Summary of the findings of the risk assessment of biogas production in the Baltic Sea Region from nutrient management perspective

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Abstract

Biogas production has increased rapidly in many countries in the Baltic Sea Region as one of the means to control greenhouse gas emissions of the energy sector, and subsidies are in place to support the production of renewable energy. However, the connections of biogas production to nutrient management and water pollution risks have not always been fully accounted for. A rapid expansion of biogas production without sufficient regulation and supervision of nutrient management can lead to severe nutrient discharges into water bodies, or disturbances in regional nutrient balances.

Increasing number of large biogas plants managing considerable amounts of biomass increase the risk of accidental nutrient leakage. When receiving additional feedstock like biowaste or energy crops from other regions, they also exaggerate already existing nutrient balance problems of regions with high animal density.

In some countries, the monitoring and enforcement of legislation related to the application of digestate on fields is insufficient. When at the same time there is no market for the digestate, and transport costs are high, biogas plants may spread an excessive amount of digestate on fields thus increasing nutrient leakage to water bodies.

In many countries, the limits for nutrients use from organic fertilizers are only defined for nitrogen. This may lead to an excessive use of phosphorus, and an increased risk of phosphorus accumulation in soil.

Liquid digestate is often disposed to sewers or, in the case of biogas plants located in the premises of waste water treatment plants, returned directly to the purification process. This increases the nitrogen load of the WWTPs, and also a high fluctuation of the load. In some cases, also the phosphorus load of the WWTPs increases.

Potential measures to improve nutrient management of biogas plants and mitigate the risks of nutrient discharge in the Baltic Sea Region include improving legislation as well as its monitoring and enforcement to better address nutrient management issues both in the Environmental Impact Assessment (EIA) and environmental permit processes.

Measures include also development of processing technologies, for example, to address regional nutrient imbalances using advanced processing of the digestate to produce high quality recycled fertilizers and exporting them from nutrient rich regions to more nutrient poor regions. Liquid digestate may be pre-treated or treated separately to reduce load to WWTPs.

Cooperation between biogas industry and various stakeholders could be developed, aiming at a sustainable biogas certificate, covering also the key nutrient management issues identified in this study.

To minimise nutrient run-off risks from biogas production, extensive awareness raising and dissemination work among different sectors is needed in the whole Baltic Sea Region.

0. Introduction

This study was carried out in order to assess the risk of nutrient discharges due to biogas production in the Baltic Sea Region. The work consisted of seven country studies of Denmark, Estonia, Germany, Finland, Latvia, Poland and Sweden as well as this paper summarizing the situation in the Baltic Sea Region and giving recommendations for controlling the potential risks.

1. General information on biogas plants

The countries studied vary in the number, type and size of biogas plants (Table 1). The largest number of biogas plants is in Germany, where there are thousands of relatively small farm-based plants. In Denmark, most of the biogas capacity is in agricultural plants, where 80 % of the feed is manure in some form. The smallest number of biogas plants is in Estonia, where their construction is just starting. In Estonia, the highest capacity is built around agricultural facilities, and the average size of the plants is relatively large. Also in Latvia biogas plants are mostly using manure as a feed.

In Finland, the majority of biogas capacity is in large municipal facilities either treating sewage sludge or solid waste. In Sweden, municipal sewage sludge or co-digestion plants prevail, but the average size of sewage sludge digestion plants is relatively small. Also in Poland, the largest biogas capacity is in sewage sludge treatment, but in addition, there is a large number of farm-based biogas plants.

Only a few industrial biogas plants exist in all countries, the largest capacity being in Sweden.

Biogas production is generally approached from the point of view of energy production, and subsidies are in place to support the generation of renewable energy using biogas. Very attractive subsidies provided for their renewable energy production have led to a rapid expansion of biogas production in Denmark and Latvia, for example.

In some countries like Denmark the economy of biogas production is based on energy production, while in other countries like Finland, the economy has traditionally been based on gate fees for receiving biowaste or sewage sludge. Lately, further processing of biogas and its use as transport fuel has helped to increase the profitability of biogas production.

*Table 1. Number of biogas plants and energy produced in the countries studied in 2016 by type of the plant. Plants collecting biogas from landfills are not included. *=Co-digestion plants treat different biomasses, including source-sorted biowaste, waste from food industry and manure.*

	Municipal sewage sludge	Co-digestion* or solid waste treatment	Industrial plants	Agricultural plants	Total
Denmark	51		A few	74 (26 collective and 48 farm size plants)	Over 125 About 2500 GWh
Estonia	4 14 GWh	-	3 28 GWh	5 105 GWh	12 147 GWh
Finland	18 221 GWh	19 355 GWh	6 37 GWh	17 17 GWh	60 630 GWh
Germany	1250	150-170	-	About 7600	9009 27 880 GWh
Latvia	3 30 GWh	6 37 GWh	-	51[1] 311 GWh	60 378 GWh
Poland	99 1123 GWh	2 no data	-	94 525 GWh	195 Over 1648 GWh
Sweden[2]	140 697 GWh	35 854 GWh	6 121 GWh	40 50 GWh	221 1722 GWh

1= Plants using manure
2= Production data from year 2015

2. Treatment and disposal methods for digestates

The treatment and disposal methods vary according to the type of biogas plants. Here, treatment and disposal methods are described for the most common types.

Digestate from agricultural biogas plants

In all countries studied, most of the agricultural biogas plants do not treat their digestate but use it directly in agriculture. The digestate is stored either at the premises of the biogas plant or on farms. If there is a need to transport a part of the nutrients further away due to pressure caused by high animal density, liquid and solid fractions are mechanically separated. The liquid fraction contains more nitrogen and can be used near the source. The solid fraction contains more phosphorus and can be transported further away.

There are some cases, for example in Latvia and Germany, of further processing of the solid digestate by drying it either using the energy produced in the process or solar energy. Dried digestate is easier to transport longer distances to be used as fertilizer, and in some countries, it is used as bedding material for cattle. The dried digestate is also in some cases granulated to form pellets, which are sold as fertilizer. In some countries, companies produce ammonium sulphate from the liquid fraction. The liquid ammonium sulphate can be crystallized to reduce transporting costs.

Digestates from waste water sludge digestion

Biogas plants treating waste water sludge most often separate the liquid and solid fraction. The solid fraction may then be composted (Estonia, Finland, Latvia, Poland). In Germany, the solid digestate from waste water sludge is mainly incinerated. The liquid fraction is often (for example in Estonia, Denmark, Poland, Finland, Germany, Sweden) directed back to the waste water treatment plant (WWTP).

The liquid digestate may pre-treated before it is led to the WWTP. The most common pre-treatment is levelling the load by storage and possible dilution of the liquid digestate (for example in Germany and Sweden) or settling part of the remaining solid matter (for example in Finland). Pre-treatment can also aim at reducing the total nutrient load that is led back to the WWTP. For example, in Germany, separate treatment of the liquid digestate in Sequence Batch Reactors (SBR) is in use in various WWTPs mainly in areas with a high population density. Ammonia stripping and aerobic treatment methods are also applied in treatment of reject waters.

In Denmark, most of the solid fraction is used in agriculture. In Estonia and Finland some of the digestate is used in agriculture, but a major part in landscaping. In Latvia, the digestate may be used in agriculture if it contains no considerable amounts of heavy metals. If the digestate contains heavy metals, it is treated as hazardous waste.

The farmers don't like to use digestate in Latvia. Also in Finland, the negative attitudes and outright bans from the food industry are decreasing the usage of waste water based digestates in agriculture. Thus, biogas plants need to find alternative usages for the digestates in the future. Especially utilisation in landscaping and greeneries is foreseen to increase, which may also cause nutrient leakage risks.

Biogas plants treating solid waste, co-treatment plants

In Latvia, the digestate from treatment of organic waste is composted and used as fertilizer. If it contains heavy metals, it is treated as hazardous waste. Farmers don't like this digestate either, so there are problems with finding a use for it.

In Sweden, the most common use is direct land application of the digestate. Solid and liquid fractions may also be separated.

In Finland, thermic hygienisation and fractioning is commonly used. The digestate is often composted, and the process liquid is fed into a WWTP. Also separate treatment of the liquid digestate is used on some biogas plants. The usage of produced digestate depends on the feedstock material used. It may be used in agriculture or in landscaping.

3. Legislative framework and permit procedures

Regulations related to starting a new biogas plant or operation of an existing plant

An Environmental Impact Assessment (EIA) process is generally required if larger energy production or waste management units are constructed or expanded. It is based on an EU directive, and Member States may also have stricter rules for which projects are required to carry out an EIA process. There has, however, been variation in the quality of the processes, and in the case of energy production, nutrient management has not always been fully assessed.

The countries studied each have their own environmental legislation and an environmental permit procedure, which is applied to larger biogas plants. The environmental permits require information on the nature and source of the feedstock as well as their quantities, but the specific nutrient management requirements in the environmental permits vary across countries.

In many cases, for example in Sweden, biogas plants must show how the digestate will be stored to avoid methane and nutrient leakages in order to get an environmental permit. Germany has detailed requirements to prevent nutrient leakages in case of tank or technical failure. Biogas plants are required to build a catchment area (e.g. a dam) with a volume equivalent to the largest above ground tank. New biogas plants are also required to install leakage detection devices under each tank, in underground slurry pipelines, and underneath the silo bunker.

Some countries like Sweden and Germany require a detailed digestate or nutrient management plan in the environmental permit procedure. For example, in Denmark one biogas plant has been required to separate the liquid and solid fraction of the digestate and export the phosphorus rich solid fraction to be used on more nutrient poor regions. For example, in Poland biogas plants are required to demonstrate adequate land on which they will use the digestate or have signed contracts with farmers who will fertilize their fields with a digestate in order to avoid nitrogen overflow. In Finland, on the contrary, there are no requirements for a nutrient management plan for digestates when starting operations of a new biogas plant.

In some countries like Latvia there are problems with the supervision of the compliance with the permit requirements.

Fertilizer legislation

The existing EU fertiliser regulation (2003/2003 EC) does not recognise organic fertilisers. A new regulation is currently under preparation, and organic fertilisers will have an official status at the EU level, which makes trade from one members state to another easier.

The fertiliser legislation is valid as such in all member states. In addition, many countries have national fertiliser legislation in place. The status of organic fertilisers varies across countries. Typically, there are quality requirements for fertilizers, and each fertilizer product type may need a registration like in Finland and Germany, or there is a certification or permit procedure for each organic fertilizer like in Poland.

Legislation related to agricultural use of waste water sludge

There are own rules for sewage sludge based on the EU Directive on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture (Council Directive 86/27/EEC). Many member states have stricter limits for heavy metals or other pollutants than specified in the directive. Many member states have treatment requirements for sewage sludge.

The specified pollutant limits in each country define the approach taken in the use of sewage sludge based digestate. Here are some examples. In Latvia, the sewage sludge is classified into 5 classes according to the heavy metal content, and the highest class is considered hazardous waste. In Germany, there are limits also for some organic pollutants. In Germany, the majority of the digestate from sewage sludge origin is incinerated due to risk caused by pollutants. The rate of agricultural use varies across states.

On the other hand, Sweden controls the quality of the sewage sludge through a certification system. It includes an efficient source control as well as strict quality control for the agricultural use.

Legislation regulating the nutrient use in agriculture

All countries studied have regulations in place defining the maximum amounts of nutrients that may be used for a hectare of agricultural land. Typically, there is a maximum level for nitrogen from manure and manure-based digestate set at 170 kg N/a per hectare, as defined in the EU Nitrates Directive. In the directive, the limit applies for Nitrate Vulnerable Zones defined by the Member States. For example, Finland, Germany and Denmark have defined their whole area as nitrate vulnerable zone, but Estonia, Latvia, Sweden and Poland only part of their area. Stricter national legislation is allowed.

For example, in Sweden the annual limit of 170 kg/ha for nitrogen application is only valid for Nitrate Vulnerable Zones. However, the amount of nutrients should not exceed plant needs in other areas either.

It is unclear in many countries what exactly is counted in the 170 kg/ha nitrogen limit – only manure, manure based digestate or all organic fertilizers, and legislation has not been updated to cover them all (for example in Latvia). In Finland, since 2015 the total nitrogen limit applies only to manure and fertiliser products containing manure, and other organic and inorganic fertilisers may be applied until the limit for soluble nitrogen is met.

The application of the nutrient limits for manure based digestate only may cause problems if other types of feedstock is imported to regions with high animal density. In the Northern Germany, water protection agencies have reported an increase in the nitrate concentration in ground waters due to the wide-spread application of digestates.

The contamination of ground water is one of the reasons that lead to the revision of the German fertiliser ordinance. The revised ordinance came into force in June 2017. Now manures as well as digestate of any kind, composts and sewage sludge are included in the definition of organic fertiliser. Their annual limit of application is 170 kg N/ha. Before the organic fertiliser only included digestate originating from manure, without taking into account the fraction generated from other organic feedstocks, namely energy crops.

The European Court of Justice (ECJ) ruled in 2018 that the German government has not taken sufficient action to curb high nitrate levels in groundwater in accordance with EU-wide directives. Currently, in Germany there are stricter nutrient balance limits than before and all federal states are required to calculate their nutrient balances.

In some countries, like Poland and Latvia, the requirements set in the legislation are not necessarily met due to insufficient supervision. Biogas plants may overfertilize the fields adjacent to the facility, especially in cases when they are unable to sell their digestate.

Moreover, many countries (for example Poland and Latvia) have set fertilizing limits based on nitrates only. This may lead to excessive use of phosphorus when compared to the plant needs and the phosphorus content of the soil. Unlike nitrogen, phosphorus accumulates in the soil, if used excessively, and it may take from 20 to 30 years to release. As history shows (for example in Finland), excessive use of phosphorus may create a long-term problem difficult to solve.

In Denmark, there is a new legislation in place, and from August 2017 there is a new limit for the application of phosphorus from manure and manure based digestate per ha. In Finland, the fertiliser regulation limits the maximum amount of soluble phosphorus applied per hectare in 5 years period. In addition, the farms which are in the environmental compensation scheme have stricter limits with regards both nitrogen and phosphorus.

4. Risk assessment

There are several issues increasing the risk of nutrient discharges from biogas plants in the Baltic Sea Region. Some of them are potential point sources, while others are related to the increased risk of diffuse nutrient discharge from agricultural sources.

Firstly, subsidies provided for renewal energy production may lead to a rapid expansion of biogas production. Without sufficient regulation and supervision of nutrient management, this can lead to severe nutrient discharges into water bodies, or disturbances in regional nutrient balances. Currently, both national and EU level legislation and regulations on organic fertilisers are lagging behind the rapid development of the biogas sector, which poses risks for the water environment.

Increasing number of large biogas plants that are managing considerable amounts of biomass also increase the risk of accidental nutrient leakage due to technical failure of the biogas plant, tank failure or flooding incidents. There have been several reported cases, for example in Germany and Finland.

Another risk related to the operations of biogas plants is the risk of accumulation of digestate on site if its use has not been solved. The risk is especially high for those biogas plants that are located far from agricultural areas. The capacity of storage tanks or other safe storage systems may be exceeded, which leads to a high risk of nutrient leakage. There have also been cases with insufficient storage space considering seasonal limitations of digestate spreading on fields. The risk increases if authorities do not require nutrient management plans from the biogas plants in the permitting phase.

The remaining identified risks are related to the use or disposal of solid or liquid digestate. One of them is related to regional nutrient balances. In some countries like Finland, Sweden and Germany, animal production is heavily concentrated in certain regions. In those regions, there are more nutrients in manure itself than can be spread on the fields considering the nutrient demand of plants. Using manure as a feedstock for biogas plants does not change the regional nutrient balance, but if biogas plants receive additional feedstock like biowaste or energy crops from other regions, this exaggerates the nutrient balance problem. On the other hand, if the digestate is processed with advanced methods, biogas plants may facilitate the export of nutrients from these regions to more nutrient poor regions.

In some countries, the monitoring and enforcement of legislation related to the application of digestate on fields is insufficient. When at the same time there is no market for the digestate, and transport costs are high, large biogas plants may spread an excessive amount of digestate on agricultural fields. This overfertilization of fields increases nutrient leakage to water bodies. The risk increases when the plants have no own fields, and when there are no established markets for digestates or recycled nutrients in general.

In many countries in the Baltic Sea Region, the limits for nutrients use from organic fertilizers are only defined for nitrogen. This may lead to an excessive use of phosphorus, which unlike nitrogen, accumulates in soil. This may create a long-time phosphorus run-off problem, as it takes 20-30 years before all excess phosphorus has leached from the soil.

With nitrogen, anaerobic digestion increases the amount of soluble nitrogen which leaks rapidly into the soil. Thus, excessive application may lead into contamination of ground waters as in Germany.

Limits and control on digestate use in landscaping seem to be missing. It might pose a potential risk of excessive nutrient use and subsequent nutrient leaching, as the nutrient amounts applied in landscaping are often quite high in comparison with agriculture. However, the nutrient load from landscaping is by nature a single occurrence, as landscaping activities are typically not performed on a regular basis at same sites.

In many countries, liquid digestate is disposed to sewers or, in the case of biogas plants located in the premises of waste water treatment plants, returned directly to the purification process. This increases the nitrogen load of the WWTPs. In some countries, like Ukraine and Belarus, where there is no separate phosphorus removal process, also phosphorus load of the WWTPs increases significantly.

Moreover, liquid digestate is generated irregularly, which leads to high fluctuation of the nitrogen load in the WWTPs. This additional load and its fluctuations may cause problems in the purification process, and as a consequence, nutrient discharges to water bodies. There are reported cases with process problems in WWTPs caused by excess nitrogen load for example in Finland, and increased phosphorus loading in Ukraine and Belarus.

5. Recommendations for mitigating adverse environmental impacts of biogas production

There are several recommendations that can be made to improve nutrient management of biogas plants and mitigate the risks of nutrient discharge in the Baltic Sea Region. Potential measures are related to legislation, processing technologies, circular economy solutions, and creating markets for recycled nutrients.

Legislative framework and permit procedures

Legislation as well as its monitoring and enforcement should be improved to better address nutrient management issues both in the Environmental Impact Assessment (EIA) and environmental permit processes.

The EIA processes carried out to assess future biogas plants or expansion of existing plants should take into account all potential impacts on nutrient discharges and their mitigation measures. The management of both solid and liquid digestate should be addressed. For example, if a management alternative for liquid digestate is its treatment on a waste water treatment plant, its impact on the WWTP processes and the purification result should be analysed, and additional treatment steps required if the WWTP capacity is not sufficient for additional load.

Local and regional nutrient balances should be considered in the EIA process to analyse how a biogas plant will change nutrient flows between different locations and how the plant affects overall sustainability of nutrient management. There is a need for an international guide for EIA best practices on the nutrient management and water pollution abatement for biogas projects, which would cover management of both solid and liquid digestate. The best practices defined should be applied also to projects funded by different development banks.

The environmental permit procedure of all countries should include a requirement of a detailed digestate management plan in order to avoid cases of site accumulation of digestate. In the case of nutrient rich regions, environmental permits should set processing requirements for the digestate in order to facilitate nutrient export to more nutrient poor regions. In addition, proper planning and design of reject water treatment and discharges should be checked as a part of environmental permitting.

Also, anticipation of technical problems in the biogas plant operations should be taken into account in the environmental permit. A buffer system against nutrient leakage, sufficient storage space in case of temporary difficulties in digestate management, and leakage detection systems are technical solutions that are in place to prevent major nutrient discharge. Also flooding should be taken into account as the incidents of extreme weather events are increasing due to the climate change.

There is a need of an international best practices paper to give a model of which issues should be covered in the environmental permit.

Processing technologies

Regional nutrient imbalances may be addressed using advanced processing of the digestate to produce high quality recycled fertilizers. These recycled organic or inorganic fertilizers can be exported from regions with a high animal density to more nutrient poor regions and used to replace chemical fertilizers.

The processing is normally based on mechanical separation of the liquid and solid fractions of the digestate. The fractions can then be further processed. The solid matter can be dried and pelletized for the purpose of stabilization and upgrading it into a marketable product.

Nutrients can be extracted from the liquid fraction, and used for fertilizer production. For extracting ammonia, the liquid phase of the digestate can be stripped. The end product of washing with sulphuric acid is liquid ammonium sulphate. Phosphorus can also be extracted during the same process since it precipitates with the calcium salt present in the solution. The final product is calcium phosphate, which can be used in fertilizer industry. Another process that can be used is struvite precipitation, which precipitates nitrogen and phosphorus into solid struvite.

Other processing methods from liquid digestate include microfiltration followed by reverse osmosis. Microfiltration removes fine particles from the liquid, and reverse osmosis removes suspended solids, organic compounds, colorants, viruses and bacteria from the water. Around 95-99 % of all suspended solids and 99 % of the bacteria can be removed through this method. This is, however, a costly method.

Some highly processed commercial products based on the solid or liquid fraction of digestate are on the market. For example, Egg Energy from Latvia produces liquid ammonium sulphate and pelleted fertilizer. In Germany, the granular fertilizer from digestate “Nadu” is marketed to wine regions. In Finland, granules with high phosphorus contents, “RANU”, as well also liquid nitrogen fertilisers are produced from e.g. sewage sludge.

However, the markets for digestate or recycled fertilizers are not yet properly established, and the costs of processing are relatively high. Some ways to support the establishment of the markets are described below.

Especially in regions with a high population density, where the waste water treatment plants (WWTPs) may be operating close to their limits, liquid digestate should be treated separately, or there should be an effective pre-treatment before they are led to a WWTP.

Also, alternative uses for liquid digestate could be searched for. For example, nutrients in liquid digestate could be used for algae cultivation. In Finland, forest industry has in some cases used the liquid digestate to add nutrients to their waste water treatment processes, which are often too nutrient poor for effective treatment of oxygen consuming components.

Is there an optimal size for biogas plants?

Large biogas plants, with part of their feedstock coming from distant areas, may contribute to exaggerating existing problems with the regional nutrient balance. On the other hand, small farm size biogas plants may not be economically feasible.

Small is not always beautiful, but can some problems be avoided by limiting the size of biogas plants in nutrient rich areas? Intuitively, it would make it easier to manage the regional nutrient balance. It would be worth studying whether, from nutrient management point of view, there is an optimal size for biogas plants in different settings. Research is also needed to understand how land use policies and spatial planning affect the size and location of biogas plants in different settings, and to develop efficient and acceptable policy tools for guidance.

Circular economy solutions

Different circular economy solutions can both provide feedstock for biogas plants and help them in nutrient management. Typically, the different operations are located in the same area, and one company or economic activity uses resources or wastes created by others. The circular economy solutions save both energy and natural resources, and make economic sense for the participants.

There are several examples (for example in Germany and Sweden) of combining biogas plants with fish farming or fish processing industry. Usually the synergy is based on heat use, but fish waste can also be used as a co-substrate in biogas production. Biogas plants are also combined with greenhouse production. Greenhouses can use the CO_2 to facilitate better plant growth, and also use the heat in their production. A Finnish company, Sybimar, has developed a circular solution that is combining both fish farming and greenhouse production with a biogas plant. However, the process descriptions provided don't indicate the use of the digestate, but the biogas plant is seen as a mere energy producer.

It seems that in order to facilitate nutrient management of biogas plants, the circular economy solutions need to be very close to farms. They should be either farm level solutions or at least one of the companies involved should have farmland available. There are examples (for example from Poland and Germany), where agriculture, agricultural industry and biogas production are combined with efficient nutrient recycling.

Creating markets for digestate or recycled nutrients

In some countries, the market for untreated or little processed digestate is poorly established. Farmers don't necessarily know about or trust the digestate. Quality management and information may help to solve this issue. The Swedish certification system for digestate that was built in cooperation with farmers organizations seems to have built the trust needed for digestate use.

Functioning markets for the high quality recycled fertilizers would greatly facilitate moving nutrients from nutrient rich to more nutrient poor regions. If high quality products exist, creation of the markets can be supported by different policy instruments ranging from legislation and economic instruments to voluntary agreements or even an obligation to use recycled nutrients. On the other hand, functioning markets would lead to further development and variety of recycled fertilizers.

One of the key issues is the price of recycled nutrients in comparison to chemical fertilizers. Generally, the chemical fertilizers are more expensive if only nutrient content is taken into account. However, organic fertilizers contain also valuable organic matter, which should also be taken into account in price comparison. Economic instruments like subsidies and taxation could be used to even up the difference between recycled and chemical fertilizers.

Information, education and research

This risk assessment indicates that both politicians, civil servants, funding agencies, and actors on the biogas field need additional information and education on nutrient management issues and risks related to biogas production. Relevant dissemination material is also needed. It could be created at an international level, and then adapted to different national conditions. Best practices examples from different settings would be a good tool for communication.

Research is needed both in technology development, especially on efficient (pre)treatment methods of the liquid digestate, nutrient management, and policy instruments. The best approach would be to connect relevant research with dissemination of its results, having a direct link from research to users of its results.

Towards a sustainable biogas certificate

So far, the sustainability discussion of biogas production has concentrated around the sustainability of the biomasses used in the biogas process, especially on the cultivation of energy crops for biogas production. Now, it is evident that the sustainability definition needs to be expanded to include nutrient management issues after digestion.

This work should be carried out in cooperation with existing organisations already working on sustainability issues related to biogas production. These include European Biogas Association that is working on sustainability criteria for biogas production, and EKOEnergy Label for renewable energy already having criteria for biomass origin.

A sustainable biogas certificate could be developed in cooperation with biogas industry and various stakeholders, covering also the key nutrient management issues identified in this study. The work would require extensive awareness raising and dissemination among different actors.