Energy transition and the role of nature-based solutions in designing new strategies for mining waste reuse coupled with C-sequestration

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Since the dawn of the Industrial Revolution in the 18th century, carbon dioxide (CO_2) emissions have surged exponentially, posing an imminent threat to global ecosystems exacerbated by the escalating rise in temperatures. Climate change is no longer a debate of existence but a race against time to adapt our lifestyles to safeguard our planet and ensure a habitable environment for generations to come. The urgency of this challenge is underscored by the sobering assessment in the 6th IPCC Report of 2023, warning that we stand on the precipice of irreversible consequences.

The primary culprits behind CO_2 emissions on a global scale stem from fossil fuel combustion, industrial activities, agricultural practices, deforestation, and land use changes. Each sector is earnestly exploring avenues within their life cycles to foster sustainable practices, mitigate CO_2 emissions, and bolster carbon sequestration efforts.

The transition towards renewable energy, led predominantly by developed nations, will require vast quantities of metals sourced from the mining industry. Termed "critical metals" (e.g., Li, Ni, Co, Cu, REEs), these metals are indispensable for powering the transition towards battery-dependent vehicles. While electric vehicles do not directly emit CO_2, their extraction processes invariably contribute to emissions, often entailing deforestation and yielding environmentally burdensome byproducts such as mining tailings. Initially, it may seem that carbon sequestration has no place within this industry, with focus seemingly confined to agricultural practices.

Phytoremediation, an umbrella term encompassing the use of plants as natural decontaminants, hinges on mechanisms such as phytoextraction, wherein plants translocate metals from soil into their above-ground biomass. Certain hyperaccumulator plants exhibit an exceptional aptitude for accumulating high concentrations of metals in their aerial parts, thus facilitating enhanced phytoextraction. Harnessing these plants to reclaim valuable resources from mining wastes (e.g., tailings) while concurrently sequestering carbon in below-ground biomass presents not a universal solution for humanity, but a potentially transformative opportunity to integrate nature-based solutions into the formulation of sustainable strategies for the future.

A parallel can be drawn with the regulation of chlorofluorocarbons (CFCs), which appeared insurmountable and economically untenable at the time. However, the Montreal Protocol precipitated substantial transformations within industries reliant on CFCs, catalyzing significant investments in the pursuit of alternatives, resulting in a significant recovery of the ozone layer.