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A review of mineral carbonation by alkaline solidwaste

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ABSTRACT

Anthropogenic activities represent a major cause of substantial carbon dioxide emission into the atmosphere, which has given rise to the phenomenon of global warming over the last decades. In this respect, it is of significance to utilize novel technologies to reduce and remove carbon emissions. Mineral carbonation is a sequestration method that can fix CO_2 in alkaline materials permanently. Carbon Capture and Storage (CCS) is one method of reducing carbon emission. It is, mainly, a three-step process: (a) CO_2 produced at power stations or industrial plants/places is captured; (b) it is transported by ships, tracks, or pipes; and (c) in the storage step, CO_2 is injected into underground rocks or to the depth of the oceans to be stored permanently. CCS is currently used on a smaller scale for economic reasons. Carbon Capture and Utilization (CCU) may solve this problem. In this method, CO_2 is captured at power plants, like coal-fired plants, to be reused in producing valuable products. CCU and CCS can be applied to ensure direct and indirect carbonation. Alkaline solid wastes containing Ca and Mg including red mud, cement waste, steel slags, potassium waste, copper waste, and MSWI are utilized in capturing CO_2. Industrial wastes are highly suitable for carbonation because they are accessible at industrial plants and do not need costly pre-treatments. Besides, industrial alkaline wastes are hazardous to the environment due to heavy metal contamination (e.g., Se, Mo, V), especially if they are released in water resources or in case the slags are scattered through the wind. Moreover, storing these materials is too costly; alternatively, they can be used in carbonation processes. CO_2 neutralizes these alkaline materials, thus resolving two issues at the same time. A diverse range of experiments, each with a different efficiency rate, have been conducted to implement the carbonation process under different conditions. This study presented a comprehensive review of the mineral carbonation process by alkaline industrial waste and the capacity of each of the methods and conditions required for the operation. Energy balance and mass balance were investigated to compare different alkaline industrial wastes as a source for the carbonation process.

1. Introduction

In recent decades, emission of greenhouse gases (GHG) into the atmosphere has increased significantly, and CO_2 is the major contributor to GHG which is the main cause of climate change. Anthropogenic activities and use of fossil fuels in various fields, such as power plants, constitute the main causes of CO_2emission. Also, greenhouse gas emissions continue to rise with a high CO_2 concentration, which has been growing from about 360 ppm in the 19th century to about 419 ppm in 2021. Global warming is directly related to greenhouse gas emissions, especially CO_2. As the emission intensity of these gases increases, the process of global warming is intensified. These factors have given rise to the Kyoto Treaty and the subsequent Paris Agreement between the developed and developing countries (Azadi et al., 2019). Based on overall estimations and research, the earth's surface temperature has increased by about 0.8 C over the last century (Azdarpour et al., 2015). CO_2 is the most important greenhouse gas released into the atmosphere due to the burning of fossil fuels. Yet, due to the dependence of the global economy on fossil fuels as the main source of energy, they are utilized by power plants in large quantities. The production rate of this gas by the power plant is about 23 Gton CO_2/Year, which generally accounts for about 26% of the total CO_2 input into the atmosphere. As a result of these factors, much effort has been made to reduce CO_2 emissions or concentration in the atmosphere to decrease the rate of global warming. In addition to these efforts, the focus is to increase the efficiency of energy produced, control energy, and minimize energy wasting. The use of non-carbon renewable energies such as wind energy, solar energy, and biomass energy are some of the examples of these

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