Gauging the Levels of Strontium in Rusted Pipes

Tap water contains many substances of which we are usually unaware. These impurities are for the most part harmless, but the effects of some, like the metal strontium, are still unclear. Recently, water utilities have begun monitoring how much strontium we ingest from drinking water. A new study shows that this monitoring may need to factor in the release of strontium from rusted pipes. Researchers using two beamlines at the APS have identified high levels of strontium in corrosion products taken from different water supply pipes. This bound strontium can eventually be released back into the water, presumably causing the strontium concentration to occasionally spike above the monitoring reporting limit.

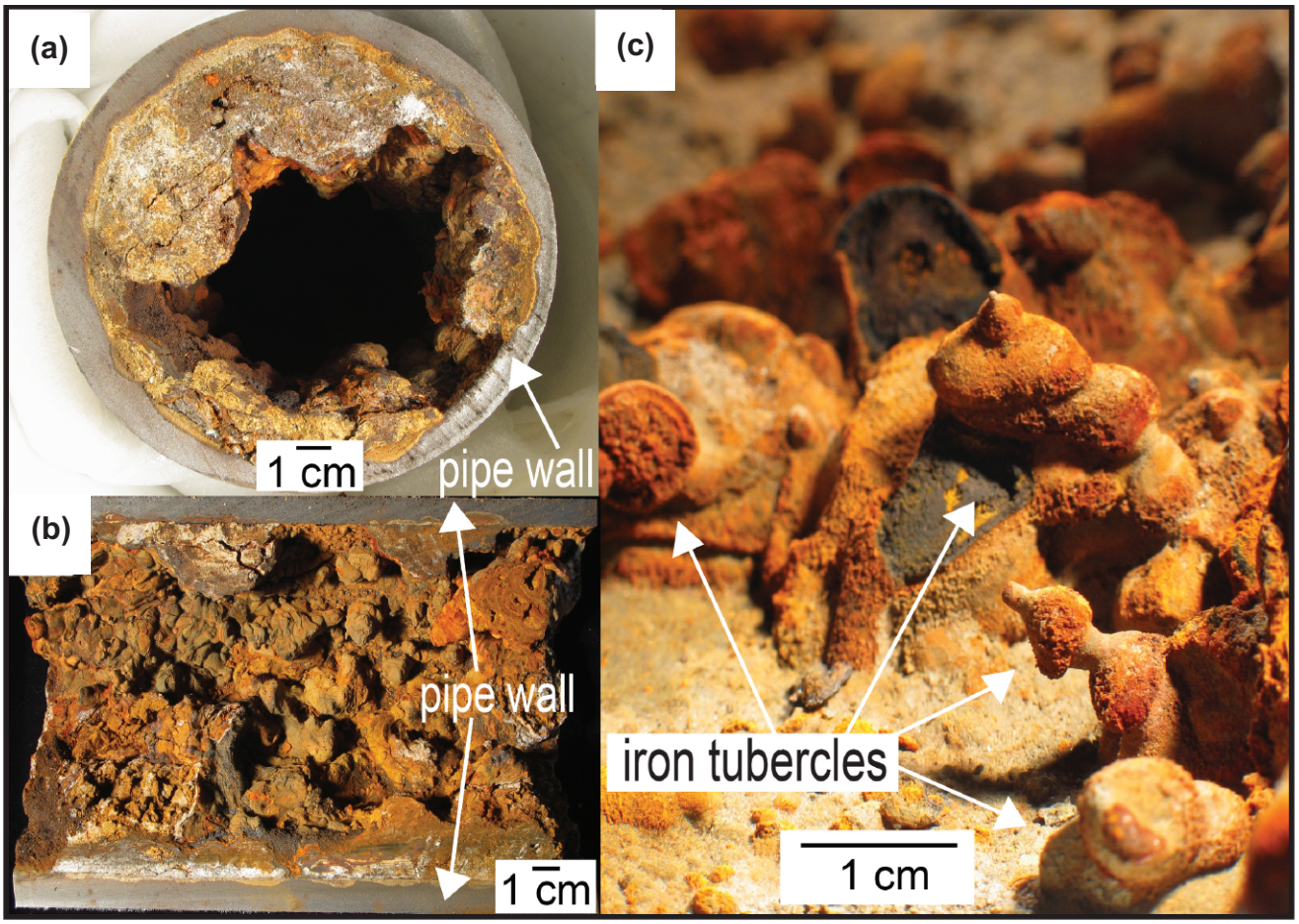

Fig. 1. Images (a) and (b) show iron corrosion products inside a cast-iron service drinking water pipe recovered from a water supply system in the Midwest. Image (c) is a close-up view of an iron corrosion product from a 15-cm-wide cast-iron service drinking water pipe from a system in New England. The mound features, called tubercles, can be seen in the photo. Images: M.K. DeSantis. Graphic: T.L. Gerke (U. Cincinnati).

The average concentration of strontium in our drinking water is around 1 mg/l. Because strontium is chemically similar to calcium, some of this strontium ends up in our bones and teeth. This may be beneficial, as certain drugs containing strontium have been shown to improve bone density. However, other studies suggest that too much strontium may lead to bone weakness. The U.S. Environmental Protection Agency (U.S. EPA) does not presently regulate strontium, but since January 2013 the agency has required certain water utilities to monitor strontium (as well as other contaminants) in their water supplies.

One unresolved issue is where best to check the strontium concentration. Strontium monitoring occurs at the point-of-entry and point-of-maximum stagnation in a water distribution system. However, this may not reflect what comes out of the faucets at the other end. Previous work has shown that the metal vanadium binds to, and later releases from corrosion products inside of water pipes. Now researchers from Miami University, the University of Cincinnati, the Naval Research Laboratory at the Stennis Space Center in Mississippi, and the U.S. EPA have investigated whether similar binding and release occurs with strontium.

The researchers looked specifically at iron corrosion products, as possible locations where strontium may concentrate. These rust concentrations, which are found in iron pipes, consist of multiple mounds of iron oxides/oxyhydroxides (Fig. 1). They are composed not only iron but other metals and minerals that have adsorbed onto iron corrosion products or precipitated from the drinking water. This "filtering" can, during normal operations, reduce the amount of contaminants that reach the tap. However, a disturbance in the water flow or in the water chemistry can cause some of the metals to be desorbed or dislodge small pieces of the surface layers of iron corrosion products.

To evaluate if strontium is a metal that adsorbs to iron corrosion product surfaces, the research team collected iron corrosion product samples from four different water distribution systems. Using x-ray fluorescence measurements, they found strontium concentrations ranging from 3 to 128 mg/kg in the surface layers of the products. But these measurements by themselves did not reveal how easily strontium can be desorbed from the surfaces of the iron corrosion products. For this, the team performed micro-x-ray adsorption near edge structure spectroscopy (μ-XANES) at the MR-CAT 10-ID-B beamline and the XSD beamline 20-ID-B,C, both at the APS.

Sample spectra were compared to several standards that contained strontium in different configurations. The comparisons revealed that strontium was primarily bound in calcite ($CaCO_3$) crystals, replacing calcium atoms. This is a fairly stable configuration with regard to release. However, they also found that a portion of the strontium was simply adsorbed on the surface of iron oxides/oxhydroxides or calcite crystals. A disturbance in the flow or in the water chemistry could cause this adsorbed strontium to release back into the drinking water.

To verify that this release happens, the team analyzed a water filter from a single home connected to one of the utilities in the study. They found that the particulates caught by the filter had the same iron and strontium concentrations as the iron corrosion products they analyzed.

The researchers surmise that sudden releases of iron corrosion particulates could potentially expose water drinkers to strontium levels above the U.S. EPA Health Reference Level of 4 mg of strontium per liter of water.

— Michael Schirber

See: Tammie L. Gerke[1‡*], Brenda J. Little[2], Todd P. Luxton[3], Kirk G. Scheckel[3], and J. Barry Maynard[1], "Strontium Concentrations in Corrosion Products from Residential Drinking Water Distribution Systems," Environ. Sci. Technol. **47**, 5171 (2013). DOI:10.1021/es4000609

Author affiliations: [1]University of Cincinnati, [2]Naval Research Laboratory, [3]U.S. Environmental Protection Agency. ‡Present address Miami University

Correspondence:

* gerketl@miamioh.edu

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10-ID-B • MR-CAT • Materials science, environmental science, chemistry • X-ray absorption fine structure, time-resolved x-ray absorption fine structure, micro x-ray absorption fine structure, microfluorescence (hard x-ray) • 4.3-27 keV, 4.3-32 keV, 15-90 keV • On-site • Accepting general users •

20-ID-B,C • XSD • Materials science, environmental science, chemistry • X-ray absorption fine structure, surface diffraction, x-ray Raman scattering, micro x-ray absorption fine structure, microfluorescence (hard x-ray), time-resolved x-ray absorption fine structure, x-ray emission spectroscopy • 4.3-27 keV, 7-52 keV • On-site • Accepting general users •