Many soils around the world are contaminated with heavy metals, such as lead, arsenic, and mercury. These can be toxic and don't degrade, so they can remain in the soil for decades, so food grown in such soils may be toxic as well, or the metals can leach into water supplies.

Bioremediation, using living organisms to clean up the soils, is the most effective and least expensive method at this point. Usually plants are chosen, because they grow and take up metals and can then be harvested and disposed of, but plants are only effective to a certain extent. Recent studies have suggested that pairing plants with beneficial bacteria, called rhizoremediation, could increase plants' effectiveness.

Now, scientists publishing in the Journal of Hazardous Materials this past July have investigated the effects that specific bacteria have on the uptake of specific metals by specific plants.

They used bacteria that they had previously isolated from a copper-contaminated lake, that were resistant to copper, a metal that is usually deadly to microbes. They tested these bacteria, all members of the genus *Pseudomonas*, for resistance to other heavy metals: zinc, lead, cesium, arsenic, and mercury. Each of their eight isolates were quite resistant to all six of these metals. The bacteria were also somewhat resistant to some antibiotics, but also susceptible to various others.

In order to see whether the bacteria were beneficial for plants that could be used for bioremediation, the researchers tested the isolates' abilities to produce a plant hormone that promotes growth, and the bacteria's ability to make phosphate, a nutrient that plants need, more bioavailable. Each of the isolates produced the plant hormone from a precursor, and they could all solubilize phosphate, though some could do more than others. However, lead and mercury inhibited plant hormone production, and copper, zinc, and mercury inhibited phosphate solubilization, though arsenic increased it.

Siderophores are molecules that many bacteria produce that take up iron in the environment that bacteria need to grow. They might be useful for taking up other metals as well. In this case, copper and arsenic increased bacterial siderophore production, while zinc and lead decreased it.

The scientists tested to see whether the isolates were actually taking up the metals, and found that the bacteria accumulated a lot of copper, zinc, and lead, but not much arsenic or mercury. No surprise there. Some strains did better than others with different metals.

Finally, they tested whether the bacteria, when grown with maize and sunflower, helped the plants take up more metals. The best isolate helped the plants take up 2-3 times more copper than they took up on their own. Sunflower grew better and took up more metal than maize.

So in summary, what the researchers found were bacteria that were resistant to contaminating heavy metals that helped plants grow better and take up more of the metals: just what we needed.

Using such a combination of bacteria and plants, we could recover contaminated soils and make them useable as cropland again, or at least keep people or animals from being sickened by the metals in them. The scientists are now looking into pairing these bacteria with red fescue, a kind of grass that grows well in cold climates, which might be a better choice for northern climates than corn and sunflowers.

Plants, people, and bacteria all share a dislike for certain heavy metals in certain forms, but bacteria are often skilled at developing resistance to many kinds of environmental stresses, so it is not too surprising that they could be useful in cleaning up contamination.

What is also interesting is that resistance to certain antibiotics correlated with the isolates' resistance to metals. They are probably making use of proteins called efflux pumps that pump out harmful substances, as these could work for resisting both metals and antibiotics. Bacteria are versatile!