Supplementary Information

for

Integrating biochar, bacteria, and plants for sustainable remediation of soils contaminated with organic pollutants

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Table S1. Physico-chemical properties of biochars obtained from various feedstocks at various pyrolysis temperatures

Feedstock	Pyrolysis Temperature (℃)	C (%)	H (%)	H.C ratio	N (%)	S (%)	O (%)	O.C ratio	C.N ratio	ON.C ratio	SA ($m^2.g^{-1}$)	TPV ($cm^3.g^{-1}$)	pH	Ash Content (%)	VM (%)	EC (μS cm^{-1})	CEC (cmol kg^{-1})	References
Wheat straw	550	69.9	2.2	0.032	0.23		10.9	0.157	303.7	0.160			9.6	16.8				Wang et al.[1]
Wheat straw	850	80.1	0.9	0.011	0.12		1.5	0.019	667.8	0.020			10.4	17.4				Wang et al.[1]
Beet pulp	400	59.3	3.8	0.064	0.90	0.20	21.8	0.368	65.9	0.383								Jerzy et al.[2]
Beet pulp	500	61.2	3.1	0.051	0.90	0.20	20.0	0.327	68.0	0.342								Jerzy et al.[2]
Wheat straw	400	49.5	3.9	0.079	1.10	0.10	15.0	0.303	45.0	0.325								Jerzy et al.[2]
Mixture	400	58.2	2.7	0.046	0.90	0.10	17.2	0.296	64.7	0.311								Jerzy et al.[2]
Wheat straw	500	51.3	2.9	0.057	1.30	0.10	13.3	0.259	39.5	0.285								Jerzy et al.[2]
Mixture	500	61.1	1.8	0.029	0.80	0.10	12.1	0.198	76.4	0.211								Jerzy et al.[2]
Rice hus0k mushroom	500	63.5	3.1	0.048	5.38		13.4	0.210	11.8	0.295				14.4	17.2			Liu et al.[3]
Corn cob	500	72.3	2.6	0.036	0.55		14.6	0.201	131.4	0.209				9.5	37.2			Liu et al.[3]
Cottonseed shell	500	69.5	2.0	0.028	1.10		11.7	0.169	63.1	0.185				15.7	20.6			Liu et al.[3]
Wheat straw mushroom	500	66.7	2.8	0.042	5.38		10.7	0.161	12.4	0.242				14.2	17.5			Liu et al.[3]

Corn cob mushroom	500	65.5	3.0	0.045	5.88		10.4	0.159	11.1	0.248				15.1	17.2		Liu et al.[3]
Cottonseed shell mushroom	500	66.2	3.6	0.055	5.74		10.4	0.156	11.5	0.243				14.0	19.3		Liu et al.[3]
Rice husk	500	50.9	2.1	0.041	0.47		7.9	0.156	108.3	0.165				38.6	31.9		Liu et al.[3]
Wheat straw	500	61.8	2.2	0.036	1.37		7.1	0.115	45.1	0.138				27.5	20.4		Liu et al.[3]
Sewage sludge	500	25.3	0.8	0.030	3.00		6.7	0.265	8.4	0.383	33.2	0.079	9.2	64.3			A Siatecka et al.[4]
Willow	500	82.4	2.3	0.028	1.09		13.4	0.163	75.6	0.176	229.3	0.108	9.3	0.8			A Siatecka et al.[4]
Willow	700	80.6	1.0	0.012	1.15		11.9	0.148	70.1	0.162	0.3	0.004	11.5	5.3			A Siatecka et al.[4]
Sewage sludge	700	24.7	0.2	0.009	1.43		0.9	0.038	17.3	0.096	63.3	0.113	11.8	72.8			A Siatecka et al.[4]
Poplar sawdust	700	62.4	2.5	0.039	2.64	0.12	19.9	0.318	23.6	0.361	572.6	0.280		12.5			Zhu et al.[5]
Sludge	300	24.0	2.7	0.112	3.36				7.1				7.3			362.0	Li et al.[6]
Pine	300	67.1	5.6	0.083	1.84				36.5				7.6			226.0	Li et al.[6]
Alfalfa	300	68.9	5.4	0.079	3.40				20.3				9.4			2716.0	Li et al.[6]
Manure	300	55.7	4.2	0.075	2.11				26.4				9.4			550.0	Li et al.[6]
Sludge	500	18.7	1.4	0.073	2.50				7.5				7.9			155.0	Li et al.[6]
Wheat	300	68.1	4.9	0.072	0.35				194.5				7.7			1403.0	Li et al.[6]

Walnut	300	71.3	5.0	0.070	0.36				197.9				7.8			78.0		Li et al.[6]
Sludge	700	17.9	1.1	0.064	1.99				9.0				8.5			197.0		Li et al.[6]
Pine	500	79.9	3.4	0.042	2.11				37.9				10.3			673.0		Li et al.[6]
Manure	500	57.5	2.4	0.042	1.60				35.9				10.8			823.0		Li et al.[6]
Alfalfa	500	76.0	3.1	0.041	2.74				27.7				10.8			4120.0		Li et al.[6]
Wheat	500	80.3	3.1	0.038	0.34				236.1				9.9			2673.0		Li et al.[6]
Walnut	500	84.5	3.2	0.038	0.42				201.3				9.8			322.0		Li et al.[6]
Wheat	700	69.8	2.2	0.031	0.52				134.2				10.2			3047.0		Li et al.[6]
Alfalfa	700	77.0	2.4	0.031	2.82				27.3				11.0			5390.0		Li et al.[6]
Manure	700	55.3	1.6	0.029	1.39				39.8				10.6			1011.0		Li et al.[6]
Pine	700	81.2	2.3	0.028	1.85				43.9				10.6			947.0		Li et al.[6]
Walnut	700	90.8	2.0	0.022	0.47				193.3				10.0			558.0		Li et al.[6]
Pine needles	400	61.7	2.6	0.041	0.97	0.05	24.5	0.397	63.6	0.412	12.5	1.620	8.1	10.3	31.5	2.6	29.5	Shaon et al.[7]
maize stalk	400	58.8	4.0	0.068	1.39	0.08	20.6	0.351	42.3	0.375	12.9	2.430	8.6	15.2	26.6	0.8	38.6	Shaon et al.[7]
Black gram	500	56.7	3.1	0.055	1.24	0.06	15.6	0.275	45.7	0.297	20.4	2.070	9.2	23.3	23.6	1.0	42.7	Shaon et al.[7]

Pine needles	500	65.8	2.1	0.032	0.78	0.04	17.8	0.270	84.4	0.282	21.8	2.320	8.9	13.5	27.6	2.8	32.2	Shaon et al.[7]
Maize stalk	500	61.9	3.6	0.058	1.17	0.07	13.7	0.221	52.9	0.240	23.2	3.130	9.4	19.7	20.7	1.0	47.6	Shaon et al.[7]
Lantana camara	400	69.8	3.1	0.044	1.01		14.5	0.208	69.1	0.222	12.7	2.890	8.2	11.6	28.8	0.5	31.9	Shaon et al.[7]
Pine needles	600	68.4	1.9	0.028	0.57	0.06	12.4	0.182	120.0	0.190	40.2	2.720	10.0	16.7	24.5	3.0	37.6	Shaon et al.[7]
black gram	600	60.3	2.9	0.048	1.02	0.08	9.3	0.154	59.1	0.171	38.9	2.470	10.3	26.5	20.6	1.1	49.6	Shaon et al.[7]
Lantana camara	500	70.5	2.7	0.038	0.86		10.3	0.145	82.0	0.158	22.1	3.590	9.0	15.7	22.6	0.7	33.6	Shaon et al.[7]
maize stalk	600	65.5	3.3	0.050	0.99	0.09	6.8	0.104	66.2	0.120	43.9	3.530	10.5	23.4	17.8	1.2	55.5	Shaon et al.[7]
Lantana camara	600	74.1	2.4	0.032	0.61		2.7	0.036	121.5	0.045	41.4	3.990	10.2	20.2	19.5	0.9	39.5	Shaon et al.[7]
Corn stover	450	48.0			3.40				14.1		229.0		9.2	28.0		4.0		Lumarie et al.[8]
Hardwood	450	77.0			0.00						388.0		8.2	0.8		0.2		Lumarie et al.[8]
Norway spruce	700	71.4	0.4	0.005	1.40	0.02	26.8	0.375	51.0	0.395	46.2	0.050		15.3	14.3			Oluwatosin et al.[9]
White Pine	500	71.8	3.0	0.042	2.52	0.17	22.5	0.314	28.5	0.349	6.3	0.010		7.2	18.5			Oluwatosin et al.[9]
White pine	700	76.1	0.7	0.010	2.07	0.04	21.1	0.277	36.7	0.305	58.5	0.020		7.9	11.6			Oluwatosin et al.[9]
White pine	900	76.8	0.8	0.010	0.95	0.09	21.3	0.277	80.8	0.290	156.1	0.060		9.0	9.1			Oluwatosin et al.[9]
Norway Spruce	900	77.4	0.6	0.007	0.92	0.05	21.0	0.272	84.1	0.284	167.7	0.080		16.1	10.6			Oluwatosin et al.[9]

Sewage sludge after acid washing	500	55.9	3.1	0.055	7.24	3.03			7.7		369.8	0.450		11.9				Li et al.[10]
Sewage sludge after acid washing	600	58.9	2.8	0.047	6.04	3.41			9.8		667.3	0.880		12.3				Li et al.[10]
Sewage sludge after acid washing	700	58.4	2.3	0.039	4.10	3.84			14.2		561.6	0.810		14.6				Li et al.[10]
Phytoremediation residue	350	58.1	2.7	0.046			17.1	0.294			3.3	0.020	7.9	29.2		1.2		Huang et al.[11]
Phytoremediation residue	550	49.2	2.1	0.042			11.0	0.223			131.7	0.070	10.0	44.5		1.0		Huang et al.[11]
Phytoremediation residue	750	47.8	0.9	0.019			6.9	0.144			241.3	0.110	10.1	48.5		1.1		Huang et al.[11]
Rice straw	900	53.4			1.70				31.4		209.2	0.320	10.1					Yang et al.[12]
Groundnut shell	600	75.3	1.2	0.016	1.70		21.8	0.290	44.3	0.312								Vaghela et al.[13]
Vine pruning	350	64.7	4.1	0.063	1.30	0.40	21.3	0.328	49.8	0.349			10.3	8.3	30.2	10.9	47.4	Asli et al.[14]
Poultry litter	350	57.0	3.2	0.056	5.30	0.20	15.9	0.279	10.8	0.372			11.3	18.4	32.7	15.8	55.5	Asli et al.[14]
Orange pomace	350	64.9	4.5	0.070	2.42	0.03	16.8	0.258	26.8	0.296			9.9	11.3	32.3	1.3	35.2	Asli et al.[14]
Orange pomace	500	63.8	3.1	0.048	3.19		15.7	0.247	20.0	0.297			10.3	14.2	24.0	3.0	29.8	Asli et al.[14]
Seaweed	500	45.3	2.2	0.048	1.40	0.31	10.9	0.241	32.3	0.272			13.3	40.0	21.1	29.9	57.5	Asli et al.[14]
Seaweed	600	45.1	1.4	0.032	1.42		9.3	0.207	31.8	0.238			13.7	42.7	11.6	30.3	49.8	Asli et al.[14]

Vine pruning	500	71.3	3.4	0.047	1.42		13.3	0.187	50.2	0.207			11.0	10.6	19.8	13.4	40.4	Asli et al.[14]
Poultry litter	500	60.4	2.4	0.040	4.16		11.3	0.186	14.5	0.255			11.9	21.8	21.6	22.9	48.4	Asli et al.[14]
Vine pruning	600	72.3	2.5	0.034	1.45		12.3	0.171	49.8	0.191			11.3	11.5	12.1	13.7	32.2	Asli et al.[14]
Orange pomace	600	68.1	2.4	0.035	2.92		10.4	0.152	23.3	0.195			10.5	16.3	17.3	3.2	25.6	Asli et al.[14]
Poultry litter	600	56.6	2.0	0.036	3.86		8.2	0.145	14.7	0.213			12.6	29.3	13.7	23.8	44.4	Asli et al.[14]
Green coconuts fiber	450	76.8	4.0	0.052	2.15	0.28	16.8	0.219	35.7	0.247	193.7		8.6	10.5	29.1	1.7		Sajib et al.[15]
Green coconuts fiber	500	78.3	2.7	0.035	2.37	0.19	16.4	0.209	33.1	0.240	278.6		9.8	11.3	19.8	1.7		Sajib et al.[15]
Green coconuts fiber	550	81.5	1.9	0.024	1.43	0.27	14.9	0.183	57.0	0.201	295.6		9.6	12.2	17.6	1.5		Sajib et al.[15]
Green coconuts fiber	600	84.9	1.8	0.021	1.71	0.19	11.4	0.134	49.7	0.154	286.7		10.0	12.2	16.7	1.6		Sajib et al.[15]
Cow manure	500	45.9	2.1	0.046	7.58	0.73	2.0	0.044	6.1	0.209				41.7	19.9			Guo et al.[57]
Cow manure	500	54.7	2.4	0.044	10.72	0.56	1.8	0.032	5.1	0.228				29.9	19.8			Guo et al.[57]
Anaerobic fermentation residues	500	54.3	2.4	0.045	10.37	0.54	1.7	0.031	5.2	0.222				30.6	18.1			Guo et al.[57]
Sugarcane filter cake	400	39.5			1.80				21.9		13.5		8.6					Tatiana et al.[16]
Sugarcane filter cake	600	35.0			1.50				23.3		41.3		8.4				3.9	Tatiana et al.[16]
Swine manure	400	49.6			2.70				18.4		7.2		9.2				10.8	Tatiana et al.[16]

Swine manure	600	47.0			1.80				26.1		36.9	10.7				28.9	Tatiana et al.[16]
Cotton husk	400	69.8			2.00				34.9		0.2	10.0				45.4	Tatiana et al.[16]
Cotton husk	600	65.6			1.80				36.4		1.9	10.0				49.0	Tatiana et al.[16]
Eucalyptus sawdust	400	78.5			0.70				112.1		0.3	7.7				56.8	Tatiana et al.[16]
Eucalyptus sawdust	600	84.0			0.80				105.0		132.0	9.6				3.7	Tatiana et al.[16]
Miscanthus	450	64.4			0.80				80.5		371.9	5.9				19.8	Tatiana et al.[16]
Biosolids	425	60.0	7.0	0.117	5.00	6.00			12.0		206.0	9.1				20.1	Shekhar et al.[17]
Biosolids	550	64.0	5.0	0.078	4.00	5.00			16.0		432.0	9.1				33.0	Shekhar et al.[17]
Feedlot manure	700	52.4	0.9	0.017	1.70	0.40	7.2	0.137	30.8	0.170	145.2	10.3	44.0	19.8	1.1		Cantrell et al.[18]
Dairy manure	700	56.7	0.9	0.017	1.51	0.15	4.1	0.073	37.5	0.100	186.5	9.9	39.5	27.7	0.7		Cantrell et al.[18]
Swine solids	350	51.5	4.9	0.095	3.54	11.10	1.1	0.022	14.6	0.091	0.9	8.4	32.5	49.8	216.0		Cantrell et al.[18]
Turkey litter	350	49.3	3.6	0.073	4.07	15.40	0.9	0.018	12.1	0.100	2.6	8.0	34.8	42.1	651.0		Cantrell et al.[18]
Poultry litter	350	51.1	3.8	0.074	4.45	15.63	0.9	0.017	11.5	0.105	3.9	8.7	30.7	42.3	1405.0		Cantrell et al.[18]
Paved_feedlot manure	350	53.3	4.1	0.076	3.64	15.70	0.9	0.017	14.6	0.085	1.3	9.1	28.7	47.9	713.0		Cantrell et al.[18]
Dairy manure	350	55.8	4.3	0.077	2.60	18.73	0.9	0.016	21.5	0.063	1.6	9.2	24.2	53.5	538.0		Cantrell et al.[18]

Poultry litter	700	45.9	2.0	0.043	2.07	10.53	0.5	0.011	22.2	0.056	50.9		10.3	46.2	18.3	2217.0		Cantrell et al.[18]
Turkey litter	700	44.8	0.9	0.020	1.94	5.80	0.2	0.005	23.1	0.049	66.7		9.9	49.9	20.8	981.0		Cantrell et al.[18]
Swine solids	700	44.1	0.7	0.017	2.61	4.03	0.2	0.005	16.9	0.064	4.1		9.5	52.9	13.4	194.0		Cantrell et al.[18]
Paved_feedlot manure	700	52.4	0.9	0.017	1.70	7.20	0.2	0.004	30.8	0.036	145.2		10.3	44.0	19.8	1140.0		Cantrell et al.[18]
Dairy manure	700	56.7	0.9	0.017	1.51	4.13	0.2	0.004	37.5	0.030	186.5		9.9	39.5	27.7	702.0		Cantrell et al.[18]
Eucalyptus residue	450	75.0	3.8	0.050	1.25	0.01	19.4	0.259	60.0	0.276			5.3	0.6	30.3	123.3		Chaves et al.[19]
Eucalyptus residue	550	79.3	1.0	0.013	1.49	0.01	18.0	0.227	53.2	0.246			6.7	0.7	16.5	97.4		Chaves et al.[19]
Eucalyptus residue	650	87.1	1.6	0.018		0.02	10.7	0.123			410.5	0.050	9.7	0.6	11.9	134.3		Chaves et al.[19]
Eucalyptus residue	950	86.9	0.9	0.010	1.34	0.01	10.6	0.122	64.9	0.137	224.4	0.020	9.2	1.1	3.6	273.1		Chaves et al.[19]
Eucalyptus residue	750	87.7	0.9	0.010	1.06	0.01	9.5	0.108	82.8	0.120	402.5	0.070	9.8	0.8	5.5	164.6		Chaves et al.[19]
Eucalyptus residue	850	88.0	0.9	0.010	1.27	0.02	9.0	0.102	69.3	0.117	362.9	0.080	9.1	0.8	3.4	161.6		Chaves et al.[19]
Wheat straw	300	60.2	4.4	0.073	1.43	0.36	20.1	0.335	42.1	0.358			8.0				0.2	Cao et al.[20]
Wheat straw	400	62.6	3.3	0.052	1.24	0.36	15.3	0.244	50.5	0.264			9.5				0.2	Cao et al.[20]
Wheat straw	500	65.5	2.0	0.030	1.23	0.40	10.0	0.153	53.3	0.172			10.2				0.1	Cao et al.[20]
Wheat straw	600	67.4	1.2	0.018	1.15	0.41	9.1	0.135	58.6	0.152			10.3				0.2	Cao et al.[20]

Wheat straw	700	67.5	0.7	0.011	1.18	0.42	7.3	0.108	57.2	0.125			10.4			0.2	Cao et al.[20]
Wheat straw	800	68.9	0.4	0.006	1.20	0.42	6.8	0.099	57.4	0.117			10.4			0.2	Cao et al.[20]
Wheat straw	900	69.3	0.3	0.004	1.17	0.44	6.5	0.093	59.2	0.110			10.2			0.4	Cao et al.[20]
Poplar sawdust	300	73.9	2.0	0.028	0.54		20.2	0.273	136.9	0.281	3.0	0.006	6.5	7.9			Xu et al.[21]
Poplar sawdust	500	84.6	1.5	0.017	0.32		10.6	0.125	264.4	0.129	31.0	0.028	6.9	16.8			Xu et al.[21]
Poplar sawdust	700	89.1	0.9	0.011	0.19		5.9	0.066	468.9	0.068	303.0	0.182	7.7	21.5			Xu et al.[21]
Desert date shell	450	72.1	4.6	0.064	4.71	0.13	18.5	0.256	15.3	0.321				6.5	32.8		Garba et al.[22]
Desert date shell	500	74.3	4.4	0.059	4.13	0.14	17.1	0.230	18.0	0.286				9.0	15.8		Garba et al.[22]
Desert date shell	550	75.0	4.2	0.056	4.45	0.19	16.2	0.217	16.8	0.276				9.2	12.6		Garba et al.[22]
Desert date shell	600	75.7	4.2	0.055	4.42	0.20	15.5	0.205	17.1	0.263				11.4	7.4		Garba et al.[22]
Wood offcuts	600	86.1			0.35				246.1				7.0				Kubaczynski et al.[23]
Sunflower husk	550	78.3			0.98				79.9				9.2				Kubaczynski et al.[23]
Raspberry stem	600	74.2			0.90				82.5				9.2				Kubaczynski et al.[23]
Potato stem	600	44.6			1.35				33.1				9.6				Kubaczynski et al.[23]
Alfalfa	300	64.7	5.3	0.081	3.10		24.2	0.375	20.9	0.422	0.6	0.010	9.2				Wang et al.[24]

Citrus	450	67.6	3.6	0.053	1.23		25.0	0.370	55.0	0.388	2.8	0.010	10.0		Wang et al.[24]
Switchgrass	600	68.2	2.2	0.032	1.90		25.0	0.367	35.9	0.395	15.0	0.020	9.8		Wang et al.[24]
Alfalfa	450	66.6	3.0	0.045	2.42		22.1	0.332	27.5	0.369	0.7	0.010	10.4		Wang et al.[24]
Alfalfa	600	73.3	1.9	0.026	2.22		19.4	0.265	33.0	0.296	0.2	0.010	10.4		Wang et al.[24]
Loblolly pine	300	69.2	5.0	0.071	0.34		17.8	0.257	203.6	0.262			7.1		Wang et al.[24]
Loblolly pine	450	80.2	3.3	0.041	0.31		15.8	0.197	258.6	0.200			7.6		Wang et al.[24]
Citrus	600	78.3	2.1	0.027	1.28		14.9	0.190	61.2	0.207	182.0	0.010	9.5		Wang et al.[24]
Loblolly pine	600	85.7	2.1	0.025	0.33		11.4	0.133	259.6	0.137			7.1		Wang et al.[24]
Rice husk	500	44.8	2.2	0.045	0.62	0.02			80.5		182.4	0.110		39.7	Zhang et al.[25]
Rice husk	600	45.7	1.7	0.033	0.52	0.07			98.1		297.4	0.150		43.5	Zhang et al.[25]
Rice husk	700	49.8	1.2	0.024	0.50	0.06			100.1		192.6	0.110		44.8	Zhang et al.[25]
Rice husk	800	36.7	0.9	0.018	0.43	0.03			116.7		174.4	0.090		46.6	Zhang et al.[25]
Rice husk	900	38.3	0.7	0.015	0.41	0.09			115.2		160.4	0.100		48.1	Zhang et al.[25]
Crofton weed	400	62.9	1.7	0.027	1.28		20.6	0.327	49.2	0.347			10.0	13.5	Fan et al.[26]
Crofton weed	500	65.7	0.9	0.014	1.34		18.0	0.274	49.0	0.294			10.2	14.0	Fan et al.[26]

Crofton weed	600	66.8	0.6	0.010	1.12		16.7	0.250	59.6	0.267			10.3	14.8		Fan et al.[26]
S. alterniflora straw	400	52.5	3.5	0.066	0.47		17.1	0.325	111.7	0.334						Wang et al.[27]
P. australis straw	350	64.6	4.3	0.067	0.70		20.0	0.310	92.2	0.321						Wang et al.[27]
S.alterniflora straw	450	53.1	2.9	0.054	0.43		16.0	0.302	123.6	0.310						Wang et al.[27]
P. australis straw	400	66.3	3.7	0.055	0.68		18.8	0.284	97.5	0.294						Wang et al.[27]
Sporobolus alterniflorus straw	500	54.5	2.4	0.043	0.43		11.8	0.216	126.6	0.224						Wang et al.[27]
P. australis straw	450	69.3	3.3	0.048	0.58		13.8	0.200	119.4	0.208						Wang et al.[27]
P. australis straw	500	72.2	3.0	0.041	0.67		9.2	0.127	107.7	0.137						Wang et al.[27]
Rice husk	600	60.0	1.6	0.027	0.84	0.02			71.4		152.4	0.080		30.5		Qin et al.[28]
Rice husk	700	59.7	1.3	0.022	0.81	0.06			73.7		106.7	0.060		31.7		Qin et al.[28]
Cottonseed hull	200	48.2	5.6	0.116	5.60				8.6				3.7	3.1	69.3	Spokas et al.[29]
Swine manure	350	50.8	5.0	0.098	3.74				13.6		0.9		8.1	32.3	46.2	Spokas et al.[29]
Distillers grain	350	67.4	4.7	0.070	7.40				9.1		0.3		6.8	11.3	43.9	Spokas et al.[29]
Pine wood chip	350	74.7	5.0	0.067	0.45				166.0				4.6	1.5	45.2	Spokas et al.[29]
Sugar cane bagasse	350	75.2	4.6	0.061	0.66				113.9				5.0	3.6	39.2	Spokas et al.[29]

Cottonseed hull	350	71.5	4.2	0.059	4.20	17.0	4.7	6.6	5.7	34.9	Spokas et al.[29]
Corn cob	450	76.5	4.2	0.055	0.70	109.3		8.7	2.8	32.2	Spokas et al.[29]
Oak hardwood	538	53.4	2.6	0.049	0.40	133.5	33.7	9.8	27.1	32.5	Spokas et al.[29]
Wood waste	500	68.7	3.3	0.048	0.10	687.0	66.3	5.0	4.6	33.6	Spokas et al.[29]
Wood waste	400	76.9	3.6	0.047	0.80	96.1	3.5	6.9	3.5	25.8	Spokas et al.[29]
Pine wood chip	465	71.0	3.3	0.046	0.20	355.0	0.1	6.8	9.0	72.3	Spokas et al.[29]
Corn cob	600	80.1	3.7	0.046	0.60	133.5		9.0	3.7	24.0	Spokas et al.[29]
Corn stover	500	25.0	1.1	0.044	0.60	41.7	4.2	8.9	69.0	41.3	Spokas et al.[29]
Corn stover	410	42.0	1.8	0.043	1.00	42.0	2.2		54.0		Spokas et al.[29]
Wood waste	450	77.9	3.1	0.040	0.70	111.3	26.8	8.4	3.6	22.8	Spokas et al.[29]
Peanut hull	481	59.0	2.3	0.039	2.70	21.9	1.0	8.0	15.0	5.3	Spokas et al.[29]
Corn stover	515	45.0	1.7	0.038	0.50	90.0	4.4	9.5	55.0	30.9	Spokas et al.[29]
Wood pellets	650	77.2	2.9	0.038	0.30	257.3		9.8	6.0	11.7	Spokas et al.[29]
Corn stover	505	46.0	1.5	0.033	1.20	38.3	17.3	10.0	54.0	13.8	Spokas et al.[29]
Cottonseed hull	500	78.7	2.5	0.032	2.50	31.5		8.5	7.9	18.6	Spokas et al.[29]

Oak hardwood	550	56.0	0.9	0.016	0.20			280.0		116.8		10.5	42.2	4.4		Spokas et al.[29]
Cottonseed hull	650	84.4	1.2	0.014	1.20			70.3		34.0		8.6	8.3	13.3		Spokas et al.[29]
Oak hardwood	550	52.0	0.6	0.012	0.20			260.0		134.8		10.2	43.4	4.3		Spokas et al.[29]
Cottonseed hull	800	84.3	0.6	0.007	0.60			140.5		322.0		7.7	9.2	11.4		Spokas et al.[29]
Pine wood chip	500	73.3			0.20			366.5				7.2	2.3	45.8		Spokas et al.[29]
Oak hardwood	540	73.3			0.30			244.3				6.6	2.4			Spokas et al.[29]
Poultry litter	400	42.3			4.20			10.1				10.3				Spokas et al.[29]
Rice straw	800	58.1	1.4	0.023	1.09	12.2	0.210	53.3	0.229	205.0		12.3			20.4	Chen et al.[30]
Plant residues	700	68.8	1.3	0.019	1.08	25.9	0.376	63.7	0.392	1224.0	0.530					Li et al.[31]
Plant residues	600	60.3	2.4	0.040	0.93	19.6	0.325	64.9	0.341	758.0	0.300					Li et al.[31]
Plant residues	800	65.3	1.0	0.016	0.34	12.4	0.190	192.0	0.195	1079.0	0.500					Li et al.[31]
Plant residues	800	78.7	1.2	0.016	0.43	14.3	0.181	183.1	0.187	2482.0	0.890					Li et al.[31]
Wheat and rye straw	400	69.1	3.9	0.056	0.28			246.8		4.5		8.4	10.6			Wystalska et al.[32]
Beech wood chips	400	76.7	4.2	0.055						2.4		4.5	1.4			Wystalska et al.[32]
Walnut shell	400	79.4	4.0	0.050						1.2		6.0	1.1			Wystalska et al.[32]

Walnut shell	500	78.0	3.2	0.041			9.1	6.9	2.0		Wystalska et al.[32]
Wheat and rye straw	500	74.4	3.0	0.040	0.32	232.5	13.0	9.5	11.6		Wystalska et al.[32]
Beech wood chips	500	82.4	3.0	0.037			89.7	5.2	1.2		Wystalska et al.[32]
Walnut shell	600	63.2	2.2	0.035			164.5	7.4	2.6		Wystalska et al.[32]
Wheat and rye straw	600	77.3	2.3	0.030	0.65	119.0	8.7	9.9	13.9		Wystalska et al.[32]
Beech wood chips	600	88.0	2.5	0.029			311.8	6.6	1.5		Wystalska et al.[32]
Wheat and rye straw	700	78.5	1.5	0.018	0.98	80.1	3.4	10.1	14.4		Wystalska et al.[32]
Walnut shell	700	77.4	1.4	0.018			152.4	9.9	3.0		Wystalska et al.[32]
Beech wood chips	700	84.6	1.5	0.017			362.2	7.8	1.6		Wystalska et al.[32]
Canola straw	300	61.6			0.19	324.2		6.5	10.7	199.0	Yuan et al.[33]
Canola straw	500	63.4			0.04	1585.0		9.4	18.1	210.0	Yuan et al.[33]
Canola straw	700	54.9			0.04	1372.5		10.8	28.6	179.0	Yuan et al.[33]
Corn straw	300	53.6			1.44	37.2		9.4	30.2	183.0	Yuan et al.[33]
Corn straw	500	41.9			0.90	46.6		10.8	50.7	304.0	Yuan et al.[33]
Corn straw	700	24.5			0.78	31.4		11.3	73.3	210.0	Yuan et al.[33]

Soybean straw	300	57.6			1.27				45.4				7.7	11.2			279.0	Yuan et al.[33]
Soybean straw	500	62.6			0.37				169.2				10.9	17.9			216.0	Yuan et al.[33]
Soybean straw	700	57.9			0.10				579.0				11.1	23.7			222.0	Yuan et al.[33]
Peanut straw	300	53.7			2.60				20.7				8.6	20.1			229.0	Yuan et al.[33]
Peanut straw	500	48.5			1.51				32.1				10.9	32.2			230.0	Yuan et al.[33]
Peanut straw	700	47.0			1.51				31.1				11.2	38.5			254.0	Yuan et al.[33]
Corn straw	700	76.9	1.1	0.014	0.65		6.0	0.078	118.3	0.086	378.4	0.190	10.2					Zhao et al.[34]
Switchgrass	400	67.3	3.2	0.047	0.91		18.7	0.277	73.9	0.291			9.5		27.4			Li et al.[35]
Biosolid	400	34.0	1.4	0.040	2.17		8.5	0.251	15.7	0.315			8.1		26.0			Li et al.[35]
Switchgrass	600	73.5	2.1	0.029	0.78		13.2	0.179	94.2	0.190			11.2		13.7			Li et al.[35]
Biosolid	600	34.7	1.0	0.027	1.74		5.8	0.168	19.9	0.218			10.1		18.1			Li et al.[35]
Switchgrass	800	74.1	2.0	0.027	0.72		12.2	0.165	102.9	0.175			11.4		9.8			Li et al.[35]
Water oak	400	76.4	2.8	0.036	0.63		12.3	0.160	121.3	0.169			8.3		39.4			Li et al.[35]
Biosolid	800	35.9	0.8	0.023	1.58		5.0	0.139	22.7	0.183			10.9		14.9			Li et al.[35]
Water oak	600	80.7	1.9	0.024	0.58		7.9	0.098	139.2	0.106			9.9		19.9			Li et al.[35]

Water oak	800	82.0	1.8	0.022	0.59	6.5	0.079	139.1	0.087			10.2		11.2		Li et al.[35]
Pine needle	300	68.9	4.3	0.063	1.08	25.7	0.374	63.8	0.389	19.9			1.9			Chen et al.[36]
Pine needle	400	77.9	3.0	0.038	1.16	18.0	0.232	67.1	0.247	112.4	0.044		2.3			Chen et al.[36]
Pine needle	500	81.7	2.3	0.028	1.11	15.0	0.183	73.6	0.197	236.4	0.095		2.8			Chen et al.[36]
Pine needle	700	79.8	1.3	0.016	1.13	11.1	0.139	70.6	0.153	490.8	0.186		2.2			Chen et al.[36]
Pine needle	600	85.4	1.9	0.022	0.98	11.8	0.138	87.1	0.150	206.7	0.076		2.8			Chen et al.[36]
Tomato plant waste	400	70.2	0.3	0.005	1.50	27.9	0.398	46.8	0.419			8.8	37.4		9.2	Abdulelah et al.[37]
Date palm fiber	500	71.7	0.1	0.001		28.2	0.393					8.8	31.4		1.5	Abdulelah et al.[37]
Tomato plant waste	500	74.5	0.1	0.001	0.12	25.3	0.339	620.9	0.341			10.2	35.8		12.0	Abdulelah et al.[37]
Chicken feather waste	300	51.5	8.8	0.171	23.00	16.7	0.324	2.2	0.771			8.0	40.2		0.2	Abdulelah et al.[37]
Date palm leaf	300	74.2	4.4	0.060	0.64	20.7	0.279	115.9	0.288			7.6	28.8		2.3	Abdulelah et al.[37]
Cucumber plant waste	400	77.7	0.3	0.004	0.70	21.3	0.274	110.9	0.283			9.9	57.9		8.6	Abdulelah et al.[37]
Date palm petiole	500	78.7	0.2	0.003		21.1	0.268					9.4	19.1		4.6	Abdulelah et al.[37]
Date palm leaf	400	79.4	0.9	0.011	0.44	19.3	0.243	180.4	0.249			9.0	24.1		2.7	Abdulelah et al.[37]
Cow dung	600	79.5	0.0	0.000	1.38	19.1	0.240	57.6	0.258			11.1	38.3		6.0	Abdulelah et al.[37]

Cucumber plant waste	500	80.5	0.1	0.001	0.12		19.3	0.240	671.0	0.241		10.3	55.5		9.4	Abdulelah et al.[37]
Poultry litter	500	80.1	0.1	0.001	2.54		17.3	0.216	31.5	0.248		10.5	49.9		4.3	Abdulelah et al.[37]
Chicken feather waste	400	59.9	6.1	0.101	21.09		12.9	0.216	2.8	0.568		7.9	39.4		0.3	Abdulelah et al.[37]
Date palm petiole	600	84.6	0.0	0.000			15.4	0.182				10.1	20.6		5.4	Abdulelah et al.[37]
Poultry litter	600	85.3	0.1	0.001	0.92		13.7	0.160	92.8	0.171		10.8	51.9		5.0	Abdulelah et al.[37]
Date palm leaf	500	86.3	0.1	0.001			13.6	0.158				9.7	27.6		3.3	Abdulelah et al.[37]
Conocarpus	600	86.7	0.0	0.000			13.3	0.153				10.5	26.9		4.1	Abdulelah et al.[37]
Date palm leaf	600	91.1	0.1	0.001			8.9	0.097				10.3	27.6		7.2	Abdulelah et al.[37]
Date palm fiber	600	91.4	0.0	0.000	0.43		8.1	0.089	212.7	0.093		10.1	39.7		3.4	Abdulelah et al.[37]
Tomato plant waste	600	92.7	0.0	0.000			7.2	0.078				10.6	42.4		12.0	Abdulelah et al.[37]
Cucumber plant waste	600	95.2	0.0	0.000			4.8	0.050				11.0	59.2		10.0	Abdulelah et al.[37]
Chicken feather waste	500	67.0	1.0	0.015	28.98		3.0	0.045	2.3	0.477		8.2	43.1		0.5	Abdulelah et al.[37]
Chicken feather waste	600	72.0	0.1	0.001	25.30		2.6	0.037	2.8	0.388		8.4	46.1		0.5	Abdulelah et al.[37]

Abbreviations:

C: carbon; H: hydrogen; N: nitrogen; S: sulfur; 0: oxygen; S.A: surface area; TPV: total pore volume; VM: volatile matter; EC=electrical conductivity, CEC=cation exchange capacity

Table S2. Some plant growth-promoting bacteria (PGPB) and their impacts on phytoremediation of organic pollutants

Organic pollutant(s)	Plant(s)	PGP**B**	Specific attributes and contribution of bacterial inoculant(s)	References
Pyrene	Rice	*Klebsiella pneumoniae* AWD5, *Alcaligenes faecalis* BDB4, *Pseudomonas fragi* DBC, *Pseudomonas aeruginosa* PDB1, *Acinetobacter* sp. PDB4	• Promotion of rice growth in pyrene-contaminated soil. • Pyrene degradation. • Stimulation of stress response through glutathione mediated reaction.	Singha et al.[38]
16 priority polycyclic aromatic hydrocarbons (PAHs)	Alfalfa	*Rhizobium meliloti*	• Stimulation of rhizomicrobiome to degrade PAHs in soil. • Plant growth-promoting activities. • Direct degradation of PAHs.	Teng et al.[39]
Chrysene	White clover (*Trifolium repens* L.)	*Rhizobium leguminosarum* bv. *trifolii*	• Enhanced dissipation of chrysene in soil. • Stimulated rhizomicrobiome to degrade chrysene. • Improved plant vigor and growth in chrysene polluted soil.	Johnson et al.[40]
Polychlorinated biphenyls (PCBs)	Alfalfa	*Rhizobium meliloti*	• Stimulated rhizosphere microflora for effective PCB degradation. • Increased accumulation of PCBs in plant roots and shoots.	Xu et al.[41]
PCBs	*Phalaris arundinacea*	*Rhodococcus* sp.	• Degradation of PCB congeners. • Promotion of lateral root emergence. • Increased plant biomass in PCB contaminated soil. • Production of 1-aminocyclopropane-1-carboxylate deaminase, which can alleviate plant stress.	Vergani et al.[42]

PCBs	Maize *(Zea mays L.)*	*Pseudomonas* spp. S5 and *Alcaligenes faecalis*	• Stimulated degradation of the PCBs in the soil. • The partnership between *Pseudomonas* spp. S5 and maize led to adequate PCB removal from the soil. • Improved both maize growth and PCB degradation.	Salimizadeh et al.[43]
Phenolic pollutants	*Arabidopsis thaliana* and vetiver	*Achromobacter xylosoxidans*	• Induced extension of root lengths and fresh weights for effective removal of pollutants. • Helped plants to tolerate stress from aromatic compounds. • Improved phytoremediation of phenolic pollutants in hydroponic and soil tests.	Ho et al.[44]
Trichloroethylene (TCE)	Poplar	*Pseudomonas putida* W619-TC	• Promotion of plant growth. • Reduction of TCE phytotoxicity. • Degradation of TCE in the leaves.	Weyens et al.[45]
Pentachlorophenol (PCP)	Chinese chive (*Allium tuberosum Rottler*)	*Pseudomonas gladioli* M-2196	• Degradation of PCB. • Promotion of Plant Growth. • Stimulated plant excretion of root exudates, which influenced PCP-degrading rhizomicrobiome in the soil.	Nakamura et al.[46]
Dichlorodiphenyltrichloroethane (DDT)	Perennial ryegrass and tall fescue	*Pseudomonas* sp. SB	• Production of biosurfactants. • Increased the bioavailability of DDT. • Enhanced microbial degradation of DDT in soil. • Assisted plants effectively in removing DDT from the soil.	Wang et al.[47]
Naphthalene, phenanthrene, fluorene, and dibenzothiophene	Hybrid poplar (*Populus deltoides* × *Populus nigra*)	*Burkholderia fungorum* DBT1	• Degradation of PAHs in soil. • Enhanced plant tolerance against the toxic effects of PAHs.	Andreolli et al.[48]

Table S3. Effects of different types of biochar on organic pollutants in different types of contaminated soil

Feedstock	Pyrolysis temperature	Modification/supplementation	Application rate (mass ratio, %)	Pollutants	Soil texture and pH	Plants/microorganisms	Key findings/Main mechanisms	References
Wheat straw	450 °C	Ball milling	1%, 2%, and 5%	Dimethyl phthalate	Silty clay loam, pH=8.4		Ball-milling contributed to the formation of biochar-soil composites, which, in turn, enhanced the sorption of dimethyl phthalate through chemisorption and physisorption	Yan and Quan.[49]
Maize straw	500 ℃	Oxalic acid	1% biochar, 0, 0.5 or 20 mg kg−1 of oxalic acid + 1% biochar	PAHs		Ryegrass (*Lolium multiflorum Lam*)	The combination of biochar and oxalic acid, the main component of ryegrass root exudates, significantly improved the removal of high and low ring PAHs from the tested soil, in particular by enhancing the proliferation and functional activity of microbial communities associated with PAH degradation.	Li et al.[50]
Corncob	500 °C		3%	Petroleum hydrocarbons and Nickel	Sand (17.99 %), silt (34.00 %), clay (48.01%), pH= 7.26	Nickel-resistant and hydrocarbon-degrading bacterial strain *Citrobacter* sp.	Biochar-based bacterial inoculant (BBI) lowered soil pH, in particular through the production of organic acids as a result of the degradation of oil pollutants by indigenous and exogenous microorganisms. Biochar enhanced adaptability and functionality of bacterial inoculant in co-contaminated soil. The efficiency of degradation of oil pollutants	Li et al.[51]

						by BBI (45.52%) was significantly higher than that of the free bacterial inoculant (30.15%), biochar (25.92%), and control (18.47%). Oil pollutants were removed more efficiently by BBI (45.52 %) than by free bacterial inoculant (30.15 %), biochar (25.92 %), and control (18.47 %).	
Sawdust (SD) and wheat straw (WS)	300 and 500 °C	5%	16 priority PAHs	Sand (24%), coarse silt (30%), coarse clay (14%), fine silt (22%), and fine clay (10%), pH= 7.61		Biochar amendment resulted in the proliferation of PAH-degrading communities. Biochar produced at a high temperature (500 °C) considerably decreased PAHs compared to biochar produced at a lower temperature (300 °C), in part owing to enhanced porosity and surface area available to support degrading microbial populations.	Kong et al.[52]
Wheat straw and pine needle (PN)	550 °C	2%	PCBs	Two Alfisols: Sand (4.2%), silt (83.2%) and clay (12.6%), pH: 6.3. Sand (12.0%), silt (66.9%) and clay (21.1%), pH= 6.1.	Pakchoi (*Brassica chinensis* L.) and carrot (*Daucus carota*)	PCB uptake by plants decreased significantly after the addition of biochar, especially due to the adsorption of PCBs by biochar.	Wang et al.[53]
Cow manure, peanut shells, *Salsola collina* Pall.,	500°C	2%	Tetracycline, oxytetracycline, and chlortetracycline	pH=8.73		Amendment of biochar, notably from cow manure, improved the removal of antibiotics, mostly by	Yue et al.[54]

Firmiana platanifolia Sawdust, and *Suaeda salsa* Pall.							boosting pollutant accessibilities to degrading microorganisms via the elevation of electrical conductivity. Biochar also improved soil properties, which in turn increased microbial degradation of pollutants in the soil.	
Blended wood chips	450 °C		0 % and 1.5 %	Thiamethoxam	pH = 6.78	Chinese chive (*Allium tuberosum*)	The uptake of thiamethoxam and its metabolite clothianidin by Chinese chives decreased by 22.8% and 37.6% after the addition of biochar, respectively. On the other hand, the half-life of thiamethoxam in soil increased from 89.4 to 120 days, suggesting that biochar increased its persistence in soil.	You et al.[55]
Maize straw	300 °C	Combination with maize straw-pig manure compost	2% biochar, 1% biochar + 1% compost	2,2',4,4'-tetrabrominated diphenyl ether (BDE-47)	Clay (32.8%), silt (56.8%) and sand (10.4%), pH: 7.43	Carrot (*Daucus carota* L.)	Immobilization of BDE-47 by biochar reduced pollutant bioavailability in soil. The application of only 2% biochar inhibited the degradation of BDE-47 in soil. The combined application of compost and biochar stimulated the microbial degradation of BDE-47 in the soil and significantly reduced its uptake by plants.	Xiang et al.[56]

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