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Original Research Article

COMPOSTING AND FERMENTATION OF BIOWASTE - ADVANTAGES AND DISADVANTAGES OF PROCESSES

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Abstract

In 2016, in EU Member States (EU), only less than half of the biowaste produced, i.e. around 40 million tonnes, was used to produce compost and, to some extent, biogas. Most of it was still incinerated or stored together with other waste. On 14 June 2018, amendments to 6 directives on waste management were published. One of the most important changes introduced in the Waste Framework Directive is the obligation for Member States to recycle biowaste at source or selectively collect it for composting or fermentation by 31 December 2023 at the latest. The article presents the potential of biowaste and its use for the production of compost and changes in directives concerning the handling of biowaste, which will shape the directions of development of this waste management in the EU after 2020. The composting and fermentation processes of biowaste were also compared, defining their advantages and disadvantages. This information can be helpful in the selection of technologies for its processing, making decisions on the construction of new or modernization of existing installations.

Keywords: feedstock, biowaste, composting, anaerobic digestion

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1. INTRODUCTION

The basic raw material for composting and fermentation is biowaste. The waste is defined in the Waste Framework Directive [1] as “biodegradable garden and park waste, food and kitchen waste from households, offices, restaurants, warehouses, canteens, catering establishments and retailers, and comparable waste from processing food plants. Biowaste does not include paper, cardboard and wood as well as sewage sludge.

A characteristic feature of biowaste is high humidity. Thanks to this property, biological processes - composting and fermentation - play a key role in closing the waste cycle. These processes make it possible to return organic matter and nutrients valuable for plants to the soil, thus contributing to the support of sustainable agricultural and horticultural practices. They also provide a more environmentally acceptable way of processing organic waste compared to storage and incineration.

The article aims to illustrate the potential of the European biowaste market, a basic raw material for the production of compost, as well as its current use for this purpose. The legal framework for dealing with biowaste, which will shape the directions of development of biowaste management in the EU after 2020, is also presented.

The article focuses on the comparison of the advantages and disadvantages of composting and fermentation processes of biowaste. This information can be helpful in the selection of technologies for its processing, making decisions on the construction of new or modernization of existing installations.

2. BIOWASTE POLICY, APPLICABLE LAW AND PROPOSED CHANGES

The discussion on biowaste management has been ongoing in the EU for over 20 years. Legal regulations regarding biowaste appeared for the first time in the new Waste Directive (2008/98/EC) [2], omitting the second Biowaste Directive draft from 2001 [3]. The Directive introduced the concept of biowaste and recommended selective collection for composting or fermentation. In addition, the Directive required the European Commission to assess biowaste management in order to submit a legislative proposal if it is appropriate.

The condition of biowaste management in the European Union is presented in the Green Paper, published in 2008. It provided the basis for discussion on the possible introduction of minimum requirements for biowaste management and quality criteria for compost and fermentation [4]. The outcome of the consultation confirmed the broad agreement that better management of biowaste is linked to specific economic and environmental opportunities, but revealed a significant difference of views on the need to develop legislative initiatives at the EU level [5].

On 2 December 2 2015, the European Commission published a circular economy package. It included the "Circulation closure - EU action plan on the circular economy" (including an annex) and the proposal - a legislative proposal on amendments to the 6 Waste Directives [6].

The proposal refers to the review of regulated objectives, first of all, the Waste Framework Directive 2008/98/EC [2], the Directive on the landfill of waste 1999/31/EC [7] and the Directive on packaging and packaging waste 94/62/EC [8]. On 18 April 2018, the European Parliament adopted the proposed amendments to the regulations, and on 14 June 2018, amendments to the directives were published. They entered into force on 4 July 2018.

The most important changes introduced by the Package include:

- an increase in the level of municipal waste recycling to 55% by 2025, 60% by 2030 and 65% by 2035;
- an increase in the level of packaging materials recycling to 65% by 2025 and 70% by 2030;
- an obligation to implement selective collection of textiles and hazardous waste from 1 January 2025;
- reducing the amount of municipal waste disposed to 10% by 2035 (Member States such as Croatia, Romania, Greece and Malta continue to store more than three quarters of their municipal waste);
- prohibition of segregated waste storage;
- supporting economic instruments that discourage waste storage.

They will be accompanied by revised, simplified and improved definitions and harmonized methods for calculating recycling rates across the EU.

Significant changes will concern handling of bio-waste. The first point in art. 22 of the Waste Framework Directive was replaced by the following: “Member States shall ensure that, by 31 December 2023 at the latest ..., the bio-waste is segregated and recycled at source or separately collected and non-mixed with other types of waste”.

Amendments were also made in Article 6 "Loss of waste status". Bio-waste has been included in a specific type of waste that may cease to be waste. The introductory part of this article has been amended and reads as follows:„1. Member States shall take appropriate measures to ensure that waste that has been recycled or recovered is no longer considered to be waste if it fulfils certain conditions.

It is also important to strengthen the rules for assessing whether selective waste collection for recycling is justified from a technical, economic and environmental point of view (TEEP test).

In addition, the Circular Economy Package encourages a 30% reduction in food wastage by 2025 and 50% by 2030. This is in line with the sustainable development goals set by the UN. However, goals other than waste recycling and storage are not legally binding.

3. THE AMOUNT OF BIOWASTE

The biowaste potential can be estimated based on the analysis of the morphological composition and the number of MSW collected. Data on the amount of waste collected in EU countries are published by the European Statistical Office (Eurostat) and they are good enough. Information on the quality of municipal waste is unfortunately inaccessible in many countries, while in others it is not numerous and shows very large diversity. It is influenced by various factors and, above all, by different methods and places of sampling, as well as by different test methods (too low mass and number of laboratory samples).

The latest biowaste potential estimate available in the literature and its growth forecast for the 27 EU Member States includes a report compiled by Arcadis Belgium nv and Eunomia in 2010 [9]. Table 1 shows the estimated amounts of biowaste produced and biologically processed in 2008 for individual EU countries according to Arcadis and the amount of biowaste subjected to composting or fermentation in 2008 and 2011, according to Eurostat [10]. In the Arcadis study, biological processing, apart from composting and fermentation in installations, also included composting at home (around 3% of the total amount).

Eurostat and Arcadis data was significantly different. According to Eurostat data, in 2008, 35.1 thousand Mg was composted or fermented, and according to Arcadis, only 20.1 thousand Mg, despite being included in the methods of home composting (3.1%).

In the EU, in 2008, 118 to 138 million Mg of bio-waste was produced annually, of which about 88 million Mg came from municipal waste and from 30 to 50 million Mg from industrial sources, such as food processing [9]. Biowaste usually accounted from 30% to 40% of the MSW's mass (range from 18% to 60%). The average biowaste production per capita in 2008 was around 176 kg. An increase in the mass of biowaste produced by 2020 was predicted by around 10%.

Table 1. Estimates and statistical data about the biowaste potential and utilisation in the EU provided in 1000 tons (Mg) per year (a)

Member State		Est. Potential of Biowaste	Biowaste Composting and Anaerobic Digestion				
		Arcadis [9]	Arcadis [9]		Eurostat [10]		
		[Gg/a] (2008)	[Gg/a] (2008)	% (2008)	[Gg/a] (2008)	[Gg/a] (2016)	(2016-2008)/ (2016) [%]
AT	Austria	1525	569	37.3	1683	1 584	-6.0
BE	Belgium	2098	1114	53.1	1 047	956	-9.0
BG	Bulgaria	907	28	3.1	0	263	-
CY	Cyprus	130	0	0.0	0	21	-
CZ	Czech Republic	1271	64	5.0	50	245	390
DE	Germany	16979	8490	50.0	8082	9 275	15
DK	Denmark	1273	554	43.5	627	853	36
EE	Estonia	350	31	8.9	28	14	-50
EL	Greece	1903	0	0.0	100	182	82
ES	Spain	9776	479	4.9	6158	2 359	-62
FI	Finland	965	212	22.0	234	355	52
FR	France	12453	498	4.0	5581	6 249	12
HR	Croatia	-	-	-	15	31	107
HU	Hungary	1592	493	31.0	85	294	246
IE	Ireland	712	85	11.9	107	180*	68
IT	Italy	7938	1588	20.0	3 106	5 721	84
LT	Lithuania	493	89	18.1	15	299	1 890
LU	Luxembourg	88	57	64.8	68	70	3
LV	Latvia	269	0	0.0	5	81	1 520
MT	Malta	61	0	0.0	0	0	-
NL	Netherlands	2703	1324	49.0	2330	2 457	5
PL	Poland	2960	672	22.7	386	814	111
PT	Portugal	1875	56	3.0	382	814	113
RO	Romania	4006	92	2.3	3	352	11 630
SE	Sweden	1905	528	27.7	522	715	37
SI	Slovenia	308	31	10.1	17	144	747
SK	Slovakia	546	22	4.0	64	143	123
UK	United Kingdom	12630	3789	30.0	4 402	5 353	22
EU-28		87716	20865	23.8	35097	39824	13

* Eurostat 2014

The amount of biowaste from municipal sources depends mainly on the amount of green waste. It is estimated that about 30% of biowaste potential (27 million Mg) was green waste. In 2008, the largest amount of biowaste produced was processed using biological methods in Luxembourg (64.8%), Belgium (53.0%) and Germany (50.0%).According to Arcadis, biowaste recycling was not carried out in Greece and Latvia, as well as in Cyprus and Malta. According to Eurostat, however, in Bulgaria and Cyprus and Malta.

An increase in the amount of biowaste subjected to composting or fermentation in 2008-2016 was very diverse. It was insignificant in several countries (Luksenburg - 3%, the Netherlands - 5%, France - 12%, Germany - 15%) or even decreased (Austria - decrease by 6%, Belgium by 9%, and Estonia by 50%). A high decrease (62%) recorded for Spain was probably the result of being included in the amount of biowaste of organic fraction mass extracted from MSW subjected to composting or fermentation in 2008, which was subjected to biological processing in MBP installations. According to Arcadis, in Spain in 2008, 479 thousand Mg was composed or fermented, not 6158 thousand Mg, Mg, as shown in Eurostat data. In seven countries, the mass increase of bio-processed biowaste ranged from 22% to 84% (United Kingdom, Denmark, Sweden, Finland, Ireland, Greece and Italy), and in the rest, it exceeded 100%.

In Poland, the share of biowaste in mixed municipal waste amounted to approx. 32% in 2008, and the rate of biowaste production per capita was about 102 kg (in 2012, respectively 31% and 105 kg).

A characteristic feature of biowaste is high moisture, usually exceeding 50% (52-80%). Organic substances constitute from 34% to 81% of their dry matter, the C/N ratio is 10-25 and the biogas potential is 0.15-0.60 m^3/kg s.m.o.

The management of biowaste in EU countries is shown in Figure 1. In 2008, 35.7 million Mg of biowaste was stored (40%).In seven countries, more than 80% of biowaste was stored (Lithuania - 82%, Czech Republic - 86%, Poland - 87%, Bulgaria - 90%, Greece - 91% and Cyprus and Malta - 100% each).

Other biowaste:

- was composted - 18.7 million Mg (Luxembourg - 54% of the mass of biowaste, Belgium - 49%, the Netherlands - 47%, Germany - 45% and Denmark - 44%);
- was burnt - 17.4 mln Mg (the most in Sweden - 64% of the mass of biowaste and 56% in Denmark);
- was processed in MBP installations - 11.2 million Mg (Spain - 38% and Italy - 26%);
- was methane fermented - 1.5 million Mg (Luxembourg - 11% and Austria - 9%);

and about 0.7 million Mg was composted in households (Austria - 15%, Estonia - 8%, Hungary - 9% and in Sweden, Ireland and Belgium - about 5% each).

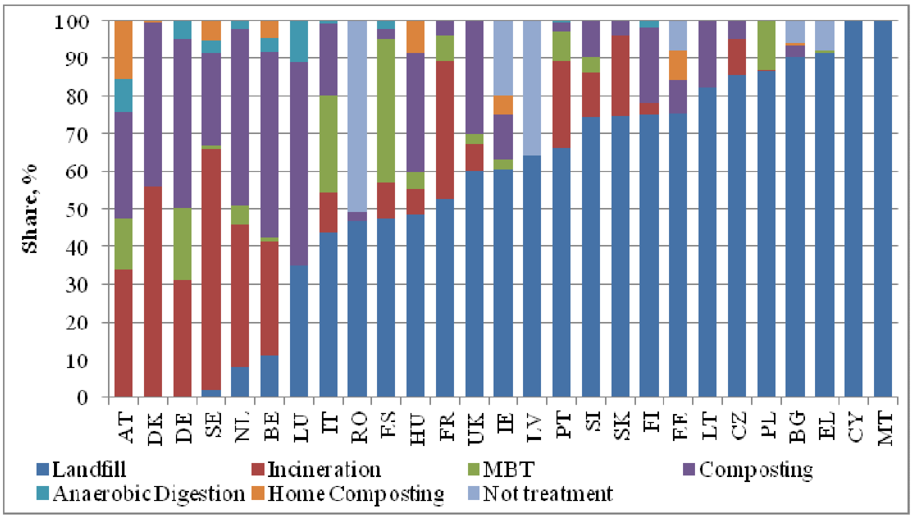


Fig.1.Waste management in 28 EU Member States, in 2008

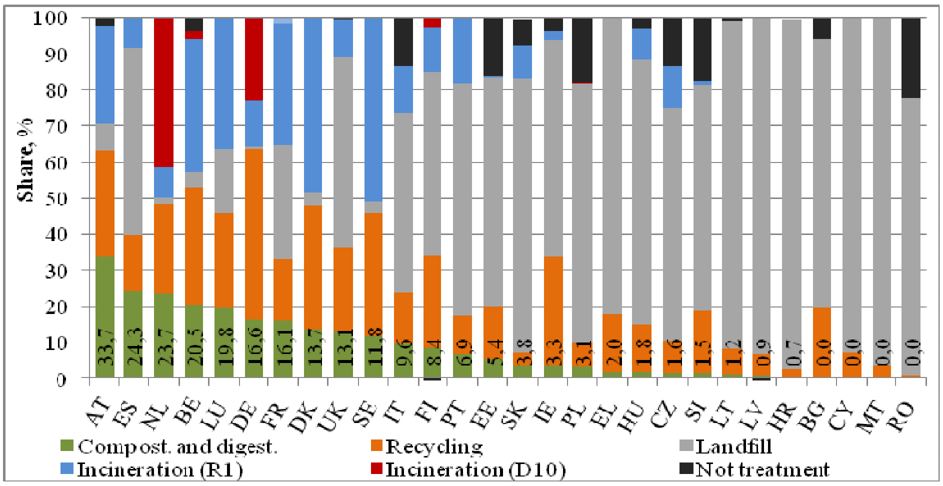
In several countries, some MSW and, consequently, also of biowaste, was not collected (Romania - 51%, Latvia - 36%, Ireland - 20%, Greece - 8% and Bulgaria - 6%).

Municipal waste management in the EU countries in 2008 and 2016 is shown in Figure 2 [1]. In 2008, an average of 521 kg of municipal waste per person was produced in the EU (with Croatia). About 38.6% of generated waste was stored, 21.1% was incinerated (including 15.0 with energy recovery), 23% was given to material recycling and 13.4% was composted or fermented. The largest amount of biowaste produced was processed biologically in Austria (34%), Spain (24%), the Netherlands (24%), Belgium (21%), Luxembourg (20%) and Germany and France (around 18%). In 2016, an average of 483 kg of municipal waste per person was generated. About 24.5% of generated waste was stored, 28.1% was incinerated (including 25.4 with energy recovery), 29.3% was given to material recycling and 16.2% was composted or fermented. The largest amount of biowaste produced was processed biologically in Austria (32%), the Netherlands (28%), Lithuania (25%) Belgium (20%), Luxembourg (20%) and in Denmark and Italy (around 19%). In general, EU Member States can be divided into three groups due to the way in which waste is handled:

- countries that commonly use incineration to limit waste storage, which achieve high levels of material recycling and often have advanced strategies to support biological waste treatment (Finland, Denmark, Sweden, Estonia, the Netherlands, Belgium, Austria, France, Luxembourg, Ireland, UK) Britain, Germany and Slovenia);

- countries based on landfills (Malta, Greece, Romania, Croatia, Cyprus, Bulgaria, Latvia, Slovakia);
- countries with average recycling levels of materials that burn more than a dozen percent of waste generated (Spain, Hungary, the Czech Republic, Poland, Portugal, Lithuania and Italy), some of them showing a high composting index (Lithuania and Italy).

A – 2008



B-2016

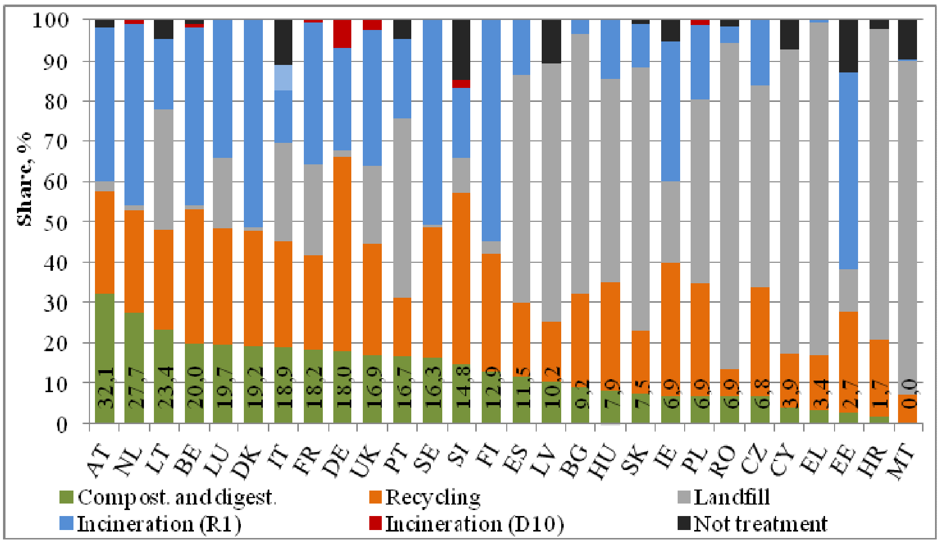


Fig.2.Municipal waste management in 28 EU member states,
A - in 2008 and B - 2016 [10]

Biowaste storage represents a significant threat to the environment due to greenhouse gas emissions, potential contamination of soil and groundwater and the irreversible removal of valuable resources (such as compost or energy) from the economic and natural cycle. Storage violates the principles of EU waste management policy and sustainable resource management, in particular regarding the waste hierarchy, which should form the basis of national waste management policy across the EU.

4. BIOLOGICAL PROCESSING OF BIOWASTE

2.1. BIOWASTE COMPOSTING

Composting is a process of controlled decomposition of biodegradable materials under aerobic conditions, which allows obtaining temperatures suitable for thermophilic bacteria as a result of biologically produced heat. A distinction is made between systems in which composting is carried out in a reactor (called "closed" systems) and technologies in which composting is carried out in the open air ("open" systems) [11].

Composting in piles - this is the oldest, the best known and the cheapest composting method. Composted waste is piled with a triangular or trapezoidal cross-section. Waste in piles is aerated by forcing air through the compost mixture by means of blowers or fans or by shifting it. The main thermophilic phase of the composting process lasts 6-12 weeks, depending on the moisture content, oxygen, C:N ratio and air porosity of the waste. Composting in piles can be carried out in open air or under a roof. Composting under a roof reduces the influence of weather on the process. The land demand for composting in piles ranges from 0.7 to 1.2 m^2/Mg.

Composting in reactors - is very similar to composting in piles, but takes place in a closed reactor, which allows better control of process parameters, such as oxygen content, humidity and waste temperature. Composting in reactors also facilitates the maintenance of low emissions to the environment through the ability to capture and purify polluted air.

Various process techniques of reactor systems are available, including composting in: containers and chambers, tunnels and closed halls as well as towers. The choice of system depends on local conditions, such as: type of waste, availability of space and required installation capacity. In most technologies, only the intensive composting phase is carried out in the reactors, ripening takes place in open piles.

The ability to control the process and eliminate emissions to the air, as well as lower land use, means that despite higher investment and operating costs, composting in closed systems is recommended in most European countries.

2.2. FERMENTATION OF BIOWASTE

Fermentation is a process of controlled degradation of biodegradable materials under anaerobic conditions (in a closed reactor) at temperatures suitable for mesophilic or thermophilic bacteria.

Products of the methane fermentation process are: digestate [2] that can be used as a soil conditioner and biogas that can be burned to produce renewable energy or purified and used as fuel for vehicles.

Waste disposal technologies in anaerobic biological processes are based on four basic parameters resulting mainly from the specificity of the methane generation process and from the requirements of conducting biological processes on a technical scale.

They are [15]:

- substrate moisture: wet and dry fermentation,
- fermentation temperature: mesophilic and thermophilic fermentation,
- substance flow: continuous or periodic,
- degree of fermentation: single- and multi-stage technologies.

Fermentation systems are divided into "wet" and "dry" fermentation due to the moisture content of the batch. "Wet" fermentation takes place with liquid substrates, in which the dry matter content does not exceed 15%. Fermentation of waste with a higher dry matter content is referred to as "dry". The maximum dry matter content in the substrates must not exceed 40%. With a lower water content, there are phenomena disrupting the course of the biological process.

“Wet" systems are mainly operated in a continuous mode, which increases the stability of the process, while "dry" solutions can work in a continuous or periodic system. Dry fermentation compared to wet requires a smaller reactor volume. Streams of processed matter are also smaller. It also allows to process a wider spectrum of biodegradable waste (higher non-homogeneity of the batch is allowed). In 2014, 62% of fermented waste was processed using the dry method [12]. The fermentation process can be carried out as one or two-stage (2014 7% [12]), in the mesophilic (20-40° C) or thermophilic (50-55° C) range (2014, 33% [12]).

Full stabilization and hygienisation of fermented waste requires aerobic stabilization (for at least 2 weeks).

Composting and methane fermentation entail the emission of greenhouse gases (GC) (Table 2) [13]. The fermentation itself shows a 35% lower GHG emission than composting. From the point of view of greenhouse gas emissions to the environment, for the treatment of highly hydrated biowaste, "wet" fermentation is favoured, without the aerobic stabilization of digestate. In some countries,

[2]digestate is a semi-solid or liquid product that has been processed and stabilized in a biological processing process, in which the last stage takes place in an anaerobic environment.

after the process is finished, the digestate is recommended to be transported directly to nearby farms and spread in the fields as a fertilizer. It takes around 30 tonnes of digestate waste per hectare of meadows or arable land. After covering the soil with a 3 mm layer of greenhouse gas digestate, it decreases rapidly due to inhibition of fermentation.

Table 2. Emissions from various biowaste treatment processes [13]

Emission	Average greenhouse gas emissions (in kg/Mg) from various processes:			
	Composting	Fermentation	Fermentation + stabilization in tunnels	Fermentation + stabilization in piles in open air
CH_4	4.060	0.950	3.000	11.00
N_2O	0.055	0.013	0.072	0.12
NH_3	0.157	0.024	0.130	0.72
CO_2 equivalent	118	76	97	506

GHG emissions from fermentation processes of biowaste with digestate stabilization in tunnels are lower than in the case of composting, while fermentation with stabilization of digestate in piles in open areas is more than 4 times higher than in the case of composting.

5. COMPARISON OF COMPOSTING AND FERMENTATION PROCESSES

According to the “Criteria for loss of waste status for biodegradable waste subjected to biological treatment: Technical proposals” document, uncontaminated, selectively collected biowaste is the basic raw material for the production of compost in composting plants or digestate in methane fermentation installations, which may lose the status of waste [14].

Requirements for raw materials in terms of content of organic substances, biogenic elements, hydration and pH of the environment are similar for aerobic and anaerobic technologies. The structure of the raw material for biological processing by aerobic or anaerobic technology is determined by its structure (size, shape and mutual grain system). For the aerobic processing, waste with a porous structure, forming a well-oxygenated environment with a sufficient amount of water, i.e. humidity of 50% to 60% (e.g. garden and park waste), is more suitable. Organic waste with no structure, higher humidity (e.g. food and kitchen waste) is more suitable for the fermentation process, because during their aerobic stabilization there is a risk of colonization and formation of anaerobic zones in piles.

The fermentation process is not suitable for the processing of wood-based materials (brown parts of plants).It is also a more complex technical process and therefore, more expensive to operate than the composting process. Obviously, the total cost of operation depends heavily on the revenues obtained from the sale of energy obtained from biogas. The available data show that the costs of processing of 1 Mg of biowaste depend on the size of the installation and for facilities with a capacity of 15-20 thousand Mg, they are comparable for both technologies. For lower capacity plants, composting is more efficient and fermentation is better for higher throughput.

Both waste treatment technologies, aerobic and anaerobic, have advantages and disadvantages. Their general features are shown in Table 3.

Table 3. Comparison of anaerobic and aerobic waste biostabilization [11,15]

Criterion	Methane fermentation / anaerobic stabilization	Composting / oxygen stabilization
1	2	3
Technology development	in a state of development	state of the technology
Microorganisms	different bacteria	bacteria, fungi, *actinomyces*
Receipt of waste	flat or deep bunkers	
Raw materials	2 ingredients (biowaste + water) and heat	3 ingredients (biowaste + water + air), possibly structural material
Products	- biologically stabilized digestate (required dehydration and oxygen stabilization) - biogas (high-energy gas) - sewage (treatment required)	- compost (for sale) or stabilizer - post-process air required purification on biofilters - condensates, sewage (recirculation recommended, excess - cleaning)
Environment: - oxygen - optimal substrate moisture - nutrients - pH value - temperature	- anaerobic process - from 60% to 90% - C/N=10:1 ÷ 30:1 - from 6.5 to 8.0 - 35^o C (mesophilic process) - 55^o C (thermophilic process)	- Oxygen process, from 5% to 15% O_2 in the air in the pores - from 40% to 60% - C/N = 20:1 ÷ 35:1 - from 5.5 to 8.0 - up to 60^o C

1	2	3
Degree of decomposition of organic substances	from 45% to 67%	approx. 55%
Nature of the process	endothermic	exothermic
Energy demand	as a rule, excess energy	energy-intensive process (continuous aeration)
Sanitary properties of the product	sanitary product, only after thermophilic fermentation	sanitary product
Odour emission	- non-odour fermentation (process carried out in a hermetic installation) - emission in the process of acceptance and pre-treatment and confectioning of the product (recommended purification on biofilters)	- in all stages of the process (purification required on biofilters)
Corrosion	- lack of oxygen reduces corrosion	- significant danger of equipment corrosion
Sewage - Quantity (dm^3/ton) - COD (g/dm^3) - BOD_5 (g/dm^3) - NH_4^+ (mg N/dm^3)	 - 200 ÷ 350 - 0.50 ÷ 2.5 - 0.10 ÷ 1.2 - 15 ÷ 300	 - 10 ÷ 60 (leachate) - 10 ÷ 100 - 5 ÷ 45 - 50 ÷ 800
Process duration (weeks)	- process:2-3 - treatment after the process: oxygen stabilization; 2-8	- process:18 ÷ 16 - treatment after the process:-
Individual space requirement	- from 0.2 to 0.4 m^2/Mg	- from 0.3 to 0.6 m^2/Mg

In the case of biowaste processing, fermentation compared to composting seems to be a more favourable solution, both for technical and technological reasons, as well as for economic reasons. The following conditions support this thesis.

- High humidity and high susceptibility of kitchen and food waste to biological decomposition allow directing this waste to fermentation without significant adjustment of its composition. In the case of biowaste composting, it is necessary to reduce its moisture content and ensure the required air porosity by mixing waste with structural material. In spite of this, the mixtures often still have a tendency to be compressed, which leads to the formation of anaerobic zones inside the piles, and consequently to odours, and inhibits the composting process.

- In the composting process, the greater part of the energy potential of raw materials is released in the form of waste heat, whereas with anaerobic digestion over 80% of energy goes into biogas and can be used.
- Fermented waste (digestate), after aerobic stabilization and possible separation of hard parts, is (just like compost) a high quality product for agricultural management.

An important advantage of fermentation compared to composting is the engineering ability to have full control over gas and sewage emissions, both recoverable and requiring purification. Waste fermentation installations are fully hermetic. The emission of pollutants into the atmosphere is minimal and can only occur during the loading and unloading of the reactor. In contrast, the problem of odour emissions from piles during composting has not been sufficiently solved yet. The concentration of volatile organic compounds in the air from the MBP installation (expressed as the sum of organic carbon) is 10-2000 mg/Nm^3, but concentrations up to 7500 mg/Nm^3 were also measured. In order to avoid adverse impact on the environment and possible complaints of the local community, it is necessary to conduct an intensive phase of the oxygen process in closed reactors and to clean a large volume of waste air, at least in the system of water scrubber + biofilter.

Anaerobic waste treatment is also more favourable due to:

- energy self-sufficiency, and usually excess energy enabling its sale; creating a gas energy carrier leads to a positive energy balance from the fermentation process. Depending on the processing technique, the surplus reaches 30-60% of electricity and/or 30-70% of heat;
- the superior perspective of energy production from renewable sources;
- less land demand - the space requirement for fermentation plants is about 50-80% lower than for a composting plant with a similar capacity.

A certain problem is the sale of compost - so far there is not much experience in the field of sales opportunities for the fermented waste. Numerous studies on the quality of waste indicate that it has qualitative features comparable to compost. Aerobically stabilized fermentation and dehydrated to approx. 30-35% has an earthy appearance and smell and, compared to typical compost, has a lower C/N ratio and fine grain structure.

The growing importance of fermentation is confirmed by a report presenting the new biowaste management strategy in Austria, recently published by the Environmental Protection Agency [16]. Among the recommendations contained therein, there are the following:

- from the point of view of the use of nutrients and greenhouse gas emissions, fermentation should be the preferred option for processing biowaste, for which it is an appropriate technology;

- composting should be used mainly for the processing of biowaste, for which fermentation is not a suitable technology (or not suitable at all - low potential for biogas production), and for digestate stabilization in the case of separation of the solid phase from the fermented liquid;
- digestate and compost should primarily be used in agriculture;
- legal requirements and application guidelines should be quickly adapted to ensure the efficient use of compost and digestate resources.

6. CONCLUSION

Biological methods of processing organic waste have a strong position in waste management. Both waste processing technologies, composting and fermentation, have advantages and disadvantages. The choice of composting or fermentation is always determined by specific local conditions. It seems, however, that in the case of biowaste processing, methane fermentation should play an increasingly important role due to a number of advantageous features that it exhibits compared to composting.

Over the past 20 years, the technological and technical solutions of the fermentation plant have been systematically optimized. The initial operational problems has been solved, and the adopted technological concepts adapted to the specific properties of solid waste. As a result, methane fermentation technology is now a fully acceptable, proven, good technology for processing biowaste and allows the production of high quality compost.

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KOMPOSTOWANIE I FERMENTACJA BIOODPADÓW – WADY I ZALETY PROCESÓW

S t r e s z c z e n i e

W 2016 roku, w państwach członkowskich Unii Europejskiej (UE) tylko mniej niż połowa wytwarzanych bioodpadów, około 40 milionów ton, była wykorzystywana do produkcji kompostu i do pewnego stopnia biogazu. Większa część nadal była spalana lub składowana razem z innymi odpadami. W dniu 14 czerwca 2018 r. opublikowano nowelizacje 6 dyrektyw dotyczących gospodarki odpadami. Jedną z najważniejszych zmian wprowadzonych w dyrektywie ramowej w sprawie odpadów jest zobowiązanie państw członkowskich, aby do najpóźniej od dnia 31 grudnia 2023 r. bioodpady były poddawane recyklingowi u źródła lub selektywnie zbierane, w celu kompostowania lub fermentacji. W artykule przedstawiono potencjał bioodpadów i ich wykorzystanie do produkcji kompostu oraz zmiany w dyrektywach dotyczące postępowania z bioodpadami, które kształtować będą kierunki rozwoju gospodarki tymi odpadami w UE po 2020 r. Porównano również procesy kompostowania i fermentacji bioiodpadów, okreslając ich wady i zalety. Informacje te mogą być pomocne przy wyborze technologii ich przetwarzania, podejmując decyzje o budowie nowych lub modernizacji istniejących instalacji.

Słowa kluczowe: surowce, bioodpady, kompostowanie, fermentacja

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