ENAS Sardegna

ENI CBCMED Cooperating across borders in the Mediterranean

Project funded by the EUROPEAN UNION

REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA

MEDISS

Mediterranean Integrated System for Water Supply «MEDISS»

project Duration:
August 1, 2019 - July 31, 2022

Technical meeting and study visit

8 - 10 November 2021

Aqaba – Jordan

WP3 ACTIVITIES

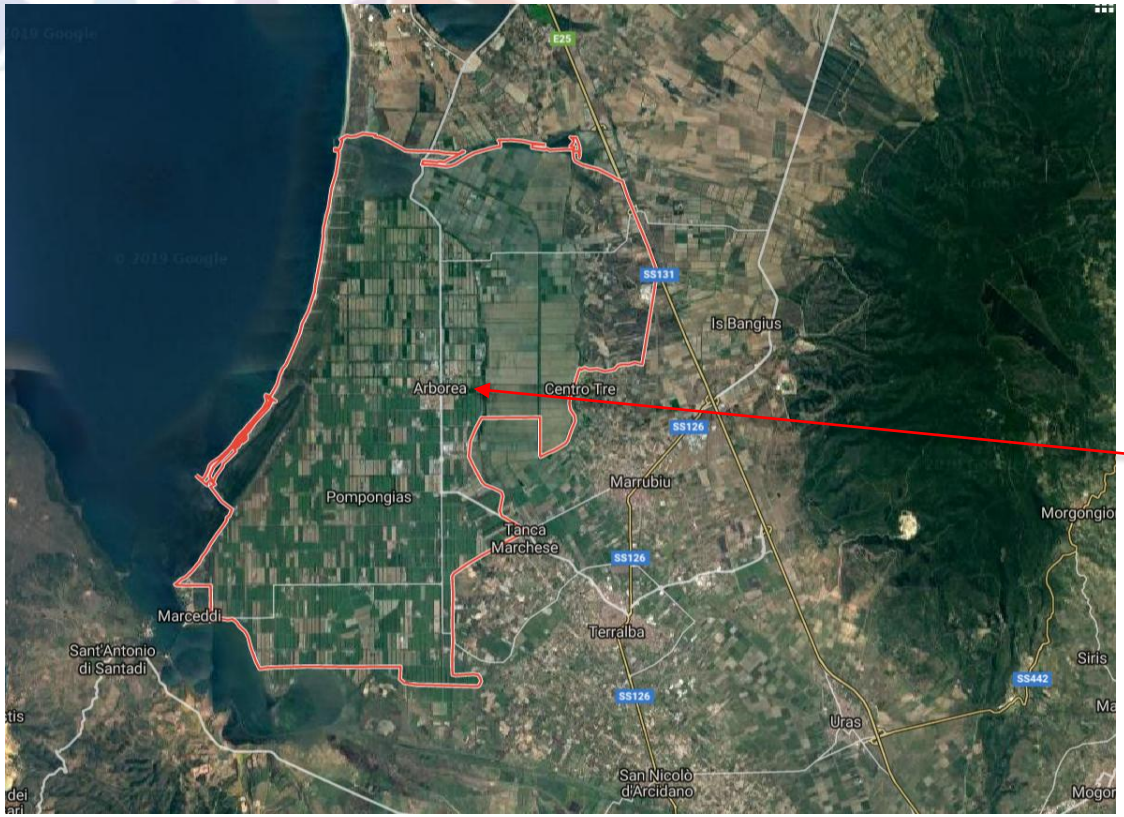
AMMONIA RECOVERY PILOT UNIT – PRELIMINARY RESULTS

PWEG Palestinian Wastewater Engineers Group جمعية مهندسي الصرف الصحي الفلسطينية

مياه العقبة Aqaba Water

The test pilot area in Sardinia: the Arborea plain

Arborea is a municipality in the province of Oristano and gives the name to a very extended area (6'ooo ha) devoted to intensive cattle farming (for dairy and meat production) and agricultural activities: It represents an excellence in the Sardinian agro-livestock system



Farmers are associated into the **"Cooperative producers of Arborea"** that is today one of the most important hub of the Sardinian agricultural and livestock industry and gathers more that 200 members

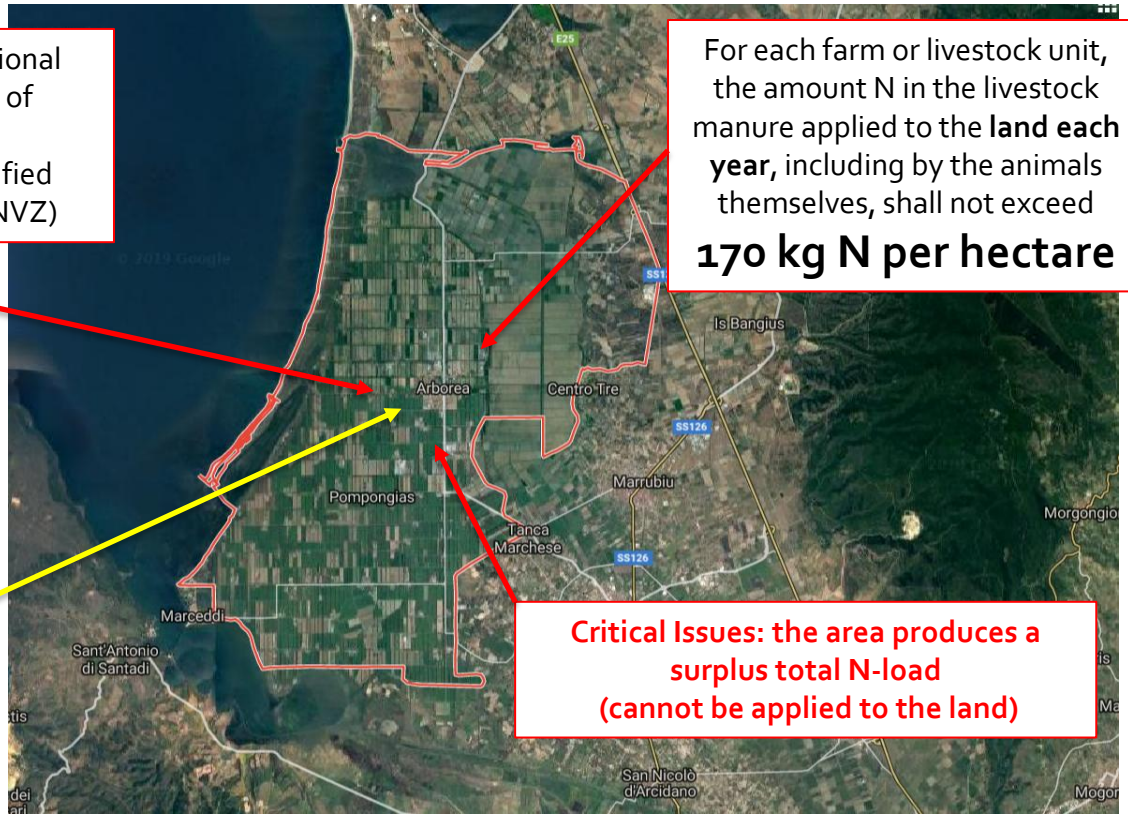
The test pilot area in Sardinia: the context

Due to the intensive agricultural practices, the Regional Council of the Sardinia Region (resolution n. 1/12 of 01/18/2005,
according to the **EU directive 91/676/EWG**) classified the plain of Arborea a **Nitrate Vulnerable Zone** (NVZ)

For each farm or livestock unit, the amount N in the livestock manure applied to the **land each year**, including by the animals themselves, shall not exceed

170 kg N per hectare

AMS Experimental Pilot Unit



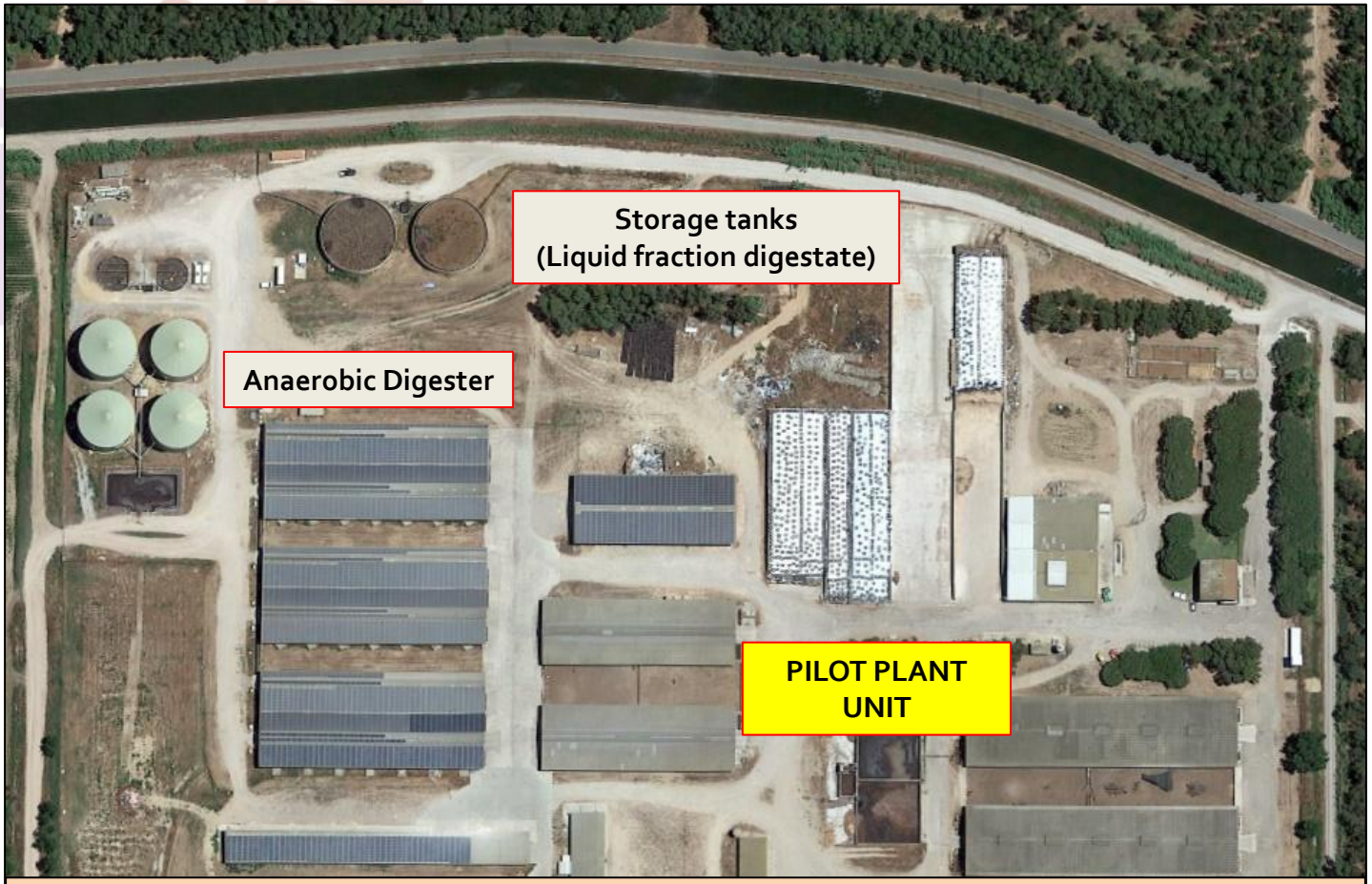
Critical Issues: the area produces a surplus total N-load (cannot be applied to the land)

AIM OF THE PROJECT:

To evaluate the sustainability of a technology to reduce N-load in the manure produced n Arborea plain and to recover the ammonia fraction as a fertilizer (ammonium Sulphate) that can be stocked and reused in controlled way

Ammonia Recovery from anaerobic digestate by means of gas permeable membranes

Fattening calves centre



Livestock manures are treated by an anaerobic digester coupled by an high efficiency power cogenerator feeded by the produced biogas
The high concentration of Nitrogen, above 2000 mg/L is suitable for the experimentation

Ammonia Recovery Scheme

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Anaerobic digestate
1800 mg/L NH_4

Effluent disposal
100 mg/L NH_4
Recovery efficiency 90 %

PRE-TREATMENT
VIBRATING SCREEN UNIT
(mesh size 50μm)

Liquid fraction Anaerobic digestate
1800 mg/L NH_4

AMMONIA
MEMBRANE
STRIPPING UNIT

Solid fraction disposal

Final Product
$(NH_4)_2S0_4$
(2% as N)

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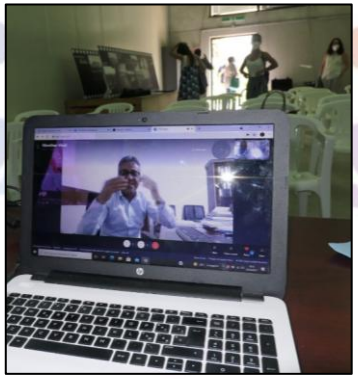
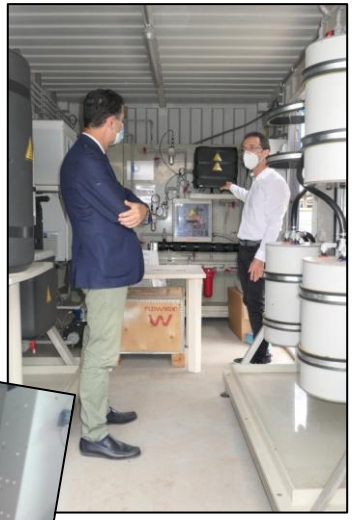
Ammonia Recovery from anaerobic digestate by means of gas permeable membranes

March 2021 – pilot plant installation

Ammonia Recovery from WWTP digester by means of gas permeable membranes

June 2021 – Press conference – inauguration and start-up of the pilot plant



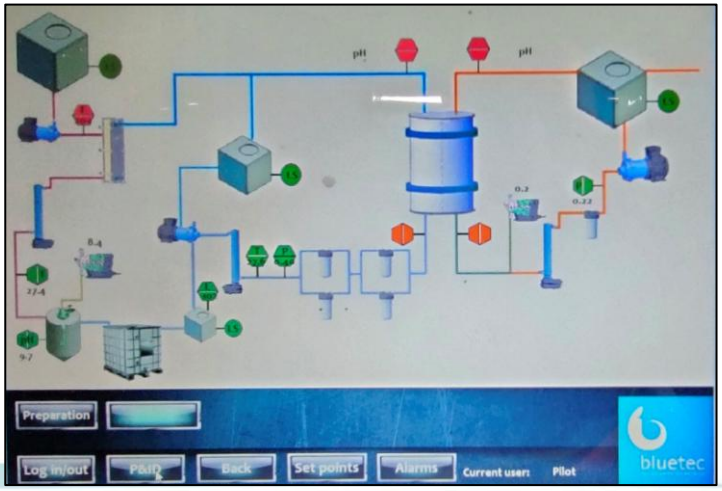



Agricoltura e zootecnia sorridono all'ambiente

Arborea. Progetto sperimentale della Cooperativa Produttori unico in Italia per riutilizzare i liquami

Ammonia Recovery from anaerobic digestate by means of gas permeable membranes

August 2021 – Beginning of the experimental activity



Ammonia Membrane Stripping Batch Process

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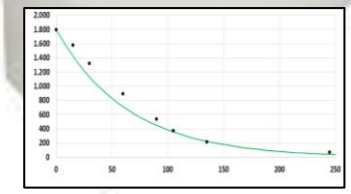
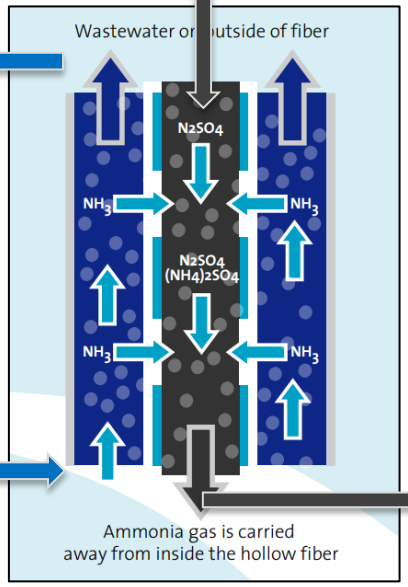
Digestate rich in NH_4

STORAGE TANK

250 L



The caustic digestate stream is lead to the feed side of a gas permeable membrane. $NH_3(g)$ passes through the membrane

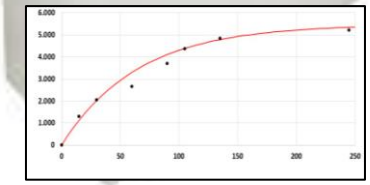


At the product side of the membrane the acidified stream transforms the NH_3 into ion-form NH_4^+ which forms ammonium sulfate $(NH_4)_2SO_4$

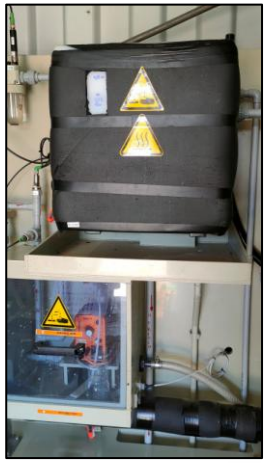
$(NH_4)_2S0_4$ Fertilizer

STORAGE TANK

60 L



HYDROPHOBIC GAS
PERMEABLE MEMBRANE



Ammonia Recovery from anaerobic digestate by means of gas permeable membranes

Pilot Plant Experimental activity programm

Optimization of the Ammonia Stripping Process

1) Adjustment of the process parameters

- ***pH*** *(feed line) and (acid line)*
- ***Temperature*** *(feed line) and (acid line)*
- ***Flow rate*** *(feed line) and (acid line)*
- *Number of* ***membrane modules*** *to be used*

2) Modeling of the change in Ammonia concentration

- *Determination of Ammonia mass transfer coefficient*

Optimization of the Chemical Analysis Protocol

1. **Sampling frequency**
2. **Testing reliability of field Ammonia spectrophotometer (GMSOLUTION Srl)**
3. **Testing reliability of field Ammonia on-line sensor**
4. **Double sampling is also repeated to analyze the same parameters at the main chemical laboratory according to the standard methods analysis**
5. **Chemical characterization of the final product (ammonium sulphate)**

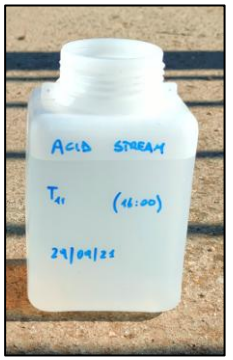
AIM: producing ammonium sulphate $(NH_4)_2SO_4$

Ammonia Recovery from WWTP digester by means of gas permeable membranes

FIELD CHEMICAL ANALISYS SETUP

DIGESTATE SAMPLE

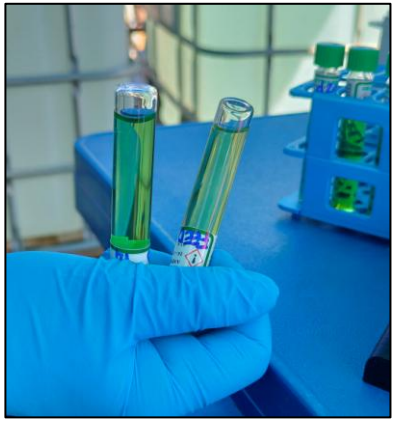
	CAUSTIC SIDE				ACID SIDE			
time (min)	pH	cond (mS/cm)	T (°C)	CAUSTIC SIDE: Ammonia - mg NH_4/L	pH	cond (mS/cm)	T (°C)	ACID SIDE: Ammonia - mg NH_4/L
0	12,00	37,80	22,00	**1.800**	1,39	58,90	18,50	**0**
15	12,29	39,30	21,90	**1.580**	1,84	38,10	31,30	**1.300**
30	12,62	47,80	22,00	**1.320**	2,33	34,30	21,80	**2.050**
60	12,87	63,50	22,50	**890**	2,28	39,00	23,10	**2.650**
90	12,86	67,80	23,70	**540**	2,48	40,00	24,00	**3.700**
105	12,76	67,50	24,90	**370**	2,33	40,80	24,90	**4.360**
135	12,72	67,00	25,80	**215**	2,37	43,00	25,60	**4.840**
245	12,71	65,90	27,90	**66**	3,15	41,10	28,10	**5.220**



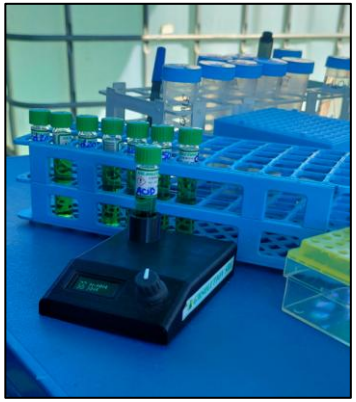
Ammonium Sulphate fertilizer (up to 2% N) SAMPLE

SAMPLING

pH, T sensor



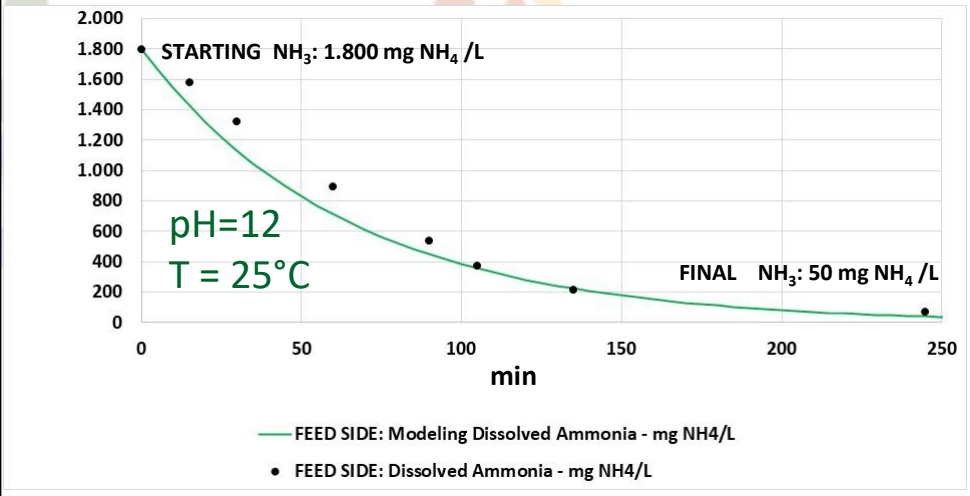
NH_4 vials



NH_4 spectrophotometer

Ammonia Recovery from anaerobic digestate by means of gas permeable membranes

PRELIMINARY RESULTS

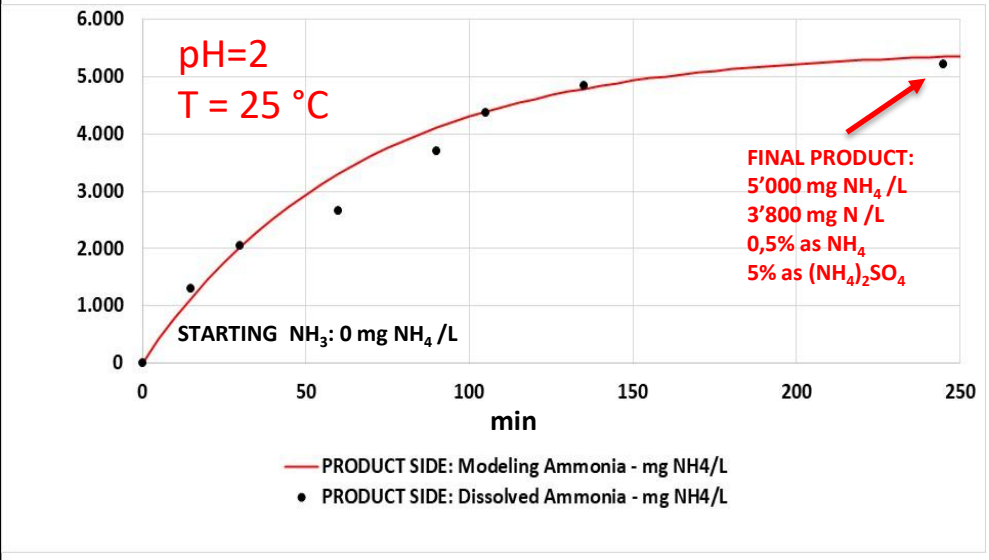


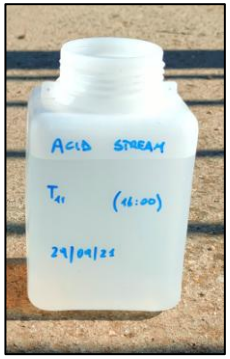
DIGESTATE SAMPLE

FEED LOOP SIDE (1 run)

STORAGE VOLUME: 260 L

TOTAL NH_3 LOAD PASSED : 455g NH_4





Ammonium Sulphate fertilizer (up to 2% N) SAMPLE

PRODUCT LOOP SIDE (1 run)

STORAGE VOLUME: 65 L

FINAL TOTAL NH_3 LOAD STORED : 455g NH_4

Ammonia Recovery from anaerobic digestate by means of gas permeable membranes

REMARKS

- The Ammonia Membrane Stripping technology (AMS) **is able to recover the ammonium** from the digestate produced by the anaerobic sewage treatment unit located in the fattening calves center of Arborea
- The Ammonia removal/recovery efficiency of the pilot unit has reached up to **95%**
- The recovered Ammonia has been converted into a solution of ammonium sulphate $(NH4)_2SO_4$ and its concentration depends on the amount of Ammonia recovered in the pilot unit (number of cycles). After three cycles the concentration of the ammonium sulphate $(NH4)_2SO_4$ solution reached about **18'000 mg NH_4/L**
- **pH** and **specific flow rate** on the membrane have high influence on the recover efficiency. **Optimization of pH is still in progress**.
- The local regional temperature of the digestate has been suitable to reach an excellent Ammonia removal/recovery efficiency (**it was not necessary to increase of temperature**)
- Due to the high content of SS (fraction < 50 μm), **filter cartridges must be frequently replaced**
- The concentration change of Ammonia in the digestate volume follow a **first-order kinetics** (the calculation of the **mass transfer** coefficient is progress)

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