Crimson Publishers
Wings to the Research

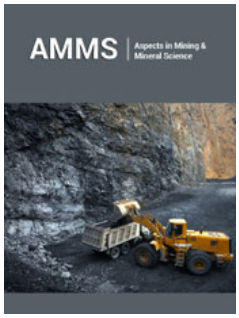
Research Article

On-Going Circularity Practices in the Latin-American Mining Sector

Gabriela Munoz-Melendez*

Department of Urban and Environmental Studies, The College of the Northern Border, Mexico

ISSN: 2578-0255



***Corresponding author:** Gabriela Munoz-Melendez, Department of Urban and Environmental Studies, The College of the Northern Border, 18.5 km Scenic Highway Tijuana-Ensenada, Tijuana, B C 22560, Mexico

Submission: April 09, 2025
Published: April 25, 2025

Volume 13 - Issue 3

How to cite this article: Gabriela Munoz-Melendez*. On-Going Circularity Practices in the Latin-American Mining Sector. Aspects Min Miner Sci. 13(3). AMMS. 000814. 2025.
DOI: 10.31031/AMMS.2025.13.000814

Abstract

Historically, Latin America (LAC) has based development on the exploitation of its abundant natural resources, in particular minerals and metals. Moreover, for the last four decades the primary export model has been followed to describe its reality. In such, mining plays a relevant role because of being an indirect and direct job generator, investment attractor and foreign exchange source. However, the mining sector has a long record of negative impacts on the environment and local communities. Given the increasing importance of mining in the energy transition; is worth asking, how sustainable could be the expansion of mining in the region? Trying to address this question, this paper aimed to identify ongoing circularity practices in the mining sector in LAC by means of literature review. Results show there are extremely few examples of circularity applications, revealing there is an ample potential to adopt circularity, it should be stressed that hindering factors persist. Moreover, it is still to be seen that circularity adoption in the mining sector could contribute to a just energy transition in LAC

Keywords: Circular economy; Mining; LAC; Ongoing circularity practices

Introduction

Natural resources are abundant in Latin America and the Caribbean (LAC), one third of freshwater resources, 23% of forests, 20% of oil reserves, and 4% of natural gas worldwide are in the region; although in a differentiated distribution [1]. Despite such natural resources' richness, its exploitation has not leaded to socioeconomical development. This regional dichotomy, and how abundance turn into a blessing or a curse, is in function of distortions that could be classified into three categories [2]:

a. Economical, biases due to limited diversification of economic activities, and maladministration of the volatility of international commodity prices, external debt and costs due to socioenvironmental conflicts.

b. Political, wicked problems related to low quality institutions, corruption, uneven distribution and poor management.

c. Social, challenges generated by the lack of education policies and conflicts associated to extractive activities.

It has been affirmed that the current model of primary exportation adopted in the region, is highly vulnerable to the economic cycle of develop nations and the adverse movements of current exchange. Thus, and given the inability to translate abundance exploitation into established periods of prosperity and development; the Latin-American economic model has been considered exhausted [3], and as irrefutable evidence are the lack of technical innovation, increasing inequality, poverty, environmental degradation and the outbreak of conflicts. Under this scenario, what will be the future role of mining? the extractive activity par excellence, historically caried out in the region. Furthermore, facing the current climate crisis, and the urgent need for a global energy transition, a vast amount of critical minerals will be required,

as those of copper, nickel, cobalt, lithium, and rare earths. It has been estimated that the demand for critical minerals will -at least- double by 2030 [4] in comparison to 2023 levels. Many of such substances are in LAC, see Table 1.

Table 1: Percentages of LAC critical minerals in global production and reserves by 2024. *Rare Earths Source: prepared by the author using [5].

LAC Country	Global Production, %					Global Reserves, %				
	Cu	Co	Ni	Li	RE*	Cu	Co	Ni	Li	RE*
Argentina	---	---	---	4	---	---	---	---	20	---
Bolivia	---	---	---	---	---	---	---	---	20	---
Brazil	---	---	2.2	3	0.1	---	---	12.2	1	23.1
Chile	23	---	---	20	---	19	---	---	10	---
Cuba	---	1	---	---	---	---	5	---	---	---
Mexico	3	---	---	---	---	5	---	---	1	---
Peru	11	---	---	---	---	10	---	---	1	---
Total	38	1	2.2	27	0.1	35	5	12.2	53	23.2

As seen, LAC countries could play a relevant role as providers of critical minerals worldwide, is worth asking, how sustainable could be the expansion of mining in the region? A regional roadmap has been proposed, this identifies 20 interventions to be carried out by governments in the regions to lay foundations for a common understanding as well as to address weaknesses [5]. Such recommendations come from a study to promote sustainable mining in LAC, applying the Environmental, Social and Governance (ESG) conceptual framework, by mean of evaluating local legislation and regulations versus international mining standards such as the standards of Towards Sustainable Mining (TSM), good practices of the International Finance Corporation (IFC), the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF), the Fraser Institute and the Natural Resources Governance Institute (NGRI). Such exercise showed that there are large opportunities for improvement in efficient use of water and energy, conservation of biodiversity, climate change issues and greater community participation. In addition, the adoption of principles of circular economy and waste management, were found to be potentially beneficial in the management of tailings, mine closure and environmental impacts, as well as to incorporate traceability, digitalization and transparency [6]. Trying to find out about the advances in the circular economy adoption in the region, this paper start presenting the details of the method applied to retrieve data, then circularity practices in the mining sector in Latin America are presented, followed by the discussion of outcomes. Finally, this document closes providing final reflections.

Methodology

A systematic literature review was carried out in three steps; the first was data retrieval from online bibliographic databases, such as Google scholar, Scopus, Taylor; using keywords: mining + "Latin America" + "circular economy" OR circularity OR closed-loop OR "material circularity" OR reuse OR refuse OR repurpose OR recycling in the period 2020-2025, in English and Spanish; through this exercise 5110 documents were identified. In addition, grey literature such as corporate reports, webpages, etc. were collected. The second step was to filter documents to those whose content included the description of ongoing circularity practices in the mining sector, leaving 12 documents: four papers, three websites and five reports. The last step was data analysis.

Result

By 2023, it was reported that there was <1% of circularity in LAC nations [7]. Though it has been recognized that the circular economy model provides a chance to reduce environmental and social impacts of the mining industry [8]. And there are reports on circularity practices; for example, bioleaching to extract copper has been used in Chile since 1980s in those early days it was applied to extract copper from low grade ores. Bioleaching application in the processing stage has increased and is reducing waste from ore-tailings although concentrations of arsenic and chloride in copper ores are challenges [9]. A second example is the reprocessing of fresh and old tailing to recover valuable metals; in Minera Valle Central, copper and molybdenum are recovered from tailings from Codelco Chile, División El Teniente. The treatment plant processes nearly 130,000t/day tailings with 0,12% of total copper [10].

On the other hand, a different circularity case is mine tailings recycling into construction products; such as the abode-liked bricks using soil, tailings and cement for community purposes in Huancavelica, Peru, a mercury contaminated site due to activities in the Santa Barbara mine; however, a study proved that there was risk of human exposure to mercury due to ingestion and inhalation of contaminated particles; this research concluded that remediation actions should be put in place [11]. A second intent to recycle mine tailing took place in Chile to make eco-cobble [12]. While these actions have potential to growth, environmental, health and social implications are usually ignored by miners, community members and researchers [13]. There are advances in the research of using mine tailings in the production of construction products [14] application is lagging. In relation to carbon footprint, mining industries have opted for electromobility, in Chile and Peru. For the

first country, 300 electric vehicles have been acquired for mining operations and there is the plan to change 1000 mining loaders from diesel to electricity to achieve zero carbon emissions by 2040 [15]. Also in Chile, recycling from lead-acid batteries is carried out, 4500 units are treated daily [16].

Regarding the high-water demand in the copper mining industry, Chile is changing the use of freshwater for desalinated water, 14 desalination plants operate in mining sites, mainly in the northern dry regions [17]. On the other hand, in this country, the application of tailings dewatering technologies to increase water recovery from tailings to reduce water losses in tailings storage facilities caused by evaporation, infiltration, and retention in pore voids: and reuse is applied [18]. The reuse of treated wastewater in copper mining is taking place since 2019 in the Mexican Buenavista Mine, this activity started in 2019 and currently covers 77% of water demand, the rest is provided by fresh water sources. The source of treated wastewater is the Municipal Government of Cananea, Sonora; northern Mexico. The consumption of treated wastewater reaches 1,000,000m^3/year (equivalent to the consumption of 1,800 families) [19].

When placing circularity practices in the mining stages [20], see Figure 1, it could be observed that most practices take place in the operation activities first and the closure phase second. Leaving the early three phases without any attention. As noticed in Figure 1, some flows of the operation phase such as treated wastewater and tailings dewatering are clearly circular, as they closed an activity; the former is an inflow from a Municipal Wastewater Treatment Plant, while the latter is an internal flow. It is not that apparent how bioleaching and electromobility close a cycle, but both reduce tailing volumes and atmospheric emissions. However, the desalinated water inflow is not intrinsically circular [21]. By its part, under the Closure, Rehabilitation & Reclamation stage, the external outflow of tailings recycling into construction products is circular but must be proven harmless and stable. Finally, the inflow/outflow reprocessing of fresh and old tailings is partially circular as could reduce its volume.

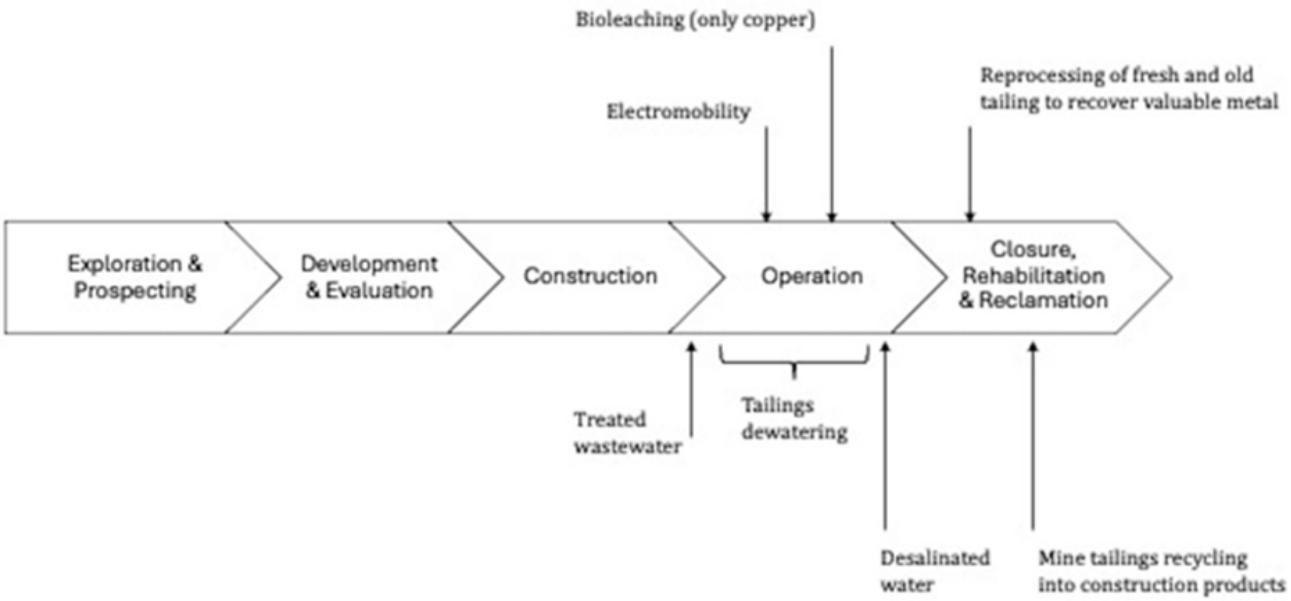


Figure 1: Circularity practices developed in each mining stage. Source: prepared by author.

Discussion

Despite the numerous reports, technical studies and papers on circular economy strategies on mining in LAC, 5,110 documents to be precise, identified during the step of data retrieval. There are in fact extremely few cases of circularity applications; and the reasons behind could be to barriers identified and classified into [22]:

a. Political: Lack of governmental incentives and support to increase resource efficiency, Lack of enforcement, monitoring control, and impunity for noncompliance with environmental regulation, Excess of bureaucracy, Scaling challenges.

b. Economic: Industry resistance to eco-friendly practices due to cost concerns, Lack of economic instruments to discourage final disposal and promote waste recovery.

c. Social: Insufficient stakeholder cooperation schemes, Inefficient communication, the circular economy is still in the early stages in the region.

d. Technological: Low level of readiness of locally available technology and dependence on imports, Lack of interconnection with other technological tools.

e. Legal: Lack of regulation and regulatory frameworks for mining-environmental practices, Inefficient handling.

f. Environmental: High rate of waste generation and low recycling rates, Lack of monitoring of the level of contamination of natural resources, Risks of environmental contamination by the informal recycling sector, Mishandling and mismanagement of hazardous wastes.

This study showed that there is an ample opportunity to design and implement circularity actions in the mining industry in LAC. Saying this and trying to address the initial question of how sustainable could be the expansion of mining in LAC; a second question arise; do we need to continue the development of extractive mining to achieve the transition to clean energy? Now with a couple of questions to answer, one should not shy away from the criticism made to Green Mining or Circular Mining of being utopian or an oxymoron due to the own nature of the sector and its long record of exploitation of workers, displacement of communities, intensive consumption of water and energy, pollution and mine abandonment. However, it is precisely due to all these issues that the mining industry must improve [23] in a feasible and realistic way.

Coming back to our search for answers and taking into account we are under the paradigm of energy transition to decarbonize the global energy matrix, we should distance from framing such transition under "energolatry", this is the cult to energy that dominates the occidental interpretation of the type of energy needed for production, competition, development and domination [24], and undertake a profound rethinking that energy transition goes beyond electromobility and the penetration of renewables on the energy matrix to generate electricity; and find a new definition of energy that is self-sufficient, autonomous, sustainable, distributed, communitarian, participative and inclusive [25-27].

But, attempting to respond our two questions and others that have not been formulated yet, we need to avoid that one dominant future emerges and consolidates in the detriment of other futures, particularly in the places from which the critical minerals for the transition are extracted [28]. One needs to embrace the hypothesis that only under an "integral" conception that contemplates its environmental, economic, cultural and political edges is it possible to deploy the transformative potential that the just energy transition contains [29].

Conclusion

This study aimed to identify the advancement of circular economy initiatives in the mining sector at Latin America, by means of the presence of ongoing circularity practices. This was done because of the potential role that Latin American countries could play as critical minerals provider worldwide. A literature review revealed there are in fact few cases of circularity applications; most of them are carried out in copper mines in Chile, and include: bioleaching, tailings valorization, use of desalinated water, change of diesel loaders and gasoline cars for electric vehicles. There are additional circularity practices elsewhere, for example the use of mine tailings to make construction products in Peru and the reuse of treated wastewater in a Mexican copper mine. It is possible that further circularity practices are in place but not documented enough to be noticed, all in all there is ample opportunity to design and implement circularity actions in the mining industry in LAC. But even if these increase, extend and upscale, the model of energy transition that LAC countries should adopt should be a just energy transition that addresses all problems related to but not limited to the mining sector in order that the abundance of critical minerals does not turn into a curse.

References

1. Economic Commission for Latin America and the Caribbean (2020) Infographic: Natural resources: Challenges and opportunities for sustainable development in Latin America and the Caribbean.
2. Altomonte H, Sánchez JR (2016) Towards a new governance of natural resources in Latin America and the Caribbean. Santiago: Economic Commission for Latin America and the Caribbean.
3. Gudynas E (2020) The exhaustion of development: ECLAC's confession. Rebelión-Economy.
4. International Energy Agency (IEA) (2023) Critical Minerals Market Review.
5. U S Geological Survey (2025) Mineral Commodity Summaries 2025. p. 212.
6. Rojas-Hayes C, Casas JE, Sucre CG (2023) Green mining in Latin America and the Caribbean: Comparative analysis of public policies and industry standards to promote sustainability in mining. Inter-American Development Bank Technical Note; 2697.
7. Circle Economy Foundation (2023) The Circularity Gap Report.
8. Schröder P, Albaladejo M, Alonso Ribas P, MacEwen M, Tilkanen J (2020) The circular economy in Latin America and the Caribbean. Opportunities for building resilience. Research Paper. Energy, Environment and Resources Programme. Chatham House, London.
9. Sasson A, Malpica C (2017) Bioeconomy in Latin America. New Biotechnology 40(A): 40-45.
10. Henriquez A (2022) The arrival of the circular economy in primary mining in Chile, Peru, and Colombia. Center for Copper and Mining Studies (CESCO), CIRCULARTE, Mining Innovation of Peru, Center for Innovation and Circular Economy (CIEC).
11. Thoms B, Robins N (2015) Remedial Investigation Huancavelica Mercury Remediation Project Huancavelica. The Environmental Health Council, Peru.
12. Tierramarillano, Chile (2019) Mujer Impacta Atacama produces eco-paving stones from mining waste.
13. Velásquez JR, Schwartz M, Phipps LM, Restrepo-Baena OJ, Lucena J, et al. (2022) A review of the environmental and health implications of recycling mine tailings for construction purposes in artisanal and small-scale mining communities. The Extractive Industries and Society 9: 101019.
14. Méndez D, Guzmán-Martínez F, Acosta M, Collahuazo L, Ibarra D, et al. (2022) Use of tailings as a substitute for sand in concrete blocks production: Gravimetric mining wastes as a case study. Sustainability 14: 16285.
15. Banamericas (2025) How electromobility will drive the transition to green mining in Chile.
16. Recimat (n.d) Responsible Circular Economy.
17. Altaley (2021). 2021 Green Mining. Opportunities and Challenges. Alta Ley Corporation, Chile.
18. Cacciuttolo C, Atencio E (2022) Past, present, and future of copper mine tailings Governance in Chile (1905-2022): A review in one of the leading

mining countries in the World. International Journal of Environmental Research and Public Health 19(20): 13060.

19. Van Hoof B, Núñez G, de Miguel C (2023) Scaling up circular economy initiatives in Latin America and the Caribbean. Project Documents (LC/TS.2023/39), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).
20. Hughes W (2021) The stages of mining: 5 lifecycle processes explained.
21. Ribeiro JM, Renfew D, Nika E, Vasilaki V, Katsou E (2025) Towards circular desalination: A new methodology for measuring and assessing resource flows and circular actions. Water Research 274: 123126.
22. Gallego-Schmid A, López-Eccher C, Muñoz E, Salvador R, Cano-Londoño NA, Barros MV, et al (2024). Circular economy in Latin America and the Caribbean: Drivers, opportunities, barriers and strategies. Sustainable Production and Consumption 51: 118-136.
23. Library of the National Congress of Chile (2021) Green mining and the challenges for a sustainable mining sector. Minutes Series No. 60-21.
24. Bernardi F (2011) After the future, AK Press, Oakland, CA, USA.
25. Akizu O, Bueno G, Barcena I, Kurt E, Topaloglu N, et al. (2018) Contributions of bottom-up energy transitions in Germany: A case study analysis. Energies 11(4): 849.
26. Bertinant P (2016) Just energy transition. Thinking about energy democratization, Analysis No. 1/2016, FES Sindical, Friedrich Ebert Stiftung.
27. Nordlund L (2008) Foundations of Life.
28. Weinberg M (2023) The off-sites of lithium production in the Atacama Desert. The Extractive Industries and Society 15: 101309.
29. Fornillo B (2018) Towards a definition of energy transition for South America: Anthropocene, Geopolitics and Post-Development. Prácticas de Oficio 2(20): 46-53.