The Hong Kong Polytechnic University

Phosphorus Recovery from Incinerated Sewage Sludge Ash (ISSA) and Turn into Phosphate Fertilizer

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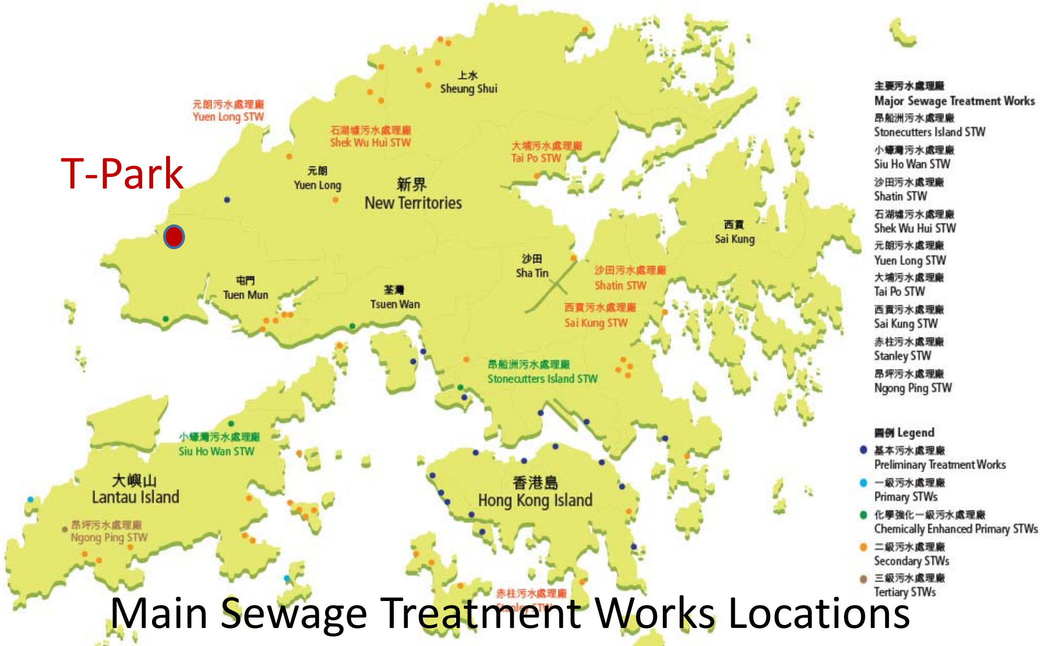
Contents

Contents

- Background and motivation
- Clarification of research key points
- Current results
- Conclusion

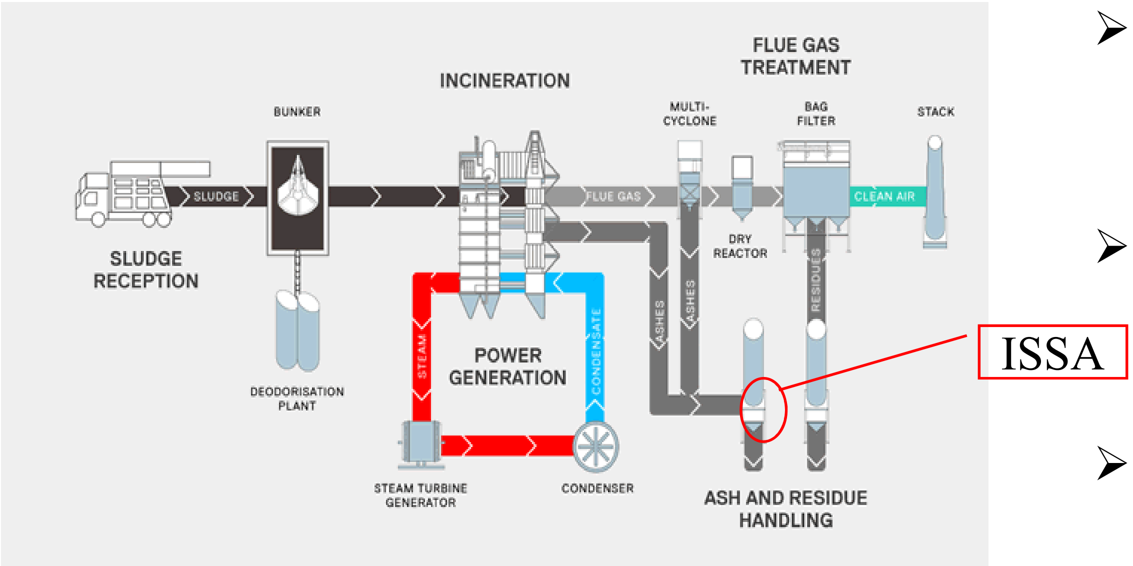
Incineration in Hong Kong - T-Park



Main Sewage Treatment Works Locations

- 1200 tons sewage sludge originated from 11 wastewater treatment plants in Hong Kong.
- Turn waste into energy. Thermal energy in incineration process was collected and transferred into electricity.
- Volume reduction by 90%. Decreased burden for landfill capacity.
- 2 s under 850 ˚C. Least formation of harmful organic pollutant.
- Incinerated sewage ash which was present disposal by landfill.

Incineration in Hong Kong - T-Park



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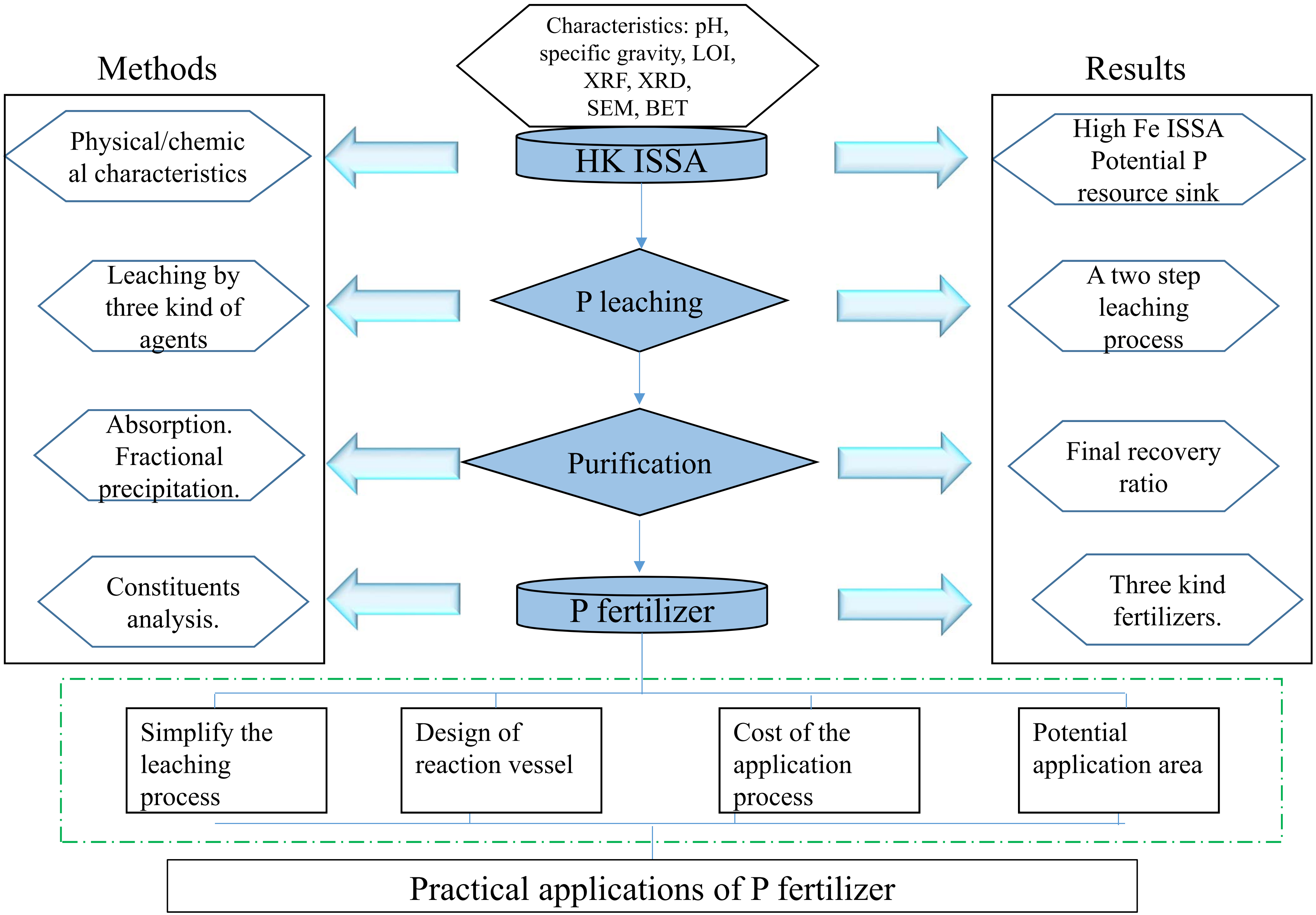
- Turn waste into energy. Thermal energy in incineration process was collected and transferred into electricity.
- Volume reduction by 90%. Decreased burden on landfill capacity.
- 2 s under 850 °C. Minimal formation of harmful organic pollutant.
- Incinerated sewage ash currently disposal of at landfill.

Contents

- Background and motivation
- Clarification of research key points
- Current results
- On-going and plan to do…

Research structure



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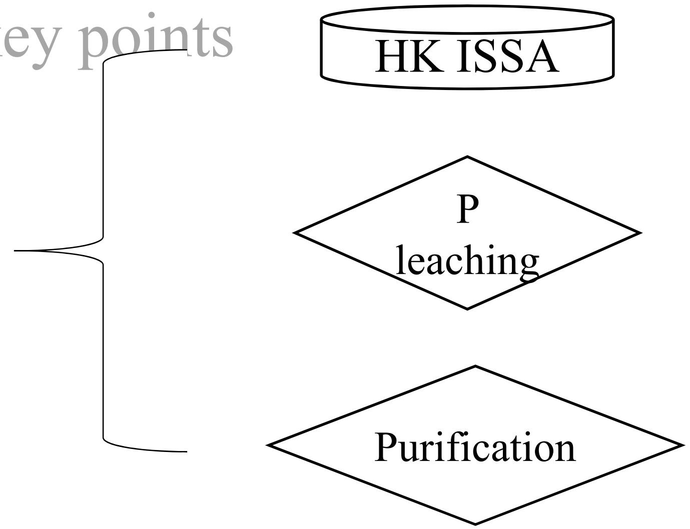
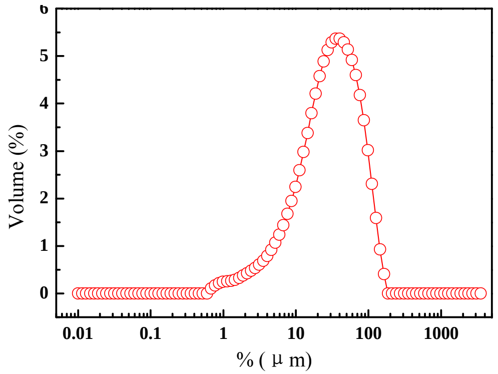
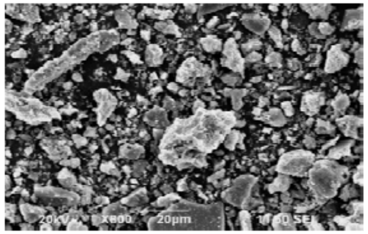
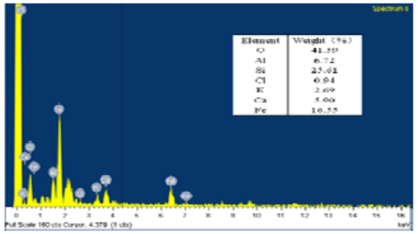
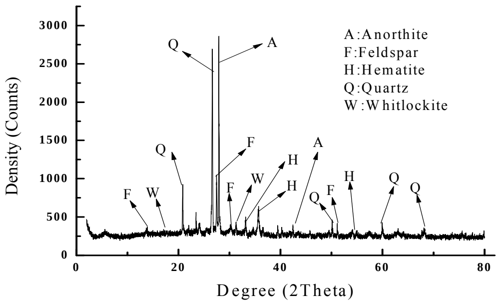


Characteristics of Hong Kong ISSA









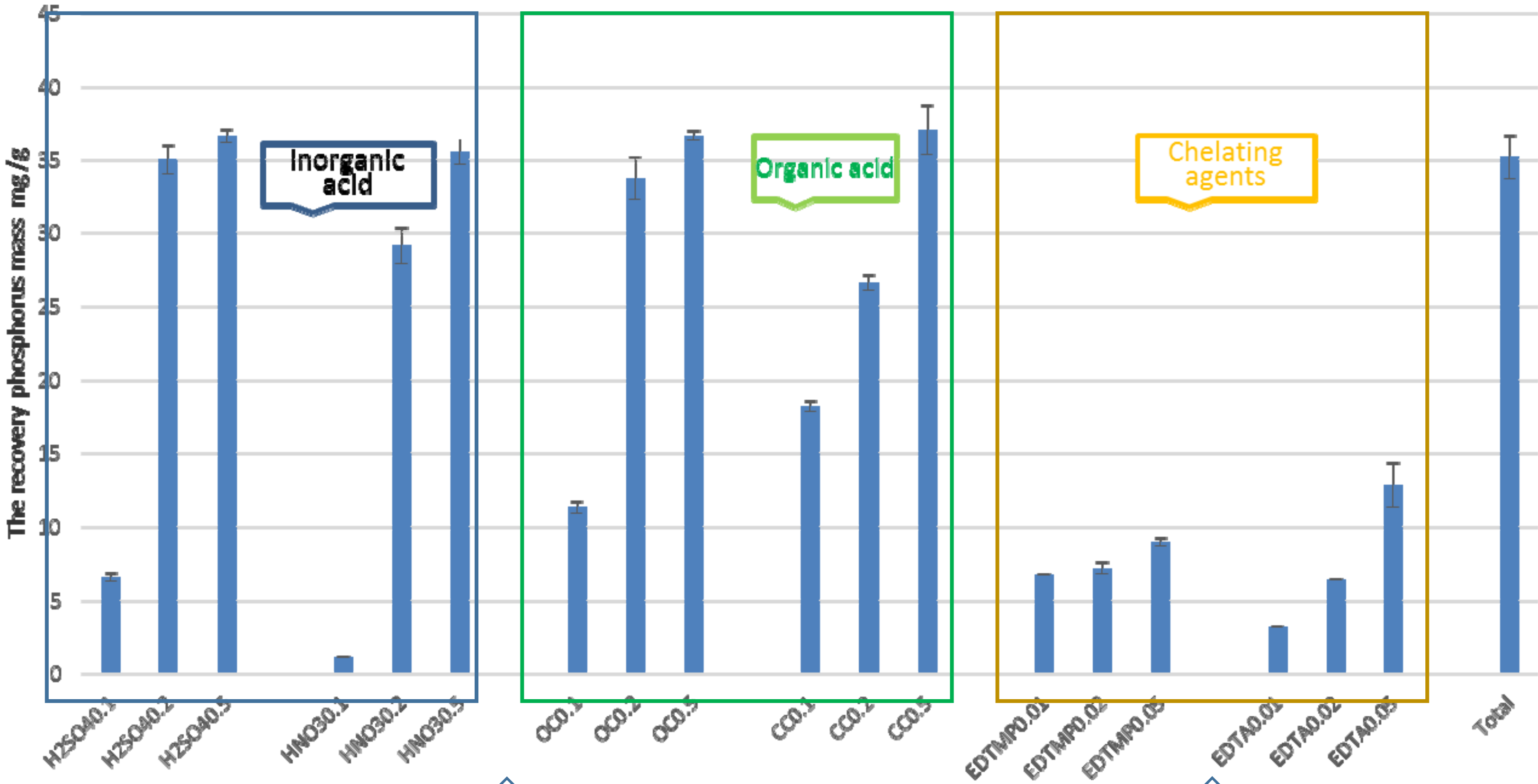
HK ISSA:

Suitable substitute for phosphorite deposit.

- Fine ash.
- Nearly no organic matter.
- High Fe ISSA.
- Contain significant P but co-exist with Fe, Al, Ca.

Items		Hong Kong ISSA	US ISSA(Donatello and Cheeseman 2013)
Physical properties	Specific gravity	2.49	2.14-2.9
	pH	8.45	7.6-8.8
	Mean particle size (μm)	56.0	51.2-108.8
	BET surface area (m^2/g)	3.42	6.4-23.8
	Loss on ignition (%)	0.99	0.9-2.1
Chemical composition (%)	Na_2O	2.21	0.01-6.8
	MgO	1.54	0.02-23.4
	Al_2O_3	11.56	4.4-34.2
	SiO_2	33.35	14.4-65.0
	P_2O_5	9.16	0.3-26.7
	Cl	0.28	—
	SO_3	4.04	0.01-12.4
	K_2O	3.50	0.1-3.1
	CaO	9.54	1.1-40.1
	TiO_2	0.55	0.3-1.9
	Cr_2O_3	0.09	—
	MnO	0.12	—
	Fe_2O_3	22.60	2.1-30
	CuO	0.18	—
	ZnO	0.69	—

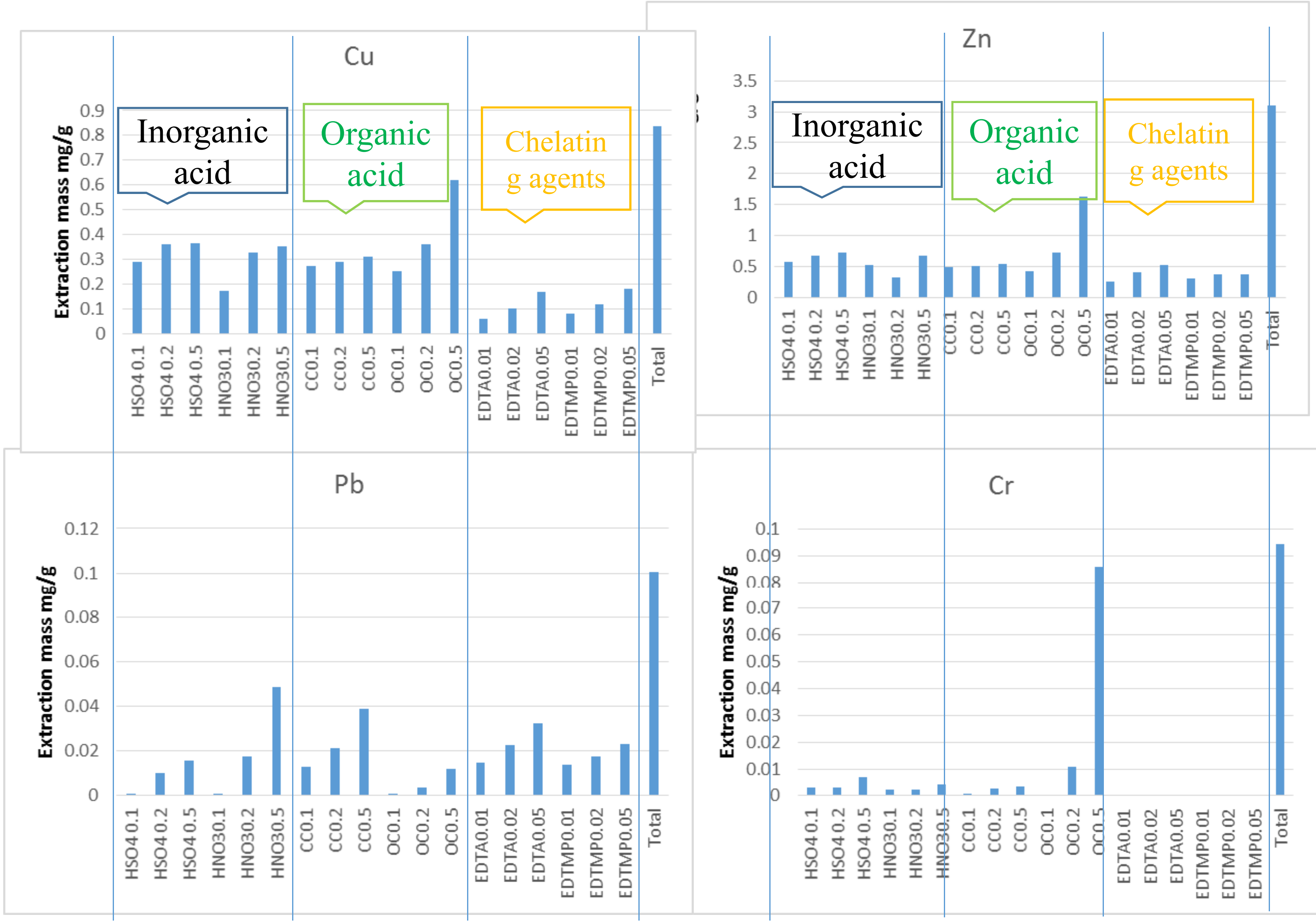
P leaching by three kind of extraction agents



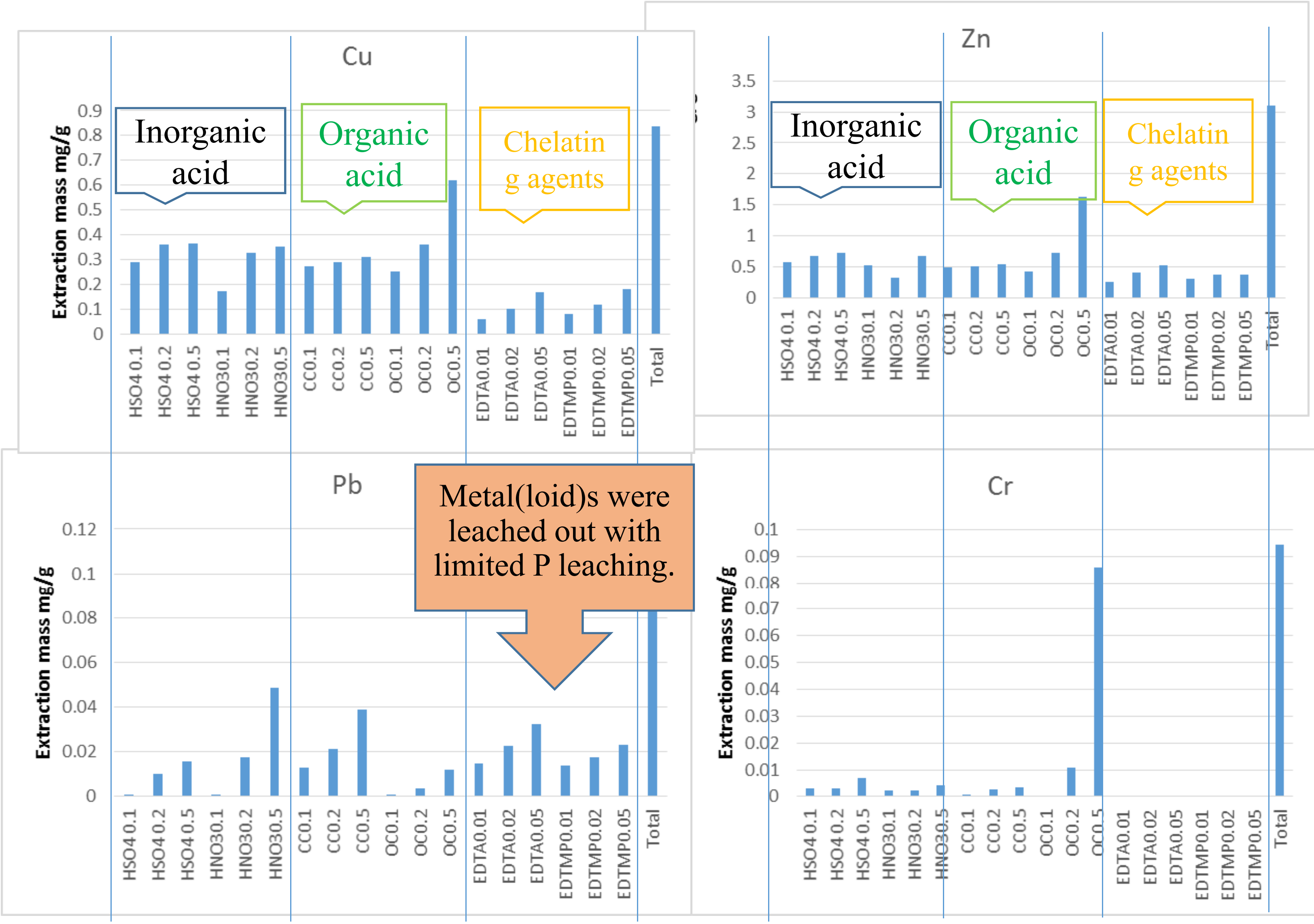
Significant P was leached out by acids.

Limited P leaching.

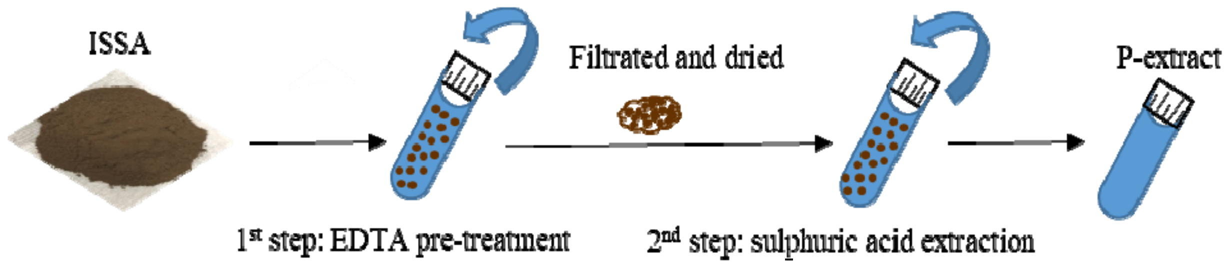
Co-leaching of metal(loid)s



Co-leaching of metal(loid)s



Two-step P extraction



- EDTA ⟶ Pretreatment

➢ Metal(loid)s were leached out with limited P leaching.

➢ Optimized pretreatment conditions: 3 hour reaction at a pH of 1.3, at a liquid-to-solid ratio of 20:1 and concentration of 0.02 mol/L.

- Sulphuric acid ⟶ P extraction

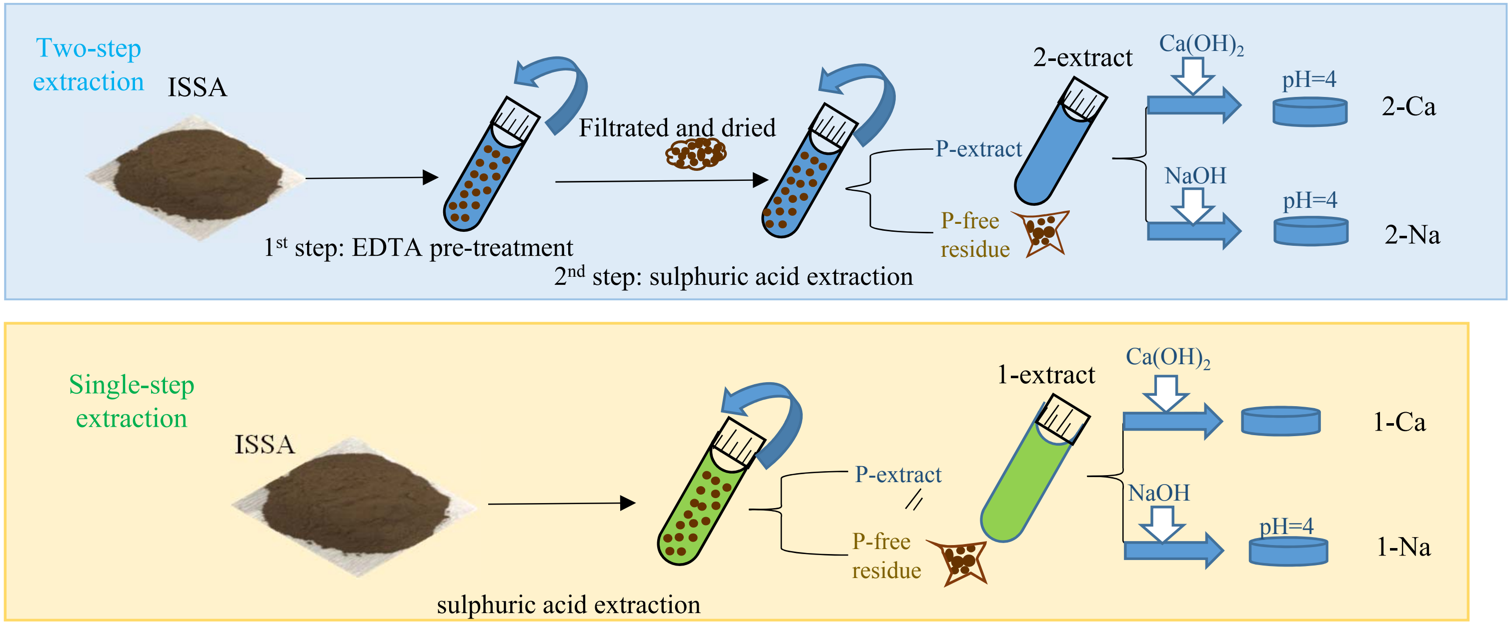
➢ High efficiency in P extraction with relatively low metal(loid)s co-dissolution.

➢ Optimized P extraction condition (94%)： 2 hour reaction with 0.2 mol/L at a liquid to solid ratio of 20:1.

Two-step leaching process with factional precipitation

1. Two-step leaching decreased concentration of metal(loid)s, such as Cr (by 92%), Zn (by 58%), Mn (by 50%), Mg (by 49%), Cu (by 49%), Al (by 37%), Fe (by 23%), etc.

2. Subsequent pH adjusting by $Ca(OH)_2$ would induce formation of Ca-P.



Purification of P-extract from two-step methods (to remove Al, Fe, Ca, Zn, etc.)

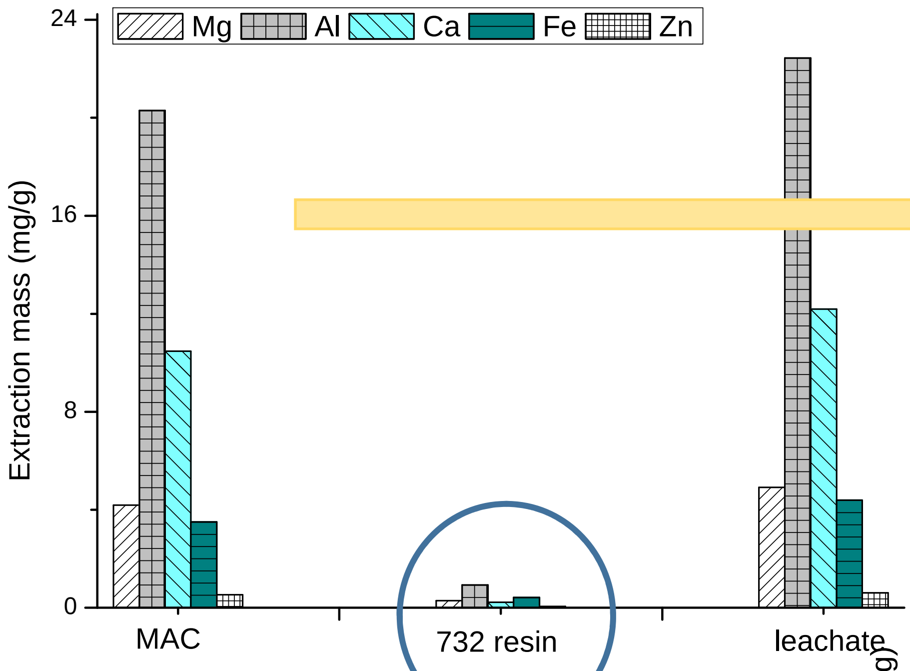
Activated carbon

Low absorption efficiency in acids.

732 cationic resin

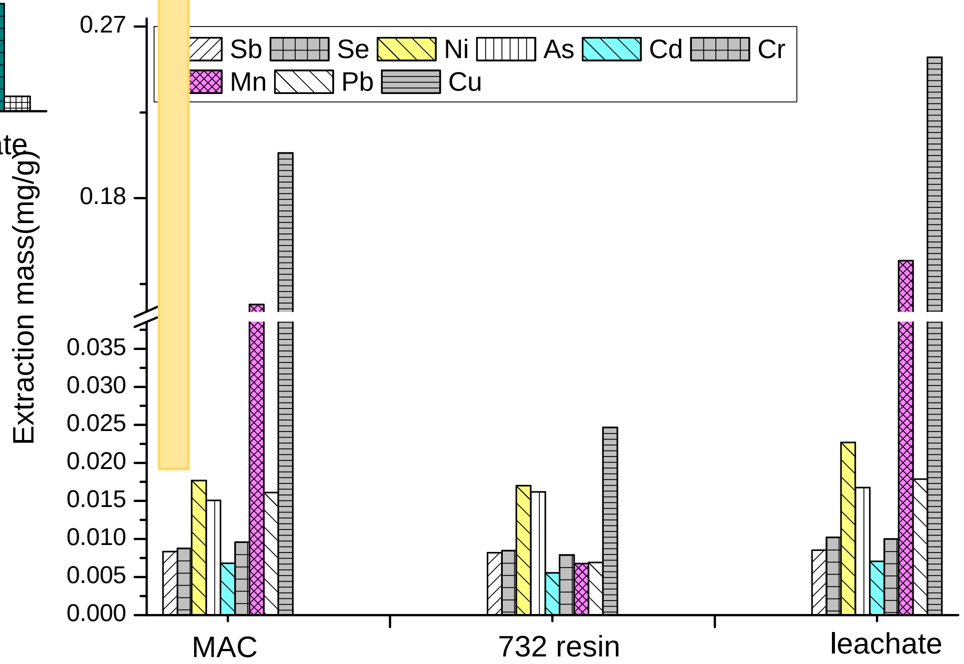
High absorption efficiency in acids.

Purification-absorption

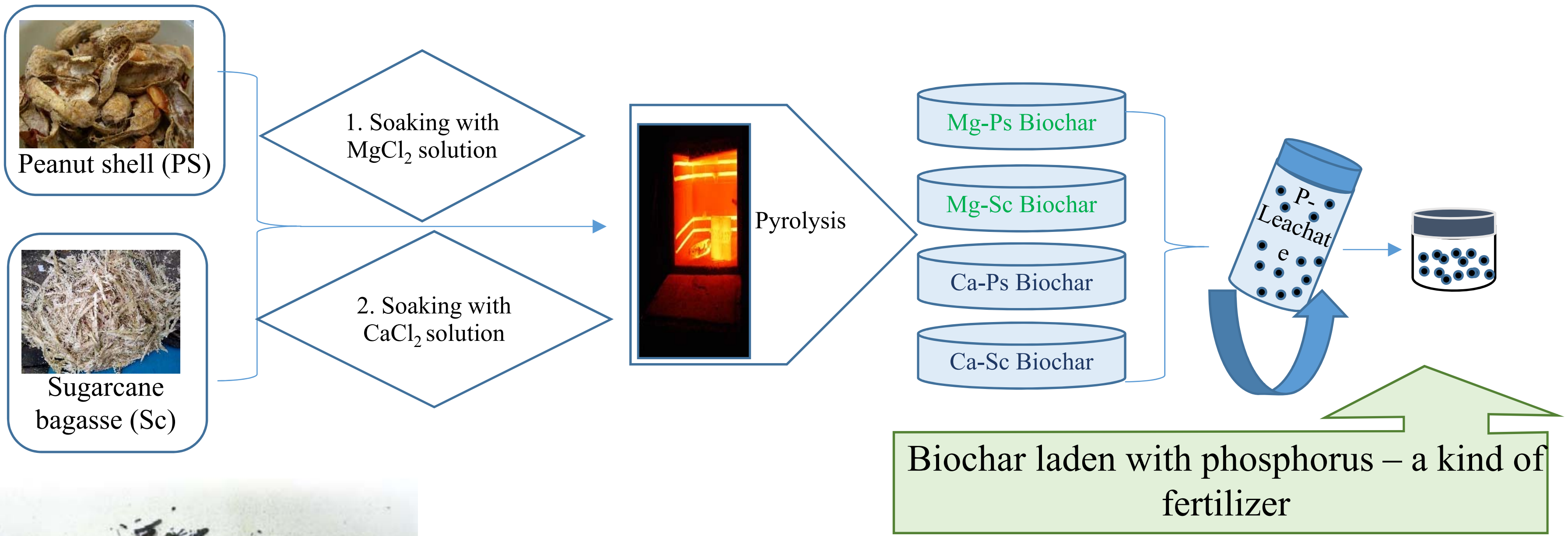


Obvious reduction of major metal(loid)s.

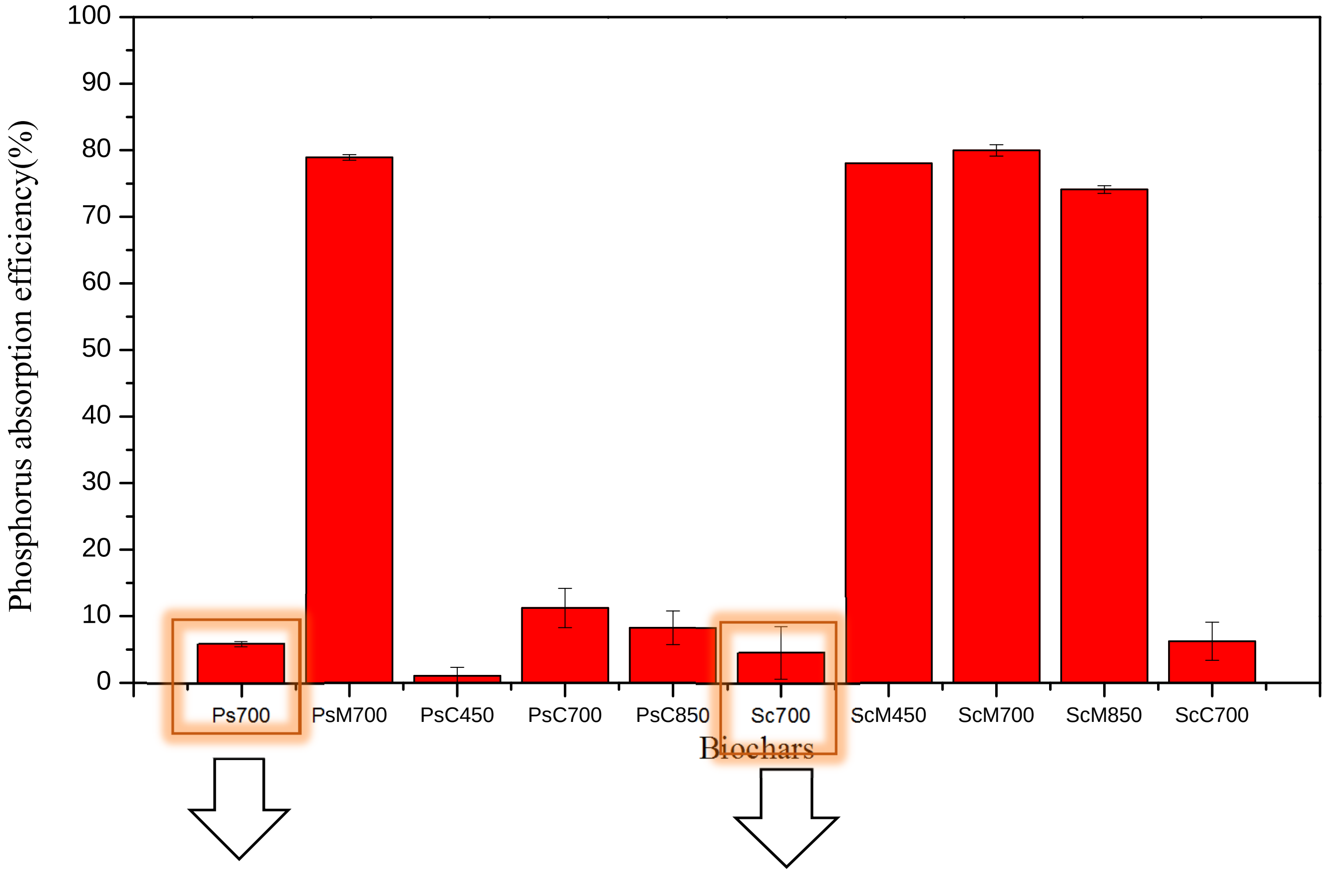
MAC can remove metal(loid)s marginally.



Modified biochar for phosphorus absorption

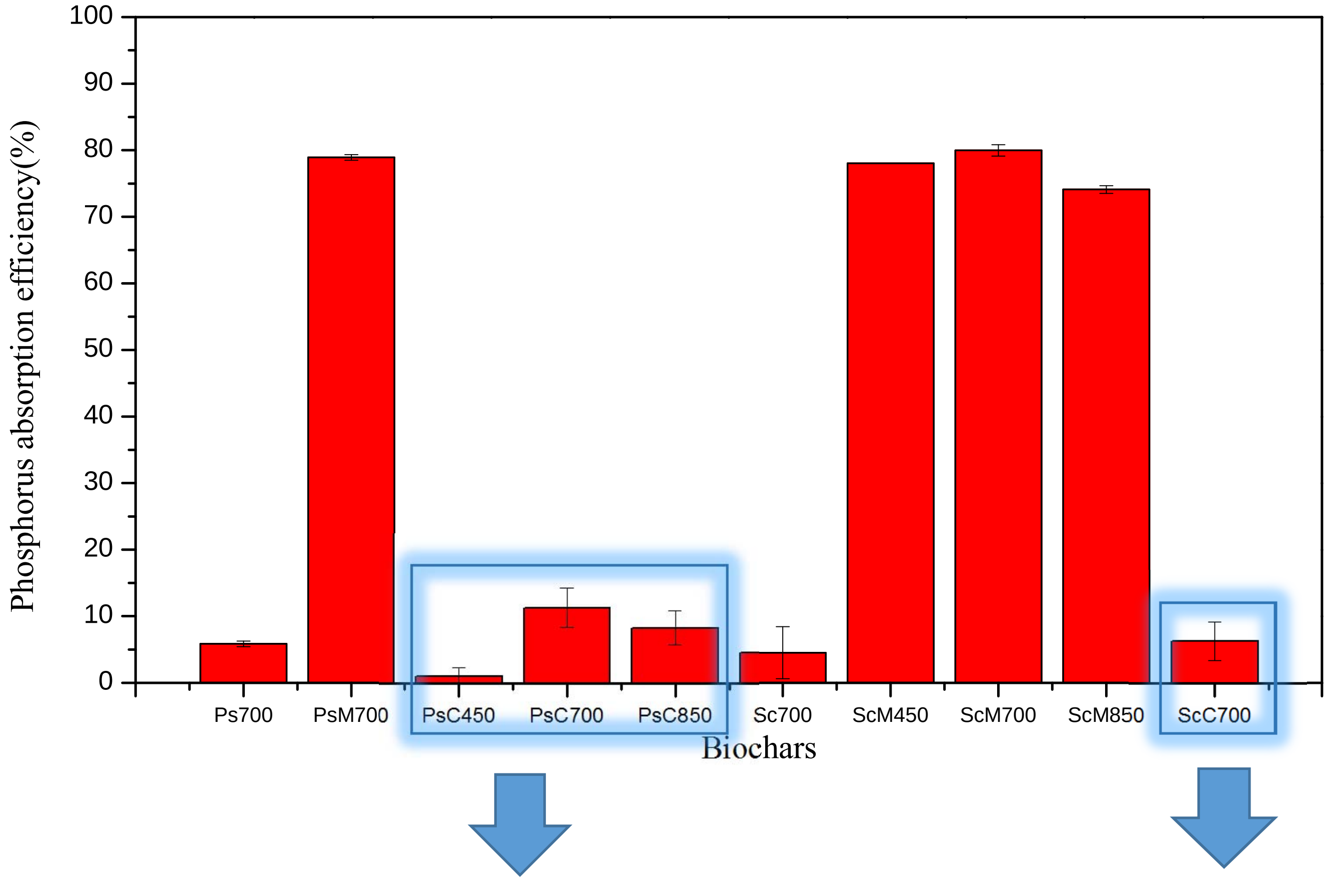


Optimal biochar for phosphorus absorption



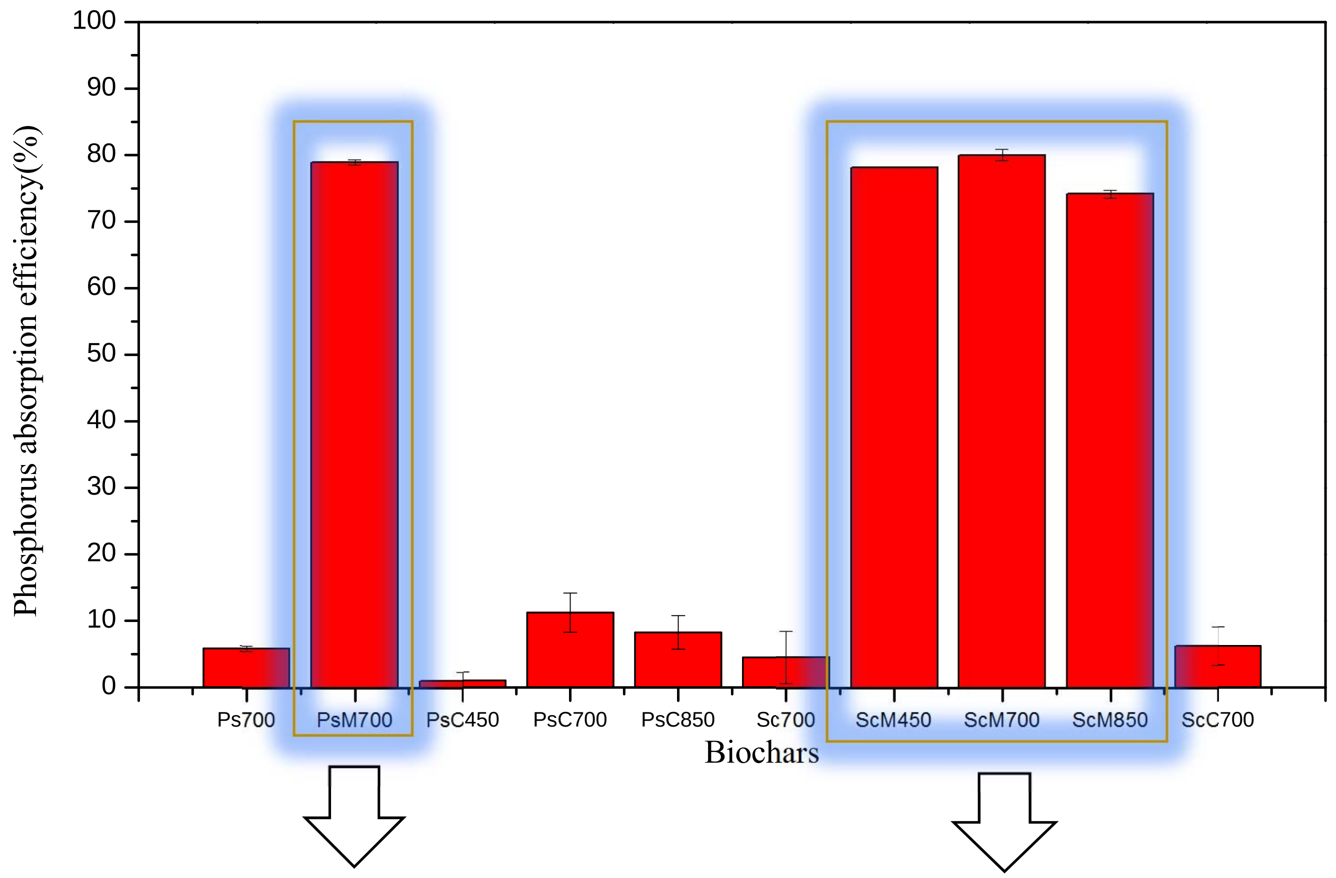
Pristine biochars have low phosphorus removal capacity.

Optimal biochar for phosphorus absorption



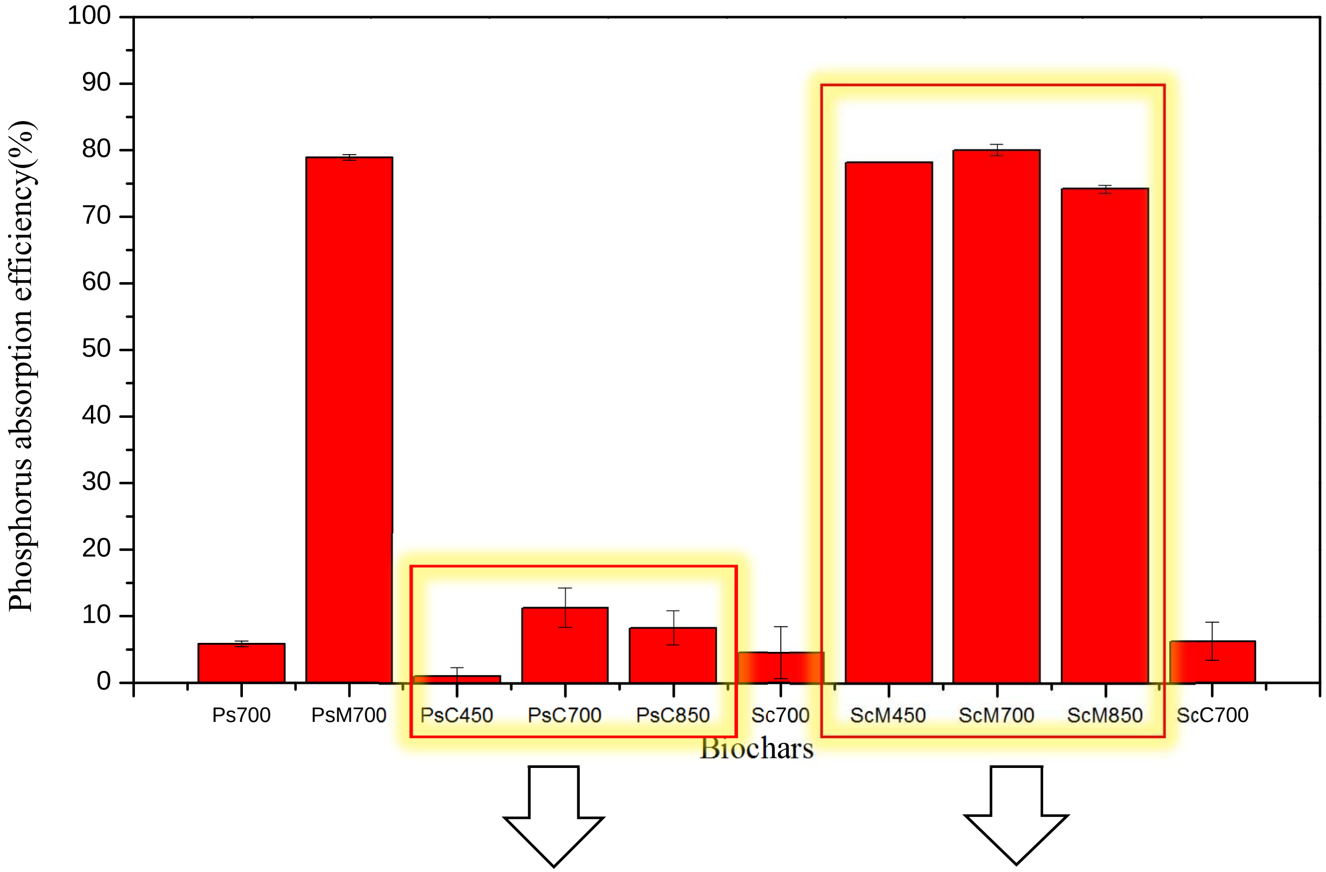
Pretreating of Ps & Sc with $CaCl_2$ cannot significantly improve phosphorus removal capacity.

Optimal biochar for phosphorus absorption



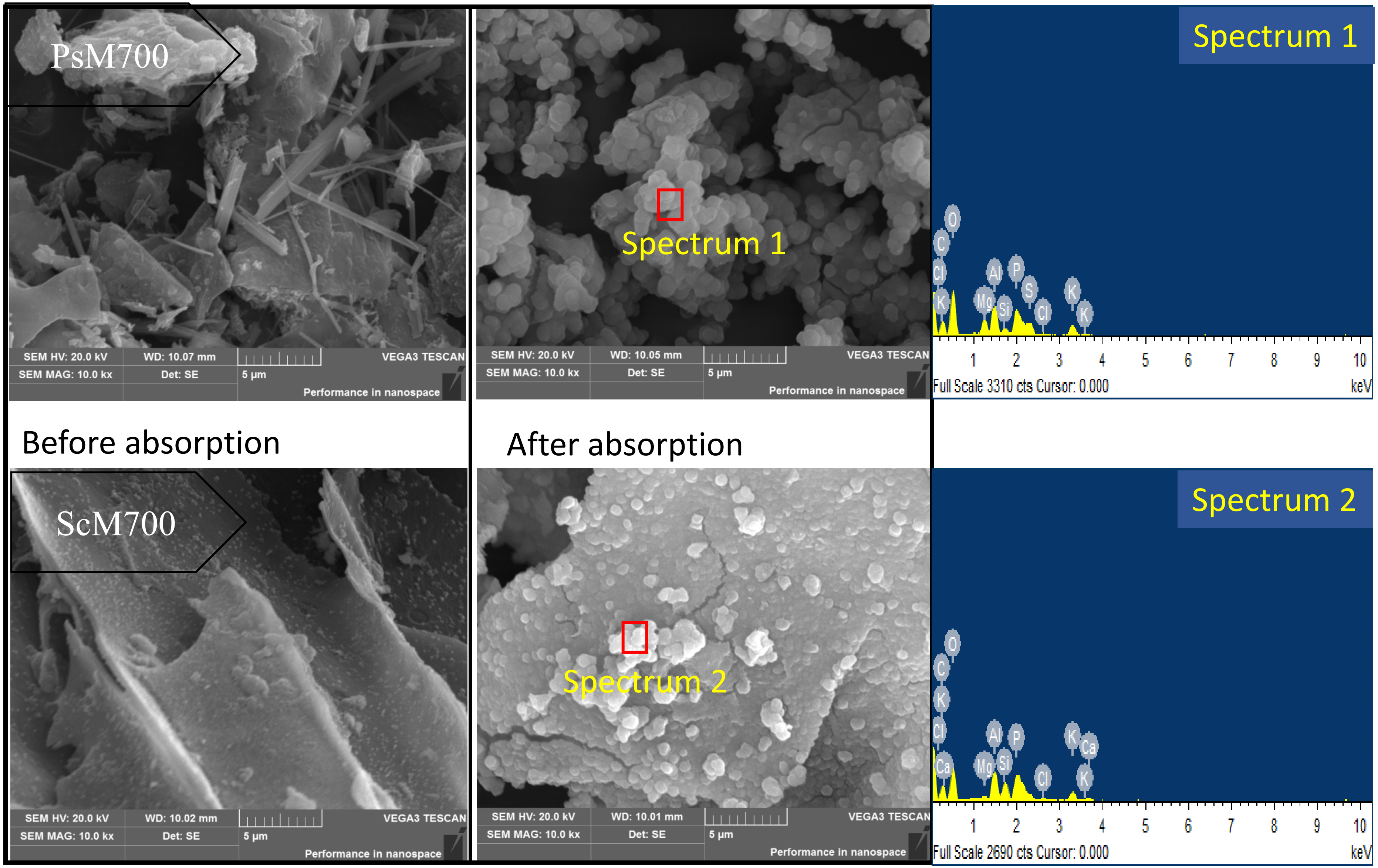
Pretreatment of Ps & Sc by $MgCl_2$ can produce biochars with high phosphorus removal capacity.

Optimal pyrolysis temperature on phosphorus absorption



Biomass pyrolysis at 700°C produced the highest P removal biochar.

Biochars laden with phosphorus



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Conclusions

- Two-step leaching method can not only decrease metal(loid)s in extraction but also increase phosphorus-purity for the subsequent purification step.

- Precipitation of leachate from the two-step method by $Ca(OH)_2$ pH adjustment induces formation of Ca-P.

- 732 cationic resin is efficient in removing macro-metalloids like Al, Mg, Zn, Fe and Cu. The purified leachate can be used for liquid phosphorus fertilizer.

- Both biomass of Ps and Sc have high phosphorus removal capacity after pretreatment by $MgCl_2$ and pyrolysis at 700^{o}C. And ScM700 has advantages of higher phosphorus adsorption capacity, less adsorbed metal(loid)s and lower working pH over PsM700.

Thank you!