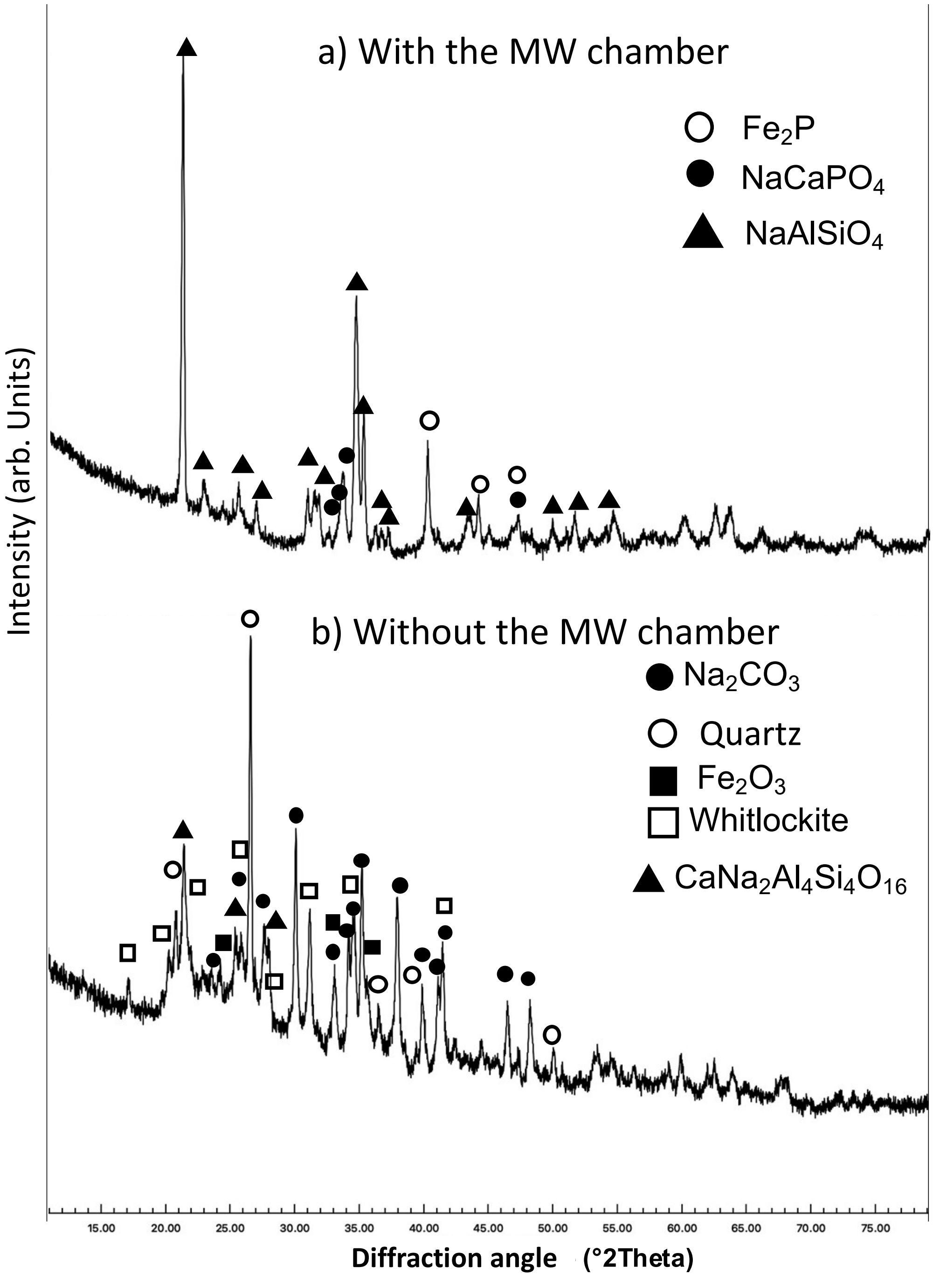
Electronic Supplementary Material (ESI)



S1: XRD patterns collected on a cyclone SSA sample derived from the mono-combustion of sewage sludge (sample 1), mixed with sodium bicarbonate and carbon, collected after 15 minutes of MW treatment; a) with the MW chamber b) without the MW chamber. The two XRD spectra highlight that the chamber is necessary to reach the conditions for whitlockite transformation into buchwaldite ($NaCaPO_4$).

Literature reports that the $Ca_3(PO_4)_2$ conversion to $CaNaPO_4$ occurs at temperatures ranging from 900 to 1000°C.

Compared with traditional heating, the heating mechanism due to microwaves is different from that deriving from conventional ones, with interesting results in terms of temperatures that can be reached and the time necessary for treatments.

Then, the energy requirement and carbon dioxide emission calculation for the proposed technology were evaluated supposing that the temperature may fall in the range of 500°C-1000°C, for 1 kg of material. Based on the coal heat capacity (1.2 J/(g°C)) and the estimated sample temperature increase, an energy requirement ranging from 0.5 to 1.1 MJ/Kg can be evaluated (Sonesson, et al, 2003).

S2: Methodology used to evaluate energy consumption of the microwave treatment.

Element	Sample	1			2			3			4			5			6			7		
		mg/L																				
Al	RAW	7.7	±	1.5	0.22	±	0.04	0.20	±	0.04	2.2	±	0.4	31	±	6	0.13	±	0.03	11	±	2
	NC-MW	12	±	2	1.9	±	0.4	0.45	±	0.09	12.1	±	2.4	0.11	±	0.02	128	±	25	0.10	±	0.02
As	RAW	< LOQ	±	< LOQ	0.03	±	0.01	< LOQ	±	< LOQ	< LOQ	±	< LOQ	< LOQ	±	< LOQ	< LOQ	±	< LOQ	< LOQ	±	< LOQ
	NC-MW	0.02	±	0.004	< LOQ	±	< LOQ	0.02	±	0.005	< LOQ	±	< LOQ	< LOQ	±	< LOQ	< LOQ	±	< LOQ	0.03	±	0.01
Ba	RAW	0.16	±	0.04	0.12	±	0.03	0.04	±	0.01	1.65	±	0.42	0.25	±	0.06	2.83	±	0.72	0.05	±	0.01
	NC-MW	0.22	±	0.06	0.11	±	0.03	0.12	±	0.03	0.15	±	0.04	0.28	±	0.07	9.50	±	2.41	0.94	±	0.24
Ca	RAW	173	±	32	160	±	29	152	±	28	413	±	76	332	±	61	2486	±	457	47	±	9
	NC-MW	1.8	±	0.5	2.5	±	0.6	3.8	±	1.0	1.6	±	0.4	49	±	13	261	±	67	36	±	9
Cr	RAW	0.03	±	0.01	0.02	±	0.004	0.13	±	0.03	< LOQ	±	< LOQ	0.02	±	0.01	0.07	±	0.02	0.11	±	0.03
	NC-MW	< LOQ	±	< LOQ	< LOQ	±	< LOQ	< LOQ	±	< LOQ	< LOQ	±	< LOQ	< LOQ	±	< LOQ	nd	±	nd	< LOQ	±	< LOQ
Cu	RAW	< LOQ	±	< LOQ	< LOQ	±	< LOQ	< LOQ	±	< LOQ	0.59	±	0.13	< LOQ	±	< LOQ	0.94	±	0.21	< LOQ	±	< LOQ
	NC-MW	0.09	±	0.02	0.07	±	0.02	0.05	±	0.01	0.85	±	0.19	0.03	±	0.01	0.12	±	0.03	< LOQ	±	< LOQ
Fe	RAW	nd	±	nd	nd	±	nd	nd	±	nd	nd	±	nd	nd	±	nd	nd	±	nd	nd	±	nd
	NC-MW	0.40	±	0.08	0.41	±	0.08	0.77	±	0.15	0.33	±	0.06	< LOQ	±	< LOQ	nd	±	nd	0.04	±	0.01
K	RAW	12	±	3	12	±	3	11	±	2	22	±	5	369	±	86	1090	±	255	2.5	±	0.6
	NC-MW	30	±	7	29	±	7	6	±	1	27	±	6	57	±	13	57	±	13	20	±	5
Mg	RAW	5.5	±	1.0	3.6	±	0.7	5.9	±	1.1	< LOQ	±	< LOQ	< LOQ	±	< LOQ	< LOQ	±	< LOQ	< LOQ	±	< LOQ
	NC-MW	0.30	±	0.05	0.48	±	0.09	0.85	±	0.15	0.30	±	0.05	4.4	±	0.8	< LOQ	±	< LOQ	1.0	±	0.2
Na	RAW	6.7	±	1.6	4.9	±	1.2	13.4	±	3.2	27.2	±	6.5	268	±	64	8369	±	1997	8	±	2
	NC-MW	84	±	20	108	±	26	68	±	16	115	±	27	165	±	39	142	±	34	124	±	30
Pb	RAW	< LOQ	±	< LOQ	nd	±	nd	< LOQ	±	< LOQ	0.34	±	0.11	< LOQ	±	< LOQ	17.71	±	5.75	< LOQ	±	< LOQ
	NC-MW	< LOQ	±	< LOQ	< LOQ	±	< LOQ	< LOQ	±	< LOQ	< LOQ	±	< LOQ	nd	±	nd	nd	±	nd	nd	±	nd
Ti	RAW	nd	±	nd	nd	±	nd	nd	±	nd	nd	±	nd	nd	±	nd	nd	±	nd	nd	±	nd
	NC-MW	0.05	±	0.01	0.07	±	0.02	0.03	±	0.01	0.03	±	0.01	< LOQ	±	< LOQ	nd	±	nd	nd	±	nd
Zn	RAW	< LOQ	±	< LOQ	nd	±	nd	nd	±	nd	0.69	±	0.19	< LOQ	±	< LOQ	1.73	±	0.47	nd	±	nd
	NC-MW	0.11	±	0.03	0.05	±	0.01	0.08	±	0.02	0.06	±	0.02	< LOQ	±	< LOQ	0.18	±	0.05	0.02	±	0.01

RAW = sample as received; NC-MW = sample after microwave treatment; nd= not determined concentration; < LOQ = concentration lower than the instrumental limit of quantification. Concentrations of Cd, Co, Mn and Ni were not detected or resulted lower than LOQ, then they are not reported.

S3: Concentrations obtained by ICP-OES analysis on the solutions after the leaching tests performed on all samples before (RAW) and after (NC-MW) the MW treatment.

			Crystalline phases										
		Sample	$KAlSi_3O_8$	SiO_2 (Quartz)	Labradorite	$Ca_{3-x}(Mg, Fe)_x(PO4)_2$	$MgSiO_3$	$CaCO_3$	Fe_2O_3	CaClOH	$CaSO_4$	$Ca(OH)_2$	NaCl
RAW	**MC**	Cyclone ash (1)		x	x	x							
		Boiler post combustion ash (2)		x	x	x							
		Bottom ash (3)	x	x			x						
	CC	Boiler post combustion ash (4)		x		x			x				
		Cyclone ash (5)		x		x		x	x				x
		Bag filter ash (6)		x						x	x	x	x
		Bottom ash (7)		x	x		x						
NC-MW			$AlPO_4$	Fe_2P	SiO_2 (Quartz)	$NaCaPO_4$	CaS	CaO	$Ca_5Al_6O_{14}$	KH_2PO_4	$CaMg(P_2O_7)$		
	MC	Cyclone ash (1)		x		x							
		Boiler post combustion ash (2)		x		x							
		Bottom ash (3)	x	x	x								
	CC	Boiler post combustion ash (4)			x	x				x	x		
		Cyclone ash (5)		x		x					x		
		Bag filter ash (6)				x	x	x	x				
		Bottom ash (7)		x									

RAW = sample as received; NC-MW= sample after microwave treatment; MC= fluidized bed mono-combustion of sewage sludge; CC= fluidized bed co-combustion of sewage sludge and municipal solid waste.

S4: Crystalline phases identified by means of XRD analysis for all samples before (RAW) and after (NC-MW) the MW treatment.

References:

Sonesson, U., Janestad, H., & Raaholt, B. (2003). Energy for preparation and storing of food: models for calculation of energy use for cooking and cold storage in households. SIK Institutet för livsmedel och bioteknik.