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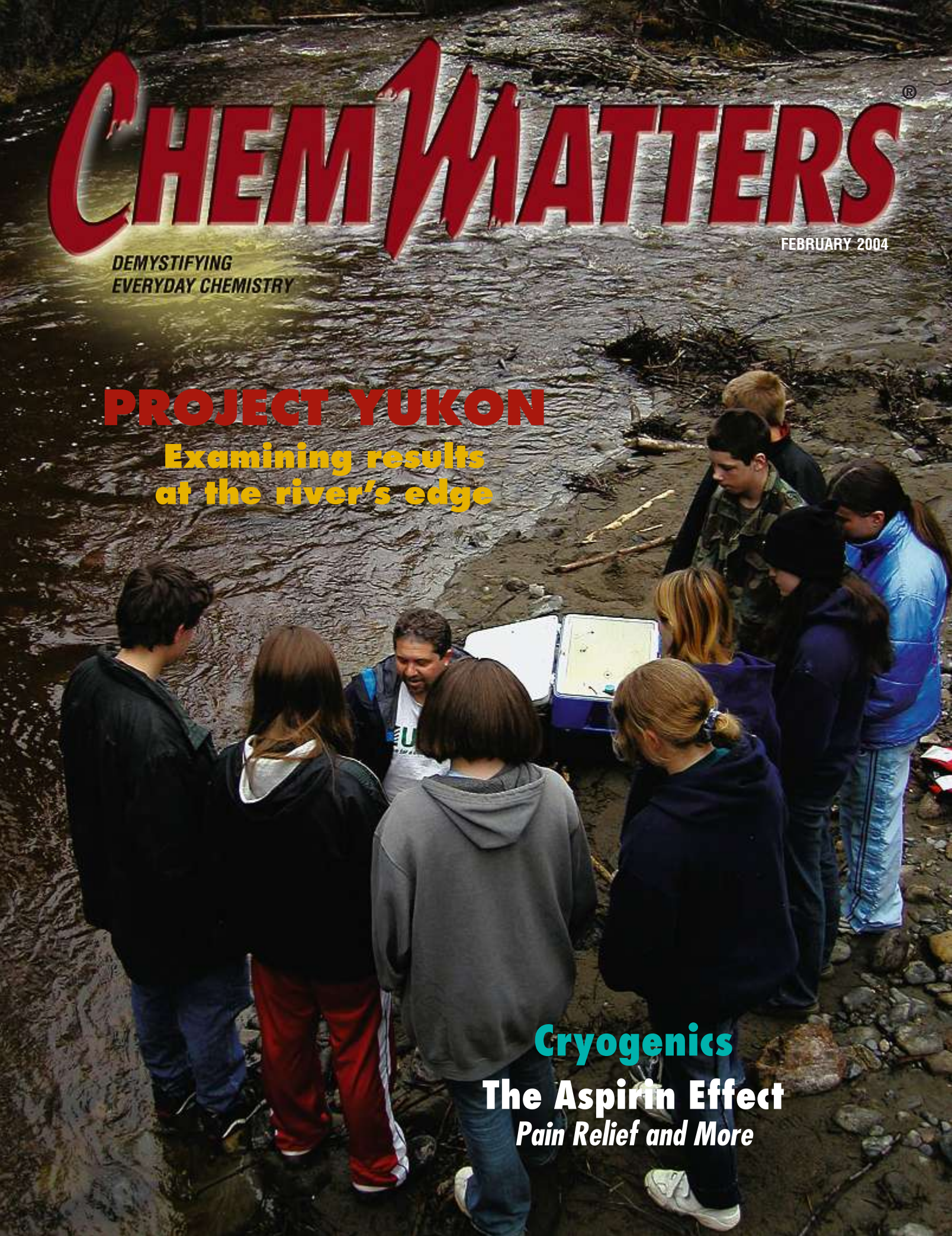
DEMYSTIFYING EVERYDAY CHEMISTRY

FEBRUARY 2004



PROJECT YUKON

Examining results at the river's edge

Cryogenics

The Aspirin Effect

Pain Relief and More

Project

Even in the middle of an Alaskan winter at 40 degrees below zero, students from Eagle Community School took water samples from a tributary of the Yukon River—part of a supercool, yearlong science project. But it's what they found when the ice melted that really surprised scientists!

YUKON

Thawing Out the Facts

Part of the Eagle classroom water-sampling team poses. From left to right, back row: Olivia Laughmiller, Ricky Nix, Selena Nix, Jubal Richey, Sabrina Nix, Starla Helmer; and in front, Brandon Robb.

By Sonya Senkowsky

Eagle, Alaska—On a class field trip to a local creek, 15-year-old Jubal Richey dunks a plastic syringe into tea-colored water, then aims it into the air and presses the plunger. As a stream of water shoots out in a 10-foot arc, he gives a hoot and grins.

Rinsing syringes with creek water provides more than a moment's horseplay; it also keeps water samples from being contaminated. Richey is having fun, but he and his fellow students at Eagle Community School are really here to accomplish serious work—checking the health of a mighty northern river, the Yukon, and one of its many tributaries.

Over the last school year, about a dozen students living in this remote town near the Canadian border have transformed themselves into water technicians. They are helping federal scientists learn more about Alaska's largest river and the tributaries that feed it, such as American Creek.

It's the ultimate chemistry class. But this is more than a class project. The students' work is contributing to the largest and most in-depth water-quality study ever of the Yukon River. Already, their results are challenging scientists' understanding of how a warming climate may be changing the Yukon.

Sampling below zero

On school days and during breaks, in the all-day Alaska sun of summer and throughout the subzero temperatures of winter, students in this far northern community have trouped out to study sites on the creek and river every month, twice a month, to take samples of water, as well as ice and snow.

"The most difficult was the cold temperatures," Richey said, "getting out in 40-below—that was pretty hard."

Even on the last day of the school, in May, the class gathered at American Creek to take a round of samples. Each of the students, in grades 5 through 12 (the school's total enrollment hovers around 30), has a job. Some of the tests look like something you'd see in a medical clinic. Using his syringe, Richey withdrew water for a lab test that will measure dissolved carbon dioxide, one indicator of river health. High concentrations can stress or kill fish.

Left top: On a balmy May day, Olivia Laughmiller holds a water bottle in place as a pump sucks water through a filter. How is sampling when it's –40? Not as much fun as you would think.

Left bottom: On the Taylor Highway, USGS hydrologist Paul Schuster collects samples that might tell scientists more about how melting permafrost is affecting the Yukon River watershed.

One of the many tributaries of the Yukon River, this creek along the Taylor Highway exhibits the distinctive rusty colors leant to it by chemistry. During snowmelt, the water has a high amount of dissolved organic carbon (DOC), a byproduct of leaf litter and other organic soil matter. The DOC molecules bind to iron and other metals, leaching them out of the soil and into the river.

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Paul Schuster places probes over the side of a USGS research boat in order to measure temperature, pH, conductivity and other indicators of river health. He and other researchers do this kind of sampling when they can, but the information gathered by students twice a month helps fill in the blanks.

His job was to affix a needle and withdraw a sample, like a doctor taking blood. Then, using the needle, he injects the water into the rubber cap of a sealed glass bottle that is filled with nitrogen gas. The idea is to make sure the only carbon dioxide that ends up in the bottle came from the water, not from the surrounding air.

Aren't they tired of all the sampling? "Yes!" exclaims 15-year-old Starla Helmer. But the students all have a special interest in making sure their water is safe. The Yukon watershed, or the entire region that supplies water to the Yukon, serves an area larger than Texas. Some locals even drink directly from American Creek in winter, Helmer says, cutting a hole through the ice to get to the water—which looks clear in spring.

Eighth-grader Ricky Nix was in charge of testing water hardness, something he does by using a piece of paper that changes color to indicate the concentration of calcium and magnesium ions in the water. After checking the strip, he records the results.

Fifth-grader Brandon Michael Robb is in charge of pH and nitrates. Sophomore Sabrina Nix filters a water sample, which will be sent to U.S. Geological Survey (USGS) scientists for further testing. Other students performed field tests for dissolved organic carbon, methane, calcium, chloride, sulfate, and potassium.

In winter, students retrieved water by dipping a bucket through a hole carved in river ice and learned to gather "pillow samples"—which are really "pillows" of snow.

"They're like water technicians," said teacher Marlys House. "They go down there, get their sample kits out, and do it."

Jubal Richey rinses a syringe for use in carbon dioxide sampling.

Paul Schuster uses a needle and syringe to take a carbon dioxide sample from the river. The sample is injected into a sealed bottle in order to avoid contaminating it with atmospheric CO_2.

Watching for change

The Yukon River.

Students and their families know the Yukon River well. They live on its banks, they travel its waters, and they watch its moods to tell when the seasons change. It doesn't matter what the calendar says; around here, the day the river ice breaks apart, or "breakup" is the real first day of spring.

Scientists also watch the river for signs of change, but on a larger scale. Records of air temperature in the region from the past 30 years show the area is slowly but steadily warming at a rate of about 0.75 °C each decade.

Frozen soil deep beneath the ground got the name *permafrost* because it never defrosts. But if the climate continues its warming trend, even permafrost will melt. So will glaciers. As they do, both are expected to release chemicals and particles that used to be securely frozen inside, including greenhouse gases such as carbon dioxide.

The big question scientists have is this: As the north continues to defrost, where will the extra contaminants, greenhouse gases, and other newly released particles and chemicals go? And can the Yukon take it?

Before now, water scientists had very little information on Yukon River chemistry, says Paul Schuster, hydrologist with the U.S. Geological Survey Water Resources Division in Boulder, CO. Most water testing in the past has focused on rivers near major cities, where industrial pollutants are the biggest concern. Alaska's water is still relatively clean. But in order to track changes, it's important to have "baseline data," or a starting point for later comparison.

To get that baseline, the U.S. Geological Survey began to gather water samples down the 2,100-mile length of the river. But it wasn't until they struck an arrangement with schoolteacher Marlys House that the agency had a way to get samples from a single tributary, month after month, all year long.

"Ever hear the term water under the bridge—meaning it's past, it's gone?" Schuster asked. "Well, that's taken literally in my line of work. If you don't sample water, it is literally under the bridge, and it's gone."

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Working late into the evening (check the time on the clock), long after students have gone home, USGS scientist Dusty Langley processes water samples in the Eagle Community School chemistry lab.

Thanks to Eagle students, the scientists didn't have to let the moment, or the water, escape. Under Schuster's guidance, the students learned the same standard techniques required by government standards, or protocols; these ensured their results could be compared to previous data and used in real research. Then they started sampling.

Schuster was impressed by the way students fell into the routine. "Everybody was kind of on automatic pilot, and that's a great sign of a group of people that know what they're doing."

Although younger students' results were only used locally, data and samples collected from upperclassmen went on to USGS labs. The volume of samples doesn't sound all that impressive. The total amount gathered and sent to Colorado between August 2002 and May 2003 wouldn't have filled a 2-liter soda bottle, said House.

But what counted here was not quantity, but quality.

Rivers and minds change course

In late May 2003, about a month after breakup, Paul Schuster could barely restrain himself from grinning as he told the class what they had accomplished. The students' sampling has turned scientists' assumptions about the watershed upside down.

Scientists had once guessed that melting permafrost would increase the amount of dissolved organic carbon added to the river, just like snowmelt does in spring. But data collected by the students at American Creek now have them thinking the opposite.

How can this be?

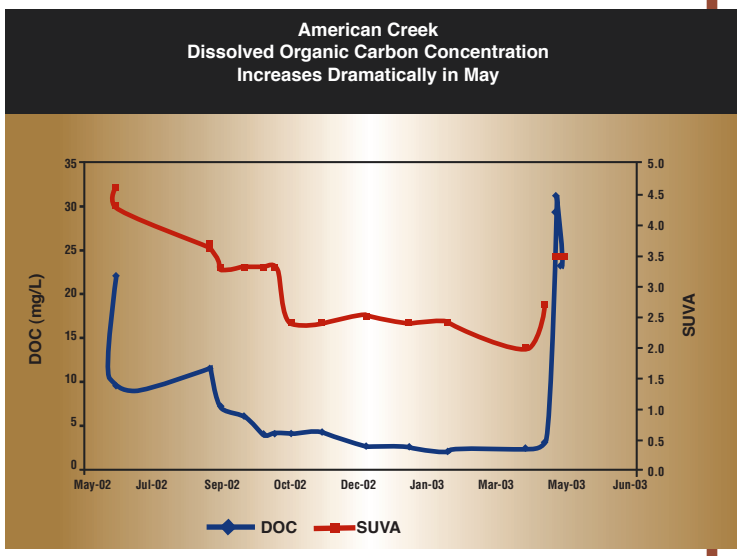
The samples taken during the thaw held the biggest clue, says Schuster. During the thaw, American Creek turns rusty brown. And not just because of mud. The tealike color is one result of a chemical process: the breakdown of dead leaves and other organic materials that occurs after they are released from ice. This decomposition results in increased levels of dissolved organic carbon (DOC). Some of these dissolved organic compounds bind to and dissolve metals such as iron, which can also contribute to changing the color of the water.

During snowmelt, dissolved organic carbon levels in the Yukon watershed shot way up, to 10 times their original levels. In typical watersheds—those without permafrost—these might gradually double or triple during snowmelt. But a 10-fold increase really got scientists' attention, said Schuster.

"(An increase) is common, but we don't see it happen this fast," said Schuster, pointing to a graph. "You see how it just goes to the roof? It's usually a more gradual response. We got to thinking about why—why is this happening? What's going on here?"

The rapid increase was a clue that the Yukon was operating differently than most rivers. What could be different? Scientists decided it was permafrost.

Right now, when groundwater in the region hits a solid layer of permafrost, it rides this frozen layer like a slide, directly into the river.



The results. Total dissolved organic carbon increases in the river during the snowmelt. The higher specific ultraviolet absorbance (SUVA) measurements indicate that the DOC has more "aromatic" compounds in it. Loosely translated: the DOC is more reactive and pulls more metal out of the soil.

If the frozen barrier of permafrost melts, says Schuster, this will completely change how groundwater moves to the river. It should be able to sink deeper into the soil, giving the soil a chance to act as a filter, maybe helping clean the water before it hits rivers and streams.

This, too, is just a hypothesis—a new one, and one that's sure to be subjected to further testing. But it's exciting to Schuster and his fellow water scientists to have a new way of looking at the Yukon. He hopes the fruitful collaboration with Eagle's newest water quality technicians will continue.

"The kids are learning about chemistry, and we're obtaining a one-of-a-kind data set," he says. "It's a win–win situation."

Sonya Senkowsky is a science writer based in Anchorage, AK.

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