Hydrothermal carbonization of swine manure in a continuous flow pilot plant

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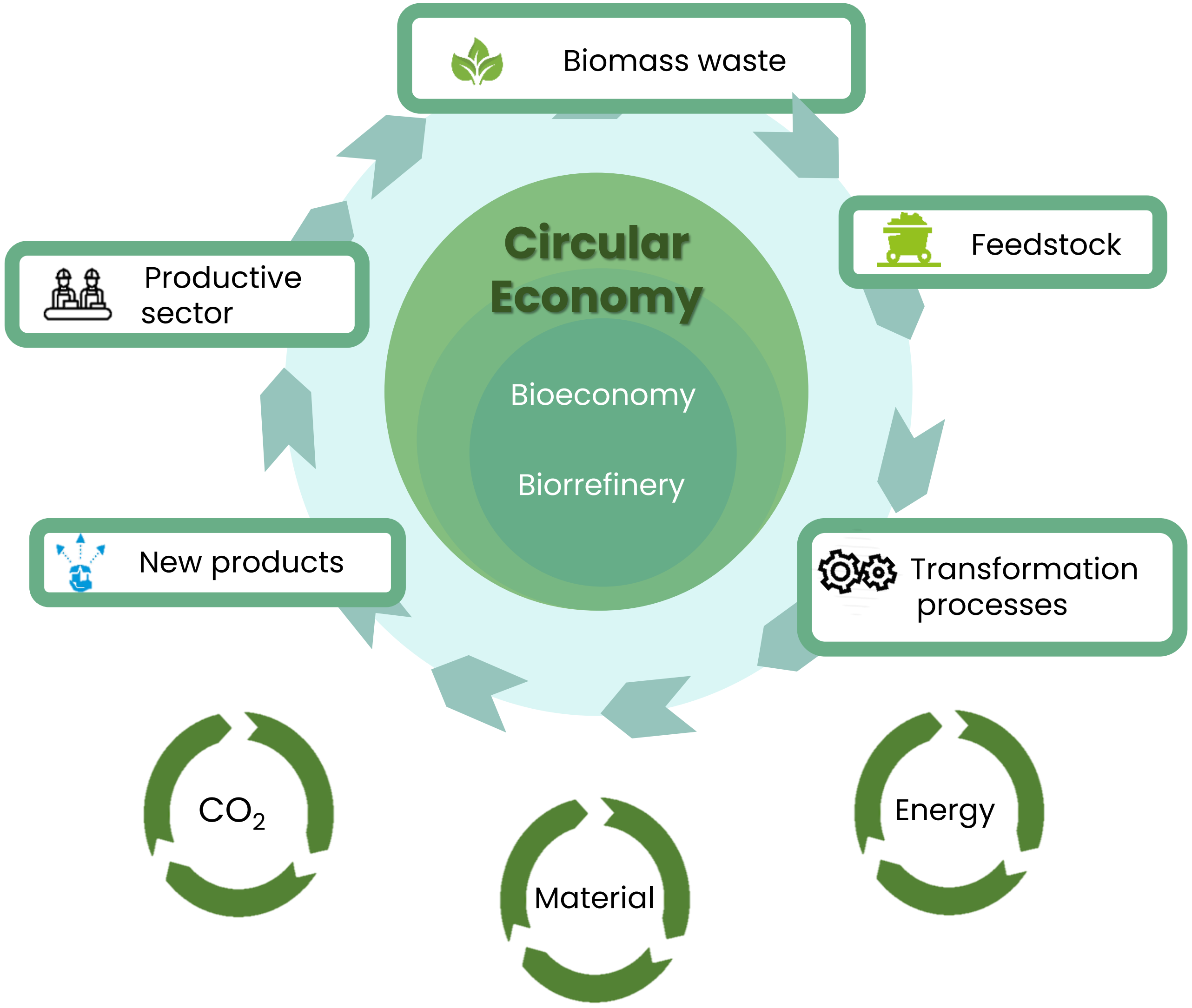
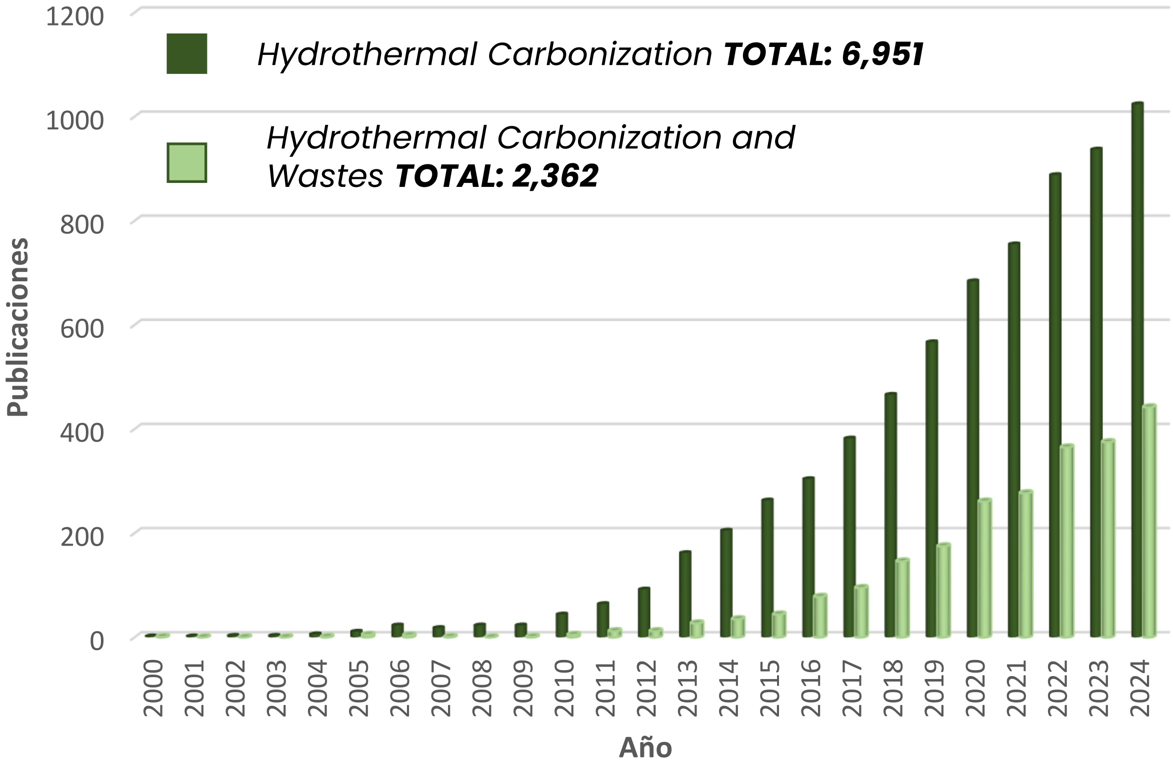
Department of Chemical Engineering

HYDROTHERMAL CARBONIZATION: AS CENTRAL STRATEGY FOR BIOMASS WASTE TREATMENT





Source: Scopus (27/11/2024)

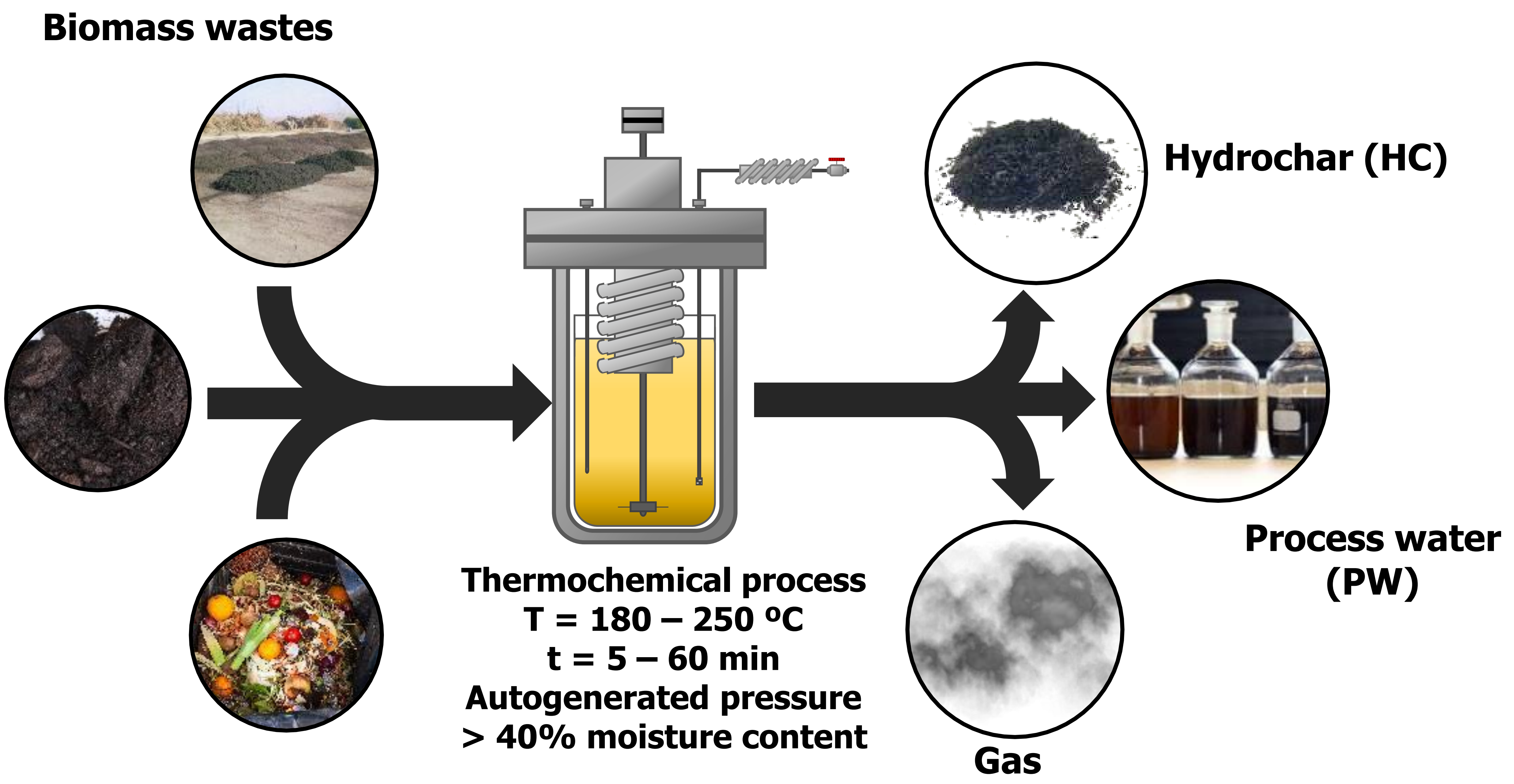
Sewage biosolids

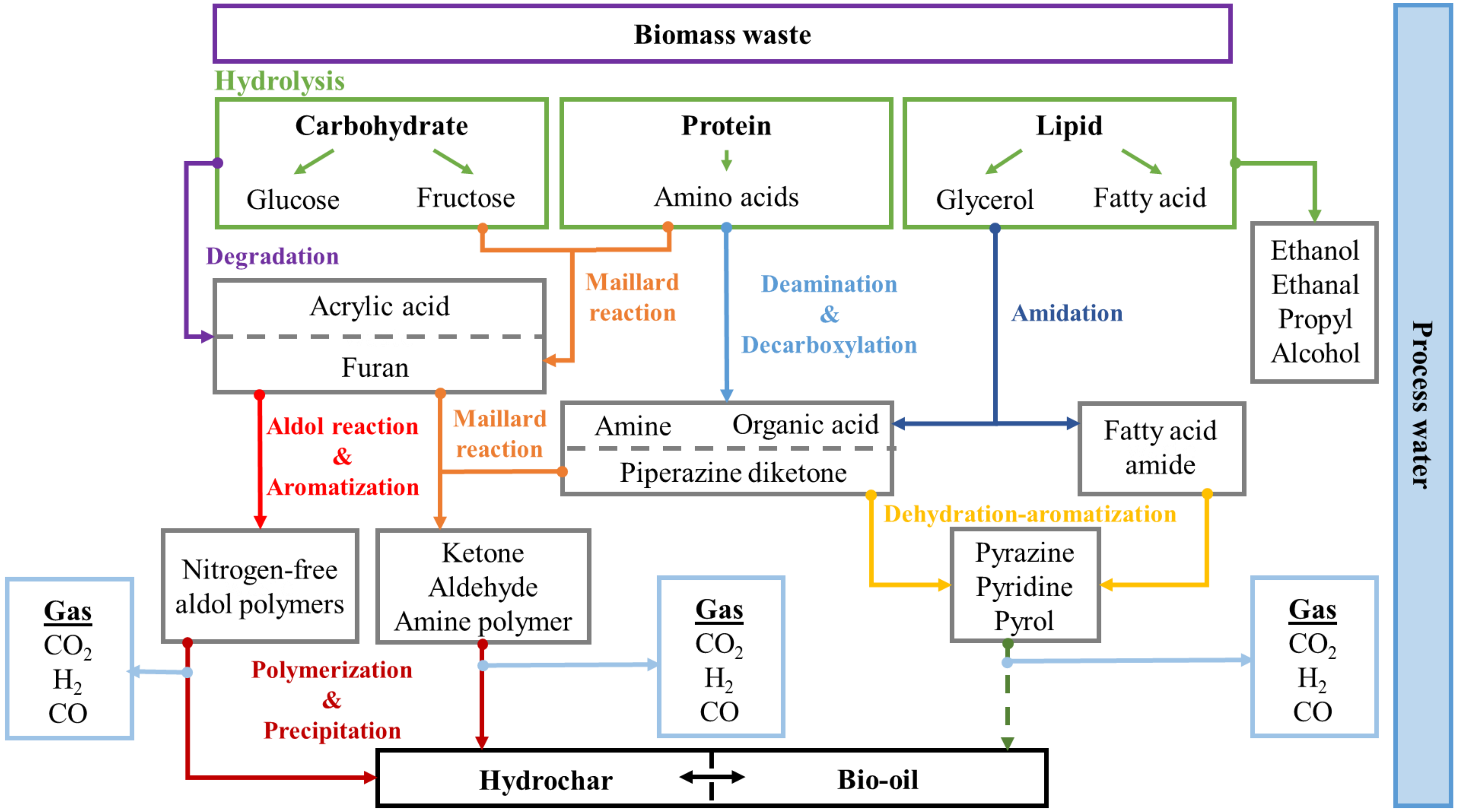
Food waste

Biomass waste: problem or resource?

Lignocellulosic waste

Swine manure


Biomass wastes
Hydrochar (HC)
Process water (PW)
Gas
Thermochemical process
T = 180 – 250 ºC
t = 5 – 60 min
Autogenerated pressure
> 40% moisture content


Biomass waste
Hydrolysis
Carbohydrate
Glucose
Fructose
Protein
Amino acids
Lipid
Glycerol
Fatty acid
Degradation
Maillard reaction
Deamination & Decarboxylation
Amidation
Ethanol
Ethanal
Propyl Alcohol
Acrylic acid
Furan
Amine
Organic acid
Piperazine diketone
Fatty acid amide
Aldol reaction & Aromatization
Maillard reaction
Dehydration-aromatization
Nitrogen-free aldol polymers
Ketone
Aldehyde
Amine polymer
Pyrazine
Pyridine
Pyrol
Gas
CO_2
H_2
CO
Gas
CO_2
H_2
CO
Gas
CO_2
H_2
CO
Polymerization & Precipitation
Hydrochar
Bio-oil
Process water

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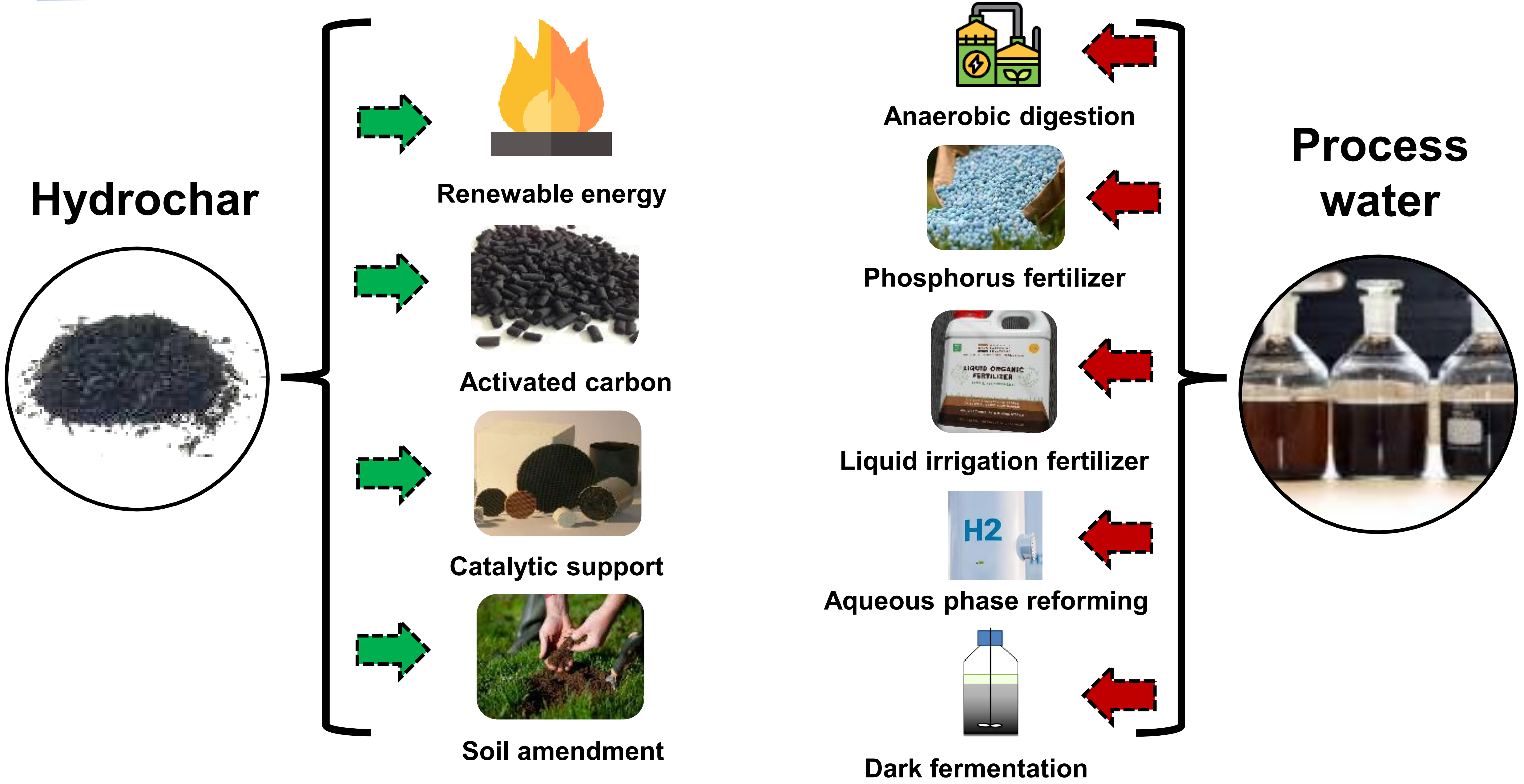

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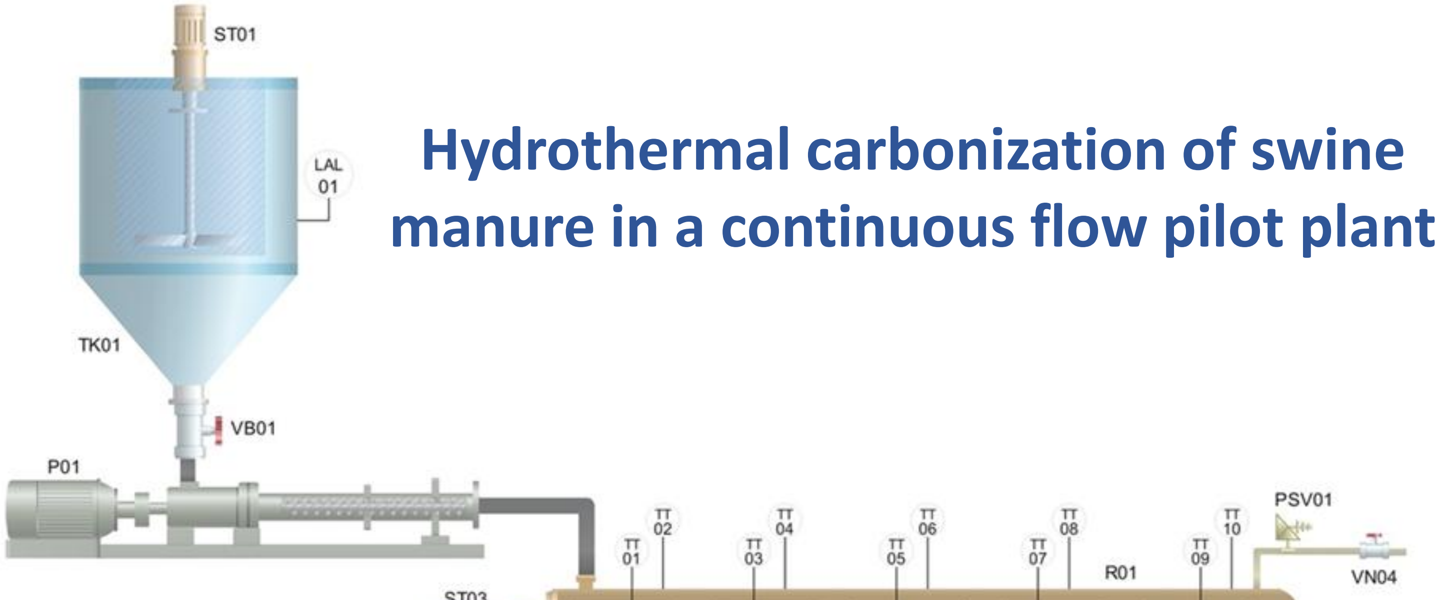
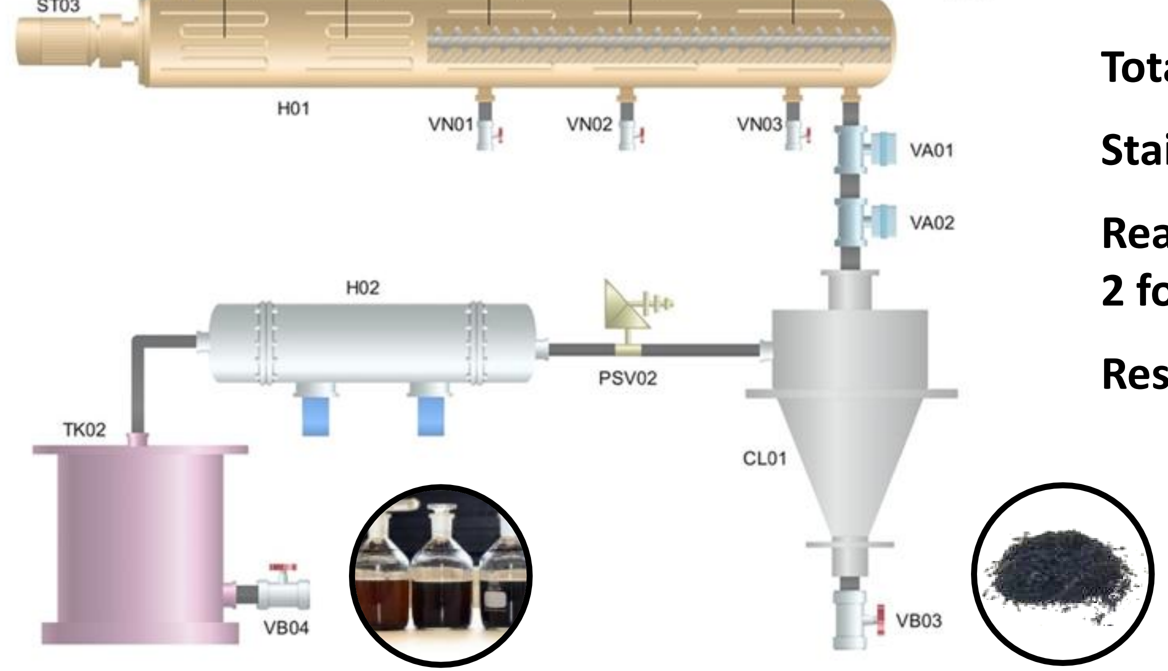
Hydrothermal carbonization of swine manure in a continuous flow pilot plant

Universidad Autónoma de Madrid

ARQUIMEA AGROTECH

PID Eng&Tech
www.pidengtech.com





Description	Name
ST01,03	Stirrer
LAL01	Level sensor
TK01	Feed tank
P01	Feed pump
VB01,03,04	Block Valve
TT01,03,05,07,09	Internal thermocouple
TT02,04,06,08,10	External thermocouple
R01	HTC reactor
PSV01,02	Safety pressure valve
VN01,02,03,04	Control Valve
H01,02	Heat exchanger
VA01,02	Isolation Valve
CL01	Cyclone
TK02	Process water tank

Total solids content 5%

Stainless steel tube R = 6 cm

Reactor divided into 5 zones:
2 for preheating and 3 for reaction

Residence time: 45 min

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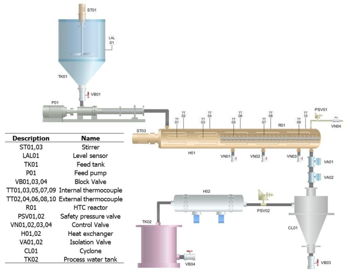
	Name
1	Feed tank
2	Feed tank agitator
3	Feed pump
4	Reactor
5	Decompression valve
6	Hydrocyclone
7	Water collection tank
8	Compressor
9	Centrifugal pump
10	IBC agitator
11	Storage IBC
12	Cooler

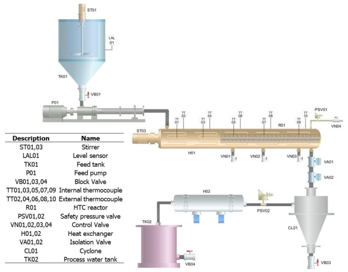
UAM Universidad Autónoma de Madrid

Characterization of dehydrated swine manure (d.b .)

		Element content (g/kg)		Heavy metals (mg/kg)	
FC (%)	14.4 (0.9)	Al	0.5 (0.2)	Cr	7.2 (0.5)
VM (%)	75.5 (0.3)	Ca	15.4 (1.0)	Cu	64.6 (4.9)
Ash (%)	10.0 (0.6)	Fe	1.0 (0.0)	Ni	4.9 (0.8)
C (%)	44.5 (0.8)	K	4.0 (1.0)	Pb	1.1 (0.3)
N (%)	1.4 (0.1)	Mg	2.5 (0.5)	Si	0.5 (0.3)
S (%)	0.5 (0.1)	Na	1.2 (0.4)	Zn	313.3 (8.2)
HHV (MJ/kg)	17.7 (0.7)	P	6.7 (2.2)		



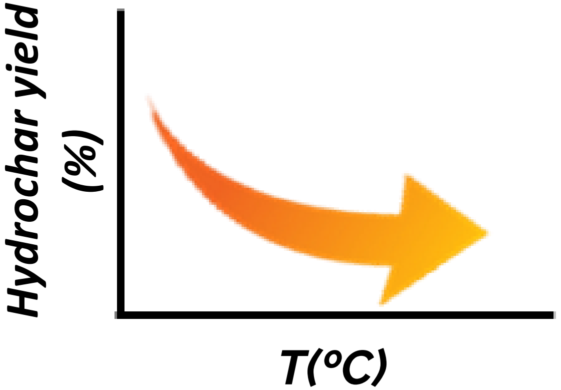
Hydrochar

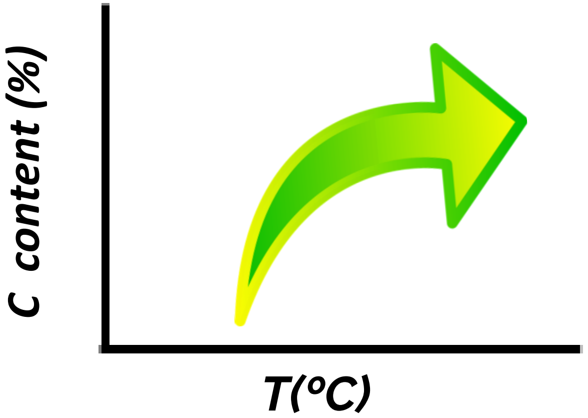


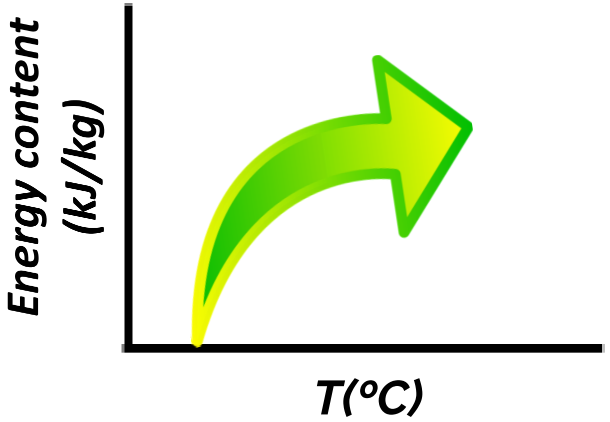
Hydrochar

Main characteristics of hydrochar

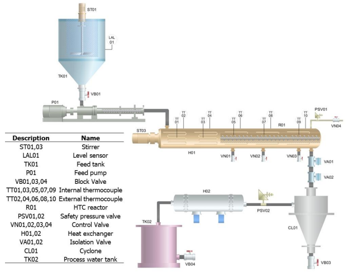
T (ºC)	SM	HC-180	HC-210	HC-230	HC-250
Yield (wt.%)	-	71.8	52.4	46.2	22.7
C (wt.%)	45.0	47.1	50.4	51.5	51.7
N (wt.%)	1.4	0.8	1.6	1.4	1.2
S (wt.%)	0.5	0.3	0.4	0.3	0.4
Ash (wt.%)	10.5	3.5	3.7	3.9	3.9
HHV (MJ/kg)	18.5	18.8	20.3	20.7	20.9





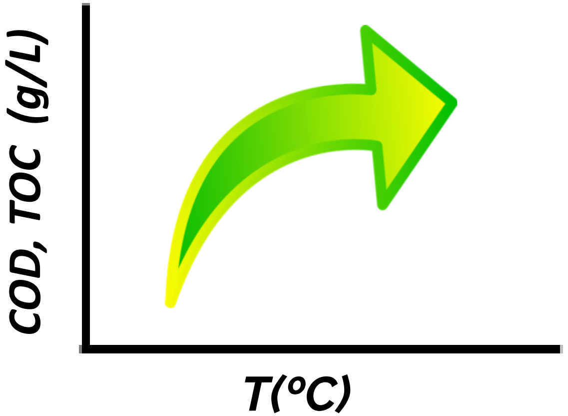


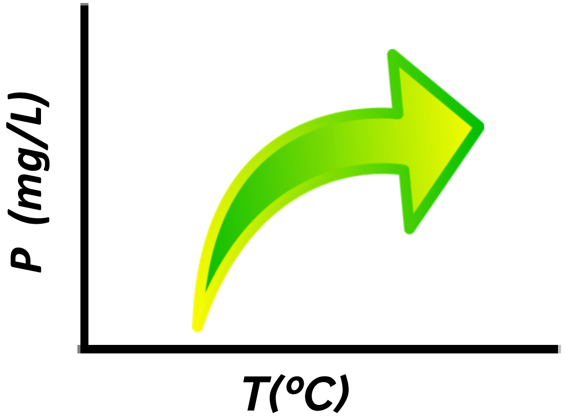
Main characteristics of process water

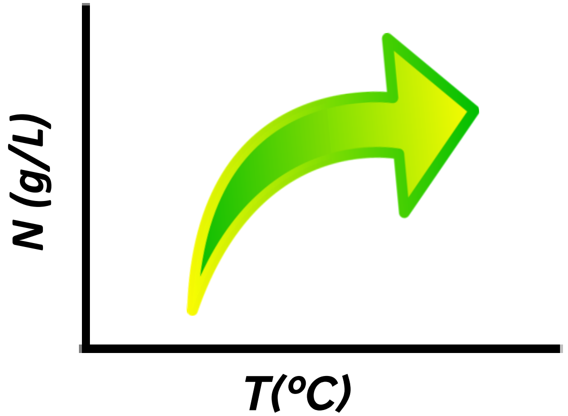


Process water

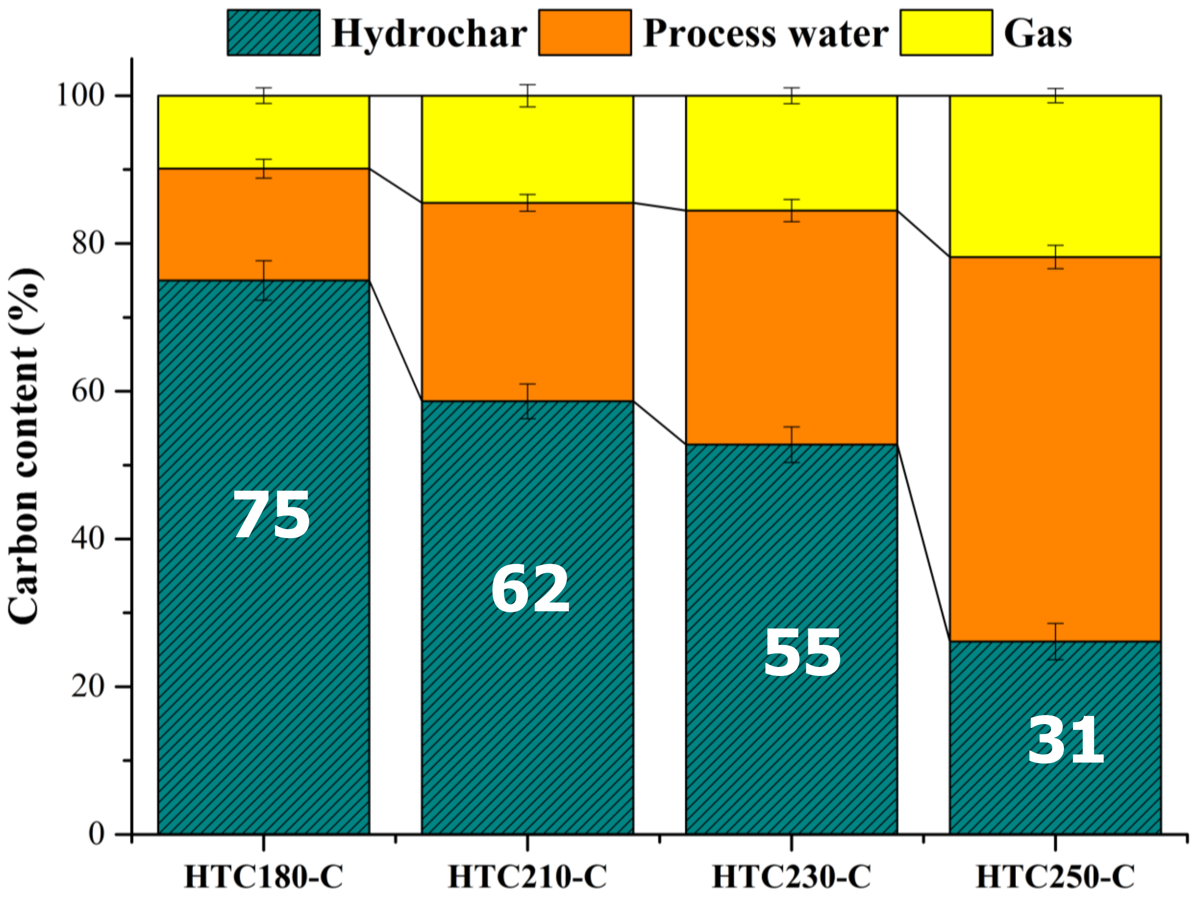
	PW180	PW210	PW230	PW250
SCOD (g/L)	6.5	10.2	11.0	12.6
TOC (g/L)	3.5	6.1	7.2	11.0
PO_4-P (mg/L)	60.0	68.8	73.0	99.5
TN (mg/L)	173.0	267.0	294.0	338.8
NH_4-N (mg L)	98.0	98.0	168.0	185.6



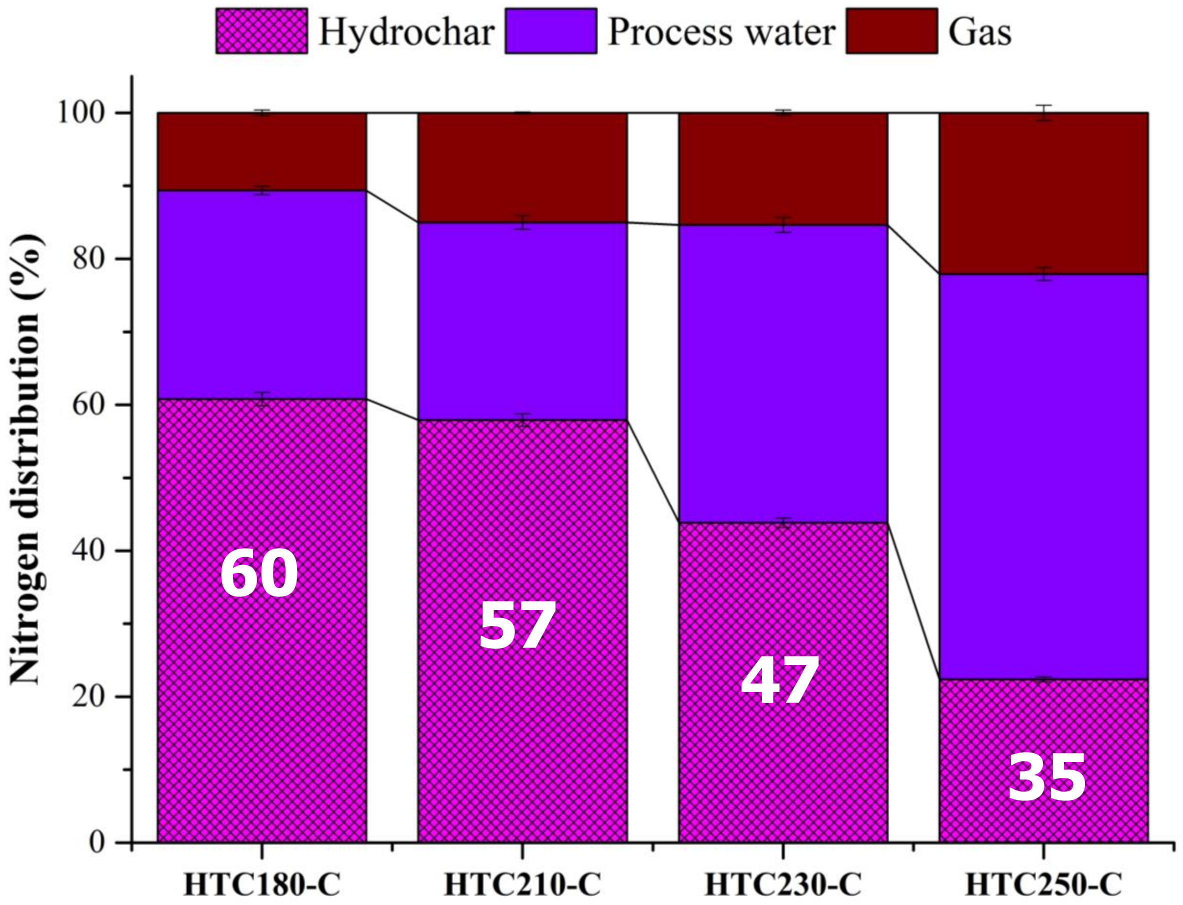




Fate of Carbon



Fate of Nitrogen



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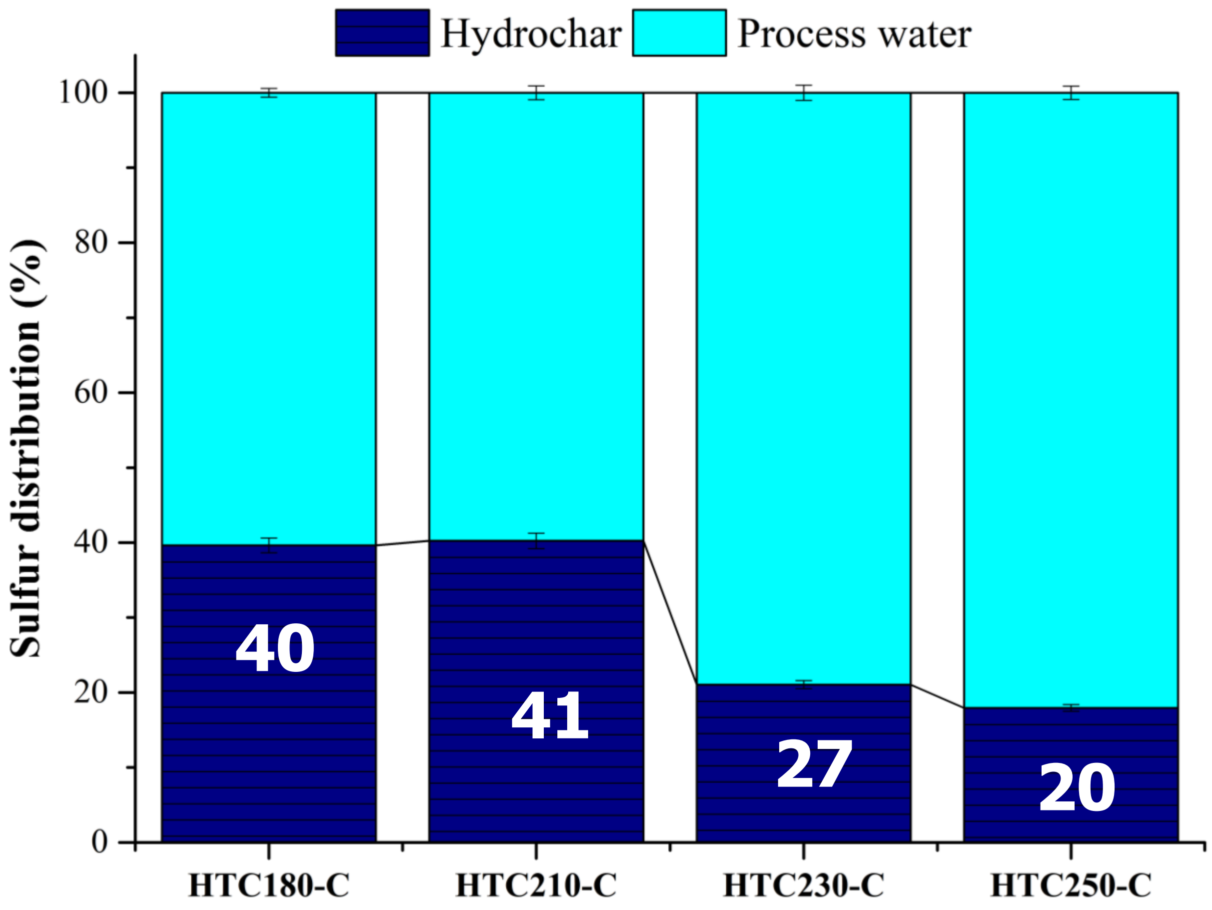
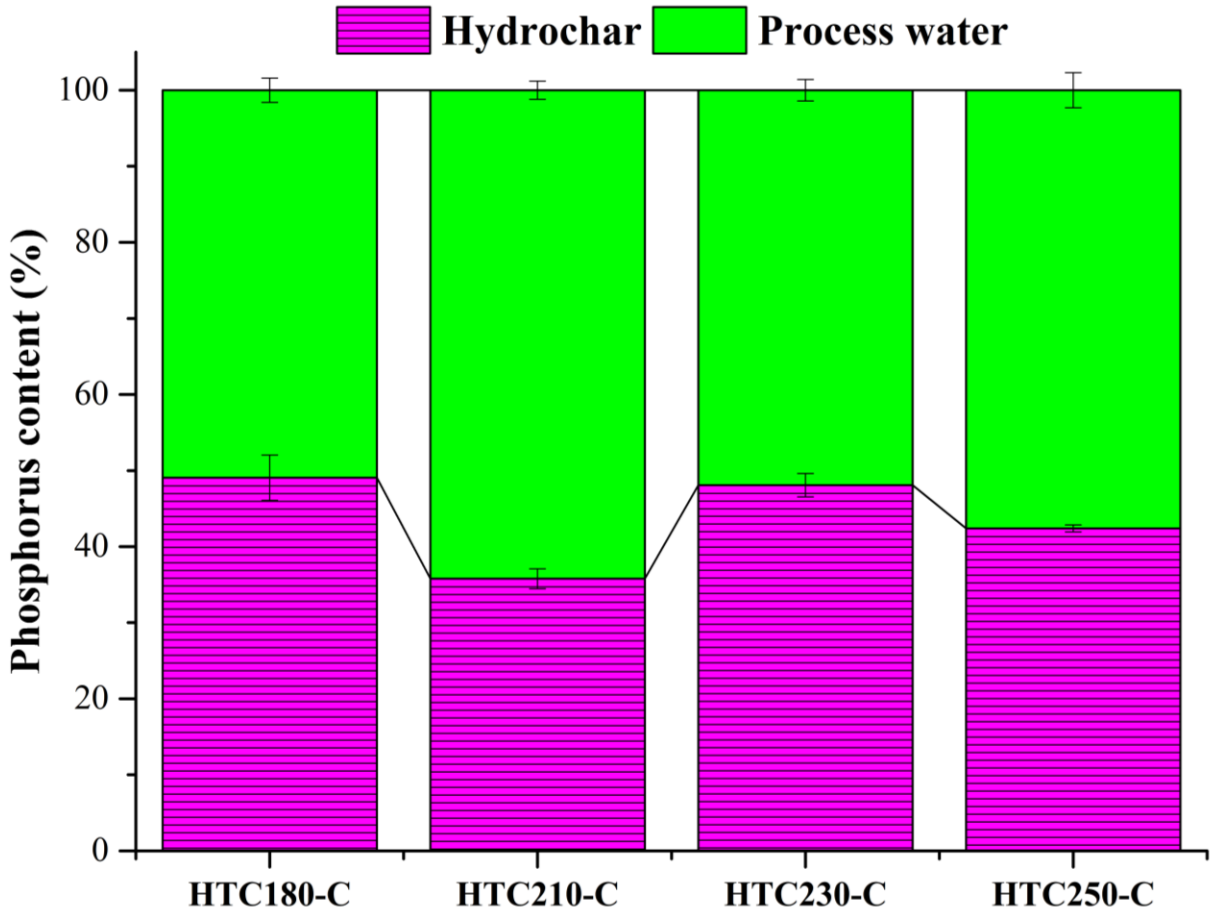
Fate of Sulfur

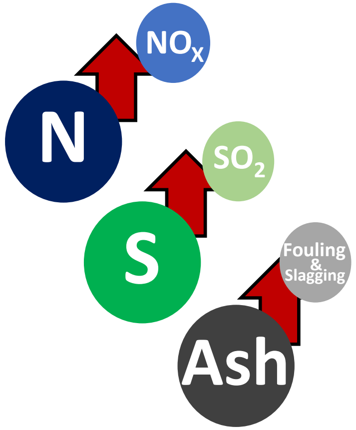


Fate of Phosphorous



Hydrochar as solid biofuel

ISO 17225
Graded thermally treated and densified biomass fuels



N (%)	S (%)	VM (%)	Ash (%)	HHV (MJ/kg)
< 3	< 0.5	< 75	< 20	> 17

Hydrochar as soil amendment

European Commission

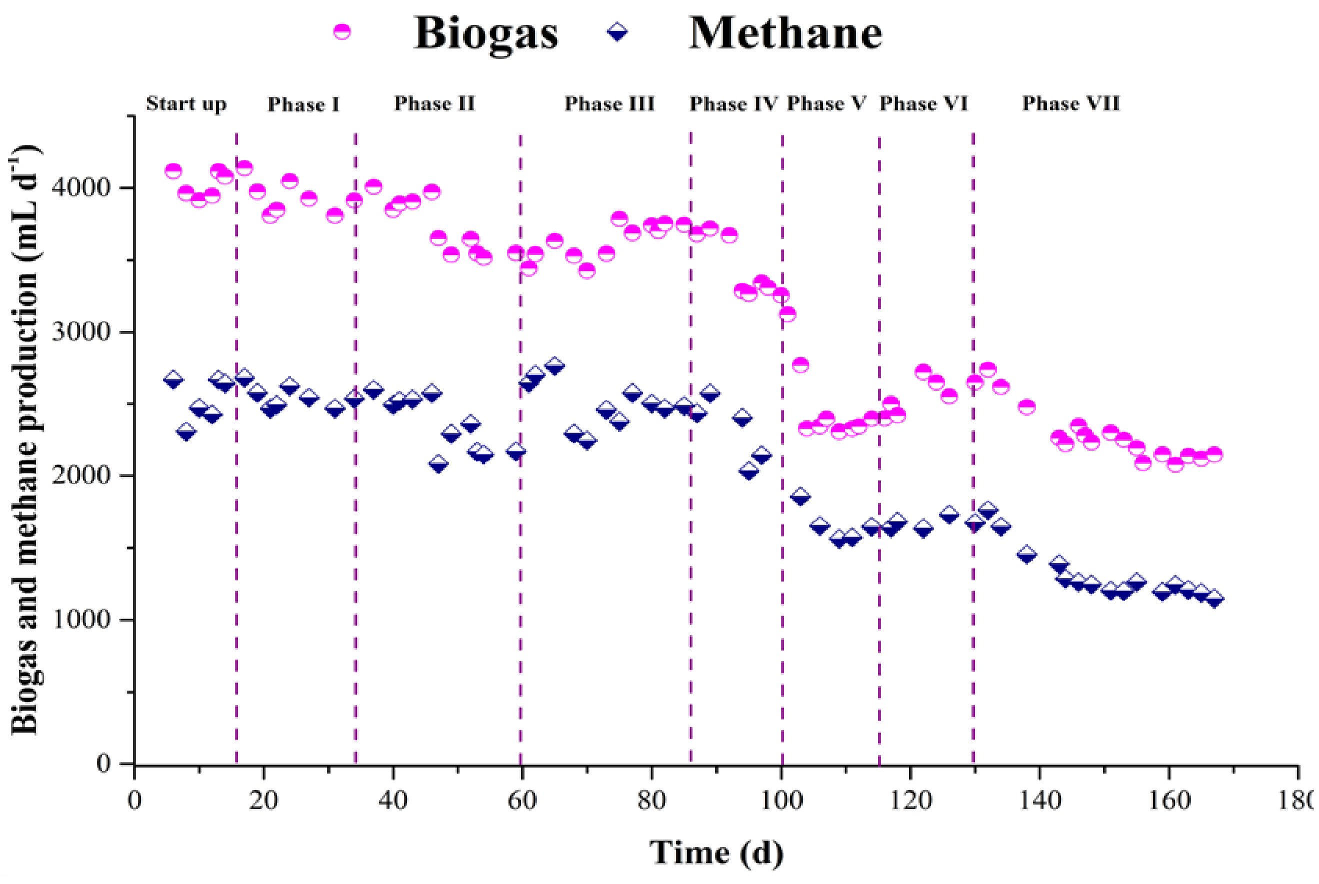
EU 2015/2099

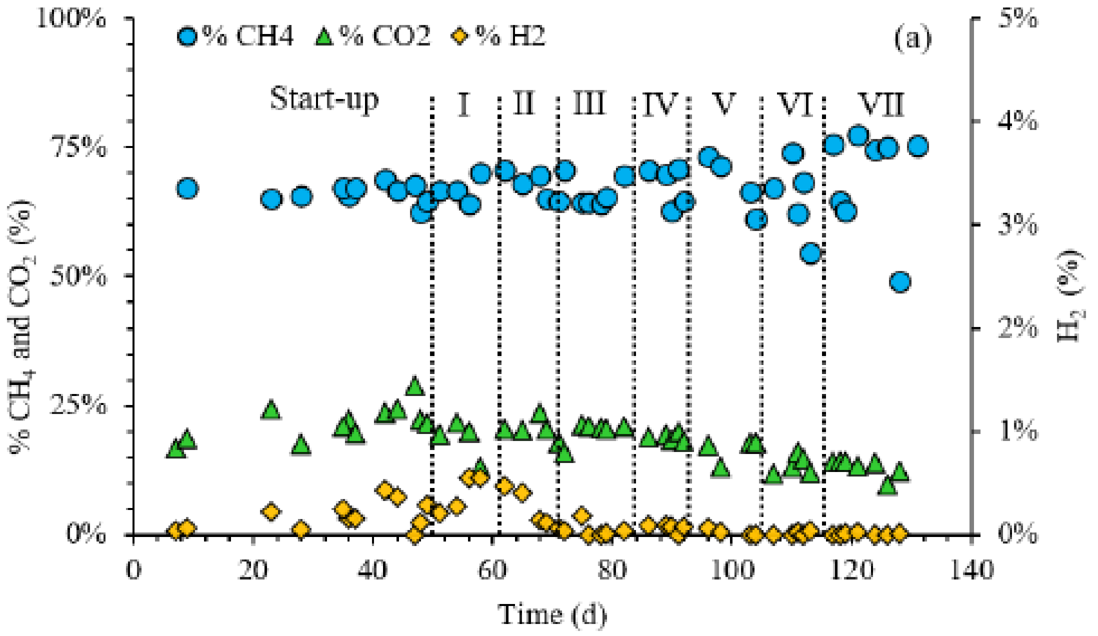
(mg kg^{-1})	HC-C
Cd	< 3
Cr	< 150
Cu	100
Ni	< 90
Pb	< 150
Zn	< 800

Anaerobic digestion of process water

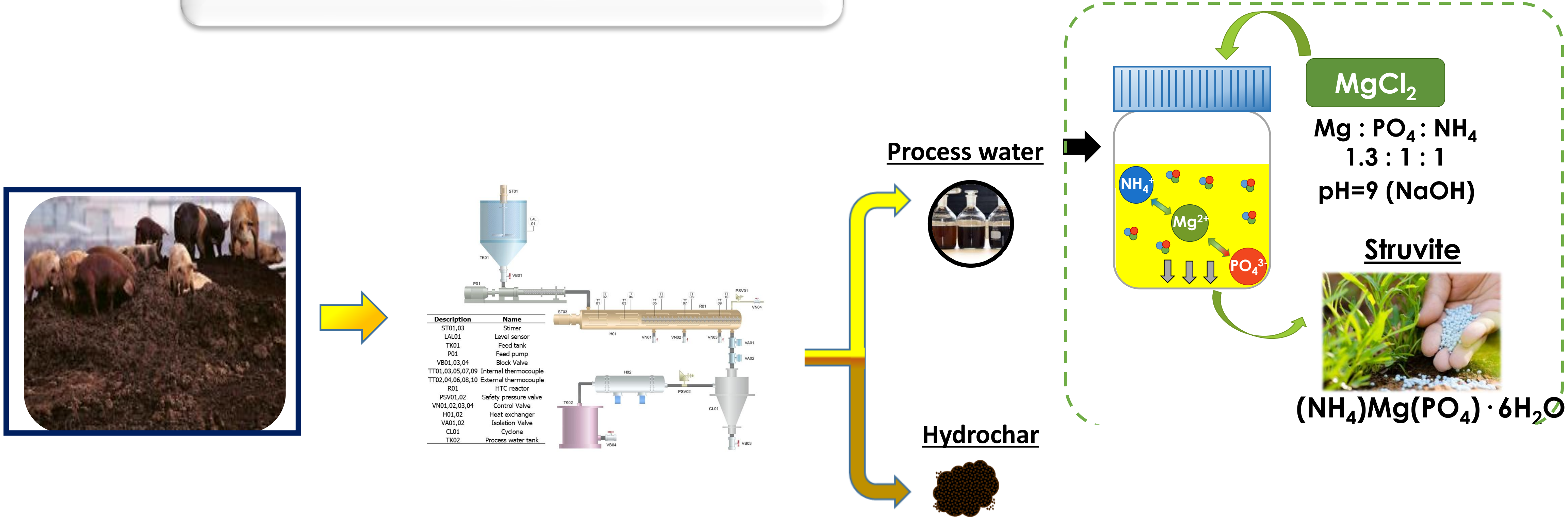
UASB
Mesophilic Conditions

Phase	Time (d)	PW/G (on a COD basis)
Startup	1 – 17	0/100
I	18 – 33	10/90
II	34 – 60	20/80
III	61 – 87	30/70
IV	88 – 100	40/60
V	101 – 117	50/50
VI	118 – 124	60/40
VII	125 – 145	75/25





Phosphorous recovery

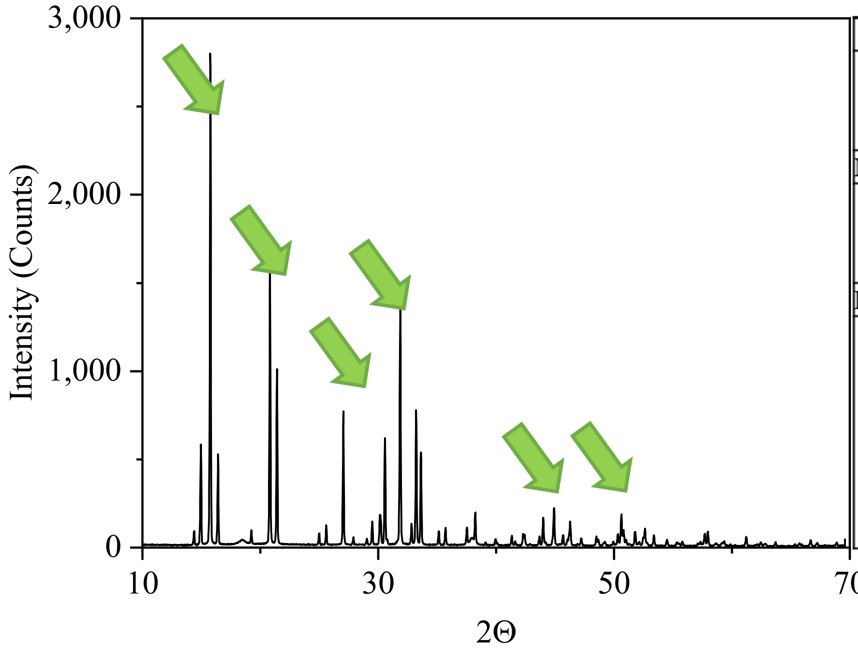


Phosphorous recovery

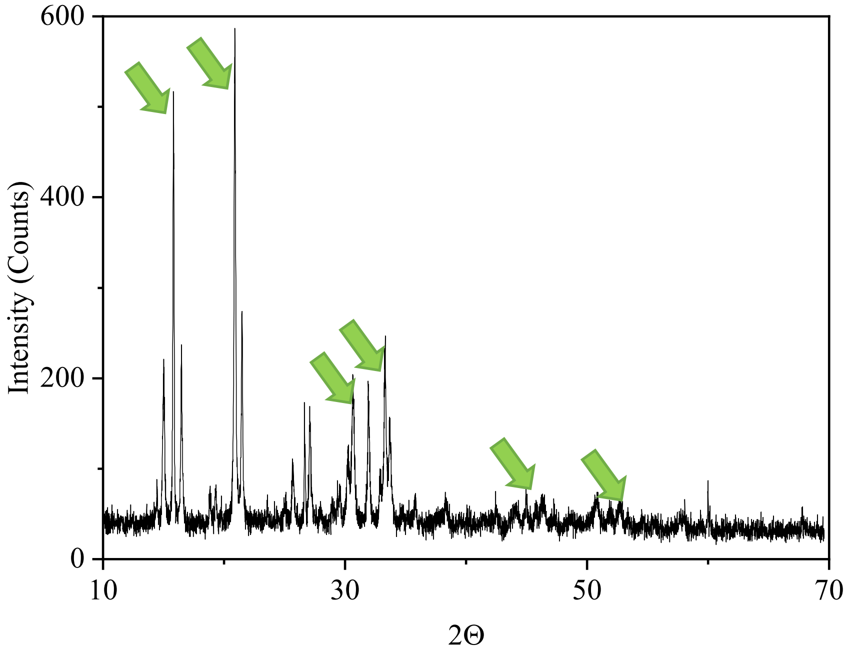
Precipitate
from process water
from HTC at 250 °C

Commercial Struvite

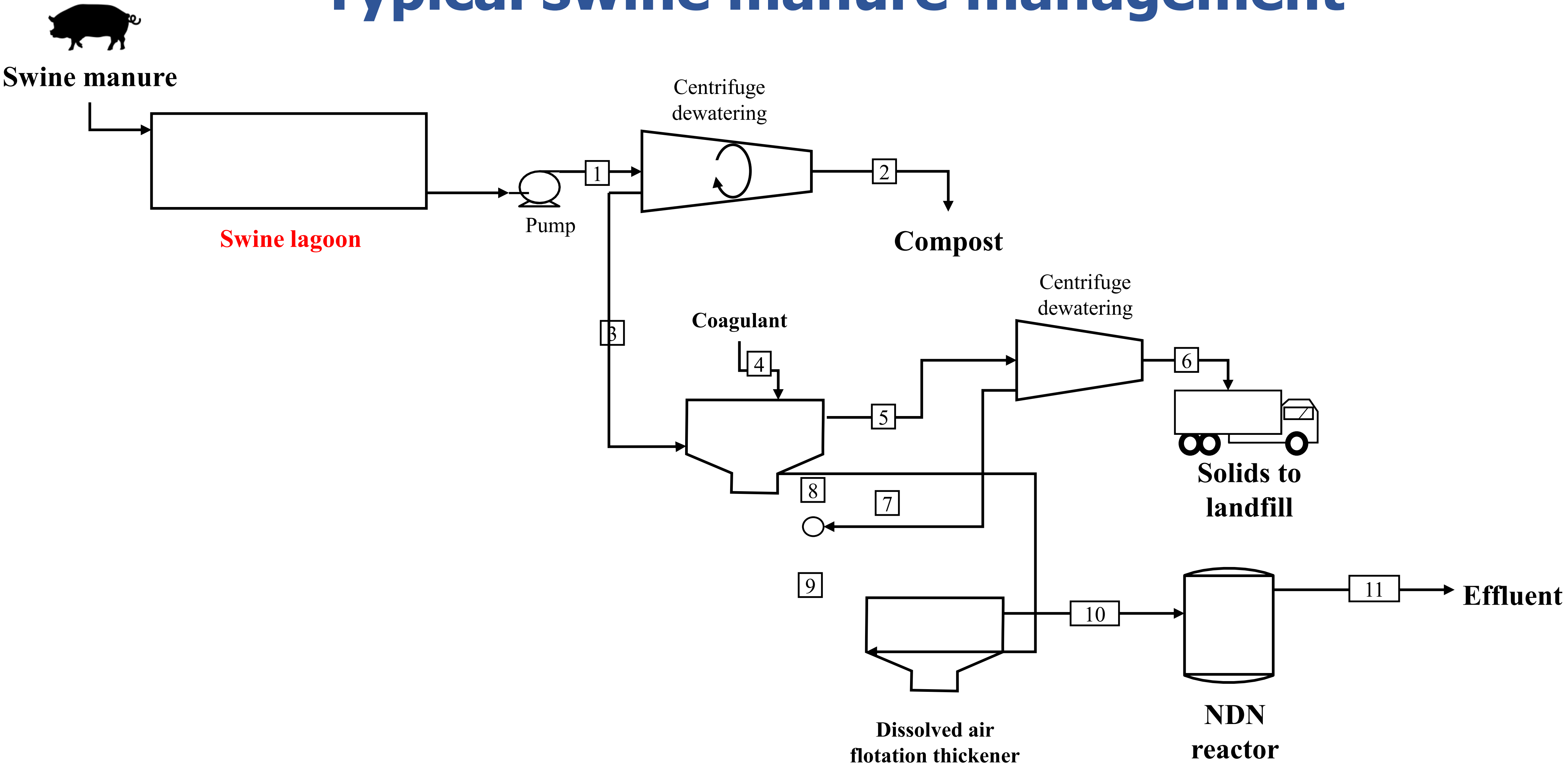
$(NH_4)MgPO_4 \cdot 6H_2O$



Nutrient (g/kg)	Solid
N	93.3
P	164.4
K	5.5
Mineral metals (g/kg)	
Ca	73.2
Mg	123.8
Na	4.1
Heavy metals (mg/kg)	
Cd	2.4
Cr	32.2
Cu	2.9
Ni	6.4
Pb	8.1
Si	91.2
Zn	271.2



Typical swine manure management



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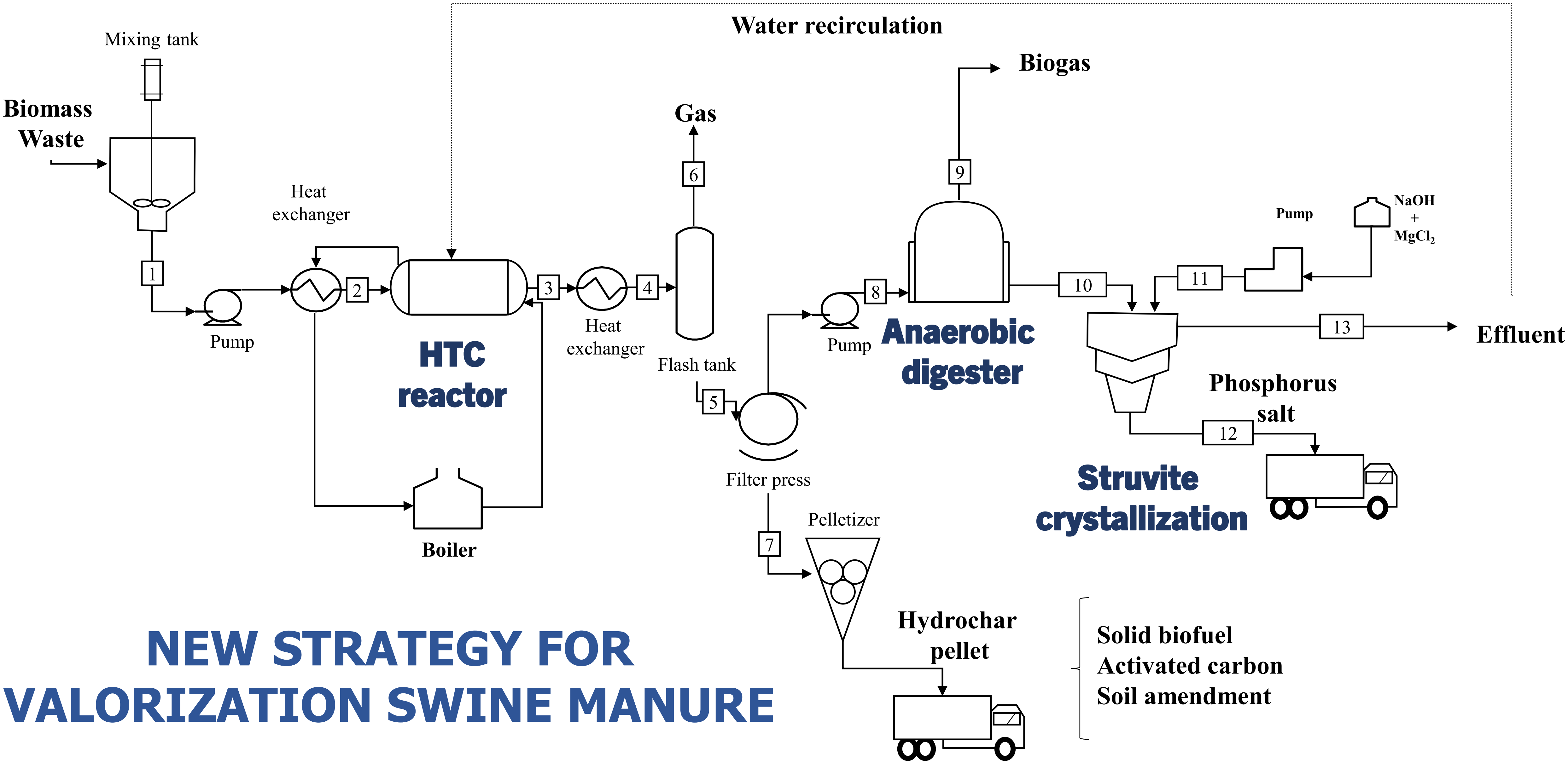

NEW STRATEGY FOR VALORIZATION SWINE MANURE

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GOBIERNO DE ESPAÑA | MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD

ACTIVACHAR (CTM2016-76564-R)

WASTEVALOR (PID2019-108445RB-I00)

VALIDAWASTE (PDC2021-120755-I00)

SLUDGEVALOR (TED2021-130287B-I00)

HYDROWASTE (PID2022-138632OB-I00)

BIO3 | BIVALIA BIORREFINERÍAS INTEGRADAS

BIOTRES-CM (S2018/EMT-4344)

BIVALIA-CM (TEC-2024/BIO-177)

ABENGOA

EPS PREDATION

ZOITECH lab | GEXMAN S.L.

MICROBAGUA19

VALPURIN20

MICROEDA20

ARQUIMEA AGROTECH | KERBEST Agropecuaria la Serrota.

TECAGROP21

PLAPURIN21

ENRIABON22

APROAGUA22

TRAPURÍN22

FERTIECO23

Santander | UAM

UAM-Santander

Chile (CEAL/2015-29) EE.UU (2017/EEUU/07)

Doctorado Industrial 2019 (IND2019/AMB-17092)

Doctorado Industrial 2023 IND2023/AMB-27285

ECONWARD TECH

BMP-AD23

RUMBO VERDE

BMP-AD24

NSF

NEWIR Manure (NSF#CBET-1856009)

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FUAM Fundación Universidad Autónoma de Madrid

CAITEC Centro de Apoyo a la Innovación y Transferencia del Conocimiento

sorpi

MATRECOM24

Programas de Transferencia UAM (2019; 2020; 2021; 2023; 2024)

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WASTE2VALUE

Providing solutions for waste management in a circular economy framework

Waste2Value

https://wastevalue.es/

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