FATE OF TECHNOLOGY-CRITICAL ELEMENTS IN THE ENVIRONMENT, WITH A FOCUS ON LESS-STUDIED ONES

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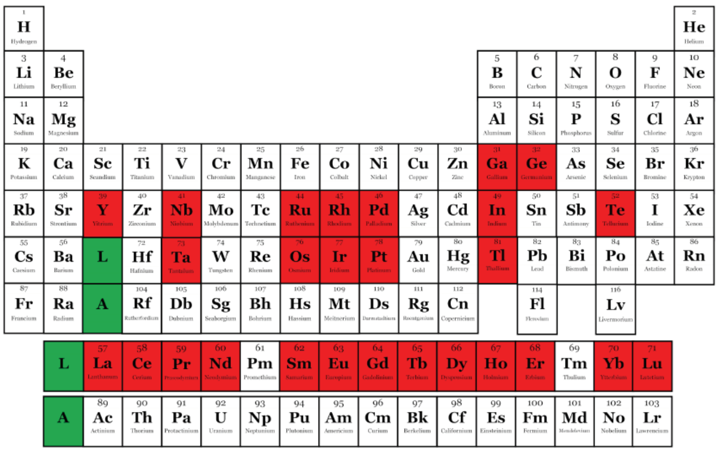
Nature has governed biogeochemical cycles for millions of years but now humans are mining and redistributing material at a very fast rate, probably contributing to shape the geology and biology of the Earth. This is considered one of the main features of the Anthropocene (Cruchten, 2002). This fast element turnover is accompanied by an increasing diversity of the material used in all types of products. Half a century ago, less than 12 materials were in wide use: wood, brick, copper, iron, gold, silver and a few plastics while today a computer chip employs more than 60 different elements (Graedel et al., 2015). A number of trace elements that until recently were only considered to be laboratory curiosities have now become essential components in a variety of applications ranging from information to 'green energy' related technologies. The current strategic importance of these elements is such that they have now been labeled as 'energy-critical elements' or 'technology-critical elements' (TCEs) and initiatives at national levels are underway to secure their availability in the coming years. The list of elements considered as TCEs is variable, depending on the source (Gunn, 2014). Figure 1 shows those considered as such in the EU COST action TD1407 (Cobelo et al., 2015).

Figure 1. Technology-critical elements (TCEs) in red (www.costnotice.net).



It should be mentioned that the TCE tag is geopolitical and economical one, not based on any scientific criteria. For this reason, under the TCE umbrella elements with very different chemical characteristics are found. Most are present at very low concentrations in the upper crust and in environmental compartments but not all of them. Some are prone to hydrolysis and relatively insoluble but, again, this is not always the case. Therefore, TCEs cannot be considered as a category of elements from a scientific point of view. Nevertheless, their study offers us a beautiful opportunity to apply what we have learned over more than 40 years of intensive work on other trace elements (e.g., Cu, Zn, Cd, Hg, As, etc.). We are now in a much better position than we were in the past to tackle the environmental challenges that the increasing use of these elements might create. Today we have highly performing analytical techniques and, more importantly, a solid theoretical background. Pitfalls, such as those derived from not taking chemical speciation into account when performing (eco)toxicological experiments, will surely be avoided.

TCEs have very diverse uses. The degree of the current knowledge on their environmental fate and (eco)toxicity is not uniform, ranging from relatively well studied elements, such as the platinum group, to essentially unknown ones, such as tantalum and tellurium. For all of them, even for the better known, the current information is insufficient to support the application of risk assessment processes and, as a consequence, they are not included in regulations (in contrast to elements with a longer record of use).

What we know and what we do not: Are existing environmental data reliable? Are their concentrations in environmental compartments increasing? How to proceed and mistakes to avoid. All these aspects will be discussed for all TCEs and, in more detail, in the case of the less-studied ones (i.e., Nb, Ta, Ga, In, Ge, Te).

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