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Recycling. Towards a circular economy - PART 2*

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In the previous issue of Chimica OGGI / Chemistry TODAY I discussed the third and last carbon source (besides biomass and CO_2) that can be used as alternative for fossil resources. This third source is the use of waste materials as feedstock. Mechanical and chemical recycling of plastics was discussed.

In this issue of Chimica Oggi / Chemistry Today I will talk about the recycling of other materials than plastics with special emphasis on metals. To get to a circular economy, we need to help conserve all valuable resources, including metals, phosphorous, and many more "endangered" elements of the Periodic Table for re-use.

Unlike endangered animals, endangered elements (except Helium) will not disappear from the Earth. However, there will be a point when supply cannot keep up with demand when it is no longer economically viable to extract or to re-use a particular element and alternatives, using other elements, will have to be developed. There are many applications where this could become problematic and finding alternatives will be a huge opportunity for future chemical research.

Let's look at some of the endangered elements in the periodic table, and why we might miss them when they are too expensive to use. In total, Figure 1 shows 53 elements whose supply is at risk. For some, the risk is more serious than for others but there are 20 elements for which there is concern that there is a serious threat to their supply within the next 10 - 50 years, and a further 13 for which there is a rising threat due to increased use (e.g. many of the rare earths).

The European Commission concluded on critical raw materials in the circular economy (1) the need to **improve recycling rates** for critical materials, some of which today are as low as 1% or non-existent (see below). Consumer goods are an important source but the elements (typically metals) are distributed at low concentrations over a wide range of products which have to be collected for recycle. There is substantial potential for improving recycling. It requires a different approach from the broad targets previously applied to the recovery rates of bulk materials. Mixed recycling in broad categories needs to be avoided. Policies for product-centric collection and recycling must be implemented. Options include deposit schemes, including return and recycling costs in the purchase price, trade-in which offers a financial reward for return, or contractual obligations.

Recycling requires technology infrastructures that can recover metals from complex mixtures to ensure their cyclical use. In product design the complexity of recycling should be considered and incompatible metal mixtures that hinder recycling should be avoided. Consumer convenience and esthetics may have to be sacrificed to facilitate recycling. We will need to seek engagement of consumer groups in a dialogue on ways of reducing or eliminating such inherent conflicts, so that 'design for resource efficiency' becomes standard practice.

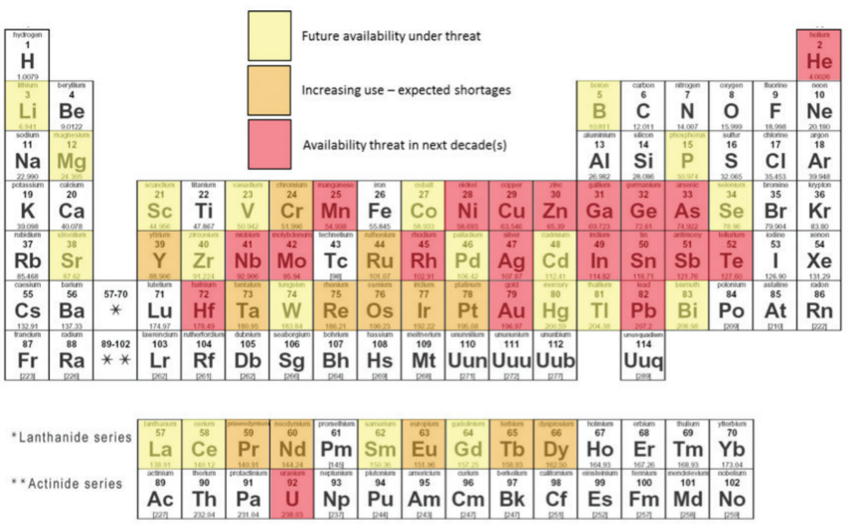

Figure 1. *Elements regarded as critical against risk criteria of supply constraints, demand growth and geographical spread.*

Developing effective recycling technologies will require considerable investment, particularly in the early stages of novel technology deployment. With critical materials, the circular economy policy needs to provide market signals which incentivize all companies to work towards a circular economy.

Let's take a look at some of these at-risk elements: their uses, why their supply is under threat, and what can be done to tackle this problem (2).

Helium. The second most abundant element in the universe is on earth still an endangered element ! The light gas has a range of uses, from supercooling magnets to very low temperatures in MRI machines. The issue is that helium is so light that is is able to escape the Earth's atmosphere with ease, meaning the amount of helium on Earth is constantly declining. We could have as little as 25 years of helium remaining, based on current rates of use. Despite the future likely scarcity of helium, it is still cheap. Higher prices will incentivise recycling.

Indium. Used in touchscreen phones and tablets as indium tin oxide. The amount of indium present in a particular device is actually rather small, often only as much as a few hundred milligrams or less. This means that work is needed in order to work out an efficient way of recovering the indium from scrapped devices. Another alternative is to use another material as a substitute. Other elements that may see demand higher than supply due to their usage in electronic devices are **gallium, silver, germanium and arsenic.**

Palladium, rhodium and platinum find major uses as catalysts for chemical reactions or in catalytic converters found in cars to help clean exhaust gases. Supplies have struggled to keep up with demand, so prices have risen, and catalytic converter designs are changing. However, currently good alternatives to the platinum-group metals for application in converters are rare. Electric cars do not have this problem.

Rare Earth Elements. The rare earth elements are those in the top row of the two removed rows at the foot of the periodic table. There is a concern about neodymium and the majority of the rare earth elements about future supply. They have a range of uses in electronic devices and powerful magnets (headphones and computer hard drives). The rare earth elements tend to occur together, and separating them from each other is difficult. The demand for rare earth elements is predicted to be fast outpacing the supply, and this will cause a problem. Recycling of these elements is still in its infancy.

Only 18 elements in the Periodic Table have recycling rates of 50% or more (Fe, Al, Cu, Zn, Ag and others); Mg, Mo and Ir have recycling rates between 25 and 50%; W, Ru and Cd have recycling rates between 10 and 25%; Hg and Sb have recycling rates between 1 and 10%. All other elements, including all Rare Earth metals, B, Ga, Zr, Hf, Os, As, Te etc. have recycling rates below 1%. As we can be certain that recycling of all these elements will be important in a circular economy, this field will have lots of opportunities for technology development.

In the next issue of Chimica Oggi / Chemistry Today I will talk about the use and recycling of phosphorous.

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