Influence of artificial biological aging on the physicochemical, biological and ecotoxicological properties of five biochars - a laboratory incubation study -

Mónika Molnár[1*], Márta Kőszegi[1], Emese Vaszita[1*], Katalin Gruiz[1], Éva Farkas[1]

[1] Budapest University of Technology and Economics, Department of Applied Biotechnology and Food Science
*H-1111 Budapest, Műegyetem rkp. 3., Hungary [*]mmolnar@mail.bme.hu, *emvaszita@mail.bme.hu*

PROBLEM DEFINITION & OBJECTIVES

Biochar (BC) is the solid by-product of biomass combustion under oxygen limited conditions, known as pyrolysis [1]. BC is used specifically as soil amendment [1], but it proved to be efficient also in carbon sequestration, reduction of agricultural greenhouse gas emissions, contaminant removal and other applications [1]. The extent of the effects of biochar on soil depend primarily on the pyrolysis conditions and feedstock [2, 3, 4], on the biochar aging process and the interactions between soil and biochar during aging [3]. BC "aging" is a temporal process including abiotic and biotic redox reactions, interactions with microbes, organic matter, minerals and solutes in the soil environment [3]. The objective of the work is to support efficient long-term utilization of biochar in soil focusing not only on the aging mediated physicochemical, biological changes of five biochar types in calcareous sandy soil, but also on the ecotoxicity to soil biota. The final aim is selection of the most persistent biochars for field experiment.

EXPERIMENTAL SET-UP AND METHODS

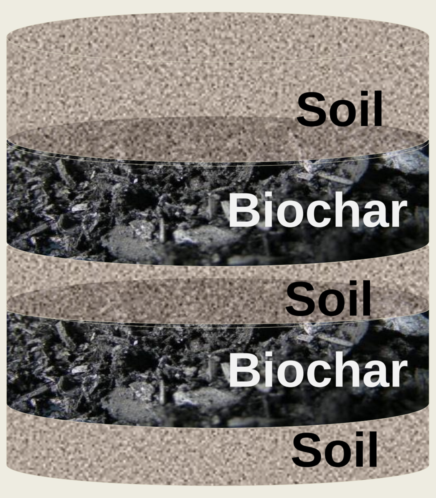

Fig. 1 Microcosm set-up

Triplicate samples of five biochar (BC) types (Fig. 2) were "aged" for 11 weeks at 25°C in 750 mL glass containers. Three calcareous sandy soil layers alternated with biochar layers (Fig. 1). Aerobic conditions were provided by glass capillary tubes inserted into the layers.

20 mL microbial inoculant (*Azospirrilum sp., Kocuria sp., Pseudomonas sp., Bacillis sp)* optimized for alkaline-neutral soil was added to each container at 3 weeks interval. After 11 weeks the biochar and soil layers were separated and removed. Biochars before and after aging were tested by an integrated methodology (Fig. 3).

A1
Grain husk & paper fibre sludge BC
(500°C[a], 20min[b], 45 m²/g[c])

B1
Wood-screenings BC
(600-700°C[a], 20min[b], 117 m²/g[c])

F1
Woodchips BC
(600-700°C[a], 15min[b], 107 m²/g[c])

H1
Herbal pomace BC
(600-700°C[a], 20min[b], 77 m²/g[c])

M2
Miscanthus BC
(600-700°C[a], 20min[b], 446 m²/g[c])

Fig. 2 The studied biochars
[a] pyrolysis temperature, [b] residence time, [c]Specific Surface Area (BET)

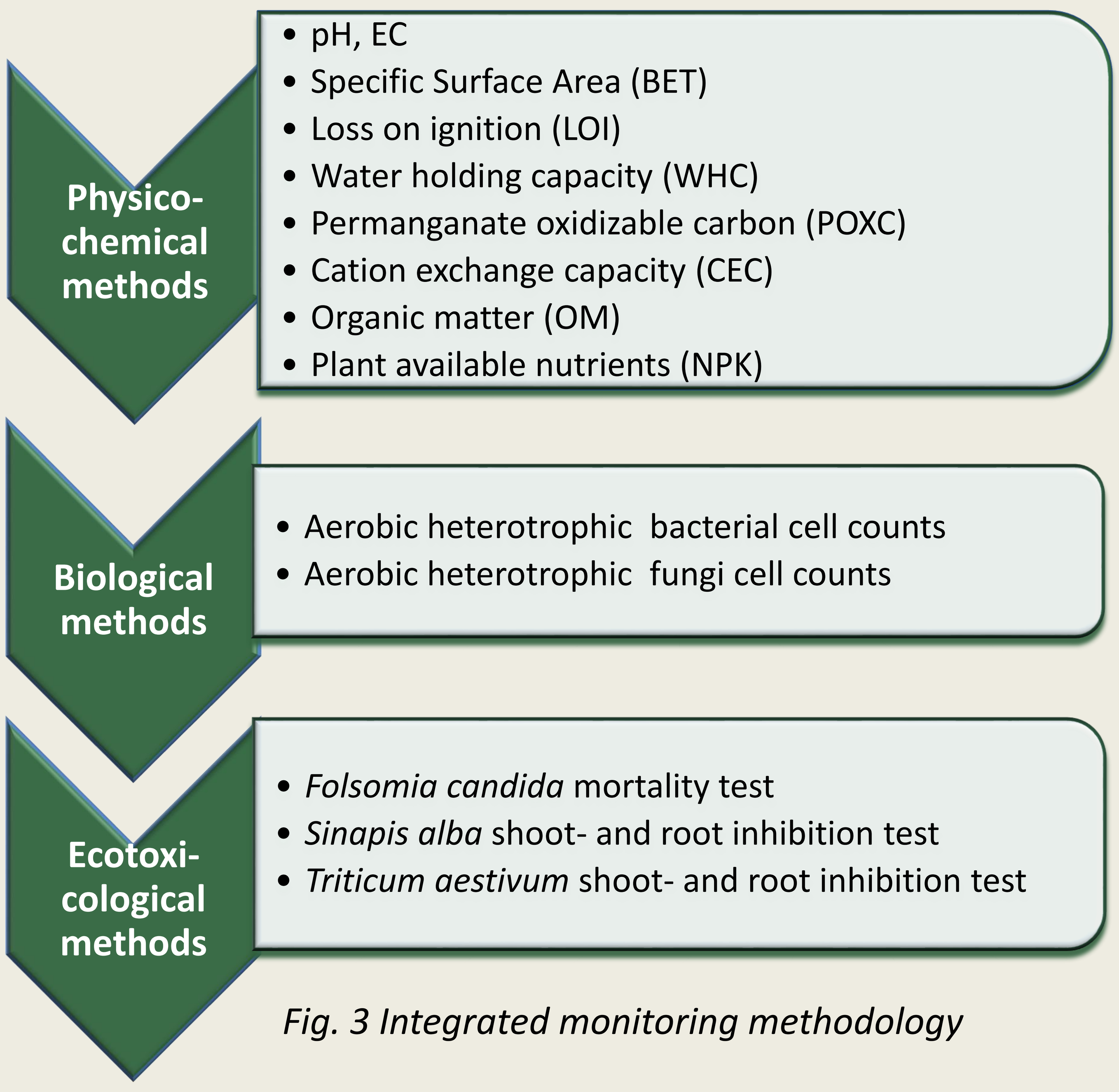

Fig. 3 Integrated monitoring methodology

RESULTS

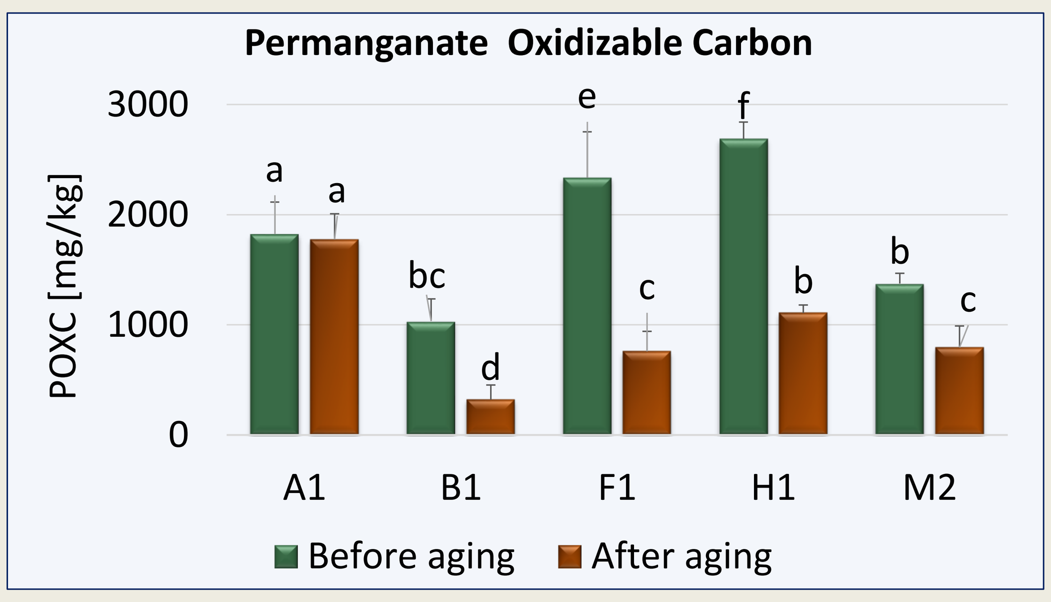

Fig. 4 Changes in labile carbon (POXC)

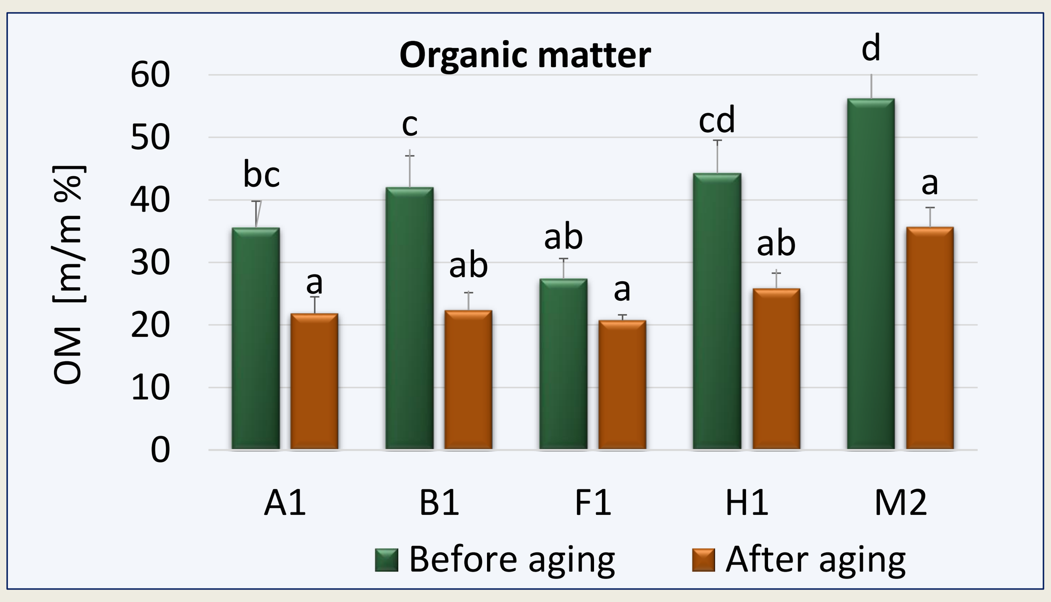

Fig. 5 Changes in organic matter (OM)

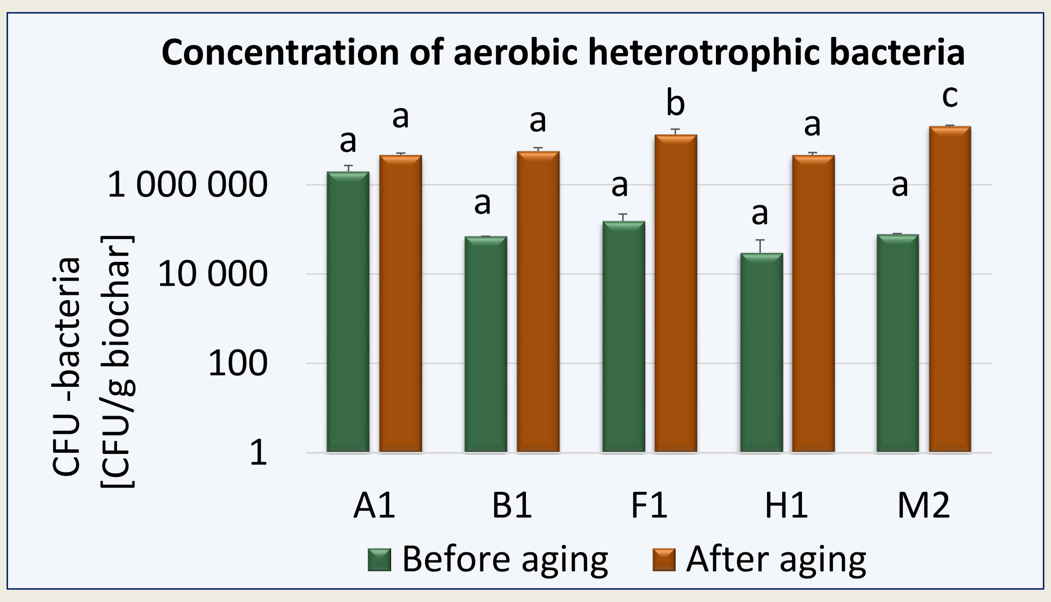

Fig. 6 Changes in microbial activity

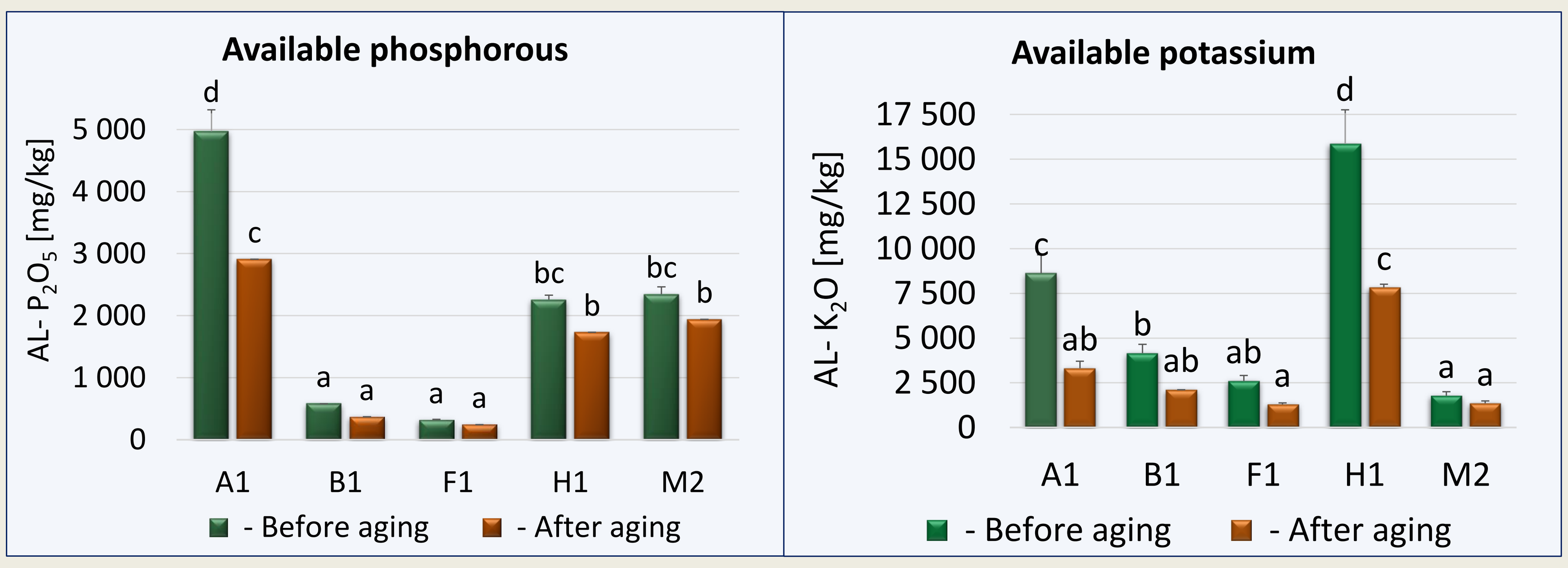

Fig. 7 Changes in available phosphorus and potassium

BC type	pH	EC	LOI	WHC	BET	Pore vol.	POXC	OM	NO_3-N	P_2O_5/ K_2O	CEC	CFU Bacteria	Plant growth
A1	–	–	–	–	–	–	–	–	–	–	–	+	–
B1	–	–	–	–	–	–	–	–	+	–	0	+	+
F1	–	–	–	–	–	–	–	–	+	–	–	+	+
H1	–	–	–	0	0	0	–	–	+	–	–	+	0!
M2	0	–	–	–	–	–	–	–	+	–	–	+	–

–	significant decrease	–	decrease	+	significant increase	+	increase	!	eco-toxicity	0	no effect

Fig. 8 Summary of the main effects of biochar aging

CONCLUSIONS

- Artificial biological aging of biochars is a promising model for studying weathering effects.
- The specific surface area (BET) of non-aged biochars highly influenced the aging-mediated changes.
- Microbial activity intensified with aging function of BET.
- Toxicity did not increase upon aging, moreover in case of F1 and B1 biochars plant growth was stimulated.
- M2 biochar proved to be the most efficient and stable on the long term due to the lowest decrease in available nutrient and labile carbon and the highest increase in microbial activity.

References

[1] J. Lehmann, Nature 447 (2007) (7141) 143–144.
[2] M. Molnar, E. Vaszita, É. Farkas……., Feigl, V., Sci. Total Env., 563-564 (2016), 855-865.
[3] A. Mukherjee, A.R. Zimmerman, …, W.T. Cooper, Solid Earth Discuss. 5 (2014) 693–704.
[4] B. Singh, Y. Fang, C.T. Johnston, Soil Sci. Soc. Am. J. 80 (2016) 613–622.

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