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HYDROTHERMAL CONVERSION OF INDUSTRIAL BIOGENIC RESIDUES INTO INTERMEDIATE BIOENERGY CARRIERS

RESULTS FROM THE **F-CUBED PROJECT**

F-CUBED

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 884226.

BIOGAS RECOVERY FROM THE FILTRATES OF HYDROTHERMALLY-TREATED WET RESIDUE STREAMS

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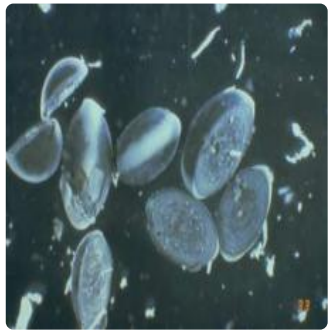
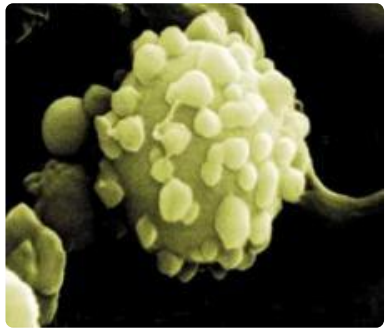
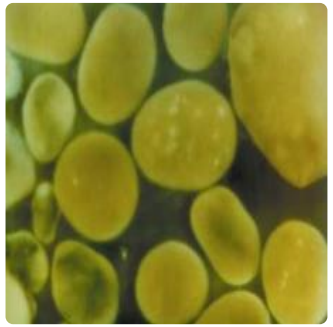
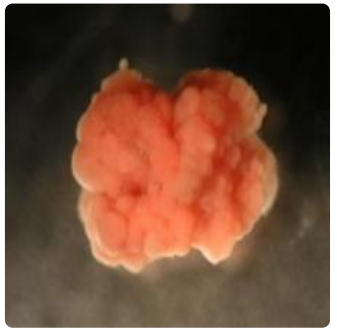
Paques develops, designs and builds industrial installations

Paques is a Global company with its origin (1960) and headquarters in Balk, The Netherlands.

Paques uses natural biotechnology to treat wastewaters

Inspired by nature, using natural micro-organisms:

Industrial scale installations for waste water and biogas treatment:

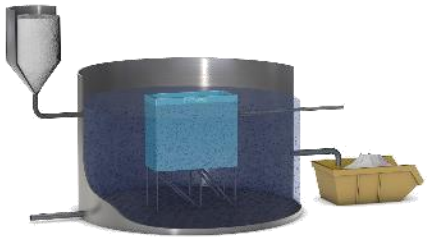
biogas production

BIOPAQ®ICX

biogas desulphurisation

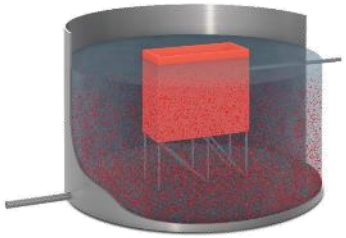
THIOPAQ®

phosphate recovery



PHOSPAQ™

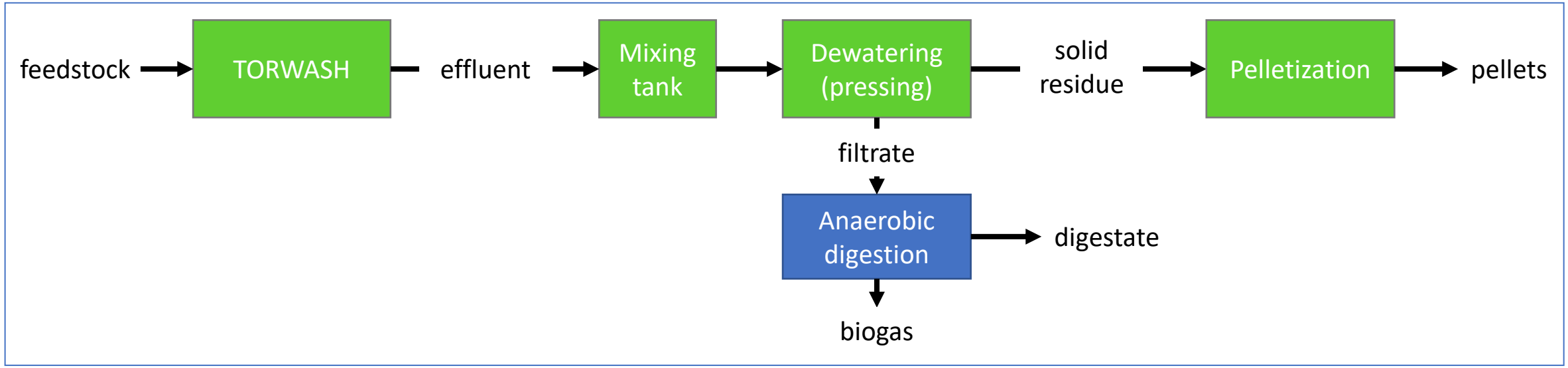
ammonium removal



ANAMMOX®

Biogas recovery in the F-CUBED project

- Biogas production in the F-CUBED process scheme:



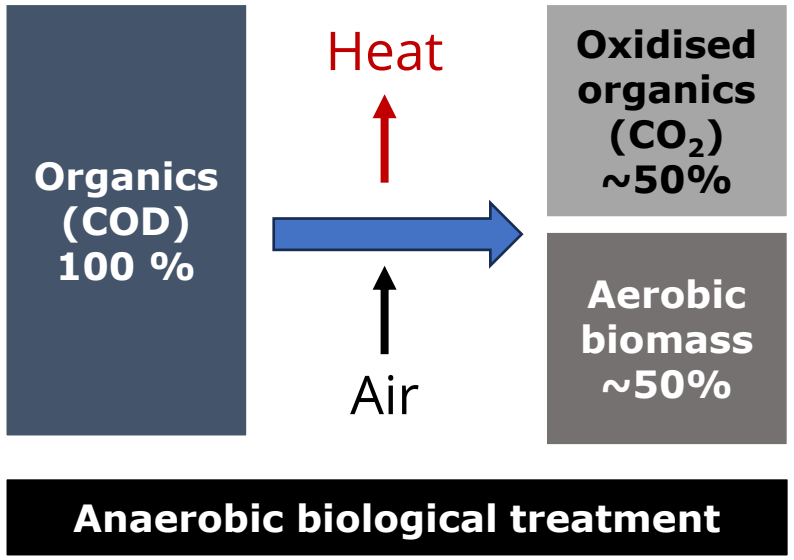
- Feasibility of biogas production by anaerobic treatment of dewatering filtrates:

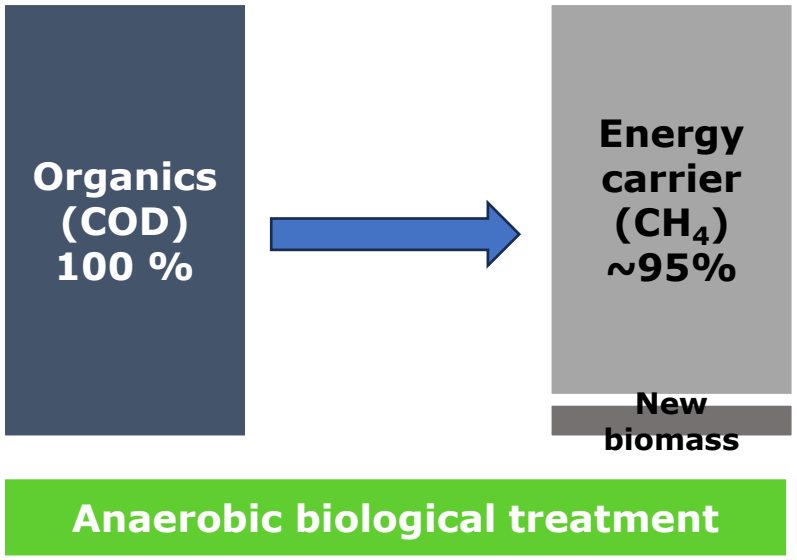
Paper sludge Olive pomace Orange pomace

- Design of industrial scale installation to treat these filtrates.

Why biogas recovery from filtrates?

- Filtrates require treatment before safe disposal is possible
- Biological treatment of the filtrates can be done aerobically or anaerobically:
  - Anaerobic treatment converts the organics into the methane
  - Methane is recovered as biogas from the anaerobic treatment installation





- Additional benefits anaerobic treatment:
  - lower energy consumption (no energy needed for air input)
  - lower excess biomass production, lower biomass processing costs

Biogas recovery in the F-CUBED project

Method for measuring anaerobic degradability

Biogas production in time with OxiTop set-up.

- Anaerobic micro-organisms added as granular biomass.
- Soluble COD measured at start & end of test.
- pH adjustment.
- Check on availability of (micro)nutrients.

By measuring the start and end COD concentrations, the anaerobic biodegradability can be calculated.

The biogas potential follows from the amount of produced biogas in the test.

Characteristics of the tested filtrates

Filtrates from three different residues were tested for their anaerobic biodegradability:

Sample		Residue	Work Package	COD (g/L)	Total N (mg N/L)	NH_4^+ (mg N/L)	PO_4^{3-} (mg P/L)
1		Paper sludge	WP2	11.04	947.4	42.9	14.0
2		Paper sludge	WP2	10.42	787.4	101.3	33.0
3		Olive pomace	WP3	29.3	301	0.119	75.6
4		Olive pomace	WP3	31.9	318	0.099	78.9
5		Orange pomace	WP4	44.98	419.8	0.1	24.1

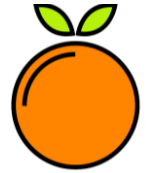
Sufficient nitrogen & phosphorus are present in the filtrate to allow for anaerobic biological treatment.

Biogas evolution in batch anaerobic assays

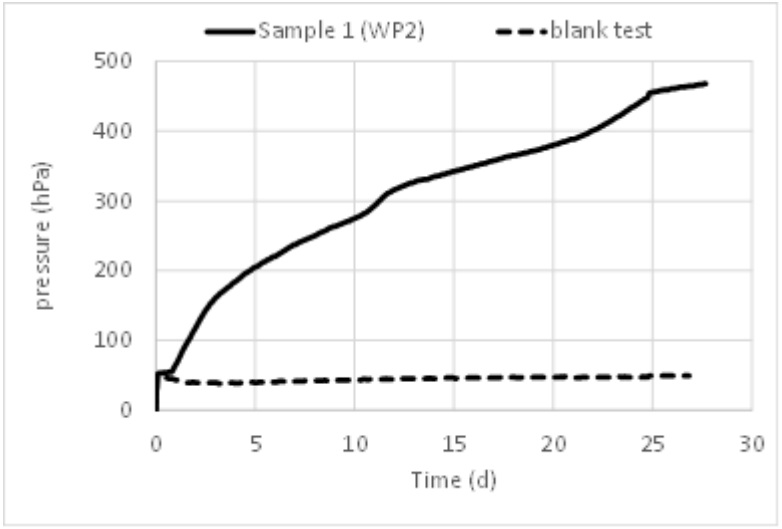
Typical biogas production curves for the filtrates from the three different substrates

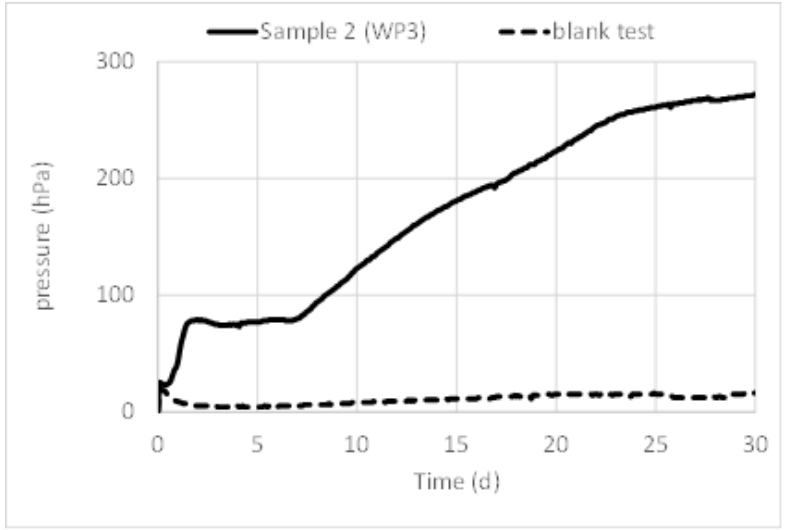
Paper sludge filtrate

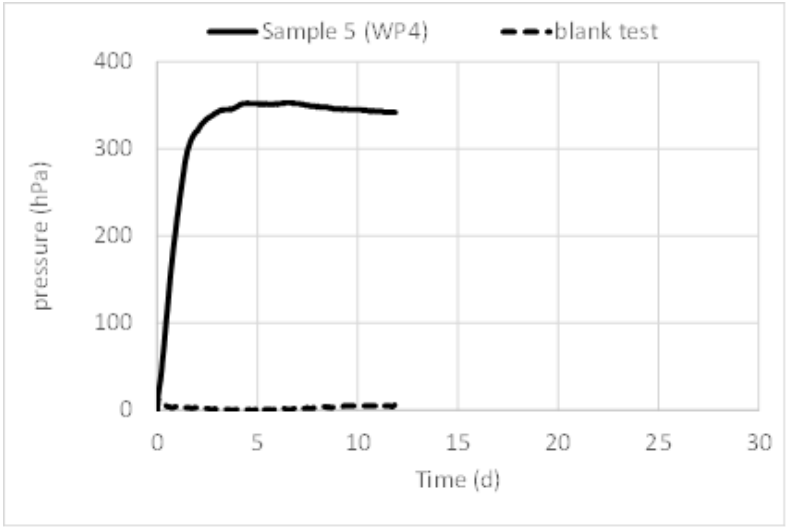
Olive pomace filtrate



Orange pomace filtrate







Anaerobic biodegradability test results

Sample		Residue	Work Package	Anaerobic biodegradability (%)	Biogas production (Nm^3 CH_4 per m^3 of filtrate)	Biogas production (Nm^3 CH_4 per kg of $COD_{filtrate}$)
1		Paper sludge	WP2	62	2.04	0.22
2		Paper sludge	WP2	63	2.51	0.22
3		Olive pomace	WP3	54	5.43	0.19
4		Olive pomace	WP3	60	6.04	0.21
5		Orange pomace	WP4	77	12.2	0.27

54 – 77 % of the organics in these filtrates can be converted to biogas

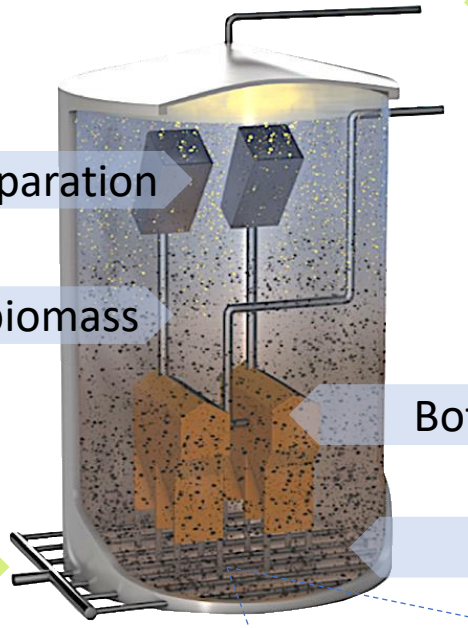
Design of an industrial scale anaerobic installation

- The results from the anaerobic biodegradability tests are needed to design an industrial scale installation.
- Representative filtrate flows are defined.
- Basis of design for industrial scale anaerobic treatment:

	Residue	**Filtrate flow** (ton/h)	**Filtrate COD** (g/L)	**Filtrate COD load** (kg/d)	**Anaerobic biodegradability** (%)	**Filtrate temperature** (°C)
	Paper sludge	2.4	98.7	5,685	62	35
	Olive pomace	47.6	28.9	33,015	57	35
	Orange pomace	3.4	45.0	3,672	77	35

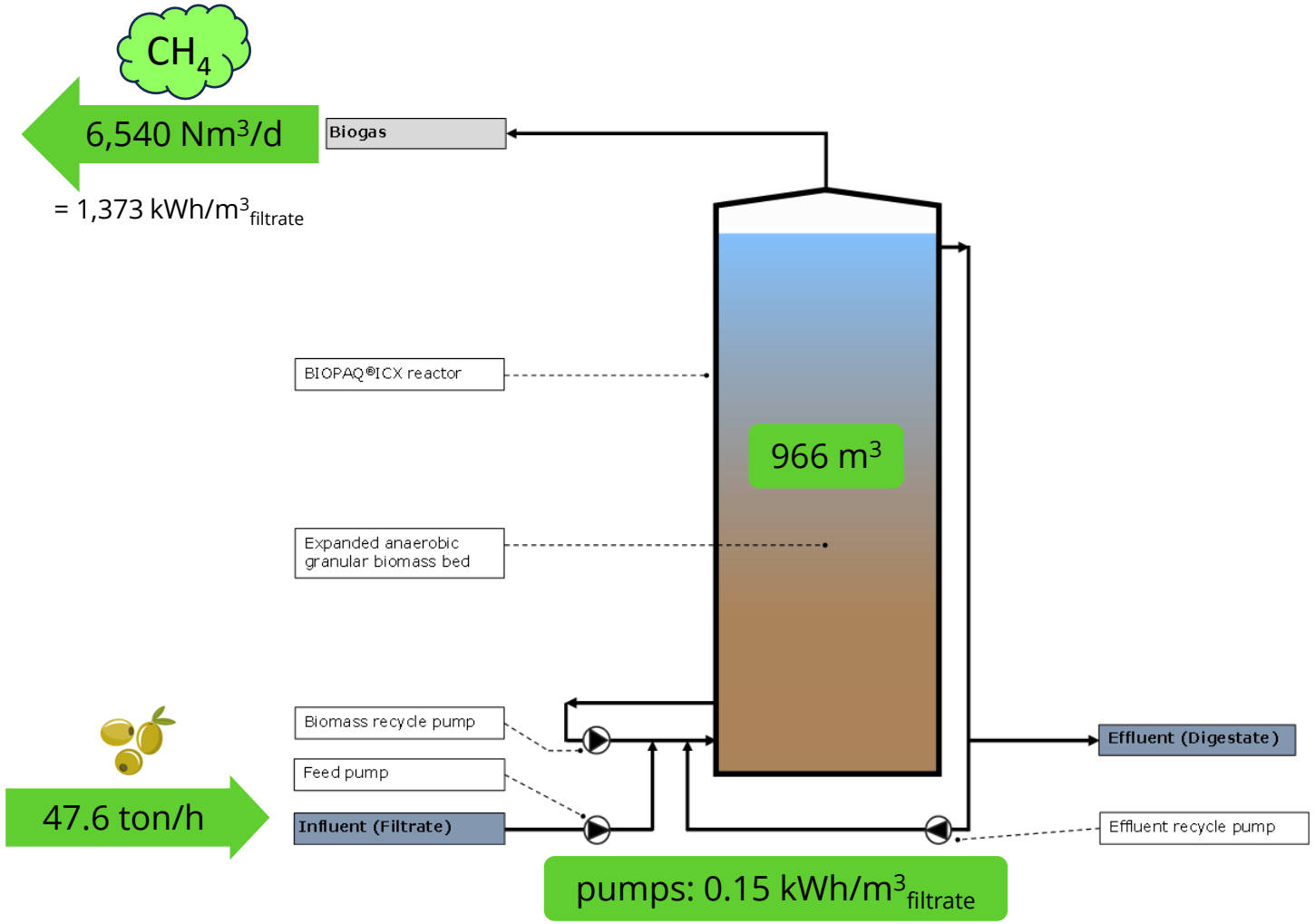
High rate anaerobic treatment installation

- High rate treatment = high treatment capacity in a small reactor volume.
- Granular anaerobic biomass = key for achieving high rate conversion rates.



Anaerobic treatment of Olive pomace filtrate

Anaerobic treatment in a Paques BIOPAQ®ICX reactor



Rough overall energy balance:

kWh/$m^3_{filtrate}$	
- 0.15	Energy consumed by pumps
57.25	Energy output, biogas (CH_4)
57.1	**Net energy output**

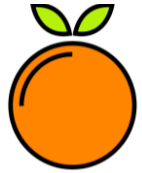
This energy contributes positively towards the overall energy balance of the F-CUBED process !

Overview of anaerobic treatment of residues

	Residue	Filtrate flow (ton/h)	Reactor volume (m^3)	Power consumption ($kWh/m^3_{filtrate}$)	Methane production ($Nm^3/m^3_{filtrate}$)	Net energy output ($kWh/m^3_{filtrate}$)
	Paper sludge	2.4	201	0.81	1,240	215
	Olive pomace	47.6	966	0.15	6,540	57.1
	Orange pomace	3.4	201	0.60	990	120

Conclusions on biogas recovery from filtrates





- ✓ Filtrates from all three residues showed good anaerobic biodegradability of 54-77 %
- ✓ Filtrates from all three residues contain sufficient nutrients to sustain anaerobic biological conversion.
- ✓ Design of industrial scale anaerobic installations showed that treatment of each filtrate will generate an excess of energy.
- ✓ The excess energy can be used in other process steps of the F-CUBED process.

THANK YOU

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