EFFECTS OF DIFFERENT BIOCHARS, COMPOST AND LIME TREATMENTS ON THE CHEMICAL PROPERTIES OF SANDY SOILS

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Abstract

Decrease in organic matter of the soil is one of the major threats to soils in Europe and other parts of the globe. Maintaining or increasing organic carbon is a great challenge in agricultural practices. Application of composts and other organic amendments is an important way of compensation of losses of organic carbon at the same time it is solving the placement and recycling of organic wastes and residues.

The favorable effect of these amendments on physical, chemical and biological properties has been proved by different studies, however the stability and the rate of the influence is an issue that can be improved.
The aim of the presented study was to investigate the effect of carbonates on the solubility of applied organic materials and selected soil parameters.

Different biochars, compost and carbonate were added to light textured soil. The pH and E4/E6 rates were studied under laboratory conditions.

Beside the increase of soil organic matter content, all studied parameters gave promising results. The decrease in E4/E6 rate suggests that the inorganic carbonates are stabilizing the fresh organic residues and prevent the leaching processes. Improved soil organic carbon stability is very important in light textured soils.
Further investigations are undergoing to determine the optimal rate of components and extend the kinds of material available for application.

Keywords: biochar, compost, sand, soil, biodegradable waste

Introduction

Composting and pyrolysis technologies can be solutions for biodegradable waste reduction, stabilization and environmentally friendly use and recycling of the by-products. (Christensen *et al.*, 1983; Joseph-Taylor, 2014). All of these techniques are advantageous for environmental and waste management (Hayland-Sarmah, 2014).

Favourable soil conditions can be achieved by applications of different soil amendments (Chen *et al.*, 2013). Applications of composts (Kádár, 2013) and biochars strongly increase the capacity of nutrient supply, soil organic matter content, soil buffering capacity and water holding capacity which stabilize and improve the soil structure, nutrient and water retention capacity (Van Zweiten *et al.*, 2010; Tammeorg *et al.*, 2014; Schmidt *et al.*, 2014).

The aim of this study was to investigate the effects of different composts and biochars treatments on sandy soils. The changes of chemical and physical parameters of the treated soil samples were investigated.

Materials

The chemical and physical properties of different composts can differ from one another depend largely on the source of raw material. The applied composts: COMPOST I. (compost produced from the green waste of park maintenances), COMPOST II. (compost produced from garden

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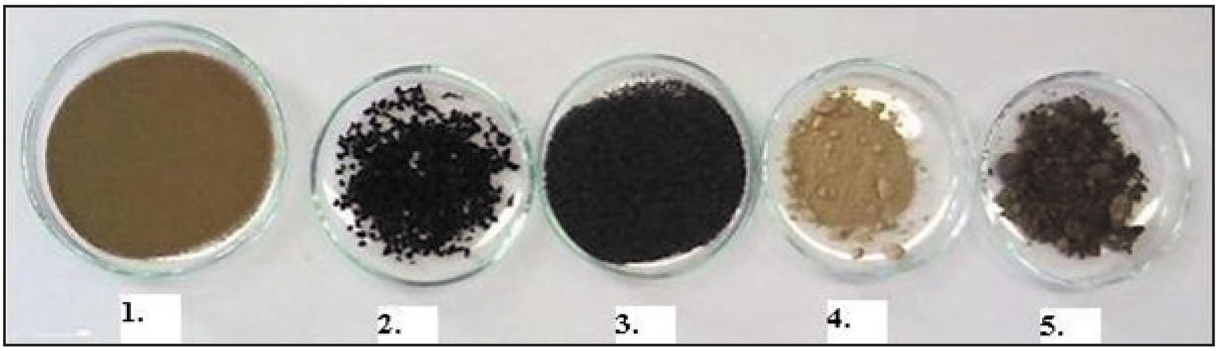
waste separately collected from households), COMPOST III. (compost exclusively produced from fallen leaves). The soil samples (Figure 1.) were collected in Szárítópuszta Experimental farm (Gödöllő, Hungary), from 0-20cm depth of an Arenosol. Two types of biochars (Figure 1.) were compared: plant origin biochar (POB) and animal origin biochar (AOB, bonechar) produced by pyrolysis. The samples were examined with added lime and without added lime. Table 1. shows the parameters of the sample mixtures. The experiments of the sixteen sample mixtures were replicated three times.

Figure 1. Investigated materials(1. - sand, 2. - animal origin biochar (AOB), 3. - plant origin biochar (POB), 4. - lime and 5. - green waste compost)



Methods

The following parameters were measured from the three types of composts (Table 2.): dissolved organic carbon (DOC) content [based on Tyurin method], soil organic matter content (SOM) [loss on ignition] and $CaCO_3$ content [calcimeter method]. The organic matter quality, pH, cation exchange capacity (CEC) and DOC of the investigated materials were measured (Table 1.). The organic matter quality was measured by E4/E6 metbod (Trubetskaya *et al.*, 2013), the CEC was measured by Mehlich method (Buzás, 1988) and the DOC was measured by Tyurin method (Buzás, 1988).

For the further biochar tests COMPOST I. was used, because it contained the highest proportion of DOC (Table 1.). Both biochar and bonechar were mixed with sandy soil in similar proportions (Table 3.) and replicated three times. The samples were incubated for four weeks in room temperature and moisturized with 150g distilled water (in 24th June to 22th July, 2013) after preparation. 1000g sandy soil was used as a control. The samples were examined with adding 0,5g lime and without adding lime (Table 1.). Every sample was air dried before measuring the parameters.

The samples of biochar-compost treatments (Table 1.) were tested for pH, and organic matter quality. The quality of the dissolved organic matter was measured by E4/E6 method (Trubetskaya *et al.*, 2013).

The results were analyzed by One Way Anova method using SPSS 16.0 Program Package [P < 0,05] (SPSS Inc. 2005).

Results and discussion

Table 2 shows the results of comparison experiments of different compost types.

The results show significant differences between COMPOST III. and the two other composts in SOM% (soil organic matter) and lime concentration. The significant differences are shown ‘a’ and ‘b’ in the indexes of the values in Table 2. There is no statistically significant difference between COMPOST I and COMPOST II in terms of SOM% and lime concentration. The DOC quantity solved in cold water shows opposite result: COMPOST I. is significantly different from the two other types of composts regardless if lime was added or not. There are no significant differences between the DOC quantity (solved in hot water) and the CEC results (Table 2.).

The soluble organic carbon sequestration

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Table 1. Treatments of samples

sample name	sand (g)	AOB [charcoal](g)	POB [biochar](g)	compost (g)	$CaCO_3$ (g)
sand	100				
compost				100	
compost + sand	80			20	
POB			100		
AOB		100			
1%AOB	495	5			
2.5%AOB	487.5	12.5			
5%AOB	475	25			
10%AOB	450	50			
1%POB	495		5		
2.5%POB	487.5		12.5		
5%POB	475		25		
10%POB	450		50		
1%AOB+comp	395	5		100	
2.5%AOB+comp	387.5	12.5		100	
5%AOB+comp	375	25		100	
10%AOB+comp	350	50		100	
1%POB+comp	395		5	100	
2.5%POB+comp	387.5		12.5	100	
5%POB+comp	375		25	100	
10%POB+comp	350		50	100	
1%AOB+$CaCO_3$	495	5			0.25
2.5%AOB+$CaCO_3$	487.5	12.5			0.25
5%AOB+$CaCO_3$	475	25			0.25
10%AOB+$CaCO_3$	450	50			0.25
1%POB+$CaCO_3$	495		5		0.25
2.5%POB+$CaCO_3$	487.5		12.5		0.25
5%POB+$CaCO_3$	475		25		0.25
10%POB+$CaCO_3$	450		50		0.25
1%AOB+comp+$CaCO_3$	395	5		100	0.25
2.5%AOB+comp+$CaCO_3$	387.5	12.5		100	0.25
5%AOB+comp+$CaCO_3$	375	25		100	0.25
10%AOB+comp+$CaCO_3$	350	50		100	0.25
1%POB+comp+$CaCO_3$	395		5	100	0.25
2.5%POB+comp+$CaCO_3$	387.5		12.5	100	0.25
5%POB+comp+$CaCO_3$	375		25	100	0.25
10%POB+comp+$CaCO_3$	350		50	100	0.25

capacity of sandy soils was improved with added lime. The quantity of soluble organic carbon is 1 mg/ml less as average with using the cold water method than in the samples treated with 0,5g lime (Table 2.).

Table 2. Comparison of composts
1. compost produced from green waste of park maintenance; 2. composts produced from garden waste separately collected from households; 3. compost exclusively produced from fallen leaves; 4. DOC: dissolved organic carbon

	SOM %	Lime concentration %	CEC	The quantity DOC (mg/ml) average [solved in cold water]		The quantity DOC (mg/ml) average [solved in hot water]	
				no added lime	added 0,5g lime	no added lime	added 0,5g lime
COMPOST I.[1]	31.84_b	3.67_a	16.32_a	5.53_b	4.52_b	8.65_a	5.44_a
COMPOST II.[2]	33.43_b	3.53_a	13.08_a	4.19_a	3.18_a	8.33_a	6.40_a
COMPOST III.[3]	20.73_a	4.39_b	13.05_a	3.18_a	2.18_a	7.37_a	3.84_a

The different degrees of decomposition and stability of the applied composts can be explained by the original 3-5% lime content (Table 2.). The different SOM content explains the differences in quantity of DOC in certain compost types during the hot water solution. It can be concluded that the DOC in COMPOST III. (compost exclusively produced from fallen leaves) is less than in the two other types of composts.

Significant differences in DOC were detectable in samples containig 10% biochar (100g POB+C, 100g AOB+C). The KCl pH results showed the same tendency as DOC, but the three samples containing lower concentrations of biochars had no significant differences (10g POB+C, 25g POB+C, 50g POB+C, 10g AOB+C, 25g AOB+C, 50g AOB+C). Significant differences were shown between control and the other samples by the pH. The reason of this is that biochar and bonechar increase the pH even at low concentrations.

The samples mixed with lime and without lime (Table 1.) were measured for E4/E6 ratio (Diagram 1.) and pH (Diagram 2.).

Table 3. Parameters of investigated materials

sample	E4/E6	pH (distilled water)	pH (KCl)	cation exchange capacity	DOC (mg/ml)
sand	7.15	6.5	5.74	7.04	5.52
compost (COMPOST I.)	7.42	7.6	7.18	72.18	13.46
sand (80%) + compost (20%)	7.9	7.64	7.3	19.14	7.63
AOB	0.35	9.56	9.02	3.54	6.97
POB	7.58	6.62	5.45	41.64	3.36

The cause of this probably is the high concentration of lignin of leaves. It is known that the decomposition of lignin is a very slow process (Fioretto *et al*, 2005).

COMPOST I. was choosen for further examinations: testing the biochars, sandy soil and lime mixtures, because it has the highest CEC value (Table 2.).

The results showed the high concentration (10%) of AOB (sample 4) decreased the E4/E6 rates (Diagram 1.) and increased the pH (Diagram 2.). This can be explained by the alkaline pH and the quite low E4/E6 ratio of AOB (Table 3.). The lower E4/E6 ratio (about 4-5) showed more stable dissolved organic materials (Aranda *et al*., 2011). The stable organic materials like humic acids had a positive effect on soil properties

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Diagram 1. E4/E6 rates (numbers of samples - horizontal axis - sample 1-4: mixed with AOB, samples 5-8: mixed with POB). The biochar concentrations: 1%, 2.5%, 5%, 10%.

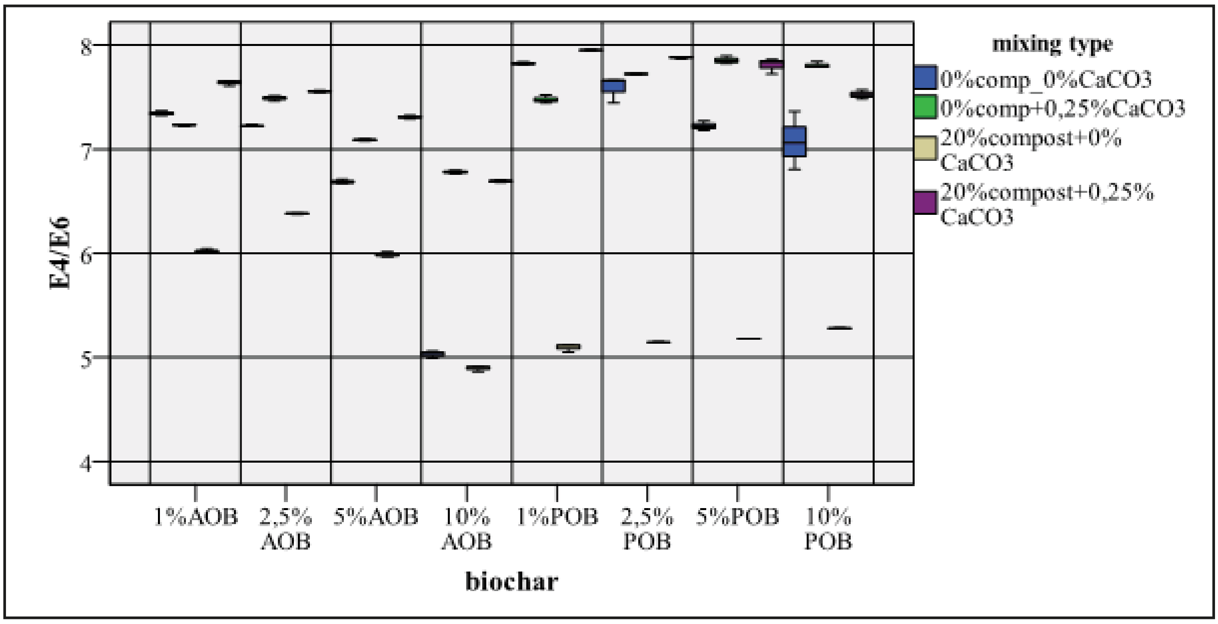
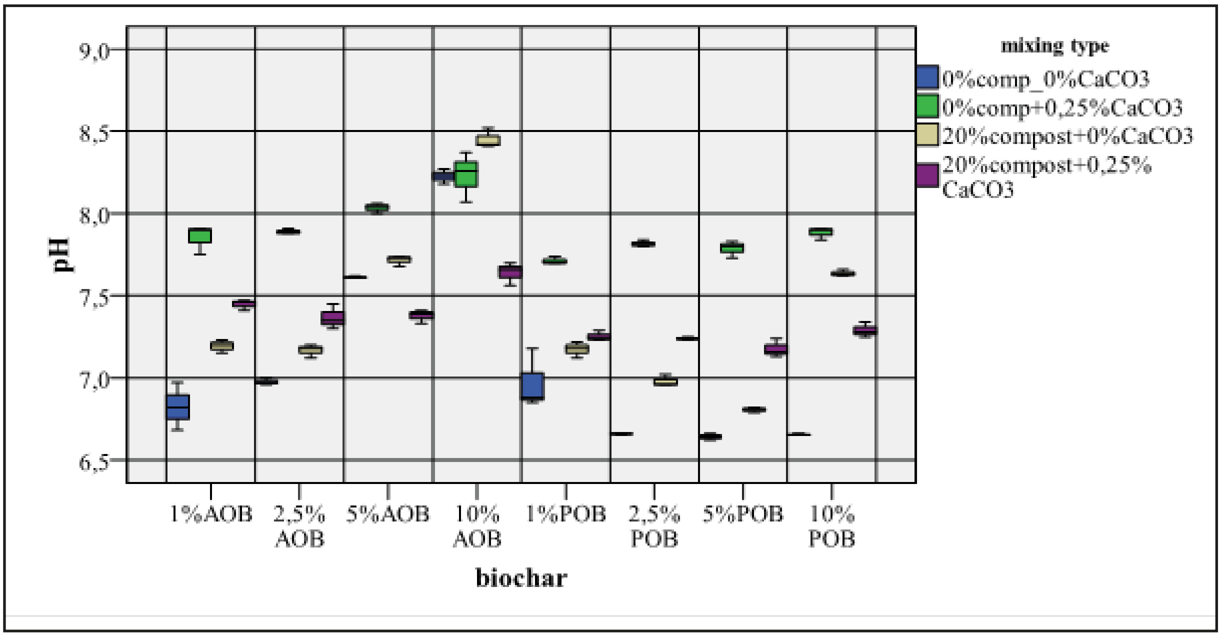


Diagram 2. pH results (numbers of samples - horizontal axis - sample 1-4: mixed with AOB, samples 5-8: mixed with POB). The biochar concentrations: 1%, 2.5%, 5%, 10%.



(Abdollahi *et al.*, 2014). The animal origin biochar could be useful for the soil melioration.

The AOB increased the E4/E6 ratio and the POB did not cause a significant modification in the E4/E6 ratio (Diagram 1.). The AOB increased the pH because the pH of AOB is about 9-10 (Table 3.) but the added $CaCO_3$ (0,5m/m %) buffered this effect (Diagram 2.).

The $CaCO_3$ had a decreasing effect on the E4/E6 ratio. This can be explained by the generated Ca-humus complexes in the soil (Six *et al.*, 2004).

The compost extremely increased the E4/E6 ratio, because it has high content of fresh organic matter compared to the soils.

Summary

The planned further experiments are measuring DOC, loss on ignition and CEC before and after pot experiments on the samples of Table 1. In the future the purpose of the experiments is to produce the compost-biochar-lime mixture with the most favourable impact to the soil fertility and crop yield. It could be useful in agricultural practice.

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