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AGH UNIVERSITY OF KRAKOW

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The fate of heavy metals during hydrothermal carbonization of sewage sludge with acidic pH

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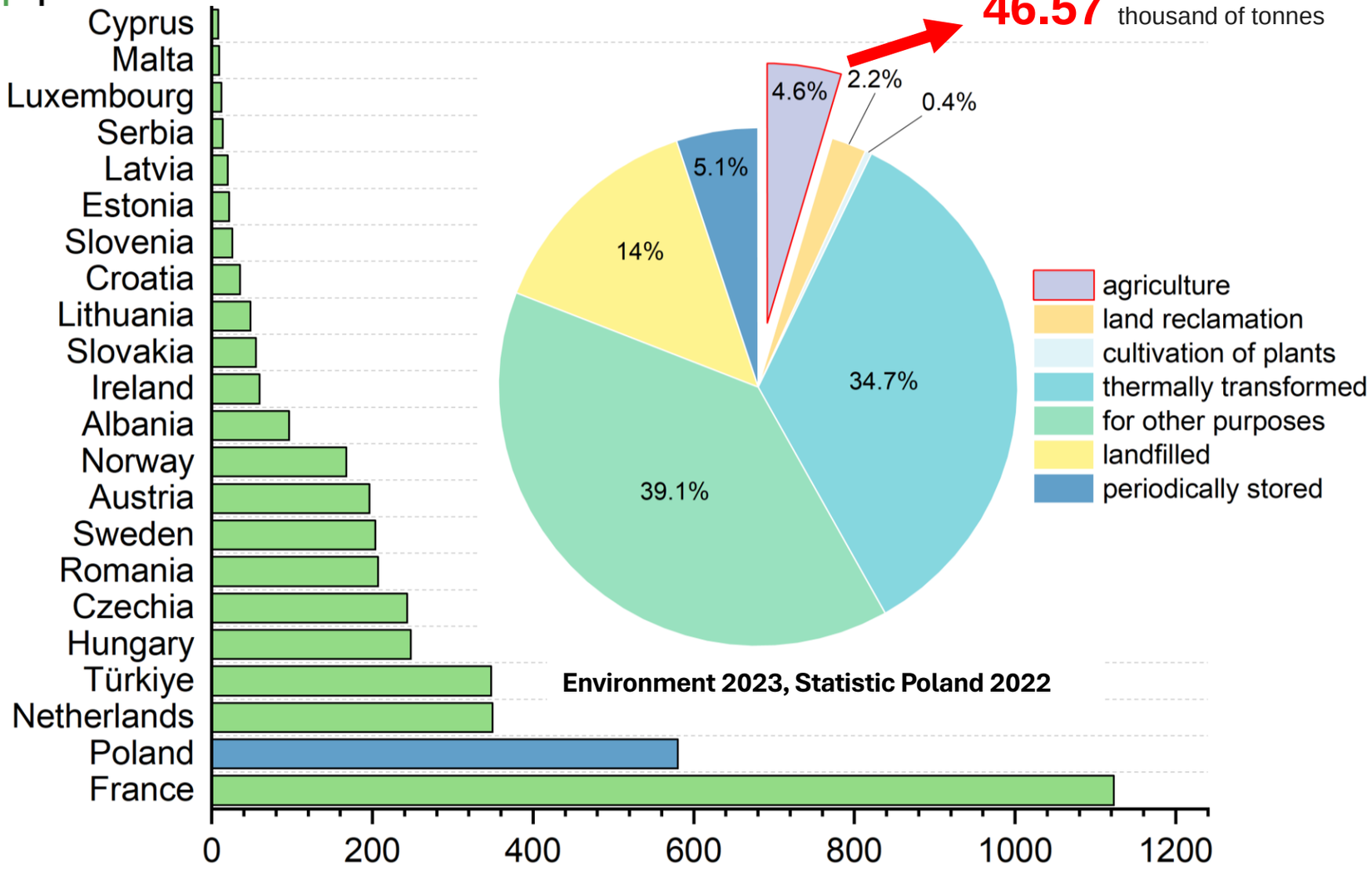
Presentation plan

- Introduction:
  - sewage sludge,
  - heavy metals,
  - hydrothermal carbonization.
- Experimental procedures.
- Main goal of the study.
- Results.
- Conclusions.

Sewage sludge



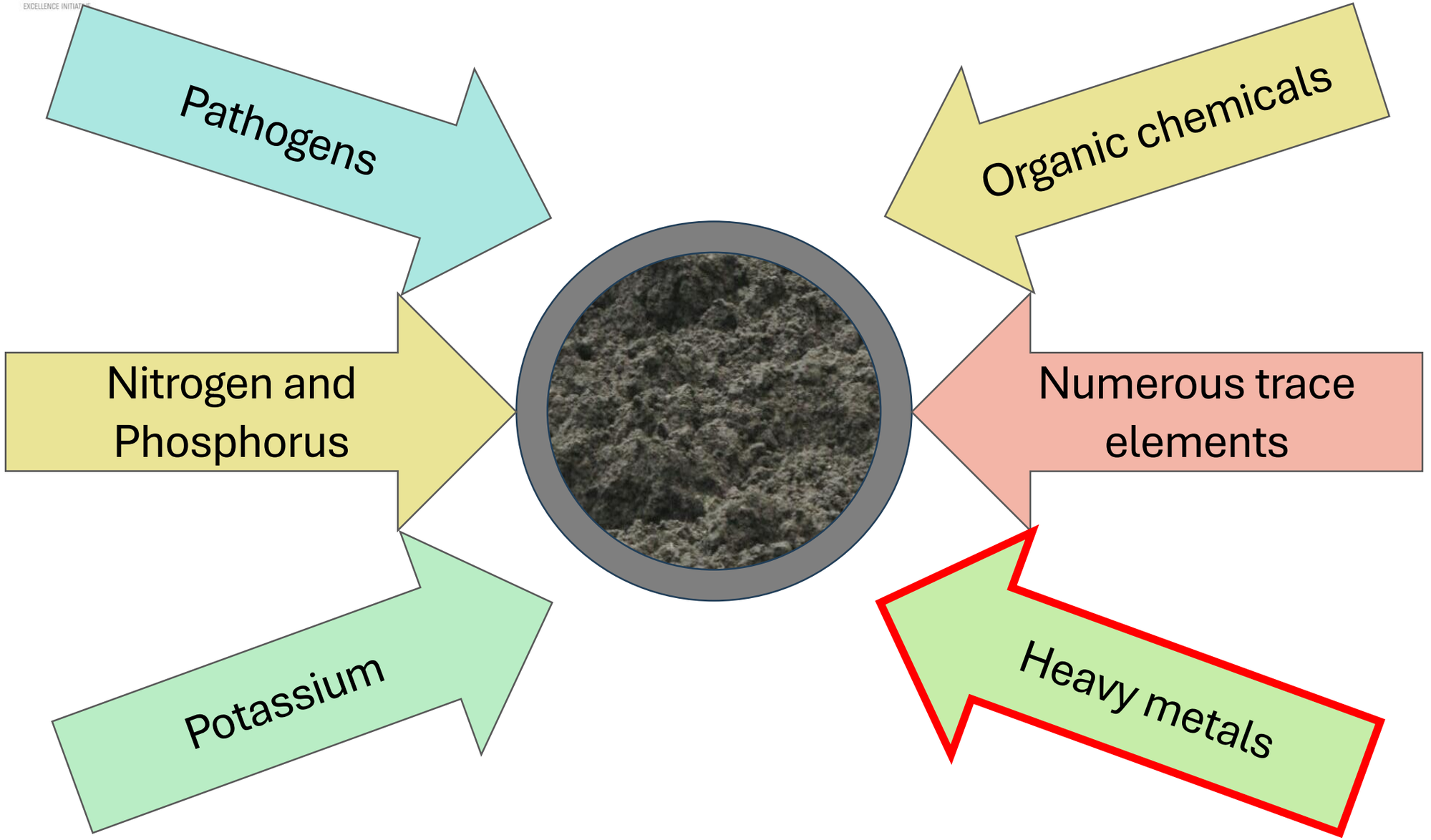
Environment 2023, Statistic Poland 2022

Sewage sludge production and disposal from urban wastewater (in thousand tonnes), Eurostat, 2022

***the date for other contries from UE are available.**

https://omaha.com/

Sewage sludge



Heavy metals in sewage sludge

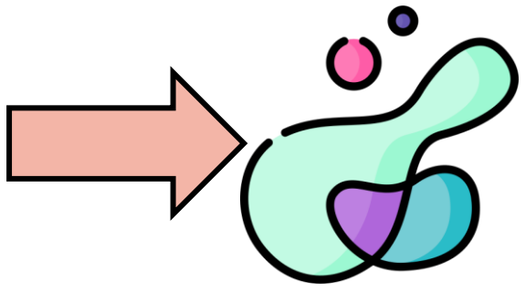
Cu, Co, Cr, Cd, Fe, Zn, Pb, Sn, Hg, Mn, Ni, Mo, V , W, As, Sb, Se

Permissible content of heavy metals in sewage sludge, mg/kg

	Soil reclamation applications	Agricultural uses
Hg	20	16
Cd	25	20
Cr	1000	500
Cu	1200	1000
Ni	400	300
Pb	1000	75
Zn	3500	2500

Journal of Laws of 2015 I, vol. 257.; Rozporządzenie ministra środowiska z dnia 6 lutego 2015 r. w sprawie komunalnych osadów ściekowych (in english: Regulation of the Minister of the Environment of 6 February 2015 on municipal sewage sludge)

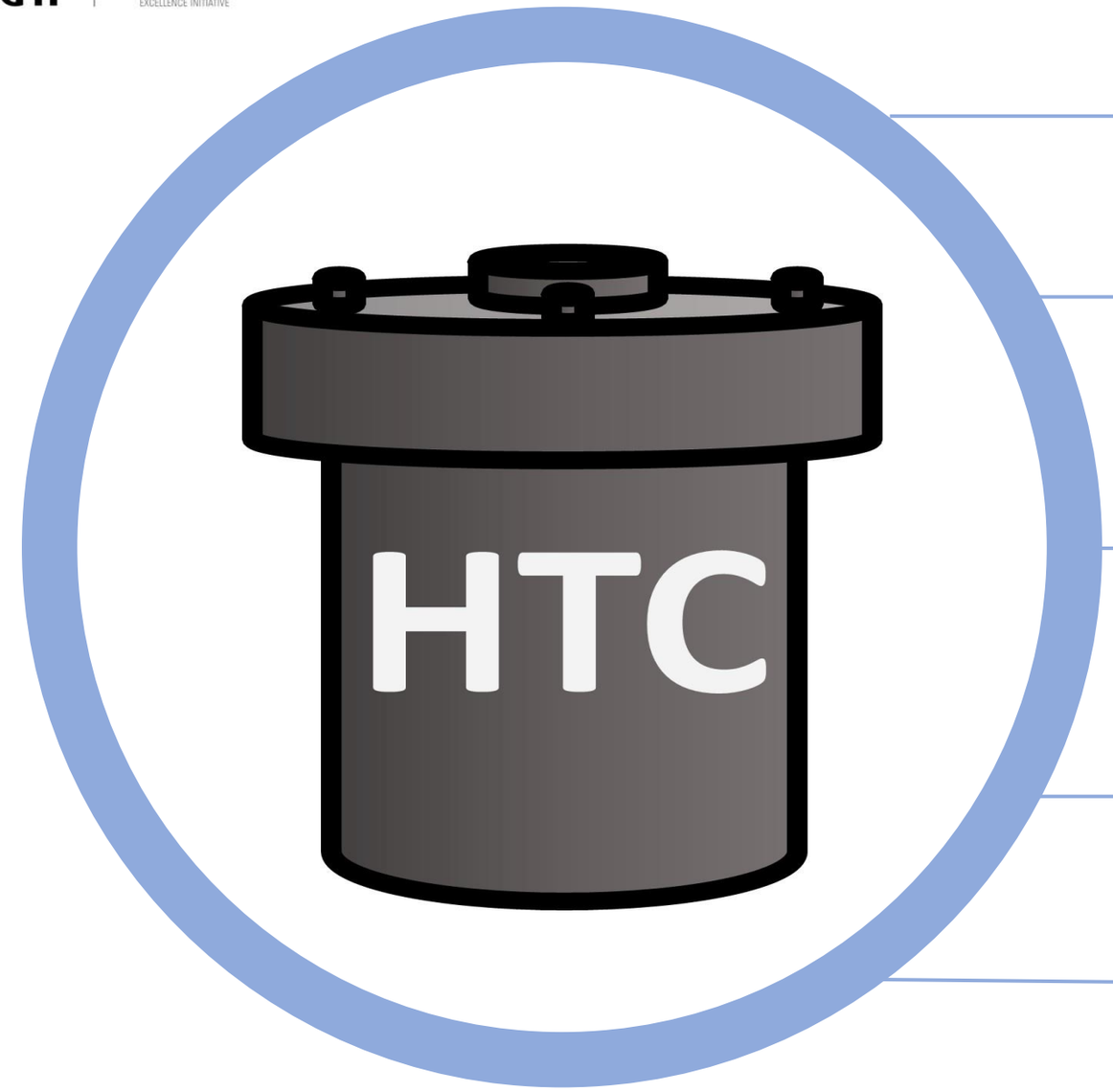
Conditions: precipitated, dissolved, absorbed or assimilated with biological residues, co-precipitated with metal oxides.



Forms: oxides, phosphates, hydroxides, sulphates, sulphides, silicates, compounds with complex sugars and organic compounds in the form of humus complexes.

Mobility fractions: exchangeable (F1), bound to carbonates (F2), bound to Fe–Mn oxides (F3), bound to organic matter (F4).

What is the HydroThermal Carbonization?



The process of converting wet sewage sludge into biofuel.

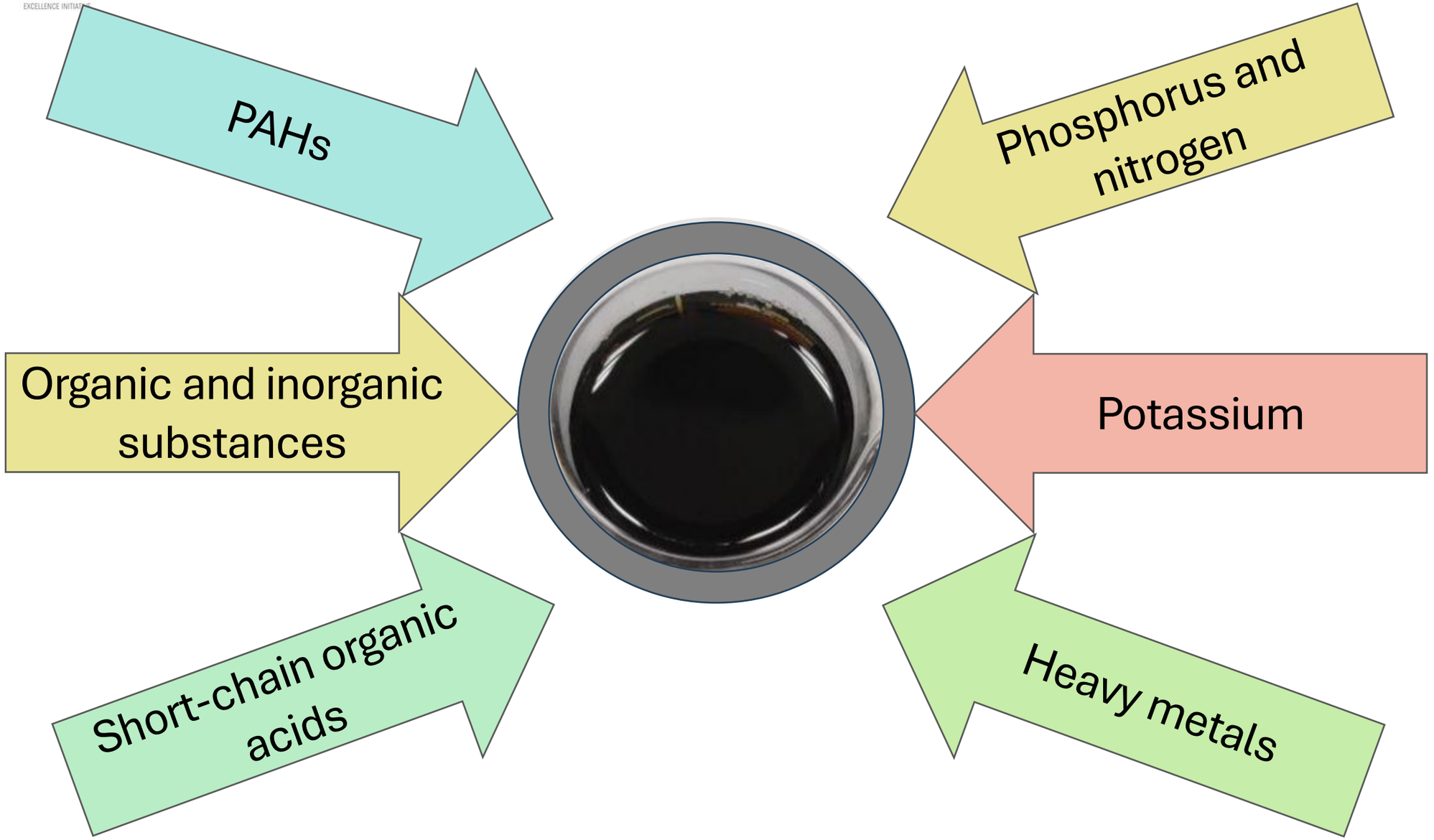
HTC is caried out in an aqueous environment.

Process parameters: temperature, time, heating rate, biomass to water ratio.

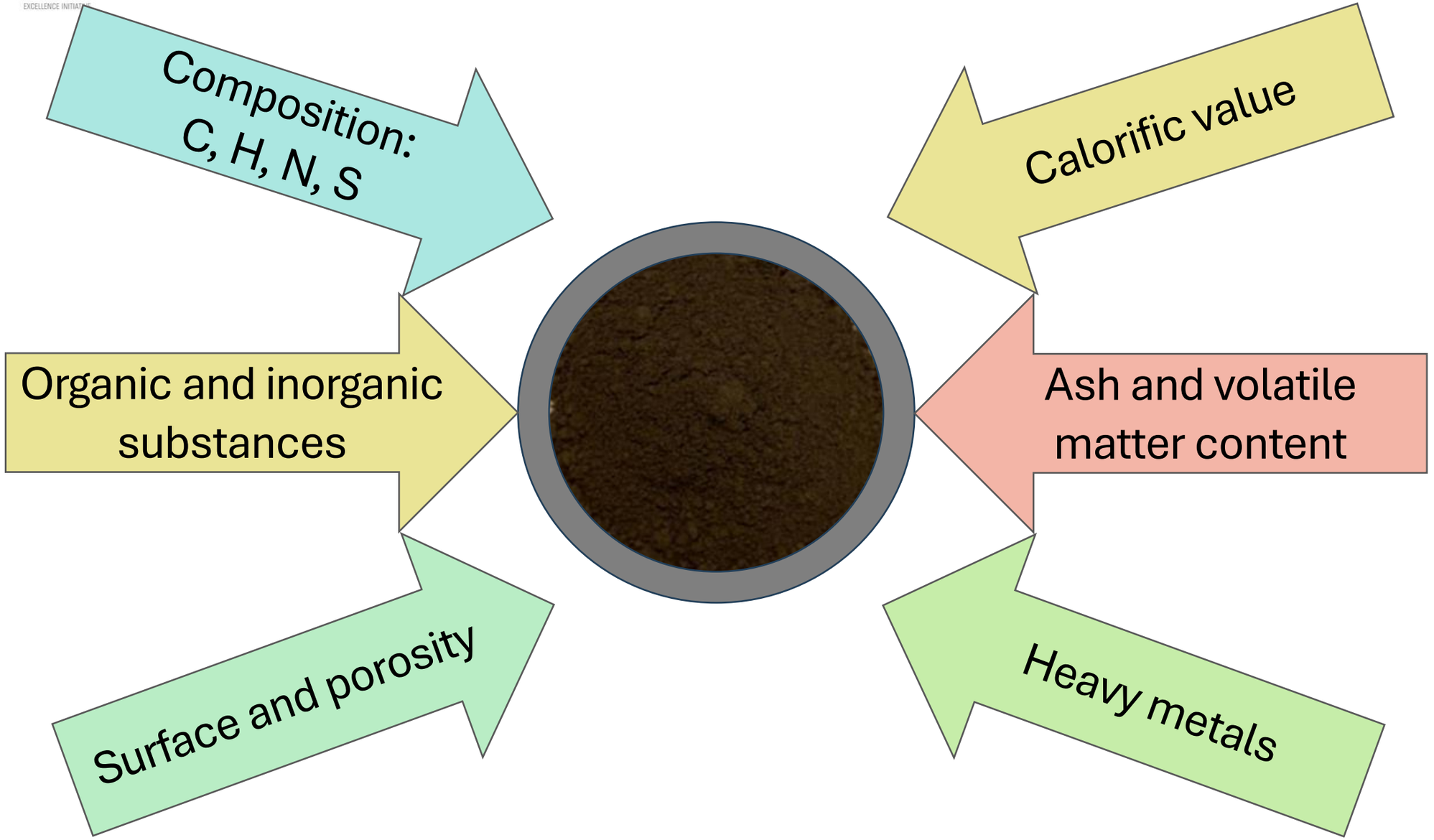
Research material: organic and inorganic material.

Reaction products:
→ **post-processing liquid**
→ **hydrochar**
→ **gas.**

Post-processing liquid



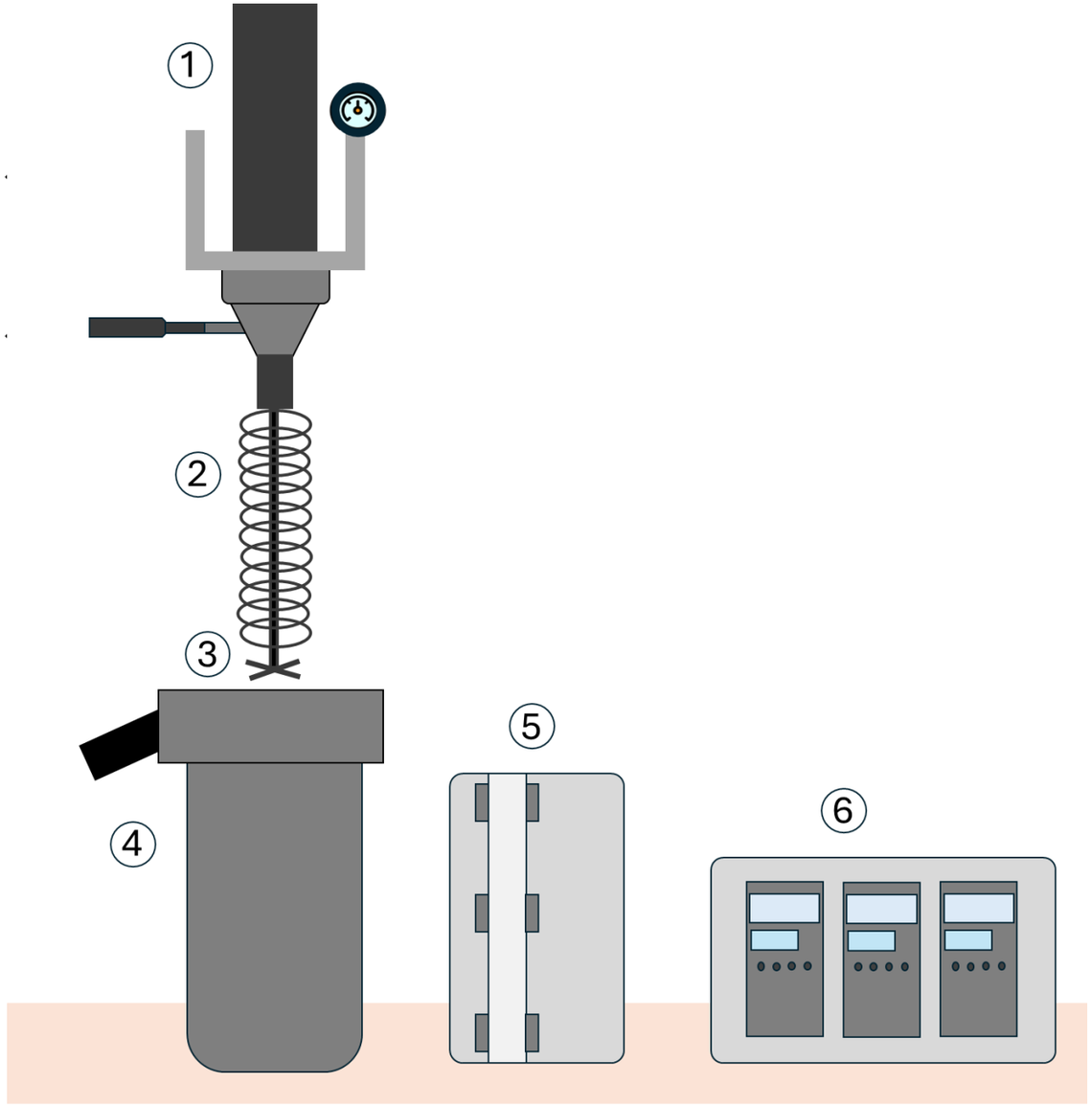
Hydrochar


Composition:
C, H, N, S
Calorific value
Organic and inorganic substances
Ash and volatile matter content
Surface and porosity
Heavy metals

The main aim of the study

1. Investigation the HTC of sewage sludge in a different acidic pH.
2. Chemical and physical analysis of hydrochar and post-processing liquid.
3. Investigation of the effects of pH on various aspects including heavy metal stability.

Parameters of the experiment



1 – MagneDrive;

2 – cooling coil;

3 – mixer;

4 – reactor;

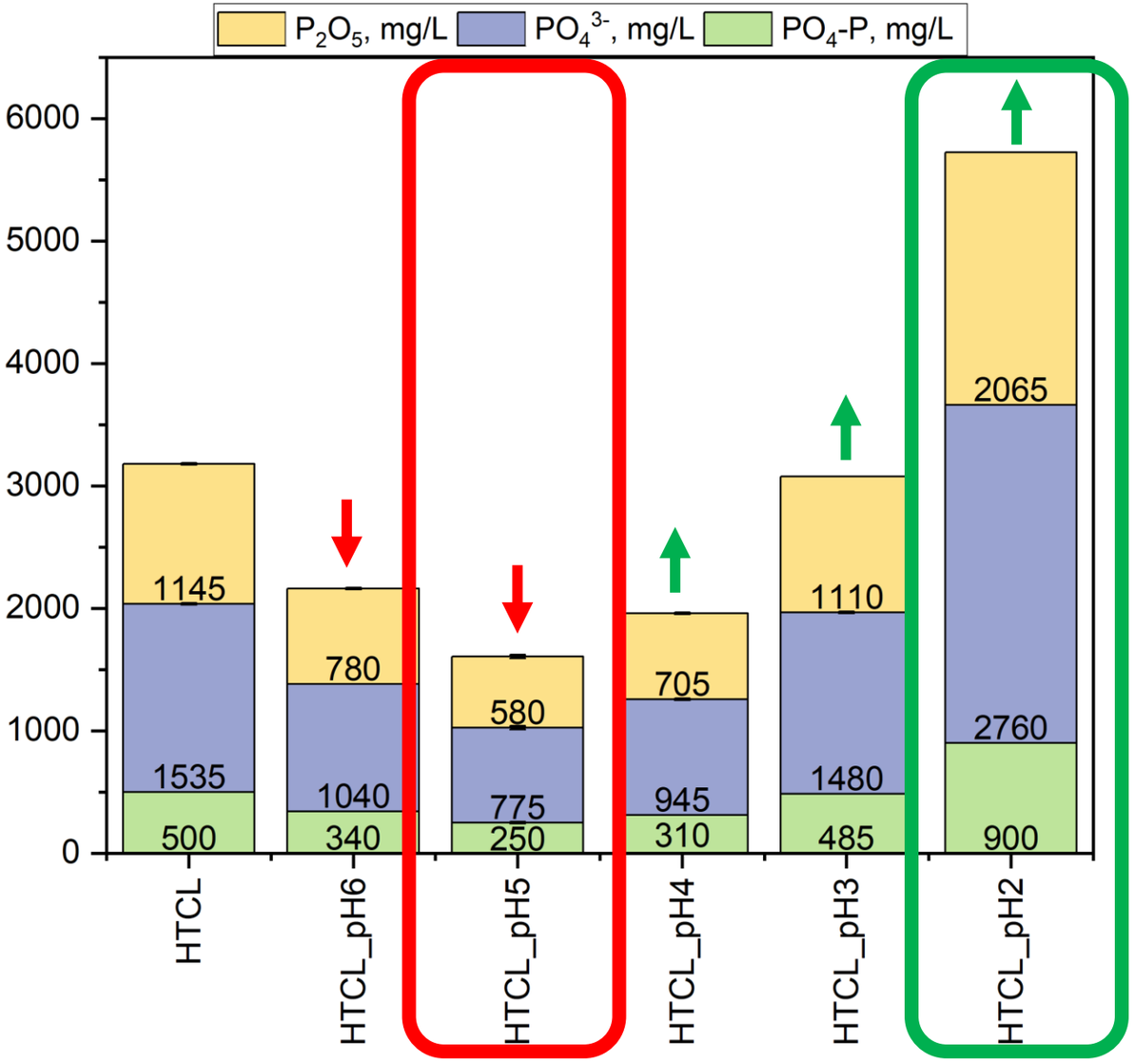
5 – heating jacket;

6 – control panel.

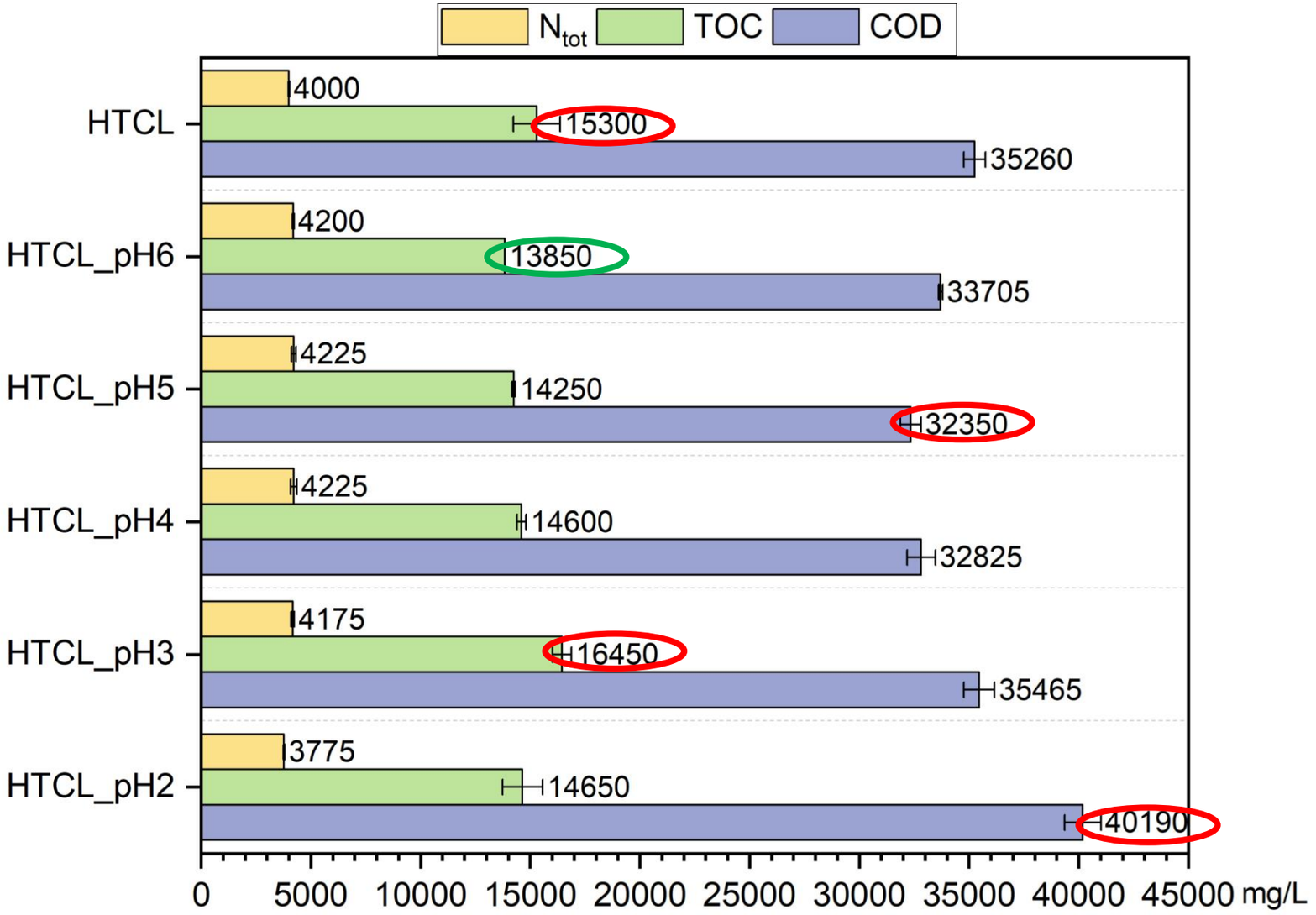
Parameters of the experiment

- Sewage sludge from the Central Wastewater Treatment Plant in Gliwice (Poland) after the anaerobic digestion process
- Reactor: Zipperclave Stirred Reactor, 1000 ml.
- Sewage sludge to water ratio to ensure free mixing.
- Residence time: 2 h.
- Temperature: 200 ^{o}C.
- pH=2, 3, 4, 5, and 6

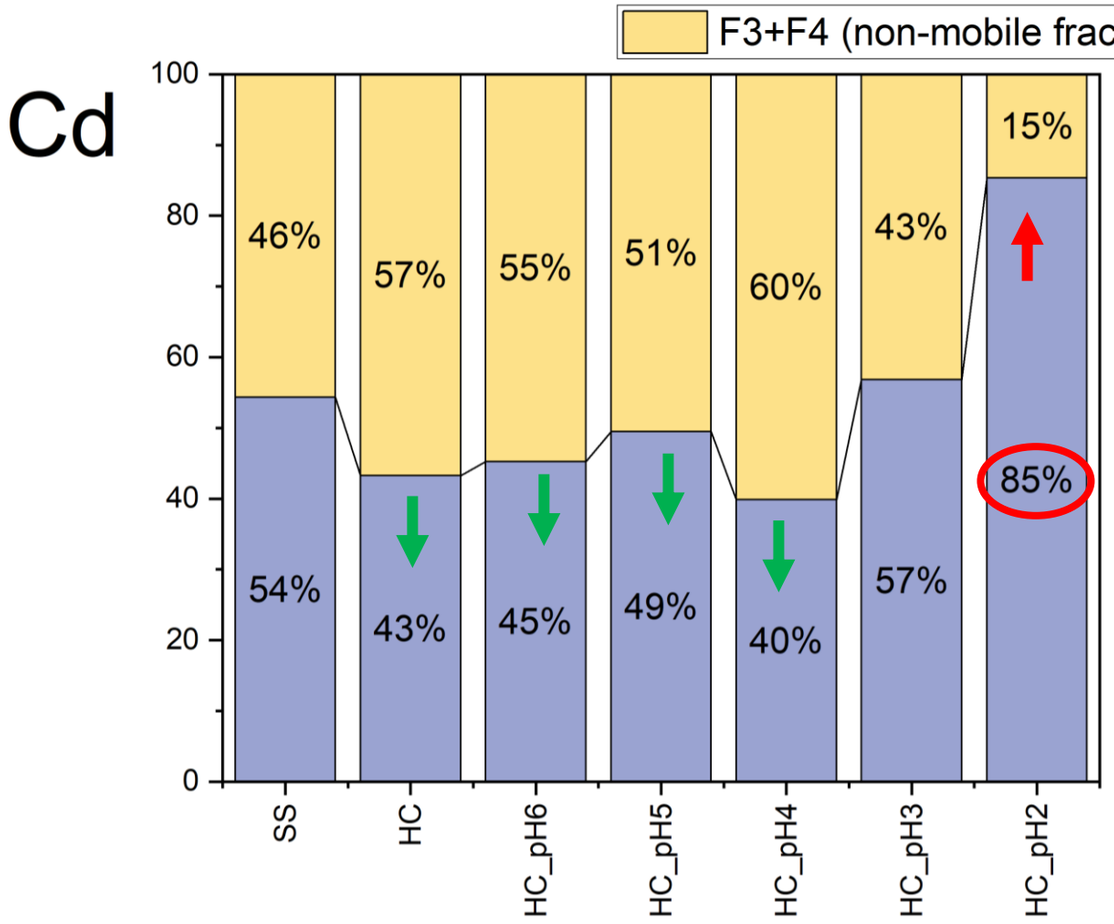
Post- procesing liquid: PO_4-P, PO_4^{3-}, P_2O_5



Post- procesing liquid: COD, TOC, N_{tot}

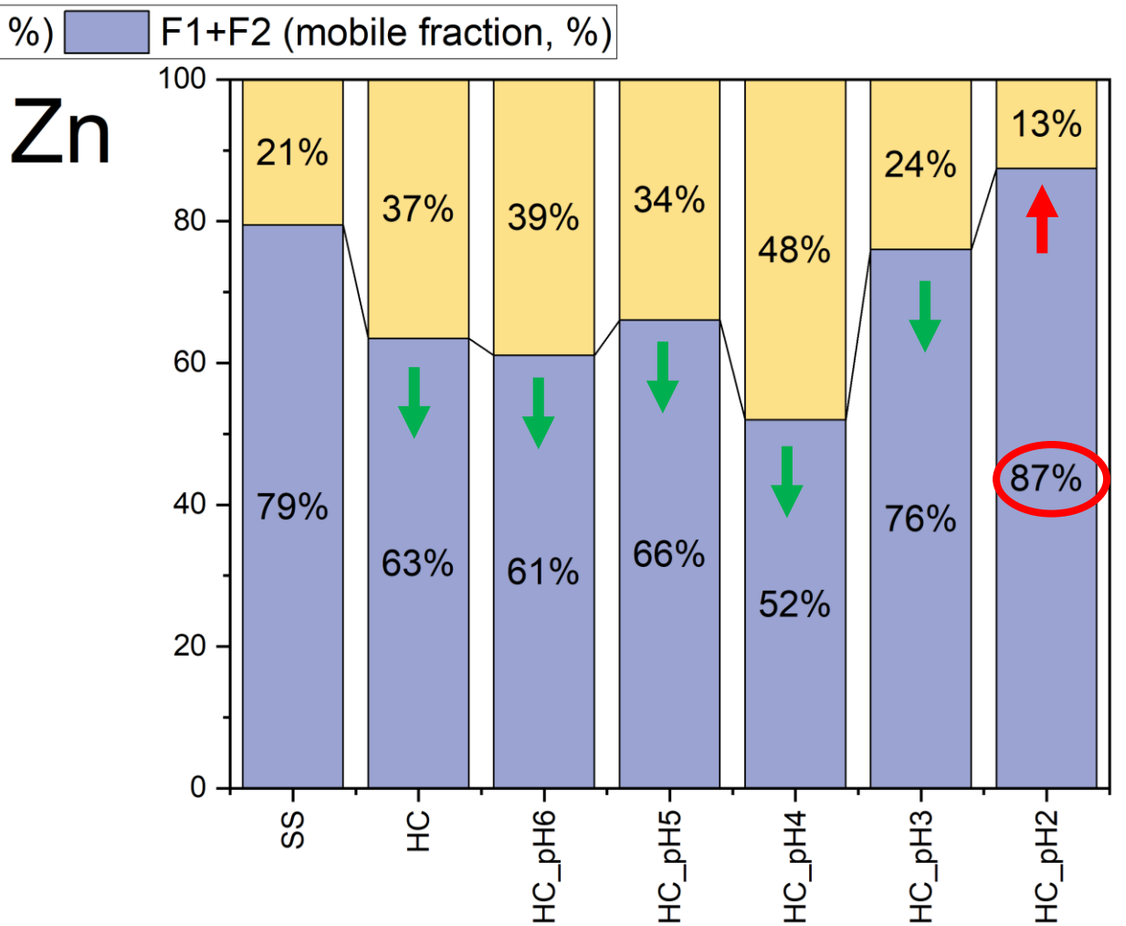


Heavy metals in hydrochar by Tessier and the Community Bureau of Reference (BCR)



ΣF1...F4	SS	HC	pH6	pH5	pH4	pH3	pH2
(mg/kg)	2.58	4.03	3.91	4.13	4.37	4.54	5.48

HIGHER

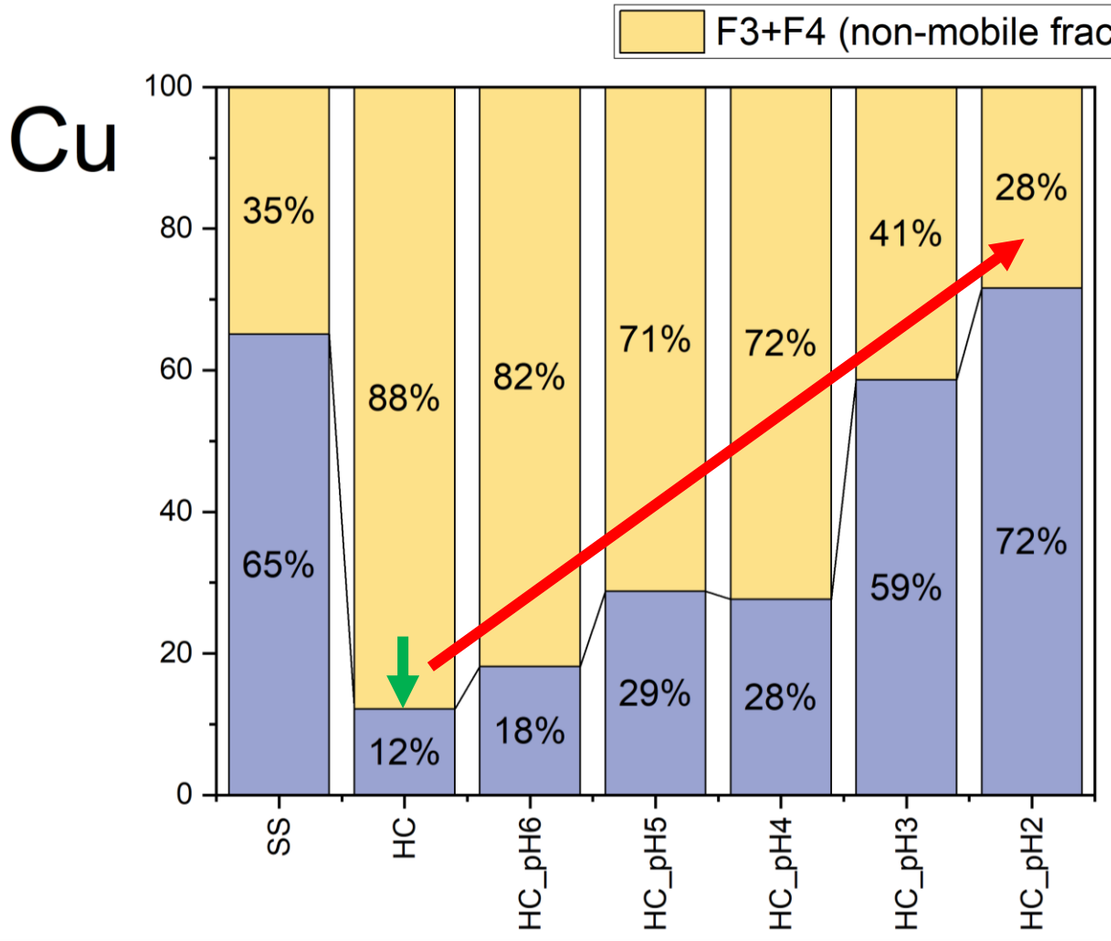


ΣF1...F4	SS	HC	pH6	pH5	pH4	pH3	pH2
(mg/kg)	1382.8	2241.7	2216.8	2204.7	2224.3	1927.7	1709.0

HIGHER

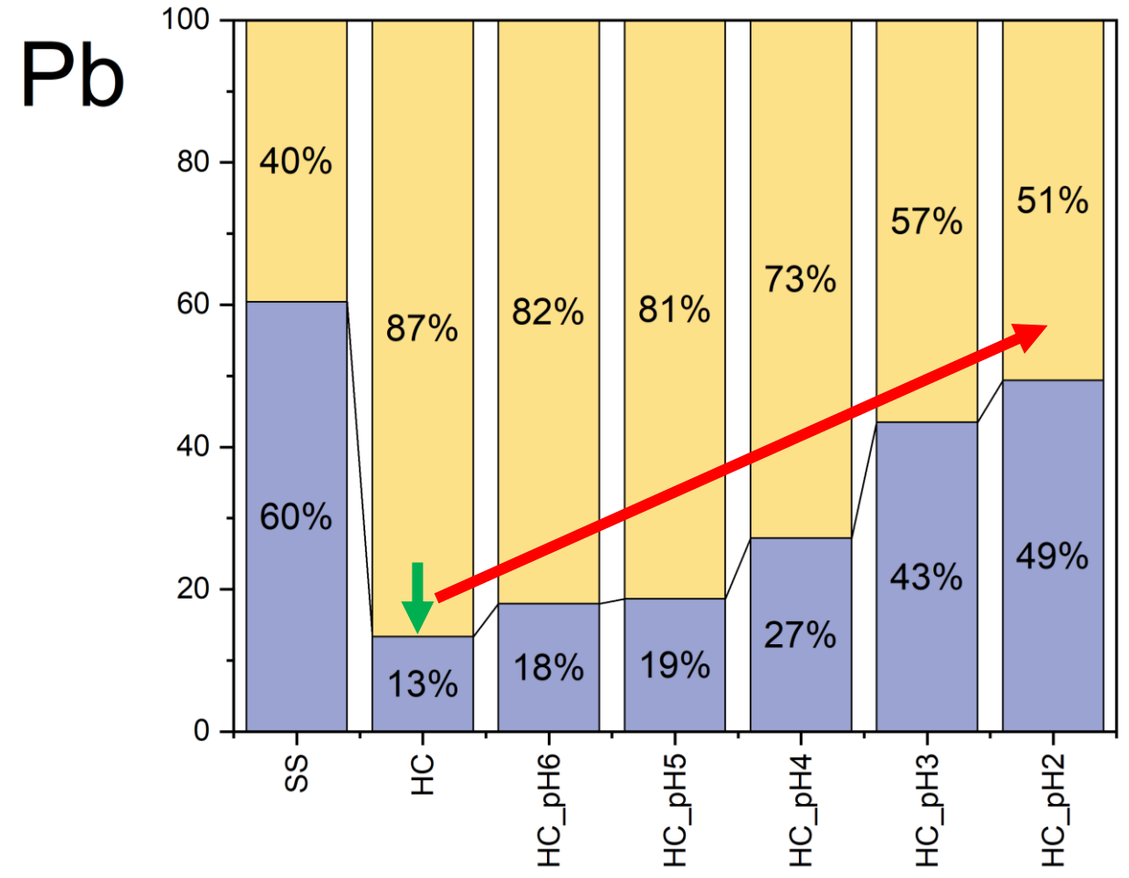
LOWER

Heavy metals in hydrochar by Tessier and the Community Bureau of Reference (BCR)



ΣF1...F4	SS	HC	pH6	pH5	pH4	pH3	pH2
(mg/kg)	155.77	285.75	304.17	282.39	292.80	249.73	312.44

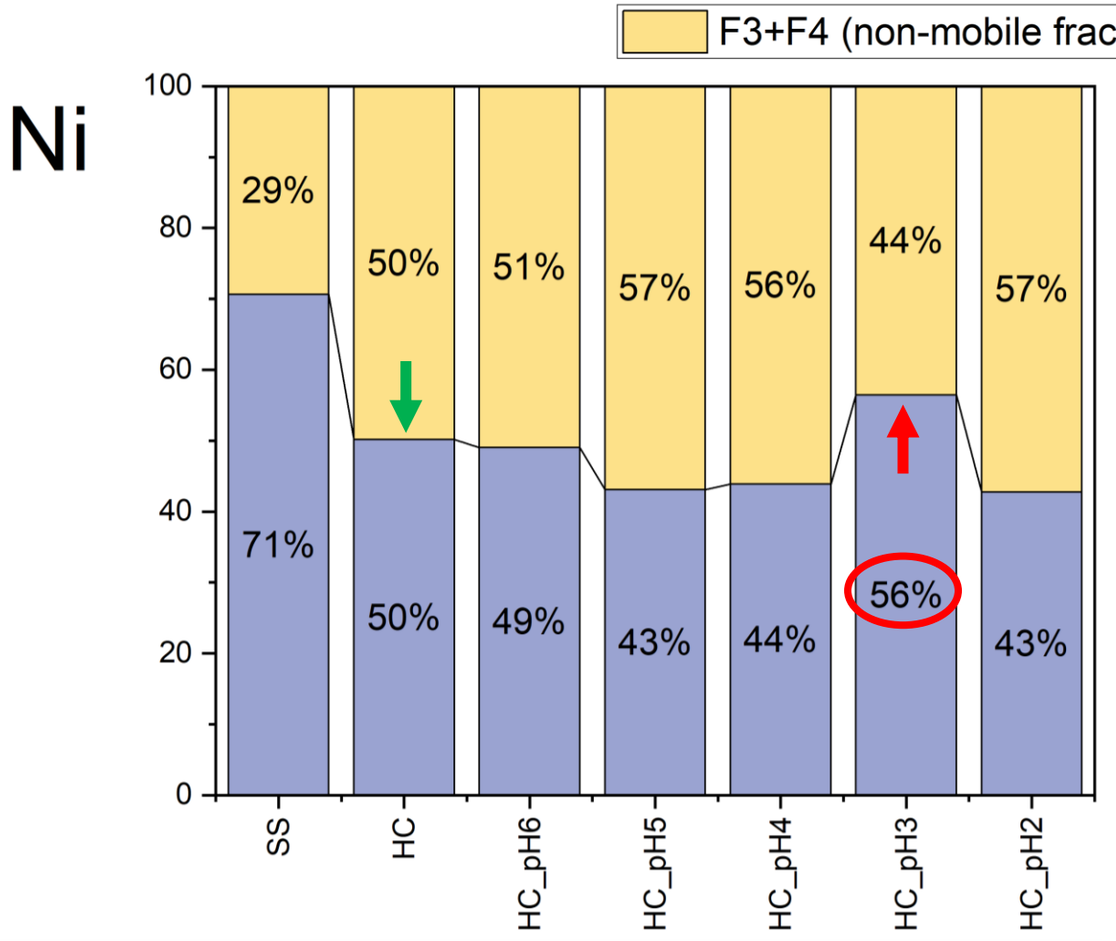
HIGHER



ΣF1...F4	SS	HC	pH6	pH5	pH4	pH3	pH2
(mg/kg)	66.49	100.00	108.11	102.21	101.46	83.46	96.16

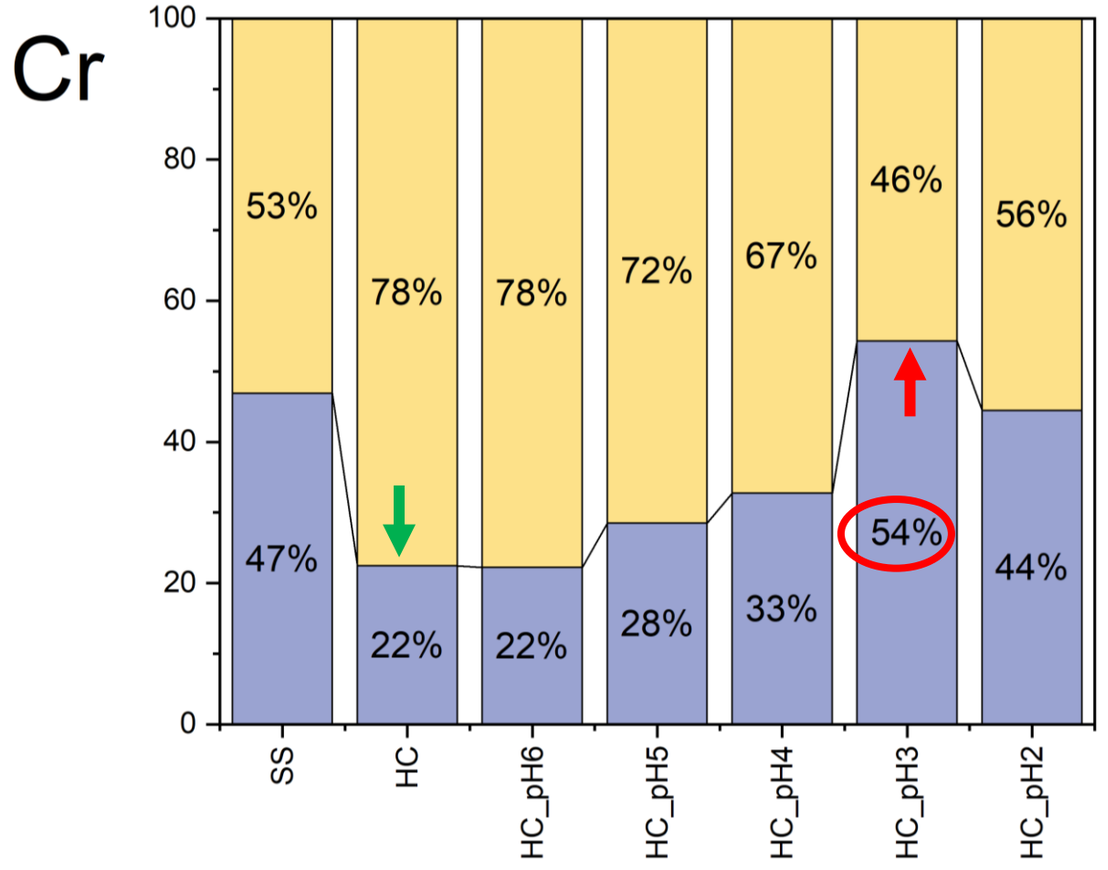
HIGHER

Heavy metals in hydrochar by Tessier and the Community Bureau of Reference (BCR)



ΣF1...F4	SS	HC	pH6	pH5	pH4	pH3	pH2
(mg/kg)	144.29	223.84	219.52	212.22	199.59	150.31	176.02

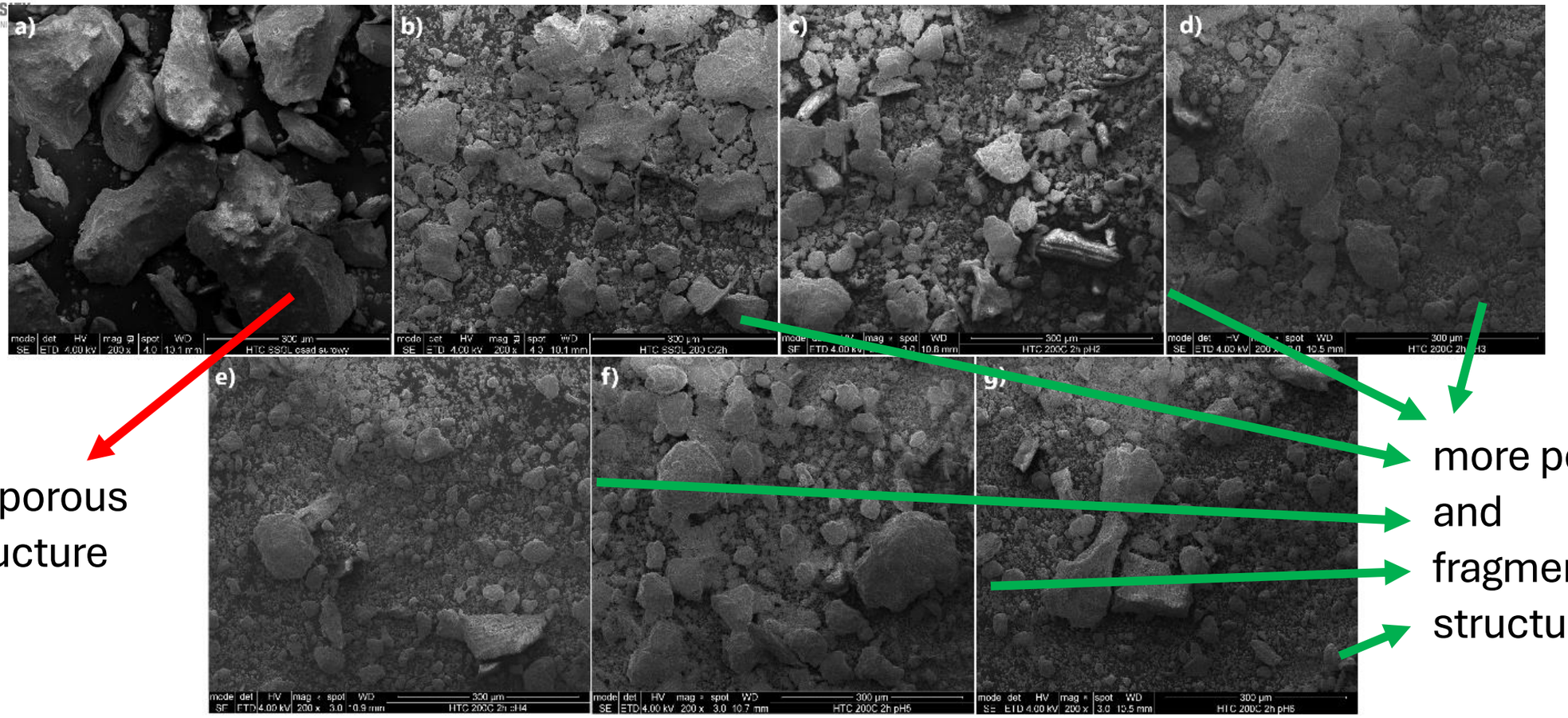
HIGHER



ΣF1...F4	SS	HC	pH6	pH5	pH4	pH3	pH2
(mg/kg)	53.61	80.19	89.34	69.46	76.69	69.87	75.68

HIGHER

SEM analysis of hydorchar



a) SS, b) HC, c) HC_pH2, d) HC_pH3, e) HC_pH4, f) HC_pH5, g) HC_pH6

	HC		HC_pH6		HC_pH5		HC_pH4		HC_pH3		HC_pH2
SSA, m^2/g	10.28	HIGHER →	12.28	HIGHER →	13.54	LOWER →	12.12	LOWER →	11.28	LOWER →	7.65

Conclusions

1. The value of pH during the HTC affects the properties of the resulting products.
2. Extremely decreasing pH causes an increasing in the phosphorus content.
3. Heavy metals content in hydrochar increase after HTC process.
4. HTC process resulted in a decrease in the content of mobile phases of heavy metals after the HTC process.

Acknowledgements

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Thank you for your attention!

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