

Review

Recycling Clay Waste from Excavation, Demolition, and Construction: Trends and Challenges

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Abstract: The recycling of clay waste from construction debris highly depends on the chemical and mineralogical composition of the waste. Clays and clay minerals are known to be among marginal construction waste, representing an interesting opportunity and platform to produce other low-cost and low-carbon materials due to their possibilities for functional material design, such as adsorbents, drug delivery, catalysts and photocatalysts, and nanocomposites. The present review analyzes a wide variety of mechanisms for encapsulating organic and inorganic species between the layers of clay minerals. Through the compilation of advances in acid activation, exchange of inorganic cations, intercalation, and pillarization, new applications for clay materials are generated, paving the way to a nanometric world with functional, magnetic, adsorption, and catalytic capabilities. New trends are consolidated in the reuse of recycled clays in infrastructure projects, such as hydraulic concrete, water purification, soil fertility, pigments and paints, food packaging and storage, and ceramic appliances. It is concluded that clay waste is suitable to reuse in many industrial products and construction materials, enabling a reduction in the consumption of raw materials.

Keywords: clay waste; adsorption; marginal construction waste; clay recycling techniques; recycling; nanostructure



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1. Introduction

Topics such as large-scale pollution [1], water scarcity [2], climate change [3], and particle matter derived from contamination [4] are now of concern not only for scientists and politicians but also for many people interested in sustainability worldwide [1]. Construction materials include concrete, soil, steel, pavement, and others, which contribute by weight and volume to the biggest industry of manufacturing in the world. As construction continues and the population increases, there is more demand for these materials, which are finite, and therefore we must pursue their recycling and reuse. Among all pollutants [5], the civil construction industry is responsible for a significant amount, with a production equivalent to one ton of cement per year for each inhabitant of the Earth, carried out in mining plants that, due to geo-accumulation, alter the pH of the soil up to a radius of 2000 m, increasing the concentrations of nitrogen (167 ppm), phosphorus (2.52 ppm), and metals such as Cd, Cr, Cu, Fe, Pb, Mn, Ni, Zn, and Co [6].

According to the UNE 2024 report, the use of construction materials has tripled in the last fifty years, growing more than 2.3% annually [7]. Likewise, it indicates that the collection of stone materials such as sand, gravel, clays, and other minerals used for concrete production constitutes the largest type of material use in the world, with records close to 45.3 billion tons in the last year, corresponding to 50% of all materials extracted worldwide.

This scenario gives us an outlook far from that of the sustainable development goals [8], one where we are facing a quadruple planetary crisis of climate change, a loss of biodiversity, pollution, and waste. The indicators of the building and construction sector are worrying,