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Digestate management practices in Latvia from nitrogen perspective

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Abstract

Biogas is a common source of renewable energy. But biogas plants also produce a by-product which is at least as valuable as renewable energy, because of its nutrients and organic matter content – digestate. Digestate is an excellent fertilizer containing many different nutrients and micronutrients necessary for agriculture, including nitrogen, phosphorus and potassium. Digestate can be characterized based on the feedstock used to produce biogas. Latvia's biogas plants produce digestate from: manure and agricultural sludge (85 %), sewage sludge (5 %) and municipal waste (10 %). However, digestate misuse can cause a serious threat to the environment. This study gathered information and proposes recommendations on the use of digestate in Latvia from nutrient perspective.

Keywords: Baltic Sea region; cogeneration; biogas; digestate; waste management

1. Introduction

Biogas is produced by anaerobic digestion which is used worldwide as treatment for industrial, agricultural and municipal wastes. It involves the degradation and stabilization of an organic material under anaerobic conditions by microbial organisms and leads to the formation of methane and inorganic products [1].

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Anaerobic digestion also produces residue called digestate which is a mixture of partially-degraded organic matter, microbial biomass and inorganic compounds [2]. Digestate is most often used as fertilizer, because of its high content of nitrate, phosphorous, potassium and other nutrients including magnesium, calcium and sulphur [3], however, exact amount of nutrients in digestate depends on feedstock used. There is a risk of over-fertilization of soil which may cause ground and surface water pollution. Inappropriately high amount of fertilizers leads to incomplete absorption of nitrogen. Nitrates then leach to groundwater causing contamination. Under environmental conditions nitrates are converted to nitrites, which are toxic for humans. They cause haemoglobin oxidation and are precursors of carcinogenic nitrosamines [4]. Also, nitrogen and phosphorus are responsible for eutrophication of water bodies [5]. These impacts may be avoided by careful planning and usage of optimal dosage of fertilizers.

Selection of biomass source is crucial to avoid a contamination of environment by heavy metals, toxic elements and pathogens. Due to the risk of high heavy metal contents usage of industrial wastewaters must be scrupulously evaluated. Regular sampling of digestate must be performed for analysis of organic contaminants, heavy metals, toxic substances and pathogens [6]. 85 % of the total amount of nitrogen, as active pesticide components, remains in the soil, 5 % in the plant, and 10 % is emitted into the atmosphere and 10 % leaches from the soil into the water [7].

The aim of this study was to evaluate situation in Latvia. The legal order and the real situation were assessed as two main aspects of digestate management practices.

2. Biogas production in Latvia

Biogas production in Latvia is relatively recent, the first biogas production plant was installed and started to work in 1983. It was built in the territory of a large pig farm and the liquid manure obtained on this farm was processed. This biogas production plant was of experimental type and soon it was shut down [8].

In 2007 there were only three biogas plants in Latvia. Since support system based on a feed-in tariff was released in 2007, now there are already 60 biogas plants with total installed capacity of 61.156 MW. In 2015 biogas plants in Latvia produced 374.87 GWh of electrical energy and worked with approximately 80 % load [9]. 33 new biogas plants have been built since 2011. However, in the last couple of years (2014–2016) number of biogas plants have stood similar (Table 1).

Table 1. Number of biogas plants in Latvia [10].

	Number of biogas plants					
Year Feedstock	2011	2012	2013	2014	2015	2016
Waste water sludge	2	2	3	3	3	3
Municipal waste (landfill)	4	4	6	6	6	6
Manure and agricultural sludge	21	32	44	48	51	51
Total	27	38	53	57	60	60

All biogas plants in Latvia cogenerate biogas, producing electricity and heat (Table 2). Six biogas plants are located in landfills and use municipal waste as feedstock. Three biogas plants use municipal wastewater sludge and 51 use manure and agricultural sludge with or without other organic materials such as industrial and food waste (i.e. residue from ethanol production).

Digestate produced by biogas plants can be used as fertilizer but treatment methods used for digestate depends on feedstock used. Digestate is rich with different nutrients and studies has shown that use of digestate as fertilizer improves yield [11]. Misuse of digestate, over-fertilization, pre-treatment failure, usage during rainy periods or usage on fields with incline towards watersheds can cause great threat to environment.

3. Digestate management and legislation in Latvia

Methods for use of digestate are divided by feedstock used in biogas plant. In Latvia most of biogas plants use manure and agricultural sludge as feedstock and these plants has less limitations for use of digestate. In these plants untreated digestate is used as a fertiliser (same as manure) or as an additional fertilizer, combined with manure or mineral fertilizer.

Digestate from biogas plants that use wastewater sludge can also be used as fertilizer, but analysis must be made if digestate has no increased concentration of heavy metals, it can be used as a fertilizer after composting. If digestate contains heavy metals, it is considered as a hazardous waste. Although legislative framework allows to use at least some of digestate as a fertilizer, farmers are not willing to use digestate from wastewater treatment plants, so biogas plant owners must find another way to utilize it.

Digestate from biogas plants that use organic waste as feedstock can be composted and used as a fertilizer, but same testing procedures apply for digestate from wastewater treatment plants (heavy metals should be analysed). Contaminants in municipal waste such as heavy metals or organic pollutants might be hazardous to nature, therefore, same as for digestate from wastewater treatment plants, the willingness of farmers to use digestate is low.

Latvian legislation restricts use of digestate from manure and agricultural sludge only based on nitrogen concentration (3.1–14 % of dry matter (DM)), but digestate also contains other nutrients, (for example – P 0.3–3.5 % of DM), K 1.9–4.3 % of DM, Mg 0.03–0.07 % of fresh matter) [12]. Overdose of these nutrients are unsuitable for plants and nutrients remains in the soil or reach groundwater.

According to Latvia's environmental monitoring data from State Plant Protection Service, about 65 % of Latvia's land has a low nitrate content, but only 44.2 % of land has low phosphorous content and only 20.2 % has low potassium content [13]. If soil is fertilized taking into account nitrate concentration only, it could be over fertilized by other compounds.

It has been calculated that in order to obtain 1 ton of wheat, 18.2 kg of nitrogen, 3.6 kg of phosphorus and 4.1 kg of potassium should be taken from the soil [14]. There is a risk that soil is being over-fertilized if phosphorus and potassium content in digestate is high.

In Latvia, every year all biogas plants together produce approximately 1649,000 tons of digestate used in fertilization. According to Central Statistical Bureau data Latvia has 2074,600 ha agricultural land from which 1887,800 ha were used in 2016 [15]. For utilizing 1649,000 tons of digestate approximately 62,900 ha is needed which is 3 % of agricultural land (calculated for amount of nitrogen allowed for wheat). It is possible to use all digestate according to limits prescribed in regulation No. 834 [16], however, real area where digestate is spread is unknown, because process of spreading digestate and other fertilizers are not strictly controlled. In future to more accurately determine the risks of over-fertilization with digestate, the area where the digestate is actually used should be identified.

Summarizing, in Latvia, usage of digestate as fertilizer is up to the farmer, and there are no clear regulations on what analysis should be performed to evaluate the quality of digestate. For this reason, public acceptance of digestate usage is low.

Current legislation considers digestate just as a fertilizer. Therefore, maximal amount of nitrogen applied with livestock manure per hectare is limited to 170 kg [16]. If produced amount of nitrogen is higher, a producer must have documents proving a passage of overproduced amounts to other households. There are some limitations for usage of digestate on sensitive nitrate catchment areas, which restricts spreading of manure and digestate on these areas from 15th of September till 15th of March [16]. For other areas only limitations are restrictions of usage of digestate (or other fertilizers) on frozen soil or soil covered with snow [16].

The maximal amount of phosphorus that can be spread on agricultural land with sewage sludge and compost is limited by Regulation No. 362 by Cabinet of Ministers "Regulations Regarding Utilisation, Monitoring and Control of Sewage Sludge and the Compost thereof" from 2006. The annual emission limit value of phosphorus is 40 kg/ha [17]. However, there are no special regulations regarding digestate. The easiest way would be to include digestate into existing directive.

Annual analysis of digestate should be performed in accredited laboratory. Within one month, the results together with digestate spreading plan for the land fields must be submitted to The State Environmental Service of the Republic of Latvia. So far, control of calculations on relationship between nitrogen and land field area, to which digestate will be spread, is done when a producer of digestate wants to change a class of the permission for polluting activities.

According to information provided by Latvian biogas association [18] there are several campaigns against biogas production and usage of digestate, also information is limited for effective selection of proper technological solutions and digester sizes.

4. Plant nutrient balance

Plant and nutrient balance is an effective method of regulating amount of nutrients used as fertiliser. However, plant nutrient balance is not required by legislation.

In 2008 there have been made NPK balance calculation for Zemgale and Latgale regions (historical regions of Latvia) and results can be found in Table 2.

Table 2. NPK balance, kg ha^{-1}, 2008 [19].

Parameters	Zemgale			Latgale		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Input						
Mineral (commercial) fertilizers	49.83	16.51	21.72	9.55	3.02	3.41
Organic fertilizer	5.5	4.01	5.56	5.13	3.62	4.72
Symbiotic N fixation	3.48	-	-	4.32	-	-
Non-symbiotic N fixation	3.62	-	-	4.48	-	-
N deposition	6.00	-	-	6.00	-	-
Seed and planting material	2.29	0.97	1.39	1.16	0.51	0.77
Total input	70.72	21.49	28.67	30.65	12.09	8.91
Output	71.51	28.72	69.27	33.33	–4.94	–27.61
Balance	–0.79	–7.22	–40.60	–2.68	–4.94	–27.61
Balance intensity, %	99	75	41	92	59	24

According to Table 2, the balance is negative, so soil should not be over-fertilized.

Some of farms are making soil balances voluntarily. For example, plant nutrient balance of farm "Ogre" for period from 1999 till 2003 is shown in Table 3.

Table 3. NPK Soil surface balance in the farm, kg [20].

Variable	1999	2000	2001	2002	2003
Nitrogen					
Input	57651	27109	33187	42484	61280
Removal by crops' yield	22584	24874	34885	31239	52003
Excess or deficit	35067	2235	–1698	11245	9277
Balance, kg ha^{-1}	91.4	5.2	–3.0	22.7	12.7
Phosphorous, P_2O_5					
Input	30752	11450	5865	9749	8349
Removal by crops' yield	7698	9441	12776	11150	18374
Excess or deficit	23054	2009	–6911	–1401	–10125
Balance, kg ha^{-1}	60.1	4.7	–12.3	–2.8	–13.9
Potassium, K_2O					
Input	33233	20532	12808	18714	17134
Removal by crops' yield	26348	29270	40761	34188	621243
Excess or deficit	6885	–8738	–27953	–15474	–44109
Balance, kg ha^{-1}	17.9	–20.5	–49.9	–31.3	–60.5

As it can be seen in Table 3 for this farm, at least one of nutrients has positive balance annually, which means that it stays in soil or reaches ground waters.

Applied N can become pollutant in 3 forms: nitrates (NO_3^-), ammonia (NH_3), nitrous oxide (N_2O) [21].

Digestate from biogas plants has higher pH and nitrate content than raw manure. These parameters allow to forecast that ammonia emissions from lands fertilized with digestate are as high as from lands fertilized with raw manure [12]. Several studies have found that with digestate even higher ammonia emissions than from raw manures are possible [22, 23].

Nitrous oxide (N_2O) is a greenhouse gas. N_2O emissions from digested materials are usually lower than emissions from undigested feedstock. It has been argued that it might be because of lower contents in easily degradable carbon in digested biomass [12, 24].

Main reason the amount of fertilizer is limited by nitrogen is based on nitrates. Due to their negative charges nitrates adsorption in soil is very low. Also, nitrates are highly water soluble, and this property makes them mobile and allows to enter and pollute the groundwater. Nitrogen leaching vary depending on soil type [12, 25].

5. Conclusions

To get the full potential advances from implementation of digestate fertilizer in terms of improvement of the nutrient use efficiency, there is the need to introduce more advanced techniques and methods to avoid counteracting effects by direct soil and water negative incorporation of the field-applied digestates.

To minimize risk of nutrient pollution, several tasks should be performed:

- Performing informative seminars and lectures for potential biogas producers and farmers;
- Providing of legal framework for biogas plant risk assessment and crisis situation management;
- Providing of legal framework regarding use of digestate on fields, that would include:
    - limitations based on content of nitrogen,
    - limitations based content of phosphorus,
    - request that nutrient balance must be made and prescribes how it shall be made;
- Providing of guidelines and recommendations for treatment of digestate minimizing environmental impacts.

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