Water-Related Problems with the Output of Digestate from Biogas Plants – data sheet DWA-M 907

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The DWA-group GB 6.6 *Effects and consequences of the cultivation and use of renewable raw materials (energy crops) on soil and groundwater* has developed the data sheet DWA-M 907 *Production of biomass for biogas plants under the consideration of soil and water conservation* for the current debate on the promotion of renewable resources for heating and energy use. The rapid growth of biogas and cofermentation plants which took place in the last 10 years helps to achieve the climate goals of the European Union, contributes to energy supply diversification, particularly on a regional scale and represents an additional source of income in rural areas.

Cultivation of energy crops is focused on maize, due to the familiarity in the cultivation of maize, existing fermentation technology and its high energy yield. In some areas this narrows the crop rotation. Rising manure application and accelerated erosion are the consequences of intensive maize cultivation, which in turn can lead to water pollution. The growing of biomass will in addition further the transition from permanent grassland to cropland, as well as reactivate fallow land and intensify agriculture generally by growing *energy crops*, which entails additional risks for water protection.

The conversion of biomass materials leave digestates as end products to be taken care of. Due to the increasing amount of digestates and the insufficient control of the nutrients in the application on agricultural land occur further risks for water protection. Also co-fermentation substrates can be contaminated which poses an additional risk for water protection.

The compiled data sheet (M-907) targets politics, administration, agricultural extension and farmers specializing in the cultivation of renewable raw materials. The paper provides agricultural consulting and positive support of agriculture in choosing the right crop rotation and the utilization of digestates consistent with soil and water conservation.

1. Opportunities and Risks

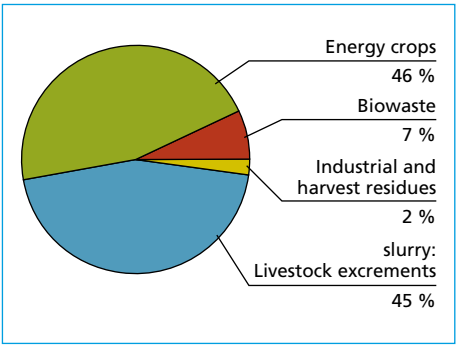

Figure 1: Substrate (mass-related) used in biogas plants in Germany 2010

Sources:
Deutsches BiomasseForschungsZentrum GmbH (DBFZ), 2010
Fachagentur Nachwachsende Rohstoffe (FNR), 2012

The operation of biogas plants is generally ecologically sensible, because about half of its substrate comes in the form of manure. Manure that is often treated as waste on farms can be turned into usable energy which reduces the need for fossil fuels and in turn reduces also CO_2 emissions. Currently only about 20 % of the total manure production in Germany are used for energy purposes. The potential of this substrate category is therefore far from being exhausted. The establishment of biogas plants operating on manure however increases the problem of organic fertilizers in areas already putting out too much fertilizers.

In this context a problem arises with the spreading of the digestates in the same way as it is often observed with slurry. For disposal and financial reasons fields near to a farm are disproportionately higher fertilized, while remotely located fields are much less often tended. Transport distances of 10 km or more are not uncommon in practice.

From the viewpoint of water protection it is difficult to assess in what extent the cultivation of energy crops competes with food crops. The latter are usually sold thus reducing the total nutrient accounting balance by exporting nutrients. If energy crops are grown instead of food crops, the amount of nutrients circulating between field and biogas plant increases which could lead to a rising danger of nutrient seepage. This danger is obviously greater, the higher the number of livestock is and the accumulation per area unit.

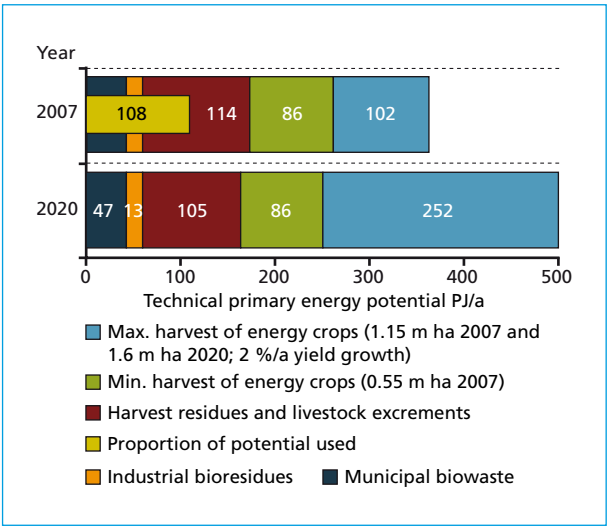

Figure 2:

Technical potential for biogas substrates in Germany 2007 and 2020

Sources:
IE, Deutsches BiomasseForschungsZentrum GmbH (DBFZ), 2009
Fachagentur Nachwachsende Rohstoffe (FNR), 2011

Currently a rising proportion of maize as biomass for biogas plants can be observed. Since the consequences of maize cultivation in terms of soil and water conservation (erosion hazard, higher proportion of manure than commercial fertiliser) are often problematic, it presents a further potential conflict.

About a quarter of the biomass used are residues and organic waste. This constitutes a significant hazard for ground and surface water. It can be assumed that the interests of water conservation continue to be extended with the implementation of the EU Water Framework Directive, but must be questioned if its statutory target is at all compatible with energy policy goals such as the expansion of biogas production.

Increase in the demand for food and supply shortages, particularly by predicted impacts of climate change, and the rapid growth of the world`s population, will cause an intensification of crop production, especially as prices will develop accordingly in the future [7]. This could lead to a lowering of today`s high environmental and water protection standards. To prevent this from happening, the objectives of soil and water conservation must increasingly find their way into practice and should be made mandatory. This compiled information sheet should contribute to this.

Influencing the quality of water bodies from growing energy crops for biogas production is on the one hand the crop management (see Chapter 2) and the other the return of the digestates of biogas plants on agricultural land (see Chapter 3). The leaflet DWA-M 907 shows in addition to the extensive legal requirements, comprehensive recommendations on how the aspects of soil and water conservation can be considered.

2. Cultivation of energy crops

For biogas production are basically all grass and herbaceous plants such as maize, wheat and non-woody crops suitable. The production techniques for energy crops are similar to those of currently used agricultural crops or grassland.

The environmental impacts of these production methods for biomass differ therefore not fundamentally from the normal farming practices [8]. However slight differences are expected due to different demands on the quantity and quality of the crop. Considerable water hazards pose the already observed changes in land use by ploughing grassland, the expansion of maize production and the intensification of production towards high mass yields. Especially the concentration on only a few highly profitable energy crops such as maize for use as silage in some regions of Germany has led to one-sided cropping patterns. With the expansion of maize acreage for biogas production, as with conventional cultivation methods and the use of excessive organic fertilizer the risk of soil erosion and increased use of plant protection products increases [1, 3, 10, 11].

However water and soil pollution can be significantly reduced even if maize is cultivated. From an agronomic point of view maize can be grown quite groundwater-friendly including low nutrient accounting balances and low nitrogen mineralization in autumn if aquatic and soil conservation cultivation practices are respected [DVGW worksheet W 104, DVGW, 2004].

In particular good practice includes:

- an appropriate crop rotation system,
- an optimized fertiliser control and a low nutrient accounting balance,
- a balanced humus level,

- Optimized plant protection measures
- Measures to prevent erosion and conservation tillage,
- Optimized climatic water balance and high water efficiency.

The peculiarities of energy crop cultivation are described in the leaflet in respect to the possible environmental impacts and are supplemented by crop management recommendations.

3. Application of digestates

3.1. Assessment

Digestates from biogas plants are counted among manure, if they originated from the fermentation of in agricultural, sylvicultural or horticultural plant materials companies, and may be mixed with animal droppings. If other substances, such as biowaste or animal by-products are fermented degistates are labeled organic fertilizers according to the German regulation for fertilizers (DüMV).

Not only from a legal perspective, but also against the background of the utilization of digestates in agriculture with a view to the protection of water this differentiation is of relevance. In order to develop appropriate strategies for the protection of water the material composition and agronomic effects of digestates must be known (nutrient analysis). This would be the prerequisite of the use of digestates as fertilizer. The material composition of the digestates varies greatly depending on the composition of the initial biomass, with which the biogas plant is fed. The criteria below are considered to determine the properties of digestates:

- Nutrient content,
- Content of organic matter,
- pH-value,
- Pollutants and hygiene issues.

The digestates left after biogas production are mainly for agricultural uses as fertilizer in an effort to keep up a nutrient cycle.

Since the digestates possess high nutrient levels in terms of the fertilizer regulation (DüV) that the statutory provisions of the DüV in the application of digestates must be observed. Observational research in soil and water conservation shows that the regulations set forth in the DüV for the protection of water are not sufficient. Further recommendations for the use of manure and digestates have to be given in order to avoid adverse effects, especially by nutrients and pollutants. General recommendations, refer to the DVGW W104 ‚Principles and policies of a water protective land management [2].

3.2. Recommendations

The data sheet DWA-M 907 proposes measures for soil and water conservation that expand the existing legal framework as outlined below:

Licensing practice for biogas plants: The establishment and updating of a qualified acreage certificate (QFN- Qualifizierter Flächennachweis) as a tool for planning and controlling is important from the viewpoint of water protectionists. This proof has to be audited continually.

It would be advisable to form a uniform national standard that governs the necessity to prepare a QFN, the kind of recording, documentation and control of material flow [1].

Limitation of nitrogen loads by acreage: The amount of nitrogen stemming from biogas plants (energy crops) does not limit the maximal admissible amount of nitrogen (170 kg N/ha rolling average of each agricultural buisness) according to the fertilizer regulation. The spreading of digestates in exceedance of the 170 kg N/ha has to be rejected from the perspective of water conservation. Nutrient concentrations in digestates are similar to those found in manure of animal origin. In this respect are all known problems in the spreading of manure expected to crop up. This relates especially to the uncertainties associated with the moment the nutrients become effective which in turn makes calculation with manure hazardous. It is to be demanded that the maximum admissible amount of 170 kg N/ha total nitrogen should not be exceeded regardless of the proportion of energy crops or animal manure in the digestates.

Storage and storage capacity: Digestates must be utilized in accordance with § 3, paragraph 4 of the DüV to feed the nutritional needs of the plant. Since the major uptake of nitrogen takes place in spring recommended application times and amounts should focus on this period. In determining the storage capacity of the required slurry container its size should be based on the slurry storage duration as outlined in the *Nutritional assessment sheet for agricultural projects in NRW* [9]. Agricultural companies who cultivate maize on > 75 % acreage should be subjected to provide for a storage capacity of up 9 months.

Identification and labeling of the nutrient contents: Due to the different nutrient levels in the original biomass and correspondingly large fluctuations in nutrients of the digestates system-specific analysis are called for to determine the nutrient content as possibly just before the spreading of digestates which should be made mandatory. In the case of cofermentation plants a full analysis should take place to account for not only nutrients and heavy metals such as copper (CU) and zinc (Zn), but also organic substances such as polycyclic aromatic hydrocarbons (PAK) and pathogenic germs such as Clostridium perfringensis.

Introduction of a quality audit for digestates: If digestates form cofermentation plants (biomass according to BioAbfV and TierNebV) are used on agricultural land these should be subjected to an independent, approved quality control procedures. The Federal Quality Compost Association (BGK – Bundesgütegemeinschaft Kompost) and VDLUFA QLA GmbH are recognized institutions for a regular quality control in terms of ordinance for biomass wastes (BioAbfV).

Quality audits for digestates from energy crops are sensible for a variety of reasons. Proper declaration is demanded for origin, type and quantity of energy crops, manure and co-fermentation biomass, nutrient level and organic pollutants (heavy metals and organic pollutants). Furthermore the digestate should be given a certificate on sanitization (eg. free from salmonella, survival rate of weeds). While a nationwide introduction of a quality audit would be preferable it would be conceivable to introduce this voluntarily as a kind of quality label. This should be made mandatory in water protection areas.

Rules for digestates-spreading in water protection areas and other sensitive areas: To evaluate the digestates in relation to your use of water reserves and other sensitive areas, it is helpful from the point of view of water protection, to consider the original biomass. This approach is based on the DVGW research W1/03/05 *Assessment of the production of biomass for energy generation from the perspective of water conservation* [3]. Four groups of digestates are distinguished by initial biomass and their area of use. Table 1 shows the relevant classification:

Table 1: Classification scheme for the digestates on the basis of the raw materials and derived requirements with regard to agricultural use

	Digestates			
	Group 1	**Group 2**	**Group 3**	**Group 4**
Biomass	From agricultural and forestry production (e.g. **energy crops**)	Manure	Residues from the treatment and processing of agricultural products	Other biogenic waste (Organic waste, animal by-products)
Examples of significant biomass	Energy crops (eg maize, whole crop silage, grass silage), Crop residues, beet leaf silage, Grass cuts from lawns, golf courses and riparian banks, Husk, husks and grain dust, Feed waste, vegetable leftovers from markets	Cattle, pig, chicken manure in liquid(slurry) or solid state	Fruit, grain and potato pulp, Residues from the manufacture of beverages (eg, pomace, brewer's grain, sludge from distilleries and breweries	**Vegetable Residues**: Residues from organic household waste, animal feed or food processing **Animal waste**: grease waste from grease traps or flotation residue, slaughterhouse waste (i.e. stomach and intestinal contents)
Use in water protection areas and water catchment basins	Not admissible in zone II, or within the 50-day perimeter		Not allowed in water catchment and protection areas as well as other sensitive areas 1) exemption possible in zone III provided monitoring by a suitable authority 2) special treatment due to regional distinctions	Not allowed in water catchment and protection areas as well as other sensitive areas

1) *sensitive* from a water protection point of view are areas with shallow soils, karst areas and steep slopes threatened by erosion(cf. Drechsler, H.; Schefer, B.: Kriterienkatalog zur Ermittlung *empfindlicher Standorte* aus Sicht des Gewässerschutzes – Diskussionsbeitrag. In: Korrespondenz Wasserwirtschaft 10/2008. DWA, Hennef)

Source: Deutsche Vereinigung des Gas- und Wasserfaches E.V. – DVGW: Beurteilung der Erzeugung von Biomasse zur energetischen Erzeugung aus Sicht des Gewässerschutzes. Abschlussbericht zum DVGW-Forschungsvorhaben W1/03/05 (Literaturstudie), bearbeitet durch das Technologiezentrum Wasser Karlsruhe, Karlsruhe, 2008

The application of digestates in protection zone II even if the digestates derive exclusively from agricultural and forestry products should be rejected due to a possible microbiological contamination. In some federal states digestates from manure are prohibited in this way. Digestates stemming from raw materials from group 3 (residues of the treatment and processing of agricultural products) and 4 (biogenic substances such as organic waste and animal by-products) should generally not be applied in water conservation and other sensitive areas. The results of the DVGW W1/03/05 research project show that digestates from cofermentation (organic waste and animal by-products in accordance with Annex 1 BioAbfV), especially co-ferments from group 4, may be contaminated with pollutants. The agricultural utilization of digestates from biomass of Group 3 in water protection zone III should be only admissible by approval of the Water Authority on the precondition that a full declaration of the digestate is available.

4. Common recommendations from DWA and DVGW

The cultivation of energy crops for biogas production must not cause an additional risk to ground and surface water. The application should not cause an increase of nutrients, heavy metals and other pollutants on the surface or an accumulation in soil and seepage into the aquatic environment. Due to the consideration of the impact and consequences of the use of biomass for biogas production on soil and water following demands are made:

- Crop rotation should be preserved in the cultivation of energy crops. The increased maize production in some German regions has to be countered. In such regions other crops are also to be integrated into crop rotation in order to ensure sustainable crop production even if this means to accept a lower yield per hectare.
- The transition from facultative grassland and long-time fallow land for cultivation of energy crops should be avoided.
- The compilation of a qualified acreage certificate (QFN) should be anchored in the approval process for construction and operation of a biogas plant. This certificate must record all material flows and is to be updated annually.
- Before application of digestates a nutrient analysis has to be made.
- The organic fertilizers should be limited to a maximum of 170 kg N/including digestates. The entire amount of nitrogen from the digestates has to be considered. This upper limit shall also apply to the individual field and not only to the rolling average. In water conservation and water catchment areas the total organic fertilizer input is to be limited to an application of 120 kg N/ha.
- To ensure a needs-based and waterfriendly application sufficient storage capacity for digestates must be available taking in account the agricultural business`s growing conditions. This is usually the case when storage space is kept for at least 9 months to avoid spreading of digestates in the fall after harvest.
- The application of digestates should be done by low-emission techniques for example the drag hose in order to minimize ammonia loss. Manure spread on raw soil should be blended in using cultivators etc.
- The acquisition of raw materials (energy crops) and the recycling of waste materials (digestates) must take place on a local scale. The material cycle in the production of biomass for energy production should be maintained regionalyl manageable in order to ensure adequate control over material flows.
- It is seen as reasonable to demand a proper declaration of digestates stating the origin, nature and quantity of energy crops, manure and co-fermentation substrates as well as nutrient and pollutant concentrations and proof of the phytosanitary safety. If digestates from co-fermentation substrates (Annex 1 of the BioAbfV) are used quality assurance must be provided and be supported by test documents. Under co-fermentation substrates biowaste of plant and animal origin in accordance with
- Co-fermentation substrates should be banned in water protection areas and other sensitive areas.
- The spreading of digestates in the protection zone II of designated or proposed water conservation areas or within the 50-day average of ground water extraction systems is not acceptable and should therefore be prohibited in general.

- The spreading of digestates in the protection zone II of designated or proposed protected areas of water reservoirs for drinking water should only be allowed after a case-by-case examination has been done.
- A further intensification of research on energy crops (crop rotation and fertilizer management) and digestates (pollutant concentrations, hygienic quality) is required to provide expert advice.

5. Abbreviations

BioAbfV: Bioabfallverordnung; Bio-waste law

DWA: Deutsche Vereinigung für Wasser, Abwasser und Abfall e.V.; German Association for Water, Wastewater and Waste

DVGW: Deutscher Verein des Gas- und Wasserfachs e.V.; German Association for Gas and Water Industry

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