Plant phosphorus availability in low-temperature biomass gasification ashes

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Aim
Since biomass resources for energy production are limited, technologies that can effectively exploit a variety of fuels are required. Low-temperature gasification is able to utilize difficult biomass fuels with high contents of low melting ash compounds, e.g. straw and sewage sludge. Non-renewable resources such as phosphorus (P) accumulated in the fuel used should be recycled to agricultural soils to improve the technology’s economic feasibility and sustainability. In this study, ashes originating from the process were tested in a pot experiment for their P fertilizer value.

Methods
Ash material generated from two different fuels (wheat straw and sewage sludge) was incorporated into a low-P soil at 0, 20, 40, 80, 120, and 160 mg total P per kg dry soil. Control treatments receiving mineral P fertilizer (KH₂PO₄) at the same rates were included in the set-up. Initial bicarbonate (Olsen-) P values of the treatments were determined in soil samples. Pots were filled with 2 kg of soil (four replicates per treatment), and four spring barley (Hordeum vulgare L. cv. Iron) plants were grown in each pot in a growth chamber (24/12 C, day/night; 16-h photoperiod) for 8 weeks. At harvest, shoot dry weight and P content was determined.

Results
Both initial Olsen-P values and shoot dry weights remained unchanged compared to the untreated control in pots receiving sludge ash at all P rates (Figure 1, 2 and 3), which indicates that P in the sludge-ash was unavailable to plant uptake. It is assumed that this is due to the treatment of the wastewater with Fe- and Al-salts in order to chemically precipitate P by forming Fe- and Al-phosphates, which reduces plant P availability. In contrast, straw ash showed a P fertilizing effect on plants (Figure 2, 3).

Conclusion
Ashes originating from low-temperature biomass gasification are valuable renewable P fertilizers, but plant availability depends on the feedstock used. Further research should clarify to what extent Olsen-P can be used as indicator to predict plant P availability of gasification ashes amended to soil.

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