

Waste water recycling products as Phosphor (P) fertilizer

Selected findings of one pot experiment

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Introduction / Objectives

The efficient use of P in agriculture as well as P recycling from waste products for food production is on primary concern. Thereby, recycling P from waste water residuals is of particular importance due to their high P concentration, as about 3 MT P globally incurred each year.

The objectives of this study were to determine how (i) different P recycling products from waste water residuals affect the P uptake of rye and amaranth and (ii) how the recycling products affect the P pools in soil in dependency of their elemental composition, which differed according to the used waste water residual and used recycling process.

Method

In the pot experiment the P fertilizing effect of

- one untreated sewage sludge ash (ut-SSA) based on Al precipitation → **Al(ut)-SSA**
- one sulfuric acid digested sewage sludge ash (SSA) based on Al precipitation → **Al-SSA**
- one thermo-chemical treated SSA prepared with CaCl_2 → **Ca-SSA**
- one thermo-chemical treated SSA prepared with MgCl_2 → **Mg-SSA**
- magnesium ammonium phosphate recovered from digested sludge by precipitation → **struvite**

were analyzed in comparison to one phosphate rock based fertilizer (Triple superphosphate, **TSP**) and one control treatment without P application (**CON**) (Tab.1).

Pot experiment: Mitcherlich pots were filled with 6 kg of a P poor loamy sand and were amended with the treatments at a rate equivalent to 200 mg P per pot. After 8 week growing time plant and soil samples were analyzed according to P uptake from the crops and the soil P pools.

Table 1 Total P (Pt) content and solubility of P (Citric acid soluble P, P_{ca}) as well as total nutrient concentration (K, Mg, Ca, N, Al, Fe) of the fertilizer treatments

	P _t	P _{ca}	K	Mg	Ca	N	Al	Fe
	g kg ⁻¹							
Al-(ut)SSA	98.6	29.9	9.5	15.1	76.1	n.d.	95.6	20.6
Al-SSA	58.5	45.9	5.1	7.7	42.6	n.d.	55.8	10.4
Ca-SSA	62.4	46.0	4.1	9.3	96.9	n.d.	23.9	29.2
Mg-SSA	65.9	44.0	4.8	49.1	54.3	n.d.	17.1	38.1
Struvite	121.7	102.7	0.6	93.4	4.9	41.7	39.6	18.5
TSP	157.0	168.9	n.d.	8.9	106.7	n.d.	29.4	22.5

Results

- Among all fertilizer treatments struvite increased the P uptake and the plant available P pools (PdI, NaHCO₃ fraction) in soil the most compared to CON followed by the Mg-SSA (Fig. 1 and 2 (1.))
- The Ca-SSA had a lower P fertilizing effect compared to the Mg-P based recycling products due to its high concentrations in low soluble P compounds, which was visible in the highest increase of the H₂SO₄ fraction (P associated with Ca and Mg minerals) in soil compared to the other fertilizer treatments (Fig. 2 (3.)).
- The Al-SSA resulted also in a lower P fertilizing effect compared to the Mg-P based products, because of its high concentrations in amorphous Al, which may increase the P sorption capacity in soil and increase the risk of Al-toxicity for crops. This is confirmed by the highest increase of the NaOH fraction (P sorbed and fixed by Al and Fe oxides) in soil after application of the Al-SSA compared to the other fertilizer treatments (Fig. 2 (2.)).

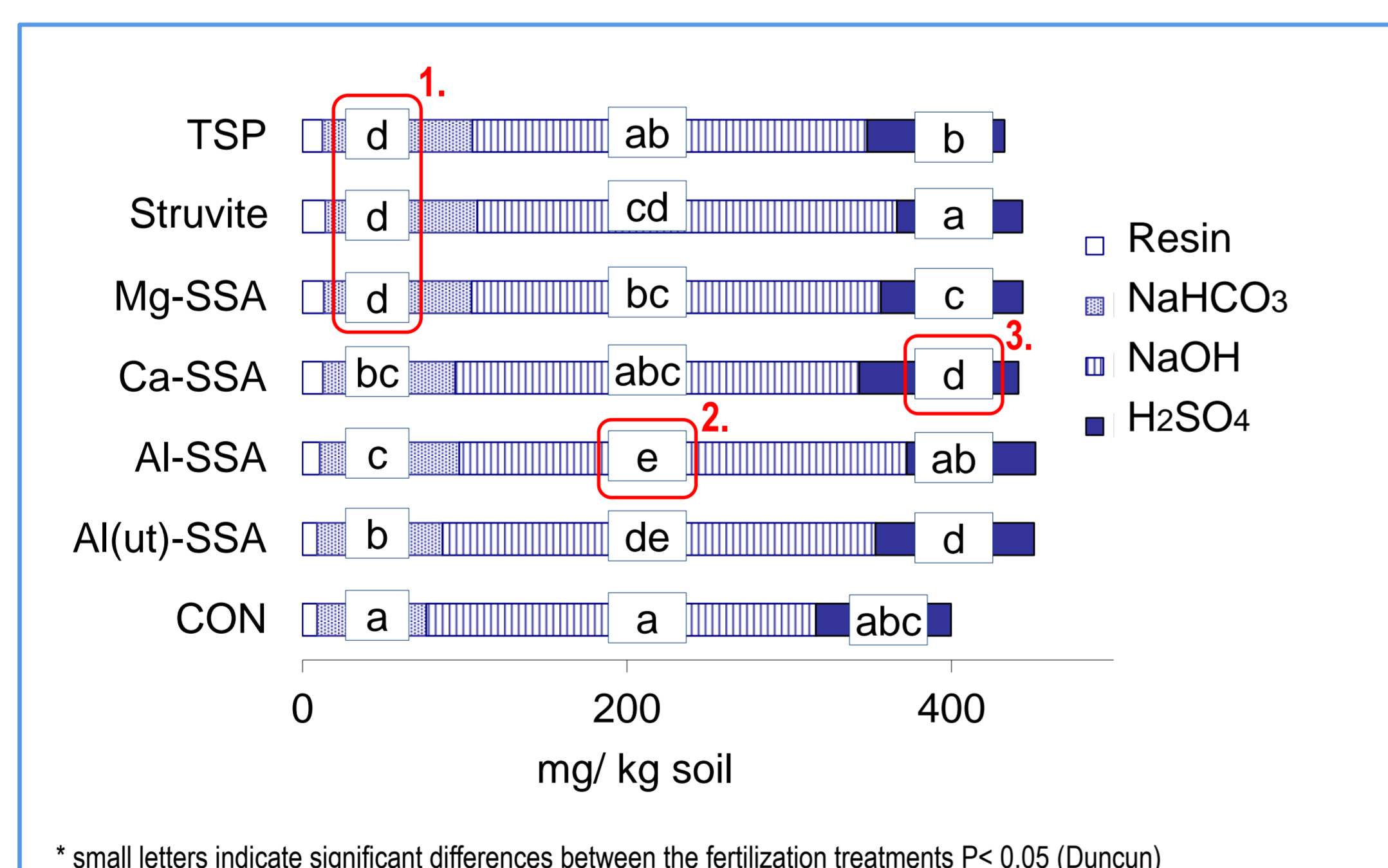


Figure 2 Effects of fertilizer treatments and control treatment without P addition (CON) on proportions of sequentially extracted P fraction in soil in average after cultivation of amaranth and rye

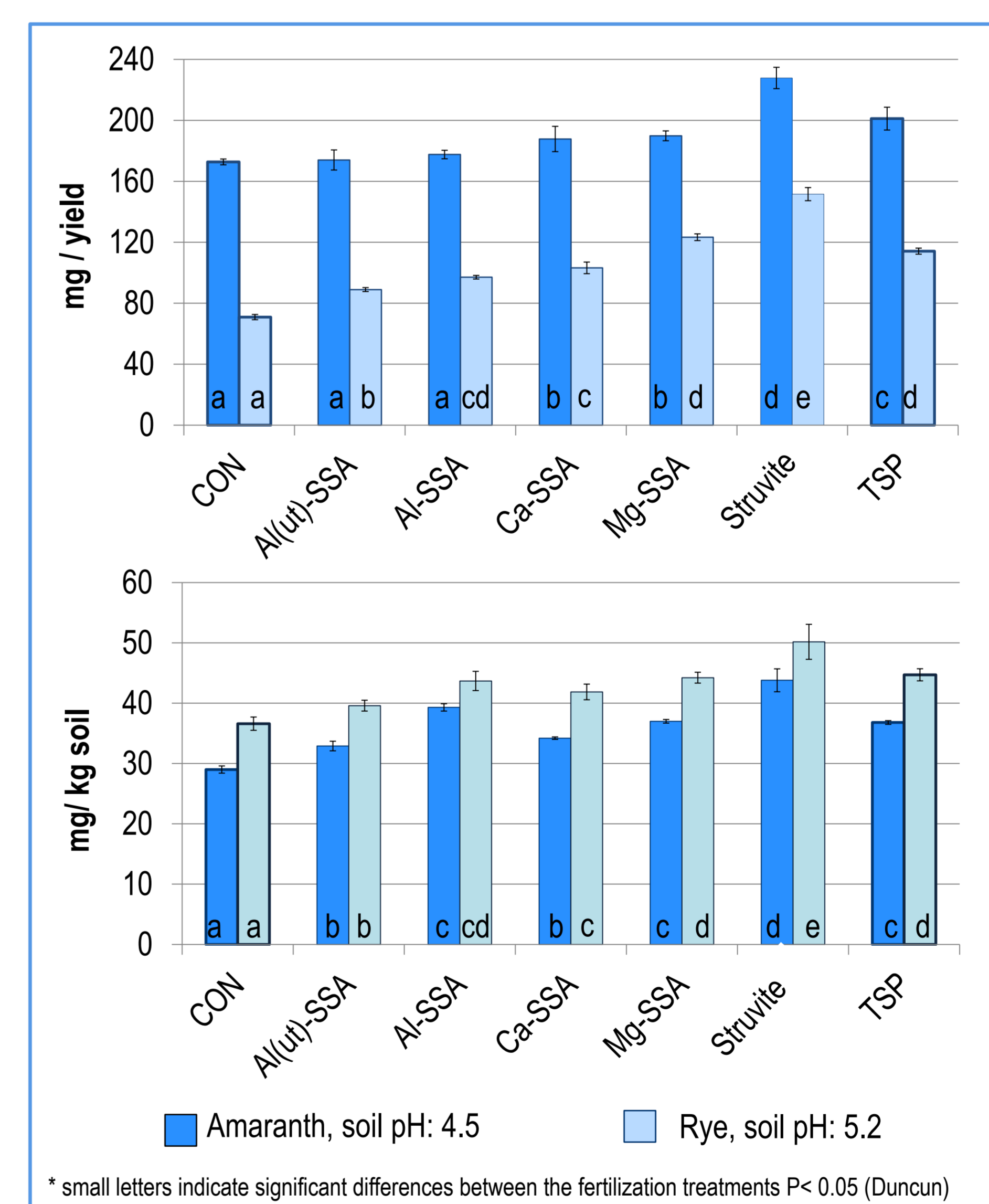


Figure 1 P uptake by amaranth and rye (upper figure) as well as doublelactate soluble P (PdI) concentration in soil (figure below) after cultivation of amaranth and rye and in control treatment and after addition of fertilizer treatments

Conclusion

- The Mg-P based recycling products, struvite and the Mg-SSA, are effective sources for P fertilization on acidic loamy sand.
- For thermo-chemical treatment the use of a Mg donor (as MgCl_2) should be preferred, because of the higher P fertilizing effect of the Mg-SSA compared to Ca-SSA.
- The Al-SSA should not be applied under acidic soil conditions ($\text{pH} < 5$) due to its high concentration in amorphous Al, which may increase the sorption capacity in soil or may even have a toxic effect on crops.
- The Al(ut)-SSA is not suitable as P fertilizer according to its low P availability for crops and its high concentration in heavy metals.