MANURE SEPARATION AS A PRE-TREATMENT METHOD TO INCREASE GASPRODUCTION IN BIOGASPLANTS

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ABSTRACT

Pre-treatment of manure by separation for producing a high-concentrated solid fraction increases significantly the biogas potential per waste volume. Theoretical methane potential and biodegradability of the solid fractions deriving from three types of manure separation were tested. Substitution of parts of the pig manure in a digestion plant with the solid fraction from pig manure can increase the gas production and 25% of the non pre-treated manure can be substituted with the solid fraction from centrifugation, without exceeding a dry-matter content of 10%, which can be handled in a CSTR digester.
Keywords: *manure separation, solid-liquid separation, decanting centrifuge, biogas production.*

INTRODUCTION

Considerable research in developing the biogas technology has been carried out in Denmark and today several co-digestion and farm scale plants are running. However, the biogas production from manure in terms of yield per volume is low and the biogas plants are dependent on the supply of easily degradable waste products for economical feasibility. The extension of new centralised plants is, however, stagnant at the moment due to a limited supply of these products. The transport of slurry from the farm to the biogas plant is a very important operating cost factor for the co-digestion plants and one of the reasons for poor economical performance of biogas plants treating mainly manure. Reducing the transport costs per m^3 of methane produced and increasing the daily methane production per m^3 digester volume, the economical feasibility of co-digestion plants will be improved. Drainage of the water from the manure by using manure separation is creating a solid fraction with a higher VS concentration and thus producing a waste fraction of the manure with a higher volumetric biogas potential. However, a part of the VS will always be present in the liquid fraction, and if only the solid fraction is used as a substrate for anaerobic digestion, it is extremely important that the separation unit is efficient in transferring VS to the solid fraction. Møller et al. (2004) found that centrifugation and chemical precipitation combined with screening were efficient methods for transferring VS to the solid fraction.

MATERIALS AND METHODS

Separation technologies

A wide range of solid-liquid separators are available on the market today. A selection of these was illustrated by Møller et al. (2000). Chemical precipitation of animal manure involves addition of chemicals to alter the physical state of dissolved and suspended solids to facilitate removal (Zhang and Westerman (1997), Westerman and Bicudo (1998)). For further agglomeration of coagulated particles, addition of polymers may under certain circumstances be needed.

The following types of separation technologies were used to produce solid fractions with a high VS concentration from the manure:

- Decanting centrifuge produced by Alfa Laval, NX 309B-31 (Rødovre, Denmark)
- Chemical treatment system with subsequent dewatering
- Faeces/urine separation (source-sorting)

For details see Møller et al. (2004). The faeces/urine separation was done by separate collection of faeces immediately after excretion.

RESULTS AND DISCUSSION

Methane production from solid fractions of manure deriving from separation

The methane potential and the biodegradability of the solid fraction deriving from the three types of manure separation were tested. The solid fractions deriving from centrifugation (SFD), and chemical precipitation (SFC) have almost the same theoretical methane yield as pig faeces (Fig. 2), but the methane yield per kg-VS is lower for SFD (average 194 L kg^{-1} VS) and SFC (247±25 L kg^{-1} VS) than for pig faeces (356±28 L kg^{-1} VS) and sow faeces (275±36 L kg^{-1} VS).The volumetric methane yield of both the solid fractions and the pig faeces is considerably higher than of pig manure, due to the higher VS content (Fig. 2); hence the volumetric methane productivity is 2.6–3.5 higher in the solid fractions from manure separation of manure compared with manure from fattening pigs, or 5–6.6 higher compared with undiluted sow manure. The methane productivity based on livestock units will, however, be reduced compared to untreated manure unless all the fractions are digested after separation. Approximately 60% of the volatile solids present in the "fresh" manure is transferred to SFD when a centrifuge is used for pre-treatment (Møller et al. 2002). 85% of the volatile solids is transferred to SFC when chemical treatment is used (Møller 2002). Other studies concerning the biodegradability of physical fractions from manure have been carried out with the solid fractions derived after filtering. Andara and Esteban (1999) found a B_o value of 165 L kg^{-1} VS in the fraction >1 mm from pig manure, which is less than that found in the solid fraction in this study.

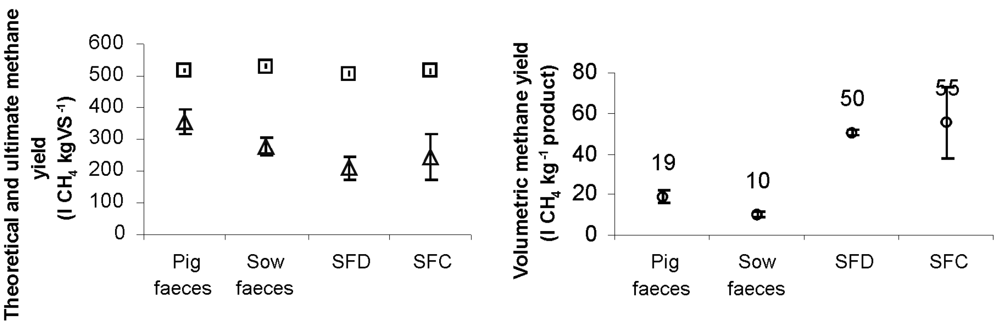

Figure 1. The theoretical Bu (❑) and ultimate methane yield Bo (Δ) in terms of VS and volume from pig manure and solid fractions of manure. The theoretical methane yield is calculated from Buswells formula after analyzing the manure. The volumetric methane yields of manure were calculated with standard DM contents.(6.6% and 4.5% in pig and sow manure respectively) (Poulsen et al., 2001). The VS:DM ratio in manure has been estimated as 0.8.

New systems for co-digestion of manure

In the development of more efficient treatment processes a number of different implementation concepts for solid-liquid separation can be considered. In Denmark, where several co-digestion plants are operating successfully, the most obvious application would be to substitute some of the non pre-treated manure with the solid manure fraction from separation (figure 2).

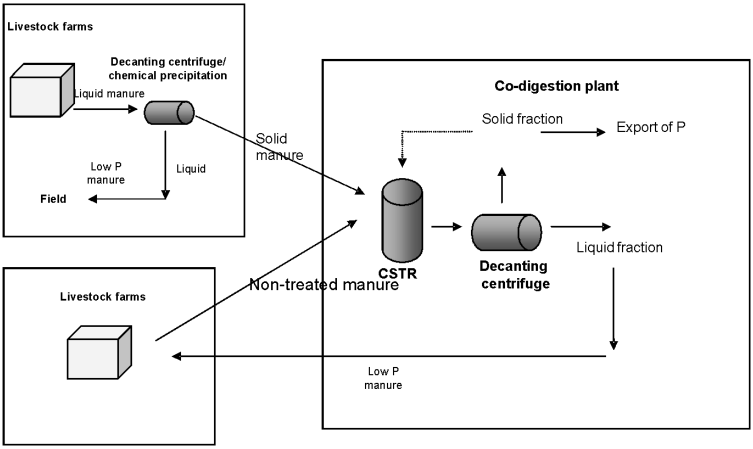

Figure 2. *New concept for a co-digestion biogas plant integrating solid-liquid separation at selected farms.*

The existing co-digestion plant technology in Denmark is the continuously stirred tank reactor (CSTR). The feeding and handling with the traditional CSTR technology demands a biomass, which can be pumped and mixed in a liquid form. Thus the dry-matter content of the feed and the effluent should not exceed 10% DM.

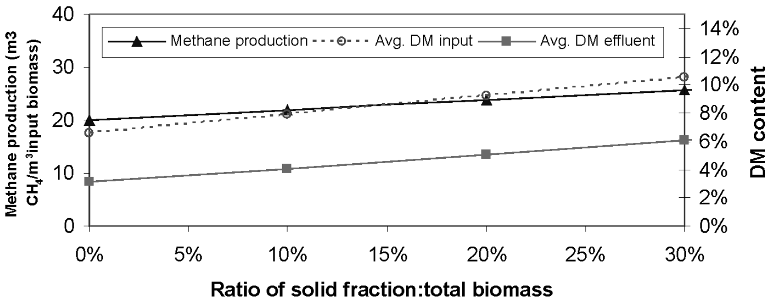

Figure 3. *Methane production (m³/m³ biomass input) and the average DM content in feed and effluent after substituting the existing biomass with increasing amounts of solid fractions from manure under the conditions listed in table 1.*

In figure 3 the consequences of substituting some of the pig manure in a digestion plant with the solid fraction from pig manure have been calculated. It can be seen that 25% of the non-treated manure can be substituted with solid fraction from centrifugation, without exceeding a dry-matter content of 10% in the mixed feed biomass and the DM content in the effluent will be less than 6%. By this substitution the gas production will increase from 20 to 25 m^3 CH_4/m^3 biomass.

CONCLUSIONS

Separation of the solid fraction from manure for increases significantly the volumetric biogas potential. By substituting some of the pig manure in a digestion plant with the solid fraction from pig manure the biogas production can be increased. 25% of the non-treated manure can be substituted with solid fraction from centrifugation, without exceeding a dry-matter content of 10%, which can be handled in a CSTR digester. Applying this substitution the biogas production will increase by 24% and at the same time the transportation costs are reduced. The farmers introducing solid-liquid separation as pretreatment will be subjected to separation costs, but often the economical prospects of extension the livestock production by export of surplus nutrients exceed these expenses.

Table 1. *Composition, theoretical methane yield by 100% conversion (B_t), ultimate methane yield (B_o) and VS conversion by anaerobic digestion.*

	Traditional biomass Pig manure	Solid fraction Centrifuged manure
DM (%)	6.60	30.90
VS (% of DM)	85.00	75.00
Bo (l CH4/kg VS)	356	210
Bt (l CH4/kg VS)	516	515
VS conversion (%)	62.09	36.70
Volumetric yield (l CH_4/kg product)	20	49

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