Lake Sediments Tell the Story of Climate Change

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Keywords: Lake Zurich · Mn/Fe ratio · Oxygen · Redox-sensitive elements · Time series

Climate change and eutrophication may both contribute to a dramatic decline in oxygen (O₂) concentrations in lakes and oceans. An analysis of Lake Zurich’s 70-year dataset of monthly water-column measurements revealed a clear impact of rising air temperature on the lake’s water temperature and O₂ concentration. A pronounced shift to higher air temperature in the late 1980s corresponded with an increase in water temperature. Warming was greater in the lake’s surface water than in the deep water, leading to an increase in water column stratification, which resulted in a general decline in bottom water O₂ concentrations.

In an attempt to extend Lake Zurich’s O₂ record further back in time, a sediment core from the lake’s deepest region (137 m) was analysed with non-destructive X-ray fluorescence (XRF) core scanning to obtain high-resolution manganese (Mn) (137 m) was analysed with non-destructive X-ray fluorescence (XRF) core scanning to obtain high-resolution manganese (Mn) and iron (Fe) element profiles. As the sediment core contains semi-annual laminations (i.e. similar to tree rings) dating back to 1895, the XRF data, which have a sampling resolution of 0.3 mm, provide high-resolution trace metal records. Because Mn and Fe differ with respect to their redox behaviour, the Mn/Fe ratio in sediment cores has been considered a proxy for anoxic conditions for decades, but this has never before been validated with monitoring data. Using the Lake Zurich core, we could show that the Mn/Fe ratio is moderately correlated with the measured maximum annual bottom-water O₂ concentration (R² = 0.6; n = 66; p < 0.01; 1936–2010). Sedimentary processes like the deposition of turbidites (underwater mass movements) or diatom blooms reduce the consistency of this relationship. Although the elemental profiles are relative, normalising the Mn signal with Fe corrected for differences in porosity, water content, terrestrial inputs and calcite dilution. Based on this correlation, the Mn/Fe ratio was shown to be useful as a semi-quantitative proxy for past bottom-water oxygen concentration in Lake Zurich. Combined with monthly monitoring data, the method shows the long-term impact of eutrophication and climate on bottom-water oxygen concentrations.

Acknowledgements

The lake data used in this study were kindly provided by the City of Zurich Water Supply (WVZ). This research forms part of project ‘HYPOX’, funded under the European Commission’s Seventh Framework Programme (contract no. 226213).

Received: March 12, 2014

References