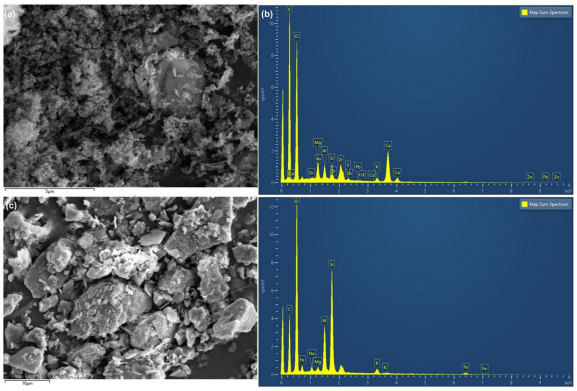
Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.34546



Leaching of potentially toxic elements from wildfire ash and implications for water systems: A case study from South Korea

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Climate change has increased the frequency and intensity of wildfires globally, posing emerging threats through mobilization of potentially toxic elements (PTEs) [1]. Wildfires generate ash residues that can concentrate PTEs, which may be transported to water environment through runoff and leaching. However, studies on PTE concentrations and leaching behavior from wildfire ash in East Asia, particularly in South Korea, remain limited [2]. This study integrates FE-SEM/EDS, ion chromatography, and ICP-MS to evaluate the occurrence, host phases, and leaching behavior of PTEs in wildfire ash. Ash, underlying soil, unaffected soil, and nearby reservoir water were collected four days after a pine forest wildfire (~93 ha) in Uiseong, South Korea, on 10 January 2026. Leaching experiments were conducted under pure water and 0.43 M nitric acid.

FE-SEM/EDS revealed that Pb (0.44 wt%), Zn, and Cd were detected exclusively in ash (Fig. 1a and b) and absent in unburned soil samples (Fig. 1c and d), confirming their plant combustion origin. Mn (up to 3.15 wt%) co-enriched with Fe (4.97 wt%) suggests Mn-Fe oxide phases as potential PTE hosts. Pure water leachate exhibited alkaline pH (7.48–9.92, mean 8.83). SO_4^{2-} (mean 1,250 mg/kg) and Cl^- (690 mg/kg) were readily leached, whereas PTE concentrations in µg/kg were substantially lower: Ni (433.8) > Cu (316.9) > Zn (123.0) > As (103.7) > Pb (3.4) > Cd (0.6), suggesting limited PTE mobility under the neutral pH conditions of wildfire ash. In contrast, 0.43 M HNO_3 leaching yielded substantially higher concentrations in µg/kg: Zn (89,034) > Ni (19,726) > Pb (15,439) > Cu (6,399) > As (2,431) > Cd (902), suggesting PTEs can be released upon dissolution of host phases under acidic conditions. Reservoir water near the burned area showed pH 7.06 and PTE concentrations below 20% of those in pure water leachates. These findings demonstrate that PTEs in wildfire ash are primarily associated with oxide and carbonate phases stable under alkaline conditions but potentially mobilizable under acidic environments, representing a concern requiring long-term monitoring in wildfire-prone regions.

[1] Abrantes et al. (2025) J. Hazard. Mater., 492, 138097.
[2] Bae et al. (2023) Econ. Environ. Geol., 56(5), 501-514.