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Directions of utilisation of waste from green areas[1]

Kierunki zagospodarowania odpadów z terenów zielonych

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Abstract
Each year communities generate large quantities of municipal waste, including green waste such as grass and leaves. According to the waste catalogue, they may be treated as belonging to the group 20 02 (garden and park waste), and more specifically, to the group 20 02 01 – biodegradable waste. The aim of the study is to characterise the development directions of the green waste generated in the municipalities. Skilful management of this waste is extremely important. The following work focuses on three different technologies that enable efficient management of the green waste: methane fermentation, pelletising and composting. According to many authors, the most common technologies are pelletising and composting. In contrast, biogas fermentation of green waste in the municipalities is performed on a much smaller scale than other technologies. This may be due to the fact that this technology requires a significant expertise and is more complicated in terms of technology.

Streszczenie
Każdego roku w gminach powstają duże ilości odpadów komunalnych, w tym odpady zielone takie, jak trawa czy liście. Zgodnie z katalogiem odpadów, zaliczyć je można do grupy 20 02 (odpady z ogrodów i parków, w tym również z cmentarzy), a dokładniej do grupy 20 02 01, oznaczającej odpady biodegradowalne. Celem pracy było scharakteryzowanie kierunków zagospodarowania odpadów zielonych powstających w gminach. Umiejętne zagospodarowanie tych odpadów jest niezwykle ważne. W poniższej pracy skupiono się na trzech technologiach, które umożliwią zagospodarowanie odpadów zielonych. Są to następujące technologie: Fermentacja metanowa, paletyzacja oraz kompostowanie. Według wielu autorów najczęstszymi technologiami zagospodarowania odpadów są peletyzacja i kompostowanie. Natomiast biogazowanie odpadów zielonych w gminach jest realizowane w znacznie mniejszej skali niż pozostałe technologie. Może to być spowodowane tym, że ta technologia wymaga znacznej wiedzy i jest bardziej złożona pod względem technologicznym.

1. INTRODUCTION

According to the act of 1 July 2011, amending the act on maintaining cleanliness and order in communes (Journal of Laws of 2011, No. 152, Item 897), local governments are obliged to collect waste from residents of the communal areas. The Act clearly imposes on commune obligation to restrict landfill of biodegradable waste. In order to implement established requirements for the municipalities, there is an urgent need for the application of relevant technology for the treatment of biodegradable green waste.

This type of technology include: methane fermentation, composting and pelletising. These technologies allow for the proper utilisation of noxious waste, which in the near future could be a serious problem for Polish municipalities. During composting of biodegradable waste, a stabilised organic material is produced, which can be used as biofertiliser cosubstrate.

The process of methane fermentation of green waste allows obtaining biogas, from which during cogeneration is produced the power and useful heat.

Municipalities that are managing their waste through pelletising receive valuable fuel material.

Fig. 1. Grass stored in a heap [image copyright]

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2. THE GREEN WASTE METHANE FERMENTATION

Green waste generated during the maintenance of parks and green belts are suitable for the production of biogas substrate [Komorowicz *et al*. 2009]. According to the waste catalogue, they may be qualified as belonging to the group 20 02 (garden and park waste), and more precisely to a group 20 02 01 – biodegradable waste. According to Central Statistical Office data, in Poland in 2007, the area of parks amounted 22,362 ha, street green belts 11,124 ha, public and settlement green areas approximately 24,760 ha, and the lawns 9545 ha. This has a huge potential for the production of green waste, amounting to hundreds of thousands of tons. The reason for difficulties in the use of green waste in the methane fermentation process is relatively high dry matter content, which limits their application as a cosubstrate. This type of substrate should be mixed with a cosubstrate with a lower dry matter content, such as slurry. This material is harvested seasonally, so there is further need of its ensiling to ensure continuous biogas production all year round. Prior to dispensing to the biogas plant, the grass should be cleaned from twigs, gravel or sand and subjected to the process of homogenisation [Kuratorium für Technik und Bauwesen in der Landwirtschawt 2005]. Obtained during the fermentation process, biogas is processed in cogeneration block module for electric energy. In addition to electrical energy, is produced a large quantity of heat, which can be used, for example, to heat a building and bring to the investor of biogas installation approximately 150 PLN/MWh (price in accordance with the decision of the Energy Regulator Office in 2013). Table 1 presents the characteristics of green waste and the methane content in the produced biogas.

Table 1. Properties of green waste after cutting

substrate	DM	DMO	N	P	The yield of biogas		Methane concentration
	%	% DM	% DM		m^3/t FM	m^3/t DMO	% V/V
mowed green	12	83–92	2–3	1.5–2	150–200	550–680	55–65

[Kuratorium für Technik und Bauwesen in der Landwirtschawt 2005, p.121]

3. THE PROCESSING OF GREEN WASTE TO PELLET

The pellet is a product (fuel material) formed from compressed green waste**:** sawdust, shavings, chips, reeds, leaves, grass, etc. It is in the form of granules, with a diameter of 6.25 mm and a length of several centimetres. Made of green waste, the pellets are burned in specially adapted furnaces equipped with automatic feeders and aeration systems to increase the efficiency of the combustion process. The calorific value of pellets is about 16 MJ/kg, compared with hard coal, of which the calorific value is approximately 25 MJ/kg, and is satisfactory, especially that the waste material is combusted [Winnicka 2009].

The production of pellets is carried out in a similar way as the production of granulated feed for animals. Differences are in significantly higher forces acting on the machine during production of pellets, and consequently, greater compressive strength of such machines. The manufacturing process of pellets can be divided into three main stages: drying, grinding and pelletising the substrate [Kornacki, Maj 2011; Kwaśniewski 2008]. Pellets production starts with a collection of feed material. Then the captured substrate has to be dried to 10% of moisture, such level of water content is required for the process of palletising and enables storage of green waste, which are not available throughout the year. It is necessary before the production of pellets to clean the biological material from sand, gravel, and so on., because these solid debris adversely affect the working parts of pellet machine, leading to excessive wear of machine. The pellet production process is shown in Fig. 2.

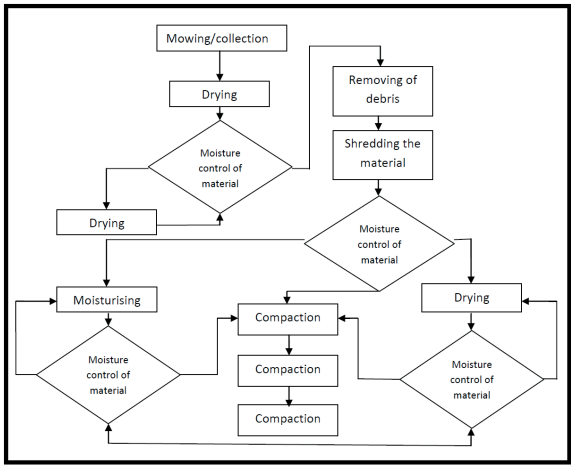

Fig. 2. Technological scheme of production of pellets of green waste, based on [Kornacki, Maj 2011]

The range of equipment for pelletising on the Polish market is relatively broad. They can achieve efficiency of both 100 kg/h, as well as 6000 kg/h [Jakubiak *et al*. 2008]. Among these devices, there are P100 (Fig. 3) and P300 machines, whose performance is respectively from 75 to 100 kg/h (P100) and from 100 to 300 kg/h (P300). They are equipped with engines with a power of 2.2 kW and 6 kW, respectively, and matrices for production of pellets with a diameter of mesh 8 mm. In addition to the equipment for the production of pellets for its own needs, there are also lines for the production of pellets, characteristic of high performance from 300 to 6000 kg/h per one press. Presses of this type can be combined modularly to give complete lines, which are used in the industrial scale production of pellets.

Fig. 3. Pellet machine P100 [image copyright]

4. THE GREEN WASTE COMPOSTING

Another way of green waste utilisation is their composting, especially grasses and leaves. Composting is a process of decomposition of organic matter by microorganisms (aerobic bacteria), which takes place under controlled aerobic conditions, at a suitable temperature and humidity. Ensuring proper conditions for composting is necessary to maintain of defined process parameters such as the porosity of the substrate or cosubstrate mixtures (250–450 kg/m^3), moisture content in the range of 50–75% and an appropriate ratio carbon:nitrogen(20:30). It is also important for composting process to input material reached a sufficiently high temperature (thermophilic phase). Temperature maintenance during composting at 70°C for at least 1 hour contributes to sanitation of composted material [Dach 2010].

The composting process can be divided into four stages, taking place at different time intervals. The existence of several such stages is additionally related to the fact that the substances forming the material for composting are not equally readily susceptible to decomposition. The first stage, also known as low-temperature or mesophilic, is the oxidation and hydrolysis of the organic substances. This stage lasts a few days. The second is the thermophilic stage, which lasts several weeks. During this process, there is a decomposition of organic substances and emission of gaseous products such as: NH_3, CO_2 and H_2O. The high temperature at this stage accelerates the breakdown of fats, proteins and complex of hydrocarbons, such as cellulose or hemicellulose. The next (third) stage of composting, lasting from 20 to 35 days, is accompanied by temperature decrease and complex chemical compound decomposition, thus among others also is observed a reduction in the weight of compost. In the last, even several months' stage, takes place the maturation of compost and humus formation. The compost before use as an organic fertiliser must be mature enough to mineralisation processes have not occurred longer [Pilarski *et al*. 2009].

According to results of tests carried out in the laboratory Eco-Technology in Institute of Biosystems Engineering, Poznan University of Life Sciences, the best effect was obtained with a mixture of composting leaves and grass in a ratio 1:1 (in dry substance). A substrate after composting is characterised by a significant content ofnitrogen, phosphorus and potassium which can be used to successfully fertilise the fields. This is also very important because of the risk of 'over-fertilisation' of cultivated soil with mineral fertilisers, which may affects the quality of the produced food, feed for animals or environmental protection (water eutrophication processes). Organic fertilisers such as compost or manure are characterised by very specific (stable) composition of macro and microelements [Pilarska *et al*. 2013]. As a result of the use of natural compost, expenditure on increasingly expensive mineral fertilisers is reduced at the same time as well.

Investments in composting of green waste are connected with incurring a relatively small cost (much smaller compared with investment in building of biogas plant) and are the source of many benefits. The plans for their implementation include many urban agglomerations in Poland.

5. SUMMARY

European Union policy aims to reduce the greenhouse effect, which dictates its Country States obligation of producing part of energy from renewable sources. Poland is obliged to increase the share of energy production from renewable sources to the level of 15% until 2020. Among the Renewable Energy Sources available in Poland, the largest technical potential is in biomass, which requires the smallest investment contributions; moreover, it can provide a stable supply of energy. Burning of biomass (pellets) in small heating devices reduces consumption of coal or natural gas. Green waste is a very good substrate for biogas production and generation of electricity and heat in a cogeneration process (from RES). On the other hand, by composting, we dispose of biodegradable waste and produce high-quality organic fertiliser as well, which can be successfully applied to a crop field, which reduces the use of mineral fertilisers. Many authors have observed that municipalities often choose utilisation of green waste in the composting or palletising way.

The biogasification of green waste in Poland is realised on a significantly smaller scale than other technologies. This may be due to the fact that this technology requires considerable knowledge and is more complex from the technological point of view.

REFERENCES AND LEGAL ACT

DACH J. 2010. Wpływ poziomu C:N na wielkość emisji amoniaku z kompostowanych osadów ściekowych. Journal of Research and Applications in Agricultural Engineering 2: 14-18.

http://www.ieo.pl/dokumenty/obszary_badan/Biogaz%20-%20Produkcja%20Wykorzystywanie.pdf Institut für Energetik und Umwelt gGmbH. 2005. Poradnik. Biogaz – produkcja i wykorzystywanie. Leipzig.

JAKUBIAK M., KORDYLEWSKI W. 2008. Pelety podstawowym biopaliwem dla energetyki. Archiwum Spalania 8, 3-4: 108-118.

KOMOROWICZ M., WRÓBLEWSKA H., PAWŁOWSKI J. 2009. Skład chemiczny i właściwości energetyczne biomasy z wybranych surowców odnawialnych. Ochrona Środowiska i Zasobów Naturalnych 40: 402-410.

KORNACKI A., MAJ G. 2011. Wybrane właściwości peletów wytworzonych z trawy pozyskanej z trawnika przydomowego. Inżynieria Rolnicza 1: 103-108.

KWAŚNIEWSKI D. 2008. Technologia oraz koszty produkcji brykietów i peletów z wierzby energetycznej. Inżynieria Rolnicza 5: 37-42.

PILARSKA A., DACH J., PILARSKI K., BONIECKI P. 2013. Produkcja i wykorzystanie pasz w Polsce: stan aktualny i tendencje. Technika Rolnicza Ogrodnicza Leśna 6: 24-27.

PILARSKI K., PILARSKA A. 2009. Parametry procesu kompostowania. Technika Rolnicza, Ogrodnicza, Leśna 1: 16-17.

Ustawa z dnia 1 lipca 2011 r. o zmianie ustawy o utrzymaniu czystości i porządku w gminach oraz niektórych innych ustaw (Dz. U. 2011, Nr 152 poz. 897).

WINNICKA G. 2009. Badania właściwości biomasy stałej do celów energetycznych. Instytut Chemicznej Przeróbki Węgla, Zabrze.