When thawing glaciers release pollutants

November 3 2014, by Thorsten Bartels-Rausch

Ice core drilling on Fiescherhorn glacier with drilling tent in background. Credit: Aurel Schwerzmann

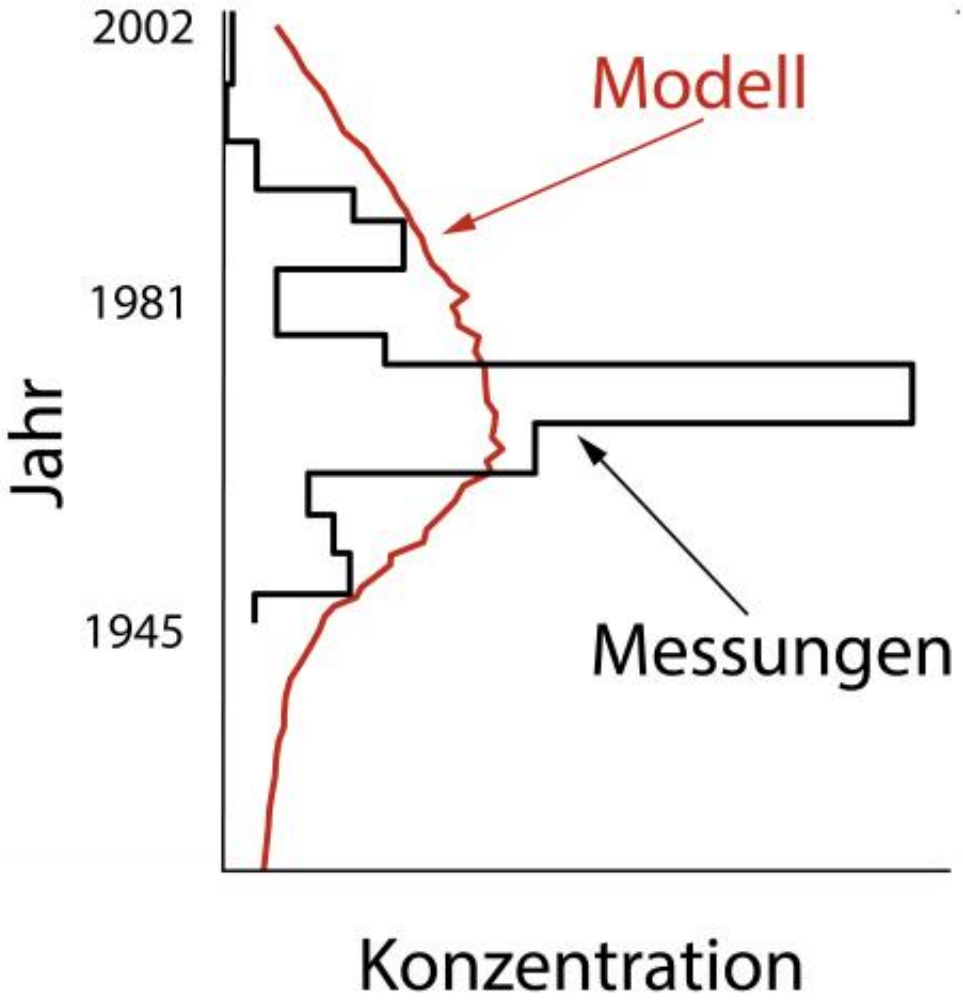
As glaciers increasingly melt in the wake of climate change, it is not only the landscape that is affected. Thawing glaciers also release many industrial pollutants stored in the ice into the environment. Now, within the scope of a Swiss National Science Foundation project, researchers from the Paul Scherrer Institute (PSI), Empa, ETH Zurich and the University of Berne have measured the concentrations of a class of these pollutants – polychlorinated biphenyls (PCB) – in the ice of an Alpine glacier accurately for the first time. The measurements reveal that the PCB levels in the atmosphere have decreased since the 1970s thanks to the meanwhile global ban on PCBs. Through the progressive melting of the glaciers, however, this residual waste risks being released back into the atmosphere.

Climate change has altered the glacier landscape of the Alps dramatically in recent decades. Where long glacier snouts once extended,

there are often only scattered ice fields now and mountain lakes are forming in their place. Fuerthermore the glaciers have melted away in low-lying areas. Not only does this change the face of the Alps; it also influences the water balance as glaciers are a major freshwater source in the Alpine region. Moreover, the thawing glaciers release pollutants that have been stored inside them for considerable periods of time.

The fact that substances from precipitation and the air are stored in glacial ice is well established. It is used to reconstruct the existence of pollutants in the atmosphere over the last few decades by drilling deep into the glacial ice and studying the pollutant content of the ice cores extracted. For the first time, two studies recently published within the scope of two dissertations conducted by researchers from PSI, Empa, ETH Zurich and the University of Berne have measured the concentrations of a class of pollutants – the polychlorinated biphenyls (PCBs) – accurately in the ice of an Alpine glacier.

The new studies were centred on chlorinated organic substances referred to as polychlorinated biphenyls (PCBs), which were broadly used in industry in the twentieth century on account of their electrically insulating and flame-retardant properties, such as in transformers and condensers, but also in joint sealants and varnishes. PCBs belong to the class of persistent organic pollutants – poorly degradable substances which can especially accumulate in living organisms and affect them negatively. PCBs are absorbed via the gastro-intestinal tract, but also the skin and lungs, spread quickly around the body and accumulate in the fatty tissue. The intake of larger amounts leads to acute skin complaints such as chloracne, causes liver, spleen and kidney damage and weakens the immune system.



Concentration of PCBs in the Fiescherhorn glacier by year. Comparison between model and measurement data. Credit: Paul Scherrer Institute.

The production and use of PCBs was already restricted in Switzerland back in the 1970s before it was scrapped globally once and for all with the Stockholm Convention in 2004. As these compounds tend to be very stable, however, there are still traces of them even in remote regions to this day. Nonetheless, direct measurements are lacking that would enable their concentrations in the environment to be determined for longer periods. The first part of the studies closes these knowledge gaps.

Residual waste remains – despite effective bans

A new analytical method enabled the extremely low concentrations of chlorinated organic pollutants to be detected in the glacial ice with high precision for the first time. The ice core studied from the Fiescherhorn glacier spans the entire period from the production to the industrial usage of PCBs, i.e. from 1940 to 2002. The concentrations detected for the different PCBs studied lay between 0.5 and 5 nanograms per litre of melted ice. The readings from the ice core reveal that the concentration of PCBs increased eightfold from 1940 into the 1970s. In the younger ice taken from the core, on the other hand, it was evident that the concentration had dropped to roughly the amount it was in 1940. However, the researchers stress that the problem is far from over as the substances stored within the ice are released back into the atmosphere as the glaciers melt.

The role meltwater plays

In order to reconstruct the atmospheric concentration of PCBs until 1940 from the data obtained, the researchers have to understand how the transfer of the chemicals takes place in the glacier. Such reconstructions, however, are complicated by the presence of meltwater in the increasingly warmer glaciers as it can rinse out and redistribute the contaminants. Moreover, contaminants are also known to get into the mountain lakes via the meltwater and can thus spread further in the environment of these remote, unspoilt areas.

Tracking the path of the pollutants in glaciers

There are currently considerable knowledge gaps regarding how the pollutants are transported in Alpine glaciers, especially if meltwater comes into play. Thanks to the close collaboration of the research groups

involved, the pollutants' path in a glacier could be traced and the important underlying processes analysed – namely the absorption of the pollutants from the air, their storage in the ice or on fine-dust particles contained in the glacier and their release back into the air.

These processes are also studied with the aid of a model of the pollutants' environmental behaviour. The newly developed model describes the dynamics of the glacial ice and, for the first time, the physical processes in the glacier, illustrating that the pollutants are stored in the glacier with varying degrees of efficiency depending on the chemical and physical properties. Volatility, solubility in water and the tendency of the chemicals to accumulate on the ice appear to be crucial. For the compounds that are stored particularly effectively in the glacial ice, the concentration profiles measured in the ice core could be reconstructed from the model. "The fundamental chemical properties of the pollutants and the glacier dynamics thus appear to be described correctly by the model, which means we can predict the fate of these compounds in glaciers," says Margit Schwikowski, who was in charge of PSI's contribution to the study. Additional projects are now scheduled to investigate how heavily glaciers affect the mountain lakes and thus the more immediate environment via the meltwater.

More information: "Polychlorinated biphenyls in glaciers. 1. Deposition history from an Alpine ice core." PA Pavlova, P Schmid, C Bogdal, C Steinlin, TM Jenk and M Schwikowski *Environmental Science and Technology* (2014). DOI: 10.1021/es5017922

"Polychlorinated biphenyls in glaciers. 2. Model results of deposition and incorporation processes." C Steinlin, C Bogdal, M Scheringer, PA Pavlova, M Schwikowski, P Schmid and K Hungerbühler *Environmental Science and Technology* (2014). DOI: 10.1021/es501793h

Provided by Paul Scherrer Institute