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INNOVATIVE TREATMENTS FOR RESOURCE RECOVERY FROM WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT

TRATTAMENTI INNOVATIVI PER IL RECUPERO DI RISORSE DAI RIFIUTI DI APPARECCHIATURE ELETTRICHE ED ELETTRONICHE

ABSTACT

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ABSTRACT

The ever-expanding population, the increasing consumption of resources and the shortage of primary raw materials have addressed the transition of waste management strategies from the linear model based on the "wear and tear" on a circular approach aiming at preventing waste and recycling materials. In this view, the attention has been focused on the use of anthropogenic stock resources in place of virgin materials as promoted by the concept of "urban mining".

Waste electrical and electronic equipment (WEEE) is regarded as the backbone stream in urban mining. It represents the waste stream characterized by the highest grow rate per year (3-5%) and by the most wide-ranging source of materials, since WEEE can contain more than 1000 different substances, including base, precious and critical metals.

The recovery of metals defined critical raw materials as rare earth elements from electronic waste appears, thus, an important opportunity both in economic and environmental terms.

However, the recycling of WEEE is challenged by the complex nature of such waste stream which, beside valuable materials, includes hazardous substances as well. The presence of these toxic components has raised great concern especially in developing countries where the informal recycling sector is still widespread, handling WEEE with unsafe and inadequate practices as a result of a lack of legislation.

In high-income countries, separate collection is the first step of a system pursuing the WEEE sustainable management; mechanical processes are then applied to separate the different materials, including metals which are destined to further recycling by means of metallurgical processes.

The metallurgical treatments currently used for metal recovery from WEEE are, however, claimed to have severe impacts on the environment due to the generation of secondary pollutants. Moreover, the industry of WEEE recycling is still in its early stage, especially if referred to the recovery of rare earth elements.

All these reasons have contributed to increase the interest of both scientific and industrial research in addressing a cost-effective and environmental friendly treatment of end-of-life electrical and electronic products.

In this background the present research work aimed to:

- the characterization of WEEE in terms of base and critical metal contents, in order to identify and quantify the valuable materials and the hazardous substances for addressing a sustainable recycling strategy;
- the assessment of critical metal fate during the conventional mechanical treatments of WEEE with reference to the sorting effectiveness and the recycling potential;
- the evaluation of the feasible application of innovative treatments in the field of hydro- and bio-metallurgy for the recovery of valuable and critical metals from WEEE.

To this end, the experimental activity was developed in three main steps, matching the specific objectives of the research project:

- the first phase was focused on the characterization of WEEE in terms of base and critical metals. Representative samples were collected over the treatment chain of a full scale mechanical treatment plant operating in South Italy and analysed by their metal content;
- the data obtained from the metal characterization were, thus, used in the second phase to carry out a mass flow analysis in order to investigate the fate of metals, particularly the critical ones, during the conventional mechanical treatments;
- the third phase focused on hydro- and bio-metallurgical tests for the recovery of valuable and critical metals from WEEE. As the results from the previous phase pointed out that after the conventional mechanical treatments significant concentrations of precious metals and rare earth elements were gathered in dust stream originating from process air cleaning, dust was used as secondary source of critical metals and tested for the treatments proposed. Both chemical agents, including a non-conventional one as thiourea, and biological species were used to perform leaching processes. The use of dust, actually destined to landfill disposal, as well as the treatments investigated for the recovery of critical metals marked the novelty of the research.

The first two phases were carried out at the Sanitary Environmental Engineering Division (SEED) of Salerno University. The hydrometallurgical tests included in the third phase were performed at SEED laboratory as well, whereas the biometallurgical tests were conducted at the laboratory facility of the Institute for water education Unesco-IHE in Delft (Netherlands).

Results of the experimental activity showed that rare earth elements contained in WEEE at trace concentrations do not enter the recovery chain as around 80% in mass were lost in dust streams during the conventional mechanical treatments. Similarly, 24% of precious metals entering the mechanical treatments were conveyed in the dust fraction. Therefore, this matrix appears a potential secondary source of valuable and critical metals to be further processed for metal recovery.

Chemical and biological leaching processes proved their great potential in extracting up to 99% of the critical metals contained in the dust. These promising outcomes suggested that both hydro- and bio-metallurgical processes can be regarded as a suitable option for the management of the dust fractions, which currently represents a cost for the treatment plant. The treatment of dust through these processes provides, indeed, a way to reintroduce this matrix, actually sent to landfill, in the "loop" of product lifecycle, thus limiting the losses of resources in accordance with the new circular economy approach. Moreover, the results of this study are of relevant interest as they highlighted the potential of recovering valuable and critical metals from waste streams using low-cost and environmentally friendly processes in the filed of biometallurgy as an effective alternative to both pyrometallurgical and conventional chemical processes, especially for treating low grade materials as WEEE.