed in Peru and elsewhere, it would behoove all not to repeat the mistakes that are recorded in the mud of Lake Junín.

More information: "The heavy metal contamination of Lake Junín National Reserve, Peru: An unintended consequence of the juxtaposition of hydroelectricity and mining." Donald T. Rodbell et al., Geology Dept., Union College, Schenectady, New York 12308, USA, rodbelld@union.edu. Pages 4–10; DOI: 10.1130/GSATG200A.1. OPEN ACCESS at www.geosociety.org/gsatoday/.

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