

# CONTAMINATION STATUS OF FLYSCH-DRAINING RIVERS OF CROATIA AND SLOVENIA, FLOWING TO THE NORTH ADRIATIC SEA

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## Abstract

Stream sediments from flysch rivers Rižana, Dragonja, Mirna, Raša and Rječina, flowing to the North Adriatic Sea, have been studied by detailed mineralogical, chemical and geostatistical methods. Levels and sources of major and trace elements determined by ICP-MS method in sediment fraction <63 μm were used as a data set for statistical analysis. Cluster analysis of Q-modality showed that according to geochemical composition of sediments Rižana forms a separate cluster. Raša, Dragonja and lower stretch of Mirna belong to the second cluster, while Rječina and upper stretch of Mirna belong to the third cluster. Sediments reflected anomalous concentrations of 20 elements, when using the same data set and two dimensional scatter box diagrams from program STATISTICA 6.0. Most anomalous values were found in Rižana and Rječina rivers, what can be of concern because they are used as sources of drinking water. Raša, Mirna and Dragonja present clean environments.

**Keywords :** *Adriatic Sea, Sediments, Pollution.*

## Introduction

The region of flysch-draining rivers is presented in Figure 1. There are some papers describing Raša River from different aspects [1, 2]. In these papers, trace metal transport was studied from land to sea and sedimentation processes were studied accordingly. Geochemistry of sediments was studied by us in Rižana and Dragonja Rivers [3] and also in Rječina River [4]. Geochemistry of sediments from Raša and Mirna Rivers studied in this work have not yet been reported.



Fig. 1. The region of flysch rivers.

The aim of the work is to apply statistical analysis on the geochemical data set of sediments from flysch region, from which is possible to obtain the information about the current state of these important water resources for Croatia and Slovenia.

## Experimental

Surface sediments were collected, wet sieved and dried at 80 °C. The sediment fraction <63 μm was analyzed in Actlabs commercial laboratory, Ontario, Canada, using ICP-MS method, with program Ultratrace 2. Program STATISTICA 6.0 was used on 27 up to now collected samples.

## Results and discussion

Q-modality cluster analysis was performed on total data set. Sampling stations were grouped in three clusters. Cluster 1 has two locations, both from Rižana River. Cluster 2 has 13 locations from Raša, Dragonja and the lower stretch of Mirna River. Cluster 3 has 12 locations from Rječina and upper stretch of Mirna. In Table 1 are presented elements with extreme and / or outlier values in particular locations. Toxic elements Cd, Sb, Pb and Hg have extreme in sample 18, what is in upper flow of Rižana. Samples of Rječina River show outliers with respect to toxic Cu, Zn, Sb, Cd and Pb. This finding can be of concern, because the sources of Rižana

and Rječina are used as drinking water supply. Raša, Mirna and Dragonja represent clean environments.

Tab. 1. Elements with extreme and/or outlier values in particular locations.

Element	Extreme sample	Outlier sample	Element	Extreme sample	Outlier sample
Na	23, 113, 105		Sb	18	95, 96, 97, 98
P	18		Ba		107
S	23, 105		La	18	
Ca	20, 22		Ce		18
Mn		18	Tl		18
Cu		95, 96, 97	Pb	18	98
Zn		97, 98	Bi	18	
Se	18		Th		95
Cd	18	97	U	18	
Sn		19	Hg	24	18, 22

## Conclusions

Geochemical and statistical investigations of flysch-draining rivers flowing to North Adriatic are of supraregional interest.

-Q-modality cluster analysis has shown that, with respect to element distribution, Dragonja and lower stretch of Mirna are similar to Raša; upper stretch of Mirna is similar to Rječina, while Rižana is completely different from other rivers.

-The most contaminated is Rižana River, follows Rječina, while Mirna, Raša and Dragonja represent clean environments.

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