A sustainable solution for pig manure treatment: Environmental compliance with the Integrated Pollution Prevention and Control directive (PIGMAN)

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Cost EU project - Partners

List of partners with co-ordinator first

	Partner	Acronym	land	role
1	Wasteman Ltd	WasteMan	CY	SME
2	Fa Knoops	Knoops	NL	SME
3	Rol-Kon Grupa	ROLKON	PL	SME
4	Hegndal svineproduktion A/S	Hegndal	DK	SME
5	A. Kailas & Sons Ltd	Kailas	CY	SME
6	Lahav Institute of animal research	LIANRES	IL	SME
7	Univ LabMET	LABMET	BE	RTD
8	Environment & Resources, Tech Univ Denmark	E&R DTU	DK	RTD
9	Adviesburo voor milieutechniek Colsen BV	Colsen	NL	RTD
10	SELOR eeig	SELOR	NL	RTD
11	Department of Biological Applications and Technologies, University of Ioannina	ABUOI	GR	RTD

Main environmental problems caused by pig manure

- Contamination soil and ground water
- Contamination surface water
- Emission of green house gasses (carbon dioxide and methane)
- Emission of ammonia gas (acidification)
- Odour emission

Pig manure on Cyprus

Sludge cleaning (KIBUTZ LAHAV-Israel)

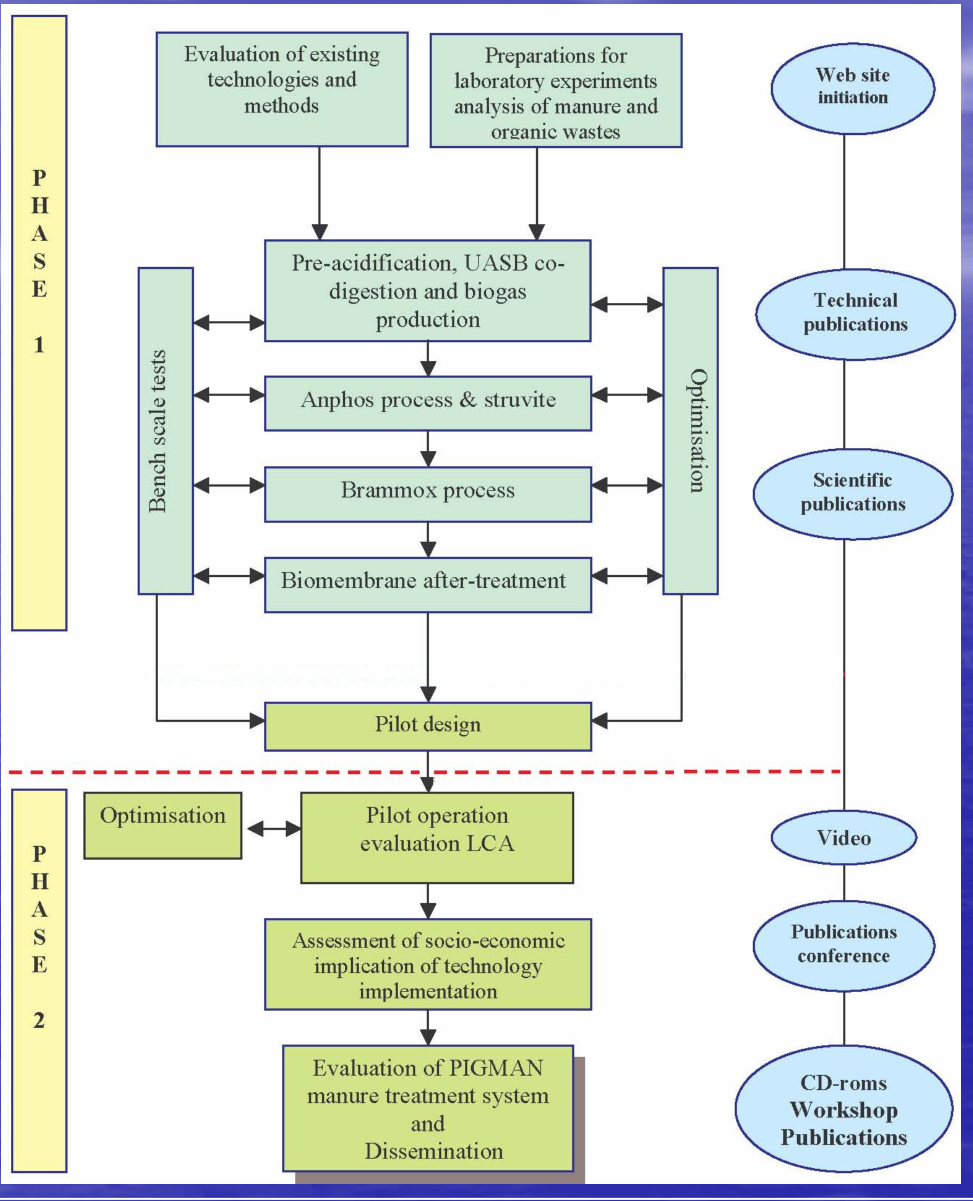
- Total swine manure 70,000 m^3/year,
- 2 settling pond (4,000 m^3)
- Sludge cleaning every year – 4,000 m^3

Main objective

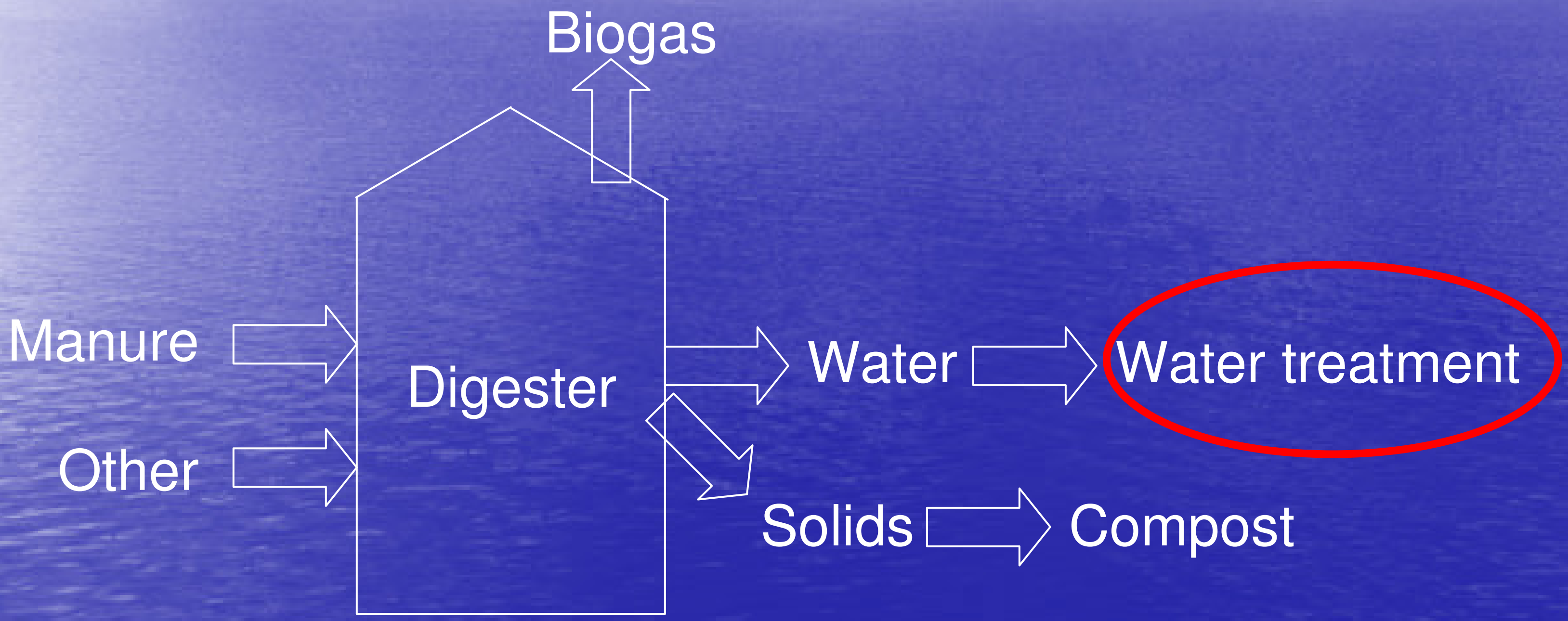
To develop and test a working prototype of a digester + water treatment plant:

- Removal of organic matter (anaerobic digestion)
- P precipitation as struvite and biofibers
- N removal by partial ammonia oxidation process and anammox process

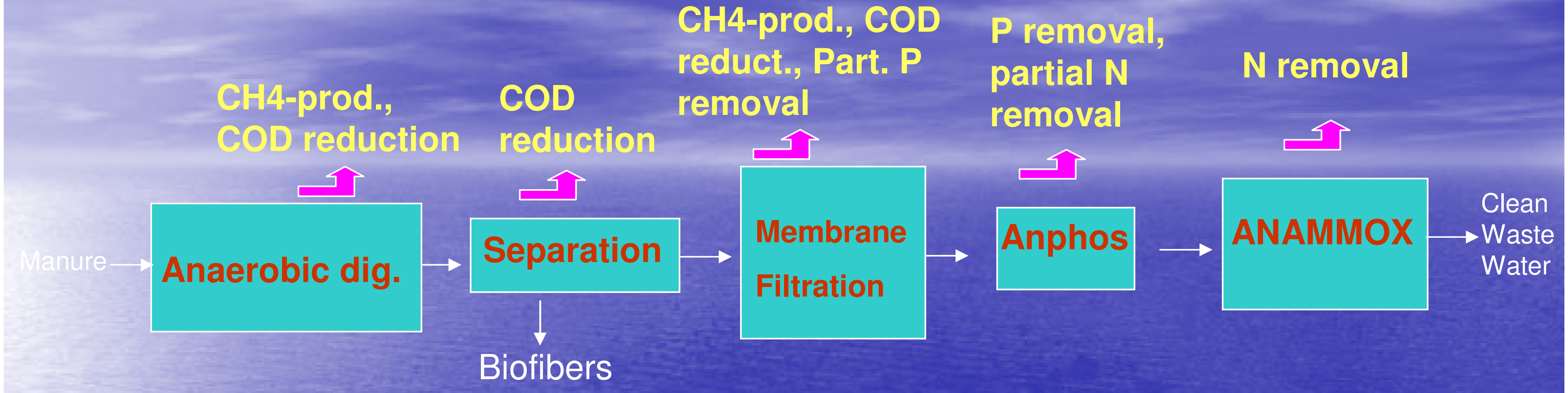
Process flow chart

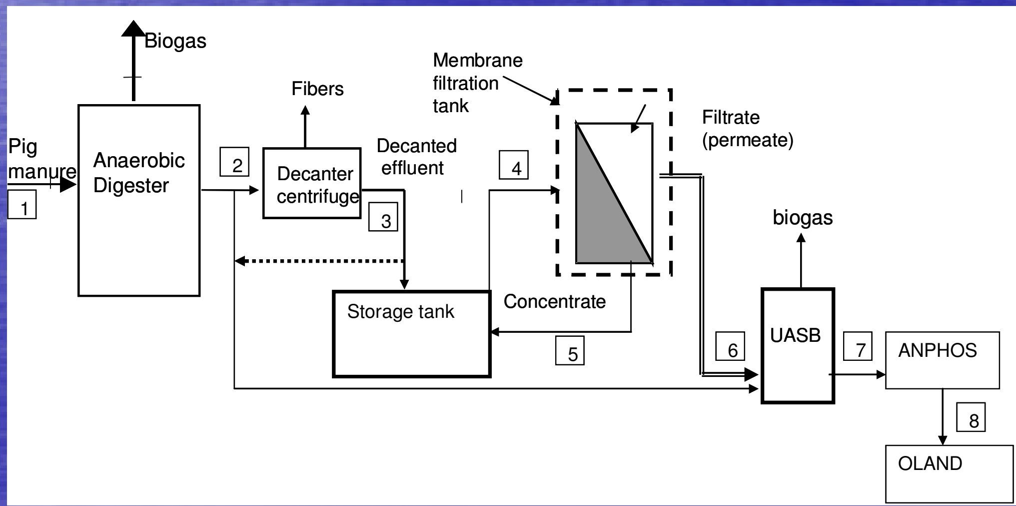


Anaerobic digestion



Flow sheet suggestion

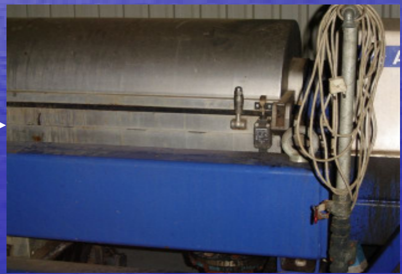




DTU's activities:

- Codigestion of manure together with animal byproducts
- Ultrafiltration of centrifugate
- P removal by struvite precipitation
- N removal by anammox process

Hegndal biogas plant



Reactor

Decanter Centrifuge

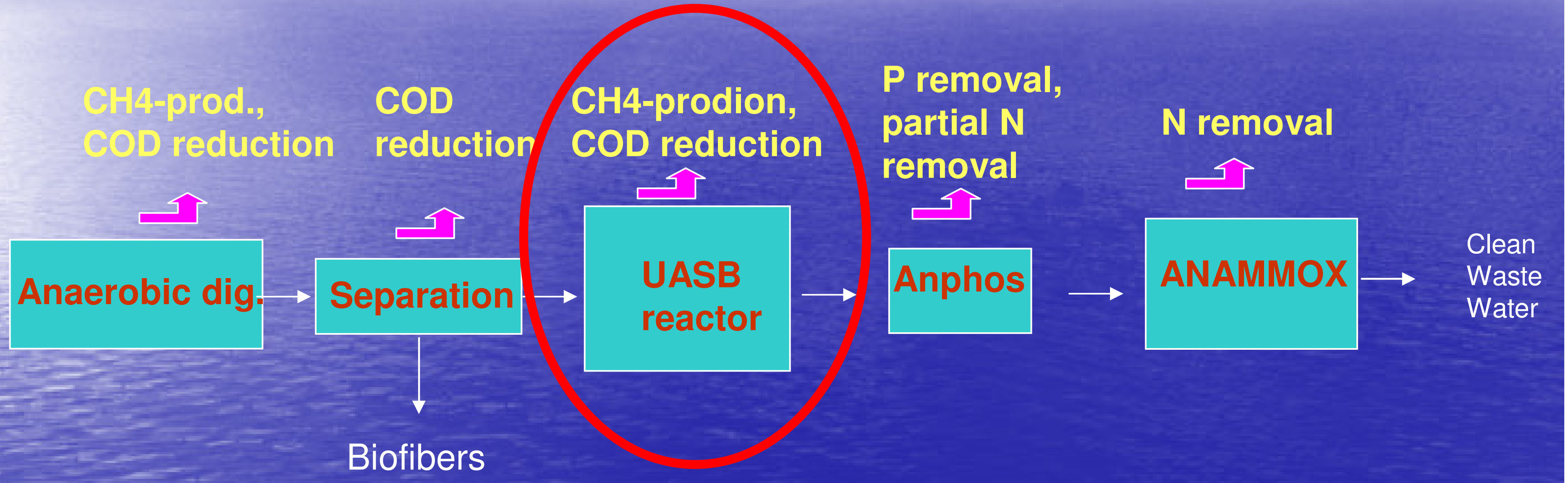
Ultra filter

Foaming 12 hours after initiation of the filtration, membrane clogging after 3 days of operation

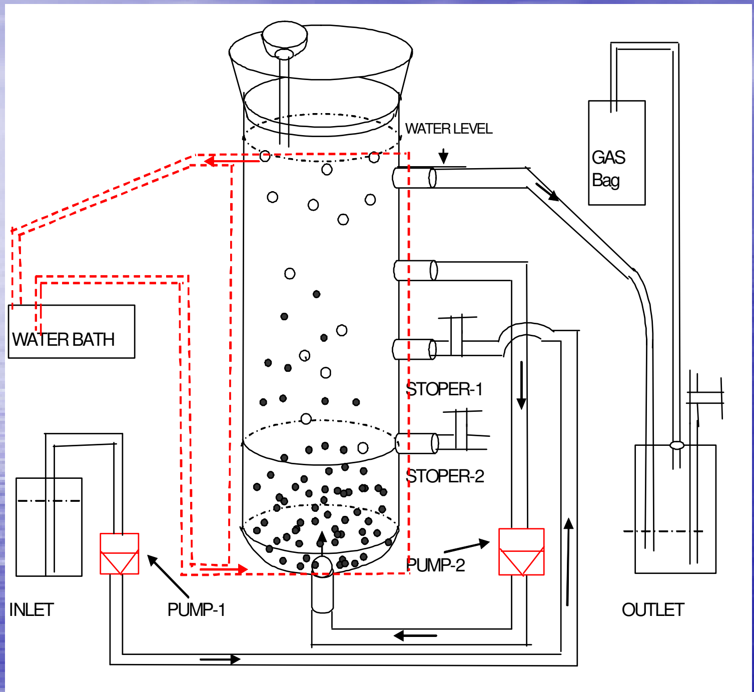
Conclusions for the membrane filtration step

- Ultrafiltration not feasible
- Problem: We need to reduce the COD content of the effluent before it enters the ANAMMOX process.
- Solution: Post digestion in UASB reactor.

Revised process scheme



Post digestion in UASB reactors

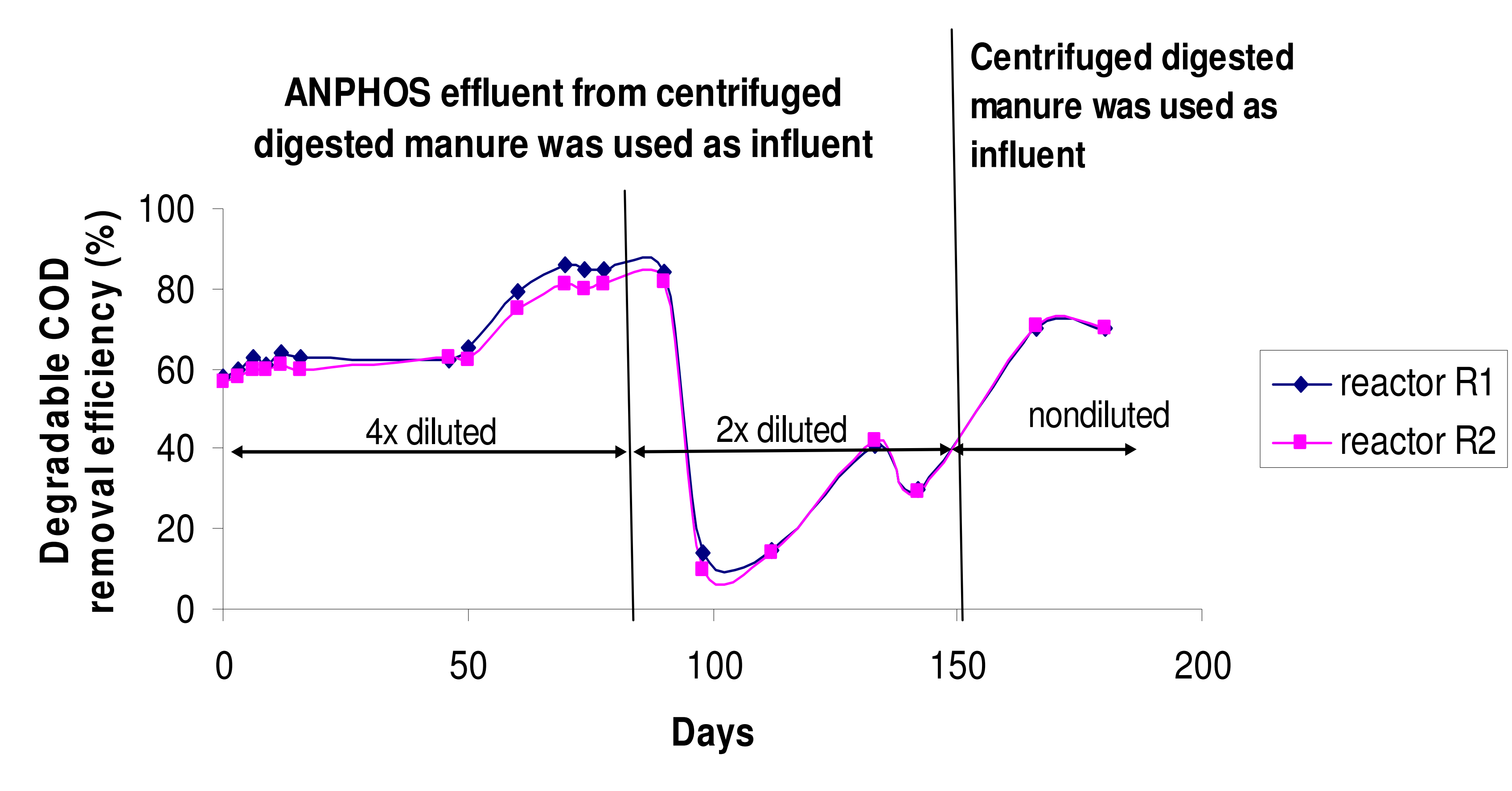


Reactor Volume: 350 ml

HRT: 96 hours

Temperature: 55oC

COD removal:UASB experiments



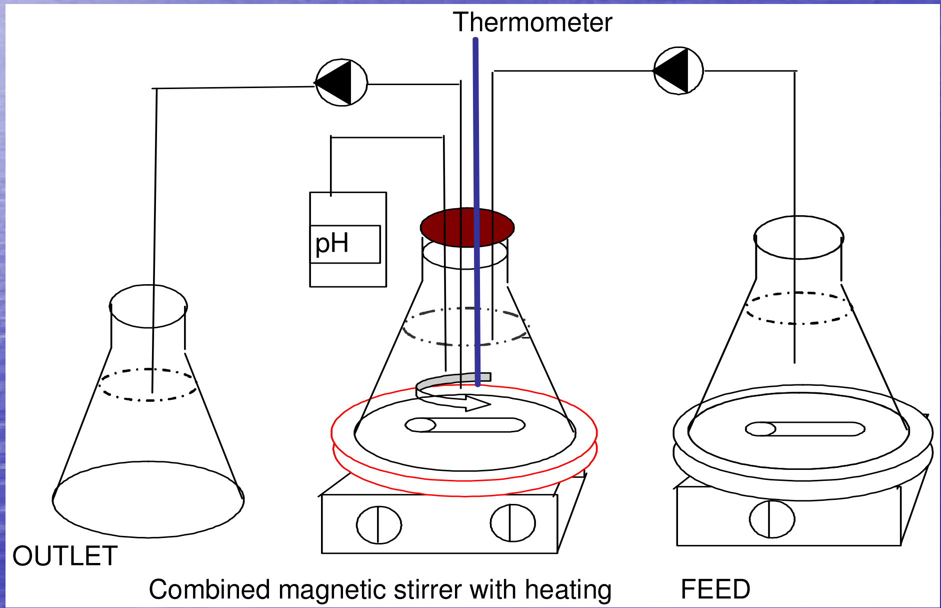
COD removal: conclusions

- 65-70 % of the organic matter in the centrifuged digested manure was anaerobically degradable.
- Degradable COD removal efficiency was around 70÷80 %.
- Almost no removal of ammonia and phosphates were noticed.

P removal as struvite (ANPHOS)

Anaerobic phosphorus removal

$$Mg^{2+} + NH_4^+ + HPO_4^{2-} + 6H_2O \rightarrow MgNH_4PO_4 \cdot 6H_2O + H^+$$



Operational Temp	Optimal pH	Mg+	Reaction time
30 oC	8-10	MgO	1 hour

ANPHOS: conclusions

- High phosphate removal (95%)
- Ammonia removal (6 - 7 %) was both due to struvite formation, but also to ammonia stripping

ANAMMOX: Batch experiments

Substrate:
Synthetic wastewater containing NH_4^+, NO_2^- NO_3^- ,, PO_4^{-3},HCO_3^-

Inoculum: OLAND sludge (Ghent University)

114 mL serum vials

UASB reactor experiments

Start – up : synthetic wastewater containing NH_4^+, NO_2^-
NO_3^- ,PO_4^{-3},HCO_3^-

Total volume=200 mL

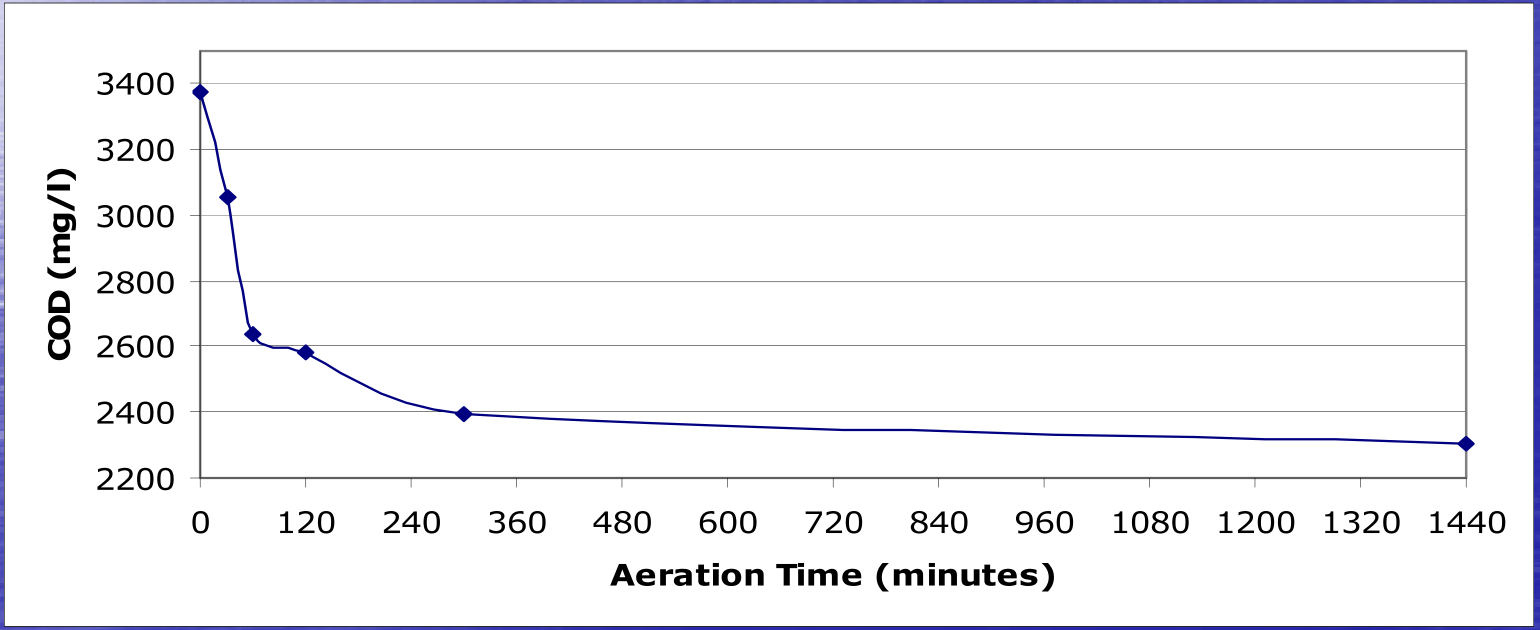
HRT= 2,2 days

Anammox bacteria: granules: wastewater =1:1:1

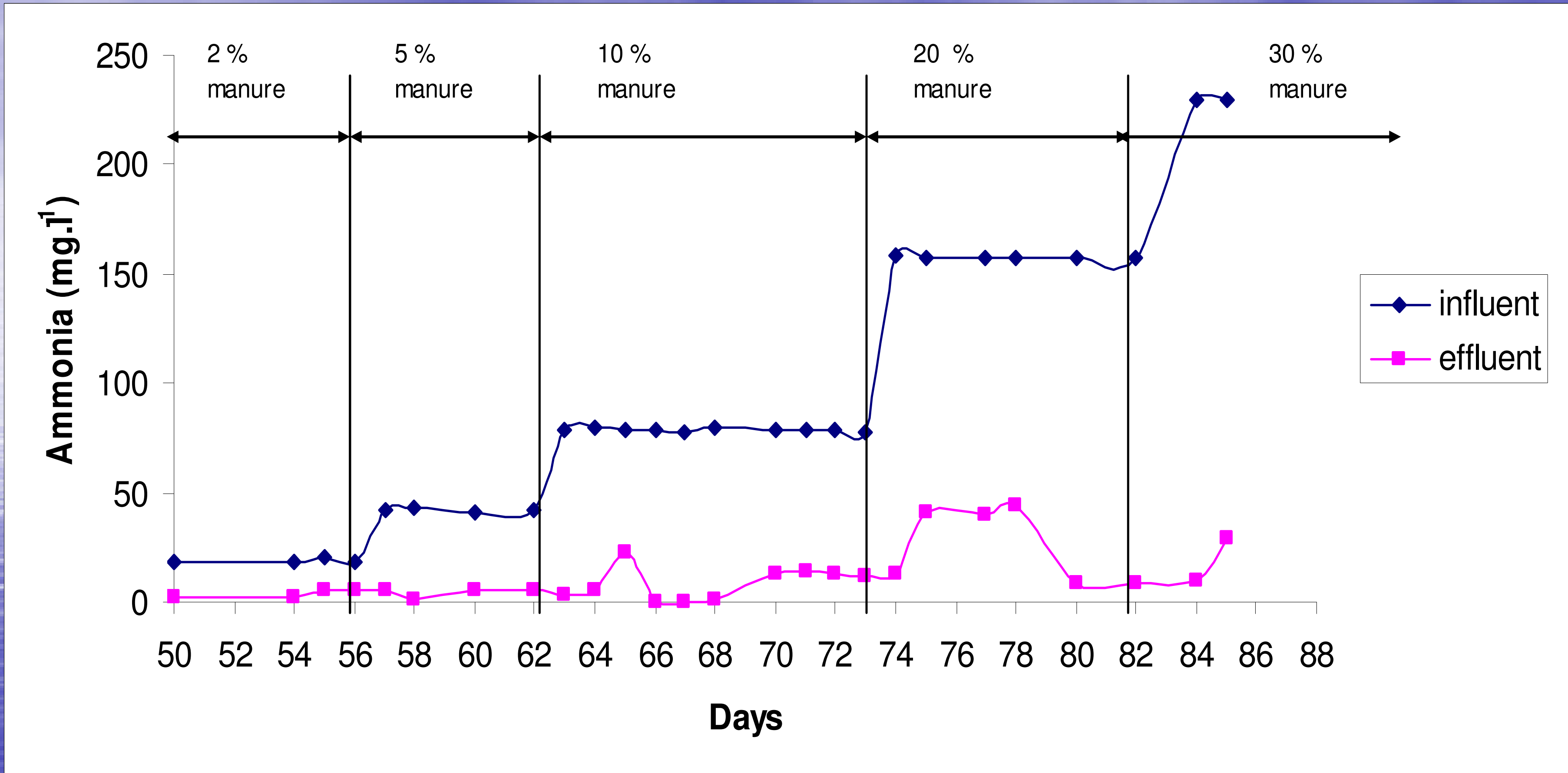
Partial aeration: an approach for improving Anammox process performance

Aeration of anaerobically digested pig manure in order to reduce as much as possible the residual biodegradable organic matter

Set-up: A mixture of 20 % of activated/nitrifying sludge and an 80% of digested pig manure, were aerated with an air pump during 24 hours.



Ammonia removal



Anammox reactor experiments are in progress

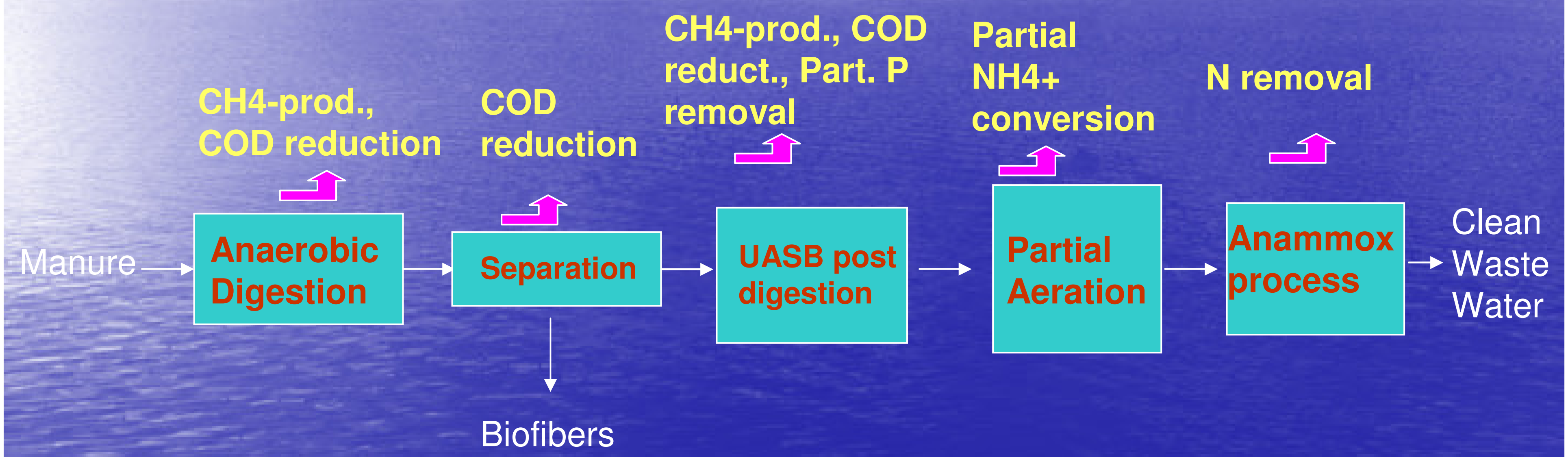
Removal of ammonia at different steps tested

Step	NH_4^+ removal (%)
UASB	0 ÷ 4
ANPHOS	6 ÷ 7
ANAMMOX	Up to 100

ANAMMOX: conclusions

- Mass balance of the batch test showed that ANAMMOX plus nitrification and denitrification were taking place.
- Reactor experiments gave indication that the ANAMMOX bacteria were immobilised in the granules.
- 100% ammonia removal was achieved

Final process scheme suggestion



Researchers involved in the present study

- Zhenwei Zhu
- Francesk Juan Roca
- Juan Carlos
- Dimitar Karakashev
- Jens Ejbye Schmidt
- Irini Angelidaki

Removal of COD, PO_4 and soluble N (NH_4, NO_2+NO_3)