

Using of growing medium based on bottom sediment as a source of nutrients and an agent for improving soil properties

Magdalena Szara-Bąk¹, Agnieszka Baran¹, Agnieszka Klimkowicz-Pawlas²

¹Department of Agricultural and Environmental Chemistry, University of Agriculture in Krakow, Poland, ²Institute of Soil Science and Plant Cultivation – State Research Institute, Puławy, Poland e-mail: Agnieszka.Baran@urk.edu.pl

The aims of the study

In this study an attempt was made to create innovative mixtures based on bottom sediment and coffee hulls used as a substrate for the cultivation of plants. Our previous studies have shown that the bottom sediments from the Rożnów reservoir are characterised by a neutral or an alkaline pH, contains relatively large amounts of silt and clay fractions as well as calcium. On the other hand, they are poor in organic carbon. The material for the mixtures was selected in such a way as to enrich the bottom mineral sediment with organic matter and complement the nutrient content of the bottom sediments.

The aims of this study were 1) to assess the chemical and ecotoxicological properties of the growing medium prepared based on bottom sediment and coffee hulls and 2) to investigate the effects of the application of the growing medium on the properties of soil and the yield of zucchini biomass.

Materials and methods

- The sediment was sourced from the Rożnów reservoir situated on the Dunajec River in the Lesser Poland Voivodeship in southern Poland. The Rożnów reservoir is the fastest silting dam reservoir in Poland, especially its backwater area (inlet zone).
- The mixture was based on bottom sediment BS (17 05 06) and coffee hulls CH (02 03 04). BS were characterised by a neutral pH, CH were acidic. Coffee hulls had higher content of carbon, nitrogen and potassium and low content of Cd, Cr, Ni, Pb, Zn (Tab. 1).
- In the first stage 3 months experiment under controlled laboratory conditions was conducted. The experimental design covered treatments with a combination of 75% bottom sediment and 25% of CH, and a control sample (bottom sediment).
- In the second stage 4 doses of growing medium (75% BS and 25% of CH) were assessed as part of a pot experiment conducted inside a temperature and moisture controlled condition, and compared with the control (soil). The growing medium in doses of 25%, 50%, 75%, 100% were added to the light soil. The test plants (zucchini) were harvested after 30 days of vegetation.
- The basic chemical parameters of the mixtures were determined (Tab. 2, 4). Ecotoxicity of the mixtures was evaluated on the basis of 4 biotests: Phytotoxkit, Rapidtoxkit, Ostracodtoxkit F, Microtox (Tab. 3).

Table 1. Properties of the materials used for growing medium

Parameter	BS*	CH
pH	7.57	4.91
TOC	13.30	457.00
N	1.20	27.90
K	1.49	11.11
Ca	116.67	6.46
Cd	0.23	0.09
Cr	24.58	1.58
Ni	26.50	1.77
Zn	66.28	15.70
Pb	8.68	0.98
Cu	16.49	39.24

*BS - bottom sediment. CH - coffee hull

Results

Table 2. Chemical properties of growing medium

Parameter	BS	BS + CH
pH	7.43	8.16
Salinity	1.28	2.58
TOC	14.00	86.50
N	1.40	7.70
C/N	10	11
Mg	3.36	7.24
Ca	116.67	18.10
P	0.28	0.46
K	1.49	6.36
Cd	0.22	0.23
Cr	28.26	18.40
Ni	24.41	29.96
Zn	67.48	70.79
Cu	16.49	27.81
Pb	8.68	12.43

Table 3. Effect of the growing medium application on change of pH and yield of tested plant

Treatment	pH	Yield g/pot
Control (soil 100%)	6.33 a*	27.26 a
25% growing medium	7.37 b	29.18 a
50% growing medium	7.40 b	28.45 a
75% growing medium	7.41 b	34.57 b
100% growing medium	7.43 b	34.76 b

*Means followed by the different letters indicate significant differences at a ≤ 0.05 according to the t-Tukey test

Table 3. Classification of growth medium toxicity

Mixture	Inhibition %									Class. Hazard
	Germination			Root growth			Feeding	Growth	Luminescence	
	Sa	Ls	Ss	Sa	Ls	Ss	Tp	Hi	Af	
BS	0	0	14	-9	-25	17	33	50	-116	II
BS + CH	0	20	4	79	75	85	56	47	22	III

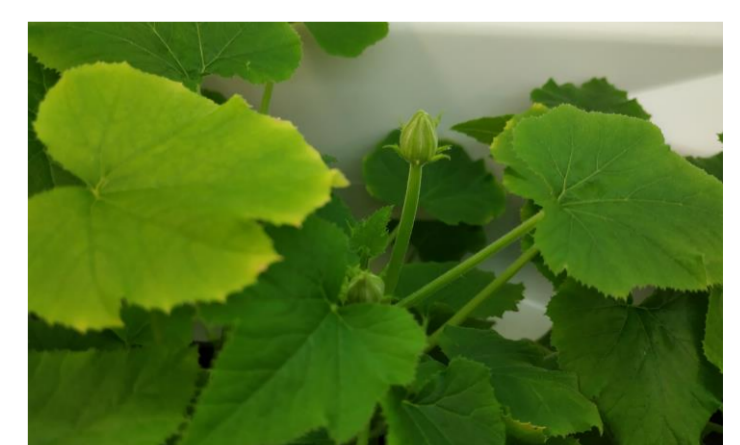
Sa – *Sinapis alba*, Ls – *Lepidium sativum*, Ss – *Sorghum saccharatum*, Tp – *Thamnocephalus platyurus*, Hi – *Heterocypris incongruens*, Af – *Allivibrio fischeri*

Table 4. Content of elements in plants and soil after experiment

Treatment	Zucchini			Soil		
	Cd mg/kg	Mg g/kg	Ca g/kg	Cd mg/kg	Mg g/kg	Ca g/kg
Control (soil 100%)	0.18 b*	2.48 a	29.38 b	0.63 c	0.56 a	1.51 a
25% GM	0.07 a	3.83 bc	31.65 b	0.62 c	3.19 b	7.83 b
50% GM	0.06 a	3.03 b	24.18 a	0.42 b	5.55 c	12.66 c
75% GM	0.05 a	3.01 b	23.84 a	0.38 a	8.07 d	17.56 d
100% GM	0.05 a	4.21 c	23.06 a	0.36 a	10.18 e	22.81 e

*Means followed by the different letters indicate significant differences at a ≤ 0.05 according to the t-Tukey test, GM – growing medium

Photo 1. Test plant - zucchini



Conclusions

- Mixture based on BS+CH had deacidifying properties and significant TOC content. The mixture caused an increase in the soil pH value ranging from 14% to 15% in compare to the control. The study revealed a low total content of heavy metals in the mixtures. The content of heavy metals in the mixtures did not exceed the permissible limits for their agricultural use (EU 2015).
- The application of mixture increased the biomass of zucchini. The highest yield was observed in the treatment with a 75 and 100% addition of the GM. Compared to the control, the biomass of the test plant exhibited a significant decrease in the content of Cd and Ca (without 5% of GM) and increase of Mg under the influence of GM doses. A significant reduction in Cd, and an increase in Mg, Ca content was found in the soil due to increasing doses of growing medium relative to the control.
- The biotests demonstrated varied toxicity of the mixture affecting the test organisms. The largest toxic effect was found for plants (roots growth inhibition). Due to its high toxicity for plants, the mixture of BS and CH constitute a potentially substrate for environmental application in agriculture, horticulture (for no consumer crops) or land reclamation.
- A detailed analysis of the chemical and ecotoxicological properties of these materials/substrates is necessary to minimise the ecological risk associated with their application.

The study was financed by the National Science Centre (no. 2016/21/B/ST10/02127), Poland and by the Ministry of Science and Higher Education of the Republic of Poland, no. 2126. by and by "Innovative program of strategic development of the University" co-financed by the European Social Fund, contract no. POWR.03.05.00-00-2020/18