Determining Anthropogenic Effects Using Principal Component Analysis on a Fluvial (E Hungary) and Two Lake Ecosystems (W Hungary, W Austria)

I. G. Hatvani[1], N. Magya[1], P. Tanos[1], J. Korponai[2], I. K. Székely[3], A. Herzig[4], J. Kovács[1]
[1] Department of Physical and Applied Geology, ELTE, Budapest Hungary
[2] Department Kis-Balaton West Transdanubian Water Authority, Keszthely Hungary
[3] Institute of Methodology Budapest Business School, Budapest Hungary
[4] Department of Limnology Vienna University, Vienna Austria

Abstract

To be able to protect the water quality of any water system from the negative effects of urbanization and industrialization its main influencing processes should be understood. Principal component analysis was conducted on mainly chemical and biological parameters of the River Tisza (HU), Kis-Balaton Water Protection System (HU) and Lake Neusiedl (AU). Because of their different spatial structures the need to show spatial changes in the background processes and their factor scores, called for different interpretation methods. In each case PCA indicated a presumed anthropogenic influence and its exact location.

Introduction

In Central Europe -and generally in the world- with urbanization, along came the deterioration of surface waters. The negative effects of growing industrial and anthropogenic activity influence every water system be it a river a wetland or any other type.

The River Tisza stretches across five countries including Hungary. Its watershed area is 157,220 km^2 [1]. Despite the fact that in the last one and a half centuries numerous anthropogenic activities have influenced its watershed area, in comparison to Europe's other large rivers it is still considered to have one of the most natural river valleys in Europe[2]. The Kis-Balaton Water Protection System (KBWPS) is a so called mitigation wetland fulfilling the purpose of the once existing Kis-Balaton Wetland which used to filter the main water input (River Zala) of Lake Balaton protecting its water quality. Both Lake Balaton and the KBWPS are under de-jure protection of the Ramsar Convention. The KBWPS is an artificial lake system (with constant waterflow) consisting of two constructional phases Phase I (eutrophic pond) and Phase II a "classical" wetland habitat which receives extra inflow affecting it [3]. Lake Neusiedl the westernmost steppe lake in Eurasia. Its largest surface inflow is the River Wulka. In 2001 the lake gained World Heritage status; since 1979 both the Austrian, and Hungarian parts of the lake have been under UNESCO protection as a biosphere reserve and in 1989 it was brought under the de-jure protection of the Ramsar Convention [4]. Despite these steps over the decades a considerable area has been built-up around the lake which has affected and continues to affect its water quality.

The aim of this study is both to compare the utilization of PCA in determining the background processes of the River Tisza, KBWPS and Lake Neusiedl and to point out the presumed anthropogenic influences determining their processes.

Materials & Methods

The characteristics of the measured datasets can be found in Table 1. The method applied was PCA where the measured parameters were correlated, whereas the hypothetical variables (called principal components (PC)) are uncorrelated and are obtained as a linear combination of the original parameters. In the case of all the study areas summer data were analysed with a sufficient temporal gap between each sample ensuring the independence of the data from each other.

Table 1, characteristics of the analysed datasets from the three study areas

Study area	Time interval	Parameters used	Amount of data
River Tisza	1974-2005	27 chemical, biological and physical parameters	~175,000
KBWPS	1993-2009	22 chemical and biological parameters	~57,000
Lake Neusiedl	2000-2009	13 chemical and biological parameters	~15,000

Results

The River Tisza is considered to be a “linear system” in comparison to the KBWPS “with its two compartments” and Lake Neusiedl with its uniform water surface. Regarding the River Tisza, the composition of the first PC both changes and increases its explanatory power as we go downstream (Fig. 1). Two significant anomalies can be observed; one at its tributary coming from abroad and one at the water barrage system. In the case of the KBWPS, its inlet is described by processes determined by phosphorous forms, while significant differences can be observed between the two constructional phases and at the sampling location where it receives external loads. These excess loads cause the ions to have significant factor loading while other parameters which were significant throughout the system are forced into the background. In comparison to the first two cases Lake Neusiedl is a much more stable system. In all the years only the ions are present in the first PC, so changes in its processes can only be observed through spatial changes in the first PC’s factor scores. There were certain areas with significant increase or decrease in the factor scores indicating anthropogenic activity.

Fig. 1, First PC’s explanatory power at all sampling locations of the River Tisza (winters of 1974-2005)

Conclusions

In all three cases mostly anthropogenic influences lay behind the anomalies. At the Tisza its tributary brings extra loads while the water barrage system increases the water’s retention time and together they locally change the pattern the processes follow. Inflows have a considerable effect on the KBWPS as well, where the processes in its inlet are determined by the diffuse agricultural phosphorous loads and in its wetland area by extra loads. In the case of Lake Neusiedl each extra inflow has a significant effect on the lake’s ion composition be it the Wulka River (NW), the sewage treatment plant (NE) or the Hotel at the west shore. In all three cases because of their unique spatial structures and habitats the PCA results had to be interpreted and explained in different ways. In the case of the Tisza and the KBWPS only the factor loadings of different parameters, while at Lake Neusiedl -because of the constant composition of the first PC-, only the distribution of its factor scores turned out to be useful in interpreting the anthropogenic effects. In each case PCA assisted in determining the anthropogenic influences and in this way helped in the long term and complicated process of conserving our natural heritage.

References

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