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Valorisation of Phosphorus Extracted from Farm Yard Slurry and Municipal Solid Waste Digestates as a Fertilizer

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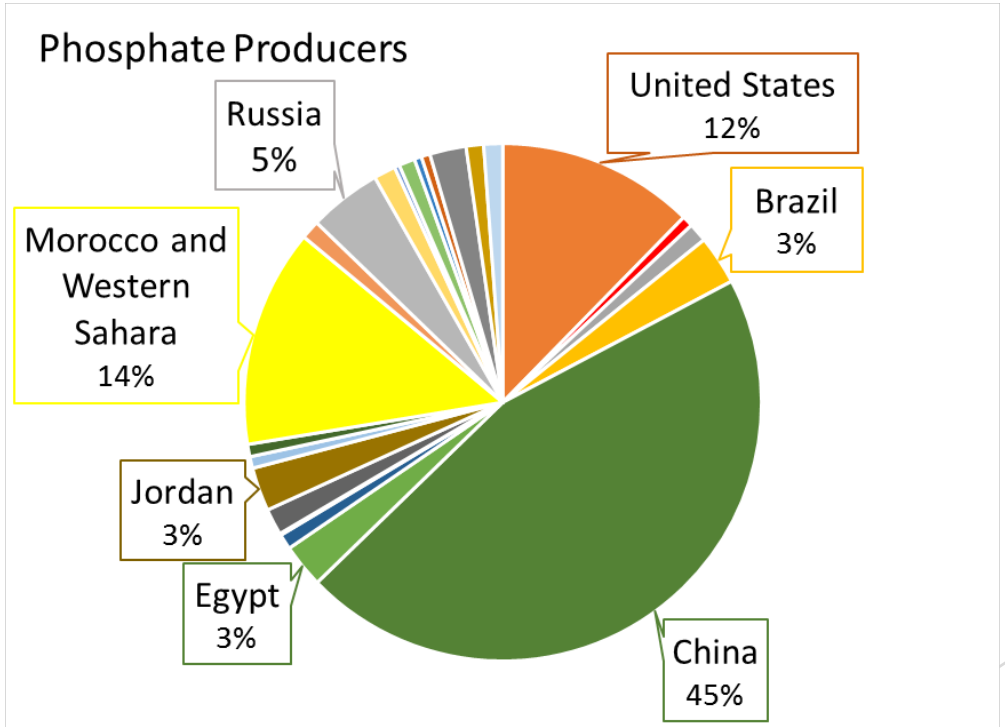
Phosphorus Issue

Phosphorus is essential and irreplaceable element for all forms of lives and does not occur by itself in nature.

Phosphate Rock

Source: https://geobancodedados.wordpress.com/2014/05/29/fosfato/



The reserves will reach their peak by 2030 and will be depleted in the next 50 – 100 years.

How can we Recover Phosphorus from Wastes and close the cycle for this nutrient?

Which wastes?

Recovery of phosphorus has been studied:

Waste Stream	Method of P recovery	Recovered Product	References
Municipal Sewage sludge	Thermochemical treatment method	P fertilizer	Adam et al (2007)
Municipal Sewage sludge ash	Acid Extraction followed by precipitation	Struvite	Xu et al (2012)
Swine wastewater	Nitrification followed by precipitation	Calcium Phosphate	Vanotti et al (2003)
Poultry Manure	Quick Wash Method	P solid	Szogi et al (2009)

European Report indicate that municipal solid wastes and their incineration residues **are an underestimated source of phosphorus**

In this work, the purpose was recovery of phosphorus from two different wastes:

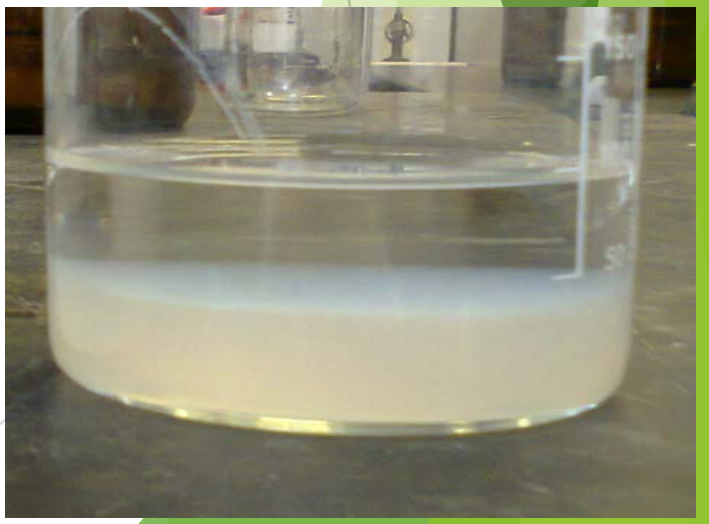
- Farm Yard Slurries and;
- Digestates of municipal solid wastes.

The farm yard slurry was collected at a local farm

The digestates of anaerobic process of municipal solid wastes were collected from a mechanical and biological treatment (MBT)

Methods

- Wastes
  - 1. HNO_3 extraction
    - Precipitation of phosphorus
  - 2. HNO_3 extraction
  - 3. Distilled Water
  - 4. NaOH extraction



Results

1. Wastes Characterization

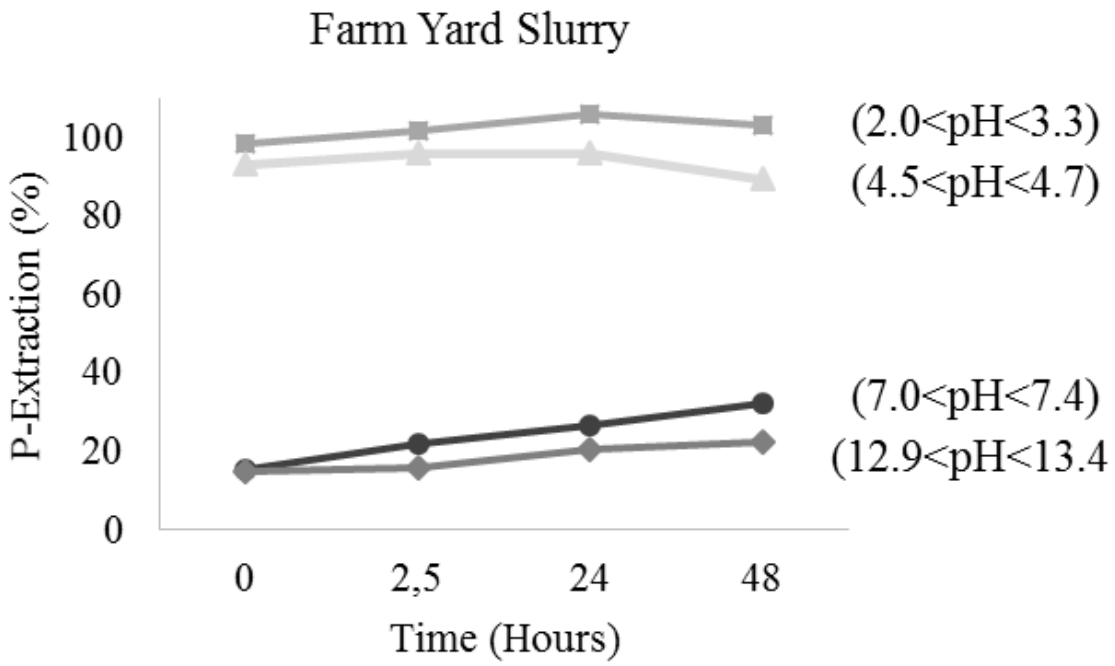
	Parameters	Farm yard slurry	MSW digestates	Portuguese Limiting Values
Physical and chemical characteristics	pH (H_2O)	6.6	7.8	-
	Conductivity (mS cm^{-1})	8.60 ± 0.18	5.22 ± 0.04	-
	Water Content (%)	85.11 ± 0.08	63.40 ± 0.51	
	Ash Content (%)	4.49 ± 0.07	18.55 ± 0.88	-
Macro Elements	Total P (mg g^{-1})	4.04 ± 0.08	8.11 ± 0.25	-
	Ca (mg g^{-1})	142.82 ± 3.85	103.68 ± 3.64	-
	Mg (mg g^{-1})	4.04 ± 0.13	12.59 ± 0.39	-
	K (mg g^{-1})	13.70 ± 3.28	9.38 ± 0.19	-
Heavy Metals	Cu (mg kg^{-1})	42.41 ± 0.95	156.04 ± 3.77	1000
	Zn (mg kg^{-1})	177.71 ± 5.51	452.44 ± 15.59	2500
	Pb (mg kg^{-1})	16.69 ± 1.89	195.86 ± 8.55	750
	Cd (mg kg^{-1})	1.64 ± 0.07	2.17 ± 0.33	20

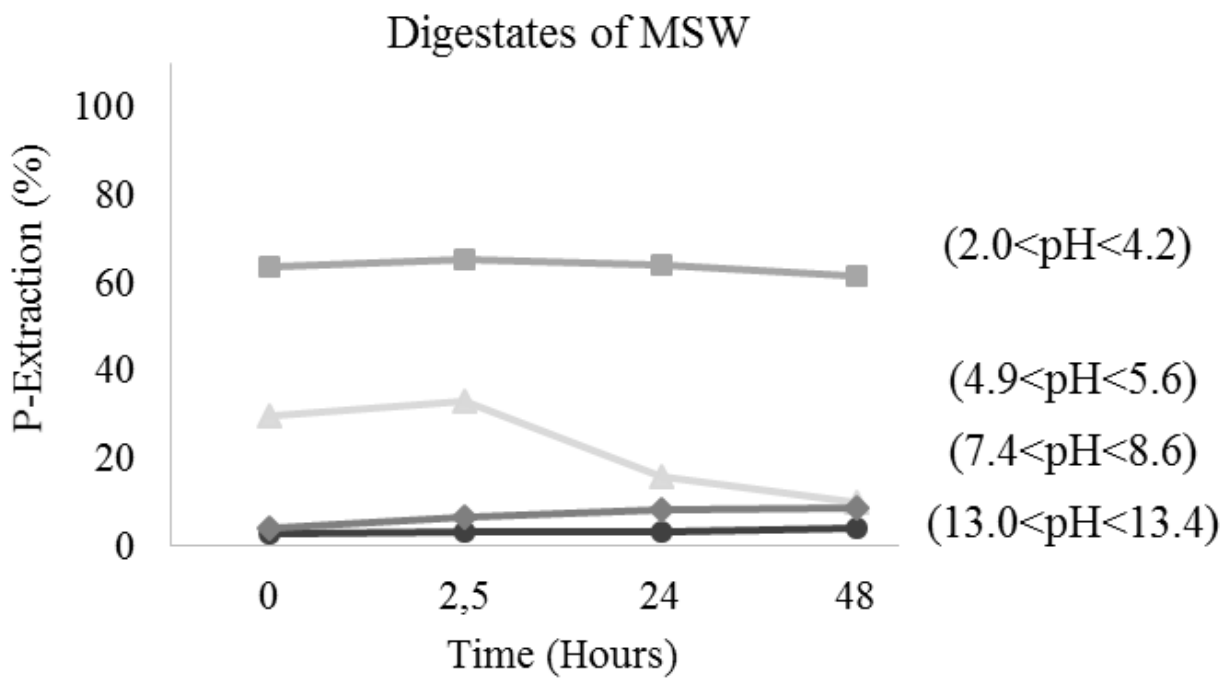
Key points for wastes characterization

- Both wastes had lower phosphorus content:
  - 0.8% for digestates of municipal solid wastes and;
  - 0.4% for farm yard slurries
- Calcium concentration in wastes was high;
- Both wastes do not exceed the heavy metals limiting values for sludge application in agricultural soils reported in the Portuguese legislation

Results

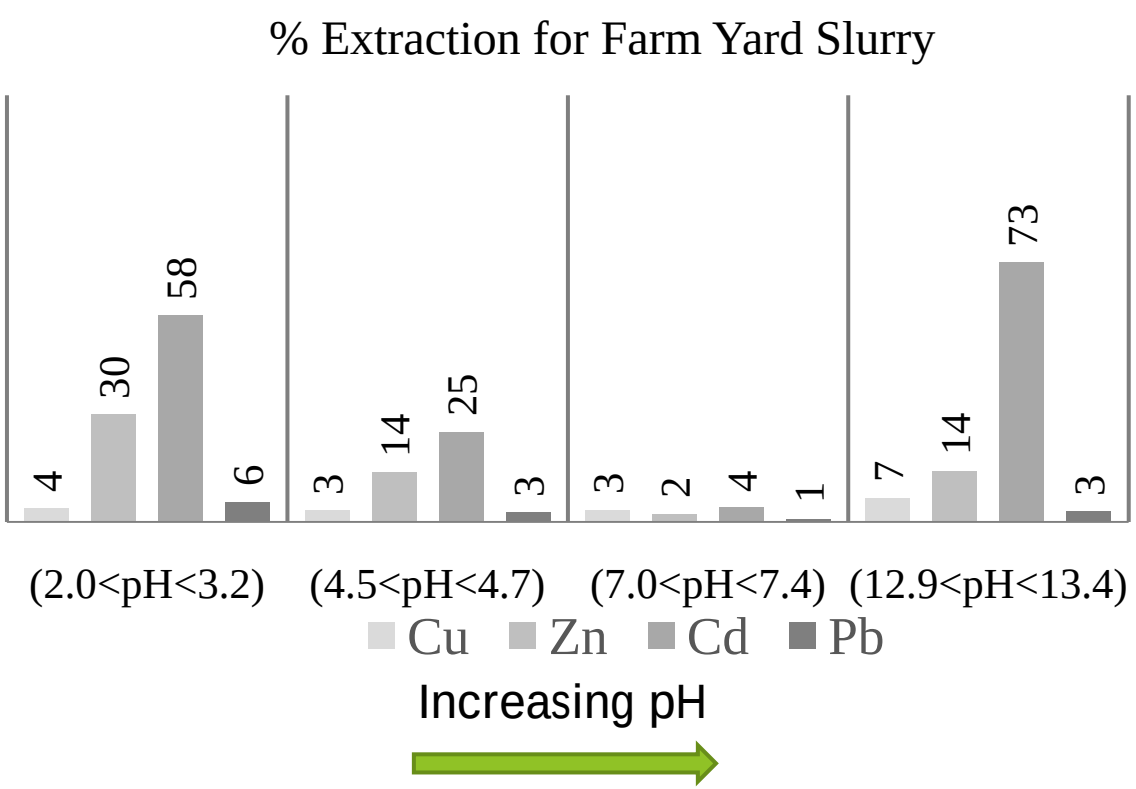
2. Extraction of phosphorus

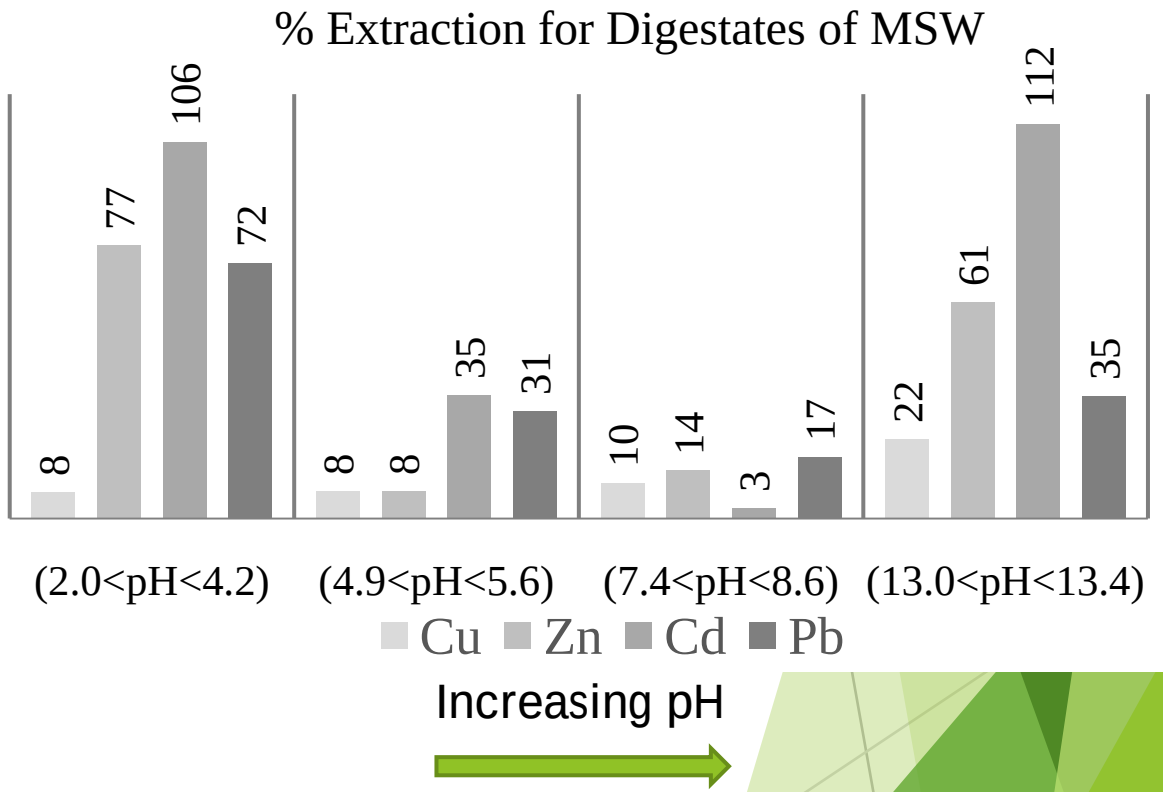




- Highest extraction in farm yard slurry than digestates of MSW;
- Acid extractions was more effective than base;
- Phosphorus solubilisation was almost immediate (2.5 hours).

Results *3. Heavy Metals Extraction*



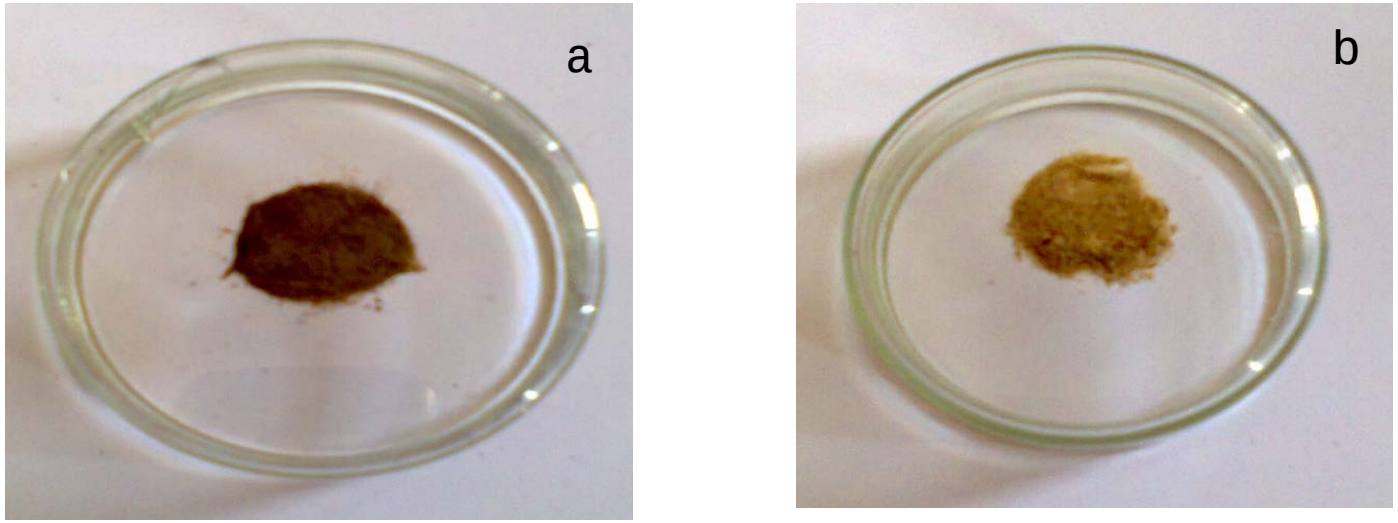


- Cd extraction was highest compared with other heavy metals
- Around pH 7 to 8 the solubility of the heavy metals decreased considerably

Results

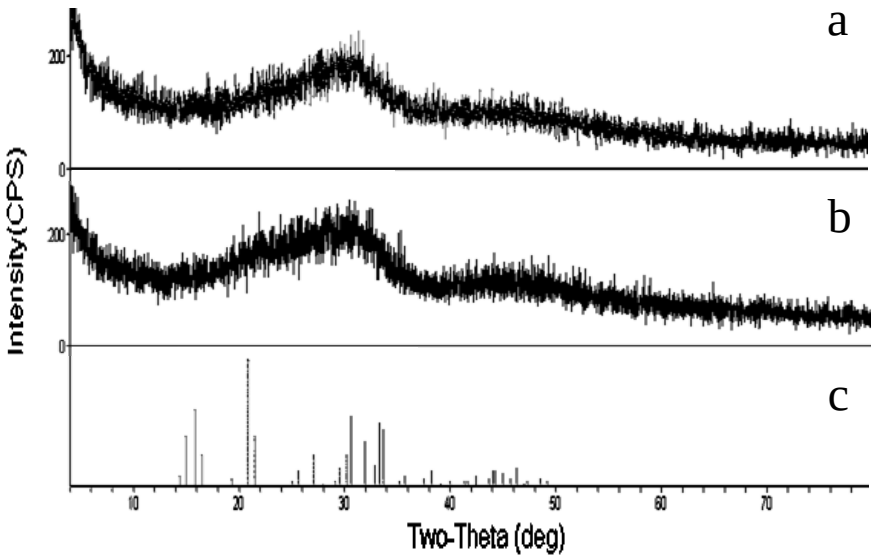
4. Recovery of phosphorus

	Farm Yard Slurry	Digestates of MSW
P removal efficiency	94.0 ± 0.3%	95.8 ± 0.8%

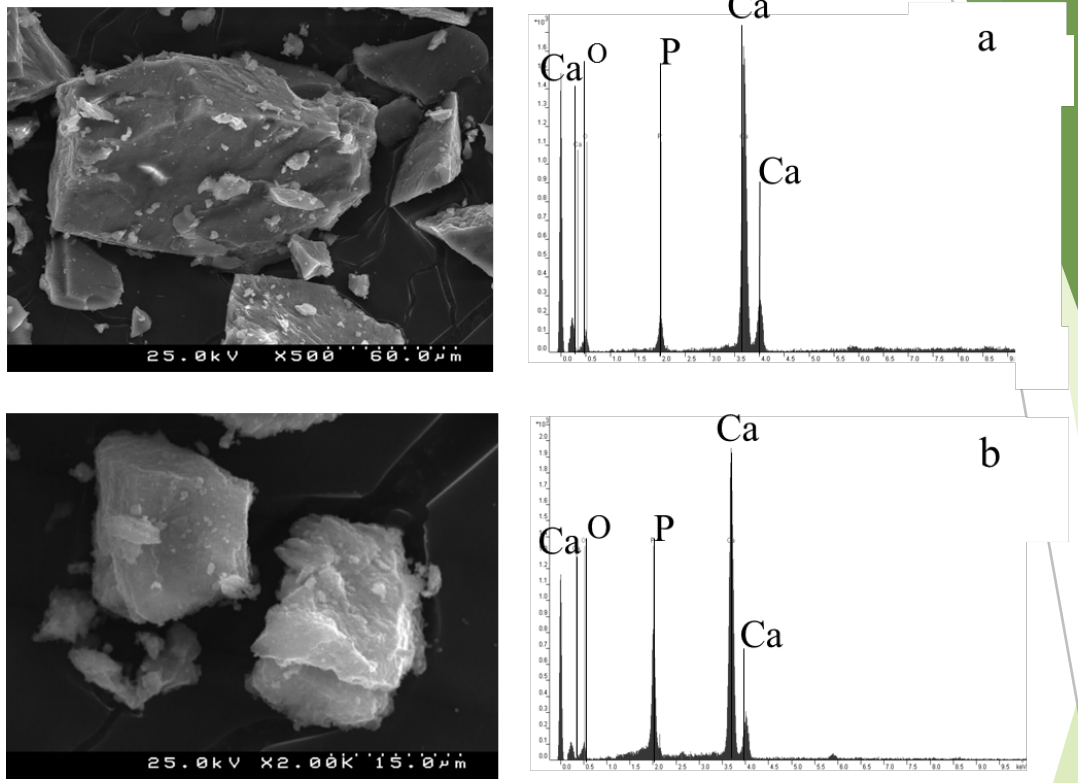


Harvested Precipitates in P precitation experiments for Farm Yard Slurry (a) and digestates of MSW (b).

Results



X-ray diffractograms of precipitates from farm yard slurry (a), MSW digestates (b) and the standard struvite (c)



SEM-EDS pictures for Farm Yard Slurry (a) and digestates of MSW (b)

Amorphous Calcium Phosphate

Fertilizer or Raw Material for fertilizer industry

Conclusions

i) Extraction of phosphorus with acid (HNO_3) was more efective than base (NaOH)

ii) The phosphorus removal in precipitation experiments was very high

iii) The harvested precipitates was amorphous calcium phosphate that can used as a fertilizer or raw material for the fertilizer industry

Summary

- Phosphorus Issue
- Characterization of Farm Yard Slurries and Digestates of MSW
- Phosphorus Extraction from Farm Yard Slurries and Digestates of MSW at different pH values
- Heavy Metals Extraction from both wastes
- Recovery of phosphorus as a precipitate

Thank You!