Effects of biochar on potential nitrification in agricultural soil

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Introduction, aim and conclusions

Biochar is a recalcitrant and persistent char product synthesized by pyrolysis of plant- or animal-based biomass and intended for soil amendment. Suggested ecosystem services of biochar include increased soil fertility, carbon sequestration and decreased nutrient leaching. Further, large specific surface area of biochars has the potential to decrease bioavailability of toxic organic contaminants in the soils, through sorptive processes. Still, however, toxic compounds present in the feedstock (e.g., heavy metals) or generated during pyrolysis (e.g., polycyclic aromatic hydrocarbons, PAH) necessitates evaluation before wider environmental application of biochar.

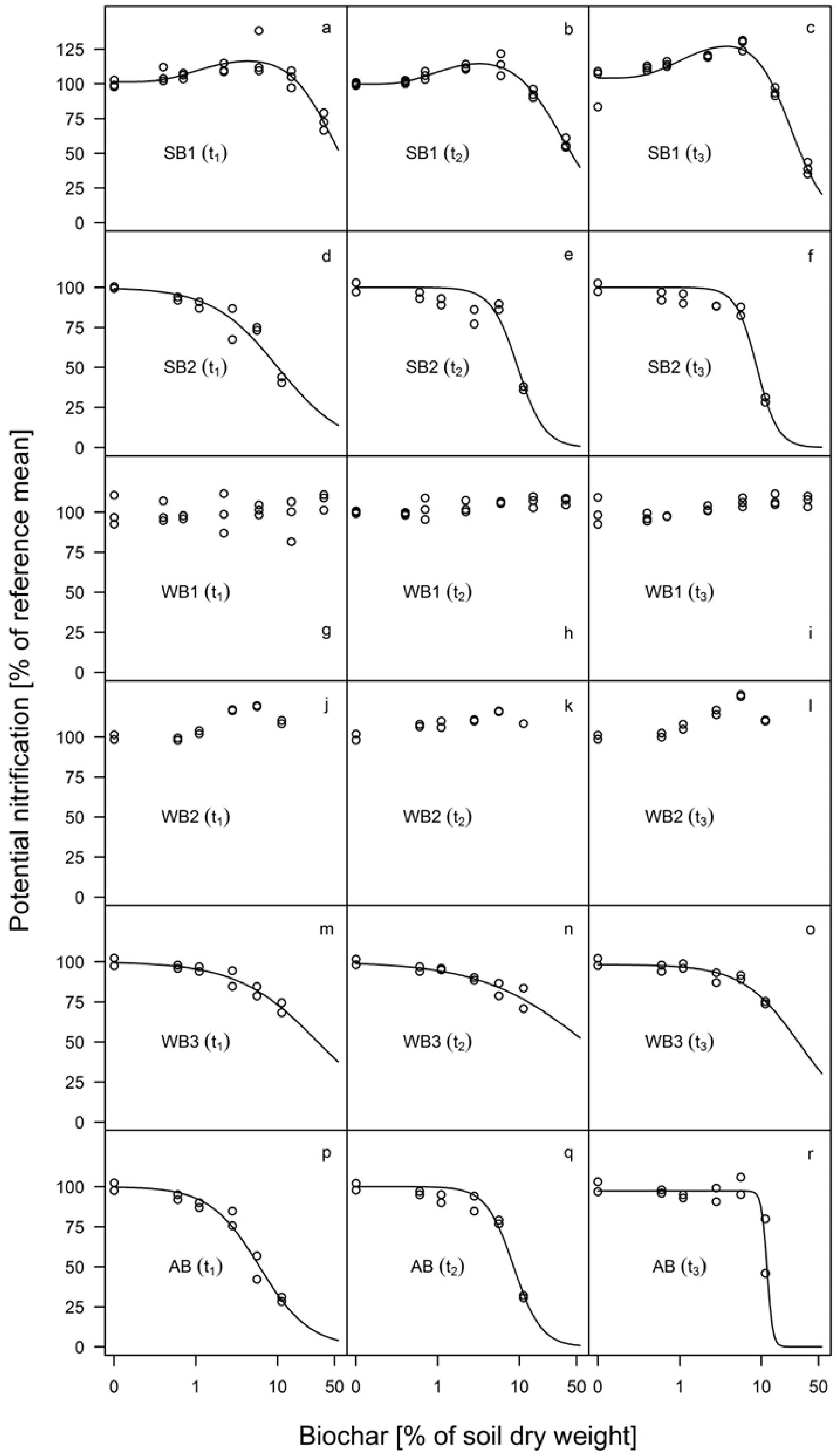
The aim of this study was to test the ecotoxicity of biochars in agricultural soil towards potential nitrification (PN) as a microbial bioindicator. Under laboratory conditions, six types of biochar derived from straw, wood, and animal bones were amended to a sandy loam soil in increasing concentrations and incubated for up to three weeks. Increases in soil pH was observed for all biochars. Assays of potential nitrification after up to 3 weeks showed that two of the three wood-based biochars either caused no effect or even stimulated potential nitrification. For other biochars, dose-responses showed some 10% effect concentrations (EC10), but with significant recovery potential. We conclude that the biochars increased soil pH to varying degree, but did not cause severe inhibition of potential nitrification. Thus, based on comparison of ecologically relevant doses and effects on the tested microbial bioindicator, the currently tested biochars (plant-based and animal bone based) had an ecologically acceptable profile.

Toxicity parameters (% biochar on soil dry wt basis) for the six tested biochars
EC10 values were estimated from modeled dose-responses shown in the figure

Property	Biochar designation and EC10 value (% biochar)					
	SB1	SB2	WB1	WB2	WB3	AB
EC10 (t1)	24	1.3	>36	>11	2.6	1.3
EC10 (t2)	17	4.2	>36	>11	2.6	3.6
EC10 (t3)	15	4.6	>36	>11	3.9	9.5

Characteristics of the six tested biochars derived from straw (SB1, SB2), wood (WB1, WB2, WB3) and animal bones (AB)

Property	Biochar designation					
	SB1	SB2	WB1	WB2	WB3	AB
Pyrolysis (°C)	725	750	725	800	*na*	625
Ash (%)	16.3	*na*	1.8	*na*	0.6	83.6
C content (%)	70.4	79.8	91.2	81.0	81.1	12.3
N content (%)	0.53	0.65	0.42	<0.08	*na*	1.16
P content (g/kg)	1.2	3.4	0.2	1.6	0.4	111
K content (g/kg)	35	34	2.3	7.0	3.0	1.0
PAH (ppm)	385	<0.5	68	0.7	10.3	1.4
Heavy metals (ppm)	1.9	44.4	2.4	52.0	30.3	14.0
pH	10.2	8.5	9.6	9.4	9.5	7.6



Dose effects of biochar on PN, Figure caption

Dose-effects of biochar on potential nitrification in arable sandy loam soil. Potential nitrification was tested after soil/biochar incubation for 1-2 d (t1), 7-8 d (t2) and 21-22 d (t3). The rates of potential nitrification are shown as percentage of the mean rate in reference treatments (i.e., soil without biochar) to highlight the effect of biochar rates. The tested biochars were derived from straw (SB1, SB2), wood (WB1, WB2 and WB3) or animal bones (AB). Lines represent the modeled dose-responses. Biochar rates beyond realistic filed application rates were included to obtain data at the lower response level.

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 289785