minerals

MDPI

Review

Challenges, Regulations, and Case Studies on Sustainable Management of Industrial Waste

Rajiv Ranjan Srivastava [1,2,*], Dilip Kumar Rajak [3], Sadia Ilyas [4], Hyunjung Kim [4] and Pankaj Pathak [5,*]

[1] Center for Advanced Chemistry, Institute of Research and Development, Duy Tan University, Da Nang 550000, Vietnam
[2] Faculty of Natural Sciences, Duy Tan University, Da Nang 550000, Vietnam
[3] Department of Chemistry, University of the Free State, Bloemfontein 9301, South Africa
[4] Department of Earth Resources & Environmental Engineering, Hanyang University, Seongdong-gu, Seoul 04763, Republic of Korea
[5] Department of Environmental Science, SRM University-AP, Amaravati 522502, Andhra Pradesh, India
* Correspondence: r2.srivastava@gmail.com (R.R.S.); pankajpathak18@gmail.com (P.P.)

Abstract: Incessant generation and mismanagement of industrial waste, resource scarcity, and environmental degradation have created non-sustainability in human life. Though industrial wastes are hazardous or non-hazardous in nature based on their source, open dumping disposal is commonly done for both types of waste. The adversity associated with waste enhances the environmental and health impacts. However, this waste has the potential to recycle and minimize resource scarcity. The circular economy works on the concept of reuse, recycling, and recovery to convert waste into a resource. Thus, industrial waste can benefit the environment and economic growth to build industrial ecology. However, the opportunities and challenges associated with industrial ecology for the reuse and recycling of waste have to be identified and preserved. Therefore, this study has identified challenges associated with waste, analyzed their impact, and industrial regulations, prioritized their criticality, and developed solution strategies to alleviate them. Two case studies on industrial byproducts, i.e., fly ash and red mud, based on different income groups are discussed in this study. It highlights the circular economy has minimized waste generation and enhanced the recovery of secondary resource materials. In addition, this study supports achieving the sustainable development goals (SDGs) 11 and 12 to build a sustainable industrial ecosystem.

Keywords: industrial waste; environmental impact; circular economy; red mud; coal fly ash

Citation: Srivastava, R.R.; Rajak, D.K.; Ilyas, S.; Kim, H.; Pathak, P. Challenges, Regulations, and Case Studies on Sustainable Management of Industrial Waste. *Minerals* **2023**, *13*, 51. https://doi.org/10.3390/min13010051

Academic Editor: William Skinner

Received: 23 November 2022
Revised: 23 December 2022
Accepted: 24 December 2022
Published: 28 December 2022

1. Introduction

The rapid increase in urban population, rise in living standards, pace in economic growth and, consequently, the change in behavioral lifestyle have resulted in different adversities. Due to the "throw-away" practice in the society, a tremendous increase in waste generation has been recorded, which comes from different sources and different practices. Commonly, "waste" is a substance belonging to the refused, rejected, abandoned mass, and unwanted surplus volume, which is generated by different anthropogenic and/or biological activities [1]. They can be divided into several categories according to their source of generation, hazardous property, disposal techniques, and degradation properties (refer to Figure 1).

Due to the structural changes in the societal behavior of an economic system, industrial activities are very important [2]. In fact, it has become an intrinsic part of the modern era to fulfill their day-to-day demands from basic needs to luxurious items by either exploring the primary sources or tapping secondary (end-of-life) materials. In order to run sustainable industrial activities, two points are vital, they are (a) the continuous supply of raw materials and (b) effective disposal of the waste generated by the industrial activities (which is an obvious part of the industrial process). Since the industrial waste generation is a huge