Using plants against soils contaminated with arsenic

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Two essential genes that control the accumulation and detoxification of arsenic in plant cells have been identified. This discovery is the fruit of an international collaboration involving laboratories in Switzerland, South Korea and the United States, with the participation of members of the National Centre of Competence in Research (NCCR) Plant Survival.

The results presented are a promising basis for reducing the accumulation of arsenic in crops from regions in Asia that are polluted by this toxic metalloid, as well as for the cleanup of soils contaminated by heavy metals. The findings are published this week in the prestigious journal *PNAS*.

The sinking of tubewells in Southeast Asia as well as mining in regions such as China, Thailand, and the United States, are the cause that arsenic concentrations in water often exceed the World Health Organization (WHO) limit of 10 µg/L, the value above which health problems start to occur. Tens of millions of people are exposed to this risk by drinking contaminated water or by ingesting cereal crops cultivated in polluted soils. A long lasting exposure to this highly toxic metalloid could affect the gastrointestinal transit, the kidneys, the liver, the lungs, the skin and increases the risk of cancer. In Bangladesh, it is estimated that 25 million people drink water that contains more than 50 µg/L of arsenic and that two million of them risk of dying from cancer caused by this toxic substance.

Plants offer a way for toxic metals to enter the food chain. We know, for example, that arsenic is stored within rice grains, which, in regions polluted with this toxic metalloid, constitutes a danger for the population whose diet depends to a great extent on this cereal.

Arsenic or cadmium in soils is transported to plant cells and stored in compartments called vacuoles. Within the cell, the translocation of arsenic and its storage in vacuoles is ensured by a category of peptides – the phytochelatins – that bind to the toxic metalloid, and are transported into the vacuole for detoxification, similar to hooking up a trailer to a truck. In terms of the process, it is the "truck and trailer" complex that is stored in the vacuole.

"By identifying the genes responsible for the vacuolar phytochelatin transport and storage, we have found the missing link that the scientific community searched for the past 25 years", explains Enrico Martinoia, a professor in plant physiology at the University of Zurich. The experiments carried out on the model plant Arabidopsis can easily be adapted to other plants such as rice.

Enrico Martinoia is one of the directors of this research that includes the Korean professor Youngsook Lee from the Pohang University of Science and Technology (POSTECH) and Julian Schroeder, biology professor at the University of California, San Diego (UCSD). Along with Stefan Hörtensteiner, also from the University of Zurich, and Doris Rentsch from the University of Bern, he is one of the three members of the NCCR Plant Survival who participated in this study which was published in PNAS.

Controlling these genes will make it possible to develop plants capable of preventing the transfer of toxic metals and metalloids from the roots to the leaves and grains thereby limiting the entry of arsenic into the food chain. "By focusing on these genes, states Youngsook Lee, we could avoid the accumulation of these heavy metals in edible portions of the plant such as grains or fruits."

At the same time, researchers have discovered a way to produce plants capable of accumulating a greater amount of toxic metals which consequently can be used to clean up contaminated soils. These plants would then be burned in blast furnaces in order to eliminate the toxic elements.

Provided by University of Zurich