Supplementary Material

Appendix A

Soil inorganic carbon sequestration through alkalinity regeneration using biologically induced weathering of rock powder and biochar

Muhammad Azeem[1,2,3,4], Sajjad Raza[5], Gang Li[1,2,3], Pete Smith[6], Yong-Guan Zhu[1,2,3]

[1] Key Laboratory of Urban Environment and Health, Institute of Urban Environment, Chinese Academy of Sciences, Xiamen 361021, People's Republic of China

[2] Key Lab of Urban Environmental Processes and Pollution Control, Ningbo Urban Environment Observatory and Monitoring Station, Chinese Academy of Sciences, Ningbo 315830, People's Republic of China

[3] Zhejiang Key Lab of Urban Environmental Processes and Pollution Control, Ningbo Urban Environmental Observatory and Research Station, Institute of Urban Environment, Chinese Academy of Science, Ningbo, 315830, China

[4] Institute of Soil and Environment, Pir Mehr Ali Shah Arid Agriculture University Rawalpindi, Punjab 46300, Pakistan

[5] School of Geographical Sciences, Nanjing University of Information Science and Technology, Nanjing 21000, People's Republic of China

[6]Pete Smith, Institute of Biological & Environmental Sciences, University of Aberdeen, 23 St Machar Drive, Aberdeen AB24 3UU, UK

Corresponding Author:

Prof. Yong-Guan Zhu

E-mail: ygzhu@iue.ac.cn

Table S1: Physiochemical composition of biochar and bone char derived from various feedstocks and pyrolyzed at various temperatures

Feedstock	Material	Pyrolysis Temp. (℃)	EC (dS m^{-1})	pH	Surface Area (m^2 g^{-1})	**Chemical Composition (%)**						**Reference**
						C	H	O	N	P	Ca	
Manure	Dairy manure	100		8.1	1.8	36.8			3.12			(Cao and Harris, 2010)
	Dairy manure	200		7.1	2.7	31.1			2.98			(Cao and Harris, 2010)
Bone-biochar	Cod fish bones	200				20.13			6.25	9.21	17.68	(Piccirillo et al., 2017)
Crop residues	Sugarcane bagasse	300		4.97	224	80.9		17.2	1.18			(Mubarik et al., 2016)
	Corn straw	300			88.6							(Lian et al., 2015)
	Rice straw	300			60.7	80.0		17.2	1.16			
	Canola straw	300		7.07		59.6			10.14			(Yuan and Xu, 2011)
	Corn Stover	300		7.31		69.9	4.04	13.6	0.94			(Chen et al., 2016)
	Maize	300	3.4	9.84	1	48.9	3.54	23.9	1.25			(Wang et al., 2015)
	Maize straw	300	1.62	7.41		61.2	4.5	31.8				(Xiao et al., 2019)
	Bagasse	300		7.3	5.2	69.5	4.2	24.4	0.9			(Sun et al., 2014)
Wood	Bamboo	300		7.9	1.3	66.2	4.7	27.7	0.4			
	Hickory wood	300		7.1	0.09	69.1	4.85	24.4	0.39			
	Quickstick wood	300	5.2	7.98								(Gunarathne et al., 2020)
	Yak manure	300			3.6	41.6	1.9	27.4	3.2			(Zhang et al., 2018)
	Cow manure	300		8.48	3.52	34.3	3.31		2.55			(Qin et al., 2019)
Bone char	Fish	300			24.2							(Brunson and Sabatini, 2009)
Bone-biochar	Cow bone meal	300			2.76	45.53	4.36	19.25	4.59	8.84	16.15	(Xiao et al., 2020b)
	Cow bone meal-Fe	300			12.94	44	4.19	15.9	4.8	5.72	11.3	(Xiao et al., 2020c)
	Magnetic cow bone meal	300			35.49	43.68	4.22	20.9	4.35	9.05	17.19	(Xiao et al., 2020b)
	Cow bone meal-Mn	300			6.92	32.1	3.65	25	1.91	8.7	15.3	(Xiao et al., 2020c)
	chicken bones	350			36.74	13.89	1.56	14.55	2.19			(Yang et al., 2020)
Crop residues	Rice husk	350		8.3		47.8	2.37		0.82			(Obia et al., 2016)

	Maize cob	350		8.8		53.8	2.36		0.65			
	Maize straw	350		7.9	6.71	58.9	3.36	21.3	1			(Ren et al., 2016)
	Rice straw	350		7.8	9.01	44.5	2.69	22.1	1.64			
	Sugarcane bagasse	350	0.3	6.68		49.7						(Azeem et al., 2020)
	Sugarcane bagasse	350			159	59	4	37	1			(Batista et al., 2018)
Manure	Dairy manure	350		10.1	7.1	25.2			2.22			(Cao and Harris, 2010)
Charcoal	Charcoal fines	350			43	52	3	43	2			(Batista et al., 2018)
Crop residues	Rice husk	400		6.84		44.6	2.5	16.3	0.69			(Jindo et al., 2014)
	Sugarcane bagasse	400		5.93	362							(Mubarik et al., 2016)
	Wheat straw	400	0.1	8.2		57.8	3.2	21.6	1.5			(Gai et al., 2014)
	Corn straw	400	0.35	10.2		56.1	4.3	22	2.3			
	Rice husk	400		6.84		44.6	2.5	16.3	0.69			(Jindo et al., 2014)
	Corn Stover	400		7.79		74.8	3.15	6.18	1.05			(Chen et al., 2016)
	Corn stalk	400				50	3.3	15	0.96			(Rombolà et al., 2015)
	Sugarcane bagasse	400	0.31	7.95		49.7			1.51			(Irfan et al., 2019)
	Chinese rice straw	400		7.84		61.7	3.41		1.27			(Yoo et al., 2016)
	Korean rice straw	400		6.75		50.5	3.62		0.89			
Manure	Swine manure	400	0.73	9.86		35.86	2.12	13.09	2.57			(Meng et al., 2013)
	Swine manure	400		11.6		36.71			3.22			(Liang et al., 2018)
	Poultry manure	400		10.87	4.3	22.04	0.87	75.45	0.95			(Hadroug et al., 2019)
	Cow manure	400		9.18	5.01	36.9	2.67		2.62			(Qin et al., 2019)
Bone char	Fish	400			98.7							(Brunson and Sabatini, 2009)
	Cattle bones	400		7.6	82.2	12.5				13.4		(Warren et al., 2009)
	Cow	400			110							(Chatterjee et al., 2018)
	Cattle bones	400			114.19							(Patel et al., 2015)
Bone-biochar	Cod fish bones	400				13.47			3.36	11.84	22.65	(Piccirillo et al., 2017)
	Fish bones	400			81.8	13.21	1.03	3.22	1.84			(Abdin et al., 2020)
	bone meal+chicken	400	0.47	9.8		33.9	2.5		5.2	8.52		(Frišták et al., 2019)

	manure											
Crop residues	Maize	450	5.37	10.47	4	53.8	3.11	18.6	1.22			(Wang et al., 2015)
	Bagasse	450		7.5	13.6	78.6	3.52	15.46	0.92			(Sun et al., 2014)
Wood	Bamboo	450		8.5	10.2	76.89	3.55	18.11	0.23			
	Hickory wood	450		7.9	12.9	83.62	3.24	11.46	0.17			
Bone char	Cattle bones	450			83.948							(Patel et al., 2015)
Bone-biochar	Cow bone meal	450			22.9	42.41	2.35	22.22	4.25	9.58	17.89	(Xiao et al., 2020a)
	Cow bone meal-Fe	450			288	39.2	2.76	15.2	3.41	5.42	10.1	(Xiao et al., 2020c)
	Cow bone meal-Mn	450			32.6	24.2	1.62	23.3	1.52	7.6	13.9	(Xiao et al., 2020c)
	Magnetic cow bone meal	450			199.52	40.21	2.35	23.48	4.04	10.08	19.06	(Xiao et al., 2020a)
	Swine bone meal	450		9.7	23.5	24	1.3	4.7	2.9	10.2	210	(Vamvuka et al., 2018)
	Chicken bones	450			116.71	12.74	1.1	13.25	1.7			(Yang et al., 2020)
Crop residues	Rice husk	500		8.99		45.1	1.27	7.12	0.47			(Jindo et al., 2014)
	Sugarcane bagasse	500		6.12	291							(Mubarik et al., 2016)
	Wheat straw	500	0.11	8.3		70.3	2.9	17.7	1.4			(Gai et al., 2014)
	Corn straw	500	0.008	10.4		58	2.7	21.5	2.4			
	Canola straw	500		10.2		63.0			0.21			(Yuan et al., 2011)
	Rice husk	500		8.99		45.1	1.27	7.12	0.47			(Jindo et al., 2014)
	Corn Stover	500		8.1		78.1	2.11	3.77	0.92			(Chen et al., 2016)
	Corn stalk	500				51	2.7	14.9	0.91			(Rombolà et al., 2015)
	Maize straw	500	2.23	10.47		67.9	3.3	27.3				(Xiao et al., 2019)
	Rape straw	500	10.89	10.89		67.4	3.5	28				
	Wheat straw	500	11.01	11.01		60.2	3.4	35.3				
	Sugarcane bagasse	500	1.99	6.28		54.81			1.02			(Abbas et al., 2020)
Wood	Quickstick wood chips	500	9.2	10.82								(Gunarathne et al., 2020)
Manure	Dairy manure	500		10.2	13	1.67			0.04			(Cao and Harris, 2010)
	Sheep manure	500	0.08	10.69	3.12	21.25		1.86	37.45			(Hosseini et al., 2019)
	Cow manure	500		9.36	7.04	37.51	1.99		2.53			(Qin et al., 2019)

	Yak manure	500			17.3	41.3	1.7	24.4	3			(Zhang et al., 2018)
Bone char	Cattle bones	500			69.78							(Patel et al., 2015)
	Fish	500			111							(Brunson and Sabatini, 2009)
	Cow bones	500		7.55		9						(Olaniyi et al., 2012)
Bone-biochar	Cow bones	500	1.09	8.2	190	10.8	3.69	15.6	2.1	9.8	21	(Azeem et al., 2021)
	Bone meal+chicken manure	500	0.5	10.1		30.3	1.3		5	11.05		(Frišták et al., 2019)
	Camel	500			162							(Alqadami et al., 2018)
	Bovine	500			115.565							(Zhou et al., 2019)
	Magnetic Bovine	500			41.773							(Zhou et al., 2019)
	Chicken bone	500			316.05	78.89	3.61	8.93	0.68			(Oladipo et al., 2017)
	Magnetic chicken bone	500			328.06	82.91	3.89	11.03	0.54			(Oladipo et al., 2017)
Bone char	Carbonized bone meal	550			58							(Medellin-Castillo et al., 2007)
Bone-biochar	Swine bone meal	550		9.9	48.2	21.1	0.9	5.7	2.6	10.5	220	(Vamvuka et al., 2018)
	chicken bones	550			122.81	12.45	0.77	12.25	1.63			(Yang et al., 2020)
Crop residues	Corn straw	600			149	85.9		11.4	0.4			(Lian et al., 2015)
	Rice straw	600			156.2	81.6		14	1.22			
	Wheat straw	600	0.14	9.2		73.4	2.1	14.9	1.4			(Gai et al., 2014)
	Corn straw	600	1.94	10.4		58.6	2	18.7	2			
	Rice husk	600		9.41		40.3	0.85	9.23	0.37			(Jindo et al., 2014)
	Maize	600	5.09	11.37	70	62.9	1.98	16.2	1.28			(Wang et al., 2015)
	Chinese rice straw	600		9.86		72.8	1.79		1.06			(Yoo et al., 2016)
	Korean rice straw	600		10.54		50.3	1.35		0.87			
	Corn stalk	600				50.7	2.4	13	0.81			(Rombolà et al., 2015)
Wood	Hickory wood	600		8.4	401	81.81	2.17	14.03	0.73			(Sun et al., 2014)
	Bagasse	600		7.5	388.3	76.45	2.93	18.33	0.79			
	Bamboo	600		9.2	375.5	80.89	2.43	14.87	0.15			

Manure	Poultry manure	600		11.47	5.34	21.22	0.54	76.9	0.64			(Hadroug et al., 2019)
	Cow manure	600		9.6	13.93	38.47	1.49		2.15			(Qin et al., 2019)
Bone char	Fish	600			112							(Nigri et al., 2017)
	Cattle bones	600			50.37							(Patel et al., 2015)
Bone-biochar	Cow bone meal	600			52.78	39.49	1.45	24.26	3.42	10.36	19.65	(Xiao et al., 2020a)
	cow bone meal-Fe	600			257	34.8	2.19	16.6	2.47	5.05	9.98	(Xiao et al., 2020c)
	cow bone meal-Mn	600			95.6	21.5	0.88	22.6	0.94	7.22	13.3	(Xiao et al., 2020c)
	Magnetic Cow bone meal	600			313.09	39.11	1.79	24	3.46	10.66	20.37	(Xiao et al., 2020a)
	Fish bones	600			90	9.28	0.56	3.14	0.97			(Abdin et al., 2020)
	Cod fish bones	600				11.63			2.53	12.46	23.82	(Piccirillo et al., 2017)
	Chicken	600		8.02	132.6				2.1	20.6	28	(Park et al., 2015)
Bone char	Cow femur residues	650			118	6.28	0.67	26.16	0.87	18.97	46.69	(Rojas-Mayorga et al., 2013)
	Cow femur bones	650			62							(Rojas-Mayorga et al., 2015)
Bone-biochar	Camel	650				5.86			1.95	36	38	(El-Refaey et al., 2015)
	Swine bone meal	650		10.2	39.6	19.1	0.7	7	2.5	10.1	24.1	(Vamvuka et al., 2018)
	chicken bones	650			140.51	11.26	0.7	10.38	1.24			(Yang et al., 2020)
Crop residues	Wheat straw	700	0.17	9.2		73.9	1.3	14.7	1.2			(Gai et al., 2014)
	Corn straw	700	1.22	10.4		58.9	1.5	16.6	1.6			
	Canola straw	700		10.9		56.4			0.07			(Yuan et al., 2011)
	Rice husk	700		9.52		38.8	0.46	12.7	0.26			(Jindo et al., 2014)
	Maize straw	700		10.6	265	43.8	1.47	31.6	1.27			(Ren et al., 2016)
	Rice straw	700		10.6	188	56.7	2.39	2.61	0.1			
	Maize straw	700	3.71	10.45		70.9	2.4	24.7				(Xiao et al., 2019)
	Wheat straw	700		10	36	47	1.7		1.6			(Lu et al., 2017)
	Wheat straw	700	0.46	10.3	23.2	69.04	1.18	5.3	1.32			(Meng et al., 2014)
Wood	Quickstick wood chips	700	14.88	10.29								(Gunarathne et al., 2020)

	Bamboo	700		9.5	907.4	83.9	1.4		0.4			(Lu et al., 2017)
	Wood chips	700	0.57	9.5	1.11	65.7	1.7	6.3	0.38			(Meng et al., 2014)
Manure	Swine manure	700	0.83	10.6		33.68	0.76	4.76	1.52			
	Cow manure	700		10.36	121.1	36.97	1.09		1.45			(Qin et al., 2019)
	Yak manure	700			82.9	41.2	1.4	20.7	2.7			(Zhang et al., 2018)
Bone char	Cow femur residues	700			110	6.14	0.62	31.12	0.94	18.16	40.57	(Rojas-Mayorga et al., 2013)
	Cow femur bones	700			69							(Rojas-Mayorga et al., 2015)
	0.1M HCL treated cow bone	700			138.8							(Brunson and Sabatini, 2009)
	Animal bone chips	700-800			40.6	13.01			1.87	15.2	28	(Siebers and Leinweber, 2013)
Bone-biochar	Cod fish bones	700				12.1			2.9	12.56	23.59	(Piccirillo et al., 2017)
Crop residues	Rice husk	800		9.62		40.4	0.28	2.69	0.22			(Jindo et al., 2014)
Bone char	Cow bone	800			283	11	1.6		4.3			(Moreno et al., 2010)
	Bovine bones	800		8.28	113.3	11.65	1.03	19.3	1.21			(Mendoza-Castillo et al., 2015)
	Cow femur residues	800				5.62	0.53	27.83	0.91	18.79	44.66	(Rojas-Mayorga et al., 2013)
	Cow femur bones	800			9							(Rojas-Mayorga et al., 2015)
Bone-biochar	Animal	800		7.34								(Hairani, 2016)
	Cod fish bones	800				10.57			2.57	12.71	23.96	(Piccirillo et al., 2017)
	Cow bones	800	1.47	10.4	210	7.1	2.58	20.2	1.3	10.8	24.03	(Azeem et al., 2021)
	Cow	850		9.6		6.75	0.4		0.47	11.3	21.9	(Ashry et al., 2016)
	Cow femur residues	900				5.04	0.13	31.04	1.02	19.72	39.81	(Rojas-Mayorga et al., 2013)
	Cow femur bones	900			4							(Rojas-Mayorga et al., 2015)
	Sheep bones	900		11.64	69.1	3.07		38.15		19.7	38.03	(Alkurdi et al., 2021)
Bone-biochar	Cod fish bones	900				10.73			1.48	13.31	24.91	(Piccirillo et al., 2017)
	Swine	930								10.8	21	(Novotny et al., 2012)

Bone char	Cow femur residues	1000		4.7	0.03	33.2	1.05	18.24	37.72	(Rojas-Mayorga et al., 2013)
	Cow femur bones	1000	2							(Rojas-Mayorga et al., 2015)
Bone-biochar	Cod fish bones	1000		9.6			2.3	14.52	27.17	(Piccirillo et al., 2017)

References

Abbas, A., Azeem, M., Naveed, M., Latif, A., Bashir, S., Ali, A., Bilal, M., Ali, L., 2020. Synergistic use of biochar and acidified manure for improving growth of maize in chromium contaminated soil. International journal of phytoremediation 22, 52-61.

Abdin, Y., Usman, A., Ok, Y.S., Tsang, Y.F., Al-Wabel, M., 2020. Competitive sorption and availability of coexisting heavy metals in mining-contaminated soil: Contrasting effects of mesquite and fishbone biochars. Environmental research 181, 108846.

Alkurdi, S.S.A., Al-Juboori, R.A., Bundschuh, J., Bowtell, L., Marchuk, A., 2021. Inorganic arsenic species removal from water using bone char: A detailed study on adsorption kinetic and isotherm models using error functions analysis. Journal of Hazardous Materials 405, 124112.

Alqadami, A.A., Khan, M.A., Otero, M., Siddiqui, M.R., Jeon, B.-H., Batoo, K.M., 2018. A magnetic nanocomposite produced from camel bones for an efficient adsorption of toxic metals from water. Journal of Cleaner Production 178, 293-304.

Ashry, A., Bailey, E.H., Chenery, S., Young, S.D., 2016. Kinetic study of time-dependent fixation of UVI on biochar. Journal of hazardous materials 320, 55-66.

Azeem, M., Ali, A., Arockiam Jeyasundar, P.G.S., Li, Y., Abdelrahman, H., Latif, A., Li, R., Basta, N., Li, G., Shaheen, S.M., Rinklebe, J., Zhang, Z., 2021. Bone-derived biochar improved soil quality and reduced Cd and Zn phytoavailability in a multi-metal contaminated mining soil. Environmental Pollution 277, 116800.

Azeem, M., Sun, D., Crowley, D., Hayat, R., Hussain, Q., Ali, A., Tahir, M.I., Jeyasundar, P.G.S.A., Rinklebe, J., Zhang, Z., 2020. Crop types have stronger effects on soil microbial communities and functionalities than biochar or fertilizer during two cycles of legume-cereal rotations of dry land. Science of The Total Environment 715, 136958.

Batista, E.M., Shultz, J., Matos, T.T., Fornari, M.R., Ferreira, T.M., Szpoganicz, B., de Freitas, R.A., Mangrich, A.S., 2018. Effect of surface and porosity of biochar on water holding capacity aiming indirectly at preservation of the Amazon biome. Scientific Reports 8, 1-9.

Brunson, L.R., Sabatini, D.A., 2009. An evaluation of fish bone char as an appropriate arsenic and fluoride removal technology for emerging regions. Environmental engineering science 26, 1777-1784.

Cao, X., Harris, W., 2010. Properties of dairy-manure-derived biochar pertinent to its potential use in remediation. Bioresource technology 101, 5222-5228.

Chatterjee, S., Mukherjee, M., De, S., 2018. Defluoridation using novel chemically treated carbonized bone meal: batch and dynamic performance

with scale-up studies. Environmental Science Pollution Research 25, 18161-18178.
Chen, T., Liu, R., Scott, N.R., 2016. Characterization of energy carriers obtained from the pyrolysis of white ash, switchgrass and corn stover—Biochar, syngas and bio-oil. Fuel Processing Technology 142, 124-134.
El-Refaey, A.A., Mahmoud, A.H., Saleh, M.E., 2015. Bone biochar as a renewable and efficient P fertilizer: a comparative study. Alex J Agric Res 60, 127-137.
Frišták, V., Pipíška, M., Soja, G., Klokočíková Packová, A., Hubeňák, M., Kadlečíková, M., 2019. Agro-Environmental Benefit and Risk of Manure-and Bone Meal-Derived Pyrogenic Carbonaceous Materials as Soil Amendments: Availability of PAHs, PTEs, and P. Agronomy 9, 802.
Gai, X., Wang, H., Liu, J., Zhai, L., Liu, S., Ren, T., Liu, H., 2014. Effects of feedstock and pyrolysis temperature on biochar adsorption of ammonium and nitrate. PLoS One 9, e113888.
Gunarathne, V., Senadeera, A., Gunarathne, U., Biswas, J.K., Almaroai, Y.A., Vithanage, M., 2020. Potential of biochar and organic amendments for reclamation of coastal acidic-salt affected soil. Biochar, 1-14.
Hadroug, S., Jellali, S., Leahy, J.J., Kwapinska, M., Jeguirim, M., Hamdi, H., Kwapinski, W., 2019. Pyrolysis process as a sustainable management option of poultry manure: characterization of the derived biochars and assessment of their nutrient release capacities. Water 11, 2271.
Hairani, A., 2016. Effect of biochar application on soil and plant [an abstract of dissertation and a summary of dissertation review]. 北海道大学.
Hosseini, S.H., Liang, X., Niyungeko, C., Miaomiao, H., Li, F., Khan, S., Eltohamy, K.M., 2019. Effect of sheep manure-derived biochar on colloidal phosphorus release in soils from various land uses. Environmental Science Pollution Research 26, 36367-36379.
Irfan, M., Hussain, Q., Khan, K.S., Akmal, M., Ijaz, S.S., Hayat, R., Khalid, A., Azeem, M., Rashid, M., 2019. Response of soil microbial biomass and enzymatic activity to biochar amendment in the organic carbon deficient arid soil: a 2-year field study. Arabian Journal of Geosciences 12, 95.
Jindo, K., Mizumoto, H., Sawada, Y., Sánchez-Monedero, M.Á., Sonoki, T., 2014. Physical and chemical characterization of biochars derived from different agricultural residues. Biogeosciences.
Lian, F., Sun, B., Chen, X., Zhu, L., Liu, Z., Xing, B., 2015. Effect of humic acid (HA) on sulfonamide sorption by biochars. Environmental Pollution 204, 306-312.
Liang, X., Chen, L., Liu, Z., Jin, Y., He, M., Zhao, Z., Liu, C., Niyungeko, C., Arai, Y., 2018. Composition of microbial community in pig manure biochar-amended soils and the linkage to the heavy metals accumulation in rice at harvest. Land Degradation Development 29, 2189-2198.
Lu, K., Yang, X., Gielen, G., Bolan, N., Ok, Y.S., Niazi, N.K., Xu, S., Yuan, G., Chen, X., Zhang, X., 2017. Effect of bamboo and rice straw biochars on the mobility and redistribution of heavy metals (Cd, Cu, Pb and Zn) in contaminated soil. Journal of environmental management 186, 285-292.
Medellin-Castillo, N.A., Leyva-Ramos, R., Ocampo-Perez, R., Garcia de la Cruz, R.F., Aragon-Pina, A., Martinez-Rosales, J.M., Guerrero-Coronado, R.M., Fuentes-Rubio, L., 2007. Adsorption of fluoride from water solution on bone char. Industrial Engineering Chemistry Research 46, 9205-9212.
Mendoza-Castillo, D.I., Bonilla-Petriciolet, A., Jáuregui-Rincón, J., 2015. On the importance of surface chemistry and composition of bone char for the sorption of heavy metals from aqueous solution. Desalination Water Treatment 54, 1651-1662.
Meng, J., Feng, X., Dai, Z., Liu, X., Wu, J., Xu, J., 2014. Adsorption characteristics of Cu (II) from aqueous solution onto biochar derived from swine manure. Environmental Science Pollution Research 21, 7035-7046.

Meng, J., Wang, L., Liu, X., Wu, J., Brookes, P.C., Xu, J., 2013. Physicochemical properties of biochar produced from aerobically composted swine manure and its potential use as an environmental amendment. Bioresource technology 142, 641-646.
Moreno, J.C., Gómez, R., Giraldo, L., 2010. Removal of Mn, Fe, Ni and Cu ions from wastewater using cow bone charcoal. Materials 3, 452-466.
Mubarik, S., Saeed, A., Athar, M., Iqbal, M., 2016. Characterization and mechanism of the adsorptive removal of 2, 4, 6-trichlorophenol by biochar prepared from sugarcane baggase. Journal of Industrial Engineering Chemistry 33, 115-121.
Nigri, E.M., Bhatnagar, A., Rocha, S.D.F., 2017. Thermal regeneration process of bone char used in the fluoride removal from aqueous solution. Journal of Cleaner Production 142, 3558-3570.
Novotny, E.H., Auccaise, R., Velloso, M.H.R., Corrêa, J.C., Higarashi, M.M., Abreu, V.M.N., Rocha, J.D., Kwapinski, W., 2012. Characterization of phosphate structures in biochar from swine bones. Pesquisa Agropecuária Brasileira 47, 672-676.
Obia, A., Mulder, J., Martinsen, V., Cornelissen, G., Børresen, T., 2016. In situ effects of biochar on aggregation, water retention and porosity in light-textured tropical soils. Soil Tillage Research 155, 35-44.
Oladipo, A.A., Ifebajo, A.O., Nisar, N., Ajayi, O.A., 2017. High-performance magnetic chicken bone-based biochar for efficient removal of rhodamine-B dye and tetracycline: competitive sorption analysis. Water Science Technology 76, 373-385.
Olaniyi, I., Moses, S., Raphael, O., 2012. Adsorption study of Cr (VI) and Pb (II) from aqueous solution using animal charcoal derived from cow bone. Der Chemica Sinica 3, 648-657.
Park, J.-H., Cho, J.-S., Ok, Y.S., Kim, S.-H., Kang, S.-W., Choi, I.-W., Heo, J.-S., DeLaune, R.D., Seo, D.-C., 2015. Competitive adsorption and selectivity sequence of heavy metals by chicken bone-derived biochar: batch and column experiment. ournal of Environmental Science Health, Part A 50, 1194-1204.
Patel, S., Han, J., Qiu, W., Gao, W., 2015. Synthesis and characterisation of mesoporous bone char obtained by pyrolysis of animal bones, for environmental application. Journal of Environmental Chemical Engineering 3, 2368-2377.
Piccirillo, C., Moreira, I., Novais, R., Fernandes, A., Pullar, R., Castro, P., 2017. Biphasic apatite-carbon materials derived from pyrolysed fish bones for effective adsorption of persistent pollutants and heavy metals. Journal of environmental chemical engineering 5, 4884-4894.
Qin, J., Qian, S., Chen, Q., Chen, L., Yan, L., Shen, G., 2019. Cow manure-derived biochar: Its catalytic properties and influential factors. Journal of hazardous materials 371, 381-388.
Ren, X., Zhang, P., Zhao, L., Sun, H., 2016. Sorption and degradation of carbaryl in soils amended with biochars: influence of biochar type and content. Environmental Science and Pollution Research 23, 2724-2734.
Rojas-Mayorga, C., Bonilla-Petriciolet, A., Aguayo-Villarreal, I.A., Hernandez-Montoya, V., Moreno-Virgen, M., Tovar-Gómez, R., Montes-Morán, M., 2013. Optimization of pyrolysis conditions and adsorption properties of bone char for fluoride removal from water. Journal of analytical applied pyrolysis 104, 10-18.
Rojas-Mayorga, C.K., Silvestre-Albero, J., Aguayo-Villarreal, I.A., Mendoza-Castillo, D.I., Bonilla-Petriciolet, A., 2015. A new synthesis route for bone chars using CO2 atmosphere and their application as fluoride adsorbents. Microporous Mesoporous Materials 209, 38-44.
Rombolà, A.G., Marisi, G., Torri, C., Fabbri, D., Buscaroli, A., Ghidotti, M., Hornung, A., 2015. Relationships between chemical characteristics and phytotoxicity of biochar from poultry litter pyrolysis. Journal of agricultural food chemistry 63, 6660-6667.
Siebers, N., Leinweber, P., 2013. Bone char: a clean and renewable phosphorus fertilizer with cadmium immobilization capability. Journal of

environmental quality 42, 405-411.
Sun, Y., Gao, B., Yao, Y., Fang, J., Zhang, M., Zhou, Y., Chen, H., Yang, L., 2014. Effects of feedstock type, production method, and pyrolysis temperature on biochar and hydrochar properties. Chemical Engineering Journal 240, 574-578.
Vamvuka, D., Dermitzakis, S., Pentari, D., Sfakiotakis, S., 2018. Valorization of meat and bone meal through pyrolysis for soil amendment or lead adsorption from wastewaters. Food Bioproducts Processing 109, 148-157.
Wang, X., Zhou, W., Liang, G., Song, D., Zhang, X., 2015. Characteristics of maize biochar with different pyrolysis temperatures and its effects on organic carbon, nitrogen and enzymatic activities after addition to fluvo-aquic soil. Science of the Total Environment 538, 137-144.
Warren, G., Robinson, J., Someus, E., 2009. Dissolution of phosphorus from animal bone char in 12 soils. Nutrient Cycling in Agroecosystems 84, 167-178.
Xiao, J., Hu, R., Chen, G., 2020a. Micro-nano-engineered nitrogenous bone biochar developed with a ball-milling technique for high-efficiency removal of aquatic Cd (II), Cu (II) and Pb (II). Journal of Hazardous Materials 387, 121980.
Xiao, J., Hu, R., Chen, G., 2020b. Micro-nano-engineered nitrogenous bone biochar developed with a ball-milling technique for high-efficiency removal of aquatic Cd(II), Cu(II) and Pb(II). Journal of Hazardous Materials 387, 121980.
Xiao, J., Hu, R., Chen, G., Xing, B., 2020c. Facile synthesis of multifunctional bone biochar composites decorated with Fe/Mn oxide micro-nanoparticles: Physicochemical properties, heavy metals sorption behavior and mechanism. Journal of Hazardous Materials 399, 123067.
Xiao, R., Wang, P., Mi, S., Ali, A., Liu, X., Li, Y., Guan, W., Li, R., Zhang, Z., 2019. Effects of crop straw and its derived biochar on the mobility and bioavailability in Cd and Zn in two smelter-contaminated alkaline soils. Ecotoxicology and environmental safety 181, 155-163.
Yang, T., Han, C., Tang, J., Luo, Y.J.E.S., Research, P., 2020. Removal performance and mechanisms of Cr (VI) by an in-situ self-improvement of mesoporous biochar derived from chicken bone. 27, 5018-5029.
Yoo, G., Kim, Y.J., Lee, Y.O., Ding, W., 2016. Investigation of greenhouse gas emissions from the soil amended with rice straw biochar. KSCE Journal of Civil Engineering 20, 2197-2207.
Yuan, J.-H., Xu, R.-K., Zhang, H., 2011. The forms of alkalis in the biochar produced from crop residues at different temperatures. Bioresource technology 102, 3488-3497.
Yuan, J., Xu, R., 2011. Progress of the research on the properties of biochars and their influence on soil environmental functions. Ecol Environ Sci 20, 779-785.
Zhang, L., Jing, Y., Xiang, Y., Zhang, R., Lu, H., 2018. Responses of soil microbial community structure changes and activities to biochar addition: A meta-analysis. Science of The Total Environment 643, 926-935.
Zhou, J., Liu, Y., Han, Y., Jing, F., Chen, J., 2019. Bone-derived biochar and magnetic biochar for effective removal of fluoride in groundwater: Effects of synthesis method and coexisting chromium. Water Environment Research 91, 588-597.