SHORT COMMUNICATION

INTERNATIONAL RESEARCH JOURNAL OF
MULTIDISCIPLINARY TECHNOVATION

DOI: 10.34256/irjmt2126

Biomining in the post-COVID-19 circular bioeconomy: a "green dispute" for critical metals

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DOI: https://doi.org/10.34256/irjmt2126
Received: 10-03-2021, Revised: 13-03-2021, Accepted: 13-03-2021, Published: 14-03-2021

Abstract: In the unparalleled response to the COVID-19 pandemic, many see beyond the pandemic a rare opportunity to build a resilient and low-carbon economic recovery. In this context, the circular economy represents a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits. The COVID-19 pandemic was a tipping point for many sectors that boost economies worldwide, mainly to mining sector. In the midst of the health and economic problems arising from the current crisis, several countries are moving ahead and outlining post-COVID-19 strategies for the supply of critical metals, which in the short term will be based on biomining.

Keywords: Biomining, Bioeconomy, Circular Economy, Urban Mining, COVID-19.

1. Introduction

Access to mineral resources is a matter of strategic security and autonomy in most countries. Minerals considered raw materials of greater economic importance and high risk of supply shortages are critical minerals. Critical minerals are fundamental to the development of green technologies, including the production of energy through wind turbines and electric vehicles, which will ensure that the world meets the goals of sustainable development SDG-ONU [1].

The vast majority of developed countries, including the G-7 countries, have gaps in their natural mineral reserves and mining capacities for critical metals and their ability to obtain them from secondary sources. The COVID-19 pandemic fully exposed the vulnerabilities of global value chains characterized by high interdependencies between leading global countries and supplier countries located on different continents [2]. With the implementation of stringent measures across the globe that caused borders to close, the COVID-19 crisis has led many parts of the world to look critically at how they organize their supply chains, especially when it comes to strategic metal supply sources.

In 2020, in the face of the COVID-19 pandemic, the USA, the European Union, the United Kingdom, and India, among others leading global countries, have listed their critical minerals and have set goals to reduce their dependence on the import of these critical raw materials (CRM) [3,4]. The US recognized that it could no longer depend on imports of critical minerals from other countries, which are increasingly necessary to maintain its economic and military strength in the 21st century; for 31 of the 35 critical minerals considered essential, the US imports more than half of its annual consumption [5].

However, it is not the first time that global supply of a metal has been disrupted. Cobalt (Co), palladium (Pd), and Rare Earth Elements (REEs), e.g., can be cited as previous metal supply constraints for geopolitical questions [6]. In general, the economic damage from the 2020 COVID-19 crisis may exceed that of the last critical 2008 global financial crisis, including mining sector. Overall damage by COVID-19 was 1.248% (the annual GDP%) for 4 months; 1.4 times that of the 2008 crisis [7]. After September 15, 2008, the decline in industries including coal, precious metals, non-metallic and industrial metal mining, petroleum and natural gas, and fabricated products was persisting [8]. In COVID-19 scenario highest risks were observed for precious metals such as gold (Au), rhodium (Rh), platinum (Pt), and Pd due price volatility or weakening of environmental regulations, as well as the positive effects related to increased demand for "safe-haven" assets. Geopolitical tensions have caused problems in the global supply of Co, gallium (Ga), and REEs [9,10].

These metals are characterized by energy-intense manufacturing and highly concentrated geographic production, suggesting that recycling and supply chain diversification may alleviate some of the identified risks [9]. Adopting the circular economy principle will alleviate some of the detrimental effects of COVID-19 pandemic in the future [11]. Based on the principles of the circular economy, the risk of supply of CRM is increasing pressure on governments to expand the capacity to mine and extract these materials from low-grade ores and primary concentrates, as well as optimizing the recovery and recycling of waste electrical and electronic equipment (E-waste).

2. E-Waste

E-waste refers to discarded devices at the end of their economic use and can no longer be used by consumers. E-waste constitutes the most considerable fraction of the fastest growing municipal waste. According to recent statistics, 53.6 million tons of E-waste was produced in 2019, and its value was estimated at USD 57 billion due to metals with economic value. It is estimated that 17.4% of this amount was recycled, generating USD 10 billion [12]. High-value E-waste contains precious metals like silver, gold, platinum group metals, and rare-earth elements (REE), which are considered CRM. REE recycling is estimated at <1% around the world. One of the main obstacles to recycling these elements is that the amount of REE in end-of-life products varies from lower mg to several kg.

E-waste is currently treated in high-temperature pyrometallurgical facilities to recover the valuable metallic fractions or use some hydrometallurgical process mimicking the unit operations used in primary ore extraction metallurgy. With the scarcity of primary resources and the increasing need to extract metallic values from complex mineral phases or reserves with low-grade or secondary sources such as E-waste, processes based on microbial activity present themselves as emerging technologies for the supply of strategic metals and minerals [13].

In this way, some bio-hydrometallurgical processes have also been evaluated for their feasibility in composing the production chain for the extraction of metallic elements from e-waste, especially because bioprocesses present lesser demands regarding the use of chemical reagents and energy consumption, as well as, in general, contribute to the sustainable character of the process [14].

3. Bioleaching

Bioleaching is a bio-hydrometallurgical process performed by different microorganisms (fungus and bacteria) with the ability to secret inorganic or organic acids or cyanide, enhancing oxidation-reduction reactions, proton-promoted mechanisms, and ligand and complex formation [15]. Mainly advantages of biomining methods comprise the high specificity, cost-effectiveness, and environmental acceptability. Bio-hydrometallurgy is already an established route to process low-grade primary ores and may play an essential role in the urban mining of CRM in the future in a circular bioeconomy concept, as shown in Figure 1.

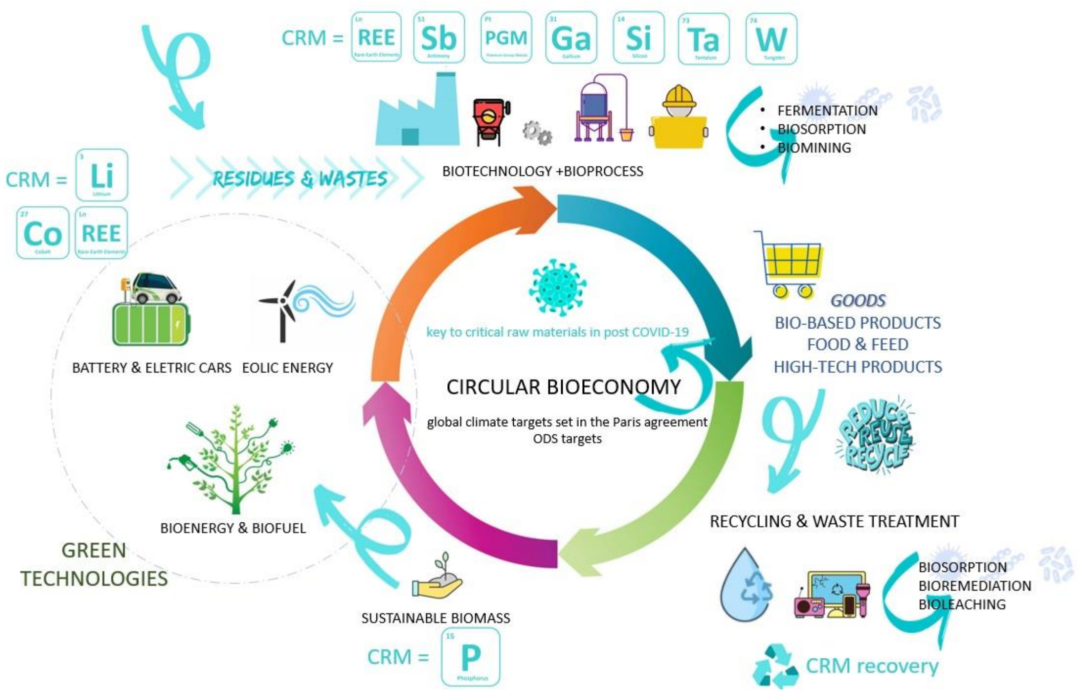

Figure 1. Suggested arrangement of sectors involved in circular bioeconomy focusing on biomining and mainly critical raw materials (CRM).

4. Biohydrometallurgy and Bioeconomy

In the last two decades, biotechnology has played a leading role in allowing the development of sustainable industrial processes that have resulted in a diverse range of innovative products and processes. A transition from conventional mineral extraction methods to bio-based methods has been attempted in the most different areas. Bio-hydrometallurgy is present in the 2030 Agenda for the bioeconomy proposed by the OECD, with actions for the development of new mineral processes based on microbial activity and the implementation of new bioleaching plants. Industrial activities should be conducted in the short term within a mineral bioeconomy agenda [16].

The bioeconomy is based on the innovative use of sustainable biological resources to cover the growing demand from the food, energy, industrial sectors, and environmental preservation. Its concept includes developing efficient bioprocesses to support sustainable production and integrating biotechnology applications between different sectors.

Access to mineral resources is a matter of strategic security and autonomy for a large number of countries. The COVID-19 crisis has prompted many parts of the world to critically analyze how they organize their supply chains, especially concerning CRM sources. The vulnerability of CRM value chains affects all industrial ecosystems and requires a more strategic approach, such as enabling new international agreements and exploring alternative sources of supply in the event of disruptions, as in this current uncertain scenario.

The scarcity of mineral raw materials has been driven by population growth and increased consumption patterns, especially in high-tech industrial sectors. In the coming years, due to the effects of the COVID-19 pandemic, the growing demands for CRM will boost urban mining, expanding the development of new technological routes based on biometallurgy to extract, separate, purify and recover critical metals from E-waste.

The search for emerging energy-saving technologies combined with low-carbon circular economic policies is crucial for re-establishing the economic and productive sectors in post-COVID-19. The current economic models and their needs in terms of resource exploitation do not guarantee the continuous use of natural and mineral goods to meet today's technological demands and, at the same time, provide the benefits of a sustainable life. For example, the SDG premises were based on globalization and sustained economic growth. COVID-19 brought to light that the SDGs as currently designed are not resistant to shocks imposed by pandemics; the projection is that two-thirds of the 169 targets will not be met by 2030 to the associated impacts. The bioeconomy emerges as a solution to guarantee long-term economic and environmental sustainability, promoting natural resources in the most different sectors.

5. Conclusion

In view of the imminent scarcity of critical metals and the need for them to run different productive sectors, and even in the COVID-19 pandemic environment, many countries realized the problem and developed ambitious plans aimed at increasing the resilience and autonomy of the advanced productive sectors. seeking to ward off any threats to their national sovereignties. The need to react to the COVID-19 crisis is a unique opportunity to transform our economy and put forward the change that our society needs to create a sustainable and desirable future. A circular bioeconomy offers game-changing solutions and is a crucial concept to move towards a carbon-neutral, renewable and inclusive economy that prospers in harmony with nature.

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Acknowledgement

CNPq nº 303301/2020-1.

Funding

No funding was received for conducting this study.

Conflict of interest

The Author has no conflicts of interest to declare that they are relevant to the content of this article.

Does the Article Screened for Similarity?

Yes.

Author's contribution

Both the authors equally contributed to this work.

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Cite this Article

E.C. Giese, Biomining in the post-COVID-19 circular bioeconomy: a "green dispute" for critical metals, International Research Journal of Multidisciplinary Technovation, 3(2) (2021) 35-38. DOI: https://doi.org/10.34256/irjmt2126