



Spatial Distribution of Lanthanum (La) in the Pülümür Stream, Eastern Türkiye

Banu KUTLU^{1*}, Serdar ÇETİNDAG²

¹ Fisheries Faculty, Munzur University, TR62000, Tunceli, Türkiye

² Tunceli Provincial Health Directorate Tunceli, Türkiye

ARTICLE INFO

Keywords:

Exotic, Rare earth elements (REEs), Lanthanum (La), Surface sediments; Surface water, ICP-OES, Pülümür Stream

Article History

Received: 10 06 2026

Accepted: 22 06 2026

Published: 30 06 2026

Original Research Article

ABSTRACT

Rare earth elements (REEs) are increasingly recognized as valuable geochemical tracers for evaluating natural processes and environmental changes in aquatic ecosystems. Among them, lanthanum (La), a representative light rare earth element (LREE), provides valuable insights into the geochemical characteristics of freshwater environments. This study investigated the spatial distribution of La in surface water and surface sediments collected seasonally from ten sampling stations along the Pülümür Stream (Eastern Türkiye) between February 2022 and January 2023. Lanthanum concentrations were determined using inductively coupled plasma–optical emission spectrometry (ICP–OES) in an ISO/IEC 17025-accredited laboratory. Dissolved La concentrations in all surface water samples were below the analytical reporting limit (0.01 mg L^{-1}), whereas sediment La concentrations ranged from 10 to 18 mg kg^{-1} , with the highest concentration recorded at St9 and the lowest at St6 and St7. The predominance of La in the sediment phase indicates limited mobility under the prevailing hydrochemical conditions, suggesting that its distribution is largely influenced by lithology, weathering processes, and sediment transport. This study provides the first baseline dataset on La distribution in the Pülümür Stream and contributes to a better understanding of rare earth element behavior in semi-arid freshwater ecosystems, providing a valuable reference for future geochemical monitoring and environmental assessment.

Introduction

Rare earth elements (REEs), including the lanthanide series together with yttrium (Y) and scandium (Sc), are widely recognized as valuable geochemical tracers for investigating geological and environmental processes. Owing to their coherent chemical properties and the systematic decrease in ionic radius across the series, REEs exhibit characteristic fractionation during weathering, transport, and sedimentation. These properties make REEs valuable tools for identifying source-rock composition, evaluating weathering intensity, investigating water–rock interactions, and understanding geochemical cycling in terrestrial and aquatic environments (Henderson, 1984; Taylor and McLennan, 1985).

Among the REEs, lanthanum (La), a representative light rare earth element (LREE), is particularly useful because of its relatively high natural abundance and its sensitivity to lithological and weathering processes, making it an effective indicator of geochemical processes in freshwater systems. Numerous studies conducted in lakes, rivers, and marine environments have shown that the distribution of REEs is controlled not only by lithological characteristics but also by environmental factors such as grain size, mineralogical composition, pH, and redox conditions (Sholkovitz, 1988; Bau, 1999). In aquatic environments, REEs are partitioned between dissolved and particulate phases, with their distribution strongly influenced by adsorption, desorption, and sediment transport processes. Therefore, the combined evaluation of surface water and sediments provides valuable insights into the environmental behavior, mobility, and geochemical controls governing REE distribution (Pourret and Tuduri, 2017).

In aquatic systems, the behavior of rare earth elements (REEs) is strongly influenced by adsorption and desorption processes occurring on

mineral surfaces (Sholkovitz, 1995; Pourret and Tuduri, 2017). Iron and manganese oxides, together with clay minerals, provide abundant reactive sites that effectively retain dissolved REEs, thereby regulating their transport, mobility, and accumulation in water and sediments. Among the light rare earth elements, lanthanum (La) exhibits a particularly strong affinity for particulate matter and mineral surfaces, making its distribution sensitive to lithology, suspended sediment dynamics, and hydrochemical conditions. Consequently, the distribution of dissolved and sediment-associated La provides valuable insights into the geochemical processes governing element transport, retention, and accumulation in freshwater environments (Elderfield and Greaves, 1982; Davranche et al., 2011).

This study was conducted in the Pülümür Stream basin (Tunceli, Eastern Türkiye) to investigate the spatial distribution of lanthanum (La) in surface water and surface sediments under the hydrogeochemical conditions of a semi-arid river system. As one of the most abundant light rare earth elements, La was selected as a representative element to evaluate the influence of lithology, weathering processes, hydrological conditions, and potential anthropogenic inputs on its environmental distribution. The combined assessment of surface water and surface sediment samples provides baseline information on the occurrence and environmental behavior of La in an understudied river basin of Eastern Anatolia. The findings contribute to a better understanding of rare earth element behavior in semi-arid freshwater ecosystems and provide a valuable baseline for future comprehensive investigations of rare earth elements in the region.

Material and Methods

Surface water and surface sediment samples were collected seasonally from

* Corresponding author

E-mail address: kutlubanu@gmail.com (Banu KUTLU)

How to cite

Kutlu, B., Çetindağ, S. (2026). Spatial Distribution of Lanthanum (La) in the Pülümür Stream, Eastern Türkiye. MARFRESH — Journal of Marine & Freshwater Sciences, 1(1): 6-9.

February 2022 to January 2023 at ten sampling stations (St1–St10) distributed along the Pülümür Stream, Eastern Türkiye (Fig. 1). The sampling stations were selected to represent the upstream, middle, and downstream reaches of the stream while encompassing variations in land use, tributary inflows, and potential anthropogenic influences. Streambed substrates ranged from fine sand and gravel to coarse gravel and bedrock, reflecting the natural geomorphological heterogeneity of the basin. Stations located adjacent to agricultural land, livestock farming areas, rural settlements, and a municipal solid waste disposal site were included to evaluate the potential influence of human activities on the spatial distribution of lanthanum (La). The geographic coordinates of all sampling stations are presented in Fig. 1.

In this study, lanthanum (La), a representative light rare earth element (LREE), was selected as an indicator element to evaluate its occurrence and spatial distribution in the Pülümür Stream. Lanthanum concentrations in surface water and surface sediment samples were determined using inductively coupled plasma–optical emission spectrometry (ICP–OES) in an ISO/IEC 17025-accredited analytical laboratory. Owing to its high analytical precision, accuracy, and capability for simultaneous multi-element determination, ICP–OES is widely used in environmental geochemistry for the quantitative analysis of trace elements in natural waters and sediments.

All chemical analyses were performed in an ISO/IEC 17025-accredited laboratory using validated analytical procedures. The results were reported in the appropriate concentration units in accordance with the laboratory’s quality assurance and quality control (QA/QC) protocols. Method detection limits (MDLs) specified by the laboratory were considered throughout data evaluation, and concentrations below the corresponding MDLs were reported as <MDL and were not interpreted quantitatively. Compliance with ISO/IEC 17025 accreditation ensured that instrument calibration, quality control, data validation, and analytical procedures were conducted in accordance with internationally recognized laboratory standards.

hydrochemical conditions of the Pülümür Stream throughout the study period (Table 1).

Table 1 Dissolved lanthanum (La) concentrations in surface water samples collected from the Pülümür Stream.

Sampling station	La (mg L ⁻¹)
St1	<0.01
St2	<0.01
St3	<0.01
St4	<0.01
St5	<0.01
St6	<0.01
St7	<0.01
St8	<0.01
St9	<0.01
St10	<0.01

Lanthanum concentrations in surface sediments

The spatial distribution of lanthanum (La) concentrations in surface sediments collected from the Pülümür Stream is presented in Table 2 and Fig. 2. Sediment La concentrations ranged from 10 to 18 mg kg⁻¹, demonstrating measurable spatial variation among the sampling stations. The highest La concentration was recorded at St9 (18 mg kg⁻¹), whereas the lowest concentrations were observed at St6 and St7 (10 mg kg⁻¹).

The upstream stations (St1–St3) exhibited relatively uniform La



Figure 1 Location of the sampling stations (St1–St10) along the Pülümür Stream, Eastern Türkiye.

Results

Lanthanum concentrations in surface water

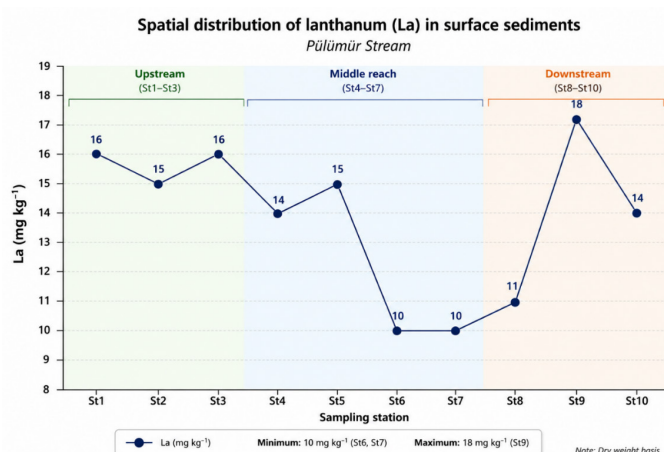
Dissolved lanthanum (La) concentrations in all surface water samples collected from the ten sampling stations (St1–St10) were below the analytical reporting limit (<0.01 mg L⁻¹). Consequently, no measurable spatial variation in dissolved La was observed among the sampling stations. These findings indicate that La was not detectable in the dissolved phase under the prevailing

concentrations ranging from 15 to 16 mg kg⁻¹, indicating limited spatial variation in the headwater reach. In the middle reach (St4–St7), concentrations varied between 10 and 15 mg kg⁻¹, with the lowest values recorded at St6 and St7. Downstream stations (St8–St10) showed concentrations ranging from 11 to 18 mg kg⁻¹, with the maximum concentration observed at St9, followed by a decrease at St10.

Table 2 Spatial distribution of lanthanum (La) concentrations in surface sediments collected from the Pülümür Stream.

Sampling station	La (mg L ⁻¹)
St1	16
St2	15
St3	16
St4	14
St5	15
St6	10
St7	10
St8	11
St9	18
St10	14

Overall, the observed distribution indicates that La was heterogeneously distributed in the sediment phase along the Pülümür Stream, reflecting localized differences in sediment geochemistry (Table 2; Fig. 2).

Figure 2 Spatial distribution of sediment-associated lanthanum (La) concentrations measured at ten sampling stations along the Pülümür Stream. Concentrations are expressed as mg kg⁻¹ dry weight.

Discussion

The present study revealed measurable spatial variations in lanthanum (La) concentrations among the sampling stations of the Pülümür Stream. Sediment La concentrations ranged from 10 to 18 mg kg⁻¹, with the highest concentration recorded at St9 and the lowest at St6 and St7. Although the spatial pattern did not exhibit a consistent downstream increase, relatively elevated concentrations at selected stations indicate that the distribution of La is spatially heterogeneous across the basin. This distribution is consistent with the environmental behavior of light rare earth elements (LREEs), which is widely recognized to be influenced by lithology, weathering processes, and sediment transport under natural environmental conditions (Sholkovitz, 1988; Bau, 1999).

The observed spatial variability in sediment La concentrations is likely related to the geological characteristics of the Pülümür Stream basin. The catchment comprises carbonate, volcanic, and ophiolitic lithologies that differ in their mineralogical composition and susceptibility to weathering. Weathering of these lithological units is widely recognized as the principal natural source of rare earth elements in aquatic environments, releasing La into surrounding soils, sediments, and surface waters (Taylor and McLennan, 1985, 1989; Goldstein & Jacobsen, 1988). Therefore, spatial variations in lithology across the basin are likely to have contributed to the heterogeneous distribution of La observed among the sampling stations.

The distribution of La in surface sediments is also influenced by adsorption and sedimentation processes operating within the river system. Rare earth elements exhibit a strong affinity for fine-grained particles, clay minerals, and Fe–Mn oxides, which provide abundant reactive surface sites for element retention (Elderfield and Greaves, 1982; Davranche et al., 2011). Consequently, La released during weathering or transported by suspended particulate matter can be retained in bottom sediments through adsorption and depositional processes. These processes are likely to contribute to the spatial heterogeneity of sedimentary La concentrations observed in the Pülümür Stream.

In addition to natural geological controls, localized anthropogenic activities may also influence the spatial distribution of La within the Pülümür Stream basin. Agricultural practices, rural settlements, and surface runoff have been identified as potential secondary sources of rare earth elements in freshwater environments by enhancing the transport of soil particles and associated trace elements (Zhang et al., 2018). Although the present study was not designed to quantify the relative contributions of individual anthropogenic sources, the relatively elevated La concentrations observed at selected downstream stations may reflect the combined effects of natural weathering processes and localized human activities. Similar distribution patterns have been reported in other river systems, where lithology represents the primary control on rare earth element distribution, while anthropogenic inputs locally modify spatial variability (Zhang et al., 2018).

Overall, the present study provides the first baseline dataset on the occurrence and spatial distribution of lanthanum (La) in the Pülümür Stream, one of the understudied river systems in Eastern Anatolia. The results suggest that the spatial distribution of La in surface sediments is likely influenced by the combined effects of lithology, weathering processes, sediment transport, and localized anthropogenic activities. Although the present investigation focused exclusively on La as a representative light rare earth element, the generated dataset provides a valuable reference for future studies incorporating comprehensive rare earth element datasets, shale-normalization approaches, and source apportionment analyses. Overall, this study contributes to a better understanding of the environmental behavior of rare earth elements in semi-arid freshwater ecosystems and provides a foundation for future geochemical investigations and long-term environmental monitoring in the region.

Conclusions

This study evaluated the spatial distribution of lanthanum (La) in surface water and surface sediments of the Pülümür Stream, providing the first baseline dataset on the environmental occurrence of this representative light rare earth element in an understudied river system of Eastern Anatolia. Dissolved La concentrations in all surface water samples remained below the analytical reporting limit (<0.01 mg L⁻¹), whereas sediment La concentrations ranged from 10 to 18 mg kg⁻¹, demonstrating measurable spatial variation among the sampling stations. The predominance of La in the sediment phase suggests limited mobility under the prevailing hydrochemical conditions of the Pülümür Stream.

The observed spatial distribution of sediment-associated La is likely influenced by the combined effects of lithology, weathering processes, sediment transport, and localized anthropogenic activities. Although the present study focused exclusively on La, the generated dataset provides a valuable baseline for future investigations incorporating comprehensive rare earth element datasets, shale-normalization approaches, and source apportionment analyses. Overall, this study contributes to a better understanding of the environmental behavior of rare earth elements in semi-arid freshwater ecosystems and provides a valuable reference for future geochemical investigations and long-term environmental monitoring in Eastern Anatolia.

Statements and Declarations

Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Declarations

Conflict of interest

The authors declare no conflict of interest.

References

- Bau, M. (1999). Scavenging of dissolved yttrium and rare earth elements by precipitating iron oxyhydroxide: Experimental evidence for Ce oxidation, Y–Ho fractionation, and lanthanide tetrad effects. *Geochimica et Cosmochimica*

- Acta, 63(1), 67–77. [https://doi.org/10.1016/S0016-7037\(99\)00014-9](https://doi.org/10.1016/S0016-7037(99)00014-9)
- Davranche, M., Pourret, O., Gruau, G., Dia, A., & Le Coz-Bouhnik, M. (2011). Rare earth element patterns: A tool for identifying trace metal sources during wetland soil reduction. *Chemical Geology*, 284(1–2), 127–137. <https://doi.org/10.1016/j.chemgeo.2011.02.006>
- Elderfield, H., & Greaves, M. J. (1982). The rare earth elements in seawater. *Nature*, 296, 214–219. <https://doi.org/10.1038/296214a0>
- Goldstein, S. J., & Jacobsen, S. B. (1988). Rare earth elements in river waters. *Earth and Planetary Science Letters*, 89(1–2), 35–47. [https://doi.org/10.1016/0012-821X\(88\)90031-3](https://doi.org/10.1016/0012-821X(88)90031-3)
- Henderson, P. (Ed.). (1984). *Rare earth element geochemistry*. Elsevier.
- McLennan, S. M. (1989). Rare earth elements in sedimentary rocks: Influence of provenance and sedimentary processes. In B. R. Lipin & G. A. McKay (Eds.), *Geochemistry and mineralogy of rare earth elements* (pp. 169–200). Mineralogical Society of America.
- Pourret, O., & Tuduri, J. (2017). Continental shelves as a reservoir for rare earth elements? A review of the behavior of rare earth elements in coastal environments. *Chemical Geology*, 451, 38–54.
- Sholkovitz, E. R. (1988). Rare earth elements in the sediments of the North Atlantic Ocean, Amazon Delta, and East China Sea: Reinterpretation of terrigenous input patterns to the oceans. *American Journal of Science*, 288, 236–281.
- Sholkovitz, E. R. (1995). The aquatic chemistry of rare earth elements in rivers and estuaries. *Aquatic Geochemistry*, 1(1), 1–34. <https://doi.org/10.1007/BF01025229>
- Taylor, S. R., & McLennan, S. M. (1985). *The continental crust: Its composition and evolution*. Blackwell Scientific Publications.
- Zhang, C., Yu, Z. G., Zeng, G. M., Jiang, M., Yang, Z. Z., Cui, F., Zhu, M. Y., Shen, L. Q., & Hu, L. (2018). Effects of anthropogenic activities on rare earth elements in the environment. *Environmental Pollution*, 233, 131–140. <https://doi.org/10.1016/j.envpol.2017.10.078>