ALEXANDRU IOAN CUZA UNIVERSITY OF IAŞI

GEOGRAPHY AND GEOLOGY FACULTY
GEOSCIENCES DOCTORAL SCHOOL

Geochemical Distribution Of Chemical Elements And Mineralogy Of Sediments From The Săsar River Basin

PHD THESIS SUMMARY

Scientific coordinator:

Prof. univ. dr. DAMIAN Gheorghe Ștefan

PhD Candidate:

Bereș Ioan Liviu

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Abstract

The geochemistry and mineralogy of river and watershed sediments are shaped by a combination of physical, chemical, geological, and biological factors, along with climate conditions and human activities. The chemical composition of natural waters largely results from interactions between water and bedrock, while agricultural, industrial, and especially mining processes contribute significantly to variations in sediment chemistry. Heavy metals may enter aquatic ecosystems through both natural weathering and anthropogenic sources.

In regions with a history of mining or active metallurgical operations, heavy metal pollution is a major environmental concern requiring urgent attention. Human activities such as ore extraction, concentration, and smelting have generated large volumes of mining waste, which often contain elevated levels of heavy metals. Due to their fine particle size, these wastes tend to disperse more easily and extensively than raw ore, especially under the influence of environmental factors like wind and water. As a result, heavy metal contamination may extend far beyond the initial source, affecting air, soil, and nearby sediments, with adverse impacts on ecosystems.

The accumulation of heavy metals in sediments pose a long-term threat to aquatic systems. When remobilized, they can harm aquatic organisms and infiltrate agricultural soils through irrigation, ultimately affecting crops and food safety. Even in trace amounts, certain heavy metals can be hazardous, depending on their origin and chemical form. Consequently, it is vital to define and apply specific pollution indices to evaluate sediment quality and assess the environmental and toxicological risks posed by heavy metals in water systems.

Because heavy metals originate from diverse sources, principal component analysis is often used to differentiate between natural and anthropogenic contributions. Additionally, multivariate statistical methods have proven valuable for understanding the relationships among various sediment-related variables.

The Baia Mare mining region is recognized both nationally and internationally for its complex geology and abundant mineral resources. Some of the most important mining operations within the Baia Mare mining region are located in the Săsar River basin. Mining here has not only involved extraction but has also included ore processing through all stages, culminating in the production of metals and associated materials.

Although the mines in the area were closed over 16 years ago, their environmental impact remains evident. Legacy pollution continues to stem from tailings dumps, tailings ponds, processing waste, mine waters, and other industrial by-products. The sediments of the Săsar River reflect the overall contamination of the watershed, and their analysis offers insight into the current environmental state of the Baia Mare mining zone. Such studies can also help trace contamination back to its sources - whether geological or human-made. The best indicator of pollution is the health of the ecosystems in the affected area, thus, based on the results obtained, an assessment of them and the effects of contamination on human health can be made.

To date, no comprehensive study has been conducted on the mineralogy of sediments in the Săsar River basin, nor on the potential health implications associated with toxic and potentially toxic elements found within them. This gap in research was a key motivating factor in the author's choice of topic.

This thesis introduces a novel and thorough investigation into the Săsar River sediments - marking the first study of its kind in the Baia Mare mining basin. The geochemical and mineralogical characterization is based on physico-chemical analyses of sediment samples collected throughout the watershed. In geological prospecting, geochemical studies are vital for identifying areas of mineralization and interpreting the regional geology. They are also increasingly used to evaluate environmental impacts.

Globally, and particularly across Europe, growing emphasis is placed on geochemical assessments of highly contaminated regions. International initiatives are underway to expand databases of contaminated sites and produce distribution maps for various chemical elements.

This study contributes valuable data to the understanding of the geochemistry and mineralogy of the Săsar River basin. It also supports the expansion of continental and international databases of polluted areas. In addition, the investigation offers insight into the health of the river ecosystem and identifies potential pollution sources. It may even offer clues to the presence of minerals with hobby or economic exploitation potential. The relevance and necessity of this study are thus clear, providing missing scientific context for the Baia Mare mining region.

As the first work of this nature for the study area, the results hold particular significance for future research - offering a foundation and benchmark for comparative studies. The interdisciplinary character of the thesis is reflected in its integration of chemistry, mathematics, mineralogy, geology, environmental science, and statistics. Together, these disciplines enable a robust investigation of the area and enhance the interpretation and application of the findings.

Hypotheses

- The sediments of the Săsar River watershed contain elevated concentrations of pollutant elements, largely originating from mining activities conducted up to 2007.
- There is a natural geochemical background of pollution, which may be more pronounced in certain areas due to the mineral composition of rocks or the proximity of deposits to the surface.
- The spatial distribution of chemical elements is influenced by proximity to contamination sources and the tendency of these elements to accumulate in sediments.
- Calculating pollution indices from chemical analysis can help quantify the degree of contamination.

Fundamental Thesis

The impact of mining activities on the geochemistry and mineralogy of the Săsar

River watershed, and their implications for the environment and public health.

Main Goal

To determine the degree of contamination in the sediments of the Săsar River basin and to identify possible pollution sources, with emphasis on their effects on the environment and human health.

Objectives

- To quantify the concentrations of major and minor elements in the sediments based on chemical analyses
- To map the spatial distribution of chemical elements
- To study heavy minerals through mineralogical analyses
- To identify the origin of heavy metals based on mineralogical evidence
- To correlate mining activities with the concentration of heavy metals in sediments
- To evaluate the geochemical distribution of elements in the sediments
- To assess contamination levels through the calculation of pollution indices

A diachronic and holistic analysis of the topic was carried out, and the approach was designed to align the stated objectives with available tools and methodologies.

Thesis Structure

Chapter I *(„Physical-Geographical Aspects")* – provides an overview of the study area's geographic characteristics, including relief, hydrology, climate, soil types, and land use patterns.

Chapter II *(„Geological Overview of the Săsar River Basin")* – outlines the regional geological framework using published literature and highlights the main mineralizations and their characteristics. It also discusses sources of anthropogenic pollution related to mining and ore processing.

Chapter III *(„Working Methodology and Analytical Techniques")* – describes the research stages: fieldwork for sample collection, laboratory sample processing, and the analytical methods employed.

Chapter IV *(„Sediment Granulometry in the Săsar River Basin")* – presents grain-size analysis and classification of sediment samples according to Folk's sediment classification system.

Chapter V *(„Mineralogy of Sediments in the Săsar River Basin")* – details the mineralogical composition of sediments, beginning with native elements, followed by sulfides, iron and titanium oxides (notably magnetite and its variants), phosphates (apatite), silicates (garnets, zircon, pyroxenes, amphiboles, feldspars, quartz), carbonates (calcite, dolomite), and anthropogenic particles such as metallurgical slag.

Chapter VI *(„Geochemistry of Sediments in the Săsar River Basin")* – analyzes the concentrations of major, minor, toxic, and potentially toxic elements, as well as rare earth elements. It also explains pollution indices and their environmental relevance.

Chapter VII *(„Discussions")* – synthesizes the findings from the mineralogical and geochemical analyses, examining the origin and distribution of chemical elements and evaluating sediment pollution levels and potential health effects.

Final Chapter *(„Conclusions”)* summarizes the study’s key results and scientific contributions, presenting the current state of sediment mineralogy and geochemistry in the Săsar River basin, especially in relation to environmental and human health impacts.