## Why this small region is important?

"...it is the first element to be used up. Life can multiply until all the phosphorous is gone and then there is an inexorable halt which nothing can prevent."

-Isaac Asimov, Life's Bottleneck, 1959













### PHOSPHORUS RECOVERY FROM SEWAGE SLUDGE FOR SUSTAINABLE FERTILIZER PRODUCTION

Satya Brat Tiwari PhD student NTU Singapore



10<sup>th</sup> International Conference on Sustainable Solid Waste Management 21-24 June 2023, Chania, Greece

#### Contents



## Recovering P from sewage sludge char (SC)



## **RESEARCH GAP**



[2] Liu et al. 2021



### Acidic pretreatment, pyrolysis and alkaline extraction



# WHAT DID WE FIND?

#### P mass balance in baseline case



## P speciation during the process



- Apatite phosphate (AP) (mainly <u>Ca-P</u>)
- Non-apatite inorganic phosphate (NAIP) (mainly <u>Al-P</u>)
- Organic phosphate (OP)
- Inorganic phosphate (IP)  $\approx$  AP+NAIP

Environmental

implications

discussion

10

### Molecular configuration of P



#### Effect of char carbon on phosphorus extraction



Pyrolysis temperature



Introduction

Objective

Exper<u>imental</u>

Results and discussion

Environmental implications

Conclusion

>12

# HOW CAN THIS PROCESS HELP?

## The bigger picture



## Alkaline P recovery from Ca-rich SS possible

· Ca-P converted to Al-P during acidic pretreatment

### Pyrolysis temperature affects P transformation

· Recalcitrant P species formed at high temperatures

Carbonization affects P extraction

· P immobilized in carbon matrix at high temperatures

15

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# THANK YOU

Questions?!



- 1. Sun, D., Hale, L., Kar, G., Soolanayakanahally, R. and Adl, S., 2018. Phosphorus recovery and reuse by pyrolysis: Applications for agriculture and environment. *Chemosphere*, *194*, pp.682-691.
- 2. Liu, H., Hu, G., Basar, I.A., Li, J., Lyczko, N., Nzihou, A. and Eskicioglu, C., 2021. Phosphorus recovery from municipal sludge-derived ash and hydrochar through wet-chemical technology: A review towards sustainable waste management. *Chemical Engineering Journal*, *417*, p.129300.