EFFECTS OF SOLID/LIQUID SEPARATION ON RAW AND DIGESTED SLURRIES

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1 INTRODUCTION

The digestate is a by-product of the anaerobic digestion (AD) process . During the AD process the organic matter content of biomass is reduced whilst the total content of nutrients (N, P) tended not to be influenced but nitrogen is partially converted from organic N to soluble ammonium N.

Solid/liquid separation of digestate, as for liquid manures, is quite common in Italy. This kind of treatment concentrates the residual organic matter in the solid fraction and ammonium N in the clarified fraction.

This latter fraction, due to the fact that ammonium N is readily available to crops, has good fertilising properties. On the other hand, the solid fraction from digestate may be considered to have good amendment properties. Adani et al. (2009) verified a relatively high biological stability of the residual organic matter and a concentration of recalcitrant fractions such as aromatic and aliphatic molecules, which are possible humus precursors.

The objectives of this research were to evaluate to what extent N is converted from organic N to ammonium N in the AD process and the partition of dry matter and nutrients as a consequence of the solid/liquid separation applied on both raw and digested slurries.

2 MATERIALS AND METHODS

Three trials on AD were set up in laboratory reactors (23 dm^3 each, Figure 1) simulating the biogas production process as performed in real scale, with daily input and output of material.

FIGURE 1 **Anaerobic digestion laboratory reactors**

Characteristics of input materials utilised in the three trials are reported in Table 1. Pig slurry was collected from a house for growers-finishers heavy pigs (up to 160-180 kg/head); cattle slurries were collected from cubicles where a small amount of chopped straw was utilised as bedding.

Each AD treatment had three replicates. Mesophilic conditions (38-39 °C) were maintained in the reactors. Table 2 reported some of the process conditions and results.

TABLE 1 **Chemical-physical characteristics of the materials used in the trials**

	pH	Total Solids (TS)	Volatile Solids (VS)		Total Kjeldahl Nitrogen (TKN)		Ammonium N
	[-]	[g/kg fm]	[g/kg fm]	[% TS]	[mg/kg fm]	[% TS]	[% TKN]
1) Pig slurry	7.2	46.9	31.3	66.6	4177	9.4	61.9
2) Cattle slurry	7.0	68.6	56.3	82.1	2718	4.0	42.8
3) Co-digestion							
- cattle slurry	7.6	66.9	54.8	81.8	2815	4.2	43.6
- silage maize	3.6	336.2	320.3	95.3	4446	1.3	1.1

TABLE 2 **Main conditions and results of the anaerobic digestion trials**

	Hydraulic retention time	Organic load rate	Methane production	Methane in biogas
	[d]	[kg VS/m^3/d]	[Nm^3/t VS]	[%]
1) Pig slurry	26	1.35	322	68.6
2) Cattle slurry	30	2.19	223	55.5
3) Cattle slurry + silage maize	50-70-90	2.60	289	51.3

Hydraulic retention times (HRT) were fixed considering the chemical-physical characteristics of materials. Only for the third trial with co-digestion of cattle slurry + silage maize, different HRT were tested but the same organic load rate was maintained modifying the volatile solids cattle slurry/silage maize ratio around 1:9.

Solid/liquid separation of raw slurries and digestates was performed by means of a laboratory centrifuge at 7000 rpm. Results cannot be directly compared with performances of the mechanical separators available on the market but they give indications on the effects due to AD process.

3 RESULTS AND DISCUSSION

In each trial:

- the ratio between volatile acidity (VA) to total alkalinity (TA) was constantly below 0.3, the value normally indicated as standard to avoid the process inhibition (Deublein and Steinhauser, 2008);
- methane production rates from organic matter were in accordance with data from literature (Deublein and Steinhauser, 2008) with higher values for pig slurry and silage maize and lower for cattle slurry;
- nitrogen balances (input-output) testified of N losses of about 1-3% due to little ammonia volatilisation in biogas.

The anaerobic digestion process determined the conversion of significant organic N quota to ammonium nitrogen. Ammonium increased from 62% (referred to Total Kjeldahl Nitrogen, TKN) in raw pig slurry to 73% in digested pig slurry, from 43% in raw cattle slurry to 52% in digested cattle slurry; in digestate from cattle slurry + silage maize it reaches 56% on TKN.

Anaerobic digestion, converting organic matter in biogas, determined a dry matter reduction in slurries, with a consequent decrease in separation efficiencies, as reported in Table 3.

TABLE 3 **Separation efficiencies in the solid fraction**

		Raw pig slurry	Digested pig slurry	Raw cattle slurry	Digested cattle slurry	Digestate from co-digestion of cattle slurry + silage maize
Weight	[%]	23.4	10.9	36.7	26.9	24.7
Total Solids	[%]	73.8	60.8	77.1	75.6	70.8
TKN	[%]	49.8	27.7	55.6	48.4	43.2

After anaerobic digestion, N separation efficiency in the solid fraction had diminished more than that of total solids, because of the mineralisation of organic N to soluble ammonium N, a process combined with the concurrent dry matter lowering in digestate (Figure 2). This effect was evident also in the third trial (co-digestion) where input N was mainly in the organic form, deriving from silage maize. This raw organic N, not digested by animals, is more reactive with respect to the organic N excreted by pigs and cattle (trials n. 1 and 2) and a significant part is converted to ammonium N.

As a consequence, ammonium N in the clarified fraction from digested pig slurry was 36% higher than that of the clarified fraction from raw pig slurry. The same difference for the cattle slurry trial was 43%.

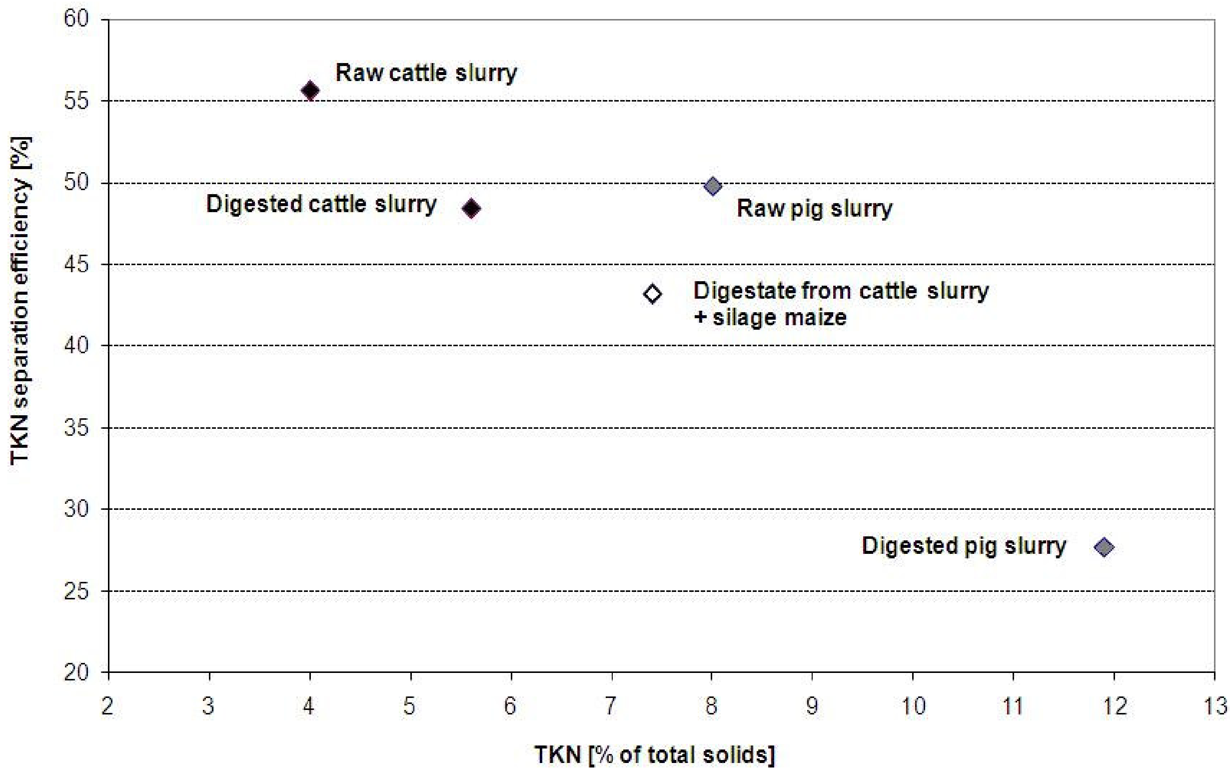

FIGURE 2 **Correlation between nitrogen concentration, referred to dry matter, and his separation efficiency**

4 CONCLUSIONS

Solid/liquid separation in practice, when applied to digestate, accumulate lower amounts of dry matter and N in the solid fraction with respect to raw slurry treatment. This is not favourable when the objective is to concentrate dry matter and N in the solid fraction, to process or export them. On the other hand, solid/liquid separation of digestate allows to maintain in the clarified fraction a higher percentage of total N in form of ammonium, readily available to crops, and in the solid fraction the slow release organic nitrogen.

Taking into consideration the fertilising effect of the clarified fraction, it should be possible to go over the 170 kg N/ha/year limit imposed by the Nitrate Directive for Nitrate Vulnerable Zones (NVZs) - in substitution to mineral fertilisers, thus reducing energy consumption and GHG emissions (Wood and Covie, 2004) - adopting Best Available Techniques (BAT) for land spreading to guarantee high N use efficiency (Mantovi et al., 2009).

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Other studies have been done in the same project on specific characteristics of both clarified and solid fractions from raw and digested slurries obtained in the trials reported (see paper of Monaco et al. in this book).

REFERENCES

Adani F, Schievano A, Boccasile G 2009. Anaerobic digestion: opportunities for agriculture and environment. DiProVe, University of Milan, Italy. 127 p.

Deublein D, Steinhauser A 2008. Biogas from waste and renewable resources – An introduction. Wiley-VCH Verlag GmbH & Co. KgaA, Weinheim, Germany, 446 p.

Mantovi P, Fabbri C, Bonazzi G 2009. Increase in the nitrogen efficiency using drip lines to apply the liquid fraction of pig slurry. Proceedings of the 16th N Workshop, June 28th – July 1st Turin, Italy. Edited by Grignani C. et al., pp. 365-366.

Wood S, Cowie A 2004. A review of greenhouse gas emission factors for fertiliser production. Report for IEA Bioenergy Task 38. http://www.ieabioenergy-task38.org/publications/ (Mar 2010).