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Environmental Forensics of Rare-Earth-Elements for the Soil-Tea Garden System using Joint Geochemical and Isotope Tracing Techniques

YAN CONG[1,2], GONG-REN HU[2], YU YAN[2], **ZHICHAO CAI**[1] AND YUESUO YANG[1]

[1]Jilin University
[2]Huaqiao University

Source identification of pollutants in environment is a tricky and timely issue in forensics and remediation strategy. Isotope tracing with sound support of geochemical data of pollution scenarios has become an effective method in meeting such a forensics purpose. There are numerous tea gardens in Southern China and most of them are located in acidic soil. Due to local geochemistry, the rare-earth-elements (REEs) have become an environmental and health risk for the tea gardens, as they can be easily absorbed and accumulated by tea leading to health risk. Therefore, environmental forensics of REEs in the soil-tea plant system is of great significance for ecological & environmental health. This paper takes the soil-tea plant system in Fujian Province (South China), as a research case study to fully investigate the REE forensics in the soil-tea gardens system through field investigations, laboratory experiments and numerical simulation methods. The causes of the REE pollution in tea gardens can be from complicated anthropogenic activities. Although the tea gardens are normally far from industrial and urban areas, it still suffers from pollution from industrial/agricultural sources and human activities. With support of a large amount on-site sampling, a series of laboratory-scale and field experiments were carried out to identify the pollution sources and migration of the REE pollutants in the soil-tea-garden system. The experiments considered soil and rock types, crop land uses and plantation practice, the data obtained on soil geochemistry and REE strontium (Sr) and Neodymium (Nd) isotopes were further analysed for correlation and isotope tracing. The results showed that Sr was identified the highest (23.9 $\mu g \cdot g^{-1}$) in the roots, that was positively correlated with Nd in the roots, indicating that these metals mainly originated from soil. The isotope ratio analysis of Sr and Nd revealed that the average values of $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ were 2.11 and 1.16 in the young leaves respectively, whilst the average value of $^{87}Sr/^{86}Sr$ was 0.71. The $^{87}Sr/^{86}Sr$ ranged in the Tieguanyin tea garden of deep soil was 0.71~0.72, and that of the same tea tree samples was 0.70~0.71, demonstrated the migration pathways of pollutants in the soil-tea tree system.

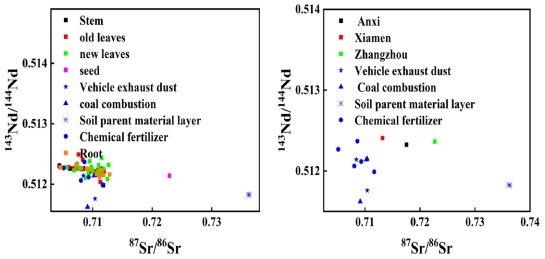

Figure 1 Speciation of the REE isotope ratios in various parts of the tea tree and soil environment in supporting environmental forensics

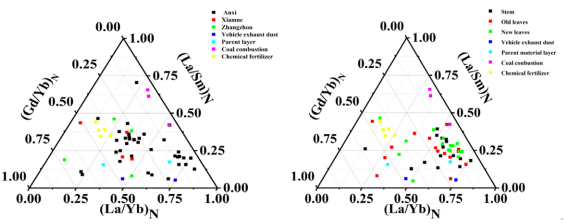

Figure 2 Ternary diagrams showing the potential pollution sources of the REE isotope ratios