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Circular Economy: emblematic case studies in Brazil

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Abstract

Considering the current industrial model "to extract, to manufacture and to discard", the circular economy is restorative and regenerative by definition. Based on innovation in experimental processes and procedures, it aims at redefining products and services to minimize the disposal of materials with high added value, minimizing the negative impacts. Sustained by a transition to renewable energy sources, the circular model builds economic, natural, and social capital.

Going beyond the current industrial extractive model, which aims at extracting, manufacturing and discard, a circular economy bears in mind redefining growth, focusing on positive benefits for the whole society. This implies the gradual decoupling of economic activity from the consumption of finite resources and the conception of system waste generation. Considering today the concentrated effort in the adoption of renewable energy sources, the concept of circular economy waves for the construction of economic, natural and social capital. It is based on three principles: a) Design out waste and pollution; b) Keep products and materials in use; c) Regenerate natural systems.

In a circular economy, economic activity builds and rebuilds overall system health. The concept recognises the importance of the economy needing to work effectively at all scales – for large and small businesses, for organisations and individuals, globally and locally. Transitioning to a circular economy does not only amount to adjustments aimed at reducing the negative impacts of the linear economy. Rather, it represents a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits.

This technical contribution aims at bringing to the scientific community the real impacts on the initiative of recycling metals out of secondary sources, such as: a) precious and base metals from electronic scraps, by chemical and biological processes; b) base metals from mining wastes; c) Aluminium from tetra-pack packing; d) Aluminium from sludge out of the water treatment plants; e) Lead from exhausted car batteries; f) Gold and mercury from wastes out of artisanal small scale gold mines; g) Recovery of precious metals from exhausted automotive catalysts and so on.
Practical Approach of Processing the Metal-Bearing Residues

a) Precious and base metals from electronic scraps

The recovery of precious metals can be accomplished by fragmenting by different ways the circuits-bearing such metals, in the first place, so as to expose, as much as possible, those metals that are coating a base metal substrate. After that a leaching process can be used for dissolving gold and other precious metals (i.e., Ag, Pd and Pt), using, for instance, cyanide, thiosulphate etc., which are further recovered from these leachates as metals.

b) Base metals from mining wastes

The tailings being generated during base metals ore prospection are being considered, nowadays, as primary source due to scarcity of high grade ores. Therefore, the bioleaching of such tailings presents a quite cost-effective way of extracting the remaining metal values as the microorganisms in charge of dissolving the base metals sulphide minerals are natural, and can be found in the acid rock drainage of any mine.
c) **Aluminium from tetra-pack packing**

The tetra-pack packing is made of a combination of several layers of paper, plastic and very thin aluminium foil. The process for recovering the aluminium and the paper is just a physical operation soaking such packing in water under a severe turbulence, releasing the aluminium foil well fragmented, which it is further separated from the paper pulp.

d) **Aluminium from sludge out of the water treatment plants**

The crude water is conventionally treated by adding aluminium sulphate, which in contact with that aqueous phase, in a pH range from 5.5 to 6.5, it hydrolyses producing aluminium hydroxide, which clarify do water generating a sludge bearing clay material and insoluble hydroxides, aluminium hydroxide in particular. Such sludge can be further leached producing a leachate bearing aluminium and iron sulphates, which can be reused back to crude water processing, and solid phase, mainly clay material, can be used to produce ceramics.
e) **Lead from exhausted car batteries**

The exhausted car batteries are initially crushed for liberating the plastic and magnetic materials. The crushed material is washed for removing the sulphuric acid solution bearing lead soluble species and also insoluble lead sulphate and peroxide. The remaining solid phase, mainly lead and magnetic material, goes through a magnetic separator for removing such magnetic phase, and the lead is further melted into ingots.

![Diagram of lead extraction](image)

f) **Gold and mercury from wastes out of artisanal small scale gold mines (ASGM)**

The gold extraction from alluvial gold is accomplished using elemental mercury in a close circuit in amalgamation drums in contact with a gravity concentrate. After finishing such process, the solid suspension in water is poured on top of an elutriator so as to separate the heaviest material (*i.e.*, Hg° + gold amalgam) from the light one, which is virtually the gangue minerals and tiny amount of gold and mercury left. Such light material is further treated by cyanidation solubilising gold and mercury as cyano-complexes. Such leachate is processed conventionally (*i.e.*, adsorption and desorption processes using activated carbon, and electrowinning).

![Diagram of gold and mercury extraction](image)
The exhausted automotive catalyst still has precious PGM metals (*i.e.*, Rh, Pt and Pd) that can be recovered using hydrometallurgical process. In fact, such catalyst has to be fine grinded, and grinded material submitted to a roasting process to oxidize the black carbon to carbon dioxide. Such carbon, the result of the incomplete combustion of fuels, has to be removed, before the precious metals leaching process, so as to avoid de preg-robbing effect, which means the absorption of the just solubilized PGM by the high surface area carbon. The grinded material can, then, be leached by suspending the grinded material in hydrochloric acid adding, gradually, hydrogen peroxide, which generates chlorine gas in the bulk of the suspension establishing the right oxidizing conditions to leach the PGM out.