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CONTENT

ENVIRONMENTAL SUSTAINABILITY

WASTE FROM BAKING SODA PRODUCTION TO BE USED FOR BIOCEMENTATION

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The current cost of the biocementation process prevents its widespread use in civil and geotechnical engineering. The use of industrial waste as raw materials for biocementation not only diminishes the cost of biocement, but also reduces the load on the environment, thereby contributing to its conservation. In baking soda production, for instance, calcium chloride ($CaCl_2$) is generated as a byproduct. Meanwhile, this compound is one of the necessary components for the production of biocement.

The production of baking soda involves several steps, including the utilization of carbon dioxide, CO_2 and ammonia, NH_3. CO_2 is chemically synthesized through the combustion of limestone, $CaCO_3$, in a lime calcining furnace operating at 900–1100 °C. This process yields CO_2 and calcium oxide, CaO. The lime is mixed with water to produce milk of lime, $Ca(OH)_2$, which participates in the ammonia regeneration reaction: $2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2NH_3\uparrow + 2H_2O$ (Rakhmatzhanovna & Ibrokhimovich, 2023).

Calcium chloride finds application in the biocementation process as a source of soluble calcium ions, which in the presence of the enzyme urease and carbamide under alkaline pH conditions form insoluble crystals of calcium carbonate, which leads to clogging of pores and channels in building materials, increasing their strength and reducing hydraulic conductivity.

Contemporary research has identified two primary methods for biocementation utilizing urease: microbial precipitation and enzyme precipitation (Ivanov & Stabnikov, 2020). Microbial precipitation of calcium carbonate relies on urease-producing microorganisms, for example, such as bacteria as *Bacillus subtilis*, *Sporosarcina pasteurii,* and *Yersinia* sp. This method faces challenges due to the high cost associated with cultivating these microbes. Additionally, there's a concern about potential microbial contamination of the environment. Enzyme precipitation involves utilizing urease derived from various sources, primarily plants of such families as *Fabaceae* and *Cucurbitaceae*. Modern research is drawing attention to the potential use of urease extracted from the leaves (*Morus alba*), roots (*Glycine max*), and shoots (*Zea maize* L.) of certain plants, which are considered agro-industrial waste. This method is more environmentally friendly compared to microbial precipitation.

Indeed, integrating multiple approaches, such as utilizing $CaCl_2$ from soda production and plant-derived urease, can yield significant benefits. This combination has the potential to reduce costs while simultaneously enhancing the environmental friendliness of the biocementation process.

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