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Animal bone chars as sorbents and providers of ammonium nitrogen from biogas digestates

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Biochars are well-known for their high sorption capacity of cationic substances. Whereas the pyrolysis of vegetation-based feedstock produces biochar with high carbon concentrations (70-90 %), these chars contain only very small fractions of plant-relevant macronutrients with good bioavailability. The usage of animal bones as pyrolysis feedstock, however, produces phosphorus-rich biochars (10-15 % P) that are low in carbon (10-20 % C). The deficiency in nitrogen of these bone chars can be compensated for by sorbing nitrogen prior to use them as soil improvers.

Among the different possibilities to enrich nitrogen-poor biochars with ammonium, the use of biogas digestate is one of the most promising options in terms of nitrogen recycling and reduction of gaseous nitrogen losses. Direct applications of biogas digestate may result in high ammonia losses during spreading of the liquid and in the first days after soil incorporation. The use of membrane distillation for separating digestates into an ammonium-enriched and an ammonium-poor fraction allows the use of a sorbate with up to 10 g NH_4^+ L^{-1} that can be used to enrich bone chars with easily bioavailable nitrogen.

Based on measurements of cation exchange capacity (CEC), it appears that ion exchange plays an important role in the sorption of ammonium. Bovine bone char showed higher CEC than pig bone char. Apparently, the nitrogen enrichment of bone char from ammonium sulfate solutions had increased the availability of the preexisting bone char nitrogen by acting as a mild acid. By testing the nitrogen availability of N-enriched bone chars with a standardized plant test (“Neubauer-Test”), we observed that chars enriched with the biogas digestate ammonium-rich fraction were able to

significantly improve the performance of bone char-treated plants (+135 % in plant dry matter, +130 % in plant N uptake compared to non-enriched bone char). This result was achieved by using bovine ribs as pyrolysis feedstock and biogas digestate from the same abattoir that had produced the cattle bones as residues from carcass processing for food production. This case study could show that the combined use of liquid and solid abattoir wastes is able to produce an efficient organic NP-fertilizer and replacement for mineral fertilizer.

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