The typical solutes of geochemical solutions (i.e., of natural waters)

The periodic table offers up 92 naturally occurring elements that could seemingly be included as solutes in the geochemical solutions that are natural waters. However, eight solutes make up most of the dissolved load of those solutions, and many chemical analyses report data only for those eight. This document presents those eight solutes, in a table that goes from dilute "upstream" solutions at left to concentrated "downstream" solutions at right.

If one were to ask "why just these eight?", one answer is that other logical candidates are too insoluble to be abundant. For examples, Earth's crust is rich in Al^{3+}, but the moderate ionic potential of Al^{3+} lets it bond in solids (for example, clay minerals) and not go into solution. Iron is likewise very abundant in Earth's crust, but in near-Earth-surface solutions it is oxidized to Fe^{3+}, and the similarity of the charge and size of Fe^{3+} to Al^{3+} means that the same arguments about insolubility apply to it as well. On the anion side, insolubility complements scarcity to make F^- at most a minor solute, and NO_3^- and PO_4^{3-} are consumed as biological nutrients too efficiently to survive as abundant solutes.

Generalized relative ranks of solutes in natural waters:

Solute	Shallow groundwater	River water	Freshwater lakes	Saline lakes	Seawater	Comments
K^+	8	8	8	7	6	The odd-numbered element of greatest atomic number in this list, and thus not surprisingly at the back of the pack.
Na^+	4	6	6	1	2	A lesser solute until concentrated in the most saline solutions, where its weak bonding lets it remain while Ca^{2+} and Mg^{2+} are precipitated.
Ca^{2+}	2	2	2	5	5	A leading solute until solutions are sufficiently concentrated that it is precipitated with CO_3^{2-} and/or $SO4^{2-}$.
Mg^{2+}	6	7	5	6	4	
HCO_3^-	1	1	1	3	7	The leading solute of upstream waters because it is the residual conjugate base of the carbonic acid that drives chemical weather.
SO_4^{2-}	5	4	3	4	3	
Cl^-	7	5	7	2	1	A lesser solute until concentrated in the most saline solutions, where its weak bonding lets it remain while other anions are precipitated.
$SiO_{2(aq)}$	3	3	4	8	11	A leading solute in meteoric waters because of its crustal abundance, but removed from seawater by biomineralizers like diatoms.

The shallow groundwater is Georgia groundwater from Railsback et al. (1996); river water is the average from Livingstone (1963 USGS Prof. Paper 440G; freshwater and saline lakes are from Drever (1982, Table 9-1) and Livingstone (1963), with freshwater lakes largely reflecting the Great Lakes of North America. Saline lakes are extremely variable.