Collecting the solid fraction from animal slurries for biogas production

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Abstract

Solid-liquid separation trials were carried out in real scale farms using screw press and sieve drum press equipment, to evaluate separation efficiencies on cattle and pig slurries. The two techniques, however different, gave similar separation results for the various parameters (weight, Total and Volatile Solids, Nitrogen, Phosphorus), and influenced primarily by the Total Solids content of the raw slurries and the type of the suspended particles.

Biochemical Methane Potential (BMP) tests were conducted at lab scale to evaluate the effect of using solid fractions of slurries in biogas plants. Fresh solid fractions from cattle slurry have a BMP of about 200 Nm^3 CH_4/t VS (at 30 days), quite interesting if compared with that of maize silage (350 Nm^3 CH_4/t VS). Solid fractions concentrate organic matter from slurry and could be collected from different farms to be utilized in anaerobic digestion plants.

Introduction

The solid-liquid separation of slurries is one of the simplest and most diffuse manure treatment techniques. It allows to concentrate the organic matter in the solid fraction, which can be transported more easily, because it has a lower water content and thick consistency.

The delocalization of the separate solid fraction of slurries outside areas of high density of farms or Nitrate Vulnerable Zones is hampered by its residual moisture, still too high, and relatively low nutrient content whilst the organic matter is more concentrated and could be profitably recycled to produce energy by anaerobic digestion.

Separation efficiency is defined as the total mass recovery of solids or nutrients in the solid fraction as a proportion of the total input of solids or nutrients [1]. Although decanter centrifuges can achieve a high separation efficiency (up to 80% Total Solids), this device is only seldom used in Italian livestock farms, due to the high investment and maintenance costs and also to operational difficulties. Relatively good separation efficiency can be achieved by screw press and sieve drum press (up to 60% Total Solids); these equipment are considered simple and reliable by Italian farmers, suitable for the needs of a wide range of farms [2]. In some cases trucks equipped with these machines are moved farm to farm for temporary separation services.

Material and Methods

Solid-liquid separation trials

Trials have been carried out into the frame of the LIFE+ AQUA project coordinated by CRPA (http://aqua.crpa.it) using simple separation techniques, such as screw press or sieve drum press, in real scale farms (cattle and pigs), to evaluate separation efficiencies under different conditions.

For each verification test, the raw slurry at the entrance of the treatment device and the two fractions produced (separated solid fraction and clarified) were sampled at the same time. Various chemical analysis were conducted on the three materials to derive separation efficiencies, including: Total Solids (TS), Volatile Solids (VS), Total Kjeldahl Nitrogen (TKN), Ammonia Nitrogen, Phosphorus.

Biochemical Methane Potential (BMP) of solid fractions

The methane yield from the solids separated were assessed by batch digestion to evaluate the possible effect of using solid fractions of slurries in biogas plants. Biochemical Methane Potential tests were conducted at lab scale [3, 4]. Solid fractions derived from slurries of milking cows kept on cubicles with sawdust in one case and chopped straw in another, as a bedding material. Both fresh solid fraction and the same solid fraction stored for 1 and 2 months were tested. A dense fraction derived from flotation of fresh pig slurries was also tested.

Results

Solid-liquid separation trials

Separation efficiencies can differ considerably when the same treatment is applied to slurries with different physico-chemical characteristics, but in general there is a significant correlation between the separation efficiency and the Total Solids content of treated slurries (see table 1 and figure 1 and 2).

The separation efficiency by weight of cattle slurry was higher due to the higher content of Total Solids and higher average size of the suspended particles. Screw press and sieve drum press, however different, gave similar efficiencies of separation for the various components, and influenced primarily by the Total Solids content and the type of the suspended particles.

Table 1 – Separation efficiency obtained in the trials, in percentage (average values, standard deviation in brackets)

	Weight	Total Solids	Volatile Solids	Total Kjeldahl N	Ammonia N
Screw press					
Cattle slurry	20.1 (±7.0)	52.2 (±13,1)	58.0 (±13.6)	23.1 (±7.5)	15.2 (±6.0)
Pig slurry	4.2 (±3.3)	27.7 (±14.0)	33.0 (±14.9)	7.1 (±5.0)	3.2 (±2.6)
Sieve drum press					
Cattle slurry	20.2 (±8.8)	44.7 (±12.6)	49.7 (±12.9)	23.0 (±9.4)	16.6 (±8.0)
Pig slurry	5.2 (±6.5)	19.8 (±16.7)	24.2 (±18.8)	9.7 (±8.3)	5.5 (±6.3)

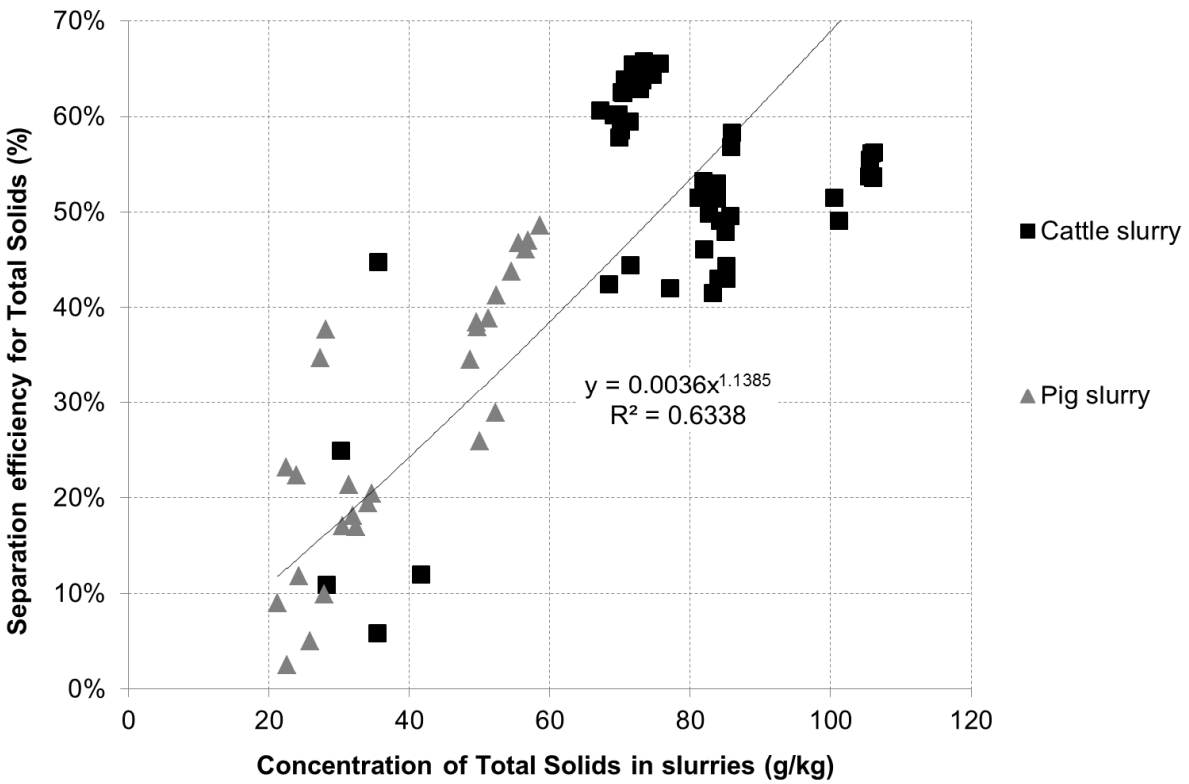

Figure 1. Correlation between the concentration of Total Solids (TS) in slurries and the separation efficiency for Total Solids (trials with screw press)

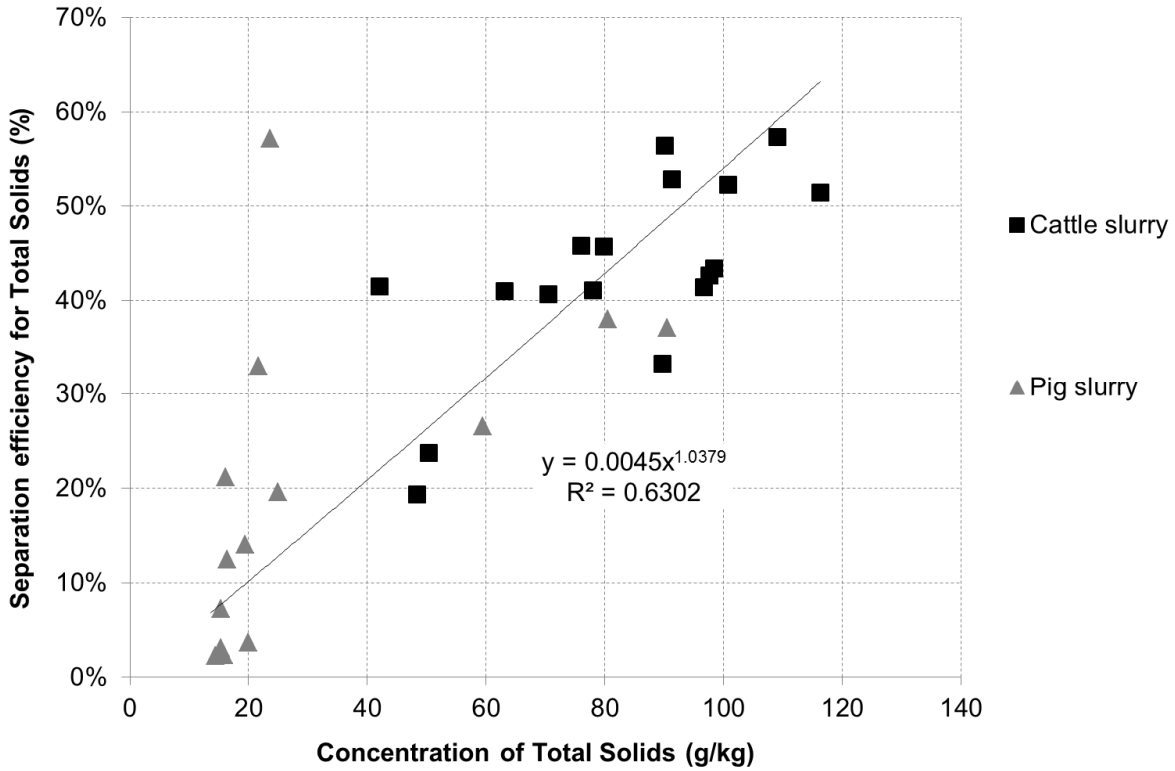

Figure 2. Correlation between the concentration of Total Solids (TS) in slurries and the separation efficiency for Total Solids (trials with sieve drum press)

Biochemical Methane Potential (BMP) of solid fractions

Table 2 reported the BMP results for fresh and aged solid fractions from cattle slurries and a dense fraction from pig slurry. The results were consistent with other studies [5, 6].

Table 2 – Results of the Biochemical Methane Potential (BMP) tests on solid fractions (average values at 30 days)

Type of solid/dense fraction	Nm^3 biogas/t VS	Nm^3 CH_4/t VS	Nm^3 CH_4/t tq	% CH_4 in biogas	VS degradability
From cattle slurry with straw, fresh(1)	375	214	41	57.1	47,3%
From cattle slurry with sawdust, fresh(2)	352	188	36	53.4	49,7%
From cattle slurry with sawdust, 1 month after separation(3)	151	80	14	53.1	23.9%
From cattle slurry with sawdust, 2 months after separation (4)	152	77	13	50.9	21.7%
From pig slurry(5)	389	275	16.3	70.8	42.3%

(1) from screw press separation, 21.2% TS concentration, 0.91 VS/TS
(2) from screw press separation, 20.9% TS concentration, 0.93 VS/TS
(3) the same as (2), 19.7% TS concentration, 0.88 VS/TS
(4) the same as (2), 19.3% TS concentration, 0.87 VS/TS
(5) from flotation, 8.0% TS concentration, 0.74 VS/TS

To make a comparison with respect to a reference product, the standard maize silage was considered. This latter can be defined as the maize silage characterized by 33% of Total Solids, 0.96 VS/TS and BMP of 350 Nm^3 methane/t VS [4].
In terms of energy potential, a ton of solid fraction from fresh cattle slurry, obtained by means of a screw press, resulted equivalent to 0.3-0.4 t of standard maize silage whilst a ton of dense fraction from pig slurry, obtained by means of flotation, resulted equivalent to 0.15 t of standard maize silage.
The conservation of the energy potential of the manure would require separation of fresh slurry, excreted in the days immediately preceding the operation of separation, and a rapid load at the biogas plant. The "aging" of such separated solid fractions can in fact cause an organic matter biodegradation with a very significant loss of energy value.

Conclusion and perspectives

Solid-liquid separation by means of screw press and sieve drum press can reach an organic matter separation efficiency of 50-60% for cattle slurry (up to 70% in case of fresh slurry with a high concentration of TS). Fresh solid fractions from cattle slurry showed a Biochemical Methane Potential (BMP) of about 200 Nm^3 CH_4/t VS at 30 days, quite interesting if compared with that of maize silage (350 Nm^3 CH_4/t VS). Solid fractions concentrate organic matter from slurry and could be collected from different farms to be utilized to produce biogas in anaerobic digestion plants of the area, having higher methane potential (per t of raw material) than that of the original liquid manure. Experiences are ongoing, to replace maize silage quota in real scale biogas plants fed by energy crops.
The adoption of this "energy option" requires to maximize separation efficiency, minimize costs and conserve as much as possible the Biochemical Methane Potential of the solid fractions.
A careful assessment of the costs and benefits that can derive from the use of solid fractions instead of maize silage is recommended for each situation, taking in consideration the price of materials, the possible variation of the hydraulic load of the digester and the quantity of digestate (and nitrogen) produced.

Acknowledgments

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