doi:10.2533/chimia.2007.532 CHIMIA **2007**, *61*, No. 7/8

Highlights of Analytical Chemistry in Switzerland

Are Lake Thun and Lake Brienz Contaminated with Explosive Residues?

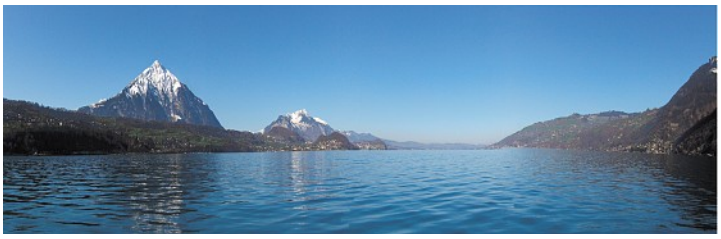
Jean-Daniel Berset*, Ueli Ochsenbein, and Markus Zeh

*Correspondence: J. D. Berset, Water and Soil Protection Laboratory of the Canton of Bern (GBL), Schermenweg 11, CH-3014 Bern
Tel.: +41 31 634 23 83, Fax: +41 31 634 23 96, E-Mail: jean-daniel.berset@bve.be.ch

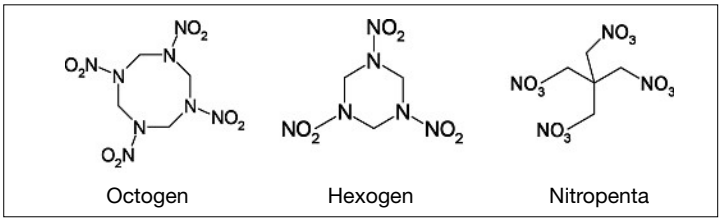
Keywords: Ammunition · External sources · Gonad alterations · HMX · LC/MS/MS · PETN · RDX · Surface waters · White fish

Between 1920 and 1963 roughly 4600 tonnes of ammunition, containing mainly TNT as explosive, were disposed in Lake Thun. Smaller amounts (280 tonnes) were dumped in Lake Brienz just after World War II. In 2000, fishermen reported the occurrence of a large number of white fish with morphologically altered gonads in Lake Thun. Could this ammunition be the cause of these phenomena? In a preliminary study carried out by a research group of Agroscope Wädenswil, no explosive residues above the limit of quantification were found in either the lake water or the sediments. In 2006, the GBL acquired a highly sensitive LC-tandem mass spectrometer (API 5000) allowing detection at the lowest ng/l levels. Thus a monitoring program was performed. Grab samples were taken at different time periods and depths of Lakes Thun and Brienz as well as of several tributaries. Additionally, several hot spots and environmental blank samples were analyzed. Samples were enriched using solid phase extraction (SPE), injected into the LC-MS/MS, and identified and quantified using the MRM mode.

Much to our surprise, traces of three explosives could be clearly identified in both lakes: Octogen (HMX), Hexogen (RDX) and Nitropenta (PETN) at concentrations of 0.1–0.4 ng/l. No concentration gradients of these explosive residues could be observed in the different lake profiles indicating a homogeneous distribution. Of the tributaries analyzed, only the Kander and Aare rivers contained minute amounts of at least one of the explosives found in the lake. The analysis of environmental blanks (*e.g.* the Oeschinensee) revealed no traces of explosives. Hot spot samples, *e.g.* from the ammunition dump site Steingletscher-Susten, showed concentrations of several explosives such as TNT and its mono- and diamino metabolites, HMX, RDX and PETN at µg/l levels. These results indicate that external sources such as military activities and ammunition dump sites close to water might play an important role in the contamination of the lakes. It must be emphasized, however, that the concentrations of explosives found in Lake Thun and Brienz are far below health-based drinking water guide values as suggested by German authorities and therefore are not expected to have a negative impact on lake water quality. **Such low concentrations of explosives do not seem to be responsible for the gonad alterations in white fish. This statement is supported by the fact that the specific gonad changes observed exclusively in Lake Thun are not found in Lake Brienz which also contains traces of explosives.**



Lake Thun: a major tourist attraction in the Bernese Oberland (picture: GBL, M. Zeh)



Acknowledgements

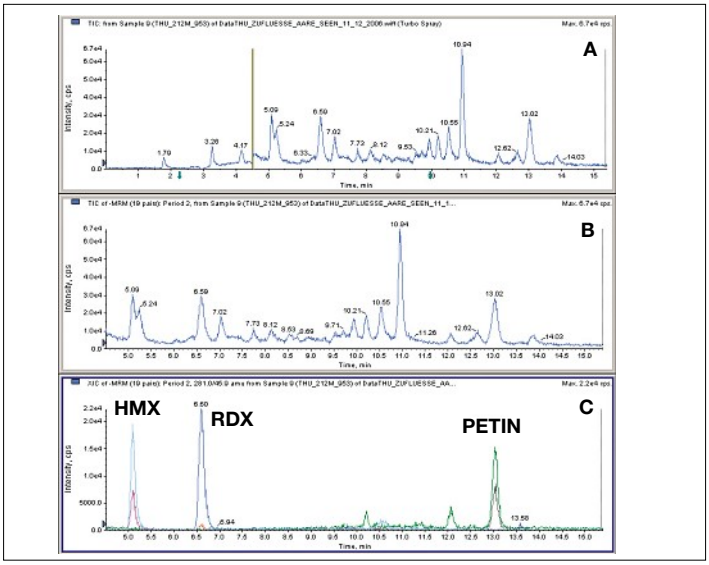
This project is supported by Armasuisse and the GSA (Amt für Gewässerschutz und Abfallwirtschaft) Bern. We thank Kim Hays for reviewing the manuscript.

Received: March 28, 2007

References

Chimia **2004**, *60*, issue 6 on Explosives, 351–413.

J. van Stuijvenberg, Geologische Beratungen Schenker–Korner GmbH, 'Gefährdungsabschätzung zu militärischen Munitionsversenkungen in Schweizer Seen', Ostermundigen & Meggen, **2005**.



LC/MS/MS run of a water sample taken at a depth of 212 m (Lake Thun): A) TIC, B) TIC 2nd period (ESI), C) EIC: 2nd period showing the presence of HMX, RDX and PETN

Can you show us your analytical highlight?
Please contact: Dr. Veronika R. Meyer, EMPA St.Gallen, Lerchenfeldstrasse 5, 9014 St.Gallen
Phone: 071 274 77 87, Fax: 071 274 77 88, Mail to: veronika.meyer@empa.ch