Use of digestate from Swedish biogas production in organic agriculture – possibilities for efficient plant nutrient recycling

EVA SALOMON[1], MARIA WIVSTAD[1]

Key words: feedstock, fertiliser, losses, nitrogen, phosphorus, utilisation

Abstract

For farmers to be interested in the digestate as a fertiliser, it must be certified for organic production, have a high plant nutrient content and be suitable for handling with best available knowledge and techniques. Co-digestion of solid and liquid organic residues can be a way to convert a relatively large proportion of the organic N into directly plant-available N in the digestate. During handling of the digestate there is a high risk of N losses. A covered storage and mixing the digestate thoroughly into the soil immediately after spreading efficiently minimise ammonia N losses. Of all animal manures in Sweden, a fraction containing 28 and 38 percent of total N and phosphorus (P), has the economic and technical potential to be digested. Source-separated food and toilet waste are organic residues containing a small proportion of N and P from an agricultural perspective. However, introducing source-separating systems can be the first step in achieving high-quality digestate.

Introduction

In recent years, about 50 small-scale biogas plants have been constructed due to an investment subsidy of 30% for farm enterprises on which animal manure corresponds to at least 50% of the feedstock to the biogas reactor. The political objective was to decrease the climate impact by producing bioenergy that can replace fossil energy. Swedish agriculture contributes 14% of the national climate impact, but the emissions mainly comprise methane from animals and manure, nitrous oxide from soils and carbon dioxide from soils with high organic matter content (SCB, 2012). This means that focusing solely on producing biogas from organic materials will not significantly decrease the climate impact from agriculture or reduce other negative environmental effects. An example of this is leaching of nitrogen (N) and phosphorus (P) to waters, causing eutrophication, where agriculture contributes almost half the total losses from Sweden.

The principle of organic agriculture, i.e. adapting production systems to local conditions and basing production on a high degree of re-use of resources such as plant nutrients, can also be applicable to biogas plants, creating conditions that promote high resource utilisation. Organic agriculture can be a driving force in the development of biogas production systems, both as a producer of feedstock to the biogas plant and as a user of digestate in crop production. Through a Swedish certification system, it is possible to label digestate for use on organic farmland (ISSN1103-4092, November 2012). So far digestate from a few biogas plants has been approved in Sweden. However, the trust in a certification system depends on meeting a variety of quality requirements.

Another challenge is to design biogas production systems that support more efficient plant nutrient recycling in agriculture, promoting secure yield levels and decreasing N and P losses. One important requirement is to develop resource-efficient technology in these kind of systems.

We have conducted an extensive review of current knowledge and experiences regarding the possibilities for use of digestate from biogas production on organic farms in Sweden to improve plant nutrient recycling (Salomon and Wivstad, 2013). The main findings of this review are presented below.

Material and methods

Potential amounts of N and P that can be circulated within the near future were quantified for different organic materials that can be biodigested. Some organic materials cannot be used today in biogas production if the digestate is to be certified for use in organic crop production.

Calculations were based on animal manure volumes produced in 2009 on Swedish pig and cattle farms with at least 100 animal units, which is estimated to be the volume required to reach the technical and economic optimum of a biogas plant (Luostarinen, 2013). Of course several farms can cooperate and pool their animal manure, but transporting manure between farms will require a hygienisation step. Horse manure from enterprises with less than 2 hectares of crop production was included, as these enterprises currently have to pay to get rid of the horse manure and are thus positive to other uses. All solid manure from poultry was

[1]EPOK –Centre for Organic Food and Farming, Swedish University of Agricultural Sciences, Sweden, www.slu.se/epok, eMail: eva.salomon@jti.se

included in the calculations, irrespective of transport distance, because the methane potential per ton solid manure is 5- to 10-fold higher than that of liquid manures.

The potential amounts of N and P from digested plant materials originating from agriculture, parks and gardens are more difficult to estimate. Possible plant materials are plant residues and catch crops, or materials discarded in subsequent handling and processing steps (Linné et al., 2008; Wivstad et al., 2009). Straw litter was excluded, as harvested straw is included in the amounts of animal manures.

The potential amounts of N and P from food consumption are mainly found in human urine and faeces. However, source-separated urine or blackwater (mix of urine, faeces, water and toilet paper) may not be used as fertiliser in organic agriculture. The amounts available in the near future were estimated based on upgrading of sewage systems to legal standard by installing source-separating blackwater systems in those households not fulfilling the law today, which corresponds to 1.8 million Swedish households (Jönsson et al., 2012).

The potential amounts of N and P from food residues will increase in future, because 84% of municipalities in Sweden have introduced, or plan to introduce, source separation systems. It is expected that within the near future, about 40% of food residues and the N and P contained therein can potentially be collected and used for biogas production (Jönsson et al., 2012).

Results

The potential amounts of N and P from animal manures that were available for biogas production corresponded to 28% and 38%, respectively, of the total amounts in animal manures in Sweden. The potential amounts of N and P from digested animal manures corresponded to more than 66% of the total potential amounts (Figure 1). On a per species basis, 34% of all manure from cattle, 81% from pigs, 100% from poultry and 29% from horses could be digested.

The potential amounts of N and P in plant materials represented the second largest source, while the N and P in source separating sanitation systems and food residues represented smaller proportions (Figure 1).

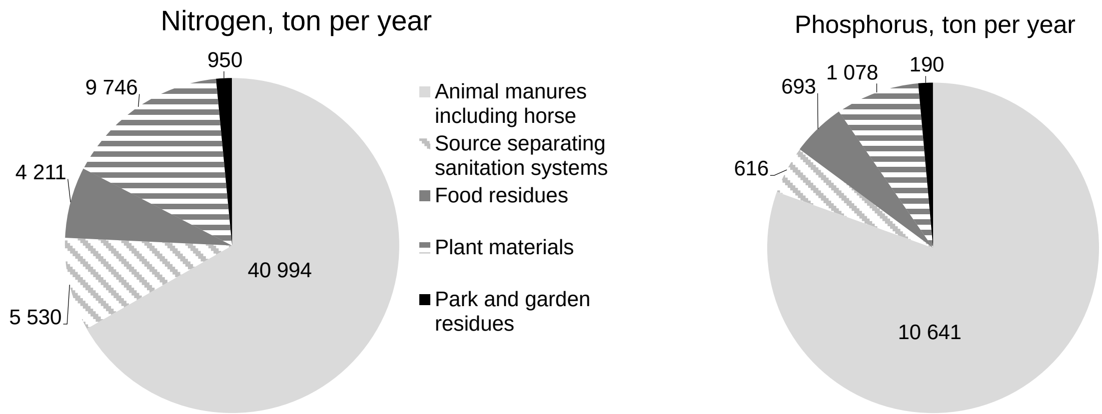

Figure 1. Potential amounts of N and P in different feedstocks for digestion.

Discussion

Our analysis shows that animal manures are the largest potential N and P source for recycling from biogas production. Manures produced on farm enterprises are currently circulated back to arable land and included in the plant nutrient cycle, which means that basic knowledge and experience exist. The question is whether production of biogas with manures as feedstock can allow more efficient plant nutrient recycling. Solid manure contains a high content of carbon, corresponding to almost 25% of total methane potential in animal manures. It would therefore be interesting to develop technology for digestion of solid manures. Mixing solid and liquid feed in the biogas plant would also produce a liquid digestate with physical properties that permit the use of precision techniques for dosing plant nutrients according to crop demands. Using solid manure or other fibre-rich materials with current handling and spreading techniques makes it more difficult to achieve good synchronicity between nutrient release and crop uptake. The objective of good animal welfare and high N use efficiency can interact positively when solid manures are digested, because it requires litter bedding to be used in animal houses. The main technical difficulties concerning digestion of fibre-rich feedstock is that it requires pre-treatment to produce a more decomposed material that is easy to mix with other feedstock and the development of energy-efficient, reliable equipment (Sindhöj and Rodhe, 2013).

Another challenge is to minimise plant nutrient losses during handling of digestate, since otherwise the potential for improvement compared with using animal manure directly is lost. Measures should focus on minimising N losses in the form of ammonia (NH_3-N), which contribute to acidification and eutrophication of aquatic systems. Part of the ammonia also becomes nitrous oxide after conversion in the N cycle. The pH of the digestate is about 8, which increases the risk of ammonia losses during storage and spreading. In order to reduce ammonia losses from storage, the digestate must be covered. Ammonia losses during spreading of digestate can be minimised by quick, thorough incorporation into soil. To achieve high use efficiency of N and other plant nutrients, the plant nutrient content of the digestate must be analysed before planning fertilisation. In addition, the digestate must be applied at a time when the crop can utilise the plant nutrients it contains.

Can biogas production improve the distribution of plant nutrients geographically? The biogas industry and large livestock farms have a growing interest in reducing transport costs by using processing techniques to reduce volume and increase plant nutrient concentration in feedstock to the biogas plant and in the digestate. Little information is available about how these techniques are actually used, their energy efficiency and whether losses of N and P to ecosystems are significantly decreased.

One possibility for recycling N and P from humans to crop production is to develop source separation systems, including a hygienisation step. This will require the development of quality control systems, logistics, cooperation and trust-building between different operators. The main long-term advantage is in the societal perspective, since a source-separating system for toilets can reduce the N and P loads reaching waters with today's wastewater treatment systems.

One strategy for producing plant material to feed the biogas plant is to choose crops that add value to the agroecosystem. A promising option would be cooperation between organic farms to invest in a biogas plant. Farms with a crop rotation that includes rotational clover/grass ley could use forage of lower quality to feed the biogas plant and receive digestate in return. Dairy farms might be interested in buying local feed and forage of high quality and supplying animal manures to feed the biogas plant. The environmental benefit of this system depends on whether the bioenergy produced can fully replace fossil fuels.

References

Jönsson et al., 2012. System för återföring av fosfor i källsorterade fraktioner av urin, fekalier, matavfall och i liknande rötat samhälls- och lantbruksavfall. Rapport ISSN 1654-9406. ET, SLU Uppsala. 62 sidor.

Linné et al., 2008. Den svenska biogaspotential från inhemska restprodukter. Avfall Sverige, SBGF, Svenska gasföreningen, Svenskt Vatten. Lund. 79 sidor.

Luostarinen S (ed.), 2013. Energy Potential of Manure in the Baltic Sea Region – Biogas Potential & Incentives and Barriers for Implementation. www.balticmanure.eu

Salomon E and Wivstad M 2013. Rötrest i ekologiskt lantbruk – möjligheter att återanvända växtnärings från biogasproduktion. EPOK – Centre for Organic Food and Farming, SLU, Uppsala, Sweden. In press, in Swedish with English summary.

SCB, 2012. Sustainability in Swedish Agriculture 2012. ISBN 978-91-618-1570-8.

Sindhöj E and Rodhe L (editors) 2013. Examples of implementing manure processing technology at farm-level. 55 pages. www.balticmanure.eu

Wivstad et al., 2009. Ekologisk produktion – möjligheter att minska övergödning. CUL - Centrum för uthålligt lantbruk SLU Uppsala. 62 sidor. Fyris-Tryck, Uppsala (English summary).