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## Circular Economy Principles in the Regulatory Oversight of the Management of By-Products –Case Study: Tin Slag 2

The tin processing industry generates an abundant amount of slag, as a by-product, that contains radioactive substances from uranium and thorium decay series radionuclides. The increase in tin production will be proportional to the increase in tin slag produced. The Circular economy is a concept that aims to minimize the extraction of primary resources, keep resources as long as possible, increase added value, or limit the final disposal of waste. The concept of reuse, recycling, or reprocessing is part of the concept. This paper aims to identify aspects of the existing regulations in Indonesia that support circular economy principles in the management of by-products, such as tin slag 2. The methodology used in this paper is a literature study of regulations, international recommendations, and related research. Based on the measurements of tin slag 2 samples originating from Bangka Belitung Province, the main chemical constituents based on XRF analysis are SiO<sub>2</sub>, CaO, MgO, Fe<sub>2</sub>O<sub>3</sub>, and TiO<sub>2</sub>. While the activity concentration of a tin slag 2 sample showed a value that exceeded the criterion of 1 Bq/gram for the radionuclides in the uranium and thorium decay series. From a material perspective, tin slag 2 can be reused or recycled for specific purposes. Various studies have proven the performance of tin slag 2 as a partial substitution of fine aggregate or cement in the manufacture of mortar or concrete. The identification result that several existing regulations in Indonesia explicitly and implicitly regulate the provisions of the circular economy concept. According to the Ministry of Environment and Forestry regulations, by-products with activity concentrations of less than 1 Bq/gram can be used as raw material, raw material substitution, energy source substitution, and other uses. Meanwhile, the by-products with activity concentrations of more than 1 Bq/gram are a challenge. As for the provisions of by-products with a value of more than 1 Bq/gram, it is regulated in BAPETEN Regulation No. 16 of 2013 (currently in the revision stage). BAPETEN Regulation No. 16 of 2013 explains that by-products can be utilized for certain activities. However, the regulation does not explain in detail the terms and criteria for the reuse of by-products. Provisions of by-product processing as stipulated in GR No. 52 of 2022 are limited to extracting nuclear minerals such as uranium and thorium. So the meaning of processing in GR No. 52 of 2022 and provisions for reuse previously contained in BAPETEN Regulation No. 16 of 2013 have a different meaning.

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