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Rice Straw Pyrolysis for Nutrient Recovery: Investigating Silicon and Phosphorus Co-Release as Alternative Fertilizer Components

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Abstract

Research on nutrient recovery and alternative fertilizers has received more attention in recent years. For growth and development, rice plants have ingested several nutrients from the soil, including nitrogen (N), phosphorus (P), potassium (K), silicon (Si), and many other mineral elements. Each nutrient has a different role in the development of roots, stems, flowers, and seeds. Si is believed to be the primary component of phytoliths, which make up the skeletal structure for many components of the rice plant. During the formation of phytoliths, there can be many nutrients assimilated from the soil, such as P, K, etc., that can be trapped inside this structure. In many agricultural countries, rice straw is freely burned to sanitize fields following each harvest. However, this approach is controversial because it does not warrant the amount of nutrients returned to the field and has a risk of increasing air pollution due to the generation of CO2 emissions during the combustion process. In this study, we focus on the optimal conditions for the release of Si and P from the burning of rice straw to increase the nutrient content, especially P, returned to the soil and minimize the negative impacts on the environment. According to results from batch heating investigations, P that had been obligated in the phytolith structure might be released when the phytolith is dissolved. The highest values of dissolved Si and P were found in the temperature range of 500 – 700 °C. Chemical composition, X-ray diffraction, infrared spectral data, and specific surface area (SSA) suggest that the presence of organic carbon is masked at temperatures smaller than 500 °C, and the crystallization of silica at temperatures larger than 700 °C is the main reason for the decrease in phytolith dissolution rate and P release. For the practice of burning

rice straw, it is possible to recommend optimal treatment conditions to return the maximum amount of P contained in rice straw back to the soil or create alternative fertilizer components for crops.

Keywords: Rice straw, Nutrient recovery, Silicon, Phosphorous, Alternative fertilizer