

# Evaluation of the usefulness of sorbents in the remediation of soil exposed to the pressure of cadmium and cobalt

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**Table S1.** The number of organotrophic bacteria,  $10^9$  cfu  $\text{kg}^{-1}$  d.m. of soil

Object	C0	Cd	Co
Control	30.615 <sup>cd</sup>	21.002 <sup>hi</sup>	23.023 <sup>f-i</sup>
Molecular sieve	41.609 <sup>a</sup>	30.073 <sup>c-e</sup>	33.524 <sup>c</sup>
Halloysite	32.784 <sup>c</sup>	21.643 <sup>g-i</sup>	21.593 <sup>g-i</sup>
Sepiolite	33.031 <sup>c</sup>	19.079 <sup>i</sup>	18.635 <sup>i</sup>
Expanded clay	34.411 <sup>bc</sup>	32.834 <sup>c</sup>	24.699 <sup>f-h</sup>
Biochar	38.207 <sup>ab</sup>	22.037 <sup>g-i</sup>	19.819 <sup>i</sup>
Zeolite	32.932 <sup>c</sup>	27.657 <sup>d-f</sup>	25.685 <sup>e-g</sup>

C0 – uncontaminated soil, Cd – cadmium ion, Co – cobalt ion. Homogeneous groups denoted with letters (a-i).

**Table S2.** The number of actinomycetes,  $10^9$  cfu  $\text{kg}^{-1}$  d.m. of soil

Object	C0	Cd	Co
Control	16.170 <sup>g-j</sup>	15.875 <sup>h-k</sup>	13.410 <sup>j-l</sup>
Molecular sieve	17.354 <sup>e-h</sup>	29.136 <sup>a</sup>	17.008 <sup>f-i</sup>
Halloysite	20.410 <sup>c-e</sup>	12.966 <sup>kl</sup>	10.599 <sup>l</sup>
Sepiolite	20.854 <sup>cd</sup>	19.276 <sup>d-f</sup>	13.459 <sup>j-l</sup>
Expanded clay	22.530 <sup>bc</sup>	17.501 <sup>e-h</sup>	19.720 <sup>c-f</sup>
Biochar	19.276 <sup>d-f</sup>	25.340 <sup>b</sup>	15.677 <sup>h-k</sup>
Zeolite	14.100 <sup>i-k</sup>	19.128 <sup>d-g</sup>	16.170 <sup>g-j</sup>

C0 – uncontaminated soil, Cd – cadmium ion, Co – cobalt ion. Homogeneous groups denoted with letters (a-l).

**Table S3.** The number of fungi,  $10^7$  cfu  $\text{kg}^{-1}$  d.m. of soil

Object	C0	Cd	Co
Control	6.754 <sup>d-h</sup>	5.522 <sup>h-k</sup>	4.388 <sup>i</sup>
Molecular sieve	7.592 <sup>d-f</sup>	6.508 <sup>e-i</sup>	5.078 <sup>ik</sup>
Halloysite	9.712 <sup>ab</sup>	7.494 <sup>def</sup>	5.374 <sup>i-k</sup>
Sepiolite	7.099 <sup>d-g</sup>	6.064 <sup>g-j</sup>	5.669 <sup>h-k</sup>
Expanded clay	10.304 <sup>ab</sup>	7.937 <sup>cd</sup>	7.789 <sup>c-e</sup>
Biochar	10.599 <sup>a</sup>	7.592 <sup>d-f</sup>	6.409 <sup>f-j</sup>
Zeolite	8.973 <sup>bc</sup>	7.148 <sup>d-g</sup>	5.423 <sup>h-k</sup>

C0 – uncontaminated soil, Cd – cadmium ion, Co – cobalt ion. Homogeneous groups denoted with letters (a-k).

**Table S4.** Dehydrogenases activity,  $\mu\text{mol TPF} \cdot \text{h}^{-1} \cdot \text{kg}^{-1}$  d.m. of soil

Object	C0	Cd	Co
Control	6.231 <sup>c</sup>	1.002 <sup>g-i</sup>	0.357 <sup>i</sup>
Molecular sieve	9.134 <sup>a</sup>	3.243 <sup>d</sup>	2.971 <sup>de</sup>
Halloysite	6.502 <sup>c</sup>	1.969 <sup>fg</sup>	1.358 <sup>gh</sup>
Sepiolite	6.564 <sup>c</sup>	1.154 <sup>g-i</sup>	0.934 <sup>hi</sup>
Expanded clay	7.776 <sup>b</sup>	1.698 <sup>f-h</sup>	0.900 <sup>hi</sup>
Biochar	6.927 <sup>bc</sup>	2.343 <sup>ef</sup>	2.037 <sup>fg</sup>
Zeolite	9.694 <sup>a</sup>	1.222 <sup>gh</sup>	3.226 <sup>de</sup>

C0 – uncontaminated soil, Cd – cadmium ion, Co – cobalt ion. Homogeneous groups denoted with letters (a-i).

**Table S5.** Catalase activity,  $\text{mol O}_2 \text{h}^{-1} \text{kg}^{-1}$  d.m. of soil

Object	C0	Cd	Co
Control	0.338 <sup>d-f</sup>	0.293 <sup>k-m</sup>	0.278 <sup>m</sup>
Molecular sieve	0.357 <sup>bc</sup>	0.327 <sup>e-h</sup>	0.315 <sup>hij</sup>
Halloysite	0.364 <sup>ab</sup>	0.345 <sup>cd</sup>	0.319 <sup>g-i</sup>
Sepiolite	0.349 <sup>b-d</sup>	0.342 <sup>c-e</sup>	0.286 <sup>lm</sup>
Expanded clay	0.342 <sup>c-e</sup>	0.334 <sup>d-g</sup>	0.293 <sup>k-m</sup>
Biochar	0.379 <sup>a</sup>	0.323 <sup>f-h</sup>	0.304 <sup>i-k</sup>
Zeolite	0.375 <sup>a</sup>	0.342 <sup>c-e</sup>	0.301 <sup>i-l</sup>

C0 – uncontaminated soil, Cd – cadmium ion, Co – cobalt ion. Homogeneous groups denoted with letters (a-m).

**Table S6.** Urease activity,  $\text{mmol N-NH}_4 \text{h}^{-1} \text{kg}^{-1}$  d.m. of soil

Object	C0	Cd	Co
Control	0.223 <sup>c</sup>	0.146 <sup>f</sup>	0.116 <sup>g</sup>
Molecular sieve	0.254 <sup>ab</sup>	0.162 <sup>d-f</sup>	0.154 <sup>ef</sup>
Halloysite	0.239 <sup>bc</sup>	0.216 <sup>c</sup>	0.139 <sup>fg</sup>
Sepiolite	0.239 <sup>bc</sup>	0.185 <sup>d</sup>	0.162 <sup>d-f</sup>
Expanded clay	0.254 <sup>ab</sup>	0.177 <sup>de</sup>	0.146 <sup>f</sup>
Biochar	0.262 <sup>ab</sup>	0.177 <sup>de</sup>	0.154 <sup>ef</sup>
Zeolite	0.277 <sup>a</sup>	0.185 <sup>d</sup>	0.162 <sup>d-f</sup>

C0 – uncontaminated soil, Cd – cadmium ion, Co – cobalt ion. Homogeneous groups denoted with letters (a-g).

**Table S7.** Alkaline phosphatase activity,  $\text{mmol PNP kg}^{-1} \text{h}^{-1} \text{kg}^{-1}$  d.m. of soil

Object	C0	Cd	Co
Control	1.349 <sup>cd</sup>	0.568 <sup>k</sup>	0.814 <sup>h</sup>
Molecular sieve	1.406 <sup>bc</sup>	0.682 <sup>i</sup>	1.306 <sup>d</sup>
Halloysite	1.404 <sup>bc</sup>	0.581 <sup>jk</sup>	0.874 <sup>gh</sup>
Sepiolite	1.544 <sup>a</sup>	0.649 <sup>ij</sup>	1.049 <sup>e</sup>
Expanded clay	1.424 <sup>b</sup>	0.574 <sup>k</sup>	0.909 <sup>g</sup>
Biochar	1.574 <sup>a</sup>	0.589 <sup>jk</sup>	1.117 <sup>e</sup>
Zeolite	1.578 <sup>a</sup>	0.644 <sup>ij</sup>	0.980 <sup>f</sup>

C0 – uncontaminated soil, Cd – cadmium ion, Co – cobalt ion. Homogeneous groups denoted with letters (a-k).

**Table S8.** Acid phosphatase activity, mmol PNP h<sup>-1</sup> kg<sup>-1</sup> d.m. of soil

Object	C0	Cd	Co
Control	1.275 <sup>de</sup>	0.812 <sup>h</sup>	0.897 <sup>h</sup>
Molecular sieve	1.593 <sup>b</sup>	1.312 <sup>d</sup>	1.106 <sup>fg</sup>
Halloysite	1.483 <sup>c</sup>	1.124 <sup>fg</sup>	1.086 <sup>g</sup>
Sepiolite	1.755 <sup>a</sup>	1.208 <sup>ef</sup>	1.129 <sup>fg</sup>
Expanded clay	1.533 <sup>bc</sup>	1.055 <sup>g</sup>	1.074 <sup>g</sup>
Biochar	1.567 <sup>bc</sup>	1.050 <sup>g</sup>	1.036 <sup>g</sup>
Zeolite	1.599 <sup>b</sup>	1.038 <sup>g</sup>	1.078 <sup>g</sup>

C0 – uncontaminated soil, Cd – cadmium ion, Co – cobalt ion. Homogeneous groups denoted with letters (a-h).

**Table S9.** Arylsulfatase activity, mmol PNS h<sup>-1</sup> kg<sup>-1</sup> d.m. of soil

Object	C0	Cd	Co
Control	0.188 <sup>bc</sup>	0.125 <sup>i</sup>	0.144 <sup>f-i</sup>
Molecular sieve	0.218 <sup>a</sup>	0.156 <sup>d-h</sup>	0.170 <sup>c-e</sup>
Halloysite	0.216 <sup>a</sup>	0.140 <sup>g-i</sup>	0.162 <sup>d-g</sup>
Sepiolite	0.204 <sup>ab</sup>	0.132 <sup>hi</sup>	0.168 <sup>c-f</sup>
Expanded clay	0.200 <sup>ab</sup>	0.144 <sup>f-i</sup>	0.166 <sup>c-f</sup>
Biochar	0.202 <sup>ab</sup>	0.148 <sup>e-i</sup>	0.170 <sup>c-e</sup>
Zeolite	0.221 <sup>a</sup>	0.131 <sup>i</sup>	0.180 <sup>b-d</sup>

C0 – uncontaminated soil, Cd – cadmium ion, Co – cobalt ion. Homogeneous groups denoted with letters (a-i).

**Table S10.**  $\beta$ -glucosidase activity, mmol PNG h<sup>-1</sup> kg<sup>-1</sup> d.m. of soil

Object	C0	Cd	Co
Control	0.550 <sup>hi</sup>	0.444 <sup>j</sup>	0.498 <sup>ij</sup>
Molecular sieve	0.661 <sup>c-f</sup>	0.629 <sup>e-g</sup>	0.641 <sup>d-g</sup>
Halloysite	0.761 <sup>a</sup>	0.663 <sup>c-f</sup>	0.751 <sup>ab</sup>
Sepiolite	0.709 <sup>a-d</sup>	0.613 <sup>f-h</sup>	0.583 <sup>gh</sup>
Expanded clay	0.665 <sup>c-f</sup>	0.608 <sup>f-h</sup>	0.604 <sup>f-h</sup>
Biochar	0.702 <sup>a-e</sup>	0.664 <sup>c-f</sup>	0.660 <sup>c-g</sup>
Zeolite	0.721 <sup>a-c</sup>	0.609 <sup>f-h</sup>	0.681 <sup>b-f</sup>

C0 – uncontaminated soil, Cd – cadmium ion, Co – cobalt ion. Homogeneous groups denoted with letters (a-j).

**Table S11.** Yield of aboveground parts of sunflower (*Helianthus annuus*), g d.m. on pot<sup>-1</sup>

Object	C0	Cd	Co
Control	25.27 <sup>b</sup>	10.34 <sup>f-i</sup>	6.78 <sup>i</sup>
Molecular sieve	27.26 <sup>ab</sup>	18.63 <sup>c</sup>	13.11 <sup>d-f</sup>
Halloysite	27.66 <sup>ab</sup>	13.00 <sup>d-f</sup>	9.12 <sup>g-i</sup>
Sepiolite	27.04 <sup>ab</sup>	16.40 <sup>cd</sup>	8.03 <sup>hi</sup>
Expanded clay	26.36 <sup>ab</sup>	14.43 <sup>de</sup>	7.99 <sup>hi</sup>
Biochar	29.89 <sup>a</sup>	12.18 <sup>e-g</sup>	8.67 <sup>g-i</sup>
Zeolite	29.06 <sup>a</sup>	11.34 <sup>e-h</sup>	10.19 <sup>f-i</sup>

C0 – uncontaminated soil, Cd – cadmium ion, Co – cobalt ion. Homogeneous groups denoted with letters (a-i).

**Table S12.** Sunflower (*Helianthus annuus*) root yield, g d.m. on pot<sup>-1</sup>

Object	C0	Cd	Co
Control	5.18 <sup>c</sup>	1.19 <sup>f</sup>	1.56 <sup>d-f</sup>
Molecular sieve	5.89 <sup>c</sup>	2.18 <sup>d-f</sup>	2.53 <sup>d</sup>
Halloysite	7.63 <sup>a</sup>	1.40 <sup>ef</sup>	1.89 <sup>d-f</sup>
Sepiolite	6.06 <sup>bc</sup>	2.24 <sup>d-f</sup>	2.32 <sup>de</sup>
Expanded clay	5.63 <sup>c</sup>	2.07 <sup>d-f</sup>	1.73 <sup>d-f</sup>
Biochar	5.80 <sup>c</sup>	1.72 <sup>d-f</sup>	2.04 <sup>d-f</sup>
Zeolite	7.15 <sup>ab</sup>	1.63 <sup>d-f</sup>	2.19 <sup>d-f</sup>

C0 – uncontaminated soil, Cd – cadmium ion, Co – cobalt ion. Homogeneous groups denoted with letters (a-f).