Factsheet
SYSTEMIC Demonstration Plant

Acqua & Sole (Vellezzo Bellini, IT)

A short introduction to Acqua & Sole

Acqua & Sole (Neorurale group) is located in Vellezzo Bellini (Northern Italy), in an area dedicated to cereal cultivation, mainly rice. Neorurale has a strong focus on nutrient recycling with special attention to the development of an efficient digestate distribution system (direct injection into the soil). The system is being developed in strict collaboration with local farmers with the aim to maximize fertilization effects and minimize ammonia and odour emissions. In addition to the production of soil improvers (digestate), the Demonstration plant generates ammonium sulphate (AS) from ammonia recovered during the digestion step, which is used as a feedstock for the production of nitrogen fertilizer. For the recovery and reuse of nutrients, Acqua & Sole has an ambition of improving soil fertility without any use of synthetic fertilizer over an area of 5000 hectares (ha), and ensuring the nutrient requirements of the surrounding farms for their annual crop production.

Table 1. Technical information of the biogas plant.

Characteristics	
Date of construction	2016
Size (MWe)	1.6
Volume (m^3)	13 500
Digester type	Thermophilic digestion

Drivers for nutrient recycling

Excess production of nitrogen (N) and phosphorous (P) has led to environmental issues such as eutrophication of surface waters and nitrate accumulation in groundwaters. Therefore, recycling of disposed waste (e.g. manure, sewage sludge, organic fraction of municipal solid waste and food waste) becomes a great opportunity for the recovery of nutrients. Furthermore, low carbon content in soils is an issue in Italy and the utilization of soil improvers is a valuable tool to tackle this. However, restrictions on N application on agricultural land limit their use, making it necessary to find solutions to lower their N content.

Feedstocks

The co-digestion plant capacity is about 120 kt organic substrate every year. In 2017 72 kt were treated, of which about 85% was sewage sludge and 15% was digestate from anaerobic treatment of source-segregated domestic food waste and liquid fraction of source-segregated food waste (Table 2). The plant can treat manure, expired food, organic wastes, sewage sludge and agri food industry sludge.

Table 2. Origin of Acqua & Sole feedstock (2017).

Type	Origin	Mass
Sewage sludge	Wastewater treatment plants	62 kt
Co-products	Digestate from anaerobic treatment of source-segregated domestic food waste	6 kt
	Liquid fraction of source-segregated food waste	4 kt
Total		72 kt

Horizon 2020

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Biogas production

AD is performed in 3 consecutive digester of 4500 m^3 each one. The biogas produced by the plant (including digesters and storage tank) is converted by a CHP engine into electrical and thermal energy. 30% of the electricity produced is consumed by the plant and the remaining 70% is sent to the national grid.

Table 3. 2017 biogas production and average composition before purification.

Component	
CH_4	55-60 %
CO_2	32-37 %
H_2S	<50 ppm
O_2	1%
Total CH_4 production	~ 2300 kNm^3 CH_4
Specific CH_4 production	~ 245 $lCH_4/kgVS$

Digestate characteristics

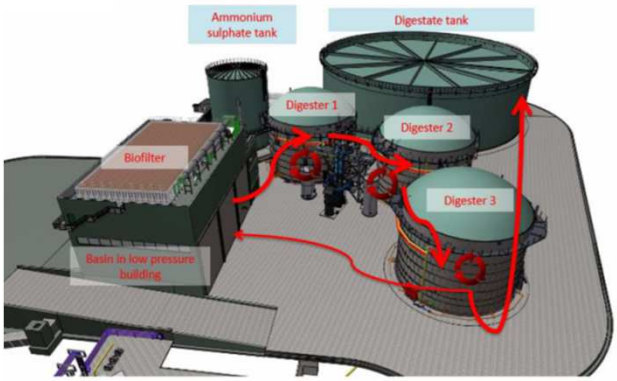
- Thermophilic digestion ensures a better control of pathogenic and intestinal microorganisms in the digestate.
- Lower N content in digestate favours a long-term fertilization effect of digestate (higher ratio organic N/NH_3-N in digestate).
- Uniformity of digestate distribution is ensured by precision agriculture system, following conservation agriculture criteria.

Nutrient Recovery and Reuse (NRR) technology

From April 2016, the plant operates as follow:

- Organic waste is collected in basins located in a closed building to prevent the release of odour. A bio-filter placed on the roof of the building purifies the exhausted air.
- Substrates are moved to a mixing unit where they are heated and homogenized with biomass coming from the third digester.
- Homogenized and inoculated feedstock is fed to the thermophilic process (minimum retention time of 20 days and temperature of 55°C) which ensures full sanitation of the incoming sludge and better agronomic properties of the digestate.
- The process is equipped with an ammonia stripping unit, whereby biogas acts as stripping agent. Ammonia is extracted from biogas by adding acid (H_2SO_4) resulting in inorganic ammonium sulphate (AS) production.
- Both digestate and AS are stored in steel tank facilities.

Acqua & Sole will implement and demonstrate a novel N recovery absorber which enables reduction of N content in the digestate. The investment for the N absorber amounted to 0.4 M€.



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Products and market

The co-digestion plant capacity is 120 kt of waste, which will be transformed into about 4 kt of AS and maximum 192 kton of organic fertilizer (digestate). Product characteristics are listed in table 4 (2017 average data since October).

Acqua & Sole estimated that the use of digestate could replace the following maximum amount of fertilizer: 1550 t/y of N, 1160 t/y of P_2O_5 and 170 t/y of K_2O.

Table 4. Composition of the recovered products.

	Digestate	Ammonium Sulphate
Dry matter (%)	10.5	-
Organic Carbon (% DM)	31.2	-
N-total (g/kg DM)	77.0	~7,2% on wet weight
P_2O_5-total (g/kg DM)	57.6	NA
K_2O-total (g/kg DM)	8.3	NA

Economic benefits

Acqua & Sole calculated that the replacement of conventional fertilizer with digestate over a surface area of 5000 ha would generate a maximum saved economic cost of about 2.3 million €/y (Table 5). The installation of the N absorber will reduce the N content in digestate, so that its concentration will not be a limitation for digestate spreading on fields. Thus, it will be possible to distribute a higher amount of digestate per hectare with benefits in terms of transport and disposal costs.

Table 5. Saved economic costs.

Conventional fertilizer	Cost €/t *	Quantity t/y	Total (€)
Urea 46% N	344	3 370	1 159 280
Perphosphate 46%P_2O_5	369	2 520	929 880
Potash 60% K_2O	669	280	187 320
Total Saved Cost			**2 276 480**

** Source: CCIAA Modena, Average 2017*

On top of that, lowering ammonia content in the digester will optimize the digestion process, avoiding toxicity effects on methanogen microorganisms and increasing AS production.

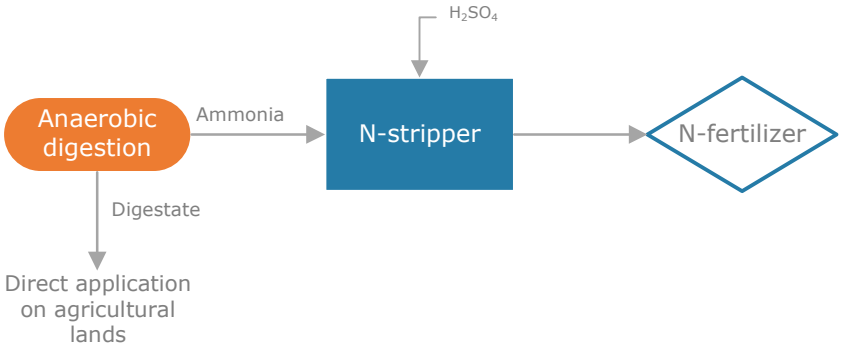
Sustainability goals

Acqua & Sole is committed to reach the following targets:

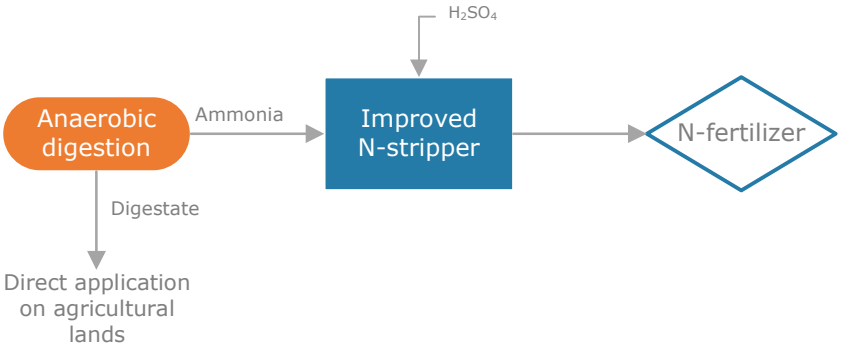
- Increase soil quality and contribute to sequestration of carbon in soil.
- Decrease GHG emissions.
- Reduce ammonia, nitrate and nitrous oxide emissions.
- Eliminate unpleasant odour to improve public acceptance.
- Promote nutrient recycling and this circular economy model in the region as an effective solution for waste management.

Annex 1: Acqua & Sole Demonstration installation – Vellezzo Bellini (IT)

Current process



Envisaged process



Technical specifications:

Current process

Name	Type	Power consumption (kW)	Heat requirement (kWth)	Ammonia removal (%)
N-Stripper + N-absorber	Stripping	45	220	21

Envisaged process

Name	Type	Power consumption (kW)	Heat requirement (kWth)	Ammonia removal (%)
N-Stripper + N-absorber	Stripping	45*	300*	30*

*estimated data