

Poster Communication 76

Assessing Ash-Derived Contaminants in Freshwaters Following Wildfires in Northern Portugal

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Abstract

Background: Wildfires are increasing in frequency and intensity worldwide, with Portugal recording the second-largest burned area during the summer of 2025 [1]. Wildfire-derived ash acts as reservoir of contaminants, releasing trace elements and other potentially toxic compounds that may alter water chemistry when mobilized through surface runoff during post-fire precipitation events [2]. Despite this threat, the impact of ash-derived pollutants on freshwater systems in Northern Portugal remains insufficiently characterized, particularly regarding environmental forensic and public health implications [3]. **Objective:** This study aimed to evaluate key physicochemical parameters (nitrate, pH, and electrical conductivity) associated with ash-derived contamination in wildfire-affected areas, comparing pre- and post-precipitation conditions. **Methods:** Surface water samples were collected from six wildfire-affected sites in Northern Portugal (Lousada, Penafiel, and Paredes) on 17 October 2025 (pre-rainfall baseline) and 11 December 2025 (post-rainfall) to assess the effects of runoff-driven contaminant mobilization. Nitrate concentrations were determined using UV-Vis spectrophotometry (Unicam UV/Vis spectrophotometer, ATI Unicam) and expressed in mg/L. pH and electrical conductivity were measured using a Crison GLP21 pH meter and a Crison GLP31 conductimeter, respectively. Data were analyzed using Jamovi (v2.6.44) and are presented as mean \pm standard error of the mean (SEM). **Results:** Mean nitrate concentrations across all sites increased slightly from 0.14 ± 0.04 mg/L (pre-rainfall) to 0.16 ± 0.04 mg/L (post-rainfall), although this difference was not statistically significant ($p > 0.05$). Similarly, pH values showed a non-significant increase from 6.15 ± 0.11 to 6.48 ± 0.26 ($p > 0.05$). In contrast, electrical conductivity decreased from 173.2 ± 45.7 to 153.0 ± 45.1 $\mu\text{S}/\text{cm}$, also without statistical significance ($p > 0.05$). Site D3 exhibited the highest pre-rainfall values (nitrate: 0.29 mg/L; pH: 6.43; conductivity: 321 $\mu\text{S}/\text{cm}$), whereas post-rainfall maxima were observed at site D1 (nitrate: 0.39 mg/L; pH: 7.07; conductivity: 365 $\mu\text{S}/\text{cm}$). **Conclusions:** Post-fire rainfall induced only minor, non-significant changes in water quality, though site-specific variability highlights the need for continued monitoring.

Keywords: wildfires; ash-derived contamination; surface water quality

Acknowledgments/Funding

This work was supported by FCT - Fundação para a Ciência e Tecnologia, I.P., in the scope of the project UID/04378/2025 (DOI identifier 10.54499/UID/04378/2025), and UID/PRR/04378/2025 (DOI identifier 10.54499/UID/PRR/04378/2025), of the Research Unit on Applied Molecular Biosciences - UCIBIO and the project LA/P/0140/2020 (DOI identifier 10.54499/LA/P/0140/2020) of the Associate Laboratory Institute for Health and Bioeconomy - i4HB and through the annual funding of 1H-TOXRUN of the University Institute of Health Sciences (IUCS-CESPU). CESPU for the grant BioMPreg-GI2-CESPU-2025 and TRYP-MAP-GI2-CESPU-2025

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