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High-efficiency cogeneration boiler bagasse-ash geochemistry and mineralogical change effects on the potential reuse in synthetic zeolites, geopolymers, cements, mortars, and concretes

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Abstract

Sugarcane bagasse ash re-utilisation has been advocated as a silica-rich feed for zeolites, pozzolans in cements and concretes, and geopolymers. However, many papers report variable success with the incorporation of such materials in these products as the ash can be inconsistent in nature. Therefore, understanding what variables affect the ash quality in real mills and understanding the processes to characterise ashes is critical in predicting successful ash waste utilisation. This paper investigated sugarcane bagasse ash from three sugar mills (Northern NSW, Australia) where two are used for the co-generation of electricity. Data shows that

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the burn temperatures of the bagasse in the high-efficiency co-generation boilers are much higher than those reported at the temperature measuring points. Silica polymorph transitions indicate the high burn temperatures of ≈1550 °C, produces ash dominated α −quartz rather than expected α-cristobilite and amorphous silica; although α-cristobilite, and amorphous silica are present. Furthermore, burn temperatures must be ≤1700 °C, because of the absence of lechatelierite where silica fusing and globulisation dominates. Consequently, silica-mineralogy changes deactivate the bagasse ash by reducing silica solubility, thus making bagasse ash utilisation in synthetic zeolites, geopolymers, or a pozzolanic material in mortars and concretes more difficult. For the ashes investigated, use as a filler material in cements and concrete has the greatest potential. Reported mill boiler temperatures discrepancies and the physical characteristics of the ash, highlight the importance of accurate temperature monitoring at the combustion seat if bagasse ash quality is to be prioritised to ensure a usable final ash product.

Keywords: Materials Science, Civil Engineering

1. Introduction

Brazil, the world's largest sugarcane cultivator, generates over 2.5 million tonnes of sugarcane bagasse ash (SCBA) per annum (Faria et al., 2012), whilst Australia generates some 40 thousand tonnes (CANEGROWERS, 2013). Sugar cane bagasse (left over cane stalk after crushing to extract cane juice) is a significant waste product of sugar processing. Traditionally bagasse was burnt for steam generation within the sugar mill and the resulting heat and energy used to process the sugarcane juice into raw sugar. The primary purpose of these early boilers was to dispose of the excess bagasse and would typically be burnt inefficiently. However, with uncertain profitability of the sugar cane industry over the last few decades, the cogeneration of electricity to increase revenue has gradually become a commercial reality where two of the three NSW sugar mills export electricity to the grid (CANEGROWERS, 2013). Initially this was done during the operating season, but now extends into the slack season. Consequently, the supply of bagasse is insufficient, and mills are supplementing bagasse with fuels such as wood chip, fuel oil, and coal. This is possible because of more efficient boiler design and operating conditions aimed at maximising cogeneration capacity (CANEGROWERS, 2013).

While burning bagasse reduces waste and provides economic benefit through cogeneration, bagasse ash is still produced as a waste material, which requires disposal. The ash from the boilers has been, and is still often blended with mill mud from juice clarification and disposed of back to the cane farms (CANEGROWERS, 2013). Although, this has been a very simple, easy, and cheap means of disposal while avoiding the regulation of environmental agencies, it is often no longer

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