Supporting Information for
Environmental Science: Water Research and Technology

Performance of biochars for the elimination of trace organic contaminants and metals from urban stormwater

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31 Pages, 21 Figures, 31 Tables, 6 Equations

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S1 Chemicals & analytical parameters

All chemicals in this study were used as received.

Table S1 Metals, organic compounds, and other chemicals used in this study.

Name	Abbreviation	Purity	Supplier
Calcium chloride	$CaCl_2$	≥99.5%	Fluka, Switzerland
Magnesium chloride	$MgCl_2$	>99%	Fluka, Switzerland
Ammonium chloride	NH_4Cl	99%	Merck, Switzerland
Sodium sulfate	Na_2SO_4	≥98%	Fluka, Switzerland
Sodium bicarbonate	$NaHCO_3$	99%	Sigma-Aldrich, Germany
Sodium nitrate	$NaNO_3$	99%	Sigma-Aldrich, Germany
Sodium dihydrogen phosphate monohydrate	$NaH_2PO_4 \cdot H_2O$	99%	Sigma-Aldrich, Germany
Potassium bromide	KBr	≥99.0%	Sigma-Aldrich
Cadmiumchloride	$CdCl_2$	99.99%	Sigma-Aldrich, USA
Copper(II) chloride dihydrate	$CuCl_2 \cdot 2\,H_2O$	BioReagent	Sigma-Aldrich, USA
Nickel(II)chloride hexahydrate	$NiCl_2 \cdot 6\,H_2O$	BioReagent	Sigma-Aldrich, USA
Lead(II)Chloride	$PbCl_2$	99.999%	Sigma-Aldrich, USA
Zinc chloride	$ZnCl_2$	99.99%	Sigma-Aldrich, USA
Atenolol		≥99.5%	Fluka, Switzerland
1H-Benzotriazole (1H-BT)		≥99.5%	Fluka, Switzerland
Dicamba		≥99.5%	Fluka, Switzerland
Diuron		>99%	Fluka, Switzerland
Fipronil		99%	Merck, Switzerland
Mecoprop		≥98%	Fluka, Switzerland
Terbutryn		99%	Sigma-Aldrich, Germany
Atenolol-d7		≥97%	Sigma-Aldrich, USA
1H-Benzotriazole-4,5,6,7-d4		99.8% D	CDN, Canada
Dicamba-d3		99.1% D	Sigma-Aldrich, USA
Diuron-d6		99% D	CDN, Canada
Fipronil sulfide			Sigma-Aldrich, USA
2,4 D-d3		98.3% D	CDN, Canada
Atrazine-d5		99% D	Sigma-Aldrich, USA

Analyte stock solutions were prepared in methanol (Optima for HPLC, 99.9%, Fisher Scientific). Aqueous solutions were prepared with deionized water ($18.1\,M\Omega \cdot cm$, Barnstead NANOpure Diamond Water Purification System). The pH-value of the synthetic stormwater was adjusted by addition of hydrochloric acid (trace metal grade, Fisher Scientific).
For metal analysis, all samples were acidified with nitric acid (Fischer Scientific, trace metal grade 67-70%). A standard mix containing 10 mg/L of cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, phosphorus, potassium, sodium, and zinc in 5% v/v HNO_3 was obtained from Inorganic Ventures, USA.

Table S2 Usage class and physicochemical properties of the selected organic compounds.

	CAS number	Usage class	Molecular mass	basic pKa	acidic pKa	Speciation at pH 7.4	log D_{ow} [a] at pH 7.4	K_{oc} [b] (L/kg)
1H-Benzotriazole	95-14-7	Corrosion inhibitor	119.12	1.6	8.4	neutral	1.4	49.0
Atenolol	29122-68-7	Pharma-ceutical	266.34	9.6	-	cationic	-1.9	302
Dicamba	1918-00-9	Herbicide	221.03	-	1.9	anionic	-0.4	31.6
Diuron	330-54-1	Herbicide/ Biocide	233.09	-	13.8	neutral	2.7	251
Fipronil	120068-37-3	Insecticide	437.14	-	-	neutral	4.0	411
Mecoprop	93-65-2	Herbicide/ Biocide	214.65	-	3.1	anionic	-0.7	20.0
Terbutryn	886-50-0	Herbicide/ Biocide	241.36	4.3	-	neutral	3.7	708

[a] Predicted octanol-water distribution coefficient; source: ChemSpider, ACD/Labs. For neutral compounds: Octanol-water partition coefficient; source: US EPA CompTox Chemicals Dashboard
[b] Soil adsorption coefficient; source: US EPA CompTox Chemicals Dashboard

Table S3 Substance-specific MS/MS settings for quantification of trace organic contaminants in batch and column studies.

	Precursor mass	m/z Product mass (Quantifier)	Product mass (Qualifier)	ESI[a] mode	DP[b] (V)	FP[c] (V)	Collision energy (V)	CXP[d] (V)
1H-Benzotriazole	120.0	65.1		(+)	46	210	31	4
	120.0		92.1	(+)	46	210	25	6
1H-Benzotriazole-d4	124.2	69.1		(+)	71	360	33	6
	124.2		68.1	(+)	71	360	31	6
Atenolol	267.2	145.0		(+)	46	210	37	10
	267.2		190.0	(+)	46	210	27	14
Atenolol-d7	274.2	145.1		(+)	41	240	39	10
	274.2		190.1	(+)	41	240	27	14
Dicamba	219.0	174.8		(-)	-76	-350	-10	-11
	220.9		176.7	(-)	-56	-270	-10	-11
Dicamba-d3	221.9	177.9		(-)	-46	-260	-10	-13
	223.8		180.0	(-)	-41	-220	-10	-11
Diuron	233.0	72.0		(+)	41	200	43	6
	235.0		72.0	(+)	51	240	43	6
Diuron-d6	239.1	78.2		(+)	51	260	41	6
	241.1		78.2	(+)	46	290	41	6
Fipronil	434.9	329.8		(-)	-56	-250	-24	-11
	434.9		249.9	(-)	-56	-250	-40	-17
Fipronil sulfide	418.9	261.8		(-)	-91	-290	-38	-17
	418.9		382.8	(-)	-91	-290	-20	-13
Mecoprop	213.0	140.8		(-)	-96	-310	-20	-9
	213.0		71.0	(-)	-96	-310	-20	-5
2,4-D-d3	222.0	163.8		(-)	-71	-340	-22	-9
	224.0		165.8	(-)	-76	-350	-20	-11
Terbutryn	242.2	185.9		(+)	66	260	27	14
	242.2		68.0	(+)	66	260	59	6
Atrazine-d5	221.1	179.0		(+)	41	230	27	14
	221.1		101.0	(+)	41	230	37	8

[a] Electrospray ionization [b] Declustering potential [c] Fragmentor voltage [d] Collision cell exit potential

S2 Synthetic stormwater

Table S4 Synthetic stormwater composition for the batch and column experiments.

Constituent	Concentration	Unit
NO_3^-	4.4	mg/L
NH_4^+	1.3	mg/L
$H_2PO_4^-$	1.5	mg/L
SO_4^{2-}	31	mg/L
HCO_3^-	60	mg/L
Mg^{2+}	1.8	mg/L
Ca^{2+}	30	mg/L
Na^+	40	mg/L
Cl^-	61	mg/L
Dissolved organic carbon[a]	5	mg C/L
pH	7.5	

[a] For batch experiments: Suwannee river natural organic matter (International Humic Substances Society). For column studies: humic acid (Sigma Aldrich).

S3 Biochars

Table S5 Specific surface areas of the studied biochars obtained from BET measurements.

Biochar	Specific surface area (m^2/g)	Total pore volume (cm^3/g)	Mean pore diameter (nm)
400°C	94	0.0580	2.47
580°C	29	0.0212	2.94
750°C	400	0.3111	3.11
MCG	610	0.3395	2.23

Table S6 Pore size distribution of MCG biochar obtained from Hg porosimetry.

Biochar	Macro pores (cm^3/g)	Meso pores (cm^3/g)	Micro pores (cm^3/g)
MCG	1.1729	0.0426	0.5545

S4 Statistical analyses

Two-way analysis of variance (ANOVA) or the Students t-test were performed to evaluate differences between multiple or two paired groups, respectively. ANOVA tests were followed by post-hoc Tukey's Honest Significant Difference (HSD) tests. The level of significance was set at 0.05. All statistical analyses and data processing were conducted with GraphPad Prism® 2020 (version 9) and the Data Analysis Tool included within Microsoft Office EXCEL® 2019.

S5 48-hour batch sorption experiments for biochar screening

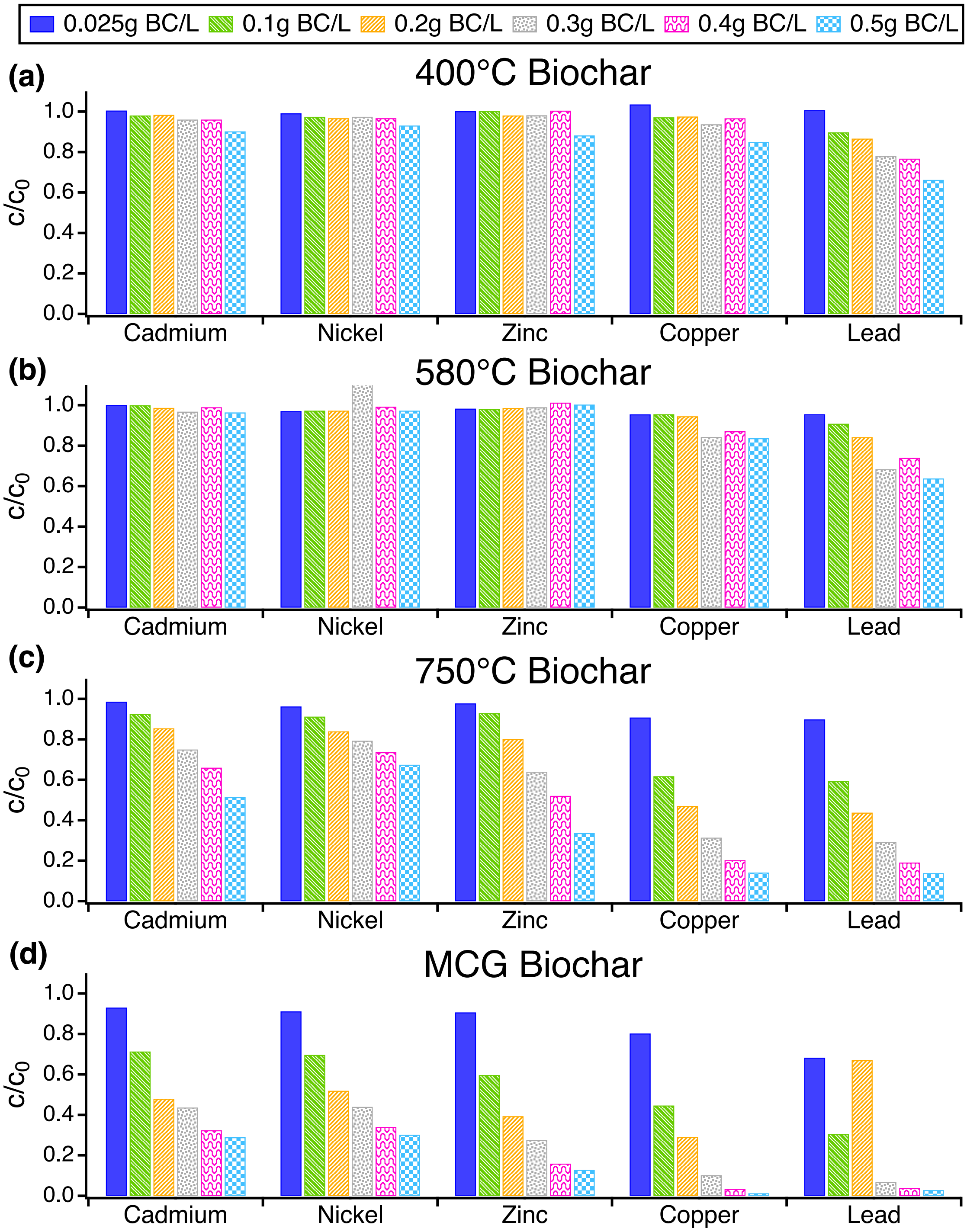

Figure S1 Sorption of cadmium, nickel, zinc, copper and lead onto three biochars produced at (a) 400°C, (b) 580°C, and (c) 750°C as well as onto (d) MCG gasification biochar. Batch experiments contained 5 mg, 20 mg, or 40 mg of the biochars in 200 mL synthetic stormwater at pH 7.5 corresponding to 0.025 g biochar/L, 0.1 g biochar/L and 0.2 g biochar/L, respectively. Batches for 0.3 g biochar/L, 0.4 g biochar/L and 0.5 g biochar/L contained 15 mg, 20 mg and 25 mg in 50 mL synthetic stormwater, respectively. Reported is the concentration c measured after 48 h of contact time divided by the measured concentration $c_0 = 50\,\mu g/L$ in the control batches without biochar.

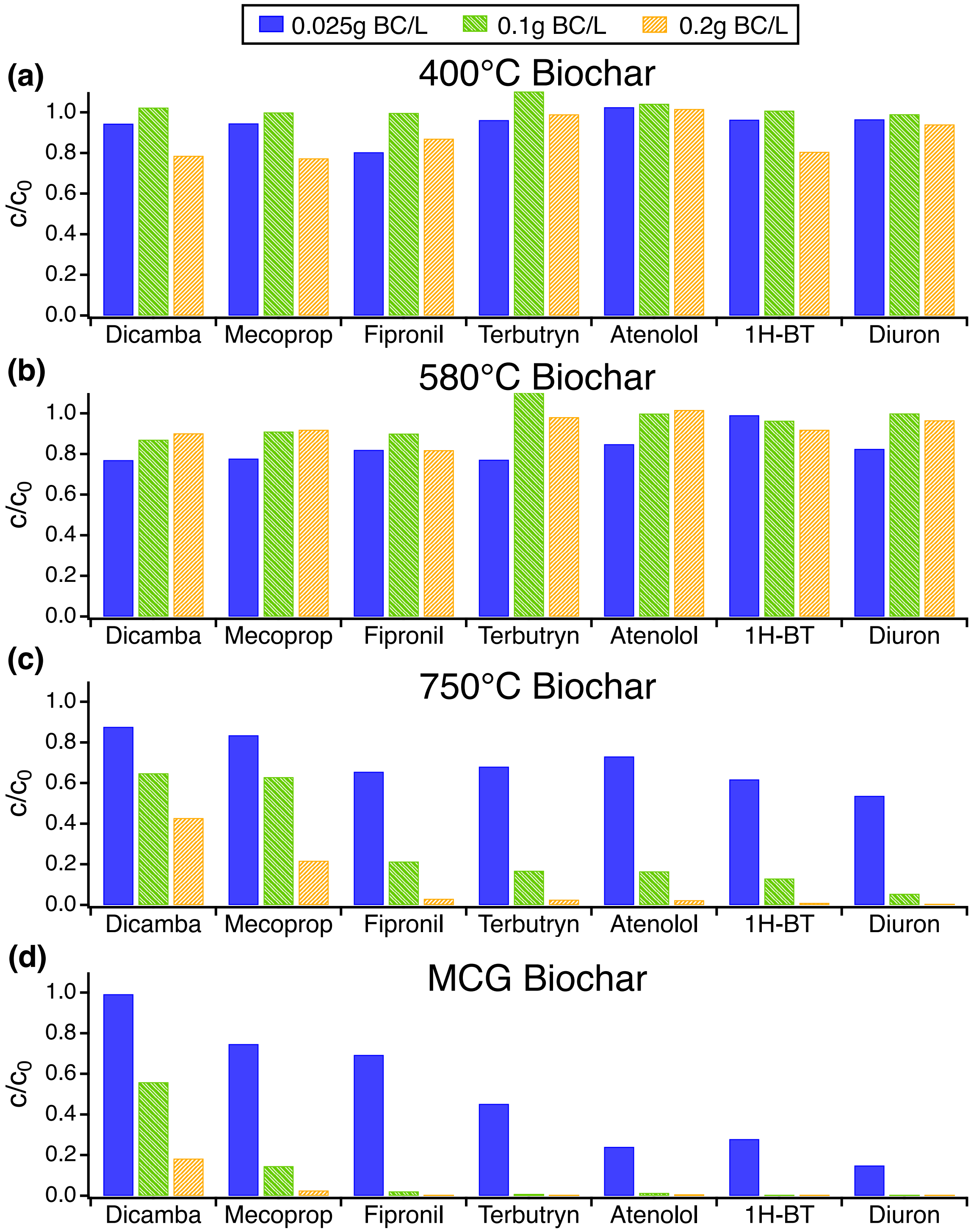

Figure S2 Sorption of dicamba, mecoprop, fipronil, terbutryn, atenolol, 1H-benzotriazole (1H-BT), and diuron onto three different biochars produced at (a) 400°C, (b) 580°C, and (c) 750°C as well as (d) onto MCG gasification biochar. Batch experiments contained 5 mg, 20 mg, or 40 mg of the respective biochar in 200 mL synthetic stormwater at pH 7.5 corresponding to 0.025 g biochar/L, 0.1 g biochar/L and 0.2 g biochar/L. Reported is the concentration c measured after 48 h of contact time divided by the measured concentration $c_0 = 100\,\mu g/L$ in the control batches without biochar.

Table S7 Linear semi-log correlation coefficients (r) between log K_d values of the TrOCs and physicochemical properties of biochar. Significance accepted at p-value<0.05 (yellow), p-value<0.1 (green), and p-value<0.2 (blue).

	1H-BT		**Dicamba**		**Diuron**		**Fipronil**		**Mecoprop**		**Terbutryn**	
	r	p-value	r	p-value	r	p-value	r	p-value	r	p-value	r	p-value
SSA (m^2/g)	**0.999**	**0.001**	**0.991**	**0.009**	**0.996**	**0.004**	**0.982**	**0.018**	**0.995**	**0.005**	**0.990**	**0.010**
Ash (%)	0.856	0.144	0.802	0.198	0.804	0.198	0.910	0.090	0.841	0.159	0.862	0.138
H (%)	-0.942	0.058	-0.897	0.103	**-0.966**	**0.034**	-0.944	0.056	-0.905	0.095	**-0.969**	**0.031**
C (%)	0.010	0.990	0.061	0.939	0.109	0.891	0.013	0.987	0.069	0.931	0.094	0.906
N (%)	-0.138	0.862	-0.227	0.773	-0.048	0.952	-0.113	0.887	-0.226	0.774	-0.044	0.956
O (%)	-0.479	0.521	-0.368	0.632	-0.542	0.458	-0.524	0.476	-0.387	0.613	-0.571	0.429
S (%)	0.746	0.254	0.730	0.270	0.671	0.329	0.786	0.214	0.763	0.237	0.720	0.280
H/C ratio	-0.914	0.086	-0.859	0.141	-0.942	0.058	-0.922	0.078	-0.870	0.130	**-0.950**	**0.050**
O/C ratio	-0.445	0.555	-0.334	0.666	-0.510	0.490	-0.490	0.510	-0.353	0.647	-0.539	0.461
(N+O)/C ratio	-0.449	0.551	-0.337	0.663	-0.514	0.486	-0.494	0.506	-0.356	0.644	-0.542	0.458

Table S8 Linear semi-log correlation coefficients (r) between log K_d values of the metals and physicochemical properties of biochar. Significance accepted at p-value<0.05 (yellow), p-value<0.1 (green), and p-value<0.2 (blue).

	Cu		**Zn**		**Pb**		**Ni**		**Cd**	
	r	p-value	r	p-value	r	p-value	r	p-value	r	p-value
SSA (m^2/g)	**0.953**	**0.047**	**0.999**	**0.001**	0.726	0.274	**0.996**	**0.004**	**0.998**	**0.002**
Ash (%)	0.733	0.267	0.845	0.155	0.267	0.733	0.879	0.121	0.863	0.137
H (%)	**-0.998**	**0.002**	-0.948	0.052	-0.830	0.170	-0.942	0.058	-0.949	0.051
C (%)	0.320	0.680	0.031	0.969	0.605	0.395	0.002	0.998	0.026	0.974
N (%)	-0.174	0.826	-0.119	0.881	-0.433	0.567	-0.139	0.861	-0.119	0.881
O (%)	-0.712	0.288	-0.493	0.507	-0.696	0.304	-0.488	0.512	-0.500	0.500
S (%)	0.536	0.464	0.731	0.269	0.053	0.947	0.767	0.233	0.764	0.254
H/C ratio	**-0.991**	**0.009**	-0.921	0.079	-0.831	0.169	-0.916	0.084	-0.923	0.077
O/C ratio	-0.687	0.313	-0.460	0.540	-0.687	0.313	-0.454	0.546	-0.467	0.533
(N+O)/C ratio	-0.690	0.310	-0.463	0.537	-0.688	0.312	-0.457	0.543	-0.470	0.530

S6 Biochar batch experiments with metals and TrOCs

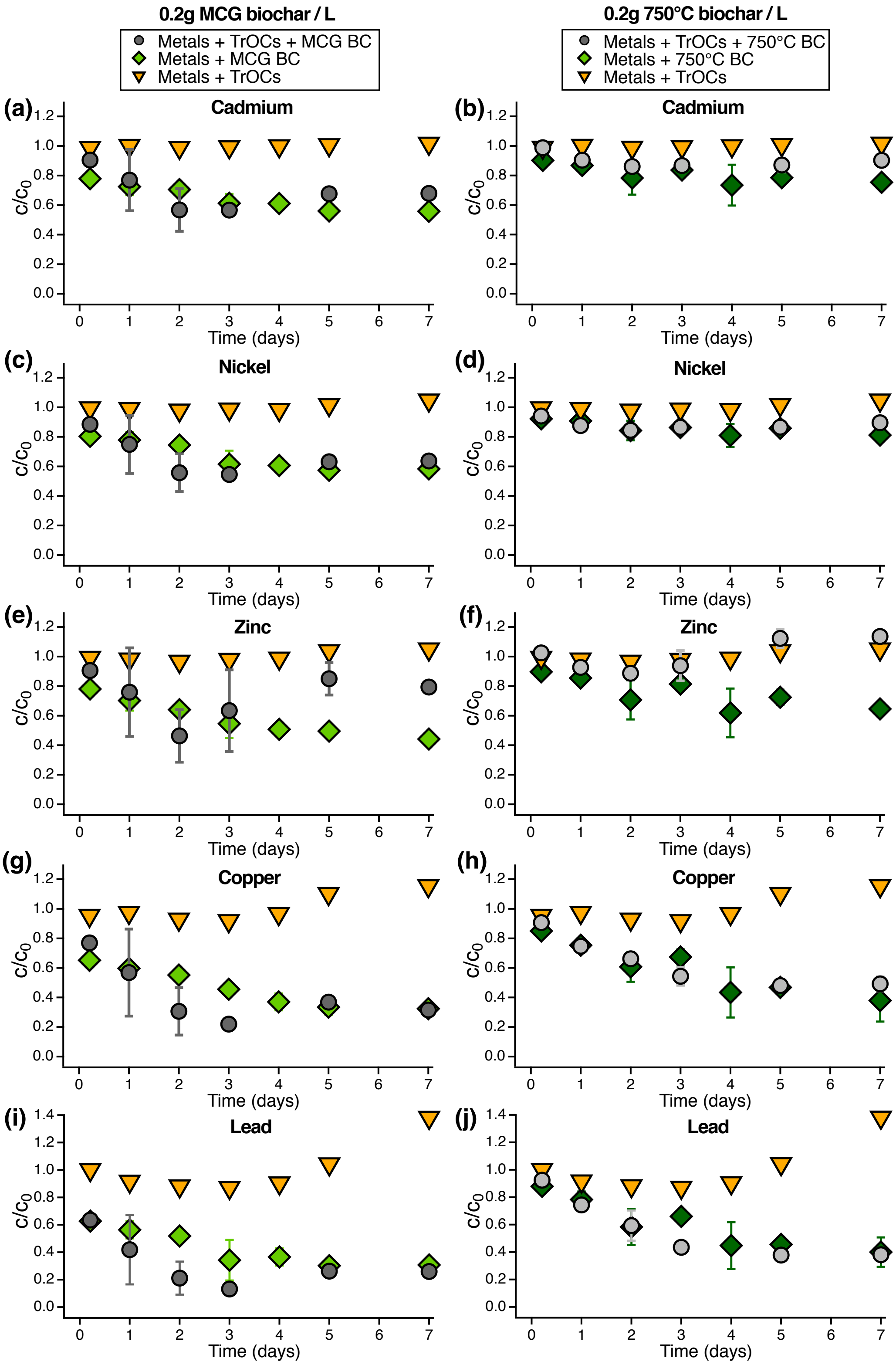

Figure S3 Sorption of five metals ($c_0 = 50\,\mu$g/L, each) onto 0.2 g MCG biochar/L (a, c, e, g, i) and 0.2 g 750°C biochar/L (b, d, f, h, j) over 7 days in the presence and absence of seven TrOCs ($c_0 = 50\,\mu$g/L, each) in synthetic stormwater (pH 7.5). Control experiments contained five metals and seven TrOCs ($c_0 = 50\,\mu$g/L, each). Error bars represent standard deviations of triplicate experiments.

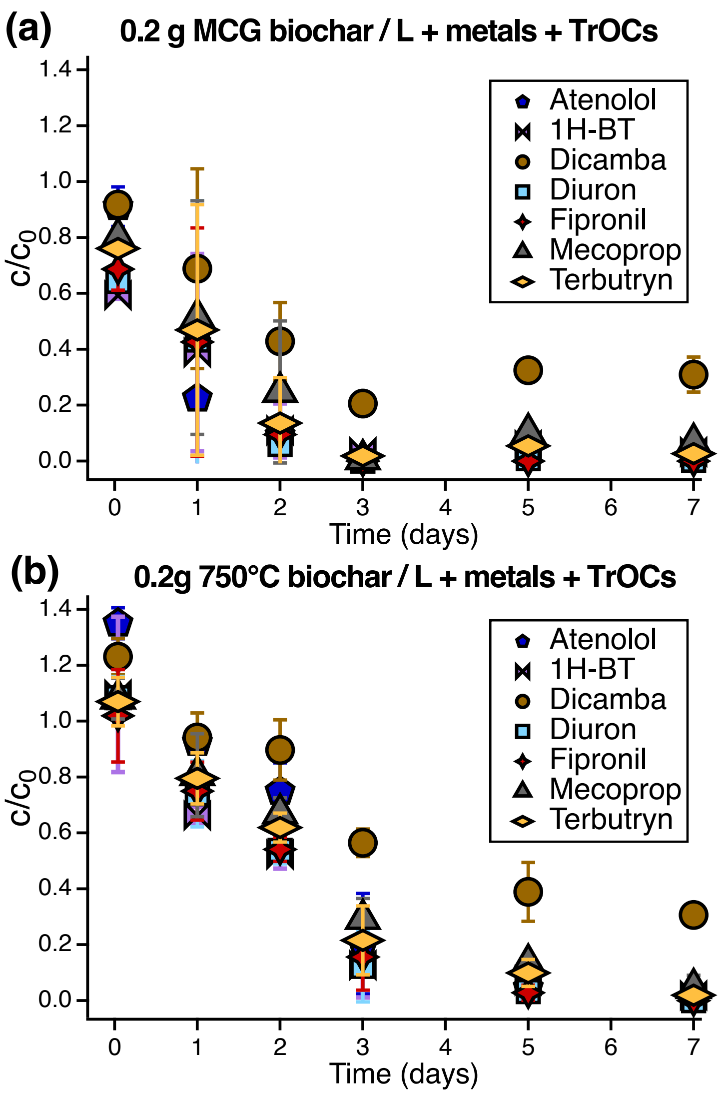

Figure S4 Sorption of seven TrOCs ($c_0 = 50\,\mu$g/L, each) onto (a) 0.2 g MCG biochar/L and (b) 0.2 g 750°C biochar/L over 7 days in the presence of five metals ($c_0 = 50\,\mu$g/L, each) in synthetic stormwater at pH 7.5.

Table S9 Comparison of batch experiments with 0.2 g biochar/L and five metals ($c_0 = 50\,\mu$g/L, each) in the presence and absence of seven TrOCs ($c_0 = 50\,\mu$g/L, each) after 7 days in synthetic stormwater at pH 7.5. Significance accepted at p-value <0.05 (yellow) and p-value <0.2 (blue).

	p-value	
Compound	MCG biochar	750°C biochar
Cadmium	**0.001**	**0.014**
Nickel	**0.021**	**0.042**
Zinc	**0.0002**	**0.001**
Copper	0.705	0.263
Lead	0.149	0.790

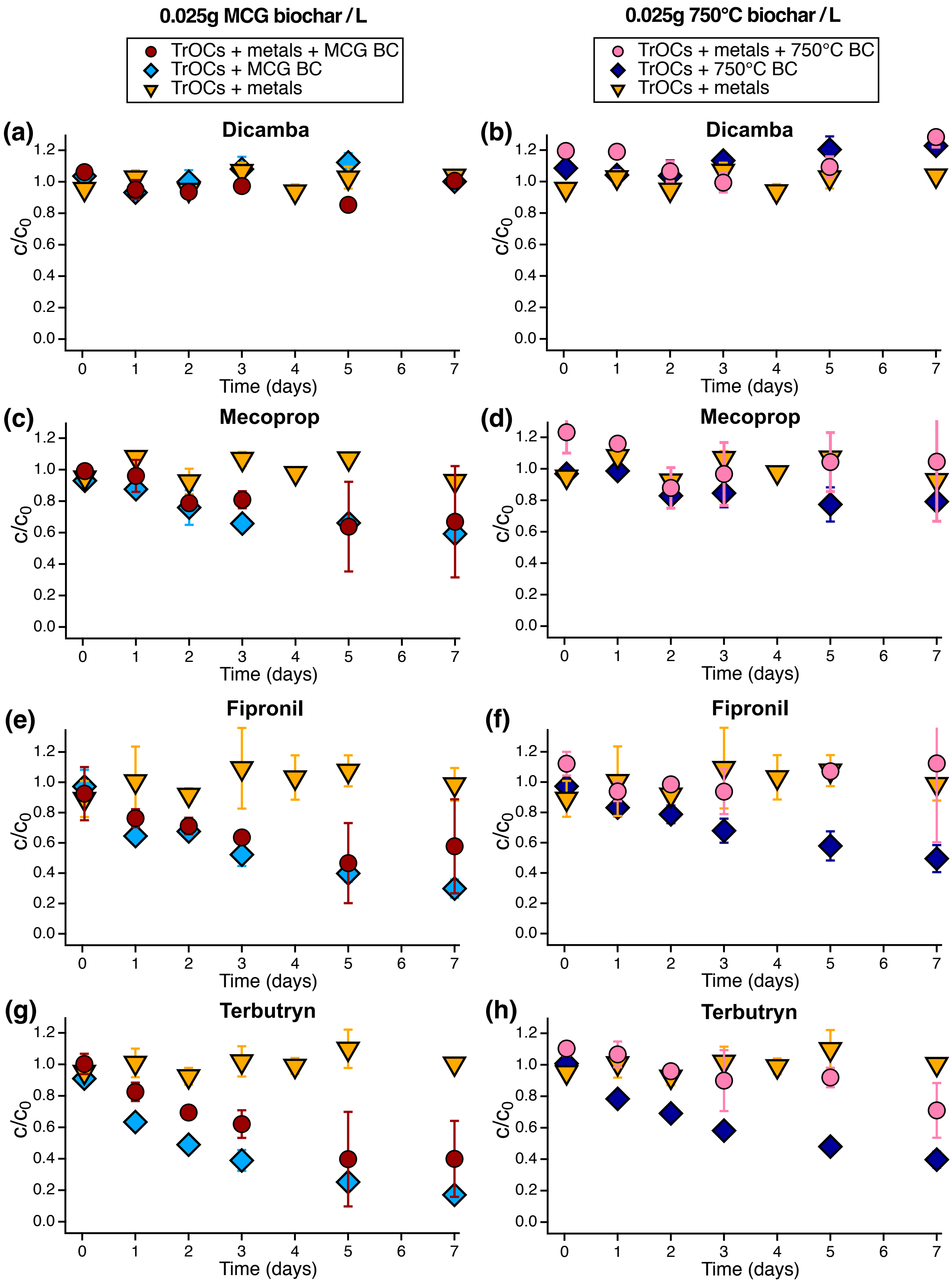

Figure S5 Sorption of seven TrOCs ($c_0 = 50\,\mu g/L$, each) onto 0.025 g MCG biochar/L (a, c, e, g) and 0.025 g 750°C biochar/L (b, d, f, h) over 7 days in the presence and absence of five metals ($c_0 = 50\,\mu g/L$, each) in synthetic stormwater (pH 7.5). Control experiments contained seven TrOCs and five metals ($c_0 = 50\,\mu g/L$, each). Error bars represent standard deviations of triplicate experiments.

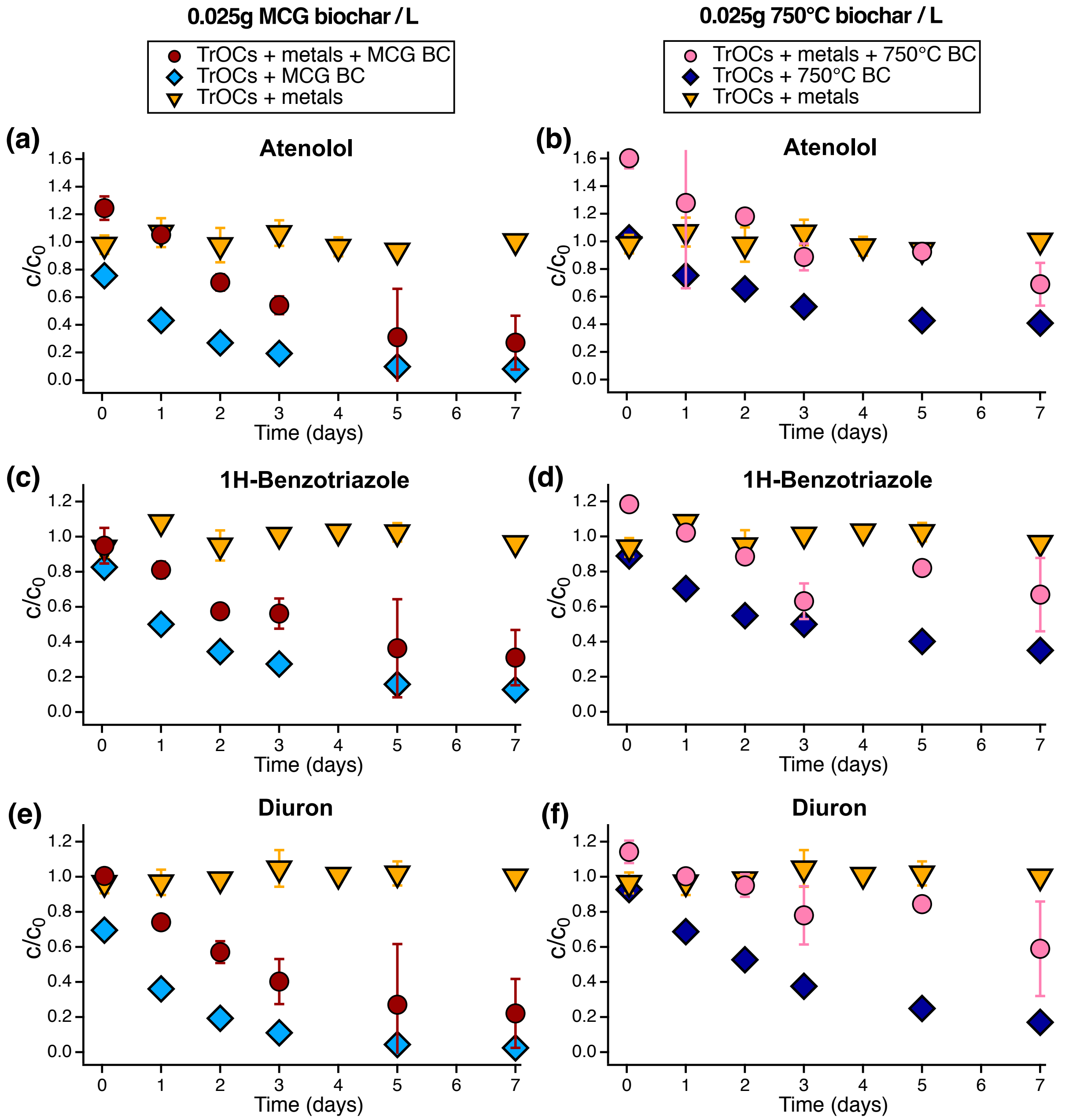

Figure S6 Sorption of seven TrOCs ($c_0 = 50\,\mu$g/L, each) onto 0.025 g MCG biochar/L (a, c, e) and 0.025 g 750°C biochar/L (b, d, f) over 7 days in the presence and absence of five metals ($c_0 = 50\,\mu$g/L, each) in synthetic stormwater (pH 7.5). Control experiments contained seven TrOCs and five metals ($c_0 = 50\,\mu$g/L, each). Error bars represent standard deviations of triplicate experiments.

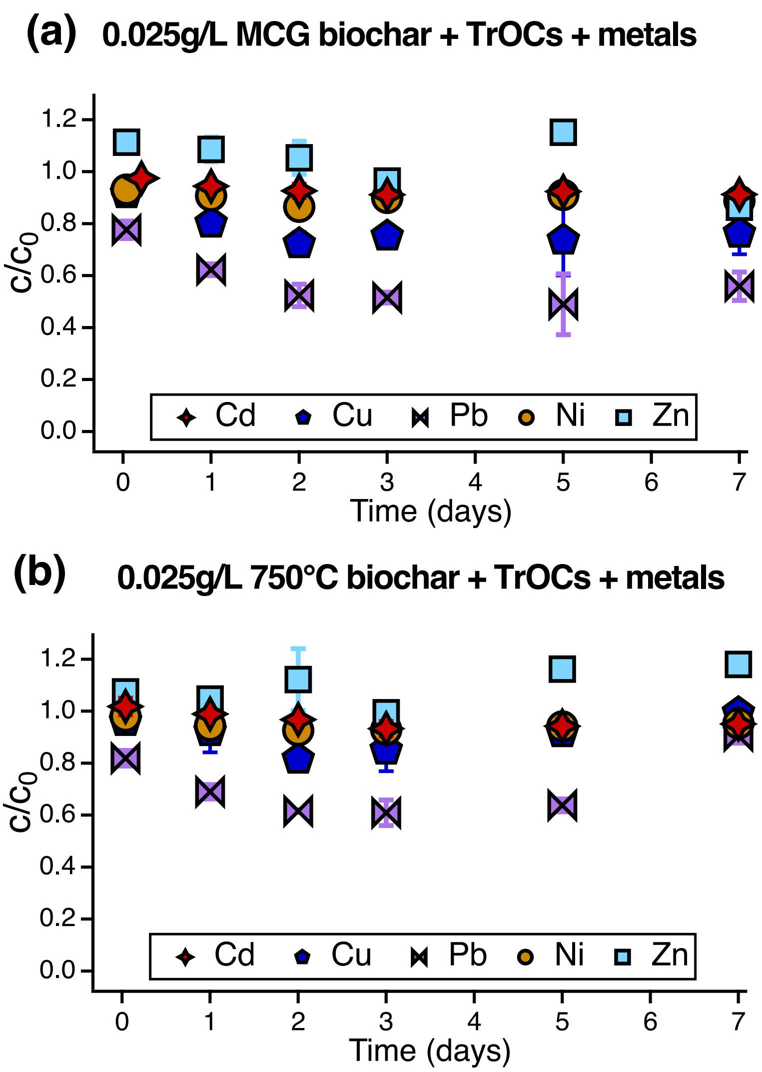

Figure S7 Sorption of five metals ($c_0 = 50\,\mu g/L$, each) onto (a) 0.025 g MCG biochar/L and (b) 0.025 g 750°C biochar/L over 7 days in the presence of seven TrOCs ($c_0 = 50\,\mu g/L$, each) in synthetic stormwater at pH 7.5.

Table S10 Comparison of batch experiments with 0.025 g biochar/L and seven TrOCs ($c_0 = 50\,\mu g/L$, each) in the presence and absence of five metals ($c_0 = 50\,\mu g/L$, each) after 7 days in synthetic stormwater at pH 7.5. Significance accepted at p-value <0.05 (yellow) and p-value <0.2 (blue).

	p-value	
Compound	MCG biochar	750°C biochar
Dicamba	0.972	0.2813
Mecoprop	0.743	0.367
Fipronil	0.266	0.175
Terbutryn	0.245	**0.040**
Atenolol	0.233	**0.039**
1H-benzotriazole	0.183	0.120
Diuron	0.226	0.117

Table S11 7-day log K_d values for sorption of the organic compounds onto the biochar produced at 750°C and onto MCG biochar in the absence and presence of five metals. Batch experiments contained 5 mg of the respective biochar in 200 mL synthetic stormwater at pH 7.5 corresponding to 0.025 g biochar/L. The seven organic contaminants were present as a mixture in solution with initial concentrations of 50 μg/L, each. Log K_d values are reported for 10 - 90% sorption. A (-) is shown where less than 10% or more than 90% of the organic compound mass was sorbed. The corresponding c/c_0 data are shown in Figures S5 and S6 and in Figure 2 of the main manuscript.

	log K_d						
	Dicamba	Mecoprop	Fipronil	Terbutryn	Atenolol	1H-Benzo-triazole	Diuron
750°C biochar	-	4.0 ± 0.1	4.6 ± 0.2	4.8 ± 0.1	4.8 ± 0.1	4.9 ± 0.02	5.3 ± 0.1
750°C biochar + metals	-	-	-	4.2 ± 0.4	4.2 ± 0.3	4.2 ± 0.4	4.4 ± 0.5
MCG biochar	-	4.4 ± 0.1	5.0 ± 0.1	5.3 ± 0.1	-	5.4 ± 0.03	-
MCG biochar + metals	-	4.3 ± 0.6	4.4 ± 0.7	4.8 ± 0.5	5.1 ± 0.4	5.0 ± 0.3	5.3 ± 0.5

S7 Column experiments

Figure S8 Laboratory column setup. Upflow columns labeled with S1-S3 contained silica sand, C1-C3 contained silica sand mixed with 20 wt% carbonate sand, SB1-SB3 contained silica sand mixed with 1 wt% MCG biochar, CB1-CB3 contained silica sand mixed with 20 wt% carbonate sand and 1 wt% MCG biochar.

S7.1 Porosity

After filling the columns with the different filter materials, we determined the dry weight of the packed columns. Subsequently, the columns were filled with water at a flow rate of 0.5 mL/min. After 48 hours, the wet weight of the columns was determined and the porosity of the filter material was calculated as difference between wet and dry weight of the columns.

S7.2 Bromide tracer tests

Bromide tracer tests were conducted to determine the hydraulic retention time (HRT) in the column at a flow rate of 1.25 mL/min. The columns were spiked with a 0.4 g/L bromide solution for eighty seconds corresponding to an injected volume of 1.7 mL. Over a period of 180 minutes, samples were collected at all column effluents in pre-determined time intervals. Samples were analyzed with a bromide probe (Hanna Instruments) and a multi-parameter meter (Orion 5 Star, Thermo Scientific) using an external calibration curve from 0.080 mg/L to 40 mg/L bromide.

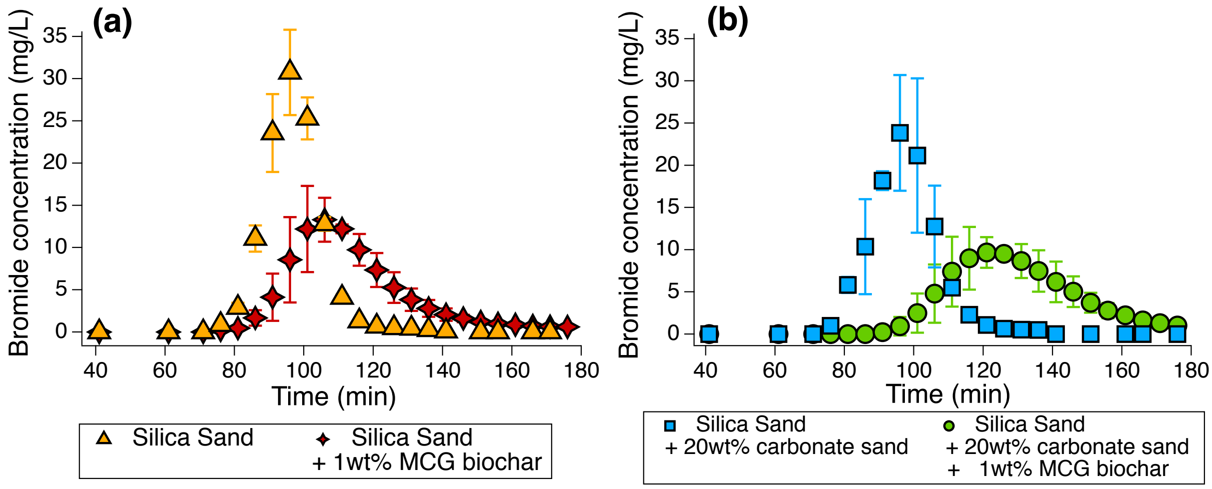

Figure S9 Bromide tracer tests for columns filled with (a) silica sand and silica sand mixed with 1 wt% MCG biochar and (b) silica sand mixed with 20 wt% carbonate sand and silica sand mixed with 20 wt% carbonate sand and 1 wt% MCG biochar. Error bars represent standard deviations of the triplicate column systems.

Table S12 Average porosity and hydraulic retention times of the different triplicate column configurations including standard deviations.

Column	Porosity (–)	Hydraulic retention time (min)
Silica sand	0.36 ± 0.047	97.1 ± 0.4
+ 20 wt% carbonate sand	0.35 ± 0.006	92.3 ± 2.1
+ 1 wt% MCG biochar	0.39 ± 0.019	109.7 ± 4.8
+ 20 wt% carbonate sand + 1 wt% MCG biochar	0.41 ± 0.011	126.1 ± 5.9

S7.3 Dissolved organic carbon and total nitrogen

Dissolved organic carbon (DOC) and total nitrogen (TN) were analyzed using a Shimadzu total organic carbon analyzer (TOC-L) with a Shimadzu ASI-L autosampler. DOC was analyzed as non-purgeable organic carbon (NPOC) using a liquid organic carbon standard (100 mg/L C, RICCA Chemical Company) for the calibration in the range of 2 - 50 mg/L C. A nitrate nitrogen standard (10 mg/L N, RICCA Chemical Company) was diluted to a calibration range from 1 - 10 mg/L N. Prior to DOC and TN analyses, samples were filtered with 0.45 μm PES syringe filters (TISCH Scientific).

Table S13 Dissolved organic carbon (DOC) concentrations in the mixing chamber and the column effluents over time measured as non-purgeable organic carbon including the standard deviations of the triplicate columns.

Pore Volumes	Dissolved organic carbon (mg C/L)				
	PV 0[a]	PV 147	PV 1000	PV 1524	PV 2185
Mixing chamber	3.4	4.2	2.1	2.3	2.0
Silica sand	5.5 ± 3.3	3.8 ± 0.6	2.2 ± 0.1	2.2 ± 0.1	2.2 ± 0.2
+ 20 wt% carbonate sand	3.4 ± 0.2	4.2 ± 0.4	2.5 ± 0.3	2.1 ± 0.3	2.1 ± 0.1
+ 1 wt% MCG biochar	2.1 ± 0.2	3.6 ± 0.3	2.2 ± 0.3	1.9 ± 0.1	1.7 ± 0.1
+ 20 wt% carbonate sand + 1 wt% MCG biochar	1.9 ± 0.1	2.9 ± 0.2	1.9 ± 0.2	1.7 ± 0.5	2.0 ± 0.1

[a] 24 hours before starting the challenge test (i.e, before introducing metals and TrOCs).

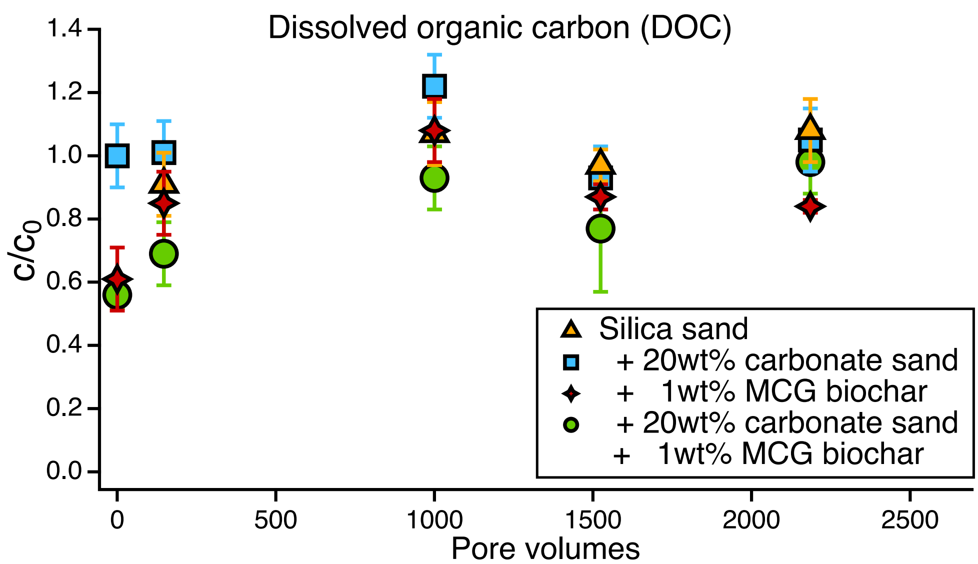

Figure S10 Dissolved organic carbon (DOC) concentrations (c) measured over time at the column effluents divided by the DOC influent concentrations (c_0) in synthetic stormwater in the mixing chamber. Error bars represent the standard deviation of the triplicate column systems.

Table S14 Total nitrogen (TN) concentrations in the mixing chamber and the column effluents including the standard deviations of the triplicate columns.

Pore Volumes	**Total nitrogen (mg/L)** PV 0[a]	PV 147	PV 1000	PV 1524	PV 2185
Mixing chamber	1.8	2.0	2.5	2.4	2.5
Silica sand	1.9 ± 0.1	1.9 ± 0.03	2.5 ± 0.03	2.3 ± 0.1	2.6 ± 0.1
+ 20 wt% carbonate sand	1.8 ± 0.1	2.0 ± 0.01	2.5 ± 0.1	2.4 ± 0.03	2.6 ± 0.1
+ 1 wt% MCG biochar	1.8 ± 0.1	1.9 ± 0.02	2.3 ± 0.03	2.3 ± 0.1	2.6 ± 0.1
+ 20 wt% carbonate sand + 1 wt% MCG biochar	1.8 ± 0.03	1.8 ± 0.1	2.4 ± 0.1	2.1 ± 0.5	2.6 ± 0.1

[a] 24 hours before starting the challenge test (i.e, before introducing metals and TrOCs).

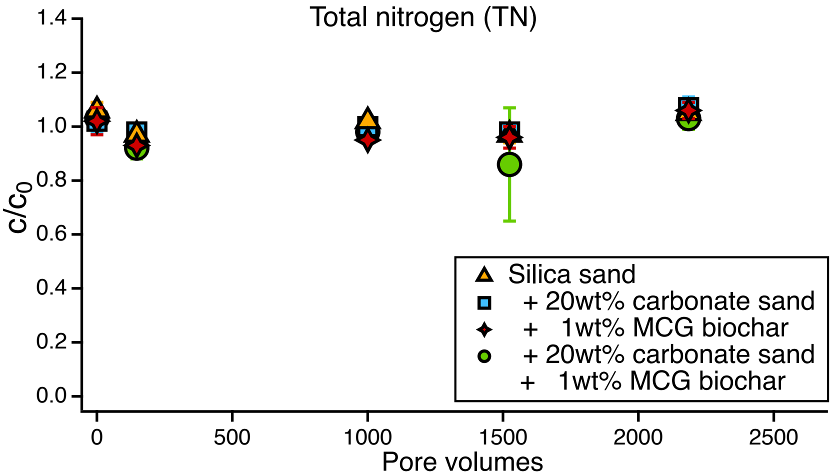

Figure S11 Total nitrogen (TN) concentrations (c) measured over time at the column effluents divided by the TN influent concentrations (c_0) in synthetic stormwater in the mixing chamber. Error bars represent the standard deviation of the triplicate column systems.

S7.4 Dissolved oxygen

Dissolved oxygen was quantified using a digital optical dissolved oxygen meter (ProODO, YSI). A flow-through cell was attached at the column effluent and dissolved oxygen measurements were recorded after 15 minutes when the value was stable.

Table S15 Dissolved oxygen concentrations in the mixing chamber and the column effluents including the standard deviations of the triplicate columns.

Pore Volumes	**Dissolved oxygen (mg/L)** PV 147	PV 1195	PV 1735
Mixing chamber	8.6	8.7	8.5
Silica sand	6.6 ± 0.5	6.8 ± 0.5	6.8 ± 0.7
+ 20 wt% carbonate sand	6.9 ± 0.1	6.5 ± 0.2	6.7 ± 0.8
+ 1 wt% MCG biochar	7.1 ± 0.2	5.7 ± 0.5	5.7 ± 0.2
+ 20 wt% carbonate sand + 1 wt% MCG biochar	7.3 ± 0.6	6.1 ± 0.2	5.7 ± 0.2

S7.5 Nutrients

Nitrate, ammonium, nitrite, and phosphate were analyzed using a SmartChem 200 Discrete Analyzer from Westco Scientific Instruments. Prior to analysis, samples were filtered with 0.45 μm PES syringe filters (TISCH Scientific). The calibration range was from 0.2 - 22 mg/L for nitrate, 0.06 - 6.4 mg/L for ammonium, 0.07 - 6.6 mg/L for nitrite (not detected in any of the samples), and 0.01 - 3 mg/L for phosphate. Sulfate was quantified using ion chromatography (Dionex Integrion HPIC with an IonPac AS11 column, Thermo Scientific). External calibration standards in the range from 1 - 30 mg/L were prepared from a sulfate standard (Inorganic Ventures).

Table S16 Nitrate concentrations in the mixing chamber and the column effluents including the standard deviations of the triplicate columns.

	Nitrate concentration (mg/L)					
Pore Volumes	PV 0[a]	PV 147	PV 205	PV 1001	PV 1525	PV 2185
Mixing chamber	3.4	4.9	9.7	7.8	7.0	6.5
Silica sand	3.8 ± 0.1	4.8 ± 0.1	9.7 ± 0.3	8.6 ± 0.9	7.3 ± 1.0	8.3 ± 1.4
+ 20 wt% carbonate sand	3.8 ± 0.2	4.9 ± 0.3	9.3 ± 0.3	6.7 ± 0.8	8.2 ± 1.5	9.1 ± 0.2
+ 1 wt% MCG biochar	3.7 ± 0.1	4.8 ± 0.2	9.4 ± 0.4	7.7 ± 0.8	9.2 ± 0.4	8.3 ± 1.6
+ 20 wt% carbonate sand + 1 wt% MCG biochar	3.7 ± 0.1	4.8 ± 0.1	9.5 ± 0.3	7.2 ± 2.0	6.7 ± 2.5	6.9 ± 0.7

[a] 24 hours before starting the challenge test (i.e, before introducing metals and TrOCs).

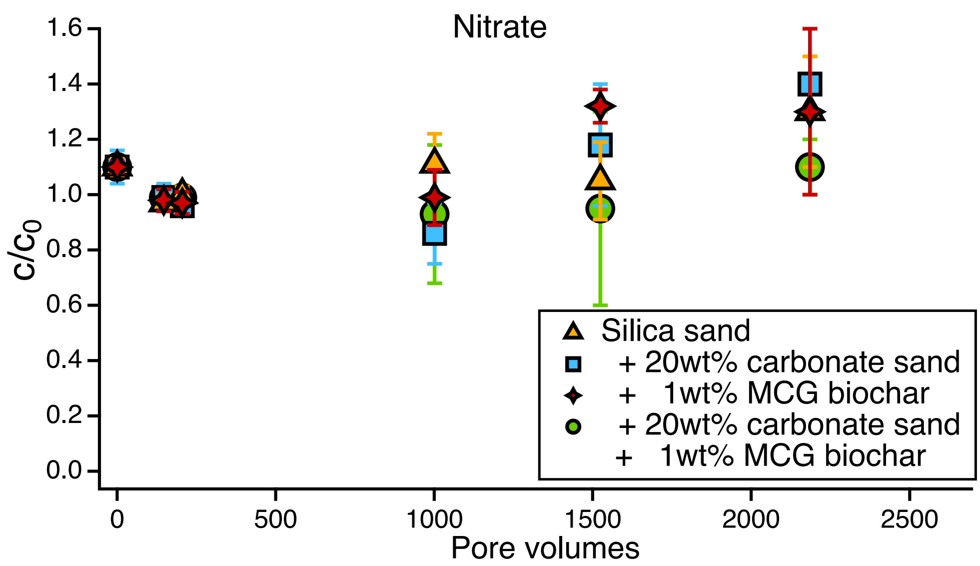

Figure S12 Nitrate concentrations (c) measured over time at the column effluents divided by the nitrate influent concentrations (c_0) in synthetic stormwater in the mixing chamber. Error bars represent the standard deviation of the triplicate column systems.

Table S17 Ammonium concentrations in the mixing chamber and the column effluents including the standard deviations of the triplicate columns.

Pore Volumes	Ammonium concentration (mg/L)					
	PV 0[a]	PV 147	PV 205	PV 1001	PV 1525	PV 2185
Mixing chamber	1.5	1.1	0.1	0.3	0.1	0.2
Silica sand	1.3 ± 0.06	1.0 ± 0.03	0.1 ± 0.003	0.1 ± 0.02	0.1 ± 0.01	0.1 ± 0.01
+ 20 wt% carbonate sand	1.3 ± 0.01	1.0 ± 0.01	0.1 ± 0.003	0.1 ± 0.01	0.1 ± 0.02	0.2 ± 0.01
+ 1 wt% MCG biochar	1.4 ± 0.02	1.0 ± 0.02	0.1 ± 0.002	0.2 ± 0.02	0.1 ± 0.01	0.2 ± 0.01
+ 20 wt% carbonate sand + 1 wt% MCG biochar	1.3 ± 0.05	1.0 ± 0.06	0.1 ± 0.006	0.1 ± 0.02	0.1 ± 0.01	0.2 ± 0.01

[a] 24 hours before starting the challenge test (i.e, before introducing metals and TrOCs).

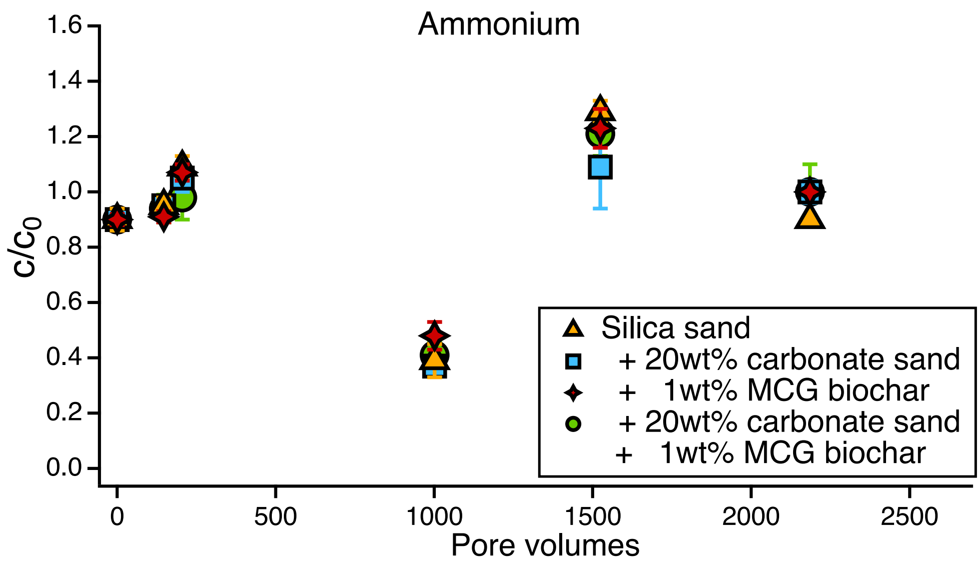

Figure S13 Ammonium concentrations (c) measured over time at the column effluents divided by the ammonium influent concentrations (c_0) in synthetic stormwater in the mixing chamber. Error bars represent the standard deviation of the triplicate column systems.

Table S18 Phosphate concentrations in the mixing chamber and the column effluents including the standard deviations of the triplicate columns.

Pore Volumes	Phosphate concentration (mg/L)					
	PV 0[a]	PV 147	PV 205	PV 1001	PV 1525	PV 2185
Mixing chamber	0.5	0.5	0.5	0.5	0.6	0.6
Silica sand	0.7 ± 0.19	0.4 ± 0.02	0.5 ± 0.01	0.5 ± 0.03	0.5 ± 0.04	0.6 ± 0.05
+ 20 wt% carbonate sand	0.6 ± 0.02	0.4 ± 0.01	0.4 ± 0.02	0.5 ± 0.03	0.5 ± 0.03	0.6 ± 0.01
+ 1 wt% MCG biochar	0.6 ± 0.02	0.5 ± 0.02	0.5 ± 0.01	0.5 ± 0.05	0.5 ± 0.05	0.6 ± 0.02
+ 20 wt% carbonate sand + 1 wt% MCG biochar	0.5 ± 0.02	0.5 ± 0.01	0.5 ± 0.01	0.5 ± 0.04	0.5 ± 0.07	0.6 ± 0.01

[a] 24 hours before starting the challenge test (i.e, before introducing metals and TrOCs).

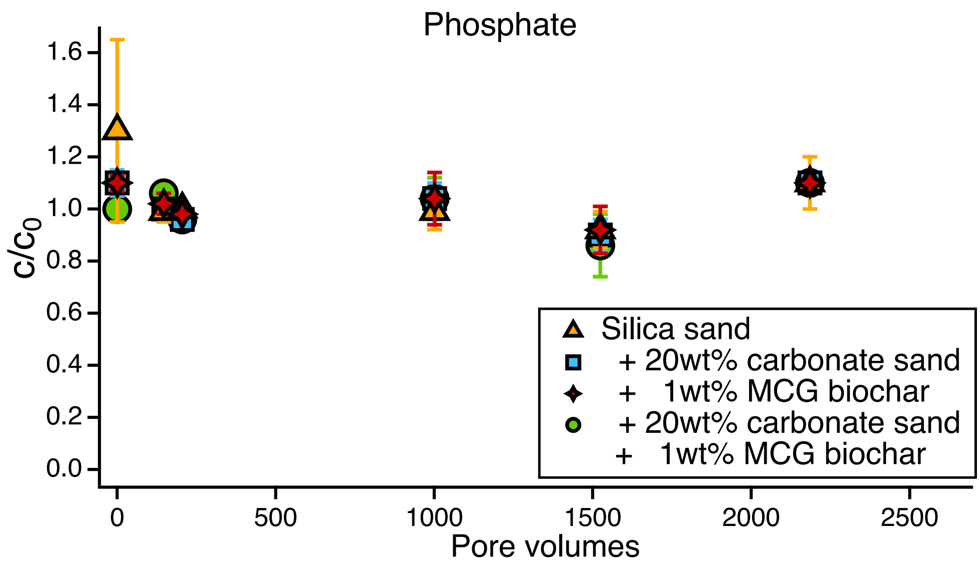

Figure S14 Phosphate concentrations (c) measured over time at the column effluents divided by the phosphate influent concentrations (c_0) in synthetic stormwater in the mixing chamber. Error bars represent the standard deviation of the triplicate column systems.

Table S19 Sulfate concentrations in the mixing chamber and the column effluents including the standard deviations of the triplicate columns.

Pore Volumes	Sulfate concentration (mg/L)		
	PV 1525	PV 1766	PV 2185
Mixing chamber	31.3	31.1	31.1
Silica sand	31.0 ± 0.4	31.1 ± 0.1	30.9 ± 0.01
+ 20 wt% carbonate sand	31.3 ± 0.4	30.6 ± 0.6	31.0 ± 0.02
+ 1 wt% MCG biochar	31.1 ± 0.1	31.2 ± 0.3	30.9 ± 0.1
+ 20 wt% carbonate sand + 1 wt% MCG biochar	30.9 ± 0.2	31.2 ± 0.1	35.2 ± 7.3

S7.6 Additional water quality parameters

Samples collected from the mixing chamber and the column effluents were analyzed for pH, oxidation reduction potential, electrical conductivity, total dissolved solids, and temperature using a multi-parameter probe from HANNA Instruments (HI98195). Turbidity was measured with a turbidimeter from HANNA Instruments (HI98713).

Table S20 pH values in the mixing chamber and the column effluents including the standard deviations of the triplicate columns.

	pH			
Pore Volumes	PV 0[a]	PV 147	PV 205	PV 1524
Mixing chamber	7.60	7.51	7.57	7.33
Silica sand	7.05 ± 0.26	6.89 ± 0.40	7.14 ± 0.03	7.14 ± 0.02
+ 20 wt% carbonate sand	7.72 ± 0.04	7.64 ± 0.04	7.43 ± 0.22	7.23 ± 0.01
+ 1 wt% MCG biochar	7.79 ± 0.06	7.62 ± 0.23	7.42 ± 0.26	6.98 ± 0.07
+ 20 wt% carbonate sand + 1 wt% MCG biochar	7.93 ± 0.03	7.85 ± 0.04	7.72 ± 0.07	7.15 ± 0.04

[a] 24 hours before starting the challenge test (i.e, before introducing metals and TrOCs).

Table S21 Oxidation reduction potential (ORP) values in the mixing chamber and the column effluents including the standard deviations of the triplicate columns.

	ORP (mV)			
Pore Volumes	PV 0[a]	PV 147	PV 205	PV 1524
Mixing chamber	178	221	235	268
Silica sand	212 ± 12	273 ± 18	252 ± 1	256 ± 1
+ 20 wt% carbonate sand	181 ± 3	231 ± 3	256 ± 15	253 ± 1
+ 1 wt% MCG biochar	178 ± 7	230 ± 8	232 ± 33	268 ± 4
+ 20 wt% carbonate sand + 1 wt% MCG biochar	167 ± 2	218 ± 3	224 ± 12	250 ± 12

[a] 24 hours before starting the challenge test (i.e, before introducing metals and TrOCs).

Table S22 Electrical conductivity in the mixing chamber and the column effluents including the standard deviations of the triplicate columns.

	Electrical conductivity (μS/cm)			
Pore Volumes	PV 0[a]	PV 147	PV 205	PV 1524
Mixing chamber	449	369	370	371
Silica sand	451 ± 2	303 ± 72	364 ± 10	370 ± 2
+ 20 wt% carbonate sand	458 ± 3	372 ± 7	363 ± 12	370 ±1
+ 1 wt% MCG biochar	457 ± 3	377 ± 7	369 ± 5	371 ± 4
+ 20 wt% carbonate sand + 1 wt% MCG biochar	462 ± 4	383 ± 2	372 ± 4	372 ± 1

[a] 24 hours before starting the challenge test (i.e, before introducing metals and TrOCs).

Table S23 Total dissolved solids (TDS) in the mixing chamber and the column effluents including the standard deviations of the triplicate columns.

Pore Volumes	Total dissolved solids (TDS, mg/L) PV 0[a]	PV 147	PV 205	PV 1524
Mixing chamber	224	184	185	186
Silica sand	225 ± 1	151 ± 36	183 ± 5	185 ± 1
+ 20 wt% carbonate sand	229 ± 2	186 ± 4	182 ± 6	185 ± 1
+ 1 wt% MCG biochar	229 ± 2	188 ± 4	185 ± 2	185 ± 1
+ 20 wt% carbonate sand + 1 wt% MCG biochar	231 ± 2	192 ± 1	186 ± 2	185 ± 2

[a] 24 hours before starting the challenge test (i.e, before introducing metals and TrOCs).

Table S24 Temperature in the mixing chamber and the column effluents including the standard deviations of the triplicate columns.

Pore Volumes	Temperature (°C) PV 0[a]	PV 147	PV 205	PV 1524
Mixing chamber	21.1	21.7	22.0	22.6
Silica sand	21.5 ± 0.1	21.3 ± 0.4	22.0 ± 0.1	22.4 ± 0.2
+ 20 wt% carbonate sand	21.5 ± 0.1	21.7 ± 0.1	22.0 ± 0.1	22.7 ± 0.1
+ 1 wt% MCG biochar	21.4 ± 0.1	21.4 ± 0.1	21.8 ± 0.2	23.0 ± 0.1
+ 20 wt% carbonate sand + 1 wt% MCG biochar	21.3 ± 0.1	21.6 ± 0.1	21.9 ± 0.1	23.0 ± 0.1

[a] 24 hours before starting the challenge test (i.e, before introducing metals and TrOCs).

Table S25 Turbidity in the mixing chamber and the column effluents including the standard deviations of the triplicate columns.

Pore Volumes	Turbidity (FNU) PV 0[a]	PV 147	PV 205	PV 1524
Mixing chamber	4.4	3.9	3.5	4.1
Silica sand	5.1 ± 0.5	3.9 ± 0.5	4.1 ± 0.03	3.1 ± 0.3
+ 20 wt% carbonate sand	6.0 ± 0.5	3.5 ± 0.1	n.m.[b]	3.5 ± 0.2
+ 1 wt% MCG biochar	3.7 ± 0.1	4.4 ± 0.1	3.8 ± 0.4	3.3 ± 0.2
+ 20 wt% carbonate sand + 1 wt% MCG biochar	3.2 ± 0.2	4.8 ± 0.8	4.0 ± 0.3	3.9 ± 0.5

[a] 24 hours before starting the challenge test (i.e, before introducing metals and TrOCs).
[b] not measured

S8 Metal removal in flow-through column experiments

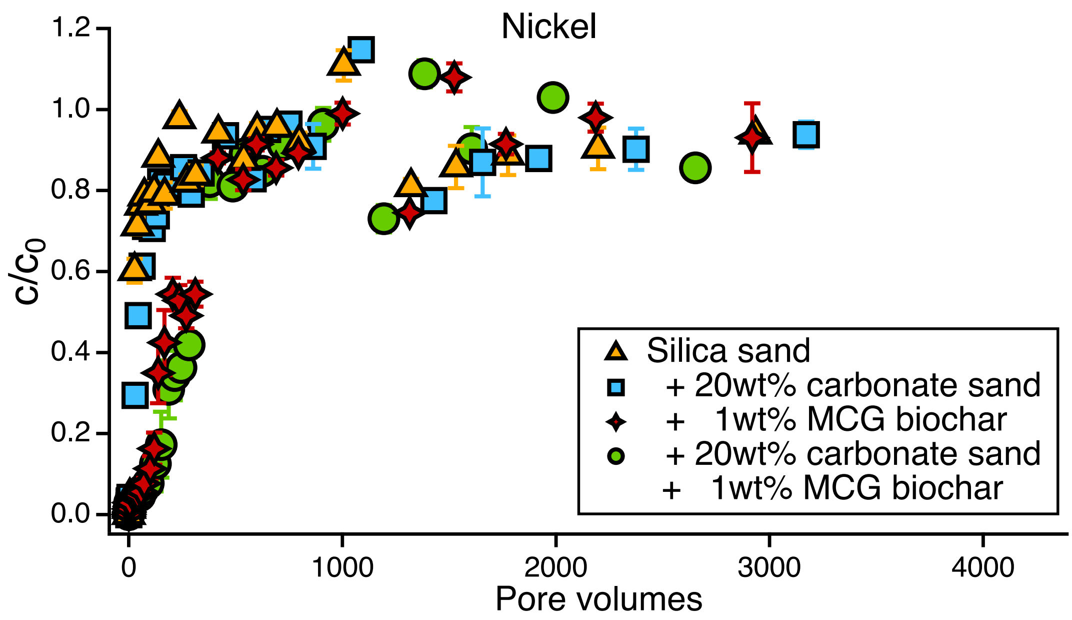

Figure S15 Breakthrough of nickel (initial concentration $c_0 = 50\,\mu g/L$) from synthetic stormwater (pH 7.5) in columns containing (i) silica sand, (ii) silica sand mixed with 20 wt% carbonate sand, (iii) silica sand mixed with 1 wt% MCG biochar, and (iv) silica sand mixed with 20 wt% carbonate sand and 1 wt% MCG biochar. The concentrations c and c_0 were measured at the column effluents and in the mixing chamber, respectively. Error bars represent standard deviations of triplicate columns.

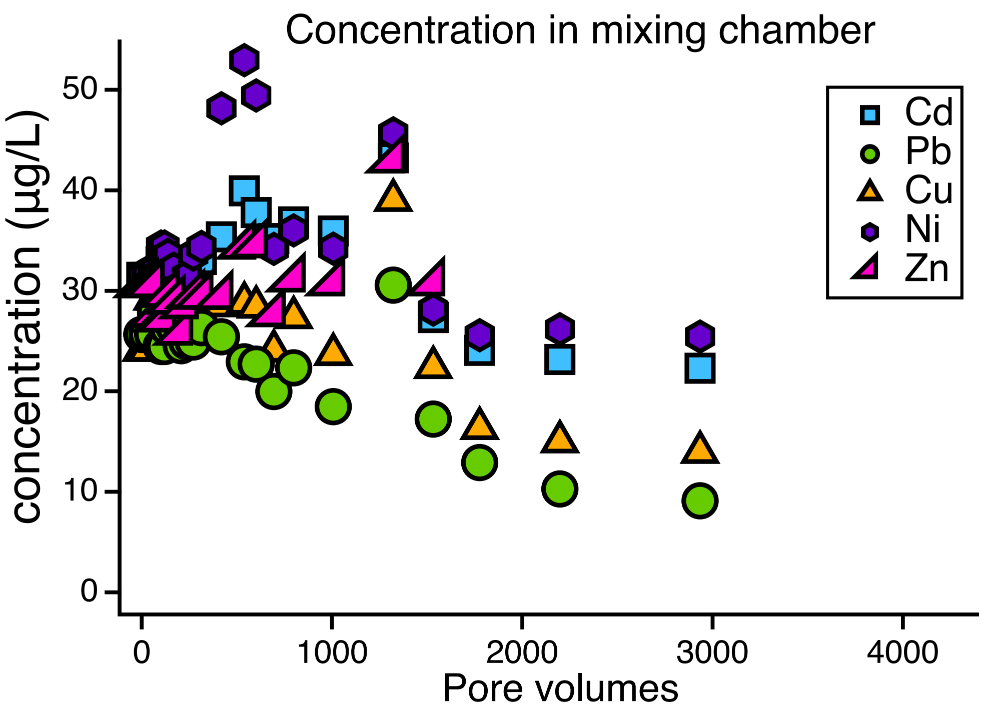

Figure S16 Concentration of the five metals in the mixing chamber over the time course of the column experiment.

Table S26 Tukey's Honest Significant Difference (HSD) post-hoc test to compare the different sand and biochar treatments concerning metal removal in column experiments ($\alpha = 0.05$). Significantly different means are indicated with a star (*).

	p-value				
Comparison	Cd	Ni	Zn	Cu	Pb
S[a] vs. SC[b]	0.0023*	0.9998	0.0036*	>0.9999	0.062
S vs. SB[c]	0.0017*	0.0036*	< 0.0001*	< 0.0001*	< 0.0001*
S vs. SCB[d]	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*
SC vs. SB	0.9996	0.0045*	0.0061*	< 0.0001*	< 0.0001*
SC vs. SCB	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*
SB vs. SCB	< 0.0001*	0.4146	< 0.0001*	0.6031	< 0.0001*

[a] S: Silica sand
[b] SC: Silica sand + 20 wt% carbonate sand
[c] SB: Silica sand + 1 wt% MCG biochar
[d] SCB: Silica sand + 20 wt% carbonate sand + 1 wt% MCG biochar

S9 TrOC removal in flow-through column experiments

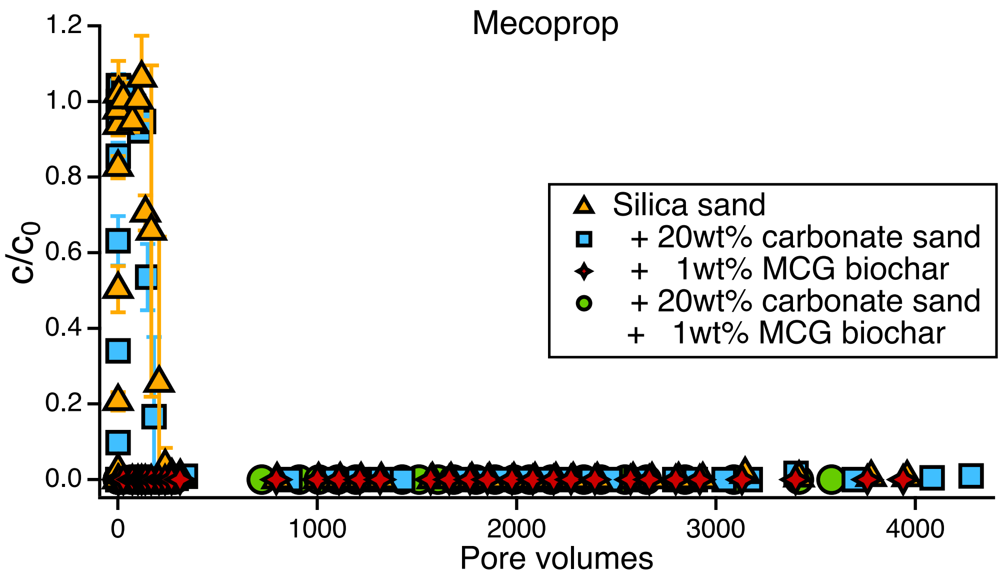

Figure S17 Breakthrough of mecoprop (initial nominal concentration $c_0 = 50\,\mu g/L$) from synthetic stormwater (pH 7.5) in columns containing (i) silica sand, (ii) silica sand mixed with 20 wt% carbonate sand, (iii) silica sand mixed with 1 wt% MCG biochar, and (iv) silica sand mixed with 20 wt% carbonate sand and 1 wt% MCG biochar. The concentrations c and c_0 were measured at the column effluents and in the mixing chamber, respectively. Error bars represent standard deviations of triplicate columns.

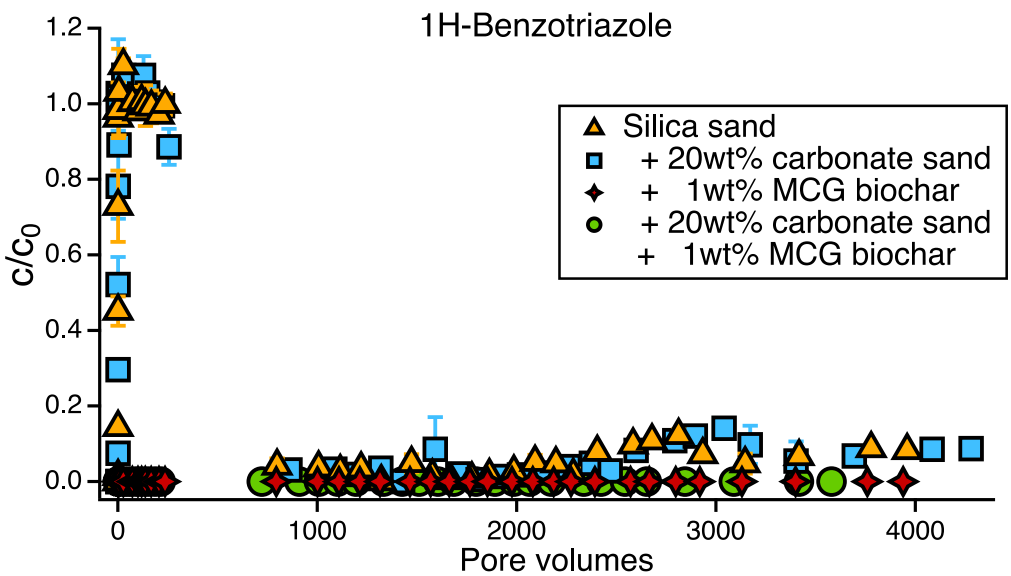

Figure S18 Breakthrough of 1H-benzotriazole (initial nominal concentration $c_0 = 50\,\mu g/L$) from synthetic stormwater (pH 7.5) in columns containing (i) silica sand, (ii) silica sand mixed with 20 wt% carbonate sand, (iii) silica sand mixed with 1 wt% MCG biochar, and (iv) silica sand mixed with 20 wt% carbonate sand and 1 wt% MCG biochar. The concentrations c and c_0 were measured at the column effluents and in the mixing chamber, respectively. Error bars represent standard deviations of triplicate columns.

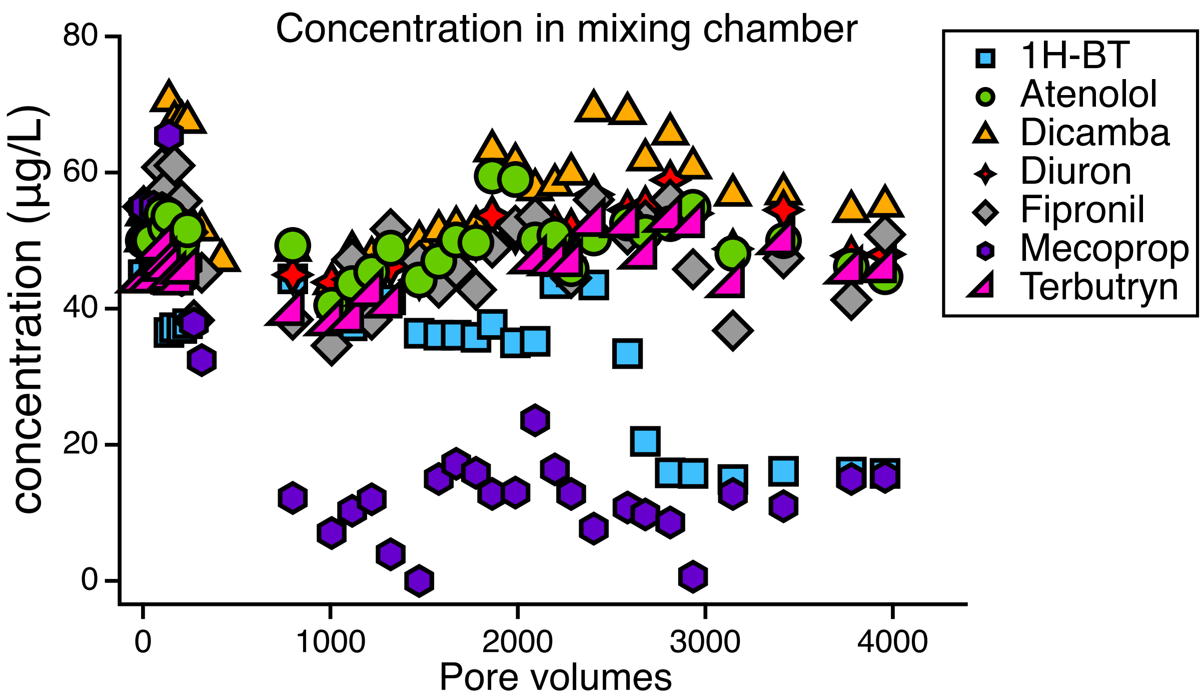

Figure S19 Concentration of the seven trace organic contaminants in the mixing chamber over the time course of the column experiment.

Table S27 Tukey's Honest Significant Difference (HSD) post-hoc test to compare the different sand and biochar treatments concerning TrOCs removal ($\alpha = 0.05$). Significantly different means are indicated with a star (*).

	p-value						
Comparison	Dicamba	Mecoprop	Fipronil	Terbutryn	Atenolol	1H-BT	Diuron
S[a] vs. SC[b]	>0.9999	>0.9999	>0.9999	>0.9999	>0.9999	>0.9999	>0.9999
S vs. SB[c]	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*
S vs. SCB[d]	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*
SC vs. SB	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*
SC vs. SCB	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*	< 0.0001*
SB vs. SCB	0.9642	>0.9999	>0.999	>0.9999	>0.9999	>0.9999	>0.9999

[a] S: Silica sand
[b] SC: Silica sand + 20 wt% carbonate sand
[c] SB: Silica sand + 1 wt% MCG biochar
[d] SCB: Silica sand + 20 wt% carbonate sand + 1 wt% MCG biochar

S10 Forward-prediction transport model

S10.1 Model equations, input parameters, and references

A one-dimensional numerical model for the transport of trace organic contaminants in the biochar columns was adopted from Werner et al. 2012[2] and Ulrich et al. 2015.[1] The movement of organic contaminant molecules in or out of the biochar particles was described by intraparticle diffusion. For the diffusion-limited sorption kinetics, the mass transport equation was[2]

$$\frac{dc_w}{dt} = E_{disp}\frac{\partial^2 c_w}{\partial x^2} - u_x\frac{\partial c_w}{\partial x} - \frac{1-\theta_w-\theta_{sand}}{\theta_w}\frac{d}{dt}\left[3\int_0^1 y^2 S dy\right] \tag{1}$$

where c_w (moles/m^3) is the aqueous concentration of the organic contaminant, t (s) is the time, E_{disp} (m^2/s) is the hydrodynamic dispersion coefficient, x (m) is the distance from the column inlet in the flow direction, u_x (m/s) is the porewater velocity, θ_w (–) is the volumetric water content of the column external to the grains, θ_{sand} (–) is the volumetric fraction of the column filled with sand, y (–) is the ratio of the radial distance r (m) from the center of the biochar particle divided by the biochar particle radius R (m), S (moles/m^3) is the volumetric concentration of the contaminants in the biochar particle.

The intraparticle diffusion is described by[2]

$$\frac{\partial S}{\partial t} = \frac{D_{app}}{R^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial S}{\partial r}\right) \tag{2}$$

where D_{app} (m^2/s) is the apparent intraparticle diffusion coefficient.[2] The non-linear Freundlich isotherm is described by

$$c_s = K_{fr} \cdot c_w^N \tag{3}$$

$$N = \frac{1}{n_{fr}} \tag{4}$$

where c_s (kg/kg) is the solid phase concentration of the organic contaminant, K_{fr} is the Freundlich coefficient in (moles/kg)(m^3/moles)$^{\mathrm{N}}$, and N is the Freundlich exponent (–).

Assuming the non-linear Freundlich isotherm, the apparent diffusion coefficient D_{app} depends on the aqueous contaminant concentration as described by[2]

$$D_{app} = \frac{D_{aq}p_{bc}}{(d_s K_{fr} N {c_w}^{N-1} + p_{bc})\tau} \tag{5}$$

where D_{aq} (m^2/s) is the molecular diffusion coefficient in water, p_{bc} (–) is the intraparticle porosity of biochar, d_s (kg/m^3) is the solid (skeletal) density of the grains, and τ (–) is the intraparticle tortuosity. The molecular diffusion coefficients D_{aq} were estimated according to[1]

$$D_{\mathrm{aq}} = \frac{2.7\cdot 10^{-8}}{\mathrm{MW}^{0.71}} \tag{6}$$

where MW is the molecular weight of the organic contaminants ($\mathrm{MW}_{\mathrm{dicamba}} = 221.04$ g/mol; $\mathrm{MW}_{\mathrm{fipronil}} = 437.15$ g/mol; $\mathrm{MW}_{\mathrm{terbutryn}} = 241.36$ g/mol).

Table S28 Input parameters for model calculations, parameter values and references.

Parameter		Parameter value	Source
Column length		$L_c = 0.48\,m$	measured
Inner column radius		$R_c = 0.015875\,m$	measured
Dry mass of biochar in the column (0.87 wt%)		$M_{bc} = 0.0058\,kg$	measured
Dry mass of sand in the column		$M_{sand} = 0.660\,kg$	measured
Flow through the column		$Q = 2.08167 \cdot 10^{-8}\ m^3/s$	measured
Hydrodynamic dispersion coefficient		$E_{disp} = 4.4 \cdot 10^{-7}\ m^2/s$	Br tracer fitting
Solid density of sand particles		$d_{sand} = 2650\ kg/m^3$	Fisher Scientific
Radius of the sand particles		$R_{sand} = 3.5 \cdot 10^{-4}\ m$	Fisher Scientific
Sorption coefficient for the sand particles		$K_{sand} = 0\ m^3/kg$	assumed
Radius of the MCG biochar particles		$R_{bc} = 3.5 \cdot 10^{-4}\ m$	sieved biochar
Solid skeletal density of MCG biochar		$d_{bc} = 1784\ kg/m^3$	measured[a]
Intraparticle porosity of MCG biochar particles		$p_{bc} = 0.70$ [-]	measured[b]
Different biochar amounts			
Dry mass of biochar in the column	1 wt% MCG	$M_{bc} = 0.0059\,kg$	calculated[c]
	2.5 wt% MCG	$M_{bc} = 0.0133\,kg$	calculated[c]
	5 wt% MCG	$M_{bc} = 0.0228\,kg$	calculated[c]
	10 wt% MCG	$M_{bc} = 0.0352\,kg$	calculated[c]
Dry mass of sand in the column	1 wt% MCG	$M_{sand} = 0.5889\,kg$	calculated[c]
	2.5 wt% MCG	$M_{sand} = 0.5201\,kg$	calculated[c]
	5 wt% MCG	$M_{sand} = 0.4323\,kg$	calculated[c]
	10 wt% MCG	$M_{sand} = 0.3167\,kg$	calculated[c]

[a] Helium pycnometry (Particle Technology Labs, PTL, US)
[b] Mercury intrusion porosimetry (Particle Technology Labs, PTL, US)
[c] Using bulk densities of 181.5 kg/m^3 for MCG biochar and 1690 kg/m^3 for sand

S10.2 Sorption parameters from column breakthrough curves

The intraparticle tortuosity τ (–) of the MCG biochar as well as the Freundlich coefficient (K_{fr}) and the Freundlich exponent ($N = 1/n_{fr}$) were obtained from fitting the measured effluent data for dicamba in columns containing sand mixed with 0.87 wt% MCG biochar. The intraparticle tortuosity obtained from fitting the dicamba data was further used for the fitting of fipronil and terbutryn breakthrough curves.

Table S29 Sorption parameters and the corresponding standard deviations obtained from fitting the column breakthrough data of the three replicate columns to the transport model. K_{fr} is the Freundlich coefficient and N is the Freundlich exponent. The tortuosity value τ was obtained from the dicamba data and applied to all compounds. The root mean squared error (RMSE) is reported to evaluate the goodness of fit.

Compound	K_{fr} (moles/kg)(m^3/moles)^N	N (–)	τ (–)	RMSE (moles/m^3)
Dicamba	0.56 ± 0.10	0.49 ± 0.021	4.1 ± 0.44	$1.1 \cdot 10^{-5}$
Fipronil	1.42 ± 0.24	0.51 ± 0.023	4.1 ± 0.44	$2.4 \cdot 10^{-6}$
Terbutryn	1.19 ± 0.15	0.46 ± 0.018	4.1 ± 0.44	$2.8 \cdot 10^{-6}$

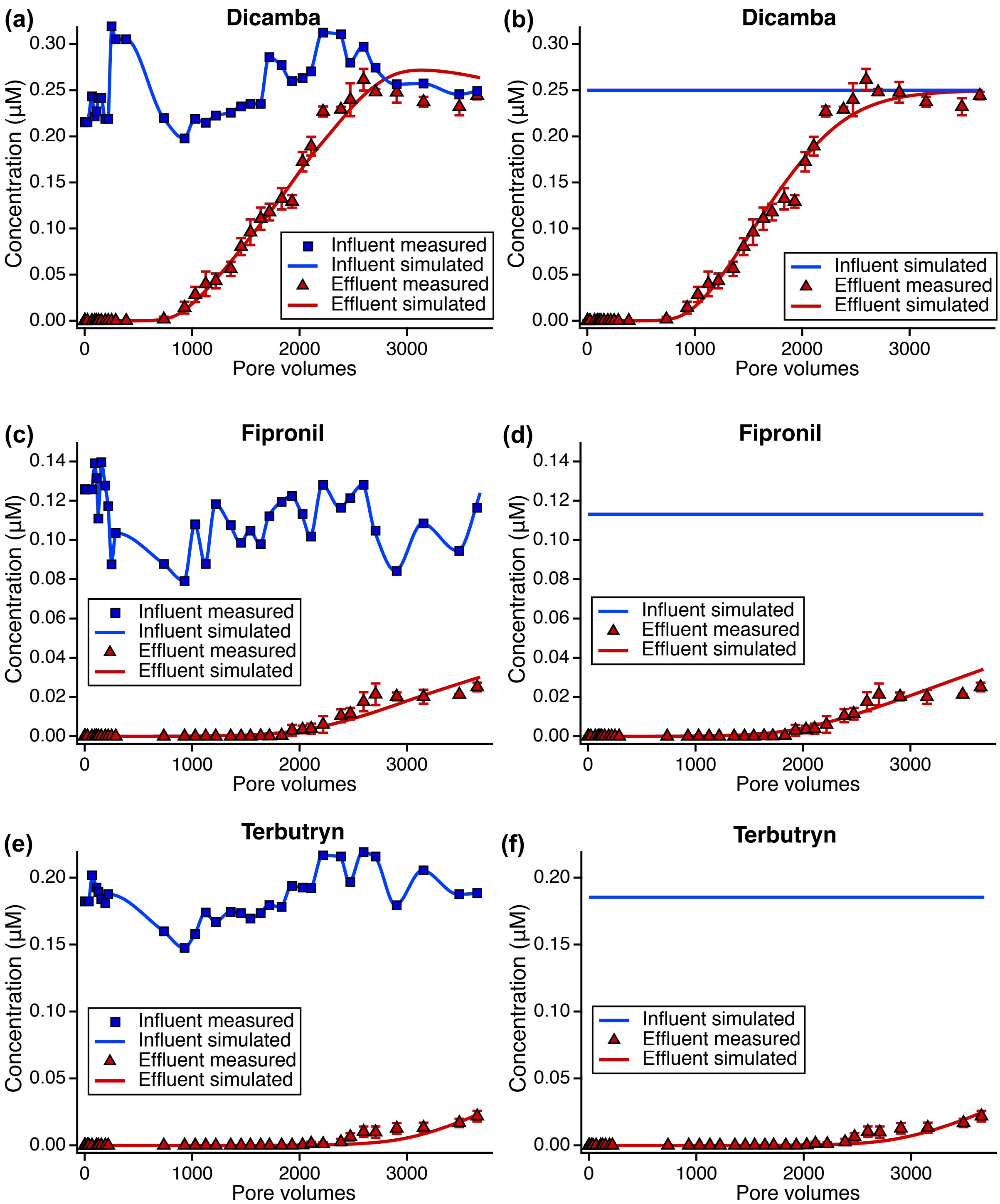

Figure S20 Trace organic contaminant breakthrough curves in columns containing sand mixed with 0.87 wt% MCG biochar. (a) The forward-prediction transport model was fitted to the measured dicamba effluent concentrations using the Freundlich parameters (K_{fr} and N) and the tortuosity (τ) as fitting parameters. (c, e) The forward-prediction transport model was fitted to the measured fipronil and terbutryn effluent concentrations using the Freundlich parameters (K_{fr} and N) as fitting parameters. (b, d, f) Simulated breakthrough curves for constant influent concentration using the obtained tortuosity and Freundlich parameters from the fitting.

S10.3 Case study to predict filter longevity

Table S30 Parameters for case study calculations.

Parameter		Value	Unit
Total volume of stormwater captured per year		$1.1 \cdot 10^6$	m^3/a
Infiltration period		122	days
Stormwater volume infiltrated per day		9016	m^3/d
Filter area		4046.86	m^2
Filter depth		1	m
Porosity of filter material	1 wt% MCG	0.39	–
	2.5 wt% MCG	0.42	–
	5 wt% MCG	0.46	–
	10 wt% MCG	0.51	–
Pore volume of the filter	1 wt% MCG	1563	m^3
	2.5 wt% MCG	1692	m^3
	5 wt% MCG	1855	m^3
	10 wt% MCG	2074	m^3

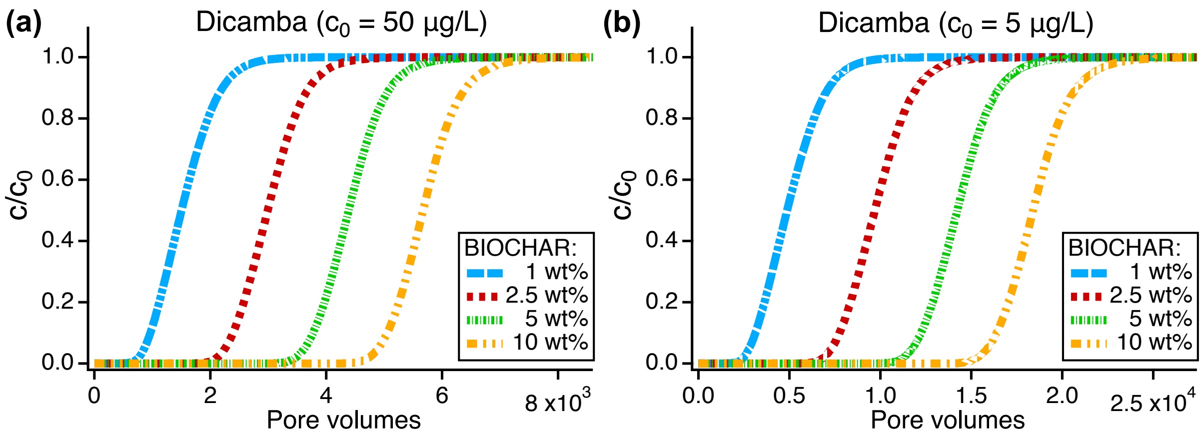

Figure S21 Simulated breakthrough curves for dicamba in columns containing 1 wt%, 2.5 wt%, 5 wt%, and 10 wt% MCG biochar using initial nominal dicamba concentrations of (a) $c_0 = 50\,\mu g/L$ and (b) $c_0 = 5\,\mu g/L$.

Table S31 Pore volumes until breakthrough of dicamba (defined as $c/c_0 = 0.2$) and estimated lifetime of biochar filters containing different weight percents of biochar (1 wt%, 2.5 wt%, 5 wt%, and 10 wt%) in years under ideal conditions with dicamba influent concentrations of $c_0 = 50\,\mu g/L$ and $c_0 = 5\,\mu g/L$.

	50 μg/L		5 μg/L	
Biochar amendment	**Pore volumes** –	**Lifetime** years	**Pore volumes** –	**Lifetime** years
1 wt%	$1.1 \cdot 10^3$	1.6	$3.6 \cdot 10^3$	5.1
2.5 wt%	$2.6 \cdot 10^3$	4.0	$8.4 \cdot 10^3$	12.9
5 wt%	$4.0 \cdot 10^3$	6.7	$1.3 \cdot 10^4$	21.7
10 wt%	$5.3 \cdot 10^3$	9.9	$1.7 \cdot 10^4$	32.1

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[2] Werner, D., Karapanagioti, H. K., and Sabatini, D. A. (2012). Assessing the effect of grain-scale sorption rate limitations on the fate of hydrophobic organic groundwater pollutants. *J. Contam. Hydrol.*, 129-130:70–79.