

Soil Heavy Metal Source Tracing in Farmland Based on the Hybrid Model of APCS-MLR and Machine Learning SVR: A Case Study of Huayuan County, Hunan Province

Fang Zheng, Bozhi Ren*

School of Earth Science and Space Information Engineering, Hunan University of Science and Technology, Xiangtan, China

Email address:

2859332832@qq.com (Fang Zheng), bozhiren@126.com (Bozhi Ren)

*Corresponding author

Abstract

Precisely apportioning the sources of heavy metal pollution in farmland soils is a critical foundation for implementing cultivated land safety management and source-oriented pollution control. Taking Huayuan County, Hunan Province, a typical mining–agriculture composite area, as a case study, this research explores a multi-source information fusion analysis method suitable for small soil sample datasets, with the aim of systematically revealing the multiple sources of heavy metals in farmland soils. The results indicate that heavy metals in farmland soils of the study area can be classified into three categories of pollution sources: natural sources include V, Cr, Fe, Mo, As, and Ni, whose concentrations are jointly controlled by soil parent materials and DEM-elevation-driven rainfall runoff deposition; anthropogenic sources include Cd, Pb, Zn, Cu, and Hg, among which Cd is dominated by fertilizer inputs, Pb by road traffic emissions, Zn and Cu by combined inputs from fertilizers and traffic emissions, and Hg by the joint influence of local point sources and rainfall runoff deposition; natural–anthropogenic mixed sources consist of Mn and Co, which are controlled by the superimposed effects of soil parent materials and minor agricultural activities. The multi-source information fusion analysis method proposed in this study effectively compensates for the insufficient accuracy of source apportionment of heavy metal pollution in farmland soils under small-sample conditions, providing a scientific basis and methodological reference for precise source tracing and cultivated land safety management in mining–agriculture composite areas.

Keywords

Machine Learning, Source Apportionment, Farmland Soil, Small Sample Size