BIOGAS PRODUCTION AND ITS IMPACT ON REGIONAL MATERIAL FLOW MANAGEMENT, LOWER SAXONY, GERMANY

SYLVIA WARNECKE*, HANS-JÖRG BRAUCKMANN, GABRIELE BROLL

ABSTRACT

This study investigates the options for regulating regional material and nutrient flows via biogas production in a region with intensive egg, poultry and livestock production, processing industries and a high number of biogas plants in Northwest Germany. The most relevant by-products associated with these processes were found to be farm animal manure and digestates from the biogas fermentation process. Combination of regional investigations and a farm level study concerning the material flow of a biogas plant showed that there is a considerable potential for biogas production and digestate separation to positively affect regional material flows.

Keywords: material flow management, intensive animal farming, nutrient surplus, renewable energy, biogas

1 INTRODUCTION

Renewable raw materials cropping is increasing worldwide. In 2007, the European acreage of energy farming reached 2.8 million ha (5.6% of the arable land). With 1.8 million ha (14.9% of arable land), Germany had a considerable share on the European acreage. For Germany as a whole the production of bio-diesel is of major importance (65% of the acreage used for energy cropping in 2007), whereas in northwest Germany biogas production prevails (58% of the acreage used for energy cropping in 2007) (HÖHER 2007).

The amendment of the German Renewable Energies Act (EEG) in 2004 (EEG 2004) led to a tremendous increase of biogas plants. In the end of 2007, almost 25% of the German biogas plants and approximately 30% of the installed electrical capacity were found in the county of

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Lower Saxony in northwest Germany (HÖHER 2007). Therefore, the traditional land use systems have been undergoing major changes. Typical feed/food crop rotations are changing into biogas crop rotations, organic fertilisation turns from untreated manure to digestates, the residues of the fermentation process. Due to the Renewable Energies Act's regulations (EEG 2004), agriculturally produced renewable raw materials are the most abundant substrates for biogas production in Germany. In northwest Germany, maize silage is most widely used because of its high potential yield (BENKE 2007). A common co-substrate is pig or cattle slurry. In recent studies, liquid manure is recommended as a prime eco-efficient substrate for biogas production, particularly in regions where it is widely available (WISSENSCHAFTLICHER BEIRAT AGRARPOLITIK 2007). To make operation profitable, both input and output materials have to come from and go to the immediate vicinity of the biogas plants.

In general, the effects of the great expansion of biogas production on soil, water, and atmosphere, on markets, or on traditional material flows are still largely unknown. In regions with high livestock densities, biogas production and only limited acreage, economic concerns include an increase of land lease prices and higher costs for exporting liquid manure and fermentation residues. Hence, an appropriate regional material flow management (HECK, BEMMANN 2002) which considers a reasonable use of renewable energy sources such as liquid manure as well as of the digestates is of particular importance to prevent both economic and environmental problems.

2 MATERIAL AND METHODS

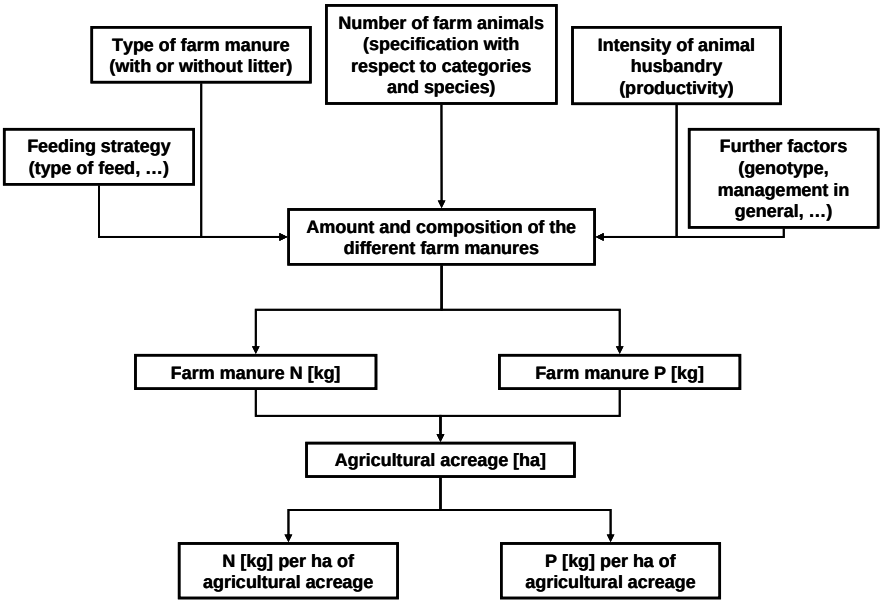
The study area is the county of Lower Saxony in northwest Germany because of its importance for German agriculture, particularly with respect to animal products (WINDHORST, GRABKOWSKY 2008).

In order to investigate a region's agricultural material and nutrient flow and to determine its impact on these flows, following steps are needed. First, the existing regional agricultural structures must be analyzed, leading to the selection and detailed characterisation of model regions. Every four years, basic data on the agricultural structures in Germany are delivered by county based statistical offices (for Lower Saxony: LSKN, Landesbetrieb für Statistik und Kommunikationstechnologie Niedersachsen). Analysis of these agro-structural statistics which are available on the county, district and commune level provides a detailed picture of the existing agricultural structures. The most recent version is from 2003. Additional informa-

tion about the number of biogas plants and installed electrical capacity were taken from external studies (HÖHER 2007).

By analysing the quantities and qualities of by-products of animal husbandry along product chains it became obvious that farm manure derived from animal husbandry is the dominant by-product. For the regional determination of the quantities and composition of animal husbandry derived farm manure a number of empirical and statistical data sets were used. The German Fertilizer Ordinance (DÜV 2006) and the Lower Saxony Chamber of Agriculture provide extensive data on quantity and composition of animal excreta and manure. Potentially, this data allows a detailed determination of the regional amounts resulting from animal husbandry (LWK 2007a, 2007b). The extent to which this potential can be used depends on availability of data on the factors determining quantity and quality of farm manure (Fig. 1).

Fig. 1: Region based determination of quantity and composition of farm manure per hectare of agricultural acreage (with N and P as example). This approach results from the various available data bases as described in the text



Source: Author‘s own

District level data on number and species of animals kept were made available for 02.01.2008 by the Lower Saxony insurance system which is in place for the case of epidemic animal diseases (NIEDERSÄCHSISCHE TIERSEUCHENKASSE, unpublished data from 2008). Because the data on age, weight and use of the animals are comparatively rough, the regional distribution of the relevant parameters was taken from the agro-structural statistics and combined with the total numbers of animals in the individual categories. Furthermore, data from farmers’ organi-

sations about milk yield per cow and lactation period, for example, or data about feeding systems were used. The calculated quantities of manure resulting from animal husbandry were then referred to the agricultural area.

Furthermore, detailed studies with respect to selected topics have to be conducted in farms representative for their region. For this study, an integrated material and nutrient flow analysis in a biogas plant typical for the study area was carried out (BRAUCKMANN et al. 2007).

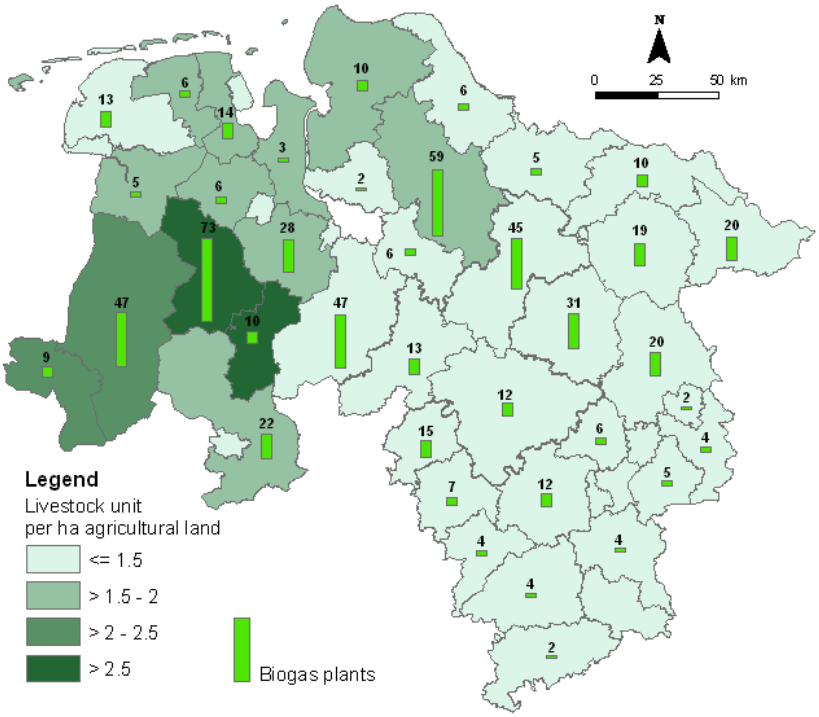
For conclusions with respect to biogas production induced impacts on regional material flow, assessments of current and alternative uses of the relevant by-products are carried out. This requires extensive and reliable data bases as well as the consideration of voluntary and legal regulations (eg, EEG 2004, DÜV 2006) and their likely future development.

3 RESULTS

Traditionally, the county of Lower Saxony is divided into a region with predominantly arable farming in the East and a region with high intensity animal farming in the West. Fig. 2 shows animal densities as livestock units. Livestock units allow the comparison of different animal species per hectare of agricultural land on basis of live weights (500kg live weight is 1 livestock unit). In the Northern part of the investigation area, extensive grasslands and livestock farming prevail, whereas poultry and egg production as well as pig fattening are predominantly found in the southern part. Particularly high livestock densities are found in the districts Cloppenburg and Vechta, together with a high number of biogas plants. This region has high nutrient surpluses. Excess farm manure from animal husbandry is typically exported into neighboured regions with lower animal densities. The transport of the farm manure is expensive, especially if water rich materials like pig slurry are concerned. Most of the biogas plants in this area use renewable energy sources like maize and crop silage. Such input materials introduce nutrients into the biogas plant which accumulated in the digestates. Thus, more or less the same arable land area used for cultivating energy crops is needed for digestate application, resulting in a high competition between biogas production and animal farming.

A possible solution to this problem is digestate separation to get a solid fraction which can be transported into regions with lower animal densities. As this technique is quite new, a detailed material and nutrient flow assessment was conducted on a representative biogas plant (BRAUCKMANN et al. 2007).

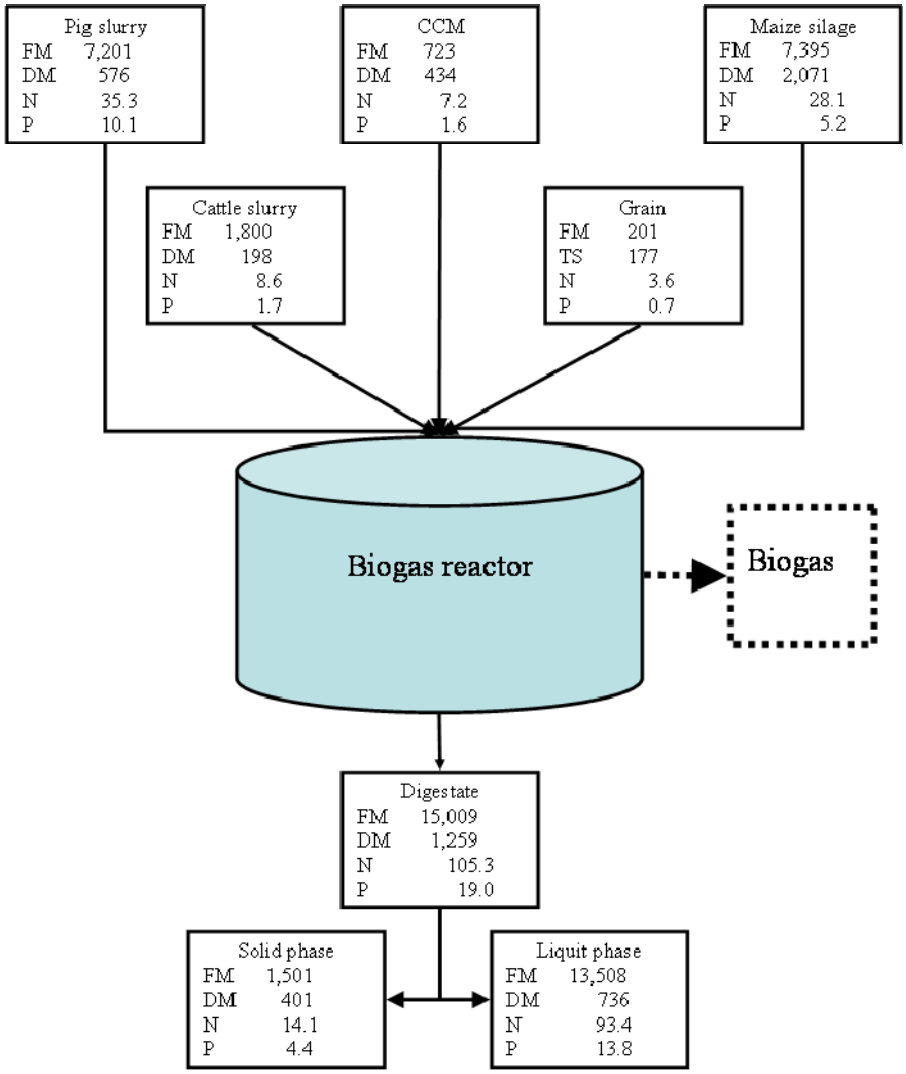
Fig. 2: **Animal density in 2008 shown as livestock units (500 kg life weight) per hectare of agricultural land and number of biogas plants in 2007 (bars with number on top) in the districts of Lower Saxony. Grey Borderlines show district and region borders. Highest livestock units ha^{-1} occur in the districts of Cloppenburg and Vechta (dark green > 2.5 livestock units ha^{-1}) with up to 4.0 livestock units ha^{-1}**



Source: Author‘s own, created on basis of data from KTBL (2008), NIEDERSÄCHSISCHE TIERSEUCHENKASSE (2008) and LSKN (2003), HÖHER (2007)

The biogas reactor was fed with pig and cattle slurry, maize silage, Corn-Cob-Mix and grain (Fig. 3). The electrical capacity is 500kW. In the separated solid phase, 35% of the dry matter, 13% of the nitrogen and 24% of the phosphorus of the digestate could be exported. The separation leads to an optimized composition of the liquid phase regarding plant requirements. Thus, its use as organic fertilizer is improved in comparison to pig slurry or unseparated digestate. The agricultural acreage necessary for applying the unseparated digestate is 541 ha, whereas only 418 ha are necessary for the liquid phase (BRAUCKMANN et al. 2007).

Fig. 3: Biogas Material Flow Scheme of the Biogas Plant (FM Fresh Mass, DM Dry Mass, P total Phosphorus, N total Nitrogen) in t a^{-1}



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4 CONCLUSIONS

In the study area traditional animal farming and biogas land use systems compete for agricultural acreage used for crop production and organic fertilization.

Although biogas production is part of this problem, it offers valuable opportunities for the regional material and nutrient flow management needed for the region:

- In areas with high livestock densities the farm animal liquid manure can be an economical and ecological efficient energy source. On the regional level, substitution of a great share of particularly cultivated energy plants with liquid manure can help to mitigate the current land use conflict as well as making biogas production more sustainable.

- Technical methods along the biogas production chain can also help solving the problems of nutrient surplus and competition for agricultural land as shown by the mechanical separation of digestates. The digestate liquid phase is a valuable fertilizer but the transportation costs are high, whereas the digestate solid phase is also a valuable fertilizer with low transporting costs.
- Hence, a regionally increased use of liquid manure for biogas production with following digestate separation can preserve resources otherwise required for transportation (nutrient export) and for the production of chemical N fertilizers. These findings can also be applied to other regions with intensive animal farming similar to the study area.
- As only a share of the available pig and cattle slurry produced in the study area can be fermented in biogas plants, it is important to study and assess additional options for an efficient regulation of material and nutrient flows in the future.

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