Thermochemical treatment of sewage sludge ash for P-fertilizer production

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Introduction

Phosphorus (P) is indispensable in its functions for all living creatures. Annually, more than 150,000 t/a of P are applied to soils in the form of mineral fertilizer in Germany. This fertilizer is produced from phosphate rock, which is often contaminated with heavy metals, especially cadmium and uranium that pose a risk to environment and health. Sewage sludge ash (SSA) is a possible alternative resource since it contains high amounts of P and may replace and/or complement mineral fertilizer and sewage sludge. Right now, the ash is almost exclusively landfilled or used for construction purposes. We conducted a complete survey of all German sewage sludge ashes and determined its elemental composition to evaluate the P-recovery and technology metals potential. However, additional treatment of SSA is mandatory in most cases to increase P bioavailability and decrease the amount of possibly harmful heavy metals. We developed a thermochemical treatment in a rotary kiln to convert the ash to a potential P-fertilizer.

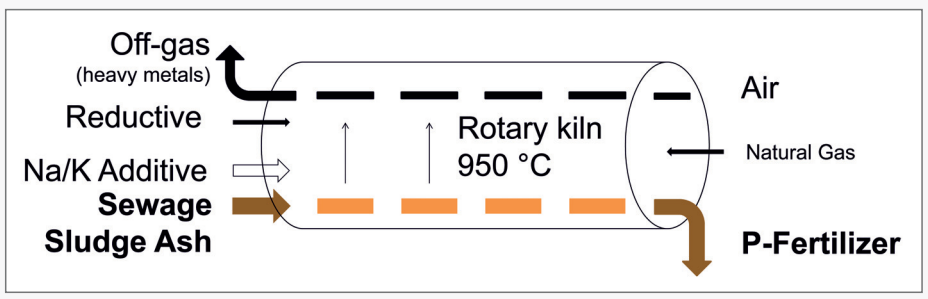
Materials and Methods

Analysis: The element composition of ashes and products was measured by ICP-OES/MS after microwave-assisted perchlorid/ hydrofluoric acid digestion. The P bioavailability was evaluated by solubility in neutral ammonium citrate (P_{NAC}).

Thermochemical Treatment: SSA was mixed with dry sewage sludge (reducing agent) and Na- and K-compounds. The mixture was treated at 950-1000 °C for 30 min in order to form bioavailable P-bearing mineral phases such as $NaCaPO_4$.

Survey of all German Sewage Sludge Ashes

- P mass fractions of SSA is 1.5 - 13.1 % (mean 7.3 %).
- Annual phosphorus recovery potential is up to19,000 t.
- 12 % of mineral fertilizer might be replaced by P from SSA.
- Cd and U in SSA are significantly lower than in P-rock .
- Secondary phosphates can help to reduce the heavy metal intake of farmlands.



Thermochemical Treatment of SSA

- Significant increase of P bioavailability by K- and Na-additives.
- Molar ratio alkali/P > 2 for P_{NAC}-solubility 90-100%.
- Higher molar ratio K/P required compared to Na-compounds
- As, Cd, Hg, Pb and Tl were removed under reducing condition.
- Process was successfully tested in a 2 t P-fertilizer production.

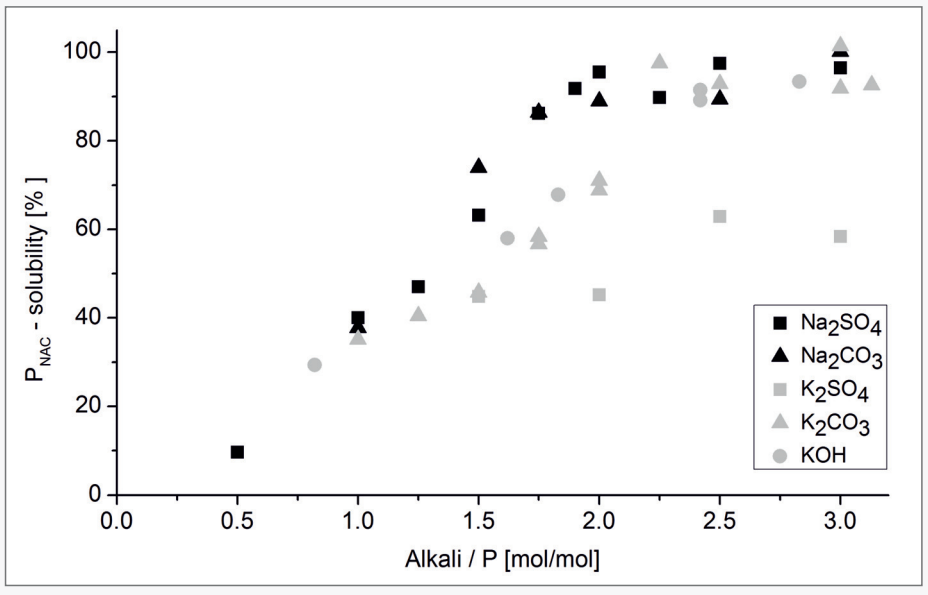


Figure 1: P_{NAC}-solubility of products from SSA calcined at 1000°C with Na- and K-additives as a function of Na/P or K/P ratio (mol/mol)

Table 1: Element mass fractions, mass flows in German SSA

Element	Min	Max	Mean	Median	Mass flow
	[%]				[t/a]
Al	0.7	20.2	5.2	4.8	14,999
Ca	6.1	37.8	13.8	10.5	42,669
Fe	1.8	20.3	9.9	9.5	29,049
P	1.5	13.1	7.3	7.9	18,812
Si	2.4	23.7	12.1	12.1	38,637
	[mg/kg]				[t/a]
As	4.2	124.0	17.5	13.6	6.7
Cd	<0.1	80.3	3.3	2.7	1.4
Cr	58	1,502	267	160	107
Cu	162	3,467	916	785	395
Hg	0.1	3.6	0.8	0.5	0.3
Ni	8.2	501	106	74.8	58.0
Pb	<3.5	1,112	151	117	62.0
U	1.58	25.5	5.8	4.9	1.6
Zn	552	5,515	2,535	2,534	763

Table 2: Mass fractions of SSA and P-Fertilizer from production trial (2 t). Mixture ratio of weight 5 SSA : 1 SS : 2 Na_2SO_4

Element	Ash	P-fertilizer	Removal
	[%]		
Al	6.72	5.24	
Fe	5.85	6.21	
Na	0.53	12.50	
P	9.37	7.71	
S	0.89	2.55	
Si	11.42	10.90	
	[mg/kg]		
As	11.1	3.6	61 %
Cd	2.1	0.3	80 %
Cr	159	127	0 %
Cu	767	601	0 %
Hg	1.1	0.3	68 %
Ni	73	56	0 %
Pb	123	60	39 %
Tl	0.6	0.2	65 %
U	11.2	7.2	0 %
Zn	2,330	1,710	9 %

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