Two and Three Way Principal Component Analysis of Environmental Data from Lake Como Basin and Watershed

B. Giussani, D. Monticelli, A. Pozzi, C. Dossi, E. Ciceri

Department of Chemical and Environmental Sciences, University of Insubria in Como
Via Valleggio 11, 22100 Como, Italy

Abstract

Multivariate techniques have been used for the study of surface and deep waters of Lake Como basin (Northern Italy). The whole system, comprehending Lake Como water column and its major tributaries, was investigated with the goal of understanding the chemical features (major and minor ions, total alkalinity and dissolved silica) and to study the sources and distribution of some heavy metals of environmental concern (Mn, Fe, Ni, Co). Seasonal variability was also taken into account with a one-year sampling campaign. Two- and three- way Principal Component Analysis (PCA) were adopted for relevant information retrieval.

Introduction

Lake Como (or Lario), the deepest alpine lake (down to –410 m), is located in Lombardy, Northern Italy. Regarding the lithology of the watershed, crystalline basement rocks of the Southern Alps are present in the northern part, while a sedimentary cover in the southern part. Lake Como represents an important environmental and economic resource as well as an important water reservoir. Unfortunately it is affected by strong anthropic pressure being densely populated, especially during the tourist season, and rich in industrial activities. Sampling campaigns of Lake Como water column were performed in December 2001 [1] and in December 2002, in which the investigation was focused on the content of trace metals of environmental concern such as Mn, Fe, Ni and Co. Surface samples of the major tributaries of Lake Como were collected in August and October 2002 and then with monthly frequency from December 2002 to August 2003 to investigate the sources of such metals. Two and three-way PCA [2] was employed to extract useful information.

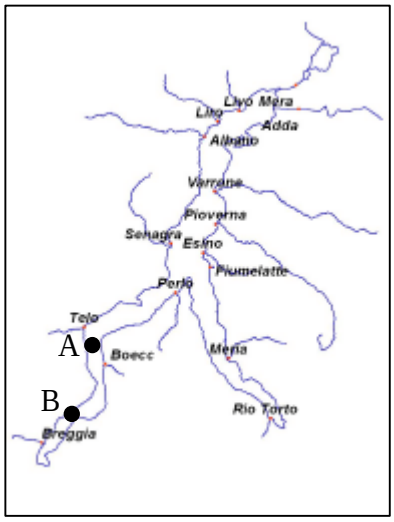

Fig.1; Water columns and rivers tributaries of Come Lake under study

Materials & Methods

Lake Como water column was sampled in the two sites shown in Figure 1: only the west part was studies as it is a closed branch and exhibits the highest pollution issues. Column A was collected in the correspondence of the depth part of Lake Como from the surface to 300m of depth (12 samples). Column B was collected in the first basin, from the surface to 100m of depth (9 samples). Sampled streams are reported in Figure 1 as well. Ion chromatography was selected for the ions analyses. Metals were analyzed in both filtered (0.45 ?m pore size nitrocellulose) and unfiltered samples. Fe and Mn content was determined by Graphite Furnace Atomic Absorption Spectroscopy while, for the simultaneous determination of Ni and Co, Cathodic Stripping Voltammetry was chosen. Multivariate analyses were performed with the Software "The Unscrambler" V9.5 (CAMO

AS) and in Matlab environment. Prior to PCA modelling, data were pretreated by autoscaling and logarithmic transformation. For multi-way analysis a j-scaling [3] on data was performed.

Results

PCA of the data concerning the two water columns gave interesting results, summarized in Figure 2 (50% of the information supplied by the first two PC). Firstly, samples collected down to about 30-50 m are spread out in the Biplot, indicating that these water are not homogeneous. On the other hand, deeper samples show similar chemical features. The chemical composition of the water column thus changes at a depth of 30 – 50m showing the presence of a thermocline confirmed by the temperature and dissolved O_2 profiles as well. Moreover, nitrite and bromide ions were found in the upper layer of the column, pointing out to a contamination. Investigation of trace metals provide further information. Fe, as an example, shows an uncorrelated behaviour in filtered and unfiltered samples, as it is present in the lake water under colloidal forms with dimensions up to 0.45 ?m. In terms of metal content Column B, collected in the first basin, seems to be more contamined then column A. The study concerning the major tributaries of Lake Como allows us to gain information about the sources of the investigated analytes, as well as information about the river themselves. The Tucker3 model with optimal complexity considered is (2, 2, 1), explaining 52% of the total variance of the data. Regarding the tributaries investigated, the major chemical characteristics reflect the chemical composition of the watershed of Lake Como. Anyway some tributaries are polluted: in particular, Esino and Breggia rivers are characterized by higher values of nitrate ion, while Varrone and Rio Torto streams show high concentrations of all of the metals.

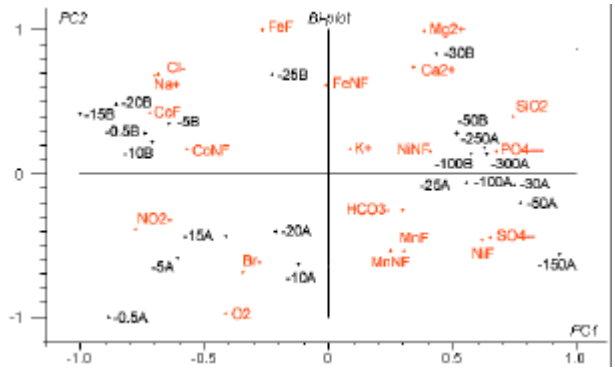

Fig. 2; Biplot: water column samples and investigated variables

Conclusions

The investigation here presented is an example of how multivariate techniques can be very helpful in the study of a complex environmental system as Lake Como and its watershed. Due to space limitations, only a few of the obtained results are presented in this abstract. An optimized analytical protocol has been necessary to assure accurate and precise chemical data. The major ion composition of Lake Como waters and tributaries seem to be mainly related to the geological composition of the basin. Nevertheless, some anthropic contributions were observed. Trace metal analysis conducted both on water column and on tributaries allows individuating anthropic inputs of such elements as well as their distribution along the column. Finally, multi-way analysis allows to consider the space trends as well as the temporal variability.

References

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