

# Development of a monitoring network on Lake Balaton, Hungary

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## Abstract

A monitoring system has been developed to characterize the bottom sediments of Lake Balaton. Samples were collected inside of the lake, from the top layers to 60 cm in depth. The samples were dried at room temperature and then sieved through 2-mm and 63- $\mu$ m sieves. The total concentration of elements was measured by atomic absorption spectrometry (AAS) with an RSD of <5% from solutions. The determination of the mineralogical phase composition of sediments was carried out by X-ray powder diffraction (XRD). The main constituents of samples were quartz, calcite, mica, dolomite, chlorite, feldspar, smectite, kaolinite, pyrite and some amorphous materials. Ten elements were investigated, and Ni, Cr and Zn were chosen to be discussed in details. Results were compared with Hungarian soils, geochemical background values, sediment quality values (SQVs) and sediment background values (SBVs). Records showed that the average concentration of elements was usually less than that of SQVs and other background values for soils. However, some high concentrations at different sampling sites and depths surpassed the geochemical background values. Based on the results, it can be confirmed that the quality of the sediment inside Lake Balaton is satisfactory.

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## 1. Introduction

In our recent detailed study from 1996 to 2001, a monitoring system was set up for the determination of the organic and elemental concentration of bottom sediments inside Lake Balaton, harbors and streams in its catchments area [1–5]. Fractionations by particle size and chemical bonding have been carried out. Air-dried samples were sieved, and fractions of 2 and 0.5 mm and, finally, 63  $\mu$ m were separated. For chemical speciation, a three-step BCR method for sediments and soils was suggested [6]. A modified four-step method was used for the determination of partitioning of elements in bottom sediments. For comparison of data on element speciation and the validation of leaching method developed, a certified reference material (BCR 601) for three-step leaching was used to estimate the systematic error characterized by accuracy and reproducibility [1].

A comprehensive sampling plan was created, and a systematic two-dimensional framework was matched to the horizontal sections of the lake. Several sampling points were located, and samples were collected during three seasons, spring, summer and autumn, in successive years. The environmentally mobile fractions were usually compared with the sum of the four-step extraction and the total concentrations [4].

Monitoring can be designed and carried out to gain information on the present level of potentially harmful pollutants in discharges to the environment. Sediments are basic components of the lake, they provide foodstuffs for living organisms and serve as sinks for chemical species. It is necessary to know the mechanisms of transport of trace elements in lakes to understand their chemical cycles in nature. Lake and reservoir sediments provide unique records of natural watershed conditions and processes and of changes caused by human activity. Out of the many pollutants that are found in lake and reservoir sediments, heavy metals are among the most persistent ones because they cannot be destroyed or broken down. For this reason, they are useful as

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markers of environmental changes [7]. In these studies, elemental analysis of bulk sediment cores and radiometric dating techniques were combined using established methods to calculate sedimentation rates and metal fluxes from metal concentration profiles. In addition to providing a chronological record of environmental change, contaminated lake and reservoir sediments are the reason for concern because heavy metals may be transported from sediments back to the surface environment. Metals contained in sediments may return to the sediment–water interface through diffusion, sediment resuspension or biological activity. Once at the sediment–water interface or in the water column, metals are more likely to be transported and to enter the food chain. Thus, it is important to record the concentration and spatial distribution of each metal to evaluate the potential for remobilization, transport and biological uptake.

Lake Balaton is the largest lake of Central Europe, with a surface of 596 km<sup>2</sup> and an average depth of 3.25 m. The shallow lake is one of the most valuable recreation zones. Monitoring of the lake with respect to the determination of toxic pollutants in sediments is fundamental to the explanation of environmental problems. In 2002, sediment samples were collected at the same 17 sampling points set earlier in three seasons but in spring, a depth-sampling procedure was also applied. Total elemental concentrations were determined and compared with data gained previously.

## 2. Experimental

### 2.1. Sampling and sample preparation

Sediment samples were collected at 17 sites (5 North coasts (N1–N5), 5 Midsection (M1–M5) and 7 South coasts

(S1–S7; Fig 1.) with a manual sediment sampler with a 1-m long sampler head made of Plexiglass (id: 5 cm). The samples were taken from 10- to 60-cm depths depending on the solidity of the sediment. A fiberglass boat was driven to the selected sampling site. Three parallel samples were taken at each site. The sediment cores were divided into 10-cm sections. They were wet sieved by a 63- $\mu$ m sieve and dried in airflow at room temperature. The acid soluble fraction of the sediments was determined by digestion in a strong acid mixture. This is called “total elemental content”, considering that no HF was used for the dissolution of silicate fractions. In a glass vessel, 1.00 g of sample was weighed by analytical precision, and the mixture of cc. 10 ml HNO<sub>3</sub>+5 ml H<sub>2</sub>O<sub>2</sub>+5 ml HClO<sub>4</sub> was added. The sample was heated for 2 h at 100 °C on a sand bath. The volume of the liquid was reduced to a few milliliters and, after cooling, 5 ml cc. HNO<sub>3</sub> and double-distilled water were added to the mixture, filtered and made up to 100 ml. The solutions were stored at 4 °C prior to analysis. Blank samples (vessel+solutions with no sediment) were carried out and absorbance values were modified accordingly. Before extraction, all glassware and plastic vessels were treated in a solution of 10 v/v% HNO<sub>3</sub> for 24 h and washed with double-distilled water.

### 2.2. Analytical measurements of elements

The elemental concentrations of the solution were determined by atomic absorption spectrometry (AAS) in an electrothermal atomization mode using Perkin-Elmer 5100 PC, HGA 600 graphite furnace with GEM software. Standard solutions were prepared from 1 g/l of each metal (Merck standard solutions) and were freshly diluted before use. The limit of detection (LoD)

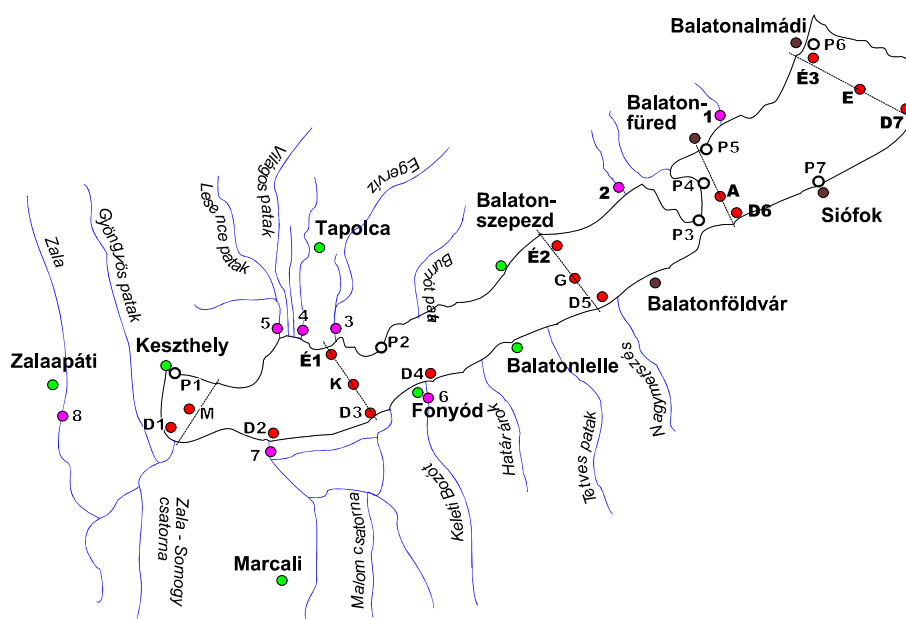


Fig. 1. The map of the sampling sites.

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