Valorization of process water from hydrothermal carbonization of biomass waste by UASB reactors

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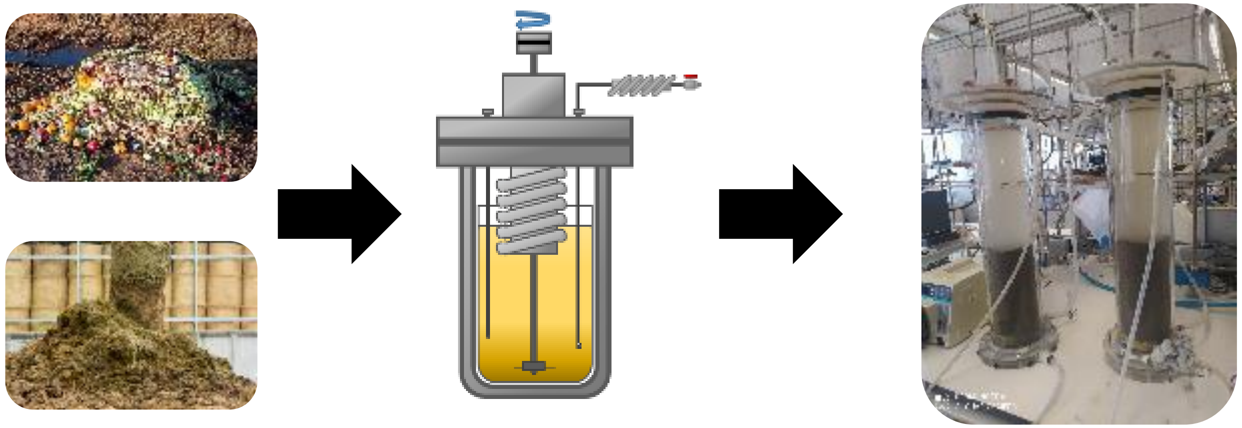

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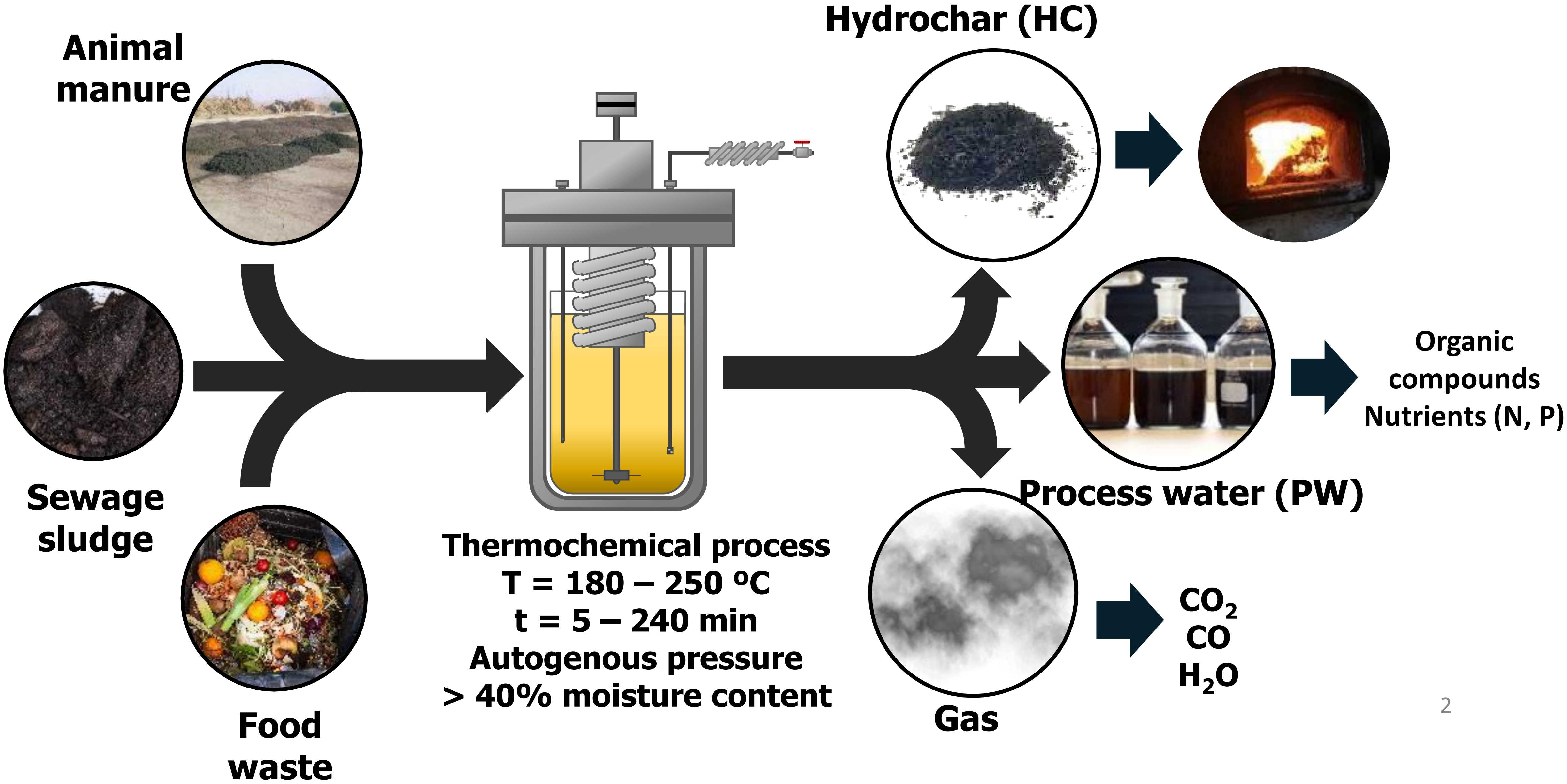
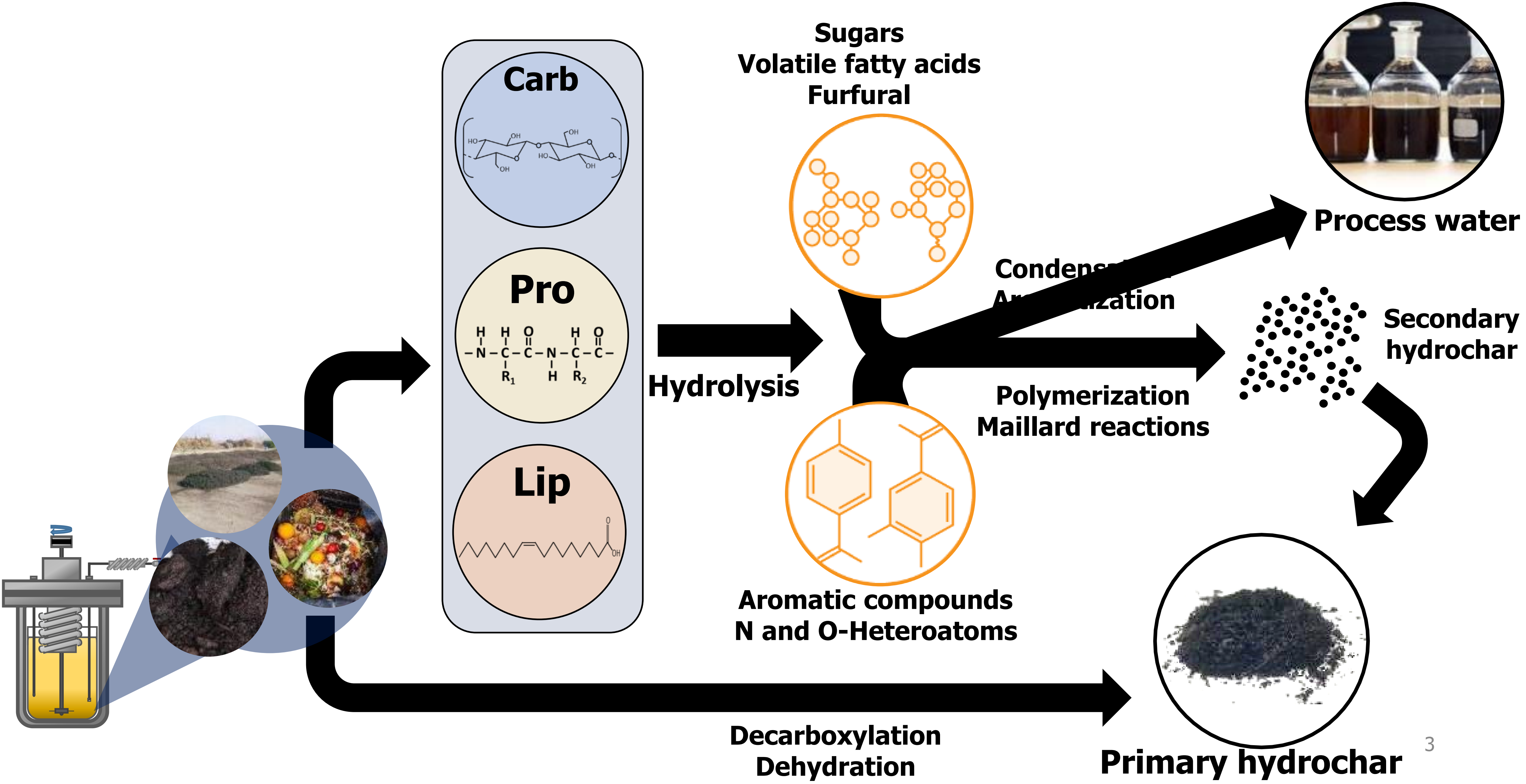
Hydrothermal carbonization (HTC)

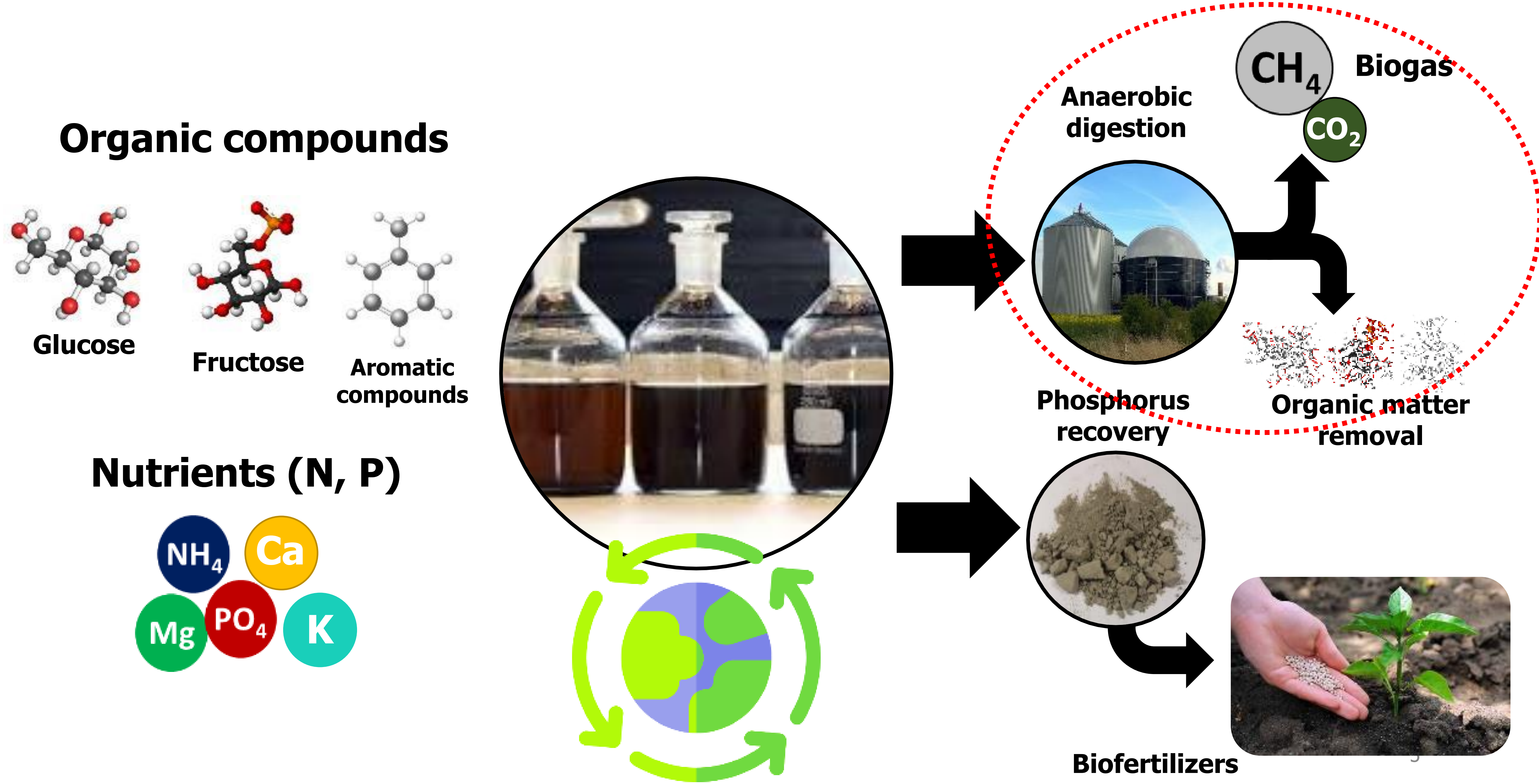


HTC reactions



Hydrochar applications

Process water a waste or resource?



Feedstock characteristics

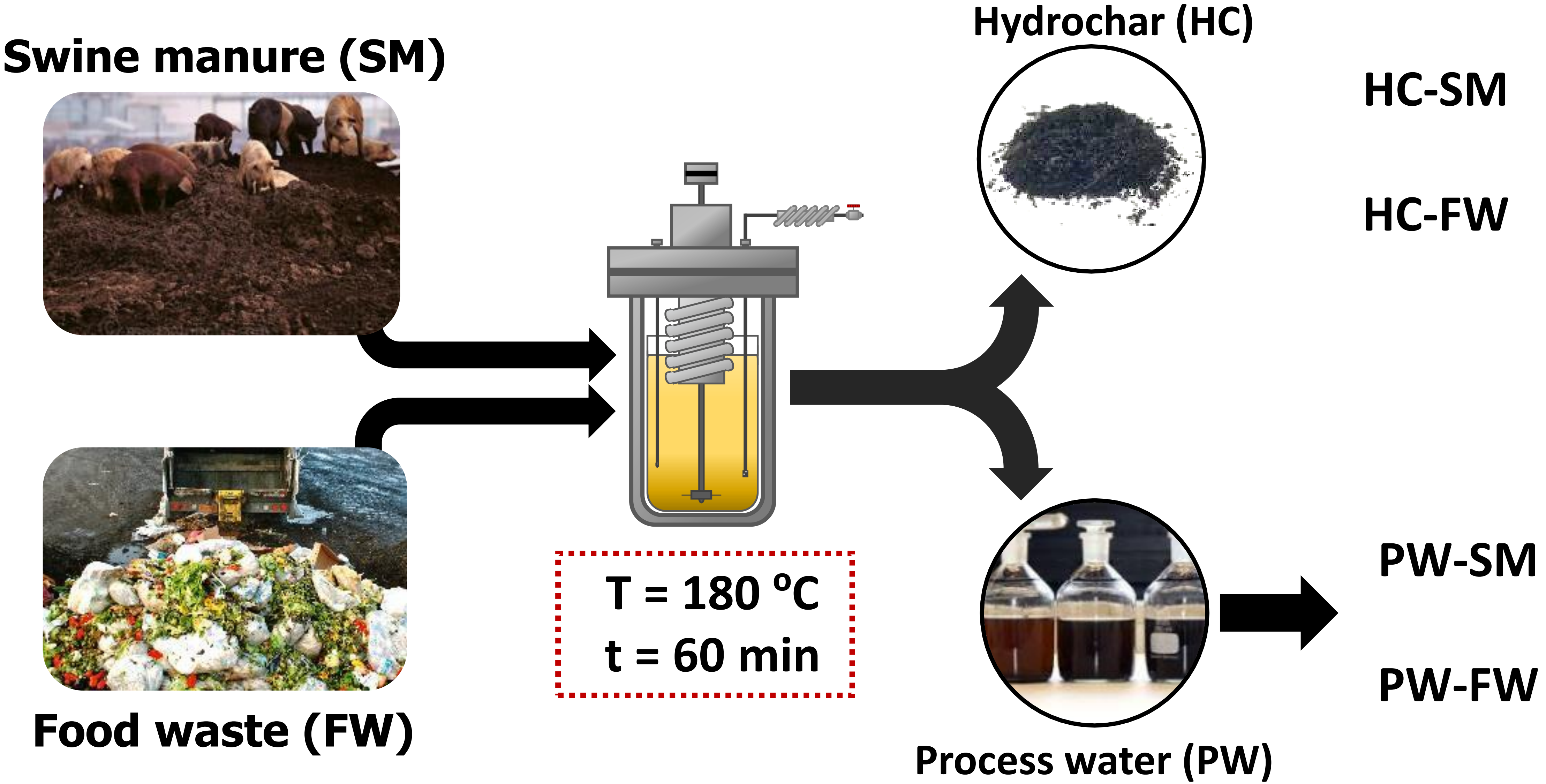
Swine manure (SM)

Swine manure (SM)	
pH	7.9
TS (g L^{-1})	57.9
VS (g L^{-1})	41.2
TCOD (g L^{-1})	67.2
TKN (g L^{-1})	3.9
C/N	1.3

Food waste (FW)

Food waste (FW)	
pH	5.9
TS (g kg^{-1})	158.2
VS (g kg^{-1})	145.8
TCOD (g kg^{-1})	327.1
TKN (g kg^{-1})	1.1
C/N	17.2

Experimental procedure

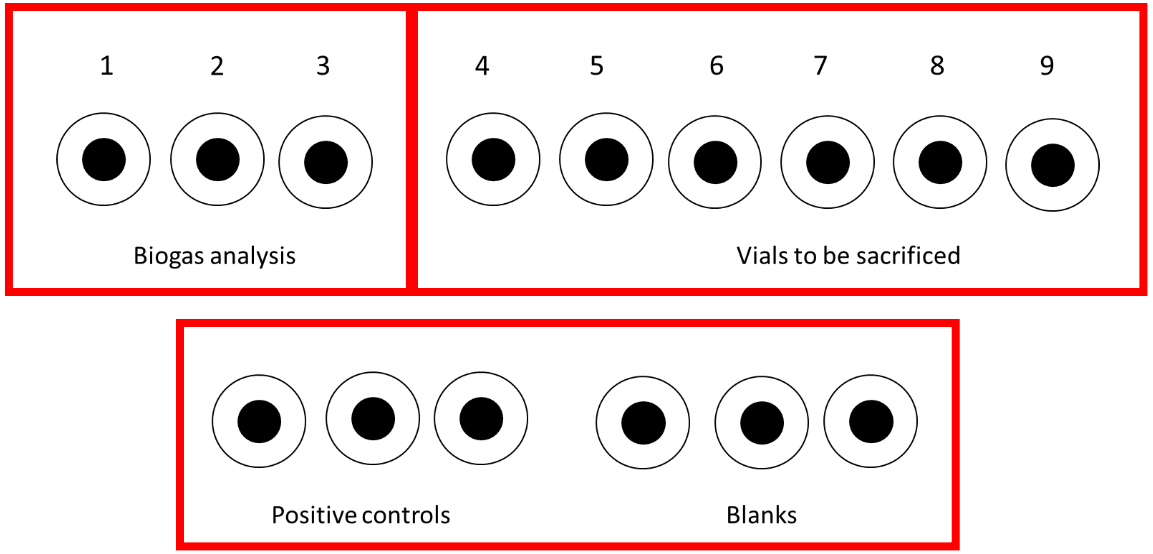


Anaerobic digestion

Biochemical methane potential test

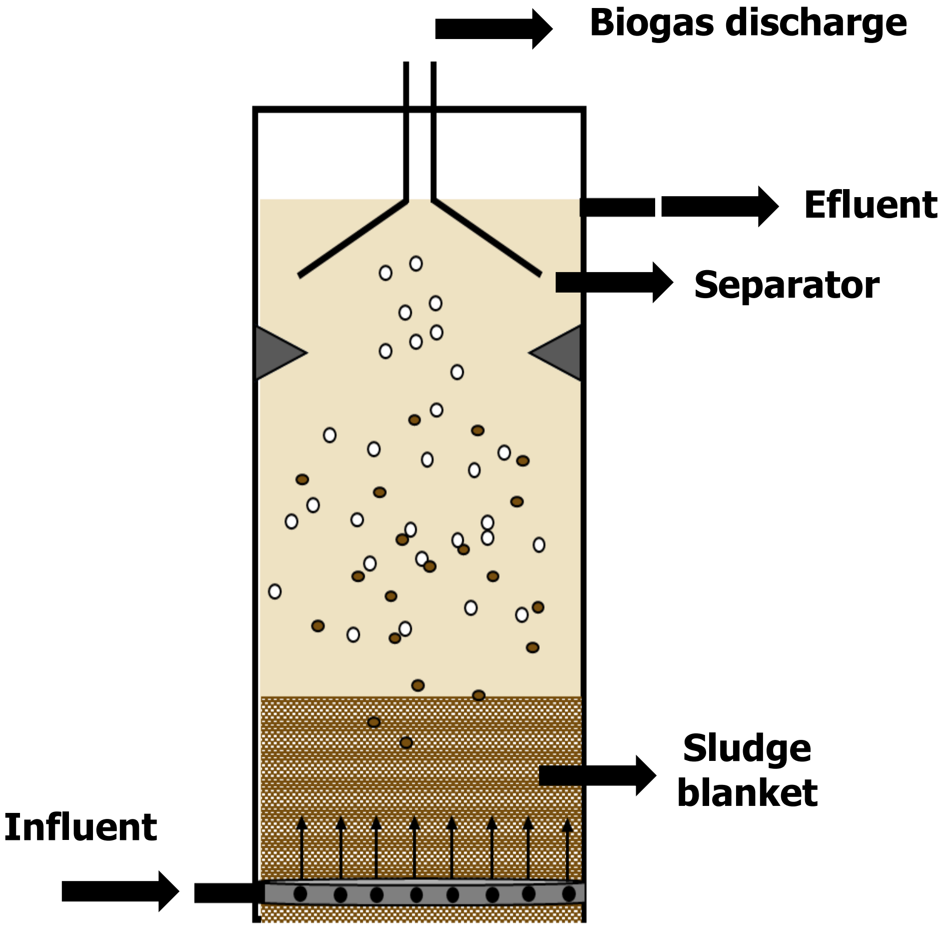
ISR = 2

- 15 g VS L^{-1} **Granular anaerobic sludge**
- 7.5 g VS L^{-1} **Process water**



Anaerobic digestion

Upflow anaerobic sludge blanket (UASB) reactor



HRT = 24 … OD $L^{-1}\cdot d^{-1}$

Flow = 1…

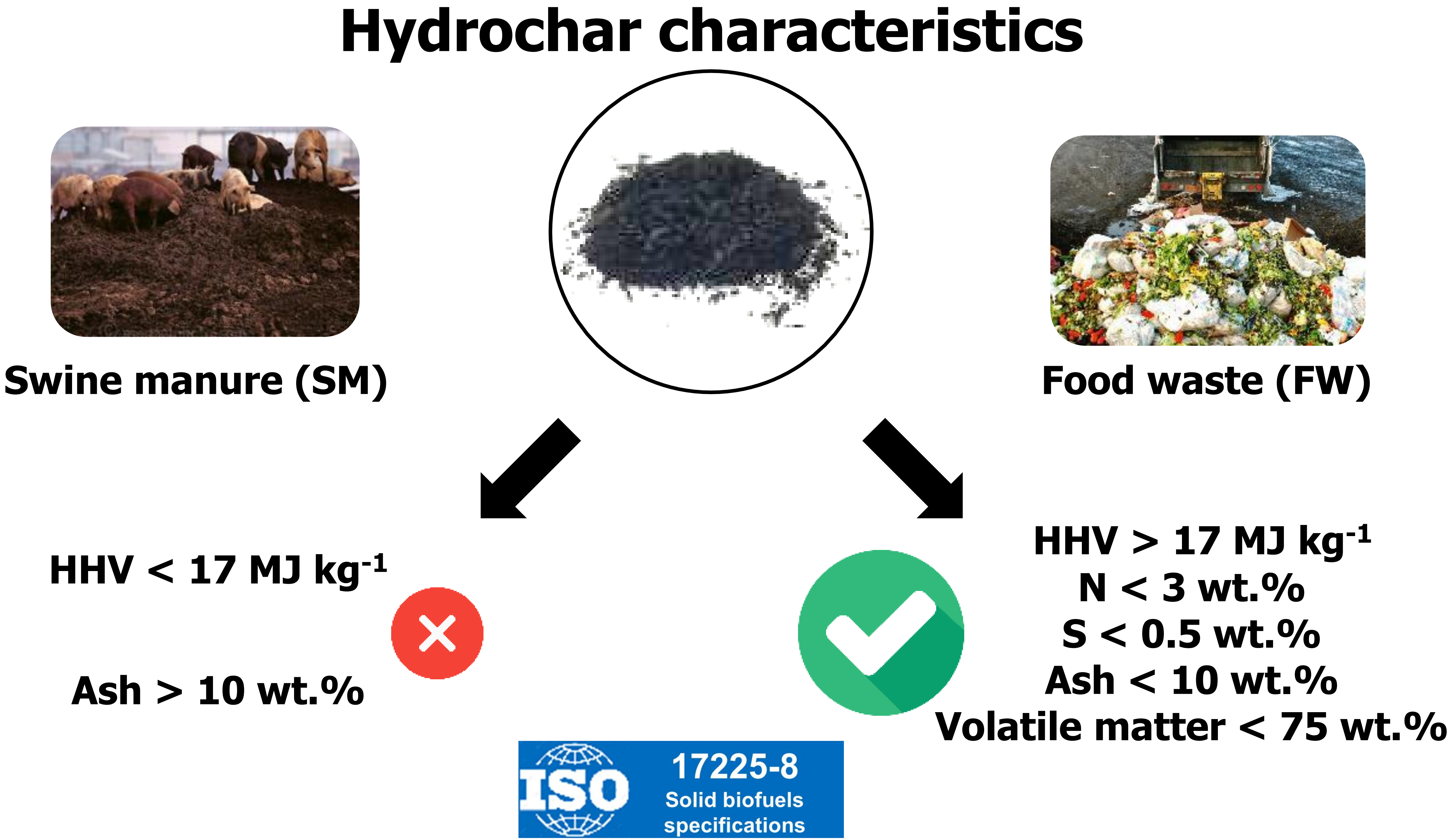
G… PW)

Ph…	COD
Star…	
I…	
II…	
I…	
V…	
VI…	

RESULTS

Results

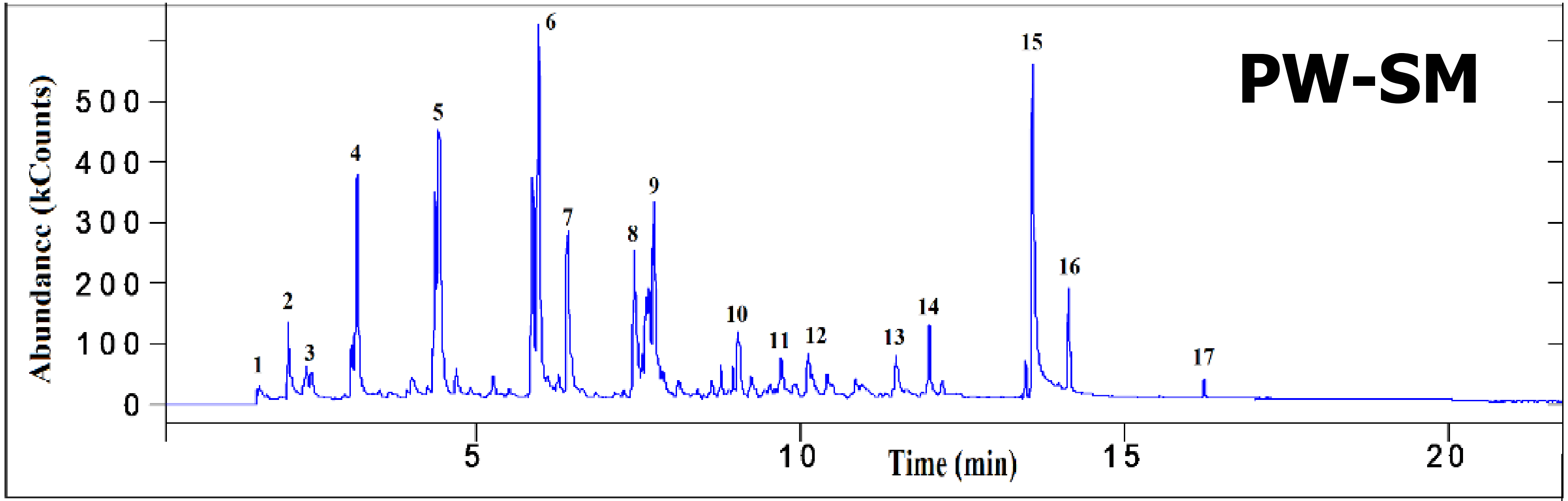
Results

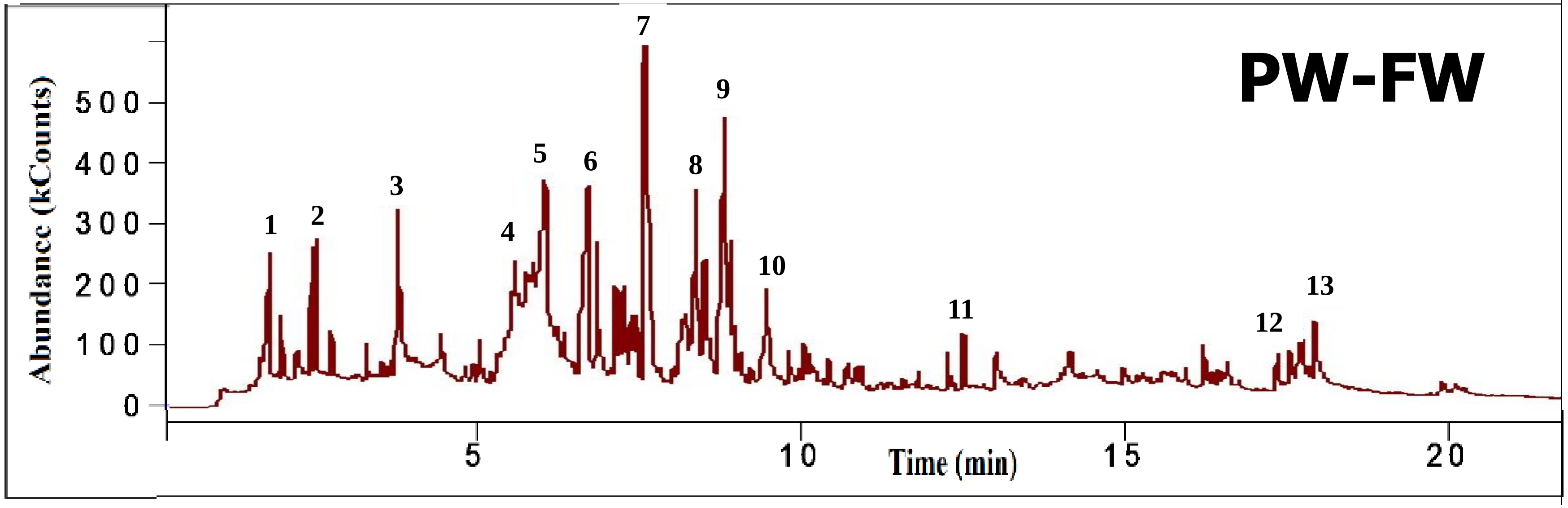

Hydrochar characteristics
Swine manure (SM)
Food waste (FW)
HHV < 17 MJ kg-1
Ash > 10 wt.%
HHV > 17 MJ kg-1
N < 3 wt.%
S < 0.5 wt.%
Ash < 10 wt.%
Volatile matter < 75 wt.%
ISO
17225-8
Solid biofuels
specifications

Process water characteristics

	PW-SM	PW-FW
pH	8.1 ± 0.3	4.3 ± 0.2
TCOD (g L^{-1})	27.8 ± 1.1	152.1 ± 2.4
TOC (g L^{-1})	4.7 ± 0.1	36.4 ± 0.6
TVFA (g acetic acid L^{-1})	1.0 ± 0.0	5.3 ± 0.3
TKN (g L^{-1})	1.7 ± 0.2	3.1 ± 0.2
$P\text{-}PO_4$ (mg L^{-1})	91.4 ± 2.4	203.1 ± 2.4
C/N ratio	2.7	11.7

GC/MS: Process water





GC/MS: Process water

Number	PW-SM
1	2-chloro-2-nitro-Propane
2	dimethyl Disulfide
3	Furfural
4	4,6-dimethyl-Pyrimidine
5	2-ethyl-5-methyl-Pyrazine
6	2,4,6-trimethyl-Pyridine
7	2-methoxy-Phenol
8	2-Thiophenecarbonyl chloride / 1,3-Dioxolane
9	2-methoxy-Phenol
10	Flamenol
11	Isoquinoline
12	Indole
13	Isoquinaldine
14	7-methyl-1H-Indole
15	n-Tridecan-1-ol
16	2,4-bis(1,1-dimethylethyl)-Phenol

Penicillamine

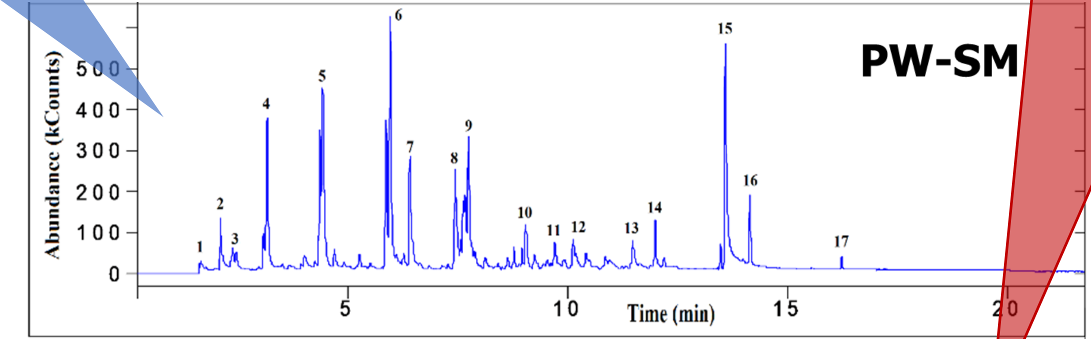

Mercaptamine

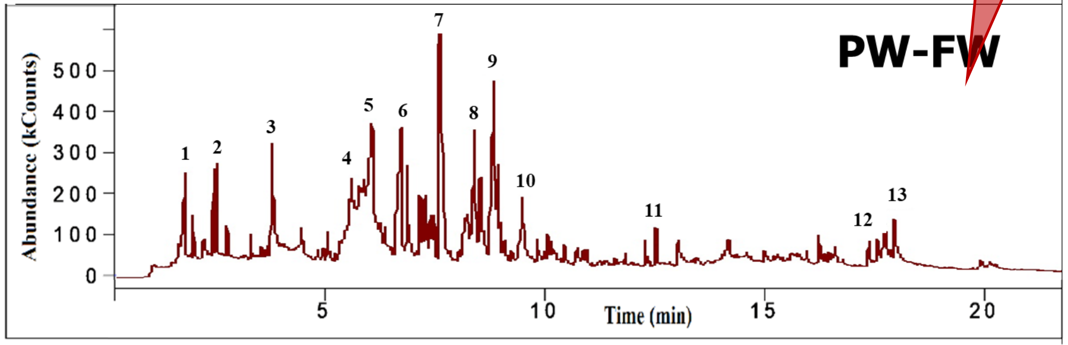

Chloramphenicol


Rescinnamine

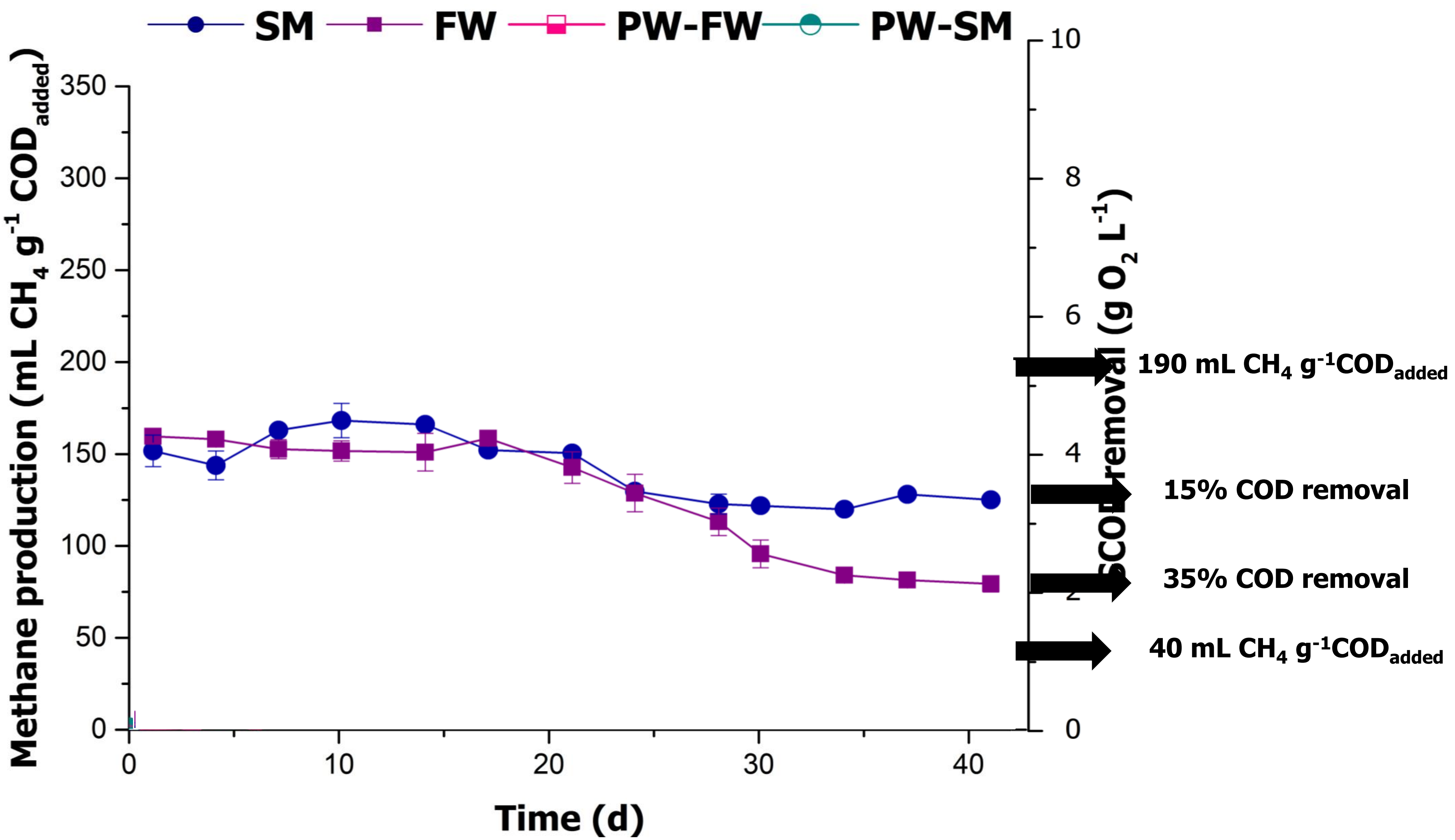

Prednisolone acetate

Number	PW-FW
1	Acetic acid
2	Hydroquinone
3	Glycerin
4	Benzoic acid
5	4-methyl-1-(1-methylethyl)-3-Cyclohexen-1-ol
6	3, 7,7-trimethyl-Bicyclo [4,1,0]hept-2-ene
7	Octanoic acid
8	2 ethyl-Hexanoic acid
9	4 hydroxy-α,α,4-trimethyl-Cyclohexanemethanol
10	hydroxy-lactone Undecanoic acid
11	n-Hexa decanoic acid
12	2(1H)-Pyridinone
13	1,6 octadien-3-ol

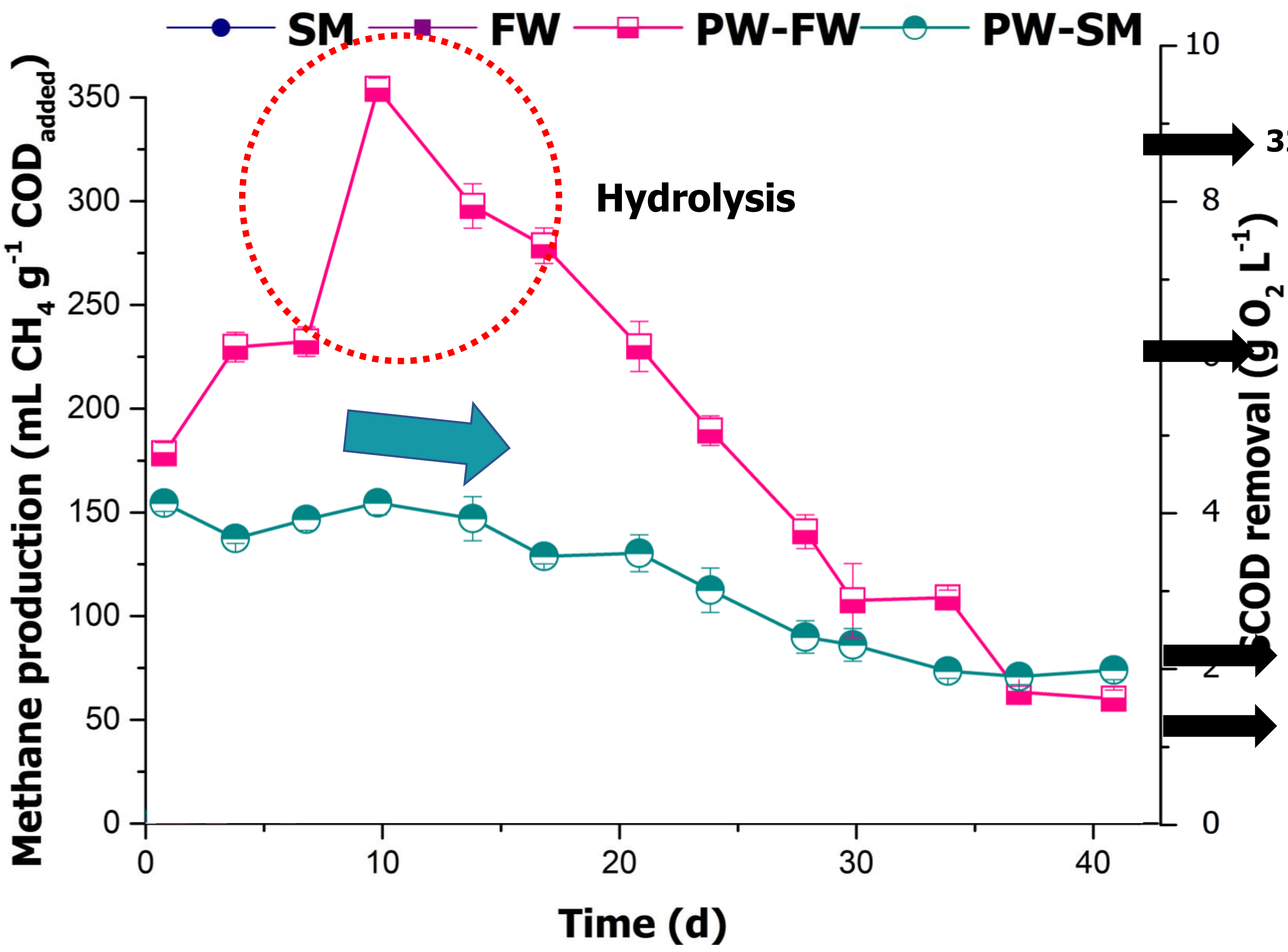




Biochemical methane potential



Biochemical methane potential



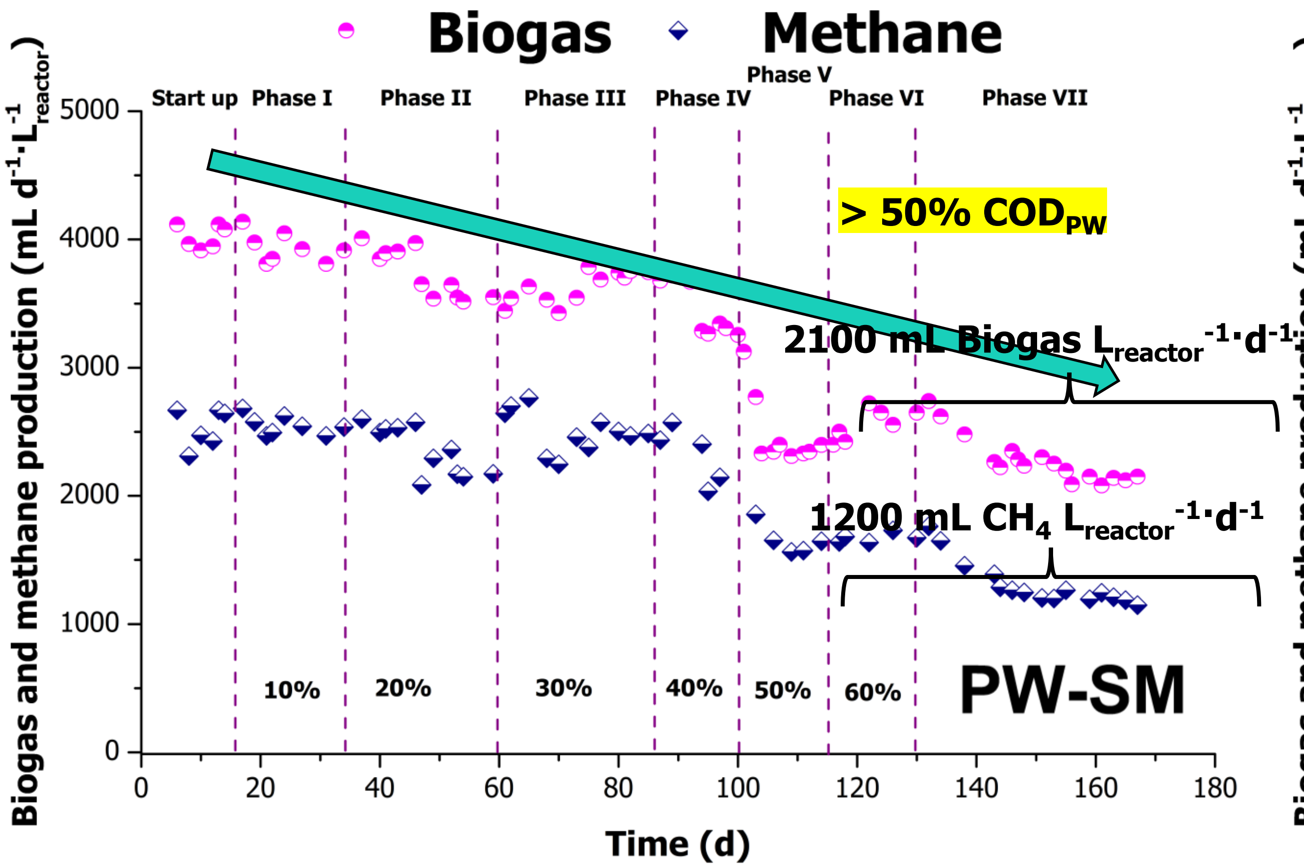
325 mL CH_4 $g^{-1}COD_{added}$

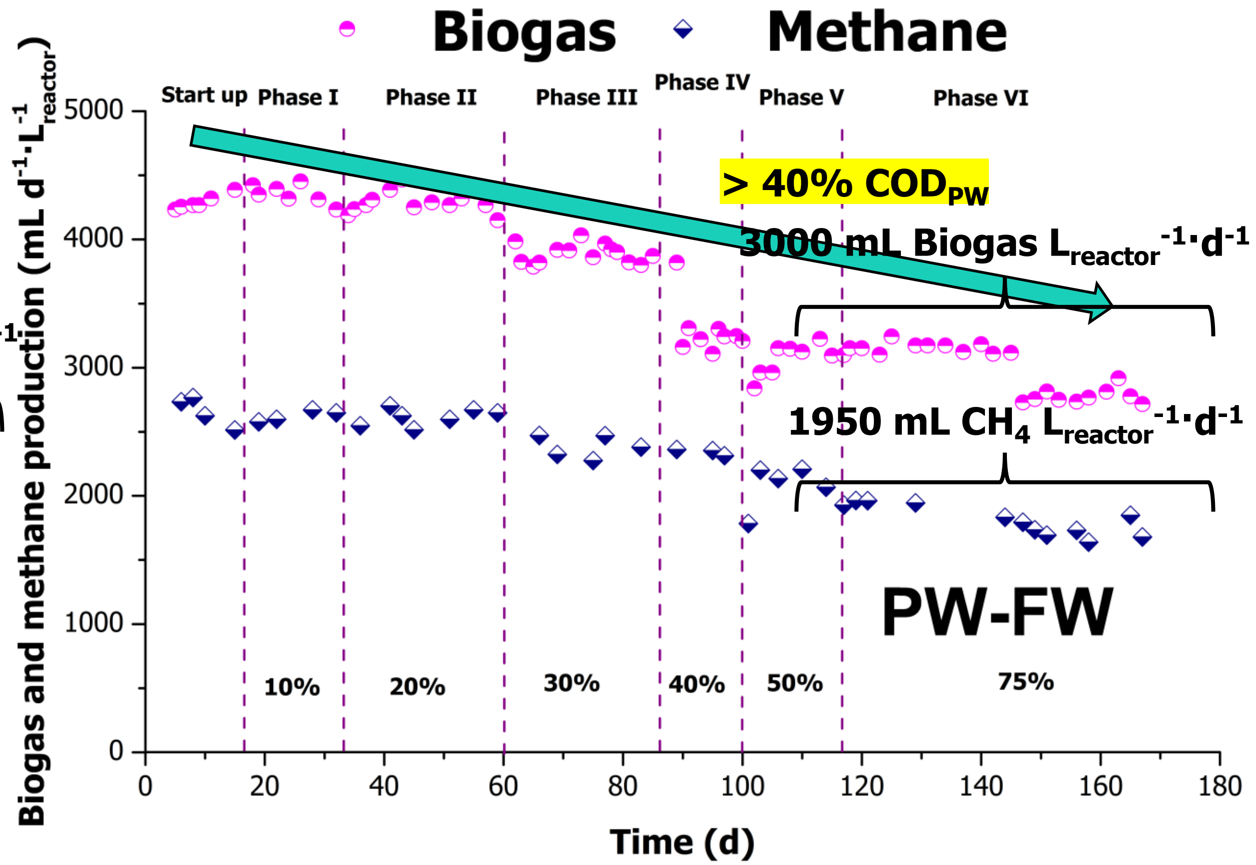
220 mL CH_4 $g^{-1}COD_{added}$

45% COD removal

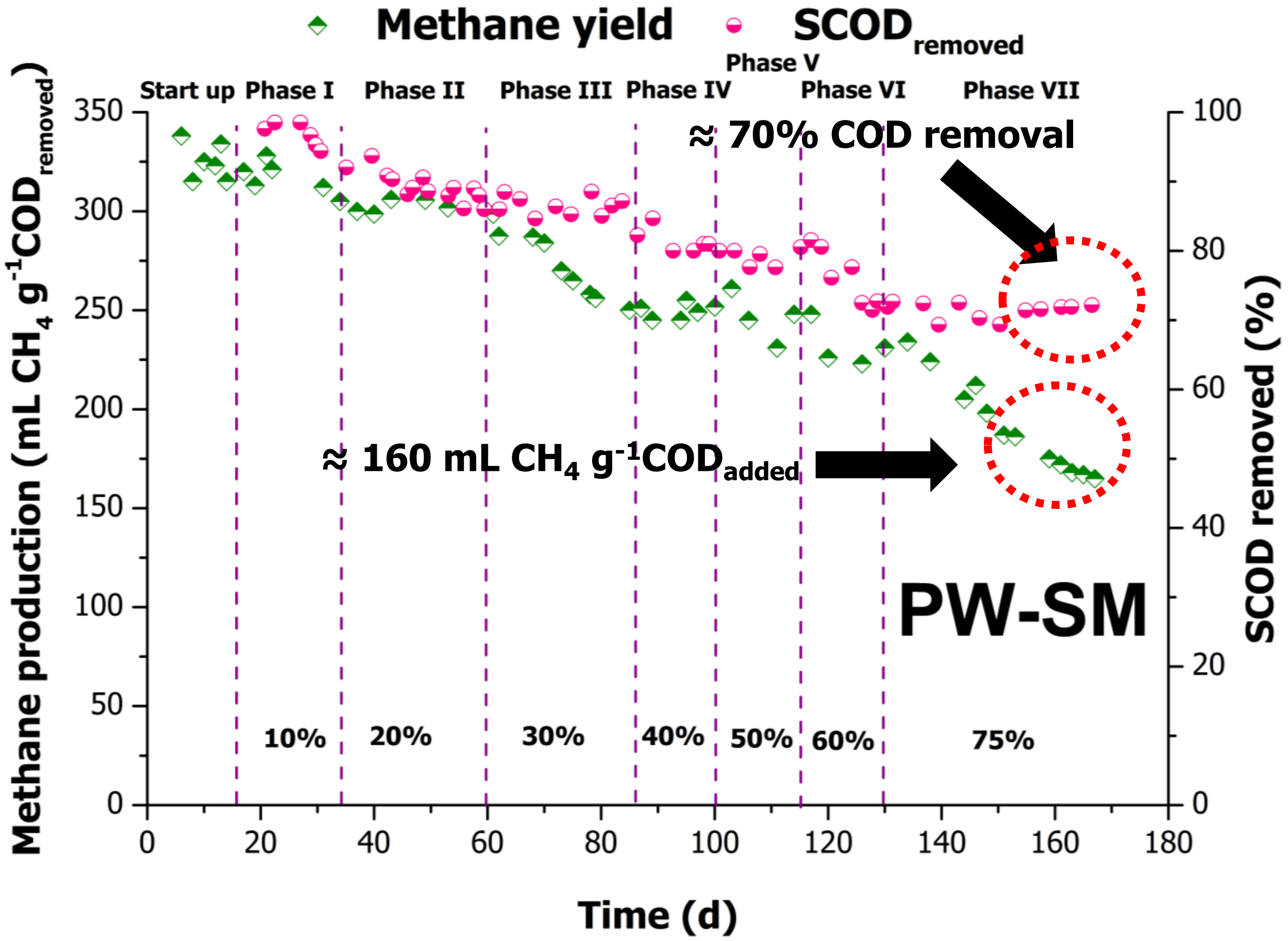
65% COD removal

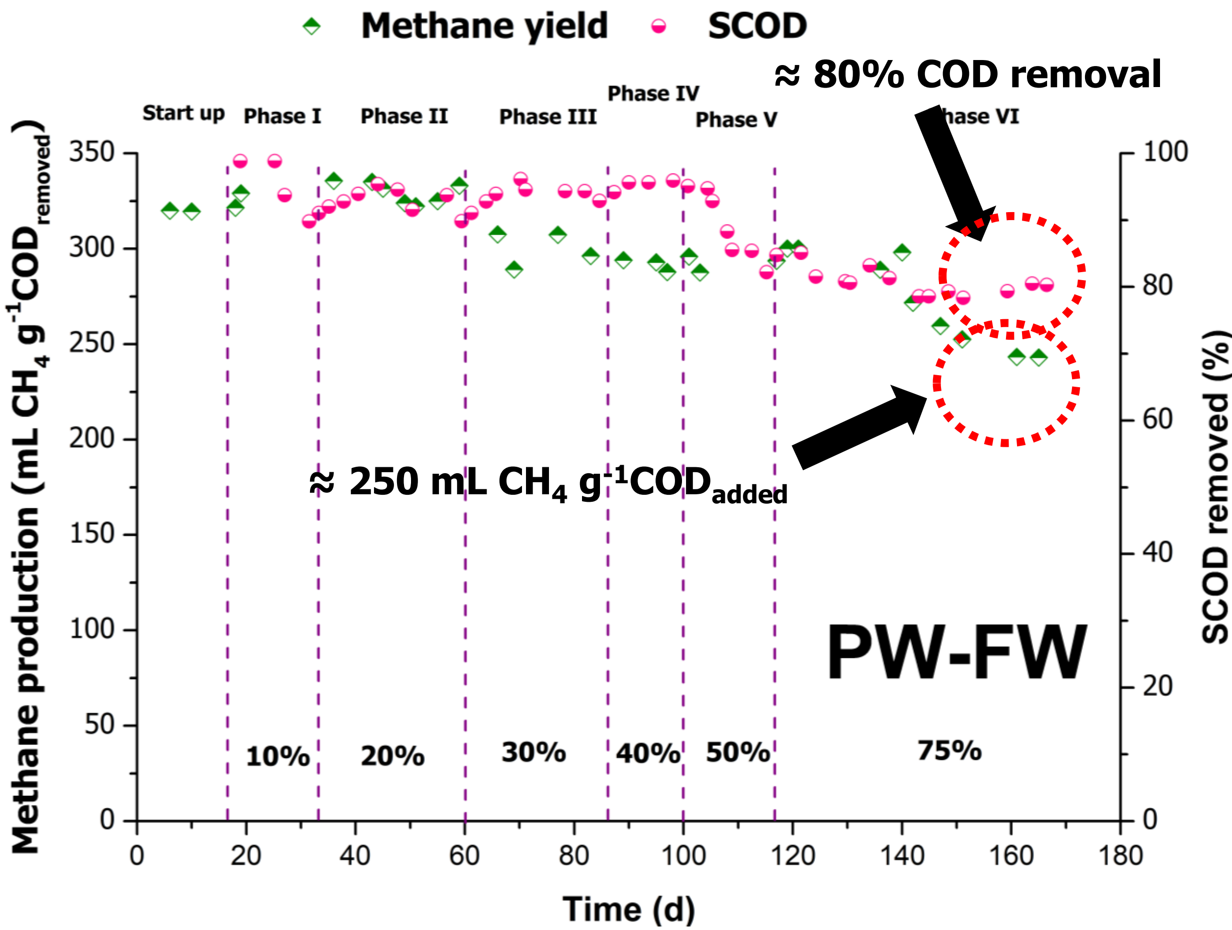
Biogas and methane production





Methane yield and SCOD removal





	Phase I	Phase VII
C/N	13	3.7

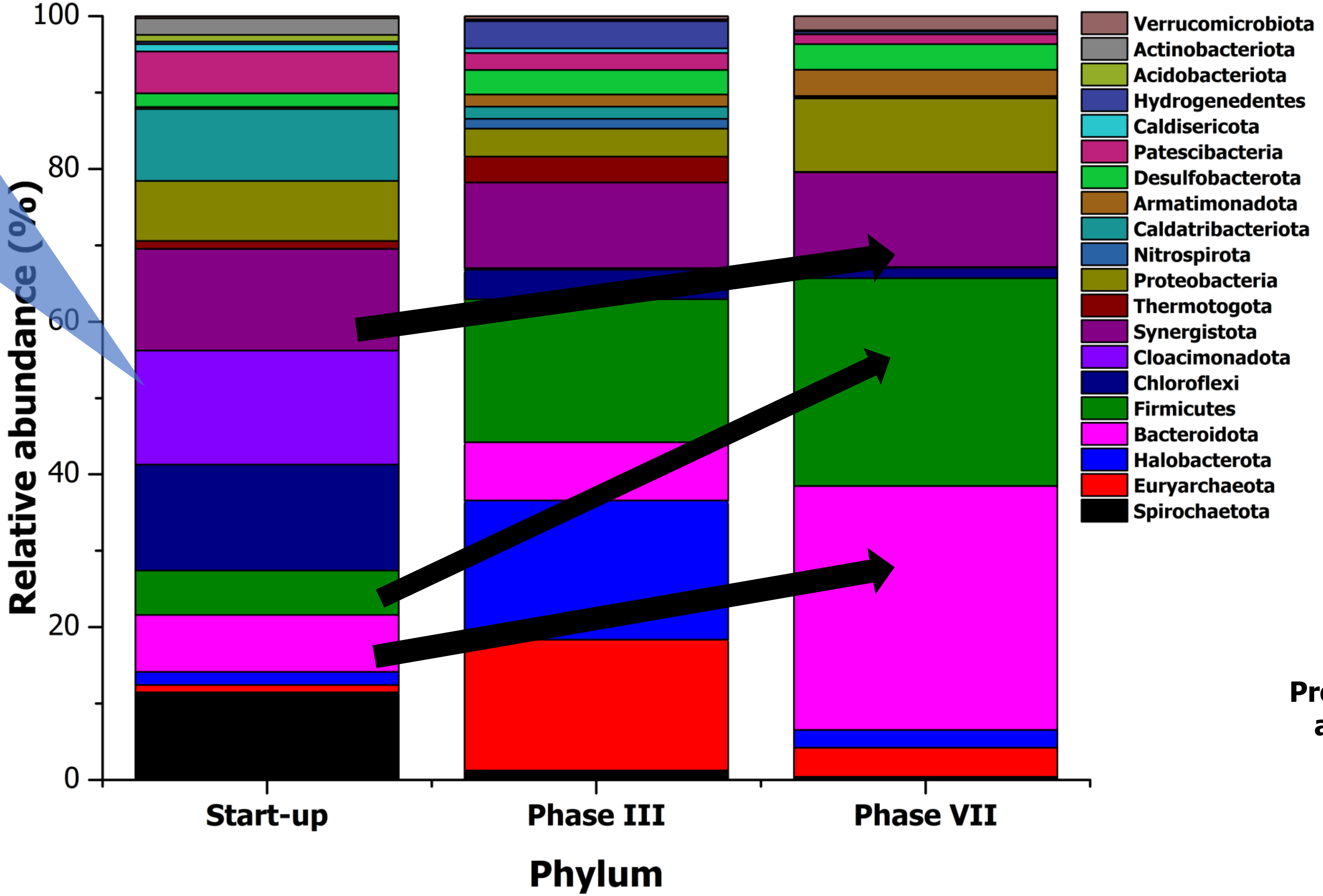
C/N = 17 – 32

Microbial community

PW-SM

Spiroachaetota
Chloroflexi
Cloacimonadota
Synergistota

Fermentative
Acidogens
Acetogens
Methanogens



Synergistota
Firmicutes
Bacteroidota

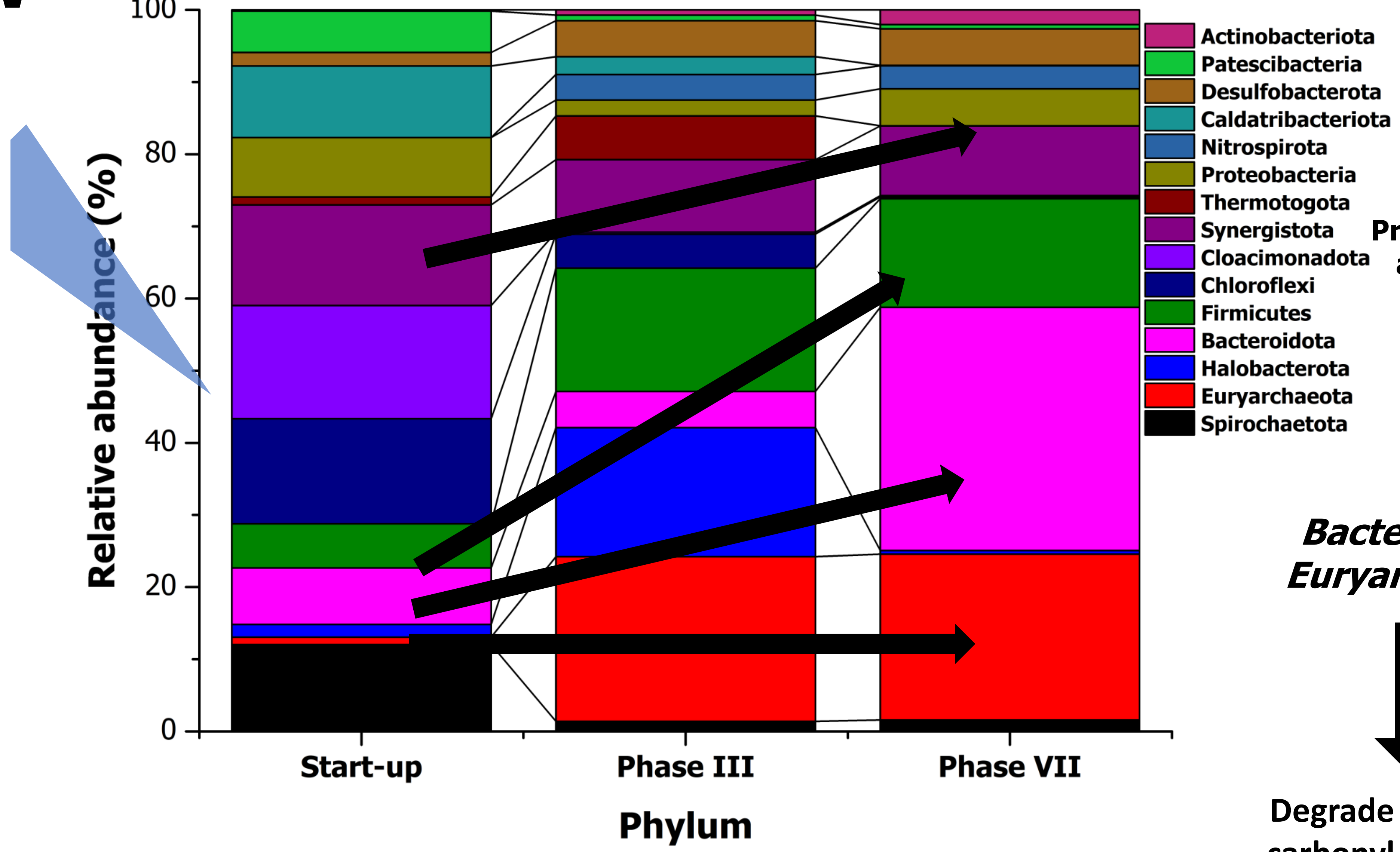
Protein and amino acid hydrolysis

Microbial community

PW-FW

Spiroachaetota
Chloroflexi
Cloacimonadota
Synergistota

Fermentative
Acidogens
Acetogens
Methanogens



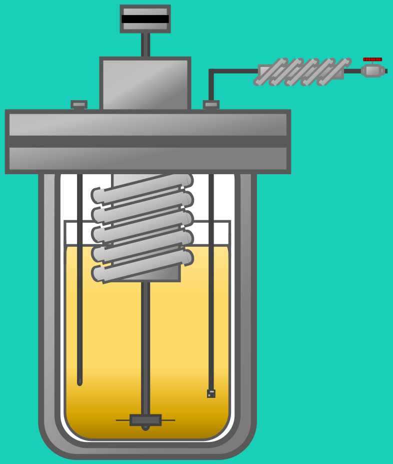
Synergistota
Firmicutes

Protein and amino acid hydrolysis

Bacteroidota
Euryarchaeota

Degrade carboxylic, carbonyl groups and TVFA

Summary



Process water rich in soluble organic compounds

	PW-SM	PW-FW
TCOD (g L^{-1})	27.8 ± 1.1	152.1 ± 2.4
TOC (g L^{-1})	4.7 ± 0.1	36.4 ± 0.6

BMP shows high methane production and organic matter removal for process water

PW-SM

220 mL CH_4 $g^{-1}COD_{added}$
45% COD removal

PW-FW

325 mL CH_4 $g^{-1}COD_{added}$
65% COD removal

UASB is suitable option to valorize process water from HTC

PW-SM

160 mL CH_4 $g^{-1}COD_{added}$

70% COD removal

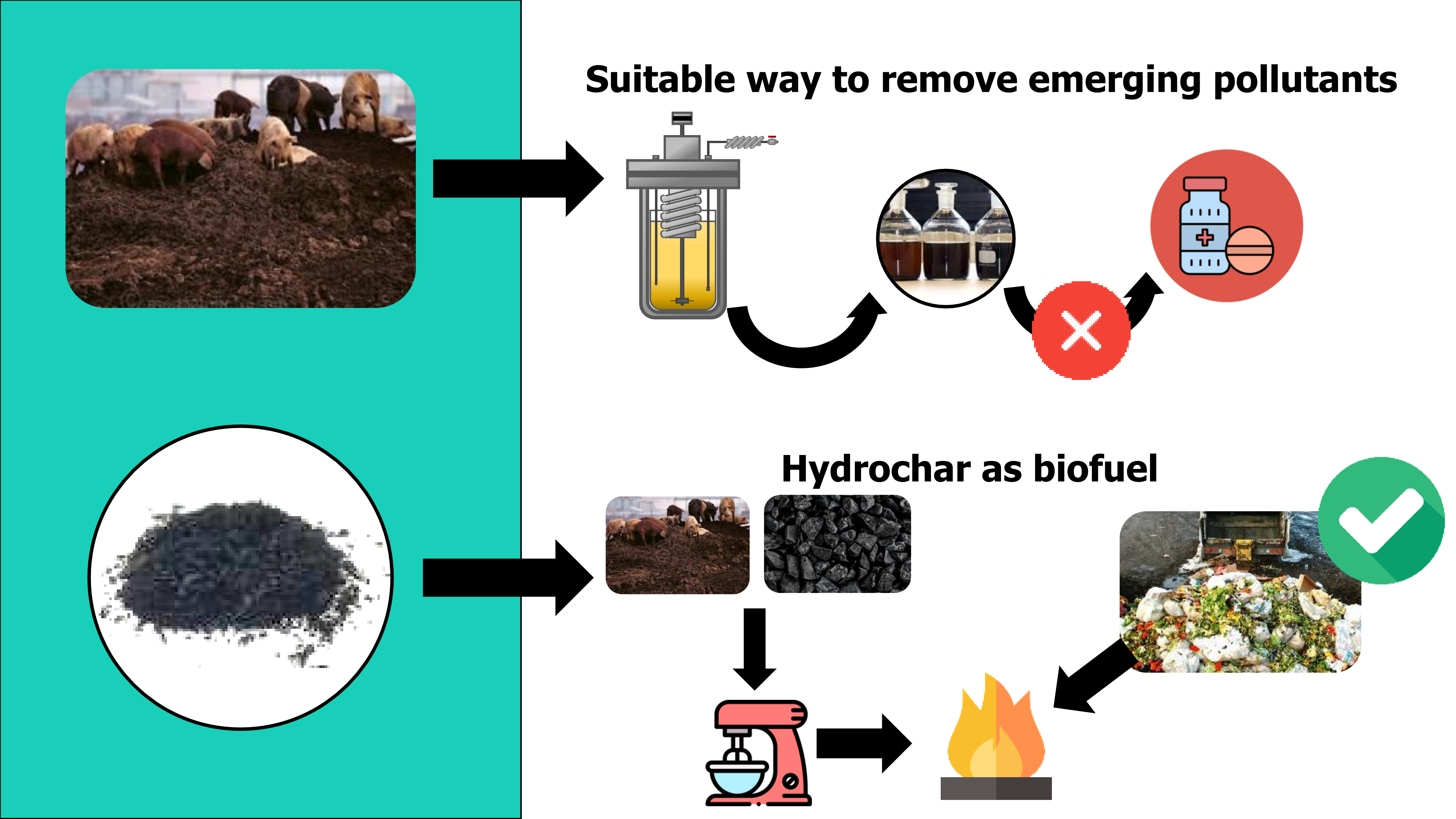
PW-FW

160 mL CH_4 $g^{-1}COD_{added}$

80% COD removal

HRT = 24 h
vs
40 d in BMP analysis

Process water characteristics


Suitable way to remove emerging pollutants
Hydrochar as biofuel

Acknowledgements

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Questions?

Surrender is not an option

R. P. IPIALES

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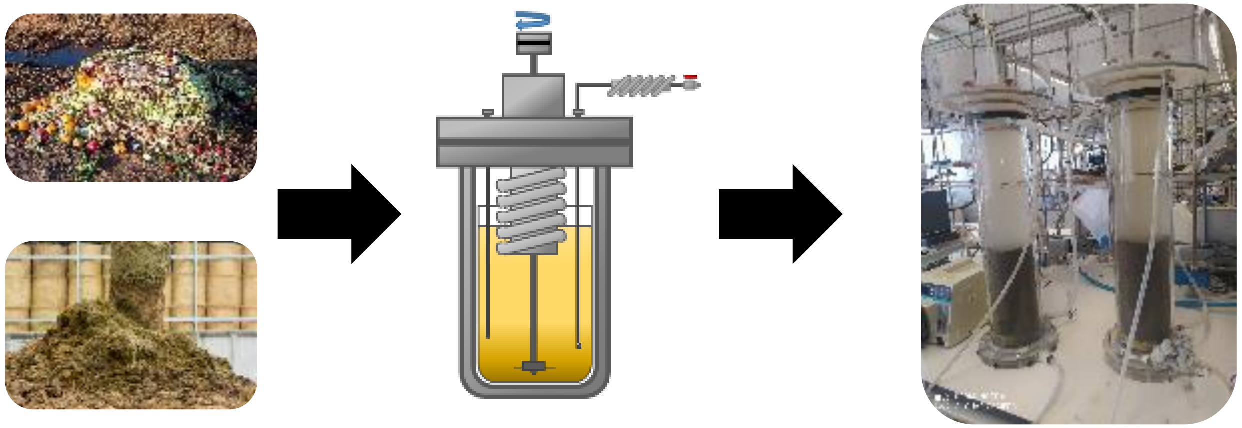

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