MANEV: Evaluation of manure management and treatment technology for environmental protection and sustainable livestock farming in Europe.

Animal manure: Biogas and treatment in Italy

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CRPA - Centro Ricerche Produzioni Animali (Research Centre on Animal Production)

CRPA mission is the conduct of research and the establishment and management of services with the aim of promoting technical, economic and social progress in the livestock farming sector and promoting the spread of the most advanced forms of environmentally friendly agriculture.

CRPA offers management and execution of research projects, economic analyses, implementation of feasibility studies, setting up and management of computer systems and data bases, technical assistance and advisory services, design of plant and structures, training, education and dissemination.

CRPA provides consultancy on important issues of concern both to public and private bodies managing environmental services, to individual farmers and the agricultural food industry.

Main topics of interest:
- introduction of clean technologies to livestock farms and agro-industrial concerns;
- gaseous emissions and organic residues treatment;
- anaerobic digestion;
- composting;
- agricultural utilization of livestock manure, digestate, sewage sludge, and compost.

Facilities for:
- chemical and physical parameters in manure, air, water and soil;
- olfactory measurements;
- feed analysis;
- sensory analysis for foods;
- anaerobic digestion pilot reactors.
European Nitrogen surplus area
Italian Agriculture in numbers

- Number of farms: 1,471,185 (-9.2%)
- Total Agricultural surface: 16,678,296 ha
- Average land size of the farms increases from 7.9 to 8.4 ha
- Livestock farm are 190,000 (12.9% of the total farm)

- Livestock sector is decreasing (variation: 2013 vs 2010)
  - pigs 8.6 millions number of head (-7.8%)
  - Cattle 6.2 millions of head (-4.5%)
  - Poultry 165 millions of head (-1.5%)
  - Sheep and goats 7.6 millions of head (+0.5%)

Five regions of Northern Italy account for more than 70% of livestock

- Number of jobs: 3.56 millions (-8.1%)
- Agriculture contribution to Italian national added value: 2.1% (of TVA)

Data relating to 2013, compared with the Agriculture Census of 2010
Source: ISTAT, 2 september 2015 – www.istat.it
For increased cost of mineral fertilizer

For a better use of Nitrogen content from manure and digestate
- Manure treatment to produce fractions with a higher nutrient value (S/L)
- Land spreading techniques more efficient
- Farmers more careful in manure management and valorization
Biogas in Italy: potential

Organic residues generated and that could be started to AD

- Animal manure: 129,000,000 t/y
- Food industry residues: 5,000,000 t/y
  (Animal by-products - Cat. 3): 670,000 t/y
- Sewage sludge: 3,500,000 t/y
- Organic fraction MSW: 10,000,000 t/y
- Crop residues: 6,400,000 t DM/y
- Energy crops: 400,000 ha

8 billions m³ CH₄/y or 25 TWh/y of EE (3300 MWe)
Biogas in Italy: situation

Data from "Statistical Report 2013- renewable source plants - Electricity Sector" by GSE, march 2015.

<table>
<thead>
<tr>
<th></th>
<th>%</th>
<th>n°</th>
<th>MWe</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL BIOGAS</td>
<td>100%</td>
<td>1713</td>
<td>1387.9</td>
</tr>
<tr>
<td>- Biogas from waste</td>
<td>20%</td>
<td>346</td>
<td>401.4</td>
</tr>
<tr>
<td>- Biogas from sludge</td>
<td>5%</td>
<td>68</td>
<td>40.8</td>
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<tr>
<td>- Agricultural Biogas (*)</td>
<td>75%</td>
<td>1299</td>
<td>945.7</td>
</tr>
</tbody>
</table>

(*)Biogas from animal manure, agroindustrial residues, energy crops
Regional distribution of the Italian biogas production, 2013

Agricultural Biogas
(CRPA data – march 2013)

- About the 62% operate in co-digestion of animal manure with energy crops (maize, sorghum…) and residues from agro-industry;
- about 18% only with animal manure;
- the most common type of reactor is the stirred and insulated tank with vertical walls (CSTR = Completely Stirred Tank Reactor);
- About 90% of the plants is located in the northern regions.

(Data from GSE, march 2015)
Biogas in Italy: Subsidies

- From 2008 up to 2012 Biogas plant (with biomass and/or manure), under <1 Mwe:
  
  Feed-in Tariff 280 €/MWh put in the grid for 15 years

- From 2013 a less convenient Feed-in-Tariff with a bonus system for 20 years
  
  - 236 €/MWh with plants <0.3 MWe
  - 206 €/MWh < 0.6 MWe
  - 178 €/MWh < 1 MWe
    
    - Plus an added bonus (15-30 €/MWh) if Nitrogen is removed to produce a fertilizer

- Next year 2016 or 2017, probably will come out a new subsidies regulamentation
CRPA activity in LIFE MANEV
CampoBo scenario: Basilicagoiano (PR)

Anaerobic Digestion

- CampoBo is a closed cycle pig farm with 950 t of live weight.
- The daily average production of pig slurry is 86 m$^3$.
- The raw pig slurry is treated by AD in a mesophilic completely stirred reactor with volume of 1780 m$^3$ and HRT of 21 days.
- The biogas produced (580 m$^3$/day and CH$_4$ content of 67%) is used by a CHP with electric power of 85 kW (daily average gross electric production during Manev monitoring is 1117 kWh, 15 operating hours per day in average).
- Methane yield of 308 m$^3$/ton VS
- Average electric production of 13 kWh/ m$^3$ of slurry to AD.
Nitrogen treatment: SHARON process of N/DN

- To remove Nitrogen from digestate was monitored the biological N/DN SHARON process (with nitrification locked to nitrite) in a pilot plant SBR (Sequential Batch Reactor).
- The pilot plant (at farm scale) was designed in collaboration by CRPA and Veolia Water Technologies Italia Service.
- SBR reactor has a cylindrical shape, with a radius of 0.66 m and height of 2.23 m (volume of 3 m³).
- During monitoring period It is able to treat about 1 m³/day.
- The reactor, mixed, heated and insulated can use the thermal energy resulting from the hot water produced by CHP.
CampoBo scenario:
Why ... SHARON process*: 
Nitrification/Denitrification with nitrification locked over nitrite

- Low COD readily available content in pig slurry digestate
- Saving E.E. to supply oxygen
- Less sludge production

Conventional Nitrification over Nitrate
\[ \text{NH}_4^+ + 1,5 \text{ O}_2 \rightarrow \text{NO}_2^- + \text{H}_2\text{O} + 2\text{H}^+ \]
\[ \text{NO}_2^- + 0,5 \text{ O}_2 \rightarrow \text{NO}_3^- \]
\[ \text{NH}_4^+ + 2 \text{ O}_2 \rightarrow \text{NO}_3^- + \text{H}_2\text{O} + 2\text{H}^+ \]
Denitrification
\[ \text{NO}_3^- + 4 \text{ g COD} + \text{H}^+ \rightarrow 0,5 \text{ N}_2 + 1,5 \text{ g sludge} \]

Nitrification over Nitrite
\[ \text{NH}_4^+ + 1,5 \text{ O}_2 \rightarrow \text{NO}_2^- + \text{H}_2\text{O} + 2\text{H}^+ \]

Denitrification
\[ \text{NO}_2^- + 2,4 \text{ g COD} + \text{H}^+ \rightarrow 0,5 \text{ N}_2 + 0,9 \text{ sludge} \]

*SHARON: Single-reactor High rate Ammonium Removal Over Nitrite
Average removal efficiency resulting during the activity (output vs input SBR)

<table>
<thead>
<tr>
<th></th>
<th>TSS</th>
<th>COD</th>
<th>BOD</th>
<th>TKN</th>
<th>N-NH4⁺</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>85.0%</td>
<td>71.4%</td>
<td>83.7%</td>
<td>81.1%</td>
<td>82.1%</td>
<td>82.6%</td>
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</table>
GHG emissions comparison between base scenario and scenario with treatment

Scenario base: storage + spreading

Scenario with treatment: AD + biological N/DN + storage + spreading
Marchini Domenico & C. scenario: Capriano del Colle (BS)

a pig farm in a closed cycle with about 1000 tonnes of live weight; a dairy farm with 200 milking cows over the replacement.

Slurry treatment management is:

1. Anaerobic digestion:
   - 140 m\(^3\)/day of slurry (80% pig slurry and 20% of cattle slurry);
   - 4 t/day of poultry manure;
   - 29 t/day of energy crops.

- reactor digester completely mixed and heated with a total volume of 7155 m\(^3\) and HRT of 41 days;
- the daily electric average production is 23627 kWh, and biogas produced is 11023 m\(^3\)/day with 53,6% di CH\(_4\);
- CH\(_4\) Specific yield of 380 m\(^3\)/ton VS loaded to AD;
- the biogas produced is used by a CHP with electric power of 1 MW;
2. **S/L separation** of digestate by screw press

3. **Aerobic biological treatment** (N/DN) of digestate liquid fraction

   - a central circular equalizing and pre-denitrification tank with volume of 192 m$^3$ completely mixed by a blades system;
   - an external circular tank with useful volume of 1290 m$^3$ that functions as nitrification/denitrification reactor in alternated cycles and completely mixed by 4 pumps system;
     - the air insufflation in the external reactor is performed by 4 idrojet aerator installed on the 4 mixing pumps.
     - the air supply to the idrojet aerator system is provided by 2 air blowers (total airflow of 1700 N m$^3$/h).
Marchini Domenico & C. scenario:

1. Slurry to biological treatment
2. Air blown
3. Treated slurry

Energy crops
Cattle slurry
Pig slurry
Poultry manure
The livestock farm consists of:

- a pig sows farm for piglets production and selling;
- a laying hens farm.

Animal manure treated in anaerobic digestion:
- 20 m$^3$/day of pig slurry;
- 31 t/day of poultry manure.

Slurry/manure management (from BTS Biogas) consists of:
- Anaerobic digestion of manure with energy crops as co-substrate (23.5 t/day of maize silage plus 2 t/day of agroindustrial by-product), the biogas produced is used by a CHP with electric power of 1 MW;
- S/L separation of digestate by screw press;
- **Ammonia stripping** (by pH, T increasing) of raw digestate or clarified liquid fraction;
- Drying of the solid fraction (by heat surplus from CHP unit).
Green Energy scenario:

Anaerobic Digestion

S/L+Drying

Dried end-product

Lime dosing

Pre-Stripping

Stripper and scrubber
• Q digestate: 1.8 – 2 m³/h;
• HRT of digestate in the stripper: 50-60 minutes (of which, 5 minutes inside the stripping column with plate);
• pH in washing scrubber: 2.5;
• T of stripping process: 65-75°C
Nitrogen removal efficiency

### Raw digestate

<table>
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<tr>
<th>Parametri</th>
<th>Media</th>
<th>Dev.ST</th>
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<tbody>
<tr>
<td>pH</td>
<td>8.1</td>
<td>0.0</td>
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<tr>
<td>ST [%]</td>
<td>6.6</td>
<td>0.6</td>
</tr>
<tr>
<td>TKN [kg/ton]</td>
<td>7.23</td>
<td>0.56</td>
</tr>
<tr>
<td>TKN [%TS]</td>
<td>11.1</td>
<td>1.8</td>
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<tr>
<td>N - NH4+ [%TKN]</td>
<td>66.6</td>
<td>2.4</td>
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### Digestate liquid fraction

<table>
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<th>Parametri</th>
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</thead>
<tbody>
<tr>
<td>pH [-]</td>
<td>8.2</td>
<td>0.0</td>
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<tr>
<td>ST [%]</td>
<td>5.2</td>
<td>0.1</td>
</tr>
<tr>
<td>TKN [kg/ton]</td>
<td>7.66</td>
<td>0.41</td>
</tr>
<tr>
<td>TKN [%TS]</td>
<td>14.9</td>
<td>1.1</td>
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<tr>
<td>N - NH4+ [%TKN]</td>
<td>70.2</td>
<td>8.8</td>
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### Ammonium sulphate solution

<table>
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<th>Parametri</th>
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<tbody>
<tr>
<td>pH [-]</td>
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<td>1.7</td>
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<tr>
<td>ST [%]</td>
<td>28.3</td>
<td>1.1</td>
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<tr>
<td>titolo N [%TS]</td>
<td>20.6</td>
<td>0.8</td>
</tr>
<tr>
<td>titolo N [% peso]</td>
<td>5.8</td>
<td>0.4</td>
</tr>
<tr>
<td>NH4+ - N [%TKN]</td>
<td>99.5</td>
<td>0.5</td>
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Conclusions

- In Italy biogas sector is still expanding and about 800 units are operating with livestock manure;
- The livestock sector could be the driving force for the development of anaerobic digestion on a larger scale with the aim to produce renewable energy and treat animal manure reducing environmental impact;
- From an analysis carried out in Italy, the use of renewable energy can reduce the carbon footprint of products (as milk, meat, eggs) up to 20%.

but the biogas sector now needs:

clear procedures and incentives for biomethane as vehicle fuel or injection into the gas grid to still expanding.
Conclusions

• Solid / Liquid separation is widespread in Italian farms (about 40% of pig farms in Northern Italy have S/L separation);

• In Italy, advanced treatments for nutrient removal or recovery (like drying, biological N/DN and stripping) are expanding due to the possible matching with anaerobic digestion and the high costs for manure transport out of non NVZ or finding new available land;

• Biogas plant are not only a manure processing, but incomes from biogas could make the post treatment more economically and thermally sustainable;

  problems

• High operating costs / Low reliability for some treatment at farm scale

It is necessary that the manure becomes a resource and end-products by treatment process get economic valorization
MANEV:
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Gracias por su amable atención

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