Risk Assessment of Biogas Production in the Baltic Sea Region from the nutrient management perspective – Estonia

FINAL REPORT

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INTRODUCTION

Biogas sector did its first steps in the 1980s in Estonia, when 2 piggeries built the biogas plants in deep Soviet time in Läänemaa and Pärnumaa in 1980s. As far we know nowadays, these plants never worked properly, because the quality of the cement of the walls of the biogas reactors was so low, that they were falling apart in first five years. So the first image and experiences on biogas production were not the best. The second attempt took place by AS Terts at the beginning of 1990-s when the Pääsküla landfill installed the pipes to landfill which was closed in 2004. The biogas was collected from Pääsküla landfill over 20 years and the biogas was used in CHPs (max 1 MW_{el} nominal capacity). During few last years the amount of collected biogas from landfill stayed so low, that the combined heat and power (CHP) plant was closed down at the beginning of this year.

In the mid of 1990-s, the first biogas plant on sewage sludge from waste water treatment plant (WWTP) was established in Tallinn and industrial biogas plant in Kohtla- Järve (Eastman). Also new landfills (Jõelähtme/Tallinn, Väätsa, Paikre and Uikala) installed pipes into newly established landfills in order to collect biogas from those landfills, according to the EU waste directive. Addiotionally to closed Pääsküla landfill in Tallinn Aardlapalu landfill was also closed in Tartu region and it installed biogas collection system as well.

The first agricultural biogas plant was in built in Saaremaa (Saare Economics) on pig slurry in 2008 with support from Nordic environmental funding facilities (Nefco).

The rest of the agricultural biogas plants were built with investment support from Estonian Environmental Investment Center (KIK) in order to convert local central district heating boiler-houses from fossil fuels to renewable fuels. The instrument included also the support to the production of renewable energy sources e.g. biogas.

Regarding the biogas policy development The Ministry of Economic Affairs and Transportation of Estonia (MKM) has adopted the new regulation[1] to support biomethane producers till 2020 with price premium in order to cover the price gap between biomethane and natural gas in 13.09.2017. To ensure the feasibility of biomethane production in long term the second policy instrument is under drafting process by MKM, namely the obligation for all natural gas dealers to have 4% of biomethane in their portfolio (so called gaseous biofuel mixing obligation) since 2020. The not fulfillment of this obligation in 2020 and onwards brings penalties to gas dealers,

[1] Majandus- ja taristuministri määrus: Biometaaniituru arendamise toetamise toetuse kasutamise tingimused ja kord.(Regulation of Ministry of Economics and Communication: Conditions and procedure of the useage of the support of the biomethane market development. Accepted 13.09.2017). Vastu võetud 13.09.2017 nr 50. RT I, 15.09.2017, 9, https://www.riigiteataja.ee/akt/115092017009

which are supposed to be higher than purchase price of biomethane. The 4% from annual natural gas consumption (500 mln Nm^3) is around 20 million Nm^3, which means that for this amount there will be demand of biomethane on the market from 2020 and onwards.

The current study on risk assessment of nutrient leakage from digestate from biogas production is just in time, if we can assume some increase of the numbers of biogas plants in Estonia in coming years. **The hypothesis of this study is that the risks of the over-dozing of phosphorus and other nutrients from the digestate of biogas production to the environment might increase.** Especially, if risks of the potential leakage of nutrients during over-fertilizing in the new biogas plant are not properly assessed and the plan of the use of digestate as part of farmer's Crop Rotation and Fertilization Plan (CRFP) of fields is not followed and implemented correctly.

The first chapter of this study gives the overview of biogas plants. The second chapter describes the main digestate treatment methods divided by types of the biogas plants e.g. agricultural, WWTP sludge based and industrial. The third chapter draws the overview of legislative framework for biogas production and digestate management. The fourth chapter deals with risk assessment of nutrient leakage from digestate of biogas plants. The fifth chapter describes the subsidies and profitability of biogas production, chapter six describes some commercial products from the digestate of the biogas. The 7th chapter gives examples of circular economy, where the biogas production is part of larger chain. The last chapter concludes the study on risk assessment of nutrient leakages to the environment with some solutions and proposals to reduce the risk of over-fertilizing with biogas digestate, especially with phosphorus. Some policy recommendations and suggestions for next steps are emphasized in chapter 8.

1. List of biogas installations in Estonia

Currently there are 5 agricultural, 4 WWTP based, 3 industrial biogas plants (Table 1) and 6 landfill based biogas plants in Estonia (Figure 1).

Most of the biogas from agricultural and WWTP sludge-based biogas plants is used in the CHP-s. The price premium for renewable electricity is 0,053 €/kWh + Nordpool Spot[2] price, regardless the renewable electricity production unit's size, feedstock or any other criteria. The same price premium is provided to all renewable electricity producers, including all renewable feed-stocks such as wind, hydro, wood chips and solar. All 3 industrial biogas plants use the biogas to produce the heat for their own use in production process. The biogas from landfills is used in CHPs 4 cases and flared in the rest plants, because the amount of biogas from these landfills is too small (Väätsa, Pääsküla). The municipal biowaste is not used for biogas production so far in Estonia.

The biogas plants are in the middle of cropland and currently the arable land size is much bigger than the surface of land, which is needed for spreading the digestate. The farmers also have the obligatory Crop Rotation and Fertilization Plan to follow and have to record and prove the amount of the nutrients they spread to the fields.

The biomethane was not produced in Estonia till 2017. However, 2 biomethane production units are under construction (Biometaan OÜ and Green Gas OÜ) and few others have developed projects, but not made the investment decisions yet (e.g. Väike-Maarja and Pärnu). Biometaan OÜ constructed the new biomethane plant, which will use the slurry from 1500 milking cows and green biomass as feed-stocks, with planned capacity of 12 GWh primary energy (1,3 million Nm^3 of biomethane with 98 % of CH_4). The company called Green Gas OÜ plans to upgrade the biogas from existing industrial biogas plant of AS Estonian Cell, so this does not add any new production units to the market. The Ministry of Economic Affairs and Transportation of Estonia adopted the regulation number 135[3] on 25.11.2015 in order to support the investment to building of CNG/CBM filling stations and purchasing of the public transport buses. The investment support (40%) has been provided to 15 new CNG / CBM filling stations during last 2 years and together with existing 6 and 1 under construction, the number of CNG/CBM filling stations will increase up to 22 in coming 2 years in Estonia (Figure 2). The instrument for public transport companies has been open for almost last 2 years, but anybody has not yet applied for this support, because the biomethane is not available on the market yet and the support scheme is based on the consumption of biomethane in transport, which has not happened yet.

[2] http://www.nordpoolspot.com/Market-data1/#/nordic/table

[3] Majandus- ja taristuministri määrus: Biometaani transpordisektoris tarbimise toetamise tingimused. Vatsu võetud Vastu võetud 24.11.2015 nr 135 RT I, 25.11.2015, 9https://www.riigiteataja.ee/akt/125112015009

Table 1. List of Estonian biogas plants, divided by feedstock, with annual primary energy capacity in GWh and year of deployment.

Installation	Feedstock	Size / capacity	Year of deployment
Agricultural mixed substrates – 105 GWh			
Vinni Biogaas OÜ	Waste, milking cow manure, slurry and silage	29,15 GWh	2013
Aravete Biogaas OÜ	Milking cow slurry, manure	26,95 GWh	2008
Tartu Biogaas OÜ	Milking cow manure, slurry and silage waste	26,4 GWh	2013
Oisu Biogaas OÜ	Milking cow slurry and manure	19,25 GWh	2013
Valjala Seakasvatus OÜ	Pig Slurry	2,86 GWh	2005
Waste water sludge – 41 GWh			
Tallinna Vesi AS	Sewage sludge sediment	9,25 GWh	1998
Tartu Vesi AS	Sewage sludge sediment	3 GWh	2014
Kuressaare Veevärk AS	Sewage sludge sediment	1,19 GWh	2013
Narva Vesi AS	Sewage sludge sediment	0,39 GWh	2005
Industrial process Waste Water Sludge – 86 GWh			
Estonian Cell AS	Aspen pulp mechanical waste water sludge	53,9 GWh	2014
Eastman Specialities OÜ	Toluene production waste water sludge	28,6 GWh	1997
Salutaguse Pärmitehas AS	East production waste water sludge	3,5 GWh	2002

Figure 1. Screenshot of interactive biogas plants map of Estonia. In total there are 17 biogas plants, divided by feedstock. The map is interactive and on google maps application and clicking on the map one can find the basic data about the plant.

The number of CNG/CBM filling stations will increase up to 22 in coming 2 years in Estonia, 15 new CNG / CBM filling stations got the investment support from KIK, currently 7 CNG/CBM filling stations are operational (click on interactive map, Figure 2) and 1 CNG/CBM filling station is under construction in Koksvere on compressed biomethane from Biometaan OÜ new biomethane plant.

Figure 2. Screenshot of interactive CNG filling stations map of Estonia. Currently there are 7 CNG filling stations.

2. The review of treatment methods of the digestate of biogas plants

2.1 Agricultural biogas plants

The agricultural feedstock based biogas plants are usually separated from farms and are thus independent private companies. In some cases agricultural farms are the minor shareholders of the biogas plant (e.g. Aravete Biogaas OÜ), in other cases the farm is not involved into biogas production and *vica versa* (e.g Tartu Biogaas OÜ).

The feedstock (slurry, manure) is usually provided to the biogas plant without charges and biogas plant gives digestate back to farmers also without charges.

The liquid and solid fractions of the digestate are not separated in agricultural biogas plants.

The transport of non-separated digestate to lagoons, which are artificial storage ponds of slurry or digestate is usually organized by biogas plant, is some cases also by farmers. Farmers have obligation to measure the content of nutrients in slurry and in biogas digestate, in order to know, how much slurry or digestate they are allowed to spread to fields according to the Crop Rotation[4] Fertilization Plan[5] (CRFP). It has been made by farmers, and crop rotation, origin of manure and fertilizers are listed and plan for each field will be made. The form of fertilizing plan is presented in annex 4.

2.3 Waste water treatment plants

Waste water treatment plant sludge based biogas plants commonly separate liquid and solid digestate. Liquid digestate is directed back to the aerobic treatment process. Nutrients have been removed from liquid digestate in the aerobic treatment of waste water. The capacity of WWTP-s has been enough so far to remove any additional nitrogen from liquid digestate. The solid digestate is mixed with some material like peat, wood chips, saw dust, etc and composted on the compost fields. WWTP-s have on-line liquid digestate quality measurement system, additionally twice a week random samples of liquid digestate are analyzed. The Water act paragraph § 26[1] regulates the allowed amount of nutrients in the reject waters of aerobic treatment. Regular samples are also taken from the reject water of WWTP before releasing the purified water to the watercourses.

[4] https://www.riigiteataja.ee/aktilisa/1291/2201/6056/PM_m4_lisa1.pdf#
[5] https://www.riigiteataja.ee/akt/116012015006?leiaKehtiv

Solid digestate is sold or given to farmers as fertilizer (90% in the case of Tartu WWTP) or to the landscape designers as cultivation soil. We expect that the similar ratio (90% used as fertilizer and 10 % used in landscaping) between selling and giving the cultivation soil for free applies also in other WWTP-s. The content of nutrients in solid digestate is measured by the WWTP and stated in certificate. When sold to end users, each batch of solid digestate based compost will have the certificate, where the amount of nutrients is stated. This ensures, that the farmers will know, how much nutrients are in the each batch of the sold solid digestate-compost. This means, that farmers can plan the spreading of digestate-compost according to the Crop Rotation and Fertilization Plan and they will spread the digestate-compost from WWTP according to the Crop Rotation and Fertilization Plan, in a similar way as they spread the slurry or slurry-digestate. Practically this should ensure, that risk of over fertilization will not take place, at least in the cases, where farmers have the Crop Rotation and Fertilization Plan and follow it and spread the allowed amounts of nutrients according to the Crop Rotation and Fertilization Plan.

Because of the legal framework regulations (look at details in chapter III) the control over the use of compost is implemented by environmental authorities (e.g. Environmental Inspection). Therefore the use of solid digestate based compost in agriculture is well organized and should avoid the risk of over-fertilization of fields with nutrients, including phosphorus.

2.3 Industrial biogas plants

The waste water from industrial production processes are digested in anaerobic tank under different conditions compared to the agricultural and WWTP biogas plants. The temperature is higher (over 50 C), retention time is shorter, the reactor is full of granules, which mass grows during the digestion process. This is the reason, why no solid digestate will occur from all 3 Estonian industrial biogas plants, the type of this anaerobic reactor is HydroThane STP ECSB. When the biogas plant started its operations, it bought the biogranules with microbes to start the digestion process. The biogranule stays in the reactor and when the process is stable, the amount of biogranule will grow, which afterwards is sold to next similar type biogas reactors. Liquid digestate is treated additionally in aerobic digestion tanks after AD process to achieve the needed low level of nutrients. To ensure the compliance with law, the nutrient content in reject water is measured before release the purified reject water to the watercourses.

Thus the risk of nutrient leakages from digestate of the industrial biogas plants is absent during the regular operations of the industrial biogas plants. In the case of accidents the procedures are foreseen to keep the safety of the environment.

3. Legislative framework and permitting procedures

At the EU level, the EU Water Framework Directive (2000/60/EC) gives the overall legal framework. At the national level, Water Act, Public Water Supply and Sewerage Act, Waste Act, Chemicals Act, and subordinate acts based on these acts form the legal framework. All regulation, which regulate the nutrient content in waste water sludge compost or in manure applies also for the digestate of biogas production from WWTP or from agricultural plants.

3.1 Water Act

In Estonia the main legal act, regulating water protection is Water Act with its secondary decrees. Water Act sets down main water protection rules for agriculture, like manure and chemical fertilizers management and use, requirements for animal husbandry etc. Secondary decrees establish more detailed technical requirements for water protection. In addition, action programs, like River Basin Management Plans and Nitrates Action Program (NAP) are launched according to Water Act.

The Estonian Rural Development Plan 2014–2020 includes environmental aid which also promotes the reduction of negative impact of agriculture on soil and water. The objective of the said measure is to compensate to the agricultural producers the costs and the loss of income related to the voluntary implementation of environmental protection measures which are stricter than those provided by law.[6]

Table 2. Limit values on heavy metals in agriculture, landscaping and re-cultivating.

Heavy metal	Limit value mg/TS kg sediment
Cadmium	20.0
Copper	1000.0
Nickel	300.0
Lead	750.0
Zinc	2500.0
Mercury	16.0
Chrome	1000

[6] Action plan for the Nitrate Vulnerable Pandivere and Adavere - Põltsamaa area for 2016-2020 (http://www.envir.ee/sites/default/files/nitrate_action_program_2016.pdf)

The Water Act regulates the use and protection of water, relations between landowners and water users and the use of public water bodies and water bodies designated for public use. According to § 24 paragraph 2 waste water must be cleaned in accordance with the limits set in the regulation before directed into watercourse.[7]

The limit values of heavy metals in waste water sludge based compost for using it in agriculture, landscaping and re-cultivating are regulated in the regulation no 78 of Ministry of Environment. (Table 2).[8]

The limits of pollution indicators of waste water discharged into the soil or water body are presented in Table 3, with the Helcom recommendations for 10,000-99,999 thousand human equivalence waste water treatment plants.[9]

Table 3. The limits of pollution indicators of waste water discharged into the soil or water body.

Pollution indicator	Limit value of the pollution indicator (mg/l)	Wastewater treatment efficiency (%)	HELCOM recommendation norm (mg/l)	Helcom recommendation norm treatment efficiency (%)
BOD7	15	80	15	80
KOD	125	75	-	-
Phosphorus	0,5	90	0,5	90
Nitrogen	15	80	0,5	70-80
Suspended solids	15	90	-	-

Section 26^1 of the Water Act states: (1) For the protection of surface and groundwater from pollution originating from agricultural production, the Government of the Republic issues a regulation which establishes the requirements for the use and storage of manure, liquid silage and other fertilizers and the measures for controlling the performance of such requirements. The calculated values of nutrient content of different types of manure and the capacity of manure storage vessels will be established with the regulation of the minister responsible for the respective field.[10]

[7] Ketre Kirs. Annupuhasti Tehnoloogiline Tsüklite Dimensioneerimine Suurupi Reoveepuhasti Näitel. http://eprints.tktk.ee/542/1/l%C3%B5put%C3%B6%C3%B6_K_Kirs_2014.pdf

[8] Keskkonnaministrimäärus. Reoveesette põllumajanduses, haljastuses ja rekultiveerimisel kasutamise nõuded. 30.12.2002, RTL 2003, 5,48 https://www.riigiteataja.ee/akt/234607

[9] Ketre Kirs. Annupuhasti Tehnoloogiline Tsüklite Dimensioneerimine Suurupi Reoveepuhasti Näitel. http://eprints.tktk.ee/542/1/l%C3%B5put%C3%B6%C3%B6_K_Kirs_2014.pdf

[10] Action plan for the Nitrate Vulnerable Pandivere and Adavere - Põltsamaa area for 2016-2020 (http://www.envir.ee/sites/default/files/nitrate_action_program_2016.pdf)

3.1 Manure-solid digestate handling regulation

The annual permitted amount of nitrogen spread with manure to one hectare of arable land is 170 kg, including the nitrogen contained in the manure left on the land during grazing.

The annual permitted amount of phosphorus per one hectare of arable land from the use of manure is up to 25 kg, including the phosphorus which is left on the land with animal excrements at the time of grazing. The amount of phosphorus given to the arable land with manure may be increased or reduced if necessary, taking into consideration that the average amount of phosphorus would not exceed 25 kg per hectare in a five-year period.

The use of fertilizers on natural grasslands is prohibited, except the nitrogen and phosphorus from the manure left on the grassland during grazing, the amount of which may not exceed the limit values of nitrogen and phosphorus established in subsections 26[1] (41) and (48) of the Water Act.[11]

Water protection requirements for fertilizer and manure storage facilities and storage sites and requirements for the usage and storage of manure, silage gases and other fertilizers

All the facilities need to be leakproof. The facilities need to be built so that the fertilizer does not get into the external environment. Safety must be ensured when transporting the manure, so that it does not get into the external environment. The manure should not be spread on snow or frozen land. Big farms (more than 300 animals) need to draw up a plan for spreading the manure in Crop Rotation and Fertilization Plan. Taking into account the amount of manure, the expanse area, ways of spreading the manure and the protection of groundwater the risk for over-fertilizing is minimal.[12]

3.2 Rules for handling and disposal of waste water

This regulation regulates the usage of reject water and the disposal of reject water. The managing of the municipal sewage water is allowed within the area where there is no opportunity to join the

[11] Action plan for the Nitrate Vulnerable Pandivere and Adavere - Põltsamaa area for 2016-2020 (http://www.envir.ee/sites/default/files/nitrate_action_program_2016.pdf)

[12] Vabariigi Valitsuse määrus nr 288Veekaitsenõuded väetise- ja sõnnikuhoidlatele ning siloladustamiskohtadele ja sõnniku, silomahla ja muude väetiste kasutamise ja hoidmise nõuded (https://www.riigiteataja.ee/akt/116082016006)

public sewerage system. The managing is only allowed within the boundaries of the waste water treatment plant. [13]

3.3 Nitrate vulnerable areas in Estonia

Pursuant to Article 5(1) and (7) of Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (hereinafter the Nitrates Directive), the Member States have to establish and implement action plans for avoiding or reducing water pollution resulting from nitrogen compounds. Action Plan for the Nitrate Vulnerable Pandivere and Adavere-Põltsamaa Zone for 2016–2020 (hereinafter the NVZ action plan) is fourth in order.

Based on the water monitoring results of the Nitrate Vulnerable Zone, the impact of agricultural production on the condition of water is most clear, as the impact of the intensive agricultural production of this region is quickly revealed in the groundwater which is mainly unprotected or poorly protected. At the same time, the content of nitrates has also increased in sampling stations outside the NVZ, which indicates the overall increase in agricultural load and insufficient water protection.

The increasing trend of the content of nitrate ion in groundwater, also an increase in the content of nitrate ion in surface water and their increasing leakage to the Baltic Sea — the extension of the NVZ based on the state water monitoring results has become topical.[14] One of the reasons for this assessment is the increase in nitrate ion during the past decade and the findings of the residue of plant protection products in the recent years.

Nitrates Vulnerable Zone (NVZ) in Estonia was determined taking into account soil and ground conditions, ground and surface water vulnerability as well as intensity of agriculture. Total area of the NVZ is 3250 km^2 which is 7,5 % of the total land area 43 200 km^2.[15]

[13] Tallinna Linnavolikogu määrus nr 16, vastu võetud 02.06.2016 Reovee kohtkäitluse ja äraveo eeskiri, (https://www.riigiteataja.ee/akt/410062016002)
[14] Action plan for the Nitrate Vulnerable Pandivere and Adavere - Põltsamaa area for 2016-2020 http://www.envir.ee/sites/default/files/nitrate_action_program_2016.pdf
[15] Water quality and agriculture http://www.envir.ee/en/news-goals-activities/water/water-quality-and-agriculture

The nitrate vulnerable Pandivere and Adavere– Põltsamaa area

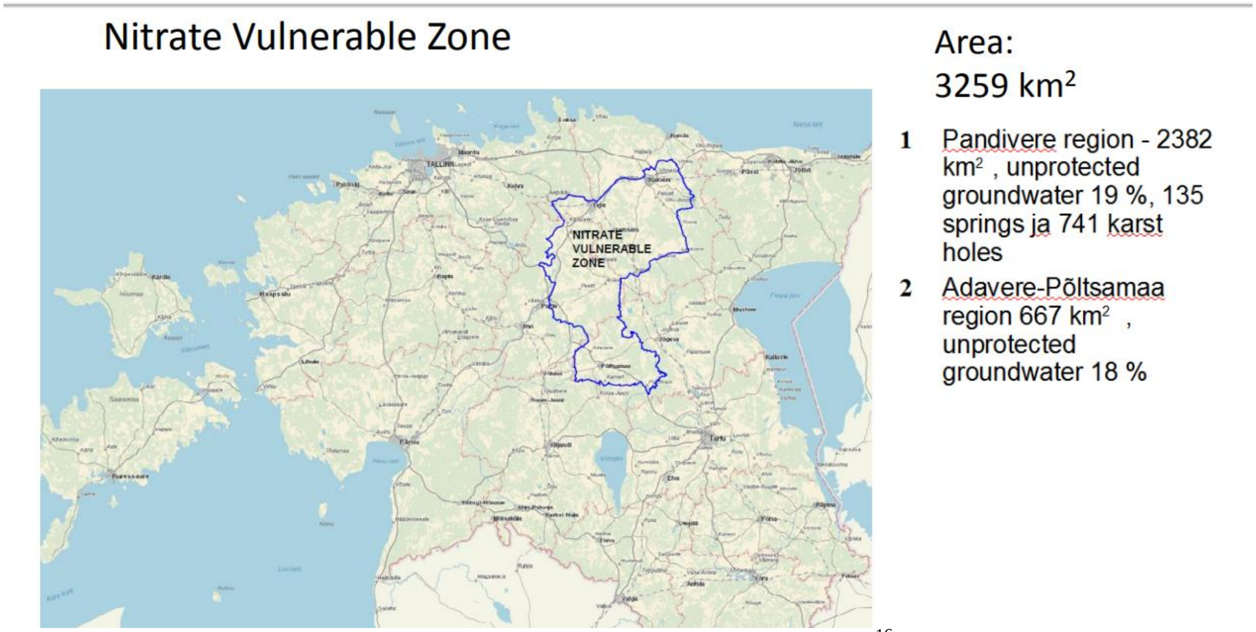

Figure 3. Pandivere and Adavere-Põltsamaa Nitrate Vulnerable Zones in Estonia.[16]

3.4 Public Water Supply and Sewerage Act

This Act regulates the organization of supply of registered immovables with water and the leading off and treatment of waste water of the registered immovables, rain water, drainage water and other soil and surface water through the public water supply and sewerage system, and provides for the rights and obligations of the state, local governments, water undertakings and clients.[17]

3.5 Waste Act

This Act provides the organisation of waste management, requirements for preventing waste generation and the health and environmental hazards arising from waste, including measures for

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[16] http://www.envir.ee/sites/default/files/veebislide1.pdf

[17] Riigikogu määrus. Vastu võetud 22.03.1999 Public Water Supply and Sewerage Act (https://www.riigiteataja.ee/en/eli/505022015004/consolide)

improving the efficiency of the use of natural resources and reducing the adverse impacts of such use, and liability for violation of the established requirements.[18]

3.5.1 Biogas digestate quality regulation

Raw biogas has 50-60% of methane (CH4). If raw biogas is purified to the same quality as natural gas with over 90% of methane content, then it is named as biomethane. Biomethane can be used in all applications and in a same way as natural gas. If biomethane is produced from biowaste, the process and end product – biofertilizer – has to be certified. In this way it won't be qualified as waste, but as a new product.

The Ministry of Environment adopted the Regulation nr 12 on biogas digestate quality and process requirements in May 2016. This regulation regulates requirements for biogas stations, also safety and quality indicators are defined. However, the practical enforcement of this Regulation requires the establishment of Certification Body, which yet needs to be accredited in first order.

Instead of using biowaste for biomethane production it is currently composted according to the Degree no 7 of Ministry of Environment[19], which sets the legal framework for certification of the compost as fertilizer.

Solid digestate from biomethane production could be a valuable biofertilizer with similar nutrient value as artificial fertilizers. Digestate has similar nutrient value as manure, but it will depend from used raw materials in anaerobic digestion (AD) = biogas production plant. The objective of biofertilizer as product development should target to turn digestate into a product with very stable nutrient content and needed balance between N, P and K, using e.g biochar, pelletizing biofertlizer to enable the transportation of pellets over longer distances.

Although most of the legal acts for using waste based digestate as fertilizer already exist in Estonia, the market has not started yet. Until now no exportable biofertilizer is produced from digestate in Estonia.

To get digestate valued and sold on the market for a proper price needs a lot of cooperation, training, awareness rising, and joint marketing via regional whole-value-chain-covered platforms (long-term cooperation business models).[20]

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[18] Riigikogu määrus 01.05.2004 Waste Act (https://www.riigiteataja.ee/en/eli/ee/520012015021/consolide/current)

[19] Keskkonnaministri määrus. Biolagunevatest jäätmetest komposti tootmise nõuded. Vastu võetud 08.04.2013 nr 7 RT I, 19.12.2015, 10 https://www.riigiteataja.ee/akt/110042013001?leiaKehtiv

3.5.2 Requirements for compost from biowaste

The certification body of compost from biowaste is Estonian Union of Waste Management Organizations (Eesti Jäätmekäitlejate Liit) and the certified compost can be sold as fertilizer. According to this Compost regulation and certification scheme the biggest compost producer, Tallinn Recycling Centre, sells the compost from biowaste at a price of 4.8 €/tonne (including VAT and loading cost); transport service is not provided; the minimum amount is 20 kg.[21]

3.6 Chemicals Act

This Act provides the legal basis for organizing the handling of chemicals, restricting economic activities that involve the handling of chemicals, and organizing state supervision over the fulfillment of the requirements provided for in this Act and in the relevant regulations of the European Union with the aim of protecting human health, the environment and property and ensure the free movement of goods.[22]

3.7 Permitting

The construction and operational safety of a biogas plant are governed by several Estonian national legislation and European Union regulations.

1) Building Act, adopted on 15 May 2002;

2) Planning Act, adopted on 13 November 2002;

3) Water Act, adopted on 11 May 1994;

4) Ambient Air Protection Act, adopted on 5 May 2004;

5) Waste Act, adopted on 28 January 2004;

6) Environmental Impact Assessment and Environmental Auditing Act, adopted on 22 February 2005;

5) Machinery Safety Act, adopted on 10 October 2008;

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[20] Keskkonnaministri määrus nr 12 Vastu võetud 10.05.2016Nõuded biolagunevatest jäätmetest biogaasi tootmisel tekkiva kääritusjäägi kohta https://www.riigiteataja.ee/akt/119052016009

[21] Keskkonnaministri määrus nr 7 Vastu võetud 08.04.2013 Biolagunevatest jäätmetest komposti tootmise nõuded (https://www.riigiteataja.ee/akt/110042013001)

[22] Riigikogu seadus In force from 01.06.2013 Chemicals Act (https://www.riigiteataja.ee/en/compare_original?id=504122013001)

7) Public Health Act[1], adopted on 14 June 1995;

8) Public Procurement Act, adopted on 24 January 2007;

9) Requirements for noise, noise level measuring and noise level tracing in equipment used outdoors and conformity assessment procedure of equipment used outdoors[1]. Regulation no. 124 of the Minister of Economic Affairs and Communications of 16 December 2009; and

10) Noise limit values in residential and recreational areas, dwellings and public buildings and noise level measuring methods. Regulation no. 42 of the Minister of Social affairs of 4 March 2002.

The construction of a biogas plant shall conform to the following development documents of the municipality and legislation where the plant will be built i.e. environment development plan, general plan and building regulations. Plan and agreements with the owners of fields are not required when permitting biogas plants in Estonia, because the landowners/farmers are interested from digestate as fertilizer in a similar way, as they used slurry and manure as fertilizers before AD. We assess this solution as not the risk to sustainability.

To build a biogas plant you need to apply a building permit and authorization permit for use by the local government. To apply a building permit you need to get designing specification, which is compliant with the county and local governments strategic development plans (i.e. county development plan, rural municipality development plan etc.). The need for a special permit for water depends on whether waste water or other water polluting substances are fed into the biogas production process. The certain analysis is necessary to have beforehand. All agricultural biogas plants have detailed plans, construction- and use licenses. Similarly, all biogas and cogeneration plants and related facilities must request by the Environment Agency atmosphere pollution permit or, if necessary, a special permit for use of water. Only the Jööri biogas plant (Saare Economics) has requested permission to use water for special purposes. All other biogas plants have a waste permit that is issued by the Environmental Board.

In the case where the digestate is used for fertilizing arable land, the proportion of contaminants, as well as organic and inorganic substances (i.e N, P, K) in the digestate must meet the requirements. Compost fertilizer obtained from sewage sludge is permitted to be used in landscaping, forestry and agriculture, provided that it does not endanger the well-being of humans, animals, plants and the environment. Before disposing of the compost, wastewater treatment plants are required to carry out appropriate analyzes to confirm the safety of the compost. The concentration of heavy metals, parasite eggs and coliform bacteria in the compost must not exceed the limits set. When the parameters fit into the limits, compost is assessed to be safe. There are no differences in quality requirements of solid digestate from WWTP-s for using it either as fertilizer or as filling material in landscaping.

4. RISK ASSESSMENT/QUALITATIVE

Generally the preliminary results indicate that the anaerobic digestion of biomass in biogas plants doesn't increase the risk of nutrient runoff to surface and ground water sources or cause any other direct negative environmental impacts. The solid and liquid digestate has used in the same way and with the same procedures are before, without AD. Usually the AD increases the positive environmental effects, like less smell, better uptake of nutrients by the plants, etc.

In more detail, the risks of potential nutrient leakage and over-fertilization are assessed by biogas plant types, mainly agricultural, industrial and waste water treatment plants.

4.1. Risks of nutrient leakages from agricultural feedstock based biogas plants

As said before, the liquid and solid fractions of the digestate are not separated in agricultural biogas plants. Some big farms separate the slurry and use solid fraction for bedding and liquid digestate is stored in leakproof lagoon and spread as liquid manure according to the Crop Rotation and Fertilization Plan.

The transport of non-separated digestate to lagoons, /artificial storage ponds of slurry/digestate is usually organized by biogas plant, is some cases also by farmers. Farmers have obligation to measure the content of nutrients in slurry and in biogas digestate, in order to know, how much slurry/digestate they are allowed to spread to fields according to the Crop Rotation and Fertilization Plan

The another nutrient overload avoiding factor from agricultural biogas plants is in fact, that current, planned and possible the future agricultural biogas plants locate close to the arable land. This means, that there is enough agricultural land to spread the slurry or digestate from agricultural biogas plants.

According to the common procedure, the digestate of agricultural biogas plants are spread to the fields by farmers. Farmers spread digestate according to the Crop Rotation and Fertilization Plan, which is agreed with environmental authority. Thus the over-fertilizing risk with digestate is "out of hands" of biogas plant owners or operators. The responsibility to follow the Crop Rotation and Fertilization Plan plant is solely on the shoulders of farmers, including in the case of spreading the digestate from biogas plant.

The risk on over-fertilization with nutrient especially with phosphorus arise in the cases, where farmers do not follow the agreed and obligatory Crop Rotation and Fertilization Plan, either because they are not aware, not responsible or not knowledgeable enough. The latter case is quite unlikely in Estonia, while the Environmental Inspection makes the random inspection of farmers, including the inspection of filling the obligations of nutrient balance and nutrient spreading according to the Crop Rotation and Fertilization Plan.

It is assumable, that if the agricultural biogas plants will not add any other feedstock (e.g. bio-waste or any other energy and nutrient rich feedstock in significant amount), the risks of over-fertilizing from agricultural biogas plant is very slow, almost non-existent.

It is also quite unlikely that additional biomaterial will be added as feedstock to the agricultural biogas plants. This is because of long transport distances between agricultural biogas plants and biomaterial owners.

The risk of double-fertilising is not the case in Estonia, like happened in Germany, e.g. utilising both mineral fertiliser and digestate on the same field, This is because authorities are calculating the total nutrient balances taking into account all sources of nutrients/fertilizers. The fertilizing limits 170 kg N/ha and 25 kgP/ha apply also to waste and wastewater based digestates, to manure based digestates and mineral fertilizers. The source of fertilizers doesn’t matter, the amount per ha can’t exceed the fertilizing limits. The risk of over-fertilizing from agricultural biogas plants is also minor, because most of the farmers are responsible, long term oriented and fulfill the legal framework, e.g. they measure the nutrient content in slurry or in the biogas digestate, they compile the Crop Rotation and Fertilization Plan according to the amount of nutrients in the digestate, farmers agree the Crop Rotation and Fertilization Plan with environmental authorities and follow the plan. This means, that if the farmers do not break the law, the over-fertilization of nutrients from slurry or from the biogas digestate is very low, even non-existent.

4.2 Risks of nutrient leakages from waste water treatment biogas plants

Waste water treatment plant sludge based biogas plants commonly separate liquid and solid digestate. As already said, the liquid digestate is directed back to the aerobic treatment process. The solid digestate is mixed with some material and composted on the compost fields. WWTPs have on-line liquid digestate quality measurement system. Regular samples are also taken from the reject water of WWTP before releasing the reject water to the watercourses.

Solid digestate is sold or given to farmers as fertilizer (90% in the case of Tartu WWTP) or to the landscape designers as cultivation soil. The content of nutrients in solid digestate is measured by the WWTP and stated in the certificate. Each batch of digestate/sludge based compost will have the certificate with measure nutrient content, when sold to end users. This ensures, that the farmers will know, how much nutrients are in the each batch of the sold solid digestate-compost. So farmers know how much each batch of digestate-compost includes the nutrients and they will spread the digestate-compost from WWTP according to their Crop Rotation and Fertilization Plan, in a similar way with the slurry or slurry-digestate. Practically this should ensure that risk of over-fertilization will not take place, while if farmers follow the Crop Rotation and Fertilization Plan and spread the allowed amounts of nutrients according to the Crop Rotation and Fertilization Plan.

Because of the legal framework regulations (look at details in chapter III) the control over use of compost and its use in agriculture is well organized and should avoid the risk of over-fertilization of fields with nutrients including phosphorus.

Identified risk – one risk of wrong use of nutrients in the WWTP digestate-compost was identified. It turned out that digestate-compost use in landscape design is not regulated very clearly. The amount of digestate-compost used is landscaping per soil surface square meter is not determined, not measured and not controlled. It can be explained with the fact, that compost is not used for the fertilizing purposes, but this does not reduce the risk, that in some places the nutrients from digestate-compost can be over-dozed. Understandable, it will not happen on the agricultural land, but nevertheless, the nutrients can leak to surface waters also in the urban areas, or on the road sides or from public parks, where ever the compost digest is used for re-cultivation purposes. At the other hand, in the case of Tartu only 10% of solid digestate-compost is used in cultivation and very common is the practice, that digestate-compost will be used only once "in lifetime" in certain places and locations with thin layers and not in the amount of „tons of digestate per m^2". Thus this risk might be also insignificant.

4.3. The risks of nutrient run-off from digestate of industrial biogas plants

The waste water from industrial processes are digested in anaerobic reactor called HydroThane STP ECSB or similar in all 3 Estonian industrial biogas plants. This is the reason, why no solid digestate will occur from all 3 Estonian industrial biogas plants. So called solid digestate which can be also named as the bio-granule, stays in the reactor and when the process is stable, the amount of bio-granule will grow, which afterwards is sold to next similar type biogas reactors. Liquid digestate is treated additionally in aerobic digestion tanks after AD process and the nutrient content in reject water is measures before release the purified reject water to the watercourses.

Thus the risk of nutrient leakages from digestate of the industrial biogas plants is absent during the regular operations of the industrial biogas plants. In the case of accidents the safety precautions procedures are foreseen to keep the safety of the environment.

5. Subsidies and profitability

Renewable electricity from biogas CHP has price premium of 0,053 €/kWh. This price premium is the same for all renewable electricity producers. Investment support to CNG/CBM filling stations (3+12 stations) in the share of 40% from CAPEX. Support to cities for biomethane buses is also available to apply, but the prerequisite is, that these buses have to consume biomethane as fuel. Estonian Government has the plan to introduce 4% biomethane blend obligation with natural gas starting from 2021. Since then price premium to biomethane producers is allocated (93-100 €/MWh minus monthly average Baltic natural gas price).

The profitability of biogas production can be increased with using biodegradable waste (organic fraction of municipal solid waste, organic industrial waste, garden waste nature and landscape conservation waste etc.), because it is valuable raw material for biomethane production. It also doesn't compete with food production and usually has lower cost compared with using silage. In Estonia, the biowaste is not digested to biomethane yet. Key problems and issues are:

(1) Biowaste is currently almost not separated at source; (2) Waste (organic fraction) is not collected separately; (3) biowaste is mostly burned or composted: a missed opportunity to produce biomethane and biofertilizers.

This chapter identifies the reasons for this situation and provides actions and measures to improve the situation.

In 2015 a new regulation 18 obliges that biodegradable kitchen and canteen waste has to be sorted at spot. The gap is in enforcement of this regulation. The reasons for this are not yet analyzed.

Estonia has set a goal that from 2020 onwards, all separately collected waste from households and municipal waste from other sources should be recycled for at least 50 %. However, only few municipalities have enforced separated biowaste collection obligation.

Annually 12'000 tons of food products are left unsold and written off at Estonian food stores. Until now this separately collected biowaste is composted or landfilled rather than being used for biomethane production. Barriers for doing this are:

1. unfavourable price of biomethane compared to the price of natural gas;
2. low demand;
3. no differentiated gate fees
4. not fully enforced legislation;
5. additional cost of un-packaging facility.

The Minister of the Environment signed an amendment to the regulation on sorting and classifying municipal waste, specifying the requirements for the collection and sorting of waste in May 2015. After 2020, Estonia is allowed to landfill no more than 20% of their municipal biowaste. The remaining 80% has to be recycled. Producing biomethane from biowaste is cheaper than from green biomass. Anaerobic digestion is a very cost effective and nature friendly waste management option, even compared with composting of biowaste.

The majority of food waste is created in households, catering companies and supermarkets. Approximately 40% out of 92.6 thousand tons of food waste annually produced can be easily used for anaerobic digestion. To support biowaste source separation, the separate collection of biowaste, the use of biowaste for biomethane production and to get digestate valued and sold on market with proper price needs a lot of cooperation, training, awareness raising, joint marketing via regional whole-value-chain-covered platforms (long-term cooperation business models).

6. Commercial products from digestate - case examples of WWTP Kuressaare Veevärk biogas plant

In the beginning of August 2017, the CEO of Kuressaare Veevärk AS was very positive to sell in the near future approx. 1500 tons of digestate as a product due to a renewed regulation that will enable water companies to produce and sell a product made from sewage sludge, i.e. digestate based compost.

Until now, according to CEO of Kuressaare Veevärk AS, the usage of digestate of sewage sludge company was unclear and unregulated zone where the compost remained as an environmentally harmful condition, has now been developed criteria (see chapter III) under the new regulation and this digestate is no waste anymore and is safe for use. It means that clear rules in the future will give the opportunity to sell sewage sludge companies' digestate properly as a product and creates a positive and effective cash flow in addition to main business.[23]

[23] . / https://www.saartehaal.ee/2017/08/01/kuressaare-reomuda-voib-tulevikus-muugiks-minna/ Kuressaare reomuda võib tulevikus müügiks minna. Author: Ain Lember, 01/08/2017

7. Circular economy case study Salutaguse Yeast Factory

Salutaguse Yeast factory rather paid the pollution charge than invested in newer and cleaner techniques for years. Waste water was going straight into the nearby Keila river and also the air was polluted due to a bad smell. Every month thousands of liters, more than permitted, of organic dark brown waste went into the nature, because the equipment which were used, were not able to process the residue in such high organic load. [24]

The bad smell decreased significantly, when a new cleaning facility was built. Salutaguse Yeast factory´s waste water is now directed through an evaporator, biogas is produced and animal feed and fertilizer are made from the same waste stream, which caused the pollution in previous times. Thanks to the investment of the biogas plant and vacuum evaporation the company now can benefit and make profit from the waste water. Vinass and condense water come out of the production process of the vacuum evaporation. Condense water is used to clean the equipment, the rest of it is going into the biogas station. Better assumptions for cleaner air and cleaner Keila river were made due to the investment of the biogas station and new waste water purification facility. (Nael, 2010). In the year 2016 Salutaguse Yeast Factory did well – the turnover was increased by one fifth and the operating profit increased to over one million €. (Kraun, 2017)

One of the circular economy example can be mixing liquid digestate with high nutrient content with biochar. According to the first results of field studies the biochar with very high surface area can absorb nutrients very efficiently and if the nutrients are spread to the soil with biochar, the nutrients will release from biochar during very long time, thus avoiding the leaching of nutrients in short time period.

8. Solutions and proposals for mitigating adverse environmental impacts of biogas production

We hereby describe our proposals for solutions to mitigate the adverse environmental risks and impacts of biogas production e.g. technologies for reject water or digestate treatment, enhanced digestate utilization (processes, logistics), improved planning of biogas installations (locations, scale etc.), improved permitting procedures and legal or economic policy instruments.

[24] Randmaa, Kristiina, 14. august 2003. Äripäev. Pärmitehas eelistab investeeringutele saastemaksu. http://www.aripaev.ee/uudised/2003/08/13/parmitehas-eelistab-investeeringutele-saastemaksu

8.1 Suggestions and proposals for agricultural biogas plants

In this chapter, we describe our ideas and proposals for further activities to perform even better in the case of agricultural biogas plants, even the risks of nutrients run-off from agricultural biogas plants are low.

8.1.1 To make further in-depth analysis on the awareness of farmers; how they enforce the law of slurry/digestate management; are the Crop Rotation and Fertilization Plans of farmers accurate; how the farmers enforce the Crop Rotation and Fertilization Plan; how efficient is the Environmental Inspection in monitoring; how much the phosphorus has been accumulated in soils and might it be the risk of releasing accumulated phosphorus.

8.1.2 To organize joint training to farmers and biogas plant operators on potential risks of over-fertilizing.

8.1.3. To organize training to environmental department and inspection to be aware of the risk of over-fertilizing in future, also how to increase the efficiency of monitoring of the spreading of the phosphorus to the fields.

8.1.4 To organize study tours and the exchange of experiences of the efficient and environmental friendly nutrient management methods, techniques etc to the biogas producers, farmers and authorities around the Baltic Sea Region.

8.1.5 To study further possibilities of manure/digestate further valorization e.g. either via AD or thermal treatment to make granules of fertilizers from manure in the locations and areas, were manure is created e.g. dry manure from grazing meat cattle on Baltic Sea coastal meadows or on the other nature protected areas, where manure is created, but land to spread it is not available at all or not available enough. In such cases there is real need for innovation and technology and technique development to store nutrients in granules in order to transport these manure/digestate based granules of nutrients to areas, where the nutrients are missing, in Estonia or in abroad. Such need was realized during this project and this was not related to the biogas production, but directly related to dry manure management problems in the areas, where manure was constantly created, but arable or agricultural land was not available at all or was not available enough to spread the manure or compost from manure to the fields. Without additional treatment the manure is not possible to transport over long distances, thus need for methods, technologies feasibility studies to treat dry manure to granules to transport it over long distances is real problem in Estonia and the sütlevadolutions are in need to be identified.

8.1.6 Exchange of all kind of positive experiences between the biogas plant operators and farmers around Baltic Sea Region on environmental friendly manure/digestate use and/or management.

8.2 Suggestions and proposals for WWTP biogas plants

8.2.1 To make additional study or survey on practices of using solid digestate in gardening and re-cultivation, including the analysis of the amounts and nutrient content in solid digestate to reduce the risk of over-use of WWTP solid digestate in re-cultivation projects.

8.2.2. To reduce the risks of the potential nutrient leakages from re-cultivation projects via enforcing proper landscape projects, which have to be agreed and accepted by the environmental authorities beforehand on the landscape-project level. In this cases the digestate-compost is used not for fertilizing purposes, but for the purpose to fill and cover the un-natural (road sides, public parks) surfaces. The acceptance from the environmental authorities to the re-cultivation projects beforehand will reduce the risk of over-using the digestate-compost in landscaping project implementation and leakage of nutrients from landscaping processes to the urban or rural environments.

8.2.3. To improve the legal framework and monitoring of the use of digestate-compost in the landscaping, adopting regulations, which regulate the use of digestate-compost in the landscaping projects in order to keep the amount of the nutrients in the compost under the acceptable limit values.

8.2.4 To improve the enforcement of digestage–compost related regulations via training, study-tours, experience-exchange of landscape designers, architects, road builders, WWTP operators, biogas plant operators, local and ministerial authorities.

8.3 Conclusions

The first results of risk assessment of nutrient leakages from biogas plant digestate indicate, that these risks are minimal or absent at all. Biogas plants do not increase the risk on pollution of ground and surface waters with nutrients. The minor risks are mitigated via existing and enforced regulation.

Slurry, manure and agricultural raw materials based biogas plants do not increase the risk on pollution of ground and surface waters with nutrients, because the non-separated solid and liquid digestate is handled in the same way as slurry and manure. The nutrient content in digestate is measured and farmers have enough arable land to spread the digestate according to the Crop Rotation and Fertilization Plan. Farmers usually also apply for the hectare based subsidy and environmental friendly management subsidies. In this case they have to present their Crop

Rotation and Fertilization Plans to the ARIB (Agricultural Register and Information Bureau – PRIA – *Põllumajanduse Registrite ja Informatsiooni Amet*), which is subsidy paying agency. ARIB controls the Crop Rotation and Fertilization Plan validity and appliance with regulation e.g. allowed nutrient amount per hectare, which is quite strong guarantee of avoiding over-fertilizing. If the farmers have mistakes in Crop Rotation and Fertilization Plans, then ARIB will not pay subsidies to farmers. This is strong economic incentive not to break the fertilizing rules and spread more nutrients to the fields, than allowed. ARIB is also making random field test among 5% of farmers about enforcement of Crop Rotation and Fertilization Plans. Additionally Environmental Inspection and environmental authorities may inspect the enforcement of Crop Rotation and Fertilization Plans they can also take the samples from slurry, digestate and from soil to measure the content of nutrients in these mediums of the environment.

The digestate from sewage sludge based biogas plants is handled in a same way as sewage sludge without biogas plant. The digestate is usually separated also after AD process. Liquid fraction is leaded back to aerobic waste water purification process. The solid fraction of the biogas digestate is usually composted for 1-2 years mixing the solid digestate with peat, wood chips, saw dust or other similar substance. The composting process should ensure the temperature 50 C for more than 3 days, which means that the digestate is hygienized after that. After composting the solid digestate from WWTP will be used as fertilizer in agriculture or as land improving substance in landscape design project or filling and covering landscapes after big constructions e.g. roads, buildings etc.

WWTP has been design big enough to treat the additional nutrients (usually not more than 10%) load in liquid digestate. Also because of increasing water and waste water fees the water consumption and waste water amount have been decreased. The constant and regular monitoring of the content of nutrients in purified reject water s of WWTP ensures that nutrient leakage to environment is avoided.

We identified only risk of potential nutrient leakage from solid digestate of WWTP biogas plants in the case, when the amounts of solid digestate are used in re-cultivation of landscapes and these amounts are not measured per surface areas (square meters). At the other hand, this risk can be also minor, because the areas in landscape re-cutlivation projects, where the solid digestate is spread, is usually not big, at least not as big as arable land or crop fields. The solution here is awareness rising first of all. Another solution is to amend the legal framework with distribution limits of digestate spreading per surface area. The monitoring and inspection can be proved as well, currently nobody controls the amounts of used of solid digestate in landscape re-cultivation projects.

Cooperation projects between WWTP based biogas plants around Baltic Sea Region can be designed and implemented to learn, how this potential risk of nutrient leakages from digestate used in the re-cultivation is mitigated in other countries.

The planning of the locations of the biogas plants is regulated by spatial planning and construction law. The selection of locations of biogas plants depends usually from 2 factors: (1) the availability of raw materials and closeness of the spot of consumption of the biogas either in CHP-s (heat consumption and its seasonality) or in transport.

The legal system provides the legal ground to certify digestate from composting and from biogas plants as fertilizer. So far non of the biogas plants have not yet applied for the certification of their digestate, because no actual need exist. Currently also certification body is missing, it means anyone of the Estonian potential certifiers have not yet applied for the accreditation. If some countries have been enforced the certification system of the digestate, then also cooperation projects can be designed and implemented to exchange experiences via study tours and training courses for actors around Baltic Sea Region on digestate certification as fertilizer.

It is more likely that voluntary schemes of environmental friendly manure /digestate management like *Sustainable Biogas Producers* will not attract interest in Estonia among existing and future biogas producers. This is because biogas plant operators and farmers are busy with filling existing legal framework and ensure the feasibility of the agricultural and biogas production, so they simple do not have time, energy and motives for additional voluntary efforts. One can assume, that legal framework is extensive enough to ensure fulfillment of the environmental protection purposes.

The main conclusion is, that the results of risk assessment of nutrient leakages from biogas plant digestate indicate, that these risks are minimal or absent at all. The potential risks are prevented via existing and enforced regulation, which fixes the allowed amounts of nutrients to be spread to land.

The second conclusion is that enforcement of regulations on nutrient spreading to land is controlled well enough.

The third conclusion is that the place for improvement is in compost / digestate use in land re-cultivation projects, where amounts of digestate with nutrients in it are not measured and calculated. However, this risk can be minor, because the digestate for re-cultivation usually is used in thin layer and it has been usually done only *"once in lifetime"*, not every year.

The fourth conclusion is, that cooperation between biogas plant operators can be planned on the field of digestate use in re-cultivation projects, certification of digestate as fertilizers, including the accreditation of the potential certifiers.

The last conclusion is, that even the interest towards voluntary environmental friendly management systems and *schemes* like „*Sustainable Biogas Producers“ is minor or absent at all in Estonia, via cooperation projects with positive and feasible working examples from other countries can create the change in current arrogant attitudes of farmers, biogas plant operators towards more positive attitude related to the environment.*

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Annex 1 Copy of the sent questionnaire to the biogas plant operators.

Lp. Tallinna Vesi AS

Harjumaa, Tallinn, Ädala tn 10, 10614

Meie 09. september 2017

Biogaasi tootmise kääritusjäägis olevate toitainetega Läänemere saastatuse riskide hindamine.

Eesti Biogaasi Assotsiatsioon osaleb rahvusvahelise Läänemereriikide uurimistöö projektis, mille eesmärk on selgitada Eesti biogaasi tootjate olukord kääritusjäägi käitlemisel ja sellest tulenevad riske kääritusjäägist pärinevate toitainete reostuse tekkeks Läänemeres. Projekti koordinaator on Kristina Rugele Riia Tehnikaülikoolist (Riga Technical University, Water Research Laboratory, e-mail: kristine.rugele@rtu.lv). Projekti rahastab Clean Baltic Sea John Nurminen Foundation. Huvi korral saadame teile projekti inglisekeelse lähteülesande: *Risk assessment of biogas production in the Baltic Sea region from the nutrient management perspective.*

Projekti elluviimise käigus oleme Teie biogaasi jaama kohta leidnud andmed, mis on toodud lisas 1. Palume teil nende andmete õigsust, aktuaalsust ja paikapidavust üle kontrollida ja vajadusel täiendada ning parandada, kui andmed on muutunud.

Palume Teil vastata järgmistele küsimustele, mille kohta me andmeid leidnud ei ole, kuid mis on projekti elluviimise seisukohast hädavajalikud. Juhime teie tähelepanu asjaolule, et kui mõned vastuste andmed on konfidentsiaalsed, siis palun tooge need andmed eraldi välja. Sel juhul me neid andmeid ei avalikusta. Üldistatud, anonüümseid ja mittekonfidentsiaalseid andmeid sisaldav projekti kokkuvõte on Tellijal plaanis panna üles kodulehele. Ootame vastuseid järgmistele küsimustele:

1. Kui palju toodate aastas biogaasi?
2. Millised on põhiliste toorainete kogused aastas, nende kuivaine sisaldused?
3. Kui palju tekib teie biogaasi jaamas kääritusjääki aastas?
4. Kas kääritusjäägi tahkeid ja vedelaid fraktsioone eraldatakse?
5. Kui jah, siis mis meetodil eraldamine toimub?

6. Kui suur on tahke kääritusjäägi kuivaine sisaldus?
7. Milline on vedela fraktsiooni kuivaine sisaldus pärast eraldamist?
8. Kui tihti teete vedela ja tahke kääritusjäägis olevate toitainete analüüse, kas enne või pärast kompostimist?
9. Milline on toitainete sisaldus tahkes kääritusjäägis pärast kompostimist kliendile kasutamiseks andmisel?
10. Kas on võimalik meile saata tahke kääritusjäägi analüüside tulemused?
11. Kui suur on põhiliste toitainete (lämmastik, kaalium, fosfor) sisaldus vedelas kääritusjäägis enne aeroobset töötlemist?
12. Kas on võimalik meile saata vedela kääritusjäägi analüüside tulemused?
13. Kui suur on toitainete sisaldus puhastatud reovees, mis suunatakse eesvoolu?
14. Mis eesmärgil, kes ja kuidas põhiliselt tahket kääritusjääki kasutab?
15. Kes teeb järelvalvet tahke kääritusjäägi kasutamise koguste üle pinnaühiku kohta selle kasutamisel haljastuses?
16. Kui suureks hindate riski, et tahkest kääritusjäägist satuvad toitainet pinnase- ja / või põhjavette ja selle kaudu Läänemerre nii põllumajanduse kui haljastuse kaudu?
17. Kas on midagi lisada, mida me küsida ei osanud

Võimaluse korral palume vastata nädala jooksul, kuna peame teise inglisekeelse vaheraporti esitama projekti koordinaatorile 15. septembriks, enne seda on vaja andmed koondada, analüüsida, üldistada ja tõlkida inglise keelde.

Tauno Trink

EBA infojuht

Täpsem info: Projektijuht Katarina Oja +37256562714, email: katarinaoja1@gmail.com

Lisa 1A: example of answers from Tallinn WWTP

TALLINNA VESI AS

Kontaktisik Tiina Kärner: tiina.karner@tvesi.ee

AS Tallinna Vesi on Eesti asutati 1997 aastal ning on suurim vee-ettevõte, mis pakub vee- ja kanalisatsiooniteenust ligikaudu kolmandikule Eesti elanikest. Tooraineks on reovee sete, 2013 aastal puhastati kokku 45,02 miljonit m^3 reovett. Biogaasi tekib umbes 1 675 428 m^3 aastas, millest ligi 70% kasutati sooja tootmiseks ning osa põletati ära.

Suurim kogus jäätmeid tekib reoveepuhastuse protsessis ning tehnilise teeninduse osakonnas. Jäätmeid tekib umbes 43 135 tonni aastas. Enamik tekkinud jäätmetest on tavajäätmed. Segaolmejäämetega tekitati 2013. aastal ökoloogiline jalajälg suurusega 392,7 ha/a. reovee puhastamise käigus puhastakse umbes 29 856 tonni setet.

Biogaasi saagis on keskmiselt 340 m3 tunnis (8160 m3/d) metaani sisaldusega ca 67 %. Kogu tekkinud biogaas kulub AS Tallinna Veel tootmishoonete kütmiseks ja metaantanki pumbatava muda soojendamiseks 37 oC-ni ning ca 700 kW võimsusega gaasimootorile, mis käitab aerotankidesse õhku andva turbiini.

Koostis: väävelvesinik - 0,1 %; lämmastik - 2,5-3,5 %; vesinik - 0,2-0,4 %; veeaur; CO2 - 36±2% ja metaan 64±2%.

Annex 2. List of biogas installations in Estonia

2.1 Agricultural mixed substrates

2.1.1 Oisu Biogaas OÜ

The Oisu biogas CHP plant (1,2 MWel) was completed in 2013. In 2016 Oisu plant produced over 4 mio m3 biogas (52,4% methane) from what in total 2,3 GWh heat and 8,5 GWh electricity was produced (2015 8,2 GWh and 2 GWh, respectively). The main source of raw material was manure from nearby farms. Additionally, silage was used. Total carbon reduction over 36 th CO2eq (2015 slightly over 35 th CO2eq). (4E Environmental and…, 2016)

Oisu biogas station has two digesters and one post-digester, which are capable to contain up to 11 000 tons of solid and liquid manure. The biogas station is able to take manure from 3000 cows from the radius of 10 km from the station. (Sammler, 2013)

Earlier the solid manure was just held in the container and the liquid manure in the lagoon, but now biogas is taken out and liquid and solid digestates are put on the fields with the same way, frequency and with the same equipment as slurry and manure before AD. (Järva teataja, 2012)

2.1.2 Valjala Seakasvatus OÜ

The Liquid manure is collected in canals through slatted floors. When it is 90% full, then the liquid manure is washed out with a vacuum technique and is transported to the liquid manure storage. From there the slurry is pumped into a slurry storage. To storage the liquid manure there are 2 underground concrete water tanks, with the size of 200 m3 and 570 m3. Every three days the slurry is pumped to the biogas station next door. (Environmental Complex Permit, 2014)

Every day 120 m3 of slurry is pumped to the biogas station. The digestate is sent to a centrifuge, where the dry and liquid fractions of digestate are separated.

The liquid digestate from the biogas station is deposited on the territory of biogas plant. The repositories are from concrete and the clearing out is done with a hose. The repositories are checked (and maintained) once a year. Heat is produced from the biogas in the boilerhouse. Energy is used for producing the heat in the central heating system and warm water. (Environmental Complex Permit, 2014)

Approximately 36 000 m3 of solid and liquid digestate emerges. Basic nutrients in the digestate are: N- 5,1 kg/m3, P- 0,9kg/m3, K- 2 kg/m3. The liquid digestate goes back to the fields. It is transported with tractors or trucks max 7km away. The digestate is then spread to fields by farmers. The hectares are coordinated with the environmental agency, they do not usually even use all the hectares. The nutrients in the digestate are measured and the needed hectares are calculated. (Jasmin, 2017)

2.1.3 Aravete Biogaas OÜ

The raw materials are 33 600 tons of the liquid manure and 3 360 tons of solid manure, which comes for milking farm every year. Liquid manure is storaged in storages with total capacity of 16 000 m3. The solid manure is removed from the barns with a tractor, when needed. (Environmental Complex Permit, 2015)

The storages of the raw material and liquid digestate locate far away from waters causes on a compact area. The liquid substrate container is closed. Special collection bases are provided for storaging the solid substrate. A collecting container is provided for the municipal sewage water. Technological water is directed liquid manure receiving tank. Rain is directed from Southern area to landscaped parts and from the raining waters in Northern area are collected and pumped liquid raw material tank. Reject water is collected in a collection well and sent to waste water purification plant. Solid and liquid digestate are used as a organic fertilizers. (Environmental Complex Permit, 2015)

The digestate is used in their own fields in the same way as liquified manure. The amount spread is regulated by law (the norms of distribution is described in the legal framework chapter). The digestate is transported to the fields approximately in a 20km radius. Digestate spreading from storage to fields is organised and paid by the farm.In Aravete municipal wastewater is not treated.

2.1.4 Vinni Biogaas OÜ

In 2016 Vinni plant produced over 4 mio m3 biogas (58,8% methane) from what 8,3 GWh electricity and 3,3 GWh heat in total was produced (2015 7,9 GWh and 2,3 GWh, respectively). The main source of raw material was 88 000 tons of manure and leftovers from food production. Additionally, silage, waste from ethanol production, potato leftovers, wheat drying leftovers, milk whey and molasses was used to increase the biogas production. Total carbon reduction almost 40 th CO2eq (2015 over 36 th CO2eq). (4E Environmental and…, 2016)

The liquid raw material (slurry) is collected in a container with the capacity of 380 m3. The solid raw material is collected in a container with the capacity of 160 m3 in a building with a concrete floor. Reject water of the biogas plant is collected in a collection well. The transfer of the waste water is documented and the leakage resistance of the collection well is checked. (Environmental Complex Permit, 2014)

To protect the surface and groundwaters the liquid raw material is loaded on a area covered with asphalt and the hoses used are controlled. The solid raw material is loaded on a concrete floor inside a building. The raw material is never stored in the open space. (Environmental Complex Permit, 2014)

Solid and liquid digestate are distributed/spread to the same fields in the same way with the same amount as liquefied manure before the biogas production.

2.1.5 Tartu Biogaas OÜ

The raw material for biogas production is milking cow slurry, manure and biowaste, annually used amount is 80 000 tons in total.

The liquid digestate is held in a lagoon- an artificial building to store the liquid digestate, which locates 7,3 kilometers North from the Ilmatsalu biogas plant. The maximum amount of liquid digestate which can be stored in the lagoon is 14 000 m3. The digestate is used as an organic fertilizer for the nearby fields with the same equipment and regime as slurry. (Ilmatsalu kompleksloa..,2013)

The liquid substrate is stored in a closed container. For the solid substrate there are special storage places. To avoid surface contamination, all the containers are leakproof. In the case of any leaks occur, drainage systems are built around the digesters. A special container is provided for municipal sewage water of the biogas plant. For the protection of the groundwater and surface water, waste water is directed to collection wells and transported to the regional WWTP.. (Environmental Complex Permit, 2012)

The lagoon locates 500- 800 meters from the river Emajõgi to the North , which according to Peipsi sub-basin water management plan is evaluated to be in a good condition. The Kossarti creek locates 1 kilometer to North from the lagoon, which according to East Estonia’s river basin management plan is evaluated to be in a good condition. (Ilmatsalu kompleksloa..,2013)

The digestate from biogas plant is not sepratated. Biogas plant operator measures twice a year the content of nutrients in the digestate and transports the digestate to the lagoons (storage places). Farmer includes the digestate to the Fertilizers’ Spreading Plan (FSP) according to the nutrient content and spreads the digestate to the fields according to the FSP. The overfertilization risk is almost non-existent, if the farmer makes proper FSP and follows it properly.

2.2 Waste Water Sludge

2.2.1 Tallinna Vesi AS (Tallinn WWTP)

AS Tallinna Vesi was established in 1997 and it is the biggest water company in Estonia that provides water and waste water service to one third of Estonian residents. (Lühiülevaade.., 2013). The raw material used for biogas production is waste water sludge and in 2016 50,2 million m^3 of waste water was purified.

In 2016 approximately 2 mln Nm^3 of biogas was produced (containing 64% of methane), from which 71% was used to produce heat and the other part was burned in flare.

On an average 1000m3 (with 3,5% dry matter content) of sludge is pumped in the methane tanks.

The general nitrogen - 2,5-3,5 %, hydrogen - 0,2-0,4 %, sulfuric acid - 0,1 %, water steam CO2 - 36±2% and methane 64±2%.

Approximately 21-32 thousand tons of digestate (before composting) emerges every year. The solid and liquid fractions are separated. To seperate the liquid fraction centrifugal presses are used and special polymers are added. Digested and dryed solid digestate has 28% of fry matter content on avarage. The liquid fraction is directed to the beginning of the cleaning process. Analyses on the solid digestate are done 3 times a week (before separating). The digestate after composting is analysed 4 at least times a year.

The purified reject water is in correspondence with The Governments regulation 99 „Requirements for wastewater treatment and discharge into the drainage and run-off water runoff limits, emission limit values for sewage pollution and measures to control compliance with these requirements" (*Reovee puhastamise ning heit- ja sademevee suublasse juhtimise kohta esitatavad nõuded, heit- ja sademevee reostusnäitajate piirmäärad ning nende nõuete täitmise kontrollimise meetmed*"). The solid digestate is given to clients or anyone who wants it for landscaping. Control over the amount of solid digestate used is done by the user of the digestate.[25]

2.2.2 Kuressaare Veevärk AS

The raw material can be different, which is used in the biogas production. The main part of the raw material is waste water sludge, which is going to the digester. Additionally the waste from the fishing industry, left over whey water from cheese factory, surplus of small water treatment plants etc, are used as inputs for example. This causes the variability in the produced biogas structure. (Addinol homepage, AS Kuressaare..,2015) The annual amount of the raw materials are: cheese whey 411 tons, biodegradable kitchen and cafe waste 15,26 tons, residual sludge from the cleaning equipments 24 917 tons where the dry matter content is 2%. (Mälk, 2017)

[25] https://www.tallinnavesi.ee/et/lisateenused/haljastusmuld/

The company produced 1 528 tons of digestate from biogas production per year, where the dry solid matter content was 25%. This content of solid matter in the digestate was achieved with centrifugation, where the waste water was removed. The digestate is used mainly on the greening the areas and as a filling of lower parts at the waste water treatment plant territory. The digestate is stored in a warehouse, with a roof, with the dimensions of 60x60 meters. There is also a open warehouse, without a roof, where the digestate is held when the weather conditions are good. It is with the dimensions of 60x120 meters. Both of the warehouses are supplied with a drainage system and the flooring is made from asphalt-concrete. Drainage water collected from the warehouses are directed back to the wastewater treatment plant. The solid and liquid digestate fractions are separated in the process of centrifugation. Solid fractions dry solid matter is 25% and the same for liquid fraction's is1%, which is directed back to the wastewater treatment plant. (Mälk, 2017)

At Kuressaare Veevärk's Biogas station measures the content of phosphorus and nitrogen from the digestate, the amount of potassium isn't analyzed. The general phosphorus is P= 21 000 mg/kg/DM and general nitrogen is N= 69 000 mg/kg/DM. Kuressaares Veevärk evaluates the risk of the nutrients almost irrelevant coming from the digestate going in the surface water and/ or to the groundwater and through that into the the Baltic Sea. (Mälk, 2017)

Reject water from biogas plant is treated in the same way and with the same technology as the wastewater treatment process. Reject water after biogas production is directed back to the aerobic purification process. They do not affect treatment process, the biogas production process does not add anything to the digest (reject water and solid digest).

The nutrients are measured before the digestate is trasported to the fields. The amount of compost that is layed down is determined with the law and is controlled.

2.2.3 Narva Vesi AS

Purifying the wastewater consists of two lines, one of which is provided for municipal sewage water the other for technological waste waters. A part of the isolated sludge is returned to the initial stage of the bioprocessing, excess mud is directed into a mud compactor. Compressed sediment and mud is fermented in a methane tank. The methane gas that forms is burned. (Säästva Eesti Instituut, 2014)

From anaerobic fermentation biogas is formed, which consists of methane and carbon dioxide. It goes through a chemical treatment and is flared in a torch. The is plan to use the biogas in heat production in the boilerhouse together with natural gas in the future. At this moment the biogas is just flared into the air. (Narva Linnavolikogu, 2010)

The raw material for biogas production is sludge from the wastewater treatment plant. About 40 000 m3 of sludge is received with the concentration of 5% DM and about 45 000 – 48 000 m3 of solid and liquid digestate with the concentration of 4-4,5% DM is generated after AD. The digestate is dryed with a decanter centrifuge and the final dry solid matter of the solid digestate is 20-25%. (Kurling, 2017)

An analysis is done on the final dry solid digestate quarterly. Heavy metals are checked, as well as the dry matter, organic matter and total nitrogen and total phosphorus. Residual potential and the content of volatile fatty acids are also measured in sollid digestate. Solid digestate ed is stored in a special sediment place and if possible, used for recultivating. (Kurling, 2017)

The content of pollutants in solid digestate of the Narva wastewater treatment plant allows it to be used to recultivate the soil. Thus there is no risk that the usage of solid digestate can somehow affect the Baltic Sea. (Kurling, 2017)

2.2.4 Tartu Vesi AS

The raw material for biogas production is waste water with total amount of 100 000 m3 per year. The waste water sludge is hygienized at 70 C during 1 hour. The solid digestate produced approximately 8 000 m3 in year, which is mixed saw dust or peat for better composting and with those materials the amount of the solid digestate increases up to 12 000 m3 in a year. The liquid digestate is pumped back to the waste water treatment plant. The purified reject water quality is measured before releasing it to the river Emajõgi. Regular ground water monitoring takes place once a year, ground water samples are taken from specified wells to detect any potential chemical, microbiological and other indicators. (Environmental Complex License, 2015)

Before spreading the digestate on the fields, the nutrient content is measured. It is done twice a week, online measuring is done all the time. The solid digestate is given to farmers together with the results of the analysis and they are responsible for the spreading.

2.3 Industrial process Waste Water Sludge

2.3.1 Eastman Specialities OÜ

Eastman Specialities OÜ is located near Kohtla-Järve. The companies territory is 25,8 ha, where benzoic acid is produced. The raw material used are toluene and compressed air. Benzoic acid is produced first as a alloy and the designed capacity of the plant is 60 000 tons a year, out of which 28 500 tons of pure benzoic acid is produced in a year. The rest benzoic acid alloy is used to produce benzoic based product (benzoflexes and benosoatez).

Biogas is burned in boilers and received heat is used to warm reject waters. After the pre-cleaner the liquid digestate is directed to the Kohtla Järve regional waste water purification plant.

For protecting the surface and groundwaters the all reject water, solid and liquid digestate sewerage buildings are leakproof and constantly checked. (Environmental Complex Permit, 2015)

2.3.2 Estonian Cell

The main objective of the factory is producing paper pulp from aspen wound dressing. The company's sole holder is Austria's leading paper industry company Heinzel Holding GmbH. (Estonian Celli Biogaasi toodang..., 2017)

According to the currently valid complex permit the avoidance of the soil pollution is guaranteed.

The waste water is processed in an aerobical way, which is why no solid digestate will occur. Estonian Cell uses an aerobic reactor HydroThane STP ECSB. The biogranule stays in the reactor and when the process is stable, the amount of biogranule will grow, which afterwards is sold. (e-mail K Luzhkov, 2017). Liquid digestate is treated additionally in aerobic digestion tanks, and reject water, which fulfills all water protection requirements, is released to the Gulf of Finland. (Lužkov, 2017)

2.3.3 Salutaguse Pärmitehas AS

The raw material is waste and waste water from yeast production. Annually half million Nm3 of biogas is produced out of this, which is used to produce heat and steam for production of yeast. Approximately 1000-1500 m3 of biogas is produced in a day.

There are 3 fermentors, 4 aerobic purification tanks, 4 dryers and 4 boilers. The liquid digestate is purified in aerobic purification tanks and reject water is released to local river. Solid digestate will stay in the reactor as biogranul and will be sold to other biogas plants to start the similar process.

Annex 3. Sample analysis of nutrients in solid digestate from selected Estonian WWTP.

Attached separate zip file.

Annex 4. Fertilizing plan form[26].

Attached separate pdf file

[26] www.pria.ee/images/tinybrowser/useruploads/files/vaetusplaani_vorm.rtf