Risk assessment of nutrient discharges from biogas production

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2017

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1. List of all biogas installations in the country in question, divided by feedstock and size + year of deployment (Landfills and gasification not in focus)

Biogas production in Latvia is relatively recent. The first biogas production station in Latvia was installed and started to work in 1983 in the village of Jumprava, Lielvarde region. It was built in the territory of a large pig farm and the liquid manure obtained on this farm was processed. But this biogas production station was of experimental type and soon it was shut down (J. Priekulis, E. Aplocina, A. Laurs, 2016).

In 2007 there were only 3 biogas plants in Latvia. Since support system based on a feed-in tariff was released in 2007, many agricultural enterprises started to receive necessary permissions to build biogas plants and now, there are already 60 biogas plants with total installed capacity of 61.156 MW. The location of biogas plants is shown in figure 1. In 2015, biogas plants in Latvia produced 374,87 GWh of electrical energy and worked with approximately 80% load (Kārkliņš, 2016). However, during the last couple of years (2014-2016) the number of biogas plants has stayed the same (see table 1). This phenomenon can be explained by the fact that existing feed-tariff is on hold until 1.1.2020, due to arising corruption concerns and a lack of transparency. All biogas plants in Latvia cogenerate biogas, electricity and heat (table 2). There are six biogas plants are 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).

Table 1: Number of biogas plants in Latvia

Data obtained from Ministry of Economics of the Republic of Latvia

	number of biogas plants									
Year / Feedstock	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Waste water sludge	0	0	0	2	2	2	3	3	3	3
Municipal waste (landfill)	2	3	4	4	4	4	6	6	6	6
Manure and agricultural sludge	1	1	12	18	21	32	44	48	51	51
Total	**3**	**4**	**18**	**24**	**27**	***38***	**53**	**57**	**60**	**60**

Table 2: Electricity produced by biogas plants in Latvia

Data obtained from Ministry of Economics of the Republic of Latvia

	electricity produced, MWh					
Year / Feedstock	2011	2012	2013	2014	2015	2016
Waste water sludge	6 787	25 336	26 883	31 884	32 508	30 141
Municipal waste (landfill)	32 348	32 684	35 881	39 860	39 291	36 866
Manure and agricultural sludge	61 841	156 316	219 091	263 794	303 077	310 984
total	**100 976**	***214 336***	**281 855**	**335 538**	**374 876**	**377 991**

Since 2011 electricity produced by biogas plants has raised nearly quadrupled (table 2).

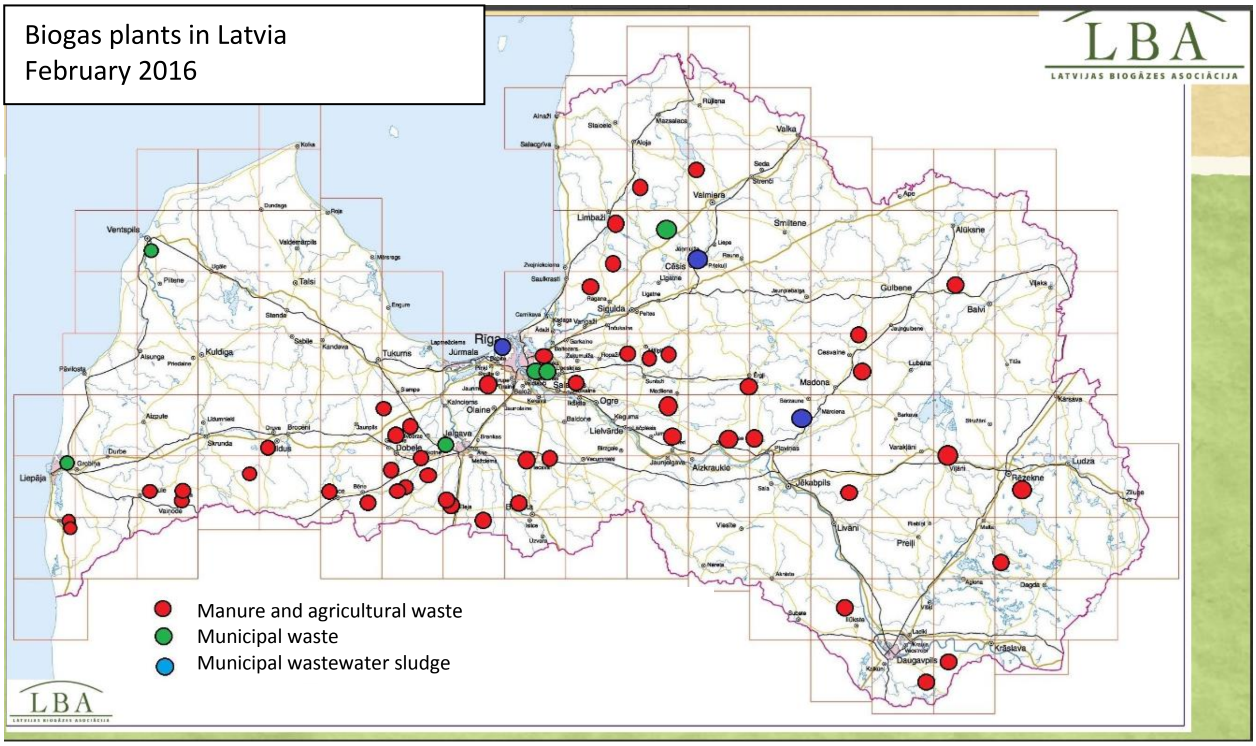

Figure 1: Biogas plants in Latvia

Adapted from "Latvian biogas association" http://latvijasbiogaze.lv/

Most of the biogas plants are located in the middle part of Latvia (see fig.1). The middle part of Latvia has nutrient rich soil, so it is intensively used for agricultural purposes. However, the area also has plenty of rivers, so most of the biogas plants are located close to the rivers that flow into the river Lielupe. Via Lielupe nutrients easily reach the Baltic Sea. It should be mentioned that central part of Latvia is considered as nitrate sensitive area (see fig.3).

2. Review of treatment methods used for solid and liquid digestate from biogas processes and prevalence of different methods in the country in question

2.1 Agricultural feedstock

47 agricultural biogas plants in Latvia do not separate solid digestate from liquid. Digestate ''as it is'' is used as a fertiliser (same as manure) or as an additional fertilizer (fig.2), combined with manure or mineral fertilizer. Maximal nitrogen applied with organic fertilizer in one hectare of agricultural land shall not exceed 170 kilograms per year. Farm based digestate is not required to be tested before use, but there are some biogas plants that test digestate voluntarily. The total maximum of nitrogen applied of the field is shown in tables 3 and 4. While 170 kg is the total amount of nitrogen that can be applied with organic fertilizers, within the limits of law double fertilization is not possible. Unfortunately, it is not checked strictly. There is no actual inspection on nitrogen amounts applied on the field. Over fertilization is possible both with only digestate, and by combination – manure and digestate. Amount of fertilizer is checked usually by sampling land for the nitrogen amount but, there is no data comparing applied amount of nitrogen on fields, used nitrogen by plants and excess nitrogen.

Some biogas plants separate solid digestate from liquid. For example, SIA "Sprūževa M" (0.499 MW) and ZS “Vecsiljāņi” (0.98 MW) use solid digestate as bedding for cattle, but liquid digestate as a fertiliser. SIA “Egg Energy” (1.996 MW) and ZS “Jaundzelves” (0.52 MW) have permissions to sell granulated digestate, which is produced by drying digestate with the heat obtained from cogeneration process.

Figure 2: Most common method for digestate spreading.

2.2 Wastewater sludge feedstock

Latvia has 3 biogas plants that use wastewater sludge as feedstock, but regulation regarding these plants differ from agricultural plants. Rules relating to wastewater sludge treatment plants are found in the Republic of Latvia Cabinet Regulation No. 362 “Regulations Regarding Utilization, Monitoring and Control of Sewage Sludge and the Compost thereof (more details in paragraph 3.4). It states that analysis must be made for digestate from wastewater treatment plants, and only if digestate has no heavy metals, it can be used as a fertilizer, but only 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 stations must find another way to utilize it. Wastewater sludge treatment biogas plants separate liquid fraction from solid fraction. Only one station in Latvia, which belongs to SIA "Rigas Udens", is using only WWTP sludge as a biomass for their biogas station. Liquid fraction is directed back to biogas plant and gets biologically and mechanically purified in additional step (reverse osmosis) and then discharged to river Daugava, but solid fraction is used to make compost that later can be used as fertilizer or utilized as hazardous waste. Where and when the solid fraction that does not exceed limits can be used is explained in chapter 3.4. Hazardous wastes are burned or disposed in specially built landfills or treated differently based by their content. For example, SIA "Rigens" (1.998 MV) dry their digestate and utilize solid fraction as hazardous waste (burned or disposed in specially built landfills or treated differently based by their content), but the liquid part is purified until it can be discharged in the river Daugava.

In Latvia, biogas plants that use wastewater sludge are not very common because use of digestate is problematic.

2.3 Waste feedstock

Digestate from biogas plants that use organic municipal waste as feedstock, can be composted and used as a fertilizer, but same testing procedures apply as 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. As all biogas plants in Latvia that use waste as feedstock are located in landfills, the risks related to these biogas plants are not in focus of this report. Gas is collected from the landfill and no additional station is built in Latvia.

3. Legislative framework and permitting procedures for biogas installations (all relevant laws and permitting practices used both for biogas installations and treatment /disposal of their digestates/reject waters)

In Republic of Latvia there is 1 relevant law and 5 regulations that must be followed for biogas installations and treatment of produced digestate:

The Saeima has adopted and the President has proclaimed the Law on Pollution.

- Republic of Latvia Cabinet Regulation No. 829 "Special Requirements for the Performance of Polluting Activities in Animal Housing" includes requirements for storing manure and silage.
- Republic of Latvia Cabinet Regulation No. 834 "Regulation Regarding Protection of Water and Soil from Pollution with Nitrates Caused by Agricultural Activity" prescribes how fertilizers shall be used.
- Republic of Latvia Cabinet Regulation No. 362 "Regulations Regarding Utilization, Monitoring and Control of Sewage Sludge and the Compost thereof" prescribes how untreated and treated sewage sludge shall be used. (There is draft law for changes in this regulation that would include paragraph that specifies use of sewage sludge for biogas production; requirements for sewage sludge digestate use as fertilizer and requirements for sewage sludge storing, monitoring and controlling, however, the time and probability if it will be accepted is unknown).
- Republic of Latvia Cabinet Regulation No. 506 "Regulations Regarding the Identification, Quality Conformity Assessment and Sale of Fertilisers and Substrates" regulates how fertilizers must be identified and sold.
- Republic of Latvia Cabinet Regulation No. 1082 "Procedure by Which Polluting Activities of Category A, B and C Shall Be Declared and Permits for the Performance of Category A and B Polluting Activities Shall Be Issued"

Although, there is no strict requirement for farmers in Latvia to calculate plant nutrient balances annually and report these data, many elements of balance approach are included in legislative acts, recommendation systems, as well as used for fertilisation planning. However, not all biogas plants follow legislative acts and recommendations systems, because they are not strictly controlled by responsible institutions.

3.1 Law on Pollution

The purpose of this Law is to prevent or reduce harm caused to human health, property or the environment due to pollution, and to eliminate the consequences of harm caused. This Law determines requirements which shall be taken into account by operators in the area of pollution prevention and control, and procedures for prevention and control of pollution. According to this Law, polluting activities are classified into Categories A, B, and C, considering the quantity and effect, or the risk of pollution caused to human health and the environment.

To start producing biogas, an enterprise must obtain a Category B pollution permission. This permit specifies the equipment and substances used and stored by the company, waste waters discharge location and amount, and there shall be justified geographical location and environmental conditions of the relevant polluting activity. Permission is issued after manufacturer hands in filled submission form, which can be found in Regulation No. 1082 "Procedure by Which Polluting Activities of Category A, B and C Shall Be Declared and Permits for the Performance of Category A and B Polluting Activities Shall Be Issued". Category B pollution permission requires to include information about contracts about transfer of digestate, but this permission does not require spreading plan. The permission is issued and supervised by Environment State Bureau. According to Law, it is the duty of the operator to control the quantity of emissions on a regular basis, perform monitoring and provide information in accordance with the procedures prescribed by the Cabinet. An operator shall carry out monitoring in accordance with the permit, which specifies the parameters to be determined, the sites of taking samples, the frequency and methods of measurements, the type of compilation and keeping of data. Performers of Category B activities shall draw up an annual report regarding monitoring results and send it to the issuer of the permit and the relevant local government. The annual report shall be available to control institutions and **the public.**

Although every biogas plant must have this permission, information given by biogas plant (for example amount of feedstock used and maximal produced digestate) is not strictly controlled, so biogas plants sometimes make up results not to exceed amounts stated in permission.

3.2 Republic of Latvia Cabinet Regulation No. 829 "Special Requirements for the Performance of Polluting Activities in Animal Housing"

Regulation No. 829 prescribes requirements for storing manure and silage. The main idea is that the base of a silage trench or a pile shall be made of a waterproof material, resistant to the effects of silage and potential mechanical damage. Storage facilities of liquid manure, semi-liquid manure and urine shall be of closed type or shall have a permanent natural or artificial floating covering layer, which reduces evaporation. It also prescribes that storing place cannot be closer than 30 m from a river, brook, ditch, wells of amelioration systems or a well, from which water for the household is being taken. State environmental inspectors shall control the compliance with the requirements of this Regulation. An operator shall indicate data in an inventory journal (on paper or in electronic form). The inventory journal shall be presented for examination upon the request of the State environmental inspector. The operator shall keep the relevant information for at least three years. Groundwater quality observation (monitoring) system shall be arranged by a merchant to whom a licence of the State Environmental Service for the use of subsoil is issued.

3.3 Republic of Latvia Cabinet Regulation No. 834 "Regulation Regarding Protection of Water and Soil from Pollution with Nitrates Caused by Agricultural Activity"

Regulation No.834 prescribes how fertilizers shall be used based on content of nitrates. This regulation contains information about maximal permitted amount of nitrogen that may be used for crops (Table 3) and other cultivated plants (Table 4) based on cultivated plants and harvest level of field. If there is not another regulation containing additional limitations or specifying the use of fertilizer, this regulation applies for everyone who uses fertilizers and all biogas plants and farms who use fermentation residues as fertilizer must follow this regulation, regardless of the feedstock used. Yet based on used feedstock there are other restrictions, which are described in the following chapters.

It requires that amount of nitrogen applied with livestock manure in one hectare of agricultural land shall not exceed 170 kilograms per year, which conforms to 1.7 animal units. However, maximum permissible amount of nitrogen for some plants are higher (see table 3 and table 4) so additional fertilizer can be used. If nitrogen produced on the farm with livestock manure and fermentation residues exceed 170 kilograms per hectare of agricultural land annually, the operator shall prove with documents the transfer of the residue of livestock manure and fermentation residues to other farms or the use thereof in a different manner.

Table 3: Maximum permissible amount of nitrogen for cereals, kg ha^{-1} N

Cultivated plant	Harvest level, t ha^{-1}			
	< 3.0	3-5	5-7	> 7.0
Winter wheat (180)	80	120	150	220
Rye (130)	65	95	130	160
Winter barley(150)	75	105	140	185
Winter triticale (140)	75	105	140	200
Spring wheat (180)	80	125	160	200
Spring barley (150)	65	100	135	170
Oats (110)	60	90	120	-

Table 4: Maximum permissible amount of nitrogen for other cultivated plants, kg ha^{-1} N

Cultivated plant	Harvest level, t ha^{-1}	Maximum permissible amount of nitrogen, kg ha^{-1}
Winter rapeseed	< 2.0	90
	2.0-4.0	150
	4.0-5.0	190
	> 5.0	230
Summer rapeseed	< 2.0	90
	2.0-3.0	120
	3.0-4.0	160
	> 4.0	200
Maize, green fodder	< 40	110
	40-60	160
	> 60	200
Potatoes	< 30	90
	30-40	140
	> 40	180
Fodder beets, sugar beets	< 40	90
	40-60	150
	> 60	190

Fertilizer shall not be spread:

- upon frozen, water saturated or snow-covered soil;
- in locations where it is prohibited in accordance with the laws and regulations regarding the protection zones (surface water body protection zones; in the 10-metre zone (10 metres from cost line) and in the bacteriological protection zone) or specially protected territories;
- on flood-lands and areas under the threat of flood.

It also requires that when building a new reservoir or re-building one for the storage of fermentation residues, it shall be intended that the capacity thereof provides for accumulation of the fermentation residues for at least eight months.

Regulation No.834 states that inspector of the State Plant Protection Service and an inspector of the State Environment Service has the right to be on the area of land of the land owner or user, informing the land owner or user accordingly, in order to control the observance of the requirements referred to in this Regulation according to the competence thereof. However, some biogas plant owners admit that requirements of Regulation No.834 are not strictly controlled.

Highly vulnerable zones in Latvia are also shown in Regulation No. 834.

Figure 3: Highly vulnerable zones

The zones shall be recognised as highly vulnerable, if the nitrate concentration in surface freshwater or groundwater is more than 50 mg/l or inland waters of natural origin and coastal waters have become eutrophic.

This area includes approximately 15% of Latvia's agricultural land and has additional rules for fertilization:

- during the period from 20th of October till 15th of March no livestock manure or fermentation residues shall be spread, but in respect of grass - from 5th of November until 15th of March;

on a slope:

- if the slope gradient is from 5 to 7 degrees and the length of the slope exceeds 100 metres in the direction of a watercourse or water reservoir, fertilisers shall be incorporated directly into the soil after spreading;
- if the slope gradient is from 7 to 10 degrees and the length of the slope exceeds 100 metres in the direction of a watercourse or water reservoir, the soil shall be handled across the slope direction and fertilisers shall be spread only if a field is covered with plants or if fertiliser is immediately incorporated directly into the soil;
- where there is a bare fallow and where the gradient of the slope is more than 7 degrees, it is forbidden to spread and incorporate fertilisers;
- where the slope gradient is more than 10 degrees and the length of the slope exceeds 100 metres towards the direction of a watercourse or water reservoir, it is forbidden to spread and incorporate fertilisers.

In highly vulnerable zones, land owners must submit a fertilizer plan that includes area of the field, cultivated plants and planned fertilizers, calculated or specified in accordance with laws and regulations of allowable amounts of nitrogen (N), phosphorus (P_2O_2) and potassium (K_2O) (kg/ha). Soil monitoring is made annually, and content of soil is controlled more strictly than in other parts of Latvia.

Regulation No.834 prescribes how fertilizers shall be used based on content of nitrates, however, there is no regulation prescribing how fertilizers shall be used based on content of phosphorus or other nutrients. There are no requirements for annual fertilizer plan for every land owner that would help monitor that the amount of nitrogen applied does not exceed permitted amount.

3.4 Republic of Latvia Cabinet Regulation No. 362 “Regulations Regarding Utilization, Monitoring and Control of Sewage Sludge and the Compost thereof”

Biogas plants that use wastewater sludge as feedstock have different regulation prescribing usage of digestate. Implementation of regulations for digestate has been in force only a very short period of time. Still involved ministries and NGOs, which are responsible for the laws, do not have a lot of information about possible digestate properties, impacts and treatment processes in soil, compared to the sewage sludge regulations, which have already been valid for some decades. In chapter 8 it says that these limits are for raw sewage sludge and compost for now. There are no specific laws for digestate from sewage sludge. Regarding limits for N and P it is treated same as compost from sewage sludge. These limits allow less N and P probably because sewage sludge has not been used for agricultural lands. Unfortunately, the reasons for changes in limitation are not stated. Regulation No.362 prescribes that following data shall be determined for the average sample of sewage sludge or a compost batch:

- mass concentration of heavy metals in dry matter– cadmium (Cd), chrome (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb) and zinc (Zn);
- the content of dry matter and agrochemical indicators – mass concentration of organic substances, nitrogen (N) and phosphorus (P) in the dry matter; and
- mass concentration of ammoniacal nitrogen (N-NH4) in dry matter shall be determined before the use of sewage sludge or compost in agriculture for soil fertilization.

If after the production of the batch of sewage sludge or compost more than 12 months have passed, then prior to the use of this batch, dry matter and ammoniacal nitrogen shall be determined repeatedly.

However, if the load of sewage treatment plant is less than 5 000 population equivalent (PE) and only municipal sewage is treated, it is not necessary to determine the mass concentration of heavy metals in sewage sludge or the compost produced from this sludge.

The producer of sewage sludge and the producer of compost must have a relevant certificate showing the quality indicators of sewage sludge and compost for each batch of sewage sludge or batch of compost.

Only treated sewage sludge and compost may be utilized for the conditioning and fertilization of soil in forestry.

Sewage sludge shall not be dispersed in the period from 15th of December until 1st of March.

Sewage sludge and compost may not be dispersed and cultivated:

- on slopes the sloping angle of which is more than 7°;
- on frozen or snow-covered soil;
- in flood and flood endangered territories;
- closer than 100 m from individual water intakes;
- closer than 100 m from residential houses, food processing facilities and food stocks; or
- closer than 50 m from the shoreline of a waterbody or watercourse; and in locations where it is prohibited in accordance with the regulatory enactments regarding protective territories.

Sewage sludge and compost may not be utilized:

- for growing vegetables and berries in covered areas;
- for growing potatoes, vegetables and berries in open field with area less than 0.10 ha;
- as surface fertilizer and row fertilizer during the vegetation period of food and animal feed crops; and
- as surface fertilizer in grazing in the year of use thereof, except for cases when the sward is renewed by the re-ploughing of soil and sewage sludge and the compost thereof are cultivated into the soil.

Table 5: Classification of Sewage Sludge and the Compost thereof

No.	Class*	Mass concentration of heavy metals in dry matter (mg/kg)						
		Cd	Cr	Cu	Hg	Ni	Pb	Zn
1.	I	≤ 2.0	≤ 100	≤ 400	≤ 3.0	≤ 50	≤ 150	≤ 800
2.	II	2.1-5.0	101-250	401-500	3.1-5.0	51-100	151-250	801-1500
3.	III	5.1-7.0	251-400	501-600	5.1-7.0	101-150	251-350	1 501-2 200
4.	IV	7.1-10	401-600	601-800	7.1-10	151-200	351-500	2 201-2 500
5.	*V*	*> 10*	*> 600*	*> 800*	*> 10*	*> 200*	*> 500*	*> 2 500*

* If the mass concentration of only one heavy metal exceeds the relevant indicator of the highest class by no more than 30%, such sewage sludge and the compost thereof shall be included in the highest class.

Sewage sludge of Class 5 shall be considered as hazardous waste.

Regulation No.362 includes limit values of some nutrients and heavy metals that can be found in table 6.

The annual emission limit value of ammoniacal nitrogen ($N\text{-}NH_4$) - 30 kg/ha.

The annual emission limit value of total phosphorus (P) – 40 kg/ha.

Table 6 Limit Values of Annual Emission of Heavy Metals in Agricultural Land

No.	Heavy metals	On average for a period of seven years (g/ha per year)	
		sand, sandy loam	loamy soil, loam
1.	Cadmium (Cd)	30	35
2.	Chrome (Cr)	600	700
, 3.	Copper (Cu)	1000	1200
4.	Mercury (Hg)	8	10
5.	Nickel (Ni)	250	300
6.	Lead (Pb)	300	350
7.	Zinc (Zn)	5000	6000

The Latvian Environment, Geology and Meteorology Agency shall perform environmental monitoring of the utilisation of sewage sludge and compost in areas to be utilised for agriculture in conformity with the National Environment Monitoring Programme.

3.5 Republic of Latvia Cabinet Regulation No. 506 “Regulations Regarding the Identification, Quality Conformity Assessment and Sale of Fertilisers and Substrates”

Regulation No.506 contains the requirements for fertiliser and substrate identification and quality, as well as the quality information that shall be declared. It requires that only accredited laboratory shall test a fertiliser according to the methods specified in Regulation (EC) No 2003/2003 of the European Parliament and of the Council of 13 October 2003 relating to fertilisers (hereinafter – Regulation No 2003/2003). If the testing method has not been specified in Regulation No 2003/2003, the fertiliser may be tested according to the applicable standards recommended by the Ministry of Agriculture, which are published by the national standardisation authority on its website (www.lvs.lv).

Maximum permitted concentration of undesirable impurity classified by type of fertilizer or substrate can also be found in Regulation No.506.

To sell a notified fertilizer or substrate in Latvia, the importer or producer shall, not later than within 20 working days before the initial placement of the fertiliser and substrate on the Latvian market, submit the following to the State Plant Protection Service:

- a submission form;
- an attestation of the competent authority of the respective country regarding legal sale of the respective fertiliser or substrate in a European Union Member State, in a Member State of the European Economic Area or in Turkey, or an attestation of the producer, if an attestation issued by the competent authority of the respective country has been appended to the submission stating that the producer has been recognised in accordance with the laws and regulations of the respective country;
- the text of the label, marking or accompanying document with the information in Latvian, which conforms to the text in the language of the country which has recognised the fertiliser and substrate. If the application submitted in paper form, the submitter shall also submit the text of the label or marking electronically;
- information regarding raw materials of the organic fertiliser and substrate;
- information regarding the organic fertiliser or substrate, if it contains animal by-products, indicating the granted registration or the official number of recognition, as well as an indication to the website of the competent authority containing information that the producer of the fertiliser and substrate has been recognised or registered in accordance with the requirements of Regulation (EC) No 1069/2009.

This regulation is supervised by The State Plant Protection Service, but it also states that the holder of a registration certificate shall be responsible for the conformity of fertilisers and substrates to the requirements laid down in the laws and regulations, regarding the circulation of fertilisers and chemical substances and products, and the circulation of by-products of animal origin.

4. Risk assessment with case examples of installations with potential adverse environmental impacts (and possibly case examples of solved problems if any)

Latvian legislation restricts use of digestate only based on nitrogen concentration (3,1-14% of dry matter (DM) (Fouda 2011; Möller et al. 2008; Voćaet al. 2005)), but digestate also contains other nutrients, (for example- P 0.3-3.5% of DM (Teglia et al. 2011a, b; Pötsch 2004; Voćaet al. 2005), K 1.9-4.3% of DM (Möller et al. 2010; Pötsch, 2004; Voćaet al. 2005), Mg 0.03-0.07% of fresh matter (Kluge et al. 2008; Voćaet al. 2005)) (Nkoa, 2014). Overdose of these nutrients are unsuitable for plants, and nutrients remain in the soil or reach groundwater.

According to Latvia's environmental monitoring data, 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. If soil is fertilized taking into account nitrate concentration only, it is 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 (Helmonts & Heils, n.d.).

Table 7: Calculated data for nutrients used for fertilization

	Percent's in digestate (according to SIA "Importech group" data)	Amount of nutrients applied proportionally from maximal amount of nitrogen, kg	Amount of nutrients absorbed, kg	Amount of nutrients accumulating and/or reaching surface and groundwaters *, kg
Nitrogen (According to Republic of Latvia Cabinet Regulation No. 834 maximum permissible amount of nitrogen for wheat is approximately 32 kg for ton of wheat)	0,61%	32	18,2	13,8
Phosphorus	0,27%	14,17	3,6	10,57
Potassium	0,51%	26,75	4,1	22,65

*amount of nutrients that is not absorbed by plants (in this example wheat). This amount of nutrients remains in soil or reaches surface or groundwater for every ton of wheat obtained.

These amounts are calculated for obtaining 1 ton of wheat using maximum permissible amount of nitrogen and digestate composition data from SIA "Importech group". This data can differ depending on the feedstock and its quality. In this example to obtain 1 ton of wheat 5245,9 kg digestate is allowed to be used. In Latvia, every year all biogas stations together produce approximately 1 649 000 tons of digestate used in fertilization. Assuming that all digestate is used according to maximal permissible amount of nitrogen for wheat (maximum permissible amount of nitrogen per wheat can be found in previous paragraph), every year 4340 tons of nitrogen, 3320 tons of phosphorus and 7120 tons of potassium remain in soil and can reach surface or groundwater.

For utilizing 1 649 000 tons of digestate, approximately 62 900 ha is needed (calculated for amount of nitrogen allowed for wheat). According to Central Statistical Bureau data Latvia has 2 074 600 ha agricultural land from which 1 887 800 ha were used in 2016, so it is possible to use all digestate according to limits prescribed in regulation No.834., however real area where digestate is spread is unknown, because process of spreading digestate and other fertilizers are not strictly controlled.

In Latvia there is not strict requirement for farmers to calculate nutrients balances systematically, but examples of how to make fertilizer plans are accessible to all farmers, for example table 8 that includes summary of fertilizer plan.

Table 8: Summary of fertilizer plan

obtained from: http://www.helcom.fi/HELCOM-Workshop_Latvia.pdf

	Parameters	Unit	Total	Applied	
				fall	spring
1.	Agricultural land	ha	*102*	×	×
2.	Fertilised area	ha	*69*	*23*	*65*
3.	Manure	t	×	×	×
3.1.	*Horse manure*	t	*80*	–	*80*
3.2.	*Fattening pigs, solid manure*	t	*30*	*30*	–
3.3.	*Compost (poultry manure + peat)*	t	*75*	–	*75*
4.	Commercial fertilisers	t	×	×	×
4.1.	*Ammonium nitrate*	t	*7.5*	–	*7.5*
4.2.	*Ammonium sulphate*	t	*8.0*	–	*8.0*
4.3.	*Single superphosphate*	t	*12.5*	–	*12.5*
4.4.	*Compound 16–16–16*	t	*12.0*	*4.6*	*7.4*
4.5.	*Potassium chloride*	t	*10.0*	–	*10.0*
5.	Farm animals	gab.	×	×	×
5.1.	*Hoerses*	gab.	*8*	×	×
5.2.	*Fattening pigs (30 – 100 kg)*	gab.	*20*	×	×
6.	Animal units	AU	*5.44*	×	×
7.	Animal units per ha of agricultural land	AU/ha	*0.05*	×	×
8.	Area required for application of manure	ha	*3.2*	×	× [8]

In 2008 there have been made NPK balance calculation for Zemgale and Latgale regions and results can be found in table 9.

Table 9: NPK balance, kg ha^{-1}, 2008

Obtained from: http://www.helcom.fi/HELCOM-Workshop_Latvia.pdf

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 fertilizers	5.50	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	×	×
Seeds 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**	**7.15**	**8.91**
Output	**71.51**	**28.72**	**69.27**	**33.33**	**12.09**	**36.52**
Balance	**-0.79**	**-7.22**	**-40.60**	**-2.68**	**-4.94**	**-27.61**
Balance intensity, %	**99**	**75**	**41**	**92**	**59**	**24**

According to table 9, the balance is negative, so soil should not be overfertilized.

Some farms are making soil balances voluntarily. For example, plant nutrient balance of farm "Ogre" for period from 1999 till 2003 (I. Līpenīte, A. Kārkliņš, 2006) is shown in table 10.

Table 10: NPK Soil surface balance in the farm, kg

Rādītājs / Variable	1999	2000	2001	2002	2003
SLĀPEKLIS / NITROGEN					
Ienesa augsnē / Input	57651	27109	33187	42484	61280
Iznesa ar ražu / Removal by crops' yield	22584	24874	34885	31239	52003
Pārpalikums vai deficīts / Excess or deficit	35067	2235	-1698	11245	9277
Bilance / Balance, kg ha^{-1}	91.4	5.2	-3.0	22.7	12.7
FOSFORS / PHOSPHOROUS, P_2O_5					
Ienesa augsnē / Input	30752	11450	5865	9749	8249
Iznesa ar ražu / Removal by crops' yield	7698	9441	12776	11150	18374
Pārpalikums vai deficīts / Excess or deficit	23054	2009	-6911	-1401	-10125
Bilance / Balance, kg ha^{-1}	60.1	4.7	-12.3	-2.8	-13.9
KĀLIJS / POTASSIUM, K_2O					
Ienesa augsnē / Input	33233	20532	12808	18714	17134
Iznesa ar ražu / Removal by crops' yield	26348	29270	40761	34188	61243
Pārpalikums vai deficīts / Excess or deficit	6885	-8738	-27953	-15474	-44109
Bilance / Balance, kg ha^{-1}	17.9	-20.5	-49.9	-31.3	-60.5

As it can be seen in table 10 for this farm, at least one of nutrients has positive balance annually, which means that it stays in soil or reaches groundwaters.

However, the main reason that the fertilizer dose is based on nitrate is due to their negative charges, nitrate is poorly adsorbed into soil, hence their high mobility through the soil and their high polluting potential. Reported results of studies that compared N leaching after applications of digested and undigested slurries vary widely, most likely because of the variability of soil types and factors that govern ammonia and nitrous oxide emissions (Nkoa, 2014).

Organic fertilizer input applied to meet crop N need may result in the buildup of P in soil. Because of low efficiency in uptake of the fertilizer (10%~25%), P accumulation in soil could be increasing with long-term continuous P input from chemical fertilizers and organic fertilizers. Many research showed that long-term continuous application of organic fertilizers in amounts exceeding the need of crops significantly increase the levels of all P forms in soil. While surface runoff is an important pathway of phosphorus losses from agricultural lands, significant losses can also occur via leaching through soils.

NH3 emissions from land application of cattle and pig slurries range from 15 to 60 % of the total ammoniacal nitrogen applied? The amount of nitrogen in slurry of dairy cows and other cattle was estimated to be 1,75-2,25 kg/m3. Ammonia emissions, in theory, are expected to be higher in lands spread with biogas digestates because of their higher pH and NH3 contents. In fact, several studies have found similar or higher emissions than raw manures (Nkoa, 2014).

N2O emissions from digested materials are generally lower than emissions from undigested feedstock. It has been hypothesized that this is the result of lower contents in easily degradable C in digested feedstock, hence less energy source for denitrifiers (Nkoa, 2014).

Table 11: Risk assessment of biogas manufacturing

	Risk	Used feedstock*			Assessment
		Waste water sludge	Municipal waste (landfill)	Manure and agricultural sludge	
1.	Digestate used for fertilization can burn leaves	X	X	X	M
2.	The digestate content may exceed the amount of nutrients required for plants (the plant does not absorb and the substance enters groundwater, the plant absorbs too much and reduces yield)	X	X	x	H
3.	Digestate used in fertilization can enter surface water or groundwater with rain	X	X	X	H
4.	Digestate can contain heavy metals, using this digestate as fertilizer can cause heavy metals entering groundwater	X	X		H
5.	Ammonia emission from anaerobic digestate	X	X	X	E
6.	N2O emissions from digestate	X	X	X	H
7.	Some digestates have high concentrations of some micronutrients such as Cu and Zn due to the use of pig and cattle slurry as feedstock			X	H
8.	The concentration of Mn in digestates can be as high as 50–55 ppm (concentrations as low as 1 ppm can be toxic to most field, horticultural, flower and forage crops)			X	H
9.	As a result of the operation of the cogeneration plant, carbon monoxide, nitrogen dioxide, sulphur dioxide, volatile organic compounds, solid particles, carbon dioxide are emitted into the atmosphere	X	X	X	M
10.	The water generated by the cooling process of biogas can dissolve CO_2 creating carbonic acid.	X	X	X	M
11.	Hydrogen sulfide can accumulate at biogas station	X	X	X	M

12.	Unpasteurized digestate may contain plant pests and pathogens (including nematodes, fungi and bacteria)	X	X	X	H
13.	Content of digestate is unknown, because regulations does not require testing			X	H

*Biogas plants feedstock type that risk applies on are marked with "x"

Table 12 assessment of risk based on likelihood and consequences

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Severe
Almost certain	M	H	H	E	E
Likely	M	M	H	H	E
Possible	L	M	M	H	E
Unlikely	L	M	M	M	H
Rare	L	L	M	M	H

L (low); M (medium); H (high); E (extreme)

There are several known cases in Latvia, when digestate leaching into water system and environment caused damage to ecosystems. For example, in 2014 SIA „Biodegviela" was punished for knowingly discharging the digestate into water that led to the death of the fish in the river Veseta. That was already second time SIA "Biodegviela" knowingly discharged digestate against the rules (http://www.lsm.lv/raksts/dzive--stils/veseliba/uznemuma-riciba-jau-otro-reizi-izraisa-zivju-bojaeju-vesetas-upe.a88129/). There are also some case examples where fault of biogas plant has not been proved, but locals think it is biogas plants fault, for example, in 2014 locals of Lestene claimed that nearby biogas plant is directly responsible for the extinction of fish in nearby ponds basing it on the assertion that before biogas station was built ponds were cleaner and there were more fish. However, violations in the operation of the biogas plant were not found. It was concluded that extinction of fish and overgrowth of pound might be due to the high level of nutrients in the soil that might be from overuse of digestate as fertilizer, but cannot be proved because usage of digestate is not strictly controlled (http://www.lsm.lv/raksts/dzive--stils/veseliba/digestata-lietosana-veicinajusi-zivju-pazusanu-lestenes-dikos.a90089/).

There are several known cases when inhabitants of rural areas of Latvia complain about possible harm to the environment (mass fish death) caused by nearby biogas plants leachate or usage of digestate (http://www.lsm.lv/raksts/dzive--stils/veseliba/digestata-lietosana-veicinajusi-zivju-pazusanu-lestenes-dikos.a90089/ ; http://www.lsm.lv/raksts/dzive--stils/veseliba/diki-blakus-kogeneracijas-stacijai-mirst-zivis.a110266/)

5. Subsidies and profitability (e.g. gate fees, electricity sold out) of production

In Latvia, electricity generation from renewable sources is stimulated through a complex support system based on a feed-in tariff, which also includes elements of a quota system and tenders. The existing feed-tariff is on hold until 01.01.2020 due to concerns about corruption and lack of transparency in the way it was carried out since 2007. The existing state support mechanisms for energy production from renewable energy resources are being assessed and revised. Stringent supervision of subsidized electricity producers, firm controls and a limited timeframe for the implementation of RES (renewable energy systems) projects has been introduced. At the same time, a new tax for subsidized electricity producers was introduced in January 2014. The tax should be paid by companies receiving financial support for power generation from renewable energy sources or, from combined heat and power plants. Since 1 January 2014, RES-E is promoted also through net-metering. According to Energy Development Guidelines 2016-2020, new national support mechanism for electricity production from RES should be developed until 2018. Heating and cooling from renewable energy sources is promoted through different tax benefits. Also, the only incentive currently available for renewable energy sources in the transport sector is a tax regulation mechanism.

Access of renewable energy plants to the grid is subject to the general legislation on energy. Electricity from renewable sources is not given priority. Also, devices for heat production from renewable energy sources are not given priority connection, and there is no special legislation promoting the connection of RES heating devices to the heat transmission network at the national level. There are regulations at the regional level that establish rules for and promote high energy performance and competition in the heat supply market (Upatniece, 2017).

5.1 Subsidised Electricity Tax Law

Section 3 of “Subsidised Electricity Tax Law”

Income obtained from the following shall be taxable:

1) electricity sold within the scope of mandatory procurement;

2) guaranteed payment received for the electric capacity installed in a cogeneration unit or power plant;

3) electricity sold to the public trader – licensed electricity transmission or distribution undertaking – in accordance with the conditions of Section 40 of the Energy Law that were in force in the time period from 6 October 1998 until 7 June 2005, and the relevant procedures stipulated by the Cabinet.

Tax rate 5 %; 10 % or 15 % depends on installed electric capacity; used products and use of produced thermal energy. (Section 5 of “Subsidised Electricity Tax Law”)

5.2 Mandatory procurement component

Mandatory procurement component (MPC) depends on the amount of electricity purchased in the previous year under the mandatory procurement and the purchase price. The MPC depends on the price of natural gas, the electricity price quotation and the consumption of electricity.

Since 2014 and up to 31 March 2019, MPC for electricity end-users is saved at 26.79 euros per megawatt hour (euro / MWh). The rest is subsidy from the state budget.

Mandatory procurement component calculation methodology

Total cost $I_{ko\dot{g}+}$ [EUR] of the amount of electricity produced in cogeneration that is purchased in the framework of mandatory procurement, which exceeds the cost of this electricity if it were purchased on the electricity market and the guaranteed cost for the installed electrical capacity of the cogeneration stations is calculated as follows:

$$I_{ko\dot{g}+} = \sum_{i=1}^{K} I^{i}_{ko\dot{g}+} + \sum_{j=1}^{12} N^{j}_{ko\dot{g}} \quad ,$$

Where

$\sum_{i=1}^{K} I^{i}_{ko\dot{g}+}$ – The cost of electricity produced from cogeneration to be purchased in the framework of mandatory procurement, which exceeds the cost of purchasing electricity on the electricity market [EUR];

$N^{j}_{ko\dot{g}}$ – Monthly costs for the guaranteed cost of electricity installed in cogeneration units [EUR];

j –index which indicates the month of the year for which the guaranteed fee is paid.

5.3. Digestate transportation costs

There are no gate fees for the digestate transportation in Latvia. All agricultural plants are working in close cooperation with neighbouring farmers or they own agricultural land near plant so that there is no need for long transportation and transportation costs are very low.

6. Case examples (if any) of commercial products from digestates (fertilizers, substrates for industrial processes)

In Latvia most biogas plants are working in close cooperation with neighbouring farmers or they own agricultural land near plant where they can use produced digestate. For that reason there is no need for long transportation and there are not many case examples of commercial products.

There is one case example of widely available commercial product in Latvia. A Latvian egg producing company Balticovo's subsidiary called Egg Energy implemented a project "Innovative fertilizer production from the digestate" in 2014-2015. The aim of the project was to create a production plant for organic fertilizer – ammonium sulphate from digestate. This is the only such digestate processing system in the Baltic countries (http://www.eggenergy.eu/en/2016/03/03/services-that-we-offers-14/). During the project, two production lines were set up – one for processing the fermented chicken manure and the other to recover the minerals from the digestate. The total amount of investments is 5,253,000 Euros. 2,135,000 Euros were funded by the European Regional Development Fund. More information about produced fertilizer called OrganiQ and the company can be found here: http://www.eggenergy.eu/en/about-us/. Mineral fertilizer produced by biogas plant SIA "Egg Energy" can be bought in Latvia. Chemical composition and appearance of the package is shown in figure 4.

pH level: 6,65
Moisture: 4,58 %

CHEMICAL COMPOSITION
Nitrogen, total (N)…...4,00%
Phosphorus as P2O5…8,00%
Potassium, as K2O….0,89%
Magnesium, as MgO…...2,62%
Sulphur, as SO3….2,72%
Calcium, as CaO….10.81%
Organic matter…...62,48%
Boron (B)….46.5 mg/kg
Manganese (Mn)….1133 mg/kg
Molybdenum (Mo)….4.4 mg/kg
Copper (Cu)….94 mg/kg
Zinc (Zn)…790 mg/kg

Figure 4: OrganiQ organic fertilizer granulated from solid digestate in biogas plant "Egg Energy"
http://www.eggenergy.eu/

There are at least one more biogas plant ZS "Jaundzelves" (0.52 MW) that has permission to make commercial fertilizer from digestate, but products of this biogas station are not yet widely available.

7. Case examples (if any) of circular economy, where biogas is a part of a larger chain (e.g. combined chain of closed circle fish farming, use of nutrients in greenhouse vegetables production, biodiesel and biogas production, use of rejects in agriculture)

Latvia does not have case examples of circular economy that would include biogas.

8. Solutions and proposals for mitigating adverse environmental impacts of biogas production with e.g. technologies for reject water or digestate treatment, enhanced digestate utilisation (processes, logistics), improved planning of biogas installations (locations, scale etc.), improved permitting procedures and legal or economic policy instruments

According to Chapter 4, Table 11 (Risk assessment of biogas manufacturing), the highest probability leading to severe consequences is that ammonia leach from anaerobic digestate. Also, according to Latvia's environmental monitoring data, 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. If soil is fertilized taking into account the nitrate concentration only, it is over fertilized by other compounds. Maximal amount of nitrogen applied with livestock manure per hectare is limited to 170 kg (MK Nr.834, 2014). If produced amount of nitrogen is higher, a producer must have documents proving a passage of overproduced amounts to other households. 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. However, there are no special regulations regarding digestate.

The solution for the described potential overfertilization with nitrogen and phosphorus could be:

- to include digestate into existing directive "Regulations Regarding Utilisation, Monitoring and Control of Sewage Sludge and the Compost thereof", thus limiting maximal phosphorus amount being spread on the agricultural land;
- to make it obligatory to perform an annual nutrient balance for fields for nitrogen, phosphorus and, possibly, potassium. This would lead to more aware attitude towards fertilization in general, as well as better choice of fertilizers. If farmers would know, that they continuously overfertilize soil and pollute groundwater, the attitude would be stricter. Especially, if people are informed of consequences, which leads to the next point;
- providing understandable and accessible information about the consequences of overfertilization and groundwater pollution;
- regular analysis of digestate to be spread on fields should be performed to ensure absence of hazardous substances and pathogens in exceeding quantities. Regular quality data, better regulated by some instance or certification bureau, could help to calculate actual amounts of fertilizer needed;
- to provide legal framework for biogas plant risk assessment and crisis management;
- performing informative seminars and lectures for potential biogas producers as well as providing of guidelines and recommendations for treatment of digestate minimizing environmental impacts.

Organic fertilizers applied to agricultural soils in high quantities and long-term application to increase crop productivity, result in accumulation of soil phosphorous (P). Soluble P is directly available to algae (Sonzogni et al., 1982) and thus particularly relevant to water quality degradation. Transport of P from agricultural soils to surface waters has been linked to eutrophication in fresh water and estuaries (Sharpley and Lemunyon, 1998). Fertilizers and biodegradable wastes application rates in agriculture are based on nitrogen requirements. This results in a P supply that is more than crops needs since the ratio of P to N in waste use to be greater than required by plants (Smith, 1995). While surface runoff is an important pathway of phosphorus losses from agricultural lands, significant losses can also occur via leaching through soil. Leaching tests are important for assessing the risk of release of potential pollutants from digestate into groundwater or surface water. Percolation tests also get information about the interaction of digestate with soils.

In addition, there is hydrogeological model of Latvia – LAMO (http://www.emc.rtu.lv/lamo.htm), which can be used to predict the possible contamination of groundwaters and to take actions in case of occurrence.

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Appendix

List of biogas stations in Latvia

Installation	address	Feedstock	Installed capacity (MW)	Year of deployment
AS "Agrofirma Tērvete"	"Jātnieki", Tērvetes pagasts, Tērvetes novads	**agricultural sludge/manure**	0.5	24-02-12
AS "Viļānu selekcijas un izmēģinājumu stacija"	"Piziči", Viļānu pagasts, Viļānu novads	**agricultural sludge/manure**	0.95	19-06-09
KS "Baltijas dārzeņi"	"Jaunbajāri", Salaspils novads	**agricultural sludge/manure**	0.999	23-12-10
SIA "LATVIJAS LAUKSAIMNIECĪBAS UNIVERSITĀTES MĀCĪBU UN PĒTĪJUMU SAIMNIECĪBA "VECAUCE""	"Līgotnes", Auces pilsēta ar lauku teritoriju, Auces novads	**agricultural sludge/manure**	0.26	27-11-08
SIA "AD Biogāzes stacija"	"Skaista", Skrudalienas pagasts, Daugavpils novads	**agricultural sludge/manure municipal wastewater sludge**	1.96	30-11-10
SIA "AGRO Cemeri"	"Cemeri", Litenes pagasts, Gulbenes novads	**agricultural sludge/manure; other organic matter**	0.76	19-09-11
SIA "Agro Iecava"	"Latvall-Jaunlūči", Iecavas novads	**agricultural sludge/manure**	1.95	10-07-09
SIA "Agro Lestene"	"Agro Lestene", Lestene, Lestenes pagasts, Tukuma novads	**agricultural sludge/manure**	1.499	24-08-12
SIA "Bērzi Bio"	"Bērzi", Mālpils novads	**Manure; Industrial wastewater sludge**	0.6	30-11-10
SIA "BIO Auri"	"Pogas 1", Kroņauce, Auru pagasts, Dobeles novads	**agricultural sludge/manure**	0.6	18-06-09
SIA "BIO FUTURE"	"Pūcītes", Vaiņodes pagasts, Vaiņodes novads	**manure**	0.999	01-04-09
SIA "BIO ZIEDI"	"Kalna Oši", Dobeles pagasts, Dobeles novads	**agricultural sludge/manure**	1.998	23-03-11
SIA "Biodegviela"	Rūpnīcas iela 15, Kalsnavas pagasts, Madonas novads	**other organic matter**	2	10-07-09

SIA "Bioenerģija-08"	"Jaunlīci", Poļvarka, Sarkaņu pagasts, Madonas novads	**agricultural sludge/manure**	1.96	06-07-09
SIA "Biopab"	"Jurku Ferma", Sējas novads	**agricultural sludge/manure**	0.6	24-04-12
SIA "BIOPLUS"	"Pakalni", Sopuški, Kastuļinas pagasts, Aglonas novads	**agricultural sludge/manure**	0.6	17-09-10
SIA "BP Energy"	"Krastmalas", Allažu pagasts, Siguldas novads	**agricultural sludge/manure**	0.25	20-07-09
SIA "Brakšķu Enerģija"	"Brakšķi", Līvbērzes pagasts, Jelgavas novads	**municipal waste**	0.16	27-04-11
SIA "Conatus BIOenergy"	"Graudiņi", Sausnējas pagasts, Ērgļu novads	**agricultural sludge/manure**	1.96	06-07-09
SIA "Daile Agro"	"Vecsmildziņas", Glūdas pagasts, Jelgavas novads	**agricultural sludge/manure**	1	30-11-10
SIA "Druvas Unguri"	"Jaunstraumēni", Saldus pagasts, Saldus novads	**agricultural sludge/manure**	0.5	27-01-12
SIA "EcoZeta"	"Jaunslovašēni", "Ekoslovašēni", Cesvaines pagasts, Cesvaines novads	**agricultural sludge/manure; other organic matter**	1.4	19-03-13
SIA "Ekorima"	"Veckļaviņas", Lēdurgas pagasts, Krimuldas novads	**agricultural sludge/manure**	0.95	06-04-10
SIA "GAS STREAM"	"Ērglīši", Vaiņodes pagasts, Vaiņodes novads	**agricultural sludge/manure**	0.999	01-04-09
SIA "Getliņi EKO"	CSA poligons "Getliņi", Kaudzīšu iela 57, Rumbula, Stopiņu novads	**municipal waste**	6.28	13-09-07
SIA "Grow Energy"	"Gravas", Limbažu pagasts, Limbažu novads	**agricultural sludge/manure; other organic matter**	1.995	17-12-10
SIA "ABGS"	"Māras", Salienas pagasts, Daugavpils novads	**Manure; municipal wastewater sludge; other organic matter**	0.9	10-04-12
SIA "International Investments"	"Gandrs", Turku pagasts, Līvānu novads	**agricultural sludge/manure; other organic matter**	0.499	06-09-12
SIA "Kņavas granulas"	"Granulas", Radopole, Viļānu pagasts, Viļānu novads	**agricultural sludge/manure**	1	18-06-09
SIA "LB Energy"	"Rukši", Lauberes pagasts, Ogres novads	**agricultural sludge/manure**	0.21	30-11-10

SIA "Lielmežotne"	"Mežotnes Selekcija", Mežotnes pagasts, Bauskas novads	**agricultural sludge/manure**	0.999	20-09-12
SIA "Liepājas RAS"	"Šķēde", Lībiešu iela 24, Liepāja	**municipal waste**	0.45	18-10-07
SIA "Liepājas RAS"	"Ķīvītes", Grobiņas pagasts, Grobiņas novads	**municipal waste**	1.05	13-02-08
SIA "MC bio"	"Mežacīruļi", Zaļenieku pagasts, Jelgavas novads	**agricultural sludge/manure**	0.795	20-07-09
SIA "NOPA LTD"	"Asinovka", Šēderes pagasts, Ilūkstes novads	**agricultural sludge/manure**	0.25	30-11-10
SIA "Pampāļi"	"Auniņi", Pampāļu pagasts, Saldus novads	**agricultural sludge/manure**	0.99	26-06-09
SIA "Piejūra Energy"	"Jaunlīvi", "Ekolīvi", Nīcas pagasts, Nīcas novads	**agricultural sludge/manure**	1.998	07-11-11
SIA "Priekules BioEnerģija"	"Nodegu skola", Priekules pagasts, Priekules novads	**agricultural sludge/manure**	1.2	23-05-12
SIA "Rekonstrukcija un Investīcijas"	CSA poligons "Getliņi", Stopiņu novads	**municipal waste**	0.735	17-03-11
SIA "Rigens"	Dzintara iela 60, Rīga	**municipal wastewater sludge**	1.998	30-11-10
SIA "RZS Energo"	"Lāses", Sesavas pagasts, Jelgavas novads	**agricultural sludge/manure; industrial wastewater sludge; other organic matter**	0.998	12-06-09
SIA "Sidgunda BIO"	"Niedras", Sidgunda, Mālpils novads	**agricultural sludge/manure**	0.8	26-11-10
SIA "Sprūževa M"	"Ferma Staroščiki 1", Janopole, Griškānu pagasts, Rēzeknes novads	**agricultural sludge/manure**	0.499	09-11-11
SIA "Ulbroka"	Acones iela 10, Ulbroka, Stopiņu novads	**manure**	0.221	13-02-12
SIA "ZAAO Enerģija"	CSA poligons "Daibe", Stalbes pagasts, Pārgaujas novads	**municipal waste**	0.35	19-06-09
SIA "Zaļā Mārupe"	"Imaku ferma", Jaunmārupe, Mārupes novads	**agricultural sludge/manure**	1	30-11-10
SIA "Zaļās Zemes Enerģija"	"Veibēni 1", Skrīveru novads	**agricultural sludge/manure**	0.547	02-02-12

SIA "Zemgales Enerģijas Parks"	Rūpniecības iela 2D, Bēne, Bēnes pagasts, Auces novads	**agricultural sludge/manure; other organic matter**	1.2	17-08-12
SIA "Zemgaļi JR"	"Bionārzbūti", Vircavas pagasts, Jelgavas novads	**agricultural sludge/manure; industrial wastewater sludge; other organic matter**	0.6	19-08-11
SIA "Zemturi ZS"	"Zemturi", Burtnieku pagasts, Burtnieku novads	**agricultural sludge/manure; industrial wastewater sludge**	0.68	18-06-09
ZS "Jaundzelves"	"Jaundzelves", Katvaru pagasts, Limbažu novads	**agricultural sludge/manure**	0.52	22-06-11
ZS "Līgo"	"Līgo", Lielplatones pagasts, Jelgavas novads	**agricultural sludge/manure**	0.5	22-06-11
ZS "Vecsiljāņi"	"Liellopu ferma", Bebru pagasts, Kokneses novads	**agricultural sludge/manure**	0.98	09-11-11
AS "Agrofirma Tērvete"	"Alus Darītava", Tērvetes pagasts, Tērvetes novads	**agricultural sludge/manure, industrial wastewater sludge**	1.5	17-05-12
SIA "Zaļā liesma"	"Jaunslovašēni", Cesvaines pagasts, Cesvaines novads	**agricultural sludge/manure**	0.4	06-07-11
ZS "Pilslejas"	"Kalnadomēni", Bebru pagasts, Kokneses novads	**agricultural sludge/manure**	0.5	18-06-12
SIA "Divjumi"	"Līgo Jumis", Lielplatones pagasts, Jelgavas novads	**agricultural sludge/manure**	0.6	23-07-12
SIA "DIGNE"	"Centrs 1-3", Valle, Valles pagasts, Vecumnieku novads	**agricultural sludge/manure**	0.042	17-05-12
SIA "Latvi Dan Agro"	"Ošlejas", Jaunbērzes pagasts, Dobeles novads	**agricultural sludge/manure**	0.9	17-07-12
SIA "Egg Energy"	"A/S Balticovo", Iecavas novads	**agricultural sludge/manure**	1.996	29-08-12