

Regional Distribution and Causes of Global Mine Tailings Dam Failures

Shui-Quan Lin ¹ , Guang-Jin Wang ^{1,2,*}, Wen-Lian Liu ^{1,3}, Bing Zhao ¹, Ying-Ming Shen ¹, Meng-Lai Wang ³ and Xiao-Shuan Li ⁴ 

¹ Faculty of Land Resource Engineering, Kunming University of Science and Technology, Kunming 650093, China; linshuiquan@stu.kust.edu.cn (S.-Q.L.); lwenzl702@sina.com (W.-L.L.); zhaobing1995@stu.kust.edu.cn (B.Z.); xinyingming@stu.kust.edu.cn (Y.-M.S.)

² Yunnan Key Laboratory of Sino-German Blue Mining and Utilization of Special Underground Space, Kunming 650093, China

³ National Engineering and Technology Center for Development & Utilization of Phosphate Resources, Yunnan Phosphate Group Co., Ltd., Kunming 650113, China; wml26382022@163.com

⁴ School of Civil Engineering, Shaoxing University, Shaoxing 312000, China; xsli2011@126.com

* Correspondence: wangguangjin2005@163.com

Abstract: Tailings ponds are one of the three major production facilities in metal mines. The volume of tailings increases year by year, but the storage capacity of existing tailings ponds is limited. Therefore, tailings dams must become more fine-grained and larger. The potential hazard they represent should not be underestimated. This paper reveals the causes and regional distribution patterns of 342 tailings dam failures globally from 1915 to 2021 through statistical analysis. It was found that tailings pond failures occur almost every year, with an average of 4.4 accidents/year (1947–2021). The frequency has been gradually increasing in recent years, and most tailings pond failures are directly related to heavy rainfall or earthquakes. The frequency of tailings pond failures was significantly higher in Asia (21.3%) and the Americas (57.9%), especially in China ($n = 43$) and the United States ($n = 107$). Causes of tailings pond failures differed among regions. Most tailings pond failures in Asia and Europe were related to hydroclimate, while those in South America were mainly triggered by earthquakes. This study will provide theoretical data for the pre-design as well as the safe and stable operation of global tailings ponds, which will help to prevent global tailings pond failures.

Keywords: tailings pond; regional distribution; dam break; accident statistics; causation analysis



Citation: Lin, S.-Q.; Wang, G.-J.; Liu, W.-L.; Zhao, B.; Shen, Y.-M.; Wang, M.-L.; Li, X.-S. Regional Distribution and Causes of Global Mine Tailings Dam Failures. *Metals* **2022**, *12*, 905. <https://doi.org/10.3390/met12060905>

Academic Editor: Lijie Guo

Received: 8 April 2022

Accepted: 21 May 2022

Published: 26 May 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

With the continued refinement of tailings particles and the increase in tailings emissions year by year, tailings dams will inevitably become more fine-grained and larger. However, extreme weather events and seismic activity will lead to frequent tailings pond failures.

From 1993 to 2009, the global population grew by 23%, while the global economy grew by 153% [1]. Rapid economic growth and population increase require the supply of more mineral resources. In this context, even low-grade minerals are now being extracted. Mineral extraction harms the environment [2,3] and generates large amounts of byproducts [4,5]. The fine particulate matter produced after beneficiation is called tailings and is usually stored in the form of a slurry in large, man-made dikes, i.e., tailings dams that are intended to protect the natural environment from pollution [6–8]. The global mining industry has produced enormous amounts of tailings, e.g., an estimated 14 billion tons in 2010 alone [4]. Ore grades are showing a decreasing trend, which means that more tailings will have to be stored in tailings impoundments in the future [9–11]. However, once a tailings pond leaks, it will severely damage downstream industrial and agricultural production and the wellbeing of local residents, as well as polluting the environment [12–14]. These negative effects will be exacerbated by pre-existing environmental threats such as land use