LIVESTOCK MANURE USE FOR BIOGAS PRODUCTION IN LATVIA

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Abstract. The raw material distribution used for the production of biogas in Latvia in 2019 has been identified in the plants where manure is used as feedstock. The focus of the study was on quantification of processed manure in biogas and estimation of the exploited potential. It has been established that in the production of biogas mainly dairy cow slurry, calf and heifer solid manure, considering that these animals are not placed in pastures, pig slurry from large farms and laying hen manure from cage housing are used. In addition, various other biomasses are used: maize silage, animal fodder residuals, animal slaughterhouse bio waste, sewage sludge, molasses, etc. The mass of other biomass may represent up to 50% of the amount of manure processed. In Latvia in 2019, 37 biogas plants used manure as feedstock. The total amount of manure processed was 840.8 thousand tonnes. Of these, 34.7% were cattle slurry and litter, 44.1% was pig slurry and 61.9% was laying hen manure. This means that the possibilities for manure processing in biogas because the capacity is not currently exhausted can be significantly increased in the future due to intensification of the livestock farming.

Keywords: biogas, biomass, manure, digestion.

Introduction

In Latvia, the first biogas cogeneration plant was installed in 2009 at the Latvia University of Life Sciences and Technologies training and research farm "Vecauce". But in 2019 there were 37 biogas production stations that processed livestock manure. Until 2014 the number of biogas plants increased, when their installation and operation were supported by the state, as manure processing resulted in a reduction in greenhouse gases (GHG), as well as ammonia and odour emissions from livestock manure management in farms [1]. The outcome of biogas depends on the used raw materials [2]. In addition, production of biogas and its use resulted not only in heating energy, which could be used for different production processes, but also in production of a digestate, which, compared to manure, no longer produces the same amount of odour and GHG emissions into the environment [3]. In addition, digestion of manure improves plant uptake of nutrients and increases the energy independence of farms [4].

However, the production of biogas also had undesirable effects as the price of electricity increased because of the subsidies granted by the state. Moreover, in addition to manure, corn silage was used as a raw material for production of biogas. In some cases, also grain, molasses and other valuable biomass were used, because use of this biomass as feedstock increased the outcome of biogas [5]. Production of this additional feedstock reduces the arable land that could be used for food production. The purchase prices of biogas were reduced in 2015 and the economic benefits of its production decreased accordingly. Therefore, construction of new plants for production of biogas was discontinued.

However, as of the 1st January 2022, biogas plants are now expected to become crucial for processing sites for agricultural waste, including manure, in line with the EU Methane Strategy of 2021 [6]. In addition, the amount of manure must not exceed 60% of the total biomass, while the other raw materials used must be organic waste from food production plants (slaughterhouses, grain processing sites and other). Partly these conditions are already covered by the Cabinet Regulation No 129 [7] and the Cabinet Regulation No 650 [8]. At this point in Latvia installation of biogas plant on a farm was assumed to be optimal for intensive livestock farms [1], but the need for renewable energy will drive adaptation also of small-scale anaerobic digesters in Europe [9]. Overall importance of biogas production will only increase to transit to circular economy and to achieve sustainable farming [10].

The aim of this article is therefore to assess the existing situation before the implementation of the Methane Strategy in practice, as well as to clarify the amount of manure processed at biogas plants in 2019 in order to improve the input data for the annual inventory of GHG and ammonia emissions.

Materials and methods

Information regarding the number of biogas plants installed in Latvia, their location and energy capacity was obtained following unpublished data compiled by the Latvian biogas association. Information on the indicative type of manure used in these plants was used from the unpublished information of the Rural Support Service, Republic of Latvia.

In developing the study methodology it was considered that biogas plants were constructed mainly near large farm holdings, as this reduced raw material transport costs. In the production of biogas may be used [11-13]:

- dairy cow slurry;
- calf and heifer manure from large farms, where also slurry from dairy cows is used as feedstock;
- pig slurry from large farms;
- laying hen manure from cage housing.

For production of the biogas cannot be used:

- manure deposited by grazing animals;
- manure from small farms, where biogas plant construction is not reasonable;
- non-dairy cattle manure, because of soil contamination, which can affect the work of the biogas plant.

Due to the spread of the Covid-19 virus, the necessary information was obtained by email or by telephone. The survey of biogas plant operators identified the following issues:

- type of biomass used in biogas production;
- manure storage conditions and duration (use of manure directly from livestock housing after storage);
- application of digestate processing and digestate storage.

All biogas plants surveyed were divided into four groups.

- Group 1: biogas plants using cattle manure;
- Group 2: biogas plants using pig slurry;
- Group 3: biogas plants using laying hen manure;
- Group 4: biogas plants using manure from various livestock groups.

The total amount of manure from cattle, pigs and laying hens used for processing was calculated by summing up the quantities of manure processed in the groups of the biogas plants.

The proportion of manure used for production of biogas produced from corresponding livestock group was calculated according to equation (1).

$$\theta_i = \frac{\sum M_i}{\sum M_{ki}} 100, \tag{1}$$

where θ_i – part of manure used for processing from livestock group, %;
$\sum M_i$ – total amount of manure processed in biogas production plants from the livestock group, t·year^{-1};
$\sum M_{ki}$ – total amount of manure produced from the livestock group, which could be used for the production of biogas, t·year^{-1}.

The total amount of manure processed at biogas production plants was obtained from the survey results. The number of livestock in the country in 2019 per livestock group was used from relevant statistical data [14]. The amount of manure that can be used to produce biogas was calculated based on the methodology described in the previous study [15].

The amount of dairy cow slurry can be estimated by equation (2).

$$M_{g.sk} = \left(\frac{100 - \chi_{g.pak}}{100}\right) \sum \left(Z_g \cdot q_{g.sk} + Z_{gt.1} \cdot q_{gt.1} + Z_{gt.2} \cdot q_{gt.2}\right), \tag{2}$$

where $\chi_{g.pak}$ – share of the number of dairy cows in the litter-based manure management system, %, according to statistical data and the methodology described the in previous study [15], it can be estimated to be $\chi_{g.pak}$ = 54.3% in 2019;
Z_g – number of dairy cows, according to statistical data;
$Z_{gt.1}$ – number of heifers till 1 year age, according to statistical data;
$Z_{gt.2}$ – number of heifers from 1 till 2 year age, according to statistical data;
$q_{g.sk}$ – production of slurry by one dairy cow, t·year^{-1} [16];

$q_{gt.1}$ – production of litter by one heifer till 1 year age, t·year^{-1} [16];
$q_{gt.2}$ – production of litter by one heifer from 1 till 2 year age, t·year^{-1} [16].

In biogas production the amount of pig slurry was estimated by equation (3).

$$M_{c.sk} = \frac{100 - \chi_{c.pak}}{100} \sum Z_{c.p} \cdot q_{c.p} + Z_{c.a} \cdot q_{c.a} + Z_{c.b} \cdot q_{s.b}\ , \tag{3}$$

where $\chi_{g.pak}$ – share of sows and boars in the litter-based manure management system, %, estimated by the same methodology as for dairy cows [15], in 2019 estimated to be $\chi_{g.pak}$ = 7.8%;
$Z_{c.p}$ – number of sows and boars, according to statistical data;
$Z_{c.a}$ – number of weaned piglets according to statistical data;
$Z_{c.b}$ – number of gilts and fattening pigs, according to statistical data;
$q_{c.p}$ – production of slurry by one sow or boar, t·year^{-1} [16];
$q_{s.a}$ – production of slurry by one weaned piglet, t·year^{-1} [16];
$q_{s.b}$ – production of slurry by one gilt or fattening pig, t·year^{-1} [16].

Laying hen manure amount was estimated by equation (4).

$$M_{d.ap} = \left(\frac{100 - \chi_{d.pak}}{100}\right) \cdot Z_d \cdot q_{be}, \tag{4}$$

where $\chi_{d.pak}$ – share of laying hens in the litter-based manure management system (these laying hens are mainly kept in smaller farms), %, estimated by the methodology described in the previous study [15], in 2019 estimated that $\chi_{d.pak} =$ 10%;
Z_d – total number of laying hens in the country, according to statistical data;
q_{be} – production of manure by one laying hen, t·year^{-1} [16].

Results and discussion

The data from the studies in 2019 show that 37 biogas plants were operating in Latvia, using livestock manure as raw materials. 21 stations used only cattle manure, 8 – pig manure, 1 – laying hen manure and 7 plants – at the same time used several types of manure, most often mixture of cattle and laying hen manure (Fig. 1).

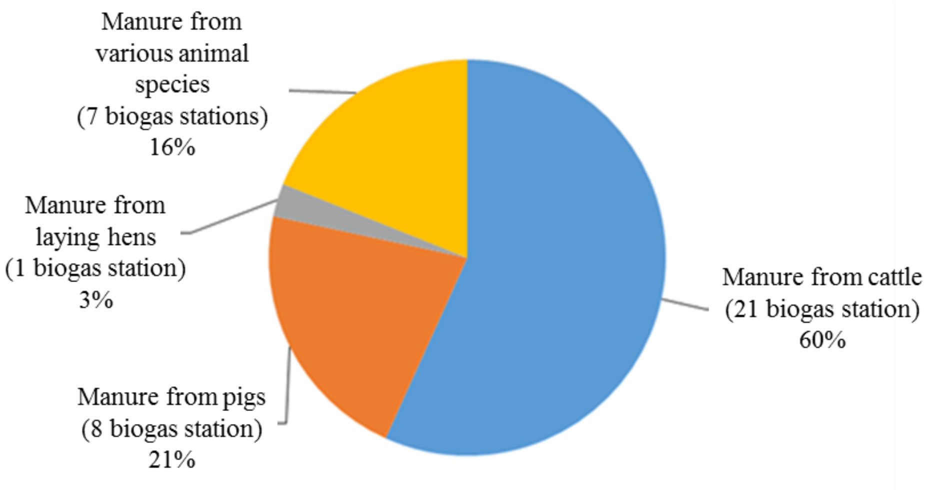

Fig. 1. **Distribution of biogas plants, depending on the type of manure processed**

In the most cases, both cattle and pig manure are supplemented with a variety of additional feedstock. Mainly the materials used are: silage, fodder residuals, grain residuals, whey, animal slaughterhouse bio waste, sewage sludge, molasses and others. The aim of additional feedstock use is to increase the outcome of biogas. In certain cases, the total quantity of these additional biomasses (by weight) may reach up to 50% of the total amount of manure to be processed.

The data collected in the study on the amount of manure used at biogas plants in 2019 is shown in Fig. 2.

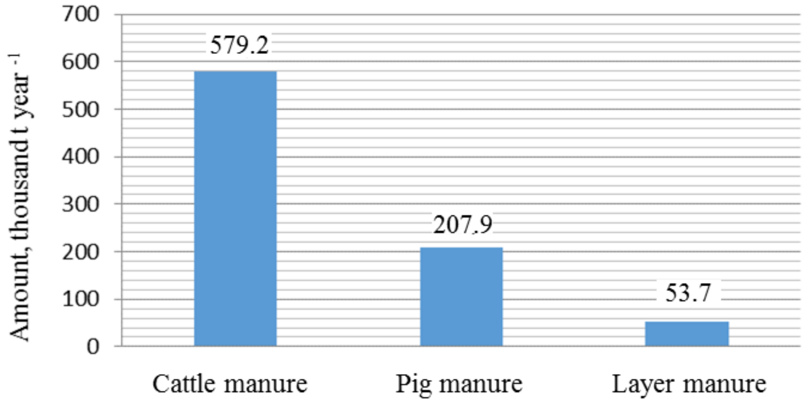

Fig.2. **Amount of manure processed in biogas plants in 2019, calculated by groups of livestock**

These data show that in 2019 the largest amount processed in biogas plants was slurry and litter manure from dairy farms, with a total of 579.2 thousand tonnes. The quantity of pig slurry processed amounted to 207.9 thousand tonnes, or by 35.9% less than dairy cow manure. Laying hen manure as feedstock was 53.7 thousand tonnes, or only 9.3% of the amount of manure processed as cattle manure.

Information on the amount of manure processed in the production of biogas compared to the potential that could be used as feedstock is given in Fig. 3.

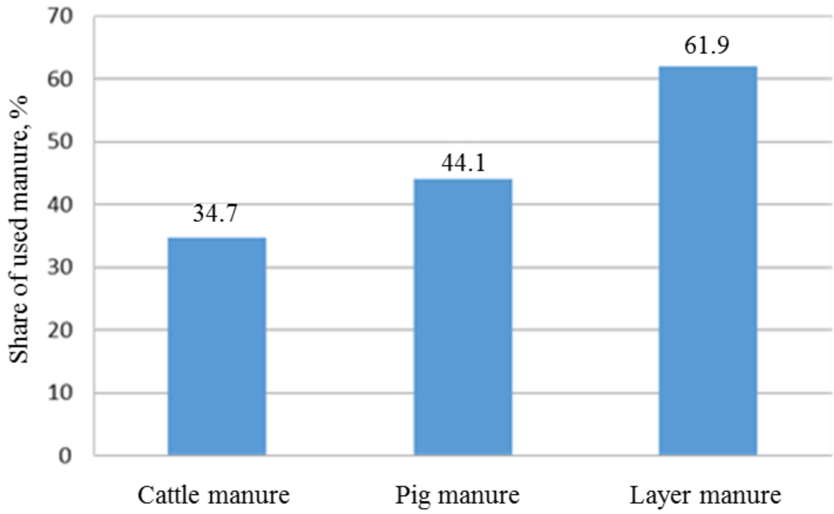

Fig. 3. **Proportion of manure processed in 2019 in relation to the calculated total amount of potential manure to use for processing, calculated by individual groups of animals, %**

According to the figure, it can be concluded that in 2019, only 34.7% of the potential of dairy cow, as well as their calf and heifer manure was used for production of biogas. 44.1% of the potential amount of pig slurry was used and from laying hens 61.9% of the potential amount of manure. This means that the possibilities for increasing the manure processing capacity have not been exhausted. In the future use of manure as feedstock in biogas plants can be increased. Especially increasing the processing of pig manure, because high intensification of pig farms in Latvia and the favourable effect of reduction of the odour emissions, which is particularly relevant for the residents in close proximity of the farms. Pig manure is also marked as the most suitable biomass by Bumbiere et.al. [17] in Latvia and poultry manure as the second, which is in accordance with the outcome of this research. However, the further development of biogas production is fundamentally dependent on the economic aspects and the change in legislation. The biogas sector could be moved towards a model, where organic wastes and agricultural by-products are mainly used as feedstocks and contribute to the reduction in agricultural CO_2 emissions.

However, studies show also methane losses relative to the calculated production rate ranged from 0.02 to 8.1%, the benefit of processing manure into biogas will be greater than manure management regarding emission reduction. In any case, a biogas system in agriculture needs to be understood more as a servicing function to farming rather than the purpose of farming [18-21].

The biogas production in the European Union represents about half of the global biogas production. Germany was one of the first European countries to implement a subsidy for renewable electricity and biogas production. Now in the same regions in Germany manure use reaches almost 50% of the feedstock. The reason for this is the high density of livestock farming. But in Switzerland manure use reaches 82%. At 54% cattle slurry and manure are the most important, followed by pig slurry and manure at 18%, horse manure at 5% and poultry manure at 4%. The use of specially cultivated energy crops is not permitted in Swiss agriculture. In the future, it is believed that the biogas sector should address these aspects to ensure its growth regarding livestock manure use towards 2030 and beyond [22]. There are still more options to increase biogas production not only in Europe, but also in Latvia in further transition to circular economy.

Conclusions

1. In 2019, 37 biogas production stations were operating in Latvia that used manure as feedstock. From these biogas plants: 21 used cattle manure, 8 stations – pig slurry, 1 station – laying hen manure, and 7 stations – several types of manure, most commonly: cattle and laying hens. In addition, all these plants also use a variety of additional biomasses for production of biogas: maize silage, fodder residuals, slaughterhouse bio waste, sewage sludge, molasses and other.
2. In 2019, 840.8 thousand tonnes of manure were processed at biogas plants in Latvia. 68.9% were cattle slurry and litter, 24.7% were pig slurry and 6.4% were laying hen manure from cage housing.
3. Comparing the amount of manure used in biogas plants with the amount of manure produced in livestock farming, it can be concluded that in 2019 34.7% of the potential amount of cattle manure was used for production of biogas, 44.1% of pig manure and 61,9% of laying hen manure.

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