



# The Green Revolution: Mineral Carbon Dioxide Sequestration and the Evolution of Environmental Biotechnology

Henk Witkamp\*

Department of Biotechnology, Delft University of Technology, Delft, The Netherlands

## DESCRIPTION

In the global combat against climate change, innovative solutions are important. Mineral carbon dioxide sequestration, facilitated by environmental biotechnological processes, has emerged as a promising avenue. This article explores the mechanisms, applications, and prospects of mineral carbon dioxide sequestration, highlighting its potential to mitigate climate change and promote environmental sustainability. Mineral carbon dioxide sequestration involves the capture and storage of carbon dioxide in geological formations through chemical reactions with minerals. This process resembles natural weathering processes but is accelerated through environmental biotechnological interventions. Key minerals involved in carbon dioxide sequestration include olivine, serpentine, and calcium and magnesium silicates, which react with carbon dioxide to form stable carbonate minerals.

### Mechanisms of mineral carbon dioxide sequestration

Environmental biotechnological processes enhance mineral carbon dioxide sequestration through several mechanisms.

**Enhanced weathering:** Environmental biotechnological interventions accelerate the weathering of minerals by optimizing conditions such as temperature, pH, and moisture content. This increases the rate of carbon dioxide mineralization, leading to more efficient carbon capture.

**Microbial mediation:** Microorganisms play a vital role in mineral carbon dioxide sequestration by catalyzing mineral dissolution and carbonate precipitation. Certain bacteria, fungi, and algae produce organic acids and enzymes that facilitate mineral weathering and carbon dioxide conversion.

**Bio mineralization:** Biological processes promote the formation of carbonate minerals through bio mineralization, where microorganisms precipitate carbonates as part of their metabolic

activities. This process enhances the storage capacity of carbon dioxide in mineralized products.

### Applications of mineral carbon dioxide sequestration

Mineral carbon dioxide sequestration holds potential for various applications in climate mitigation and environmental management. Mineral carbon dioxide sequestration offers a viable approach for capturing and storing carbon dioxide emissions from industrial sources such as power plants and cement kilns. By converting carbon dioxide into stable carbonate minerals, this process prevents its release into the atmosphere, thus reducing greenhouse gas concentrations. Incorporating carbonate minerals into soil improves its carbon content and fertility, enhancing agricultural productivity and soil carbon sequestration. This approach promotes sustainable land management practices and mitigates soil degradation and erosion. Carbonate minerals in sea water helps buffer pH levels and counteract ocean acidification caused by increasing carbon dioxide concentrations. By replenishing alkalinity, mineral carbon dioxide sequestration supports marine ecosystems and protects coral reefs and shellfish habitats. Carbonated minerals produced through carbon dioxide sequestration can be utilized in various industrial processes such as construction materials, wastewater treatment, and chemical manufacturing. These applications create value-added products while sequestering carbon dioxide emissions, contributing to a circular economy.

### Challenges and opportunities

Despite its potential, mineral carbon dioxide sequestration faces several challenges and opportunities.

**Scale-up and cost:** Scaling up mineral carbon dioxide sequestration processes to industrial levels requires significant investment in infrastructure and technology. Cost-effective solutions must be developed to make these processes

**Correspondence to:** Henk Witkamp, Department of Biotechnology, Delft University of Technology, Delft, The Netherlands, E-mail: henkwitkamp@tudelft.nl

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economically viable and competitive with other carbon capture technologies.

**Technological innovation:** Continued research and development are needed to optimize environmental biotechnological processes for mineral carbon dioxide sequestration. Innovations in bioreactor design, microbial engineering, and mineral processing can enhance efficiency and reduce energy consumption and environmental impacts.

**Environmental impacts:** While mineral carbon dioxide sequestration offers environmental benefits, its implementation may have unintended consequences such as land disturbance, water usage, and ecosystem disruption. Environmental assessments and mitigation strategies are essential to minimize these impacts and ensure sustainable deployment.

**Policy and regulation:** Supportive policies and regulatory frameworks are essential for incentivizing investment in mineral carbon dioxide sequestration and facilitating its integration into climate change preventive strategies. Carbon pricing mechanisms, tax incentives, and emissions trading schemes can promote the adoption of carbon dioxide sequestration technologies.

Looking ahead, several avenues for advancing mineral carbon dioxide sequestration through environmental biotechnological processes can be explored. Integrating mineral carbon dioxide sequestration with other carbon capture and utilization technologies can enhance overall carbon removal efficiency and create synergies between different preventive strategies. Drawing

inspiration from natural carbon cycling processes, biomimetic approaches can be developed to mimic biological carbon fixation and mineralization pathways. With the control of nature, innovative solutions for carbon dioxide sequestration can be realized. Increasing public awareness and understanding of mineral carbon dioxide sequestration is essential for receiving support and engagement. Educational initiatives and outreach programs can raise awareness of the potential benefits and challenges of carbon dioxide sequestration and foster informed decision-making. Collaboration between governments, research institutions, and industry stakeholders is essential for advancing mineral carbon dioxide sequestration on a global scale. International partnerships can facilitate knowledge exchange, technology transfer, and capacity building, increasing progress towards climate goals.

## CONCLUSION

Mineral carbon dioxide sequestration, enabled by environmental biotechnological processes, holds significant potential for addressing climate change and promoting environmental sustainability. By joining natural processes and using technological innovations, this approach offers a pathway towards achieving carbon neutrality and mitigating the impacts of global warming. Continued research, investment, and collaboration are essential to unlock the full potential of mineral carbon dioxide sequestration and increase its adoption as a key climate mitigation strategy.