Scientists simulate gut reaction to arsenic exposure

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A simulated gastrointestinal system is helping scientists test contaminated soil for its potential to harm humans. The method is likely to save time and money for people hoping to repurpose land with an industrial past.

Most testing for potential arsenic exposure is conducted in recognition of a dirty little secret of modern life: Humans unknowingly eat a little bit of soil each day. For children who might play on contaminated soil and ingest dirt, the testing is considered particularly important.

Chronic exposure to arsenic can cause cancer, impaired nerve function, kidney and liver damage, and skin lesions.

An in-vitro method that simulates digestion of arsenic-laden dirt in a glass flask has been shown in comparison studies at Ohio State University to be as effective as arsenic testing in young pigs, the most common animal model used for this purpose.

This phase of testing is meant to determine how much of the ingested soil arsenic dissolves during digestion and eventually enters the bloodstream. Some soils can bind up arsenic, preventing the compound from dissolving, which reduces the exposure risk.

"We can't tell you how much arsenic gets absorbed into the blood with the in-vitro method, but we can tell you how much dissolves from the soil in the gastrointestinal tract. Arsenic can't get into the blood unless it

dissolves," said Nicholas Basta, professor of soil and environmental chemistry and lead developer of the testing method. "And right now we tell people that under worst-case assumptions, any arsenic that gets dissolved also gets absorbed."

Basta described the in-vitro testing method in Houston Tuesday (10/7) at the joint meeting of the Geological Society of America, Soil Science Society of America, American Society of Agronomy, Crop Science Society of America and Gulf Coast Association of Geological Societies.

Arsenic is a chemical element that naturally occurs in small amounts in many types of soil, as well as in water and air. Higher-than-normal levels of inorganic arsenic soil contamination can result from mining, pesticide use and other industrial operations.

Soil testing comes into play when land owners want to develop commercial or residential properties on ground previously used for industrial purposes, Basta said. First, soils are tested for their arsenic content. Most moderately contaminated soils are subject to further testing to determine how dangerous the arsenic content is to humans.

Arsenic limits for drinking water have been set by the Environmental Protection Agency, but no similar single standard exists for arsenic in soil. Instead, the EPA sets ranges based on geographic zones and exposure risks to humans and different kinds of animals.

In worst-case scenarios, highly contaminated soil must be manually removed and sent to a landfill. The cost for this type of remediation can reach the hundreds of millions of dollars. Less contaminated soils can be treated prior to development, but must be assessed again to ensure the treatment reduces arsenic contamination.

Only a handful of labs in the world are equipped to use animals to test

contaminated soil and whether the arsenic in those soils dissolves in the gastrointestinal tract and is absorbed into the blood, where it can circulate throughout the body. The animals are fed the contaminated soil, and their urine is tested for arsenic content to determine the amount of arsenic that was absorbed from the soil by the intestine and into the systemic circulation of the blood.

The highly controlled animal tests, usually conducted with pigs but also with primates, are lengthy and expensive, costing thousands of dollars per assessment.

"What happens if 1,000 people want to do these assessments? They can't get done fast enough and they are very expensive," Basta said. "So we've come up with an inexpensive, fast test for the lab."

Basta and colleagues combine enzymes and other chemicals in a simple glass flask to simulate stomach contents. After introducing arsenic-contaminated soil to the solution, the scientists stir the contents to mimic a churning stomach and adjust the pH level to maintain proper acidity. The researchers later simulate the introduction of the solution to the small intestine, where absorption would occur in the body.

The method can't mimic the animal absorption of arsenic into the blood, so the scientists instead determine how much arsenic has dissolved during the process. The more that dissolves, the more likely the contaminated soil is dangerous to humans and requires treatment or remediation.

A 2007 study comparing the in-vitro testing results to the gold standard pig method showed that Basta's findings of how much arsenic dissolved during digestion correlated strongly with the animal study showing concentrations of arsenic in urine.

"We can say this method has met the first prerequisite of becoming an official method," he said.

Basta and colleagues are continuing to refine the method, but have already put it to use testing between 20 and 50 soil samples each year.

The relatively low cost ($100) and ready availability of ingredients for the lab-based testing method might help reduce the drastic costs and dramatic effects of soil remediation, Basta said.

"Let's say we go to a site where there's historic contamination, and we generate 200 grid samples. We could find the hot spots, where most contaminants are, and find the rest is relatively clean. With this method, we could test those hot spots to find out if arsenic there dissolves, and then that one spot might be what has to be removed or treated," he said. "That's going to save huge amounts of cleanup costs. In many cases, six samples might be excavated, and three are high in arsenic, that amount is averaged, and the whole site has to go. That includes trees and shrubs, pipes are broken in the process. It's devastating. We are saying you might not have to do that."

Soil chemists like Basta have observed that certain soil properties, especially the presence of iron oxide, can bind up arsenic and prevent it from dissolving.

"If it doesn't dissolve in the gastrointestinal tract, it's not harmful to humans," Basta said. "But not everyone is ready to embrace that.

"Right now, many assume that if arsenic is present at above natural background soil levels, then the entire site is dangerous to humans. Since we know iron oxide binds to arsenic, we might be able to come up with one treatment that works really well. And we could use the in-vitro method as a mechanism to quickly test the effects of the cleanup. It's not

perfect, but it might let us make some adjustments so we don't assume the worst case of arsenic at low but above background levels is harmful."

Source: Ohio State University