Summary

Arsenic and phosphorus are chemical analogues, and it is proposed that they have similar chemical behaviors in environmental systems. To gain a better understanding of the geochemical processes that control the mobility and stability of arsenic and its phases exposed to low phosphate levels, a variety of environmental matrices was studied using different experimental approaches. Among the samples studied were contaminated agricultural soils, mine waste materials, streambed sediments and river waters from a contaminated fluvial system, and synthetic arsenate phases. A number of common methods and techniques used for geochemical and mineralogical investigations were chosen, such as XRD, Raman spectroscopy, ATR-FTIR, ICP-OES, or EPMA.

The results obtained during my doctoral studies are presented in the form of three manuscripts. The first study explores the long-term impact of continuous input of relatively low phosphate discharged from a small-capacity wastewater treatment plant on arsenic mobility within a small fluvial system located in a natural arsenic anomaly. Here, we document a significant decrease in total arsenic concentrations and sequestration of phosphorus in sediments downstream of a treatment plant. This part of the research highlights the past and ongoing mobilization of arsenic from Fe (oxyhydr)oxides due to competition with phosphate and demonstrates a problematic consequence of effluent discharges into fluvial systems that are contaminated by arsenic.

Further, the distribution, speciation, and mobility of arsenic and antimony are examined within historical mining wastes and agricultural soils in two ore districts. Here, the lowest phosphate concentration capable of increasing arsenic mobilization from agricultural soils by 33 to 50 % is 0.1 mM. This finding suggests that common fertilization practices could inadvertently enhance arsenic mobility in agricultural soils and lead to its release into fluvial and groundwater systems.

The final aspect of the research focuses on the stability of ferric arsenate mineral(oid)s, such as amorphous ferric arsenate and nano-crystalline yukonite, in the presence of dissolved phosphate. The findings indicate that the phosphate concentrations commonly used in chemical extractions and remediation procedures trigger substantial arsenic release from the arsenate phases due to incongruent dissolution or phosphate substitution. This challenges the application of phosphate in the remediation of waste materials and through common fertilization practices to contaminated soils rich in arsenate mineral(oid)s. Furthermore, we propose omitting phosphate extraction steps when applying sequential extraction procedures to materials rich in arsenate mineral(oid)s.