

## Combined carbon storage and nutrient recovery from residues and waste materials

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Sustainable soil management is crucial to maintain soil resources fertile for the feed and food production for a rapidly growing global population. Recovery of nutrients (phosphorus, potassium, silicon, nitrogen, etc.) is essential. Moreover, stabilization of carbon offers an additional benefit.

Results of thermo-chemical conversion techniques (in particular pyrolysis and hydrothermal carbonization) is presented. The effect of operation parameters such as residence time, temperature, additives, pH on the char composition as well as on the nutrient availability is given for selected feedstock materials (biogas sludge; chicken, cow and pig manure, sewage sludge). Mass balances of constituents within the feeds as well as the products lead to suggestion of mix of products to provide tailored products. Moreover, values for carbon stabilization in the soil are given.

Summarizing, the presented results prove the concept of multiple functionalities of the products such as carbon storage, nutrient recycling as well as increased water storage capacity in the soil. This approach will help to close nutrient cycles, protect the diminishing phosphate resources, reduce  $CO_2$  levels in the atmosphere and improve the fertility of agricultural soils.