THE USABILITY OF SUBSTRATES FROM AGRICULTURE AND AGRICULTURAL AND FOOD INDUSTRY WASTES IN THE LIGHT OF LITERATURE DATA

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Abstract. The work contains an analysis of the usability of substrates from agriculture and from agricultural and food industry in the aspect of their suitability for biogas production. The analysis has comparative character and concerns literature data.

Key words: biogas, substrates, literature data

Introduction

Resources and market of renewable energy sources in Poland, in particular biomass, are highly dispersed and may satisfactorily function with reference to small, communal biogas plants. Moreover, the energy production from biomass should be carried out without any losses in food production. Considering this, wastes and residues from agricultural production should be used for energy production purposes first.

Agricultural biogas plants working on the basis of methane fermentation process, introduced on a large scale all over the world, are employed as installations for biological disposal of organic wastes. Organic wastes from food production: vegetable and fruit wastes, milk plant wastes (fats, whey, wastes from in-house sewage treatment plants), glycerine, and distillery, sugar plant and brewer's draff present high energy potential, and are cheap raw material for biogas plants since in many cases they require their producers (e.g. slaughterhouses) to cover costly utilisation. Especially, food processing plants should be interested in disposal of their own production wastes, which, according to applicable regulations, require utilisation as arduous for environment, and their straight storage is impossible. These wastes are: slaughter residues, including animal rumen content, blood, fat residues, fish wastes. Food processing plants incur considerable costs on account of their utilisation, and in meanwhile these costs may significantly increase the economic efficiency of biogas plants.

The purpose of the work

The purpose of the work was to analyse the usability of selected agricultural substrates, agricultural and food industry wastes, and slaughter wastes for biogas production in agricultural biogas plants. In particular, the purpose of the comparative analysis is to demonstrate the differences in literature data as regards efficiency of biogas acquired from a given

substrate, which may result from the methodical dissimilarities occurring during the biogas efficiency determination, and from the differences between the substrates, which belong to the same group but have a different constitution.

Research methodology

In their work, the researchers employed a comparative analysis of literature data obtained from the different authors as regards individual substrates. The data is compiled in tables for homogeneous groups in order to expose differences between individual literature sources.

Substrates for biogas acquisition

Table 1. Potential for biogas production from animal excreta

Substrate	Dry matter [%]	Dry organic matter [%]	Biogas production [$m^3 \cdot t^{-1}$ d.o.m.]	CH_4 content [% by vol.]	Source
Swine liquid manure	7	82	220-637 (428)	-	Oniszk-Popławska 2003
	-	70-86	300-700	60-80	Jędrczak 2008
	7	75-86	300-700	60-70	Głodek 2007
	6.6	76.1	301	-	Oniszk-Popławska 2009
	7.5	82	815	58	Cebula 2005
	-	-	170-450	55-65	Ledakowicz 2005
	4.7	71.9	447	60,8	Podkówka 2007
Cattle liquid manure	10	80	175-520 (347)	-	Oniszk-Popławska 2003
	-	75-85	200-500	55-75	Jędrczak 2008
	8-11	75-82	200-500	60	Głodek 2007
	8.5-9.5	77.4-85.5	154-222.5	-	Oniszk-Popławska 2009
	10	68.5	801	55	Cebula 2005
	-	-	190-220	68	Ledakowicz 2005
	8.5-12.3	81.4-86.2	220-345	55.7-61.9	Podkówka 2007
Swine dung	20	90	220-637 (428)	-	Oniszk-Popławska 2003
	-	75-80	270-450	70-80	Jędrczak 2008
	20-25	75-80	270-450	60	Głodek 2007
Cattle dung	23	80	175-520 (347)	-	Oniszk-Popławska 2003
	-	68-76	210-300	60	Jędrczak 2008
	25	68-76	210-300	60	Głodek 2007
Hen droppings	15	76	327-722 (524)	-	Oniszk-Popławska 2003
	-	57-80	250-600	60	Jędrczak 2008
	32	63-80	240-450	60	Głodek 2007
	15.1	75.6	320	-	Oniszk-Popławska 2009
	-	-	300-450	57-70	Ledakowicz 2005
	27	67	773	58	Cebula 2005
	86.4	69.3	385	51.4	Podkówka 2007

Table 2. Potential for biogas production from crop plants and agricultural wastes

Substrate	Dry matter [%]	Dry organic matter [%]	Biogas production $m^3 \cdot t^{-1}$ d.o.m.	CH_4 content [% by vol.]	Source
Maize	30	94	410 (CH_4)	-	Oniszk-Popławska 2003
	20-33	93.8-95.9	602-635	53	Cebula 2005
	21.9-49.1	94.7-96.3	578-642	51.9-54	Podkówka 2007
	-	-	350-500	50	Ledakowicz 2005
Maize ensilage	18-32	93-95	588-635	53	Cebula 2005
	32.6	90.8	317.6 (CH_4)	-	Oniszk-Popławska 2009
		85-95	450-700	50-55	Jędrczak 2008
	20-35	85-95	450-700	50-55	Głodek 2007
Grass	11.7	88	587.5 (CH_4)	-	Oniszk-Popławska 2009
	19.3	92.3	335	70	Podkówka 2007
	15-22	87-93	581-678	56	Cebula 2005
	12	90	600 (CH_4)	-	Oniszk-Popławska 2003
	-	-	450-530	55-57	Ledakowicz 2005
Grass ensilage	40.3	83.4	396.6 (CH_4)	-	Oniszk-Popławska 2009
	40	85.6-89.9	596-674	56	Cebula 2005
	-	60-90	550-620	54-55	Jędrczak 2008
	25-50	70-95	550-620	54-55	Głodek 2007
	35	88	560	54	Podkowka 2007
Sugar beets	23	90-95	800-860	53-54	Głodek 2007
	23	92.5	444 (CH_4)	-	Oniszk-Popławska 2009
	19.5	96	775	50	Podkówka 2007
	23	88	425 (CH_4)	-	Oniszk-Popławska
	-	-	620	65	Ledakowicz 2005
Fodder beets	12	75-85	620-850	53-54	Głodek 2007
	18	90	684	51	Podkówka 2007
	13.5	85	546.6	-	Oniszk-Popławska 2009
Sugar beet ensilage	18	80.5	675	55	Cebula 2005
Beet leaves	16	79	450 (CH_4)	-	Oniszk-Popławska 2003
	16	75-80	550-600	54-55	Głodek 2007
	18	73	704	49	Podkówka 2007
Potato leaves	25	79	587.5 (CH_4)	-	Oniszk-Popławska 2009
	25	79	550 (CH_4)	-	Oniszk-Popławska 2003
	-	87	550	75	Jędrczak 2008

Table 3. Potential for biogas production from agricultural and food processing wastes

Substrate	Dry matter [%]	Dry organic matter [%]	Biogas production [$m^3 \cdot t^{-1}$ d.o.m.]	CH_4 content [% by vol.]	Source
(Brewer's) draff	18	85	380(CH_4)	-	Oniszk-Popławska 2003
	-	70-80	580-750	59-60	Jędrczak 2008
	20-25	70-80	580-750	59-60	Głodek 2007
	20.5	81.2	545.1 (CH_4)	-	Oniszk-Popławska 2009
	23.7	95.3	581	59	Cebula 2005
	19.9	95.3	589	57.1	Podkówka 2007
Molasses	80	95	300 (CH_4)	-	Oniszk-Popławska 2003
	-	85-90	360-490	70-75	Jedrczak 2008
	81.7	92.5	301.6 (CH_4)	-	Oniszk-Popławska 2009
	77	93	600	58	Cebula 2005
	80	85	250	-	Kowalczyk-Juśko 2009
	80-90	85-90	360-490	70-75	Głodek 2007
Potato pulp	13	90	250 (CH_4)	-	Oniszk-Popławska 2003
	-	90	650-750	52-65	Jędrczak 2008
	-		880	54	Ledakowicz 2005
	19	94.7	480	58	Podkówka 2007
	18	96.5	738	51	Cebula 2005
Potato extract	6-7	85-95	400-700	58-65	Głodek 2007
	13.6	89.5	387.7 (CH_4)	-	Oniszk-Popławska 2009
	4.7	85.1	674	54.4	Podkówka 2007
		81-95	300-700	58-65	Jędrczak 2008
	6	85	230	-	Kowalczyk-Juśko 2009
Cereal extract	6-8	83-88	430-700	58-65	Głodek 2007
	6.9	94.5	673	54.2	Podkówka 2007
		81-95	300-700	58-65	Jędrczak 2008
	8	83	380	-	Kowalczyk-Juśko 2009
Apple pomace	24-45	85-90	660-680	65-70	Głodek 2007
	22	97.7	566	53	Cebula 2005
	12-40	-	320	-	Kowalczyk-Juśko 2009
	30	94	330 (CH_4)	-	Oniszk-Popławska 2003
Whey	5	92	750	53	Podkówka 2007
	5.4	86	383.3 (CH_4)	-	Oniszk-Popławska 2009
	5.6	92.2	764	53	Cebula 2005
Grapevine pomace	40-50	80-90	640-690	65-70	Głodek 2007
	40	80	420	-	Kowalczyk-Juśko 2009
Pomace	25-45	90-95	590-660	65-70	Głodek 2007
	45	61.5	400 (CH_4)	-	Oniszk-Popławska 2009
	20-30	90-95	380	-	Kowalczyk-Juśko 2009
Compressed sugar pulp	22-26	95	250-350	70-75	Institute 2005
	22	95	180	-	Kowalczyk-Juśko 2009

Table 4. Potential for biogas production from slaughter wastes

Substrate	Dry matter [%]	Dry organic matter [%]	Biogas production [$m^3 \cdot t^{-1}$ d.o.m.]	CH_4 content [% by vol.]	Source
Stomach contents	16	82	300 (CH_4)	-	Oniszk-Popławska 2003
	12-15	75-86	250-450	60-70	Institute 2005
	15	84	264 (CH_4)	-	Oniszk-Popławska 2009
Pre-stomach contents (rumens)	14	88	195	-	Oniszk-Popławska 2003
	11-19	80-90	200-400	58-62	Institute 2005
	15	86.7	300	60	Podkówka 2007
Blood	9.7	95	410 (CH_4)	-	Oniszk-Popławska 2003
	22-90	95	400	-	Kowalczyk-Juśko 2009
Fat from degreasers	36	84	700 (CH_4)	-	Oniszk-Popławska 2003
	2-70	75-93	700	60-72	Głodek 2007
Adipose tissue	37	84	700 (CH_4)	-	Oniszk-Popławska 2003
	34.3	49.1	700 (CH_4)	-	Oniszk-Popławska 2009

Summary and conclusions

Comparison of parameters characterising substrates from apoint of view of the biogas efficiency indicates high divergence of results provided by individual authors. This confirms the need to carry out laboratory studies in Polish conditions on the usability of individual substrates, according to standardised methodology. This is confirmed by the fact that many Polish authors quote results obtained in other countries. These big differences in the results of biogas yield from a given base may result from many methodical factors and substrate properties, including:

1. Measurement errors and/or different methods and conditions occurring when carrying out fermentation, in which measurements were performed, and which affect fermentation process efficiency,
2. Inaccuracies when determining e.g. dry matter or dry organic matter values, which translates into the result of biogas yield from a given raw material,
3. Different plant constitution, dependent on many factors, including: variety, climate, or soil conditions. The same plant species may indicate high fluctuations in the content of structural material constituents and dry matter.
4. Crop or animal breeding specificity. These factors have huge impact: plant harvest date and its current growth phase, and/or plant preservation and storage type. Whereas, regarding animals, constitution of excreta depends on animal species, food they get, and breeding technology.

Therefore, the conclusion arises that there is a need to carry out individual identification and studies concerning input substrates for each biogas plant in a given area. Another issue is the size of samples subject to fermentation process in laboratories?

Bibliography

Cebula J. 2005. Biogazownie rolnicze elementem gospodarczego wykorzystania pozostałości z produkcji rolniczej oraz rozwoju rozproszonej energii odnawialnej. s. 5-7.

Głodek E.(pod red.), 2007. Pozyskiwanie i energetyczne wykorzystanie biogazu rolniczego. Instytut Śląski Opole. s. 25-26.

Institut für Energetik und Umwelt gGmbH. 2005. Biogaz - produkcja i wykorzystanie. Dostępny w Internecie: http://www.ieo.pl/dokumenty/obszary_badan/Biogaz%20-%20Produkcja%20 Wykorzystywanie.pdf

Jędrczak A. 2008. Biologiczne przetwarzanie odpadów. PWN Warszawa. s. 29-34.

Kowalczyk-Juśko A. 2009. Dobór substratu a proces fermentacji. Dostępny w Internecie: http://www.czystaenergia.pl/pdf/farma2009_09.pdf

Ledakowicz S., Krzystek L. 2005. Wykorzystanie fermentacji metanowej w utylizacji odpadów przemysłu rolno-spożywczego**. s**.11-12.

Oniszk – Popławska A., Zowsik M., Wiśniewski G. 2003. Produkcja i wykorzystanie biogazu rolniczego. EC BREC Warszawa. s. 12-13.

Oniszk – Popławska A. 2009. Uwarunkowania prawne i ekonomiczne produkcji biogazu rolniczego w Polsce- prezentacja pdf. FAPA Warszawa. s. 34-39.

Podkówka Z. 2007. Biopaliwa dziś i jutro. Kukurydza 2(31). s. 4-35.

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PRZYDATNOŚC SUBSTRATÓW POCHODZENIA ROLNICZEGO I ODPADÓW PRZEMYSŁU ROLNO-SPOŻYWCZEGO W ŚWIETLE DANYCH LITERATUROWYCH

Streszczenie: W pracy dokonano analizę przydatności substratów pochodzących z rolnictwa a także z przemysłu rolno-spożywczego w aspekcie ich przydatności do produkcji biogazu. Analiza ma charakter porównawczy i dotyczy danych literaturowych.

Słowa kluczowe: biogaz, substraty, dane literaturowe

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