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Biogas production and its impact on regional material flow management

Introduction

- In 2007, two thirds of the European acreage used for the cultivation of energy plants were found in Germany.
- In northwest Germany biogas production is predominant (58 % of the energy plant acreage in 2007) (Tab. 1).
- Subsequently, typical feed/food crop rotations are changing into biogas crop rotations, organic fertilization turns from unfermented manure to digestates.
- Thus, the established regional agricultural material flow patterns are affected.

	Germany	North-west Germany (Lower Saxony)
Acreage of energy plant cultivation	1.770.000 ha	200.000 ha
Percentage on arable land	14.9 %	11.2 %
Percentage on energy plant acreage		
• Production of bio-diesel	65 %	33 %
• Production of bio-ethanol	10 %	9 %
• **Production of biogas**	15 %	**58 %**

Tab. 1: Acreage of energy plant production in Germany and northwest Germany and percentage of the different conversion forms.
Source: Höher 2007

Objectives

Determination of options and problems for regional material flow management associated with biogas production combining farm based information with statistical and expert data available for various regional scales.

Methods

- Analysis of regional agricultural structures, selection and detailed characterisation of model regions
- Identification and assessment of the relevant by-products from animal husbandry and biogas production
- Conducting detailed single farm and enterprise based studies
- Assessment of utilisation of the relevant by-products and associated regional material flows

Biogas plant in the district of Vechta. Source: Brauckmann et al. 2007

Results: Nutrient amounts in the model regions

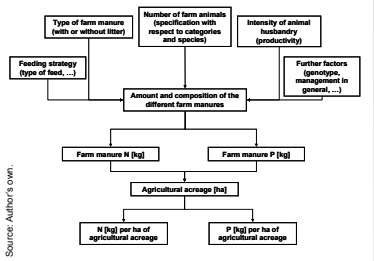


Fig. 2a: Region based determination scheme of quantity and composition of farm manure per hectare of agricultural acreage.

For the regional determination of the quantity and composition of farm animal manure per hectare of agricultural land, a range of data bases such as official statistics, empirical and expert data is used (Fig. 2a). On the district level, Cloppenburg and Vechta are outstanding in manure borne nitrogen (Fig. 2b) and particularly phosphorus (Fig. 2c) amounts per ha agricultural land.

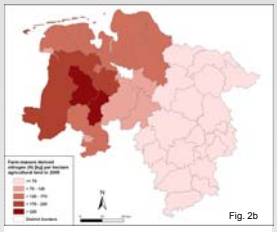


Fig. 2b

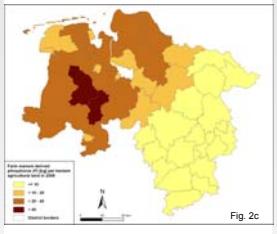


Fig. 2c

Fig. 2b and 2c: District based amounts of nitrogen (2b) and phosphorus (2c) [kg ha^{-1}] from farm animal manure.

Source: Author's own, created on basis of unpublished data from Lower Saxony insurance system for animal epidemics (TSK 2008), agro-structural data from Lower Saxony statistical office (LSKN 2003) and data on quantity and composition of animal excreta and farm manure (Chamber of Agriculture Lower Saxony (LWK 2007), German Fertilizer Ordinance (DüV 2006)).

Conclusions

In the study area traditional high intensity animal farming and biogas landuse systems compete for agricultural acreage. This study shows that while now still being part of the problem, biogas production even has a potential to help mitigating the current landuse conflict:

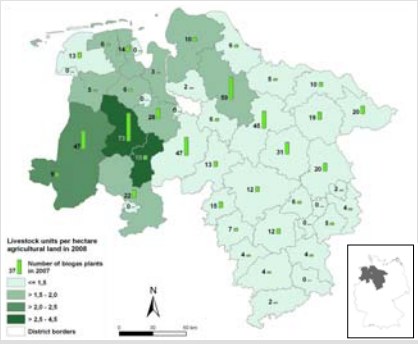
- Biogas production can efficiently use liquid manure as a substrate, which can partially substitute particularly cultivated biogas crops such as maize.
- Technical methods along the biogas production chain such as digestate separation can be one of a set of tools for managing nutrient surpluses.

The combination of a regionally increased use of liquid manure for biogas production with following digestate separation can

- Return acreage now used for biogas cropping to feed/food cropping and
- Preserve resources otherwise required for nutrient export and production of chemical N and P fertilizers.

As only a share of the liquid manure produced in the study area can be fermented in the existing biogas plants further studies are required assessing additional options for efficient regulation of material and nutrient flows. This must also take into account both economic and ecological considerations.

Results: Model regions



In several districts of northwest Germany, high intensity animal farming results in regional nutrient surpluses from farm manure. An additional high density of biogas plants with renewable raw material substrates intensifies the problem of nutrient surpluses and leads to a competition for agricultural land needed for cropping and for farm manure and digestate application, respectively. The model regions are the districts of Cloppenburg and Vechta (dark green in Fig. 1) with 3.7 and 4.0 livestock units per hectare.

Fig. 1: District based animal densities (livestock units per hectare agricultural land) in 2008 and number of biogas plants in 2007 in northwest Germany (county Lower Saxony). Small map indicates the location of Lower Saxony in Germany.

Source: Author's own, created on basis of data from KTBL (2008), unpublished data from Lower Saxony insurance system for animal epidemics (TSK 2008), Höher (2007) and LSKN (2003).

Results: Detailed biogas study and implications for the model regions

During the biogas production process, methane (CH_4) is produced from the carbon (C) in the organic matter of materials such as maize and farm animal manure. Hence, C is depleted from the digestate, the by-product of biogas production. Nitrogen (N) and phosphorus (P) contents both in the substrate and in the digestate are not affected by the fermentation process and thus stay the same (Fig. 3).

Mechanical separation of the digestate results in the relative enrichment of P in the solid phase, while N contents are similar in both the liquid and the solid phase (Brauckmann et al. 2007). In comparison to the unseparated digestate, both phases have an improved N:P-ratio regarding crop requirements and soil conditions.

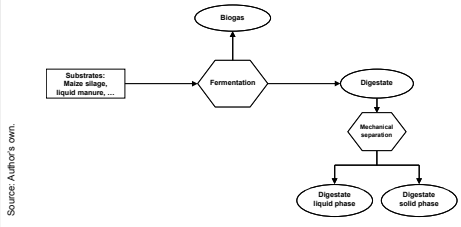


Fig. 3: Schematic overview of the input and output materials of a biogas plant with mechanical digestate separation into a liquid and a solid phase.

The improvement of the N:P-ratio due to digestate separation (Fig. 3) is of importance when considering the nutrient surpluses in the study area:

The liquid phase – with relatively low P and a high water content – can be used as organic fertilizer on the farm land close to the biogas plant. Soil P contents of the study area are generally high to very high, and fertilization with the liquid phase does not further enrich these soils.

The solid phase – with relatively high P and a low water content – can be exported from the region as fertilizer. Soils in areas with low animal densities often have low P contents. Alternatively, the solid phase can be used energetically.

A farm-based scenario showed that the application of the unseparated digestate requires 541 ha, while it requires only

418 ha for the digestate liquid phase (with annual application rates based on the German Fertilizer Ordinance 2006) (Brauckmann et al. 2007).

References

- Brauckmann, H.-J.; Broll, G.; Schomaker, B.; Stania, B.; Warnecke, S. (2007): Nährstoffstromanalyse einer Biogasanlage mit Gärrestaufbereitung im Landkreis Vechta. ISPA Mitteilungen - Heft 65.
- Düngeverordnung (DüV) (2006): Verordnung über die Anwendung von Düngemitteln, Bodenhilfsstoffen, Kultursubstraten und Pflanzenhilfsmitteln nach den Grundsätzen der guten fachlichen Praxis. Ausfertigungsdatum 10. Januar 2006 (BGBl. I S. 33). Düngeverordnung in der Fassung der Bekanntmachung vom 27. Februar 2007 (BGBl. I S. 221).
- Höher, G. (2007): Entwicklung Energiepflanzenanbau und Biogas in Niedersachsen. Presentation during the Workshop „Basisdaten zum Flächendruck durch den Energiepflanzenanbau für die Biogasnutzung". Berlin, Niedersächsisches Ministerium für den ländlichen Raum, Ernährung, Landwirtschaft und Verbraucherschutz.
- Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL) (2008): Livestock units online calculator. http://www.ktbl.de/index.php?id=356, 23.02.2008
- Landesbetrieb für Statistik und Kommunikationstechnologie Niedersachsen (LSKN) (2003): Agrarstrukturerhebung 2003. Bodennutzung und Viehhaltung.
- Landwirtschaftkammer Niedersachsen (LWK) (2007): Nährstoffausscheidungen landwirtschaftlicher Nutztiere je Stallplatz und Jahr. Ausfertigungsdatum 25.04.2007. http://www.lwk-niedersachsen.de/index.cfm/portal/pflanze/nav/340/article/8505.html, 21.12.2007
- Niedersächsische Tierseuchenkasse (TSK) (2008): Unpublished data on number of animals in the districts of Lower Saxony on 02.01.2008.

Funded by Ministry for Science and Culture of Lower Saxony

FORUM 2008

Poster presented at IAMO Forum 2008 in Halle (Saale).
Poster paper available on Proceedings CD and online at
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