Climate Change May Increase Mine Impacts

A U.S. Geological Survey researcher has found a first-flush effect related to acid-mine and acid-rock drainage in the western United States that may intensify with climate change. D.K. Nordstorm examined historical evidence of first-flush events preceded by long dry spells. He also examined studies at three mine sites—one each in California, New Mexico, and Virginia.

Metal concentrations in acid drainage increased gradually due to evaporation during dry summers and droughts. The first rainstorms that followed were found to cause a sudden increase in dissolution of soluble salts and the concentration of acids and metals in the receiving stream during the period before peak flow was reached. The increase in flow diluted the concentration. As the rainy season ended, the process of concentration began again.

As climate change progresses in the West, the shift to earlier snowmelt prolongs the dry summer period, increasing accumulation of soluble salts and constituents. The rainstorms that do come may be more intense, dissolving soluble salts more rapidly and causing a bigger spike in concentration.

If mine sites are not remediated, Nordstrom says water quality will deteriorate. He warns that remediation will have to consider more extreme conditions: past extremes of runoff and metal loads may become the new average. Capacity of treatment plants and engineered plans for dams, diversions, and revegetation will have to be increased, adding to cost.

See Nordstrom, D.K., 2008. Acid rock drainage and climate change, J. Geochem.Explor., 100(2-3): 97-104.

Trout Choose Cool Water Over Low Metals

When faced with a choice of warmer stream temperatures with low metal exposures or cooler water with higher metal concentrations, trout head toward the cooler, more contaminated waters, according to an article in the April issue of *Environmental Toxicology and Chemistry*.

Trout generally avoid waters containing metals, which have a range of effects on their abundance and health, but they also thrive in cooler waters. The researchers studied Prickly Pear Creek in Montana, which has increased levels of zinc, arsenic, and lead as a result of more than 100 years of hard-rock mining. Reclamation began in 1988, but zinc levels still exceed U.S. Environmental Protection Agency guidelines.

The authors examined trout behavior from June to August 2001 at three sites along Prickly Pear Creek: PP1 was the reference site, upstream from most hard-rock mining activities; PP3 was about 5 miles away and downstream of Prickly Pear's confluence with metal-contaminated Spring Creek; and PP5 was 9 miles downstream from the Spring Creek confluence, where metal concentrations are more diluted because of input from tributary streams.

Average water temperatures furthest downstream at PP5 were the warmest, frequently exceeding 22°C, and temperatures at the reference site, PP1, were the next highest, but never exceeded 21°C. Water temperatures at PP3 did not exceed 18°C. Metal concentrations in the water were highest at PP3, followed by PP5 and PP1.

Fish densities were greatest at PP3, but most trout samples here also had higher concentrations of metals than samples from the other two sites, along with kidney and liver abnormalities. The researchers say the most acute threat to trout in Prickly Pear Creek appears to be higher water temperatures, causing the preference for cool water to supersede behavior to avoid metals.

See Harper, D.D., A.M. Farag, C. Hogstrand, and E. MacConnell, 2009. Trout density and health in a stream with variable water temperatures and trace element concentrations: Does a cold-water source attract trout to increased metal exposure?, Envir. Toxic. Chem., 28(4):800-808, www.allenpress.com/pdf/entc/ENTC_28.4_800_808.pdf.

Bottled Water is Energy Hog

Bottled water is up to 2,000 times more energy-intensive than tap water, reported Pacific Institute researchers in the February issue of *Environmental Research Letters*. The Institute estimated that the consumption of bottled water in the United States in 2007 required the equivalent of 32 to 54 million barrels of oil, with the exact number depending on water source, bottling process, transportation, and other factors.

The researchers calculated energy requirements for various production stages including manufacturing the bottle, processing the water and the bottles, transportation, and cooling.

The authors estimated that to satisfy global demands, the energy equivalent of 50 million barrels of oil per year is used just to produce the bottles. This energy input dominates the energy requirements of bottled water transported short distances. However, long-distance transport can lead to energy costs comparable to or even higher than the energy costs to produce the bottle.

Visit www.pacinst.org. See Gleick, P.H. and H.S. Cooley, 2009. Energy implications of bottled water, Environ. Res. Lett., 4, stacks.iop.org/ERL/4/014009/.

Private Well Water Quality a Concern

More than 20 percent of private domestic wells sampled nationwide contain at least one contaminant at levels of potential health concern, according to a U.S. Geological Survey study published in March.

Around 43 million people in the United States use drinking water from private wells, which are not regulated by the Federal Safe Drinking Water Act. USGS scientists sampled about 2,100 private wells in 48 states for up to 219 properties and contaminants, including pH, major ions, nutrients, radionuclides, trace elements, pesticides, volatile organic compounds, and microbial contaminants.

The contaminants most frequently measured at concentrations of potential health concern were inorganic contaminants, including radon and arsenic, which are mostly derived from the natural geologic materials that make up the aquifers from which well water is drawn. The most common inorganic contaminant derived from human sources was nitrate, exceeding the federal drinking water standard for public water supplies in four percent of sampled wells. Only seven

of 168 organic contaminants exceeded health benchmarks, and in less than one percent of sampled wells. Bacteria, including total coliform bacteria and *E. coli*, were found in as many as one third of a subset of 400 wells. These bacteria are typically not harmful but can be an indicator of fecal contamination.

The occurrence of selected contaminants varies across the country, often related to geology, geochemical conditions, and land use. For example, nitrate levels were high in the Central Valley of California and other areas with intensively farmed land, while radon was found in crystalline-rock aquifers in areas such as central Colorado.

Contaminants found in private wells usually occurred in mixtures with other contaminants, a concern because the toxicity of mixtures can be greater than that of any single compound. Mixtures of contaminants at relatively low concentrations were found in the majority of wells, but mixtures with multiple contaminants above health benchmarks were uncommon (about four percent).

See DeSimone, L.A., 2009. Quality of water from domestic wells in principal aquifers of the United States, 1991–2004, USGS Sci. Invest. Report 2008–5227, pubs.usgs.gov/sir/2008/5227.

Erin Brockovich Was Right

Federal scientists have concluded that hexavalent chromium (chromium 6), made famous as a water contaminant by Erin Brockovich, is carcinogenic when swallowed, according to *Environmental Health News*, reporting on results of a study published online last December in *Environmental Health Perspectives*.

Chromium 6 has been known to cause lung cancer when inhaled, but its carcinogenicity in drinking water was not previously known. Some scientists had thought gastric acids in the stomach could turn hexavalent chromium into chromium 3, an important nutrient. But in a two-year study by the National Toxicology Program, mice and rats that drank water containing different doses of hexavalent chromium developed malignant tumors in their small intestines and mouths.

California and the U.S. EPA are currently re-evaluating existing health guidelines for hexavalent chromium based in large part on this study, said *Environmental Health News*. However, scientists who conducted the study told the news service that setting a human drinking water standard based on extrapolation from animal studies is difficult and controversial.

Visit www.environmentalhealthnews.org. See Stout, M.D., R.A. Herbert, G.E. Kissling, and others, in press. Hexavalent chromium is carcinogenic to F344/N rats and B6C3F1 mice following chronic oral exposure, Environ. Health Perspect., www.ehponline.org/members/2008/0800208/0800208.pdf.

PPCP Persistence Found to be Low

Concentrations of pharmaceutical drugs and endocrine-disrupting compounds (EDCs) in public drinking water are likely too low to impact human health, according to the authors of a recent Water Research Foundation (formerly AwwaRF) report. The study examined the presence in water of trace levels of EDCs and drugs and explored potential links between those levels and human health. The research team selected 62 representative chemicals for further evaluation based on likelihood of occurrence, production volume, toxicity, and analytical capability. Three hundred water samples were collected from 19 sites nationwide and analyzed for a selected suite of compounds using extremely sensitive analytical methods with low-part-per-trillion detection limits. The team conducted risk evaluations of exposure through drinking water for all target pharmaceuticals, 10 suspected EDCs, and three hormones.

Only three of the 62 compounds analyzed—atrazine (herbicide), meprobamate (antianxiety), and phenytoin (antiepileptic)—were consistently found in water samples. Trace concentrations of 24 compounds were detectable in at least 20 percent of untreated water samples, and trace concentrations of 11 compounds were found in at least 20 percent of treated drinking water samples. These included five prescription drug compounds, atrazine, DEET, a pesticide, and two flame retardants. Atrazine was detected at the highest concentration, but far below the federal regulatory limit.

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Of the nine pharmaceuticals that were detected at least once in finished drinking water, none had concentrations higher than the U.S. Food and Drug Administration's calculated acceptable daily intake (ADI). Only four EDCs were detected in drinking water, none above their ADIs.

See the project summary (Toxicological Relevance of Endocrine Disruptors and Pharmaceuticals in Drinking Water, #3085) and order the full report at www.waterresearchfoundation.org/research/TopicsAndProjects/projectProfile.aspx?pn=3085.

Development Effects on Carson River Unclear

A new U.S. Geological Survey report shows that the impacts of groundwater pumping and of changes in land and water use on streamflow in the Carson River of California and Nevada were too small to be measured, masked by variations in annual precipitation, or offset by each other.

Scientists compiled data on changes in land and water use, groundwater pumping, groundwater levels, streamflow, and water quality in the Carson River basin upstream from Lahontan Dam for 1940 to 2006. Stream-gauge data showed that annual Carson River streamflow is highly variable, averaging 297,000 acre-feet but ranging from 26,000 to more than 800,000 acre-feet.

Increases in groundwater pumping and changes in land and water use were greatest during dry and wet periods, so any effects of development on streamflow were masked by the annual precipitation variations. Increases in groundwater pumping occurred at the same time as other changes such as increased application of treated effluent for irrigation or the reduction of irrigated acres, offsetting any noticeable effects.

Estimated pumping in the upper basin has increased considerably since the 1970s, particularly in dry years to supplement irrigation normally served by streamflow.

See Maurer, D.K., A.P. Paul, D.L. Berger, and C.J. Mayers, 2009. Analysis of streamflow trends, ground-water and surface-water interactions, and water quality in the upper Carson River basin, Nevada and California: USGS Sci. Invest. Report 2008–5238, pubs.usgs.gov/sir/2008/5238/.

Clay Can Clean Pharmaceutical Pollution

Modified clay could be used to clean up pharmaceutical pollution in water supplies, according to a study published in the February issue of *Ecological Engineering*.

The new study demonstrated that light-expanded clay aggregates (LECA), or artificially modified clay, can reduce up to 90 percent of ibuprofen and the antiepileptic drug carbamazepine in water. LECA can be produced from natural sources by high-temperature treatment. Removal efficiency decreases slightly as the drugs' concentrations increase, and is lower in wastewater than clean water. The scientists found that LECA was not as effective at removing

clofibric acid (a blood-lipid regulator) as vermiculite. Most pharmaceuticals were removed in the first 24 hours.

A substantial amount of ibuprofen remains after wastewater treatment because of its high incoming concentrations. Wastewater treatment processes have also been inefficient at removing carbamazepine. The researchers hope that their study can help select materials to be used in constructed wetlands, which with LECA could provide a cheaper alternative to other methods of reducing pharmaceutical pollutants.

Visit ec.europa.edu. See Dordio, A.V., A.J. Estévão Candeias, A.P. Pinto, C. Teixeira da Costa, and A.J. Palace Carvalho, 2009. Preliminary media screening for application in the removal of clofibric acid, carbamazepine and ibuprofen by SSF-constructed wetlands, Ecol. Engin., 35: 290-302.

Wasp May Control Arundo

The Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture issued an environmental assessment in March regarding the potential release of a wasp, *Tetramesa romana*, to control *Arundo donax* infestations.

Arundo donax, also known as giant reed or Carrizo cane, is found throughout the southern United States and is most invasive in the Southwest. It can grow up to 10 centimeters per day and cause loss of biodiversity, altered channel morphology, increased costs for control along transport corridors, and difficulty for law-enforcement activities on the international border. It is also estimated to use three times more water than native riparian vegetation (see *Southwest Hydrology*, Nov/Dec 2007).

Current control methods include herbicides approved for wetlands, prescribed fire, heavy machinery, and hand-cutting. According to the assessment, these options are often ineffective, expensive, and temporary, and may impact nontargeted species.

The wasp weakens the weed by laying eggs within it, causing abnormal outgrowths of plant tissue that stunts the stems and sometimes kills them. It has been demonstrated to be specific to the weed through scientific literature, field observations, and host-specificity testing, according to the assessment.

Although *Arundo donax* habitat is used by some endangered bird species, it has been documented as less than suitable for them. However, the wasp is not expected to cause rapid reduction of the weed, leaving nesting habitat for birds and other species.

The assessment determined that the wasps may not necessarily reduce the ability of the weed to reproduce, but may be effective in combination with other control methods. ■

See the Federal Register *notice and environmental assessment at www.regulations.gov/fdmspublic/component/main?main=DocketDetail&d=APHIS-2008-0141.*