National Research Programme NRP 69
Healthy Nutrition and Sustainable Food Prodution

Analysis of the movement of trace metals to make farming more sustainable

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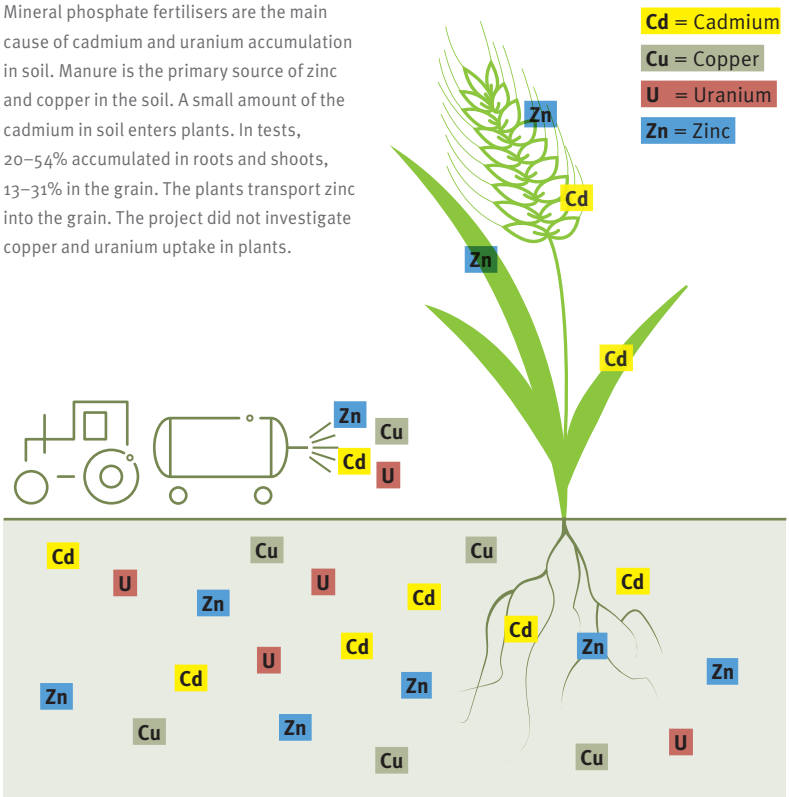
Current agricultural practices are increasing metal content in soil

In the course of agricultural production, trace elements make their way into the soil, and from there into crops. Accumulation in the soil is not sustainable due to its lasting effect on soil fertility and plant quality. As part of NRP 69, a research group investigated the levels of cadmium, copper, uranium and zinc in Swiss arable land and grassland. It also analysed whether these metals enter the human food chain. The biggest sources of these potentially harmful metals in the agricultural systems examined were mineral phosphate fertiliser (cadmium and uranium) and manure (copper and zinc).

Sustainable agriculture that benefits from a healthy equilibrium between added and harvested nutrients is essential to the production of high-quality food. This means preventing pollutants such as trace metals from accumulating in soil and in the crops that are grown in it. Studies show that in some cases, high levels of different trace metals are added to Swiss arable land and grassland. Apart from the elements that occur naturally, fertiliser use is resulting in trace metal deposition in the soil. These deposits could have a detrimental effect on the quality and quantity of crops harvested in the longer term. As part of NRP 69, a research group investigated where the cadmium, copper, uranium and zinc found in soil come from and whether these trace metals are making their way into crops. The results are expected to contribute to a more sustainable approach to the issue of heavy metals in agriculture.

Mineral phosphate fertilisers are the main cause of cadmium and uranium accumulation in soil. Manure is the primary source of zinc and copper in the soil. A small amount of the cadmium in soil enters plants. In tests, 20–54% accumulated in roots and shoots, 13–31% in the grain. The plants transport zinc into the grain. The project did not investigate copper and uranium uptake in plants.



To establish the sources of the trace elements in soil, the researchers measured the metals' isotope ratios. Under certain circumstances, it is possible to use this technique to identify whether the metals in soil are naturally occurring or if they are the result of human activity. The research group analysed soil samples from six different locations: three cornfields to which mineral fertilisers are applied and three pastures that are manured. This enabled the project to cover the two main forms of agricultural land use in Switzerland. The researchers investigated all metal inflows and outflows on the six fields over a period of one year, taking account of factors such as atmospheric influences, fertilisation, harvesting and leaching. They also carried out greenhouse investigations of cereal and grass growth processes. They analysed how the plants absorb the trace elements cadmium and zinc as well as the mechanisms by which the plants retain or mobilise the metals. These processes are important because they control how the metals are transported into the grain. As a result, the researchers were able to ascertain whether the elements enter the human food chain.

Accumulations of cadmium, copper, uranium and zinc were found in all the upper soil layers that the group examined. Whereas copper, uranium and zinc accumulate continuously, cadmium levels vary depending on the type of cereal grown. Mineral phosphate fertilisers were found to be the primary origin of cadmium and uranium, while copper and zinc came mainly from manure. Feed additives, which animals partially excrete, were found to be a particular source of the latter trace metals. It was found that only a small amount of the cadmium introduced into the soil by fertiliser makes its way into the plants themselves; most of the element remains in the soil. Cadmium from soil was deposited primarily in the non-edible roots and shoots of cereal crops (20–54%). In the tests, however, between 13 and 31% of the metal entered the grain and thus the human food chain. The researchers suspect that agricultural practices during the last fifty years have resulted in cadmium accumulation in the soil. The same is true of uranium, even though the project yielded no indication that uranium from the soil is entering groundwater. Crop plants actively transport zinc into the edible grain. Since zinc is an important nutrient for both plants and humans, however, this effect is welcome in most cases. Increasing amounts of copper are also being deposited in soil. However, there was no evidence from the tests that a single application of manure results directly in a measurable increase in the copper content of pasture plants. It can be assumed that copper accumulates and that it will either be absorbed by plants in the long term or leached out into groundwater.

The work carried out under NRP 69 indicates that if current agricultural practices continue, concentrations of copper, uranium and zinc in the soil will keep on rising, and this will have a detrimental effect on the quality and quantity of crops harvested. The research group therefore recommends a variety of measures to reduce metal exposure and thus contribute to sustainable food production.

Further information:
www.nrp69.ch

Recommendations

Tighten up and check guideline values for trace elements

The research project has produced a number of recommendations for limiting metal contamination in the soil and increasing sustainability in food production.

Cadmium and uranium inputs:

- To prevent cadmium entering the soil, the guideline values for mineral fertilisers should be checked more strictly. In addition, a guideline value for uranium should be introduced and enforced.
- To detect uranium accumulation in the soil, guideline values that describe the upper limit of normal background uranium values should be specified. Furthermore, uranium should be systematically investigated as part of the trend analyses conducted by the Swiss Soil Monitoring Network (NABO).
- Cadmium and uranium accumulation in the soil could be reduced by using fertilisers made from recycled materials that are low in trace metals.

Zinc and copper inputs:

- Zinc and copper accumulation in agricultural soil could be reduced by stricter application of the existing guidelines for adding copper and zinc to animal feed and applying farmyard manure in accordance with recommendations.
- Local accumulations can be avoided by optimising liquid manure distribution over the entire agricultural area of farms.

Healthy grain varieties:

- Grain varieties that absorb the smallest possible quantities of cadmium and transport zinc – a nutrient – efficiently into the grain should be identified and their adoption encouraged. Such varieties could help ensure optimum nutrient intake and support a healthy diet.