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Long-lived organic compounds in glacial lake sediments

Unwanted heirlooms from glaciers

When glaciers melt they set free chemicals which have been locked for decades in the "eternal ice". Researchers from Empa, the ETH Zurich and Eawag have analyzed sediment layers in the Oberaarsee and have been able to reconstruct the processes by which long-lived organic compounds have accumulated in the ice over the last sixty years. A study just published in the journal «Environmental Science and Technology» describes how shrinking glaciers have, for about ten years now, become a secondary source of pollutants which have long been banned and are no longer produced in industrial quantities.

When glaciers shrink due to the effects of global warming, the retreating tongues sometimes reveal things which have been buried in the ice mass for decades or even centuries. This includes chemical substances which have been banned for years and which really ought to be kept under lock and key anyway, such as those known as POPs – short for persistent organic pollutants. These are organic environmental pollutants which take a long time to decompose and include for example chemicals used as plasticizers (softeners) in various synthetic materials, pesticides and also dioxins. Many of these POPs are endocrine disrupters and carcinogenic, and are suspected of interfering with human and animal development. In addition they are extraordinarily long-lived, and can be transported great distances through the atmosphere. POPs can therefore be found all over the world, even in glaciers in environments high in the Alps, where ecosystems are extremely sensitive.

A drill core from a glacial lake

When glaciers melt the accumulated chemicals – deposited years ago by air currents onto the snow layer and then frozen into the ice – are carried by the runoff water into the nearest glacial lake. There, together with other matter suspended in the melt water, they sink to the bottom of the lake and accumulate in the sediment. This has taken place, for instance, in the Oberaarsee, an artificial reservoir at an elevation of 2300 metes near the Grimsel Pass in the Bernese Oberland region.

In the winter of 2006 sedimentologists from Eawag journeyed to the frozen mountain lake to extract drill core samples of sediment, each about a meter long and six centimeters in diameter. "We then took the cores and cut them into slices which we freeze dried," explains Peter Schmid, a chemist at Empa. Back in the laboratory, he and his team analyzed the various sediment layers for a range of chemicals, including POPs.

A history of POPs over the past half century

The researchers were able to read the sediment layers in the Oberaarsee drill cores like tree rings, layer for layer all the way back to 1953, when the dam which created the lake was first built. “Based on our analysis of the layers we were able to confirm that POPs were being produced in large quantities from 1960 to 1970, and deposited in alpine lakes,” says Christian Bogdal, who completed his doctoral thesis at Empa on the polluting effects of these organic chemicals and who now conducts research in the field at the EZH Zurich. Equally clearly visible in the cores was the reduction in the quantity of pollutants at the beginning of the 1970s when many of these environmentally damaging substances were banned.

Just as impressive, and also somewhat surprising, was the renewed increase in POP concentrations in sediment layers which were only ten to fifteen years old, according to Bogdal. For example, the quantities of chlorine-containing chemicals found in sediment layers from the end of the 1990s were sometimes higher than those seen in the 60s and 70s. A possible explanation for this is that the lake is fed primarily by the runoff from the Oberaar glacier, the tongue of which has receded by 1.6 km since 1930. In the last ten years alone it has shrunk by more than 120 meters, and could therefore have released a relatively large amount of accumulated toxic substances. As environmental scientists have long suspected, and now proven, glaciers represent a serious secondary source of POPs re-entering the environment.

Research into the “eternal ice” continues

This study is by no means the end of investigations into long-lived organic pollutants in glaciers. “In the meantime we have had results from other mountain lakes which confirm our data. There are still many other unanswered questions of great interest to us chemists, as well as the sedimentologists and glaciologists too, of course,” says Peter Schmid. For instance not much is known about how POPs actually accumulate in glaciers, what paths they follow within the glacier and what chemical changes they undergo, if any, when they are exposed to intense UV light. “We also want to know if we should expect even larger quantities of pollutants to be released from glaciers,” he adds. Bogdal and Schmid, together with glaciologists, chemists and sedimentologists from the ETH Zurich, the Paul Scherrer Institute and Eawag, are therefore currently submitting a project proposal to the Swiss National Science Funds to investigate the path of pollutants in the “eternal ice”.

References

Ch. Bogdal, P. Schmid, M. Zennegg, F. Anselmetti, M. Scheringer, K. Hungerbühler: Blast from the Past: Melting Glaciers as a Relevant Source for Persistent Organic Pollutants, Environ. Sci. Technol. Publication Date (Internet): 24 September 2009; doi: 10.1021/es901628x

Further information

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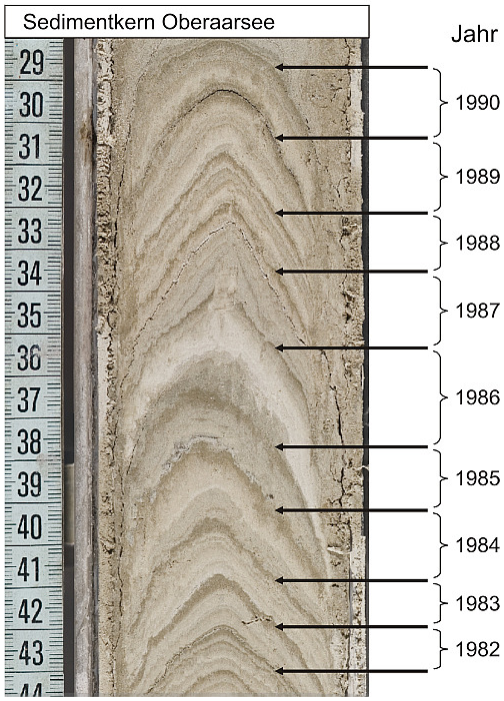
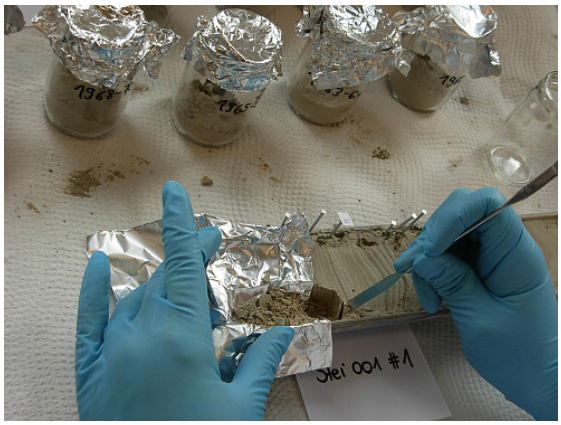


The drill core from the Oberaarsee tells a story which goes back 50 years.

In order to provide a stable enough platform for the core extraction equipment the lake had to be covered with a thick ice layer.



The different sediment layers were analyzed for chemicals – including various POPs – at Empa's laboratories.

The study in pdf form and the electronic text of the press release are available from redaktion@empa.ch

These and related images can be downloaded from www.empa.ch/bilder/gletscher