

Long-term development of subalpine lakes: effects of nutrients, climate and hydrological variability as assessed by biological and geochemical sediment proxies

Manuela Milan

Akademisk avhandling

som med vederbörligt tillstånd av Rektor vid Umeå universitet för avläggande av filosofie doktorsexamen framläggs till offentligt försvar i Lilla Hörsalen (KB3A9), KBC, fredagen den 26 februari, kl. 10:00. Avhandlingen kommer att försvaras på engelska.

Fakultetsopponent: Professor Atte Korhola,
Department of Environmental Sciences, University of Helsinki, Helsinki, Finland.



Department of Ecology and Environmental Science
Umeå University
Umeå 2016

Organization
Umeå University
Department of Ecology and
Environmental Science

Document type
Doctoral thesis

Date of publication
05 February 2016

Author
Manuela Milan

Title
Long-term development of subalpine lakes: effects of nutrients, climate and hydrological variability as assessed by biological and geochemical sediment proxies.

Abstract

Sediment records of two Italian subalpine lakes (Lake Garda and Lake Ledro) were analyzed in order to reconstruct their ecological evolution over the past several hundred years. A multi-proxy and multi-site approach was applied in order to disentangle the effects of local anthropogenic forcings, such as nutrients, and climate impacts on the two lakes and their catchments. Biological indicators (sub-fossil pigments, diatoms and Cladocera) were used to reconstruct changes in the aquatic food web and to define the lake reference conditions, while geochemical methods, i.e. wavelength-dispersive X-ray fluorescence spectroscopy (WD-XRF), were used to provide quantitative information on the different physical or chemical processes affecting both lake and catchment systems.

Sub-fossil pigments and diatoms, together with their respective inferred TP values, suggested very stable oligotrophic conditions in both lakes until the 1960s. The period following was affected by nutrient enrichment, which led to a drastic shift in the phytoplanktonic community. The response of sub-fossil pigments and diatoms to major climatic anomalies such as the Medieval Climatic Anomaly (MCA) and the Little Ice Age (LIA) were not pronounced, and the taxonomic composition remained relatively stable. On the contrary, these proxies showed an indirect response to climate variability since the beginning of the nutrient enrichment phase in the 1960s. In Lake Garda, the winter temperature regulates the water column mixing, which in its turn controls the degree of nutrient fertilization of the entire water column, and the related phytoplankton growth. In Lake Ledro a rapid reorganization of planktonic diatoms was observed only during the temperature recovery after the LIA, while recent temperature effects are masked by the prevailing nutrient effects. In Lake Garda, Cladocera remains responded in quantitative and qualitative terms to climatic changes, whereas in Lake Ledro they appeared to be mainly affected by variations in hydrological regimes, i.e. flood events. Cladocera remains corroborated the nutrient enrichment after the 1960s in both lakes as inferred by diatoms and pigments.

In Lake Garda, the geochemical data showed a pronounced shift in elemental composition since the mid-1900s, when major elements and lithogenic tracers started to decrease, while some elements related to redox conditions and other (contaminant) trace elements increased. The general trends since the mid-1900s agree with the biological records. However, some differences recorded in the two different basins of Lake Garda reflected the effects of local conditions, both related to hydrology and sedimentation patterns. Lake Ledro showed higher short-term variability for most elements, even though some features were comparable to Lake Garda. The geochemical record of Lake Ledro revealed a major influence of human-induced lake-level fluctuations and catchment properties.

This paleolimnological study allows us to place temporally restricted limnological surveys into a longer-term secular perspective, which is highly valuable for the definition of lake reference conditions. Because the restoration targets are usually based on the lake reference conditions, this study highlighted also the necessity to pay particular attention to the lake-specific sensitivity patterns. The multi-proxy and multi-site approach showed that the lake conditions of large and deep lakes in northern Italy, such as Lake Garda, are mainly driven by nutrient enrichment and/or climate change. In contrast, smaller lakes with larger catchment areas, such as Lake Ledro, are seemingly more impacted by conditions and processes occurring in the drainage basin.

Keywords

Paleolimnology, diatoms, Cladocera, sub-fossil pigments, geochemistry, wavelength-dispersive X-ray fluorescence spectroscopy, Lake Garda, Lake Ledro, reference conditions, nutrient enrichment, climate change, hydrological regime.

Language
English

ISBN
978-91-7601-396-0

Number of pages
22 + 4 papers