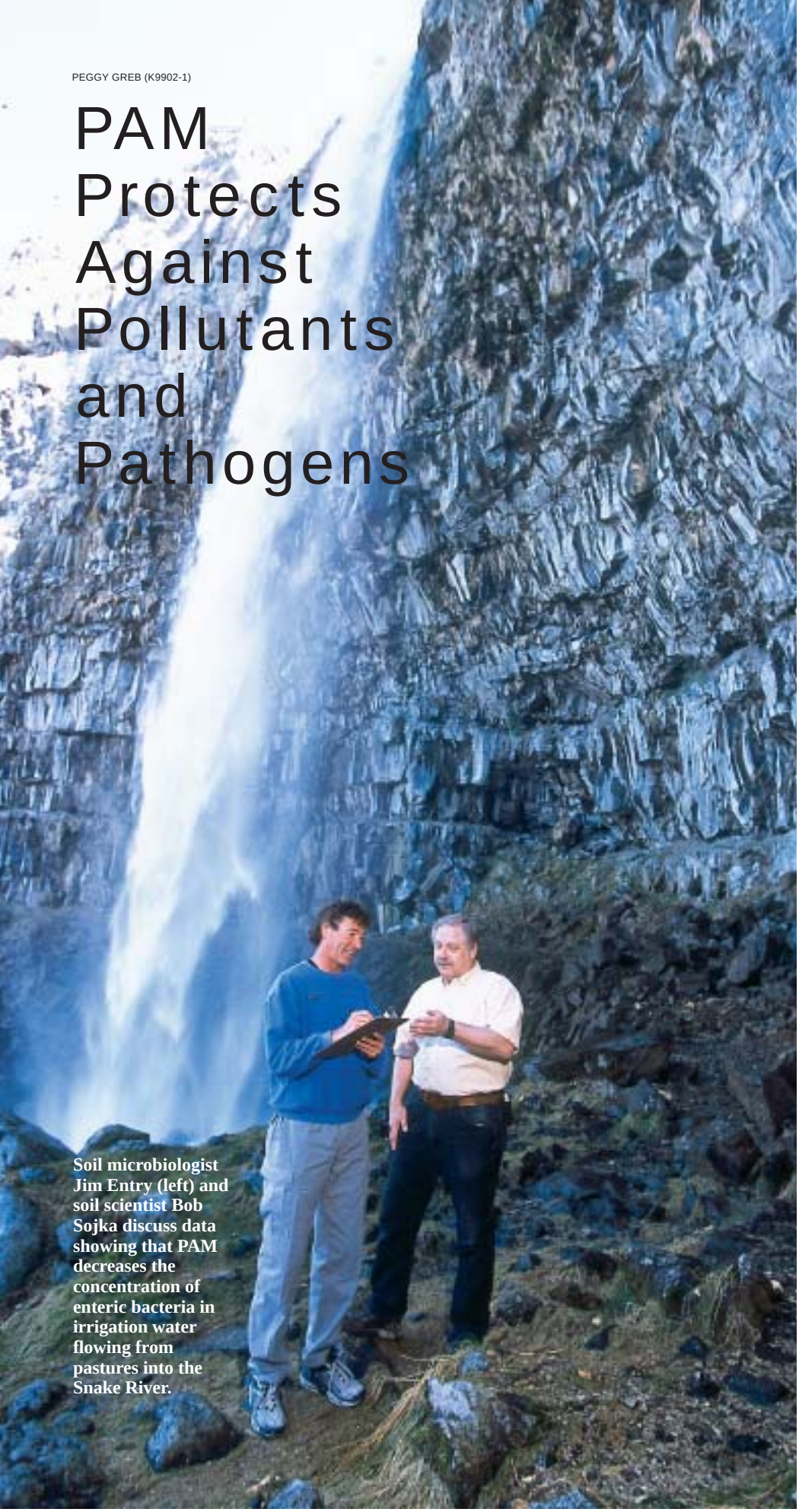
PEGGY GREB (K9902-1)

PAM Protects Against Pollutants and Pathogens



Soil microbiologist Jim Entry (left) and soil scientist Bob Sojka discuss data showing that PAM decreases the concentration of enteric bacteria in irrigation water flowing from pastures into the Snake River.

An environmentally friendly compound nabs nutrients and troublesome microbes before they can escape from farmers' fields and make their way to ponds, lakes, streams, or rivers. Known as a polyacrylamide, or PAM, this powder can help keep nutrients—such as the phosphorus in fertilizers—from traveling beyond the farm in irrigation runoff. Similarly, PAM helps keep disease-causing microbes, like those in cow, pig, or fish manure, from being swept beyond the confines of farmyards or feedlots.

That's according to investigations by ARS scientists with the Northwest Irrigation and Soils Research Laboratory in Kimberly, Idaho. Researchers there are already world leaders in discovering safe, practical, and affordable PAM-based tactics that prevent soil particles from ending up in irrigation water. Without PAM's help, particles can become dislodged when farmers irrigate their fields.

Findings from the team's laboratory and outdoor experiments have prompted U.S. growers to put PAM to work on more than 1 million acres of irrigated farmland. "Growers who mix PAM with irrigation water can expect to reduce erosion from their furrow-irrigated fields by 80 to 99 percent," says Rodrick D. Lentz, an ARS soil scientist at Kimberly. "One ounce of PAM anchors as much as 1,000 pounds of topsoil that might otherwise be carried away by irrigation water."

Says Kimberly colleague David L. Bjorneberg, "We achieved slightly less dramatic results with sprinkler irrigation." Bjorneberg is an ARS agricultural engineer.

The idea of using PAM to thwart erosion from furrow-irrigated fields dates back to about 1975. But the Kimberly studies, begun in 1991, were the first to determine precisely how much PAM farmers should use, as well as when, where, and how to apply it. In fact, their work has led to PAM's being hailed as "possibly the most successful soil-conservation practice ever developed for furrow irrigation."

Now, new information from ARS soil microbiologist James A. Entry and ARS

soil scientist Robert E. Sojka shows that pairing PAM with other compounds boosts its ability to fasten onto nutrients in runoff. "It's a matter of when a nutrient becomes a pollutant," says Entry, in explaining their interest in keeping nutrients in fields. "On the farm, nitrogen and phosphorus are regarded as nutrients plants need to thrive. If these same natural chemicals make their way into water as it leaves the farm, however, they may become pollutants."

PAM Catches Nutrients

Nitrogen and phosphorus in runoff, for example, can become culprits behind algal blooms in ponds or lakes. Fueled by these pollutants, algae flourish. Later, their decay uses up oxygen needed by fish and other aquatic dwellers. So some states—in setting pollution limits for runoff—specify not only the allowable amount of sediment, but also the permitted amount of these potentially polluting nutrients.

PAM helps growers avoid exceeding these "Total Maximum Daily Loads" for sediments and nutrients. Entry and Sojka, building on the Kimberly lab's earlier nutrient-pollution studies, tried some new PAM-chemical combinations to see whether they would bolster PAM's pollution-fighting prowess. In these nutrient-loss trials, they combined PAM with aluminum sulfate or calcium oxide.

Why match PAM with these other chemicals? Explains Entry, "We already knew, from work others had done, that chemicals like aluminum sulfate and calcium oxide can slow the loss of phosphorus. We also knew, from textbook chemistry, that they would help PAM bind to phosphorus."

Entry and Sojka put PAM in furrows containing cow, pig, or fish manure. They irrigated the field and then analyzed the runoff. Entry reports, "PAM alone did a good job of removing nutrients, as we've seen before. But the new PAM combinations were even more effective."

Waterborne nutrients can either flow overland or move down through the soil and potentially pollute underground water. "In a washed-sand study in our laboratory," Entry notes, "we mimicked the flow of nutrients as they leach through soil."

Sand Columns Simulate Nature

Entry and Sojka assembled 48 plastic columns, each 18 inches high and 4 inches in diameter. They added clean, loosely packed sand to each column.

To some columns, they added a small amount of either PAM or PAM mixed with one of the other chemicals. On top of that, they placed some cow or pig manure from local farms, or fish droppings from a nearby hatchery. Then they poured distilled water into the columns and captured this leachate as it flowed out the bottom into flasks.

PEGGY GREB (K9905-3)

Agricultural engineer Dave Bjorneberg demonstrates a PAM application method for furrow irrigation. About 2 tablespoons of PAM would be used per 1,000 feet of furrow.

"This is a tough challenge for PAM," says Entry, "because water drains through clean sand faster than through most soils. The fast rate of flow means PAM has much less time to grab onto nutrients.

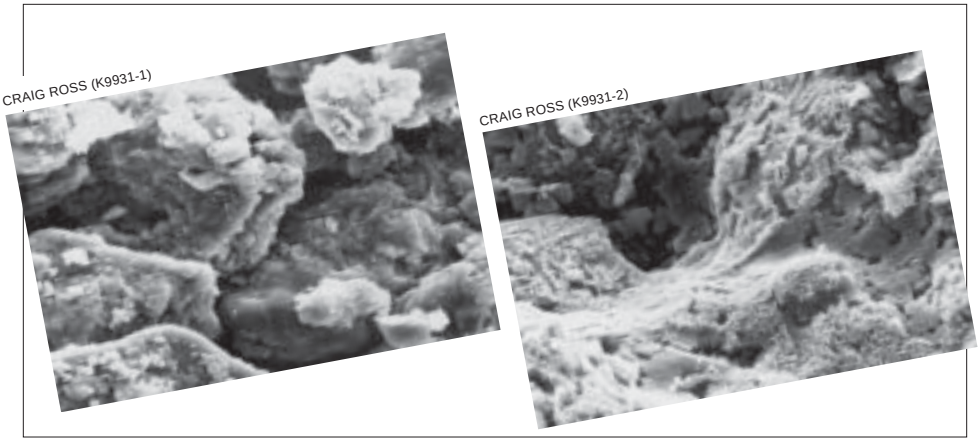
"We found that water draining from sand columns that had PAM alone contained significantly fewer nutrients from the cow or pig manure," says Entry. "But columns with the PAM combinations held back twice as many nutrients from those manures. None of the treatments reduced already-low levels of target nutrients in flow-through from fish manure."

Sojka comments, "Earlier, our outdoor studies had suggested that if nutrient concentrations in runoff are low to begin with, there's less chance that the nutrients will contact binding sites on PAM molecules. We think that might be the case with the fish manure leachates."

Even though they provide needed nutrients, manures can pose a problem: they usually harbor microbes—some of which can cause disease. That's why Entry and Sojka have newly explored PAM's ability to grasp such pathogenic

CRAIG ROSS (K9931-1)

CRAIG ROSS (K9931-2)



Scanning electron micrographs of untreated silt (left) and silt treated with PAM (right). The PAM creates a gauzelike netting that holds the silt, nutrients, and microorganisms in place against the force of flowing water. Magnified about 1300x.

microbes from runoff. They did this by analyzing microbes from the column leachate and furrow runoff.

PAM Works on Manure Microbes

"PAM alone significantly reduced bacterial microbes in these water samples," Entry points out. "Specifically, PAM alone reduced populations of total and fecal coliform and fecal streptococci in the cow and pig leachate from the column experiments—as well as from our outdoor runoff—by about 90 percent."

The PAM combinations did even better. PAM plus aluminum sulfate and PAM plus calcium oxide reduced total and fecal coliform bacteria and fecal strep by about 99 percent. "From a practical water-treatment standpoint, that means the PAM combinations were far more effective than PAM used alone. That's the same thing we observed in our nutrient studies," says Entry.

Says Sojka, "We think these findings have important implications for keeping microbes from moving away from farms or places where animal manure accumulates. For instance, if producers use manure on their fields, they could apply PAM with their irrigation water."

Entry adds, "We want to find out if PAM might be used effectively around the perimeter of farmyards or feedlots. Farmers and feedlot managers already do many things to control losses of nutrients and pollutants from manure. But sometimes their systems fail. Let's say a manure pond breaks or overflows during a storm or flood. When that happens, you need an emergency measure. We plan to determine whether—under these conditions—putting down a layer of PAM could help limit the spread of microbes that otherwise might flow into streams or groundwater.

"Keeping the microbes in place helps protect the health of water users downstream," emphasizes Entry. "PAM doesn't kill microorganisms. With or without PAM, they die off at the same rate. The advantage of PAM is it keeps down the number of these microbes in farm runoff.

PEGGY GREB (K9903-1)

Jim Entry (left) and Dave Bjorneberg record sediment concentrations from furrow irrigation runoff samples. The darker sample on the left is from an untreated furrow.

PEGGY GREB (K9906-1)

Biological technician Sheryl Ver Wey prepares to count colonies of fecal coliform bacteria in a water sample.

"PAM's performance in clinging to microbes in water in confined spaces, such as sewage-treatment plants, is already well-known," Entry says. "But our data are likely the first about PAM's interaction with microbes in water flowing over land."

More information about these and other PAM results from the Kimberly scientists is presented on the World Wide Web at http://Kimberly.ars.usda.gov/pampage.shtml.—By **Marcia Wood,** ARS.

This research is part of Soil Resource Management, an ARS National Program (#202) described on the World Wide Web at http://www.nps.ars.usda.gov.

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