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MASTER THESIS PROJECT

PHYTOLITHS DERIVING FROM RICE STRAW OPEN BURNING: EFFECT OF ASHING TEMPERATURE AND DISSOLUTION ON CHANGING PARTICLE SIZE AND SHAPE

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ABSTRACT

Open burning of rice straw is the most common and easy-to-go practice of re-utilization of crop residue, making included nutrients available for the next crop. Moreover, this agriculture practice produces significant amounts of burned silica structures deriving from plant phytoliths, which have recently been recognized as a source of nutrients boosting biological Si feedback loop in agroecosystem. While several studies highlighted the impact of intrinsic properties of phytolith on governing solubility, knowledge on their particle size and shape and changes of these properties upon dissolution is still scarce, despite marked effects on properties of the fine-sized fraction in soils and microaggregate architecture. Therefore, in this study, the quantification and classification of particle size and shape by Confocal Laser Scanning Microscopy (CLSM) was conducted to determine to what extent short (3 days) and long-term (10 days) dissolution inducing marked release of Si impacts the mechanical stability of phytolith particles. Size was quantified by the equivalent circle diameter (ECD) and the shape was determined in 9 different classes. Three ashed phytolith samples were produced at temperatures of 400, 600 and 800°C and were dissolved at pH range of 6.0-6.5, reflecting pH observed in rice paddy fields. Si release after 10 days revealed a solubility following the order: ash 600 >> ash 400 > ash 800. Toward increasing of pyrolysis temperature, the removal of organic carbon increase from 75.45 to 95.09 and 99.48%, while Si were found to be 166, 193, and 112 $g.kg^{-1}$ for ash 400, 600 and 800℃, respectively. Ashing temperature clearly affected phytolith micromorphology by transformation of angular forms to roundish forms towards higher temperature. CLSM analysis revealed some analogy in size distribution as for all three heating treatments as the < 5 μm fraction always accounted for 70% of the total number of particles. The share of the coarsest fraction > 50 μm increased towards higher ashing temperature. From shape analysis, it could be deduced that phytolith particles were more flat and elongated with increasing particle size. Particles with an ECD 0.5-1 μm were typically compact and accounted for approximately 20% of total particles. Their poor preservation during dissolution indicated that these ash particles likely serve as a short-term Si source for plants. In the samples ashed at 400 and 600°C not much change in the share of the finest fraction was observed during dissolution as losses were compensated by abraded fragments from phytoliths occurring in larger fractions. Flat and elongated particles in larger fractions appear the best preserved against dissolution as their share remained relatively stable during dissolution. Depending on internal (surface area, small Al content) and external factors (pH, soil temperature, plant uptake, physical weathering), this > 50 μm fraction with flat and elongated shapes could be abraded and broken into smaller parts and serve hereby as a source of plant-available Si in paddy soils in longer terms.