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Annually-layered lake sediments reveal strongly increased release of persistent chemicals due to accelerated glacier melting

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Melting glaciers may represent a secondary source of chemical pollutants that have previously been incorporated and stored in the ice. Of particular concern are persistent organic pollutants (POPs), such as the insecticide dichlorodiphenyl trichloroethane (DDT) and industrial chemicals like polychlorinated biphenyls (PCBs), which are hazardous environmental contaminants due to their persistent, bioaccumulative and toxic properties. They were introduced in the 1930s and eventually banned in the 1970s. After release into the environment these chemicals were atmospherically transported to even remote areas such as the Alps and were deposited and stored in glaciers. Ongoing drastic glacier melting due to global warming, which is expected to further accelerate, implies the significance of studying the fate of these 'legacy pollutants'. Proglacial lake sediments provide well-dated and high-resolution archives to reconstruct timing and quantities of such a potentially hazardous remobilization.

The goal of this study is to reconstruct the historical inputs of POPs into remote alpine lakes and to investigate the accelerated release of POPs from melting glaciers. Due to their lipophilic character, these chemicals exhibit a high tendency to adsorb to particles whereas concentrations in water are expected to be low. Therefore, quantitative determination in annually-layered lake sediment provides an excellent way to investigate the temporal trend of inputs into lakes that act as particle sinks. For this purpose, sediment cores were sampled from proglacial lakes in the Bernese Alps (Switzerland), which are exclusively fed by glacial melt waters. For comparison, cores were also taken from nearby high-alpine lakes located in non-glaciated catchments, which only should record the initial atmospheric fall-out. Sediment layers were dated by annual varve counting and radionuclide measurements; they cover the time period from the mid 20th century to today.

The measured time series of POPs indicate indeed different patterns in proglacial and non-glacial lakes. Similar to lowland Swiss plateau lakes [1,2], high-alpine lakes show a historic maximum of POP-concentrations some decades ago, which is synchronous with their primary use at that time. However, only proglacial lakes exhibit a dramatic re-increase in POP-input during the last years, thus confirming the crucial role of glaciers as reservoir and secondary source of these pollutants. The burden of pollutants in these sediments due to glacier melting is already in the same range as the earlier accumulations from direct atmospheric fall-out. Furthermore, the undiminished increase of the fluxes of many POPs into the sediment of proglacial lakes does not yet indicate an exhaust of the glacial inventory of these contaminants. Considering ongoing global warming and accelerated massive glacier melting predicted for the future, our study indicates the potential for significant environmental hazards due to pollutants delivered into such remote mountainous areas. [3]

[1] Zennegg M. et al., Chemosphere 2007, 67, 1754.
[2] Bogdal C. et al., Env. Sci. & Technol. 2008, 47, 6817.
[3] Bogdal C. et al., Env. Sci. & Technol. 2009, 43, 8173.