HYDROTHERMAL CARBONISATION OF SEWAGE SLUDGE: CHAR CHARACTERISATION AND REFERENCE TO INTERNATIONAL LEGISLATIONS

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The aim of this work is to apply Hydrothermal Carbonisation (HTC) to different kinds of sludge such as thickened sludge, digested sludge and dewatered sludge, and compare the composition of the solid produced by the process, i.e. hydrochar, with soil and biosolid legislations: Table 1. For the purpose, experimental tests were performed at different operating conditions, namely three temperatures (190, 220 and 250 °C) and two reaction times (30 and 60 minutes).
The different kinds of sludge were fed to a 50 mL s.s. batch reactor capable to withstand high pressure (140 bar) and temperature (300 °C) and, after the process, hydrochar was separated from the HTC process liquid through paper filtration and subsequently dried. Apparatus and procedures were previously fully described [1].
The hydrochars from HTC at different operative conditions were characterized in terms of ultimate, proximate and ICP-OES analyses.
The resulting chars have an ash content between 18 and 79 wt%, a C content between 10 and 46 wt%, a N content between 2 and 7wt% (all values on a dry basis, d.b.), a P, Mg, Na, K and Ca content of several g/kg, a Pb, Cd, Ni, Zn, Cu, Hg, Cr, As and Co content of the order of mg/kg (Table 1). The HTC process tends to concentrate P, Mg and Ca and reduce K and Na content in the hydrochar in respect to the initial dry sludge, due to the high solubility of K and Na in the water phase. Hydrochars have a higher content in heavy metals than the initial sludge due to their extremely low solubility in the water phase and substantial overall solid mass reduction. Such mass reduction is due to the degradation of the organic fraction during the HTC process.

	As [mg/kg]	Cd [mg/kg]	Co [mg/kg]	Cr_{tot} [mg/kg]	Cu [mg/kg]	Pb [mg/kg]	Hg [mg/kg]	Ni [mg/kg]	Zn [mg/kg]
Austria - Compost [2]		4		150	400	500	4	100	1000
Belgium - Compost [2]		1		70	90	120	0.7	20	280
Denmark - Compost [2]		1.2				120	1.2	45	
France - Compost [2]		8				800	8	200	
Germany - Compost [2]		1.5		100	100	150	1	50	400
Spain - Compost [2]		40		750	1750	1200	25	400	4000
Italy - Compost [3]		1.5			230	140	1.5	100	500
USA - Biosolid [2]	75	85			4300	840	57	420	7500
Italy - soil law (residential) [4]	20	2	20	150	120	100	1	120	150
Italy - soil law (industrial) [4]	50	15	250	800	600	1000	5	500	1500
Char from Primary Sludge	1-2	0-1	0-2	23-39	417-1098	30-51	19-33	14-29	642-1104
Char from Digestate	0-1	0-1	2-3	35-48	630-749	54-108	11-18	23-39	680-906
Char from Dewatered Sludge	4-5	0-1	1-2	25-29	317-1340	40-50	-	16-21	794-992

Table 1 – Char characterization and comparison with different legislations concerning biosolid, composting and Italian soil legislation

[1] Basso, D., Weiss-Hortala, E., Patuzzi, F., Castello, D., Baratieri, M., Fiori, L., 2015. Hydrothermal carbonization of off-specification compost: a byproduct of the organic municipal solid waste treatment. Bioresource Technology 182, 217-224. doi:10.1016/j.biortech.2012.06.116
[2] Libra, J. A, Ro, K.S., Kammann, C., Funke, A., Berge, N.D., Neubauer, Y., Titirici, M.-M., Fühner, C., Bens, O., Kern, J., Emmerich, K.-H., 2011. Hydrothermal carbonization of biomass residuals: a comparative review of the chemistry, processes and applications of wet and dry pyrolysis. Biofuels 2, 71–106. doi:10.4155/bfs.10.81
[3] Italian Law 152/2010, Norms concerning fertilizers
[4] Italian Law 152/2006, Norms concerning the environment