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POMERANIAN BIOGAS MODEL

Inventory of experiences with digestate application

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Digestate composition and its quality depends on the substrates that are used in the fermentation process. Different parameters of digestate can be obtained by mixing certain substrates. The table below presents the parameters of residue from the fermentation process of different substrate mixtures. Each mixture is associated with various concentrations of elements as well as with the different content of dry matter.

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Digestate composition in accordance to substrates used in the process

Substrate	Content of substrate [%]	Dry matter content [%]	Concentration of elements in digestate [kg/m³]			
			N	$N\text{-}NH_4$	P_2O_5	K_2O
Corn silage (35% d.m.) Cattle slurry (8% d.m.)	70 30	9,0	5,8	3,8	2,3	9,1
Corn silage (35% d.m.) Pig slurry (6% d.m.)	40 60	6,3	5,5	3,6	2,6	5,2
Corn silage (35% d.m.) GPS ray silage (29,4% d.m.)	80 20	10,9	7,0	4,6	2,8	11,1
Corn silage (35% d.m.) Pig slurry (6% d.m.) Wheat (86,6% d.m.)	85 10 5	10,5	7,5	4,9	3,6	10,1
Cattle slurry (8% d.m.)	100	5,1	5,0	3,3	1,8	6,5

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- Digestate composition is also influenced by substrate origin.
- When the organic fraction is separated from the municipal waste stream it can be polluted with heavy metals.
- Digestate obtained after fermentation of source separated domestic food waste has higher plant nutrient and lower PTE content than digestate from the organic fraction separated from municipal wastes.
- Digestate liquor from the mechanically separated organic fraction exceeds typical limits for potentially toxic elements. Moreover, it also possesses some plastic and other physical contaminants that limit the material’s potential as a valuable product.
- The parameters of digestate fibre as well as liquor from domestic food were both within typical limit values for PTE.

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Composition of digestate obtained from substrates of different origin: source segragated domestic food and mechanically segregated organic fraction

	Source segregated domestic food		Mechanically- segregated organic fraction	
	Fibre	Liquor	Fibre	Liquor
% of whole digestate	1,2	98,8	22	78
TS (%WW)	14,7 ± 0,1	5,84 ± 0,02	35 ± 0,3	6,57 ± 0,01
VS (%WW)	12,1 ± 0,0	4,16 ± 0,02	21,2 ± 0,4	3,28 ± 0,01
VS (%TS)	82,6 ± 0,1	71,2 ± 0,2	60,5 ± 0,6	49,9 ± 0,0
TAN (g NH_3-N kg^{-1} TS)	23,6 ± 0,1	65,1 ± 0,7	4,76 ± 0,11	22,4 ± 0,2
TKN (g kg^{-1} TS)	54,7 ± 0,4	112 ± 0,0	16,2 ± 0,2	48,1 ± 0,3
TK (g kg^{-1} TS)	18,0 ± 0,1	46,1 ± 0,2	3,89 ± 0,27	17,5 ± 0,0
TP (g kg^{-1} TS)	10,5 ± 0,2	11,9 ± 1,3	3,40 ± 0,18	4,52 ± 0,24
Cd (mg kg^{-1} TS)	<1,0	<1,0	1,36 ± 0,17	2,37 ± 0,02
Cr	10,9 ± 0,4	29,1 ± 0,2	64,0 ± 2,6	166 ± 2
Cu	19,6 ± 0,0	37,8 ± 0,3	146 ± 2	291 ± 2
Ni	11,4 ± 1,1	25,2 ± 0,2	57,6 ± 2,2	138 ± 1
Pb	<10	<10	170 ± 7	265 ± 2
Zn	128 ± 7	151 ± 1	438 ± 66	840 ± 2

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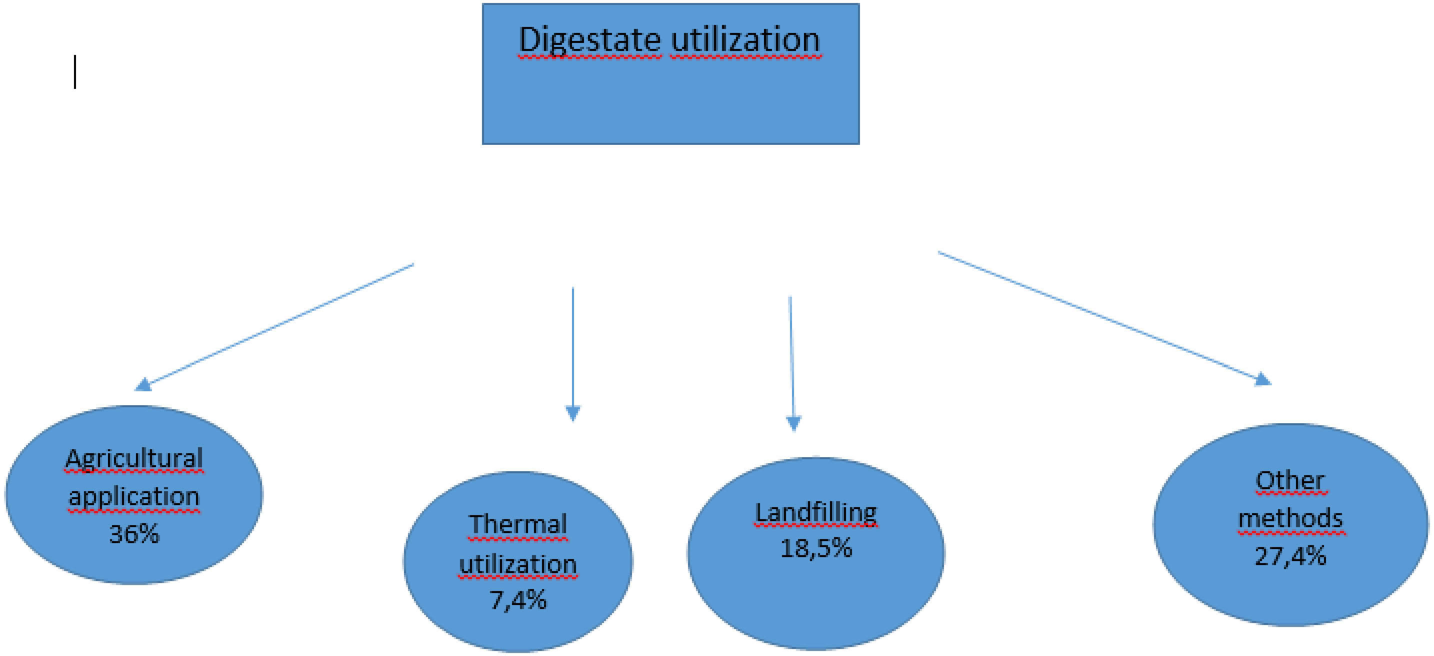
Different methods of digestate utilization



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Physio-chemical characteristics of soil according to fertiliser treatments

Parameter	Control	Cattle manure	Digestate	Mineral fertiliser
pH	7.9	7.8	7.7	n. d.
	8	7.9	7.9	7.9
	8.1	8	8	8.1
	7.8	7.8	7.8	7.7
	8.1	8	8	8
EC (dS/m)	0.12	0.14	0.16	n. d.
	0.16	0.25	0.23	0.24
	0.13	0.14	0.14	0.13
	0.23	0.24	0.22	0.31
	0.12	0.14	0.14	0.14
TN (g/kg)	1.7	2.1	2	n. d.
	1.5	1.8	1.3	1.3
	1.5	1.3	1.2	1.1
	1.6	1.8	1.3	1.5
	1.3	0.9	1	1.1

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NH_4- N (mg/kg)	1.5	1.4	1.7	n. d.
	0.1	3	3.2	0.2
	15.4	14	7.5	14
	1.8	1.1	1.3	1.5
	5	4.3	3.4	3.8
NO_3- N (mg/kg)	14.5	25.1	64.7	n. d.
	2.8	2.9	3.2	7.2
	1.4	1.6	1.5	1.7
	6.9	9.2	8.9	11.3
	2.4	2.8	4.4	3.8
Available - P (mg/kg)	28.5	36.3	36.7	n. d.
	24.2	37.4	48.2	32.2
	24.8	42.4	54.8	32.9
	39.7	53.5	75.8	59.4
	38.3	27.8	34.6	46.4

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- Soil pH was affected only slightly by the digestate, probably due to the high buffering capacity of the soil that was used. It is clearly visible that soil treated with cattle manure or digestate had the highest concentration of total nitrogen after the first addition of fertiliser. Then the differences between the concentrations were very small and insignificant.
- Moreover, the NH_4-N concentration in soil amended with digestate or cattle manure was higher than for the control and mineral fertiliser treatment. Generally, the concentration was very low; only in sample three were these values high, which means that nitrification was only partial and that the nitrate concentration was the lowest for all of the samplings. Inhibition of nitrification could be stopped by the same substances present in the sample that are harmful to bacteria from the Nitrosomonas group.
- The first addition of digestate caused a rapid increase in the soil nitrate concentration, but there were no significant differences among the other samplings. Similarly, available P levels were higher after treatment with digestate, but at the end of the experiment these concentrations were similar to one another.

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• Fertilization

Digestate is considered a very valuable fertilazing material. It is used more and more often as a substitute of artificial fertilizers. There are many benefits resulting from application of digestate, but on the other hand, there are also many people against that method of utilization.

Comparison of watermelon production depending from the used fertilizer

Treatment	Marketable production (Mg/ha)	Non- marketable production (Mg/ha)	Mean fruit weight (kg per fruit)
First year			
Control	32,1	0,6	2,27
Cattle manure	37,7	1,8	2,34
Digestate	47,9	2,7	2,56
Mineral fertilization	42	2,4	2,1
Second year			
Control	31,6	0,6	2,29
Cattle manure	31,2	1,4	1,9
Digestate	41,9	0,6	2,13
Mineral fertilization	56,6	0,0	2,2

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Plant pots 7 and 11 were treated with digestate, 15 with raw manure and 3 was control sample. It is easily seen that soil treated with digestate gave the highest crops

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There are also many other advantages coming from the treatment of soil with digestate. Comparing with the manure, dispersion of digestate is associated with smaller odour emissions. Table below presents the average odour emission from different manure types:

Manure Type	Average Odour Concentration (OU/m^3)	Odour Flux (OU/m^2*s)
Fresh Raw Manure	2527	1,62
Aged Raw Manure (28 days)	1834	1,18
Digestate	683	0,44
Aged Digestate (28 days)	298	0,19

From the data obtained it is seen that application of digestate causes much smaller odour emission (three times smaller than in the case of raw manure).

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The most important regulations connected with agricultural digestate utilization:

- Digestate should be analysed before dispersion
- Concentrations of metals cannot exceed threshold values
- Agricultural utilisation cannot cause any nuisance to people, animals and the environment
- Salmonella bacteria are not present
- The amount of live parasites does not exceed given values (agricultural usage- 10 per kg of dry matter, soil reclamation- less than 300 par kg of dry matter)

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Digestate cannot be used in the following areas:

- National parks and nature reserves
- Areas of water intake
- Ranges situated closer than 50m from the water line of a sea, lake or river
- In areas that are in danger of being flooded
- In agricultural areas with a slope larger than 10%
- In areas where vegetables and fruits are cultivated
- In areas that are to be pastures

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Agricultural application of digestate

- **Irrigation**

Water content in digestate is very high. It reaches even 98% of the material. Thus fermented substrate can be used to the irrigation process. After application to the land, plants can treat it like a water source.

- **Soil reclamation**

Digestate is reach in minerals. That is why it can be successfully used in soil reclamation. There are many places that are so degraded, that cultivation of plants is no more possible. Digestate has low content of organic matter (about 30% of carbon content is reduced in the process of fermentation), but the most important is the concentration of elements N and P.

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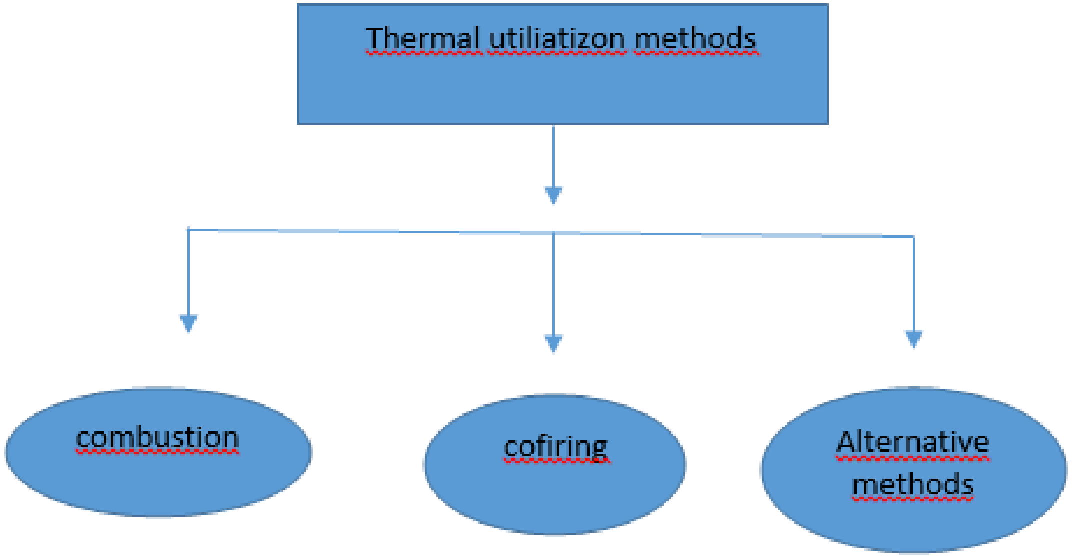
Thermal utilization of digestate



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Combustion of digestate

- Combusiton is possible when calorific value exceeds 8000kJ/kg
- Combustion of digestate releases higher concentration of nitrogen oxides than combustion of wood. Moreover combustion of digestate is associated with bigger amount of produced ash.
- Calorific value of the substrate after fermentation is lower than the calorific value before fermentation. Fermentation proces decreases calorific value for about 2MJ/kg d.m.
- The most important thing, limiting the utilization of digestate through combustion is sustainability of nutrients. Digestate combustion means destruction of these closed loops of nutrients, and known diversion from the idea of sustainable development.

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Incineration of digestate pellets

Digestate can be transported in order to be used as fertilizer in another place, but it is proven that transport is rather not economic. When the distance is bigger than 5-10 km, costs of transport exceed the fertilizer value.

Production of digestate pellets allow transport of that material. First step required before the production is digestate drying.

Initially, water content makes 90-95% of the total mass. It is necessary to reduce water content to 15-20%. Belt press removes water in digestate to dry matter of 25%, then material goes to the drum dryer, where finally dry mass content reaches the value of 80-85%.

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Comparison of nutritional value of digestate pellets and wood pellets

Element	Digestate fuel pellets	Wood fuel pellets	THRESHOLD VALUE
% dry basis			
C	45,3	49,7	-
N	2,9	0,13	0,3
O	28,4	43,3	-
H	5,2	6,3	-
P	1,3	0,03	-
S	0,9	0,02	0,08
K	1,4	0,1	-
Cl	0,84	0,01	0,03
[mg/kg] dry basis			
As	0,93	0,48	0,8
Cd	0,29	0,23	0,5
Cr	13,2	6,8	8
Cu	58,8	3,5	5
Pb	4,4	2,17	10
Hg	0,07	0,04	0,05
Zn	304	35	100

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Comparison of nutritional value of digestate pellets and wood pellets:

Firstly, digestate fuel pellets are rich in elements that are associated with noxious emissions. Nitrogen, sulfur and chlorine content of digestate pellets exceeds threshold value many times. The content of zinc is higher then threshold value, whilst contents of arsenic, cadmium and mercury are close to the threshold value.

Emissions:

Average	Temperature (°C)	O_2 (%)	CO_2 (%)	CO (mg/m³)	NO_x (mg/m³)	Dust (mg/m³)	Dust-electrostatic filter (mg/m³)	SO_2 (mg/m³)	C (mg/m³)
Digestate	227	10,5	10,1	275	334	100	40	n.d	n.d
Pinewood	-	-	-	320	108	68	-	-	30

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Ash composition

Oxides of elements [%]	ASH FROM DIGESTATE PELLETS	ASH FROM WOOD PELLETS	THRESHOLD VALUE
P	26,7	2,6	-
K	15,5	6,4	-
Mg	8,4	6	-
Na	0,8	0,7	-
Ca	13,6	41,7	-
Si	30,4	25	-
S	0,9	1,9	-
Fe	1,8	2,3	-
Al	1,2	4,6	-
[mg/kg]			
As	1,1	4,1	40
Pb	2,3	13,6	150
Cd	<0,5	1,2	1,5
Cr	184	325,5	2
Ni	285	66	80
Hg	<0,1	0,01	1

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Ash composition:

Ash content is much bigger in comparison to wood pellets. Concentration of heavy metals in ash is rather low and did not exceed the threshold values. Only concentration of Ni and Cr is higher then the reference value. A high concentration of P and K makes ash from digestate very valuable material for plants growth, thus it can be used as the fertilizer.

Calorific value:

Heating pellets obtained from digestate have high fuel value - 15 MJ/kg, whilst the moisture content is 9,9%. In comparison, heating value of pellets from wood equals to 16,3 MJ/kg with moisture of 12%. Fuel value of pellets from two materials have similar value, but production of pellets from digestate is associated with many problems connected with dewatering and drying processes.

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