Geochemical Normalizations for Potentially Hazardous Elements

This document summarizes geochemical normalization indices applicable to environmental and hydrogeochemical studies. The objective is to distinguish natural contributions (lithological, water–rock interaction) from anomalous inputs (mining, industrial, or hydrothermal), reducing the effects of dilution and hydrochemical variability.

Element	Normalization index (conceptual)	Environmental interpretation
As	As / (Ca + Na)	Anomalous input independent of hardness and salinity
Hg	Hg / (Ca + Mg)	Diffuse halos and external Hg sources
Cd	Cd / Zn	Contamination vs Zn-associated natural background
Se	Se / SO4	Sulfide oxidation and acid drainage
Li	Li / Na	Deep or geothermal inputs
U	U / (Ca + Mg)	Reduces carbonate control; highlights oxidizing sources
P	P / Ca	Natural vs anthropogenic input
Pb	Pb / Al	Separation of particulate Pb and contamination
Cu	Cu / (Ca + Na)	Metal input independent of dilution
Zn	Zn / Ca	Mobilization in carbonate environments
Ni	Ni / Mg	Ultramafic control vs contamination
Sb	Sb / As	Anomalous Sb sources
Cr	Cr / Fe	Natural vs anthropogenic Cr
Co	Co / Fe	Relative mobility with respect to oxides
Ca	Ca / (Na + K)	Carbonate dissolution
Al	Al / Si	Detrital vs dissolved input
K	K / Na	Ion exchange
Mg	Mg / Ca	Dolomite–calcite equilibrium
Tl	Tl / K	Association with clays and sulfides
Fe	Fe / Mn	Redox control
Mn	Mn / Fe	Oxidizing conditions

Technical note: Indices should be evaluated comparatively between samples and together with pH, Eh, lithology, hydrology, and analytical QA/QC. They do not replace environmental standards but help interpret processes and sources.