Thallium: highly toxic, but little studied

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Topics: Pollutants

One of the heavy metals naturally present in soils is thallium. Since little is known about its environmental behaviour, a research group at Eawag has been studying this metal in detail.

In Agatha Christie's novel The Pale Horse, the victims die of thallium poisoning. The author describes the action of the poison: the initial symptoms are similar to those of influenza; later signs include hair loss and stripes on the fingernails – at which point it is too late to administer an antidote. Precisely because thallium poisoning is difficult to diagnose, this odourless, tasteless substance was once a popular murder weapon.

But as well as being found in poisoned cocktails, this metal – toxic to humans in minute doses – enters the environment as a result of industrial processes such as cement production, metal mining and coal combustion. Thallium can also accumulate naturally in soils and is found at certain sites in Switzerland. In 2013, for example, the Office of Environmental Protection and Energy of Canton Basel-Landschaft discovered that soils at Erzmatt near Buus contain exceptionally high levels of naturally occurring thallium, with concentrations of up to several thousand milligrams per kilogram. Thallium concentrations in soil typically range from 0.01 to 1 milligram per kilogram.

Another site in Canton Basel-Landschaft discovered: (20 Minuten July, 10th, 2020; in German)

Scientific studies almost non-existent

Geochemist Andreas Voegelin of the Water Resources & Drinking Water department learned by chance of the thallium?rich soil at the Erzmatt site. Having reviewed the scientific literature, he concluded that very little was known about the environmental behaviour of thallium. Since then, his research group has been studying this metal.

Überlandstrasse 133
CH-8600 Dübendorf
T +41 58 765 55 11
F +41 58 765 50 28
info@eawag.ch
www.eawag.ch
eawag aquatic research

The group's first project sought to establish in what chemical form thallium occurs in soils from Erzmatt. This information can help to determine the solubility of thallium in soil, and whether it could potentially be absorbed by plants or enter groundwater. It was found that, in deep soil layers, thallium is mainly bound in weathering products of ores. In topsoils, by contrast, a large fraction of the metal is fixed in the clay mineral illite, but it is also bound to manganese oxides. Four years ago, geologist Silvan Wick joined Voegelin's group, as a doctoral student, to investigate the chemical reactions between thallium and illite and manganese oxides in laboratory experiments using pure minerals and Erzmatt soils. The doctoral thesis was a joint project involving Eawag, the Paul Scherrer Institute and ETH Zurich. To analyse the binding of thallium, Wick used methods such as X-ray absorption spectroscopy at synchrotron light sources. He explains: "The models resulting from this work make it possible to estimate the solubility of thallium in soils on the basis of soil composition." For the Erzmatt site, it was also shown that the relatively low solubility of thallium can be attributed to the fact that, in the course of soil formation, the metal was largely integrated into the structure of the clay mineral illite.

Geogenic thallium also present in other regions

Andreas Voegelin says: "Because no limits have been specified for thallium in Switzerland, this heavy metal is not normally determined in environmental samples." Following the discovery at the Erzmatt site, the question arose whether elevated concentrations of thallium could also occur elsewhere. Over the past two years, Voegelin and lab technician Numa Pfenninger have therefore analysed drinking and stream water in the Baselbieter Jura region and in neighbouring communes. Their findings corroborate the conclusions of a study carried out by the Federal Office of Public Health: in Northwestern Switzerland, elevated concentrations of geogenic thallium may occur in water. However, the levels measured are always well below the US drinking water limit of 2 micrograms per litre and thus do not pose any risk to human health.

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Contact

Andreas Voegelin

Tel. +41 58 765 5470

andreas.voegelin@eawag.ch

Bärbel Zierl

Science editor

Tel. +41 58 765 6840

baerbel.zierl@eawag.ch

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