Composting in Bags

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Abstrakt

A progressive method of processing biodegradable waste is its composting in bags which is considered a very advantageous technology from the financial and operational point of view (Diaz, 2007). This composting method is relatively new, it was developed in Germany in the early 1970's, and consequently it spread into other countries as well. Currently, attempts to apply composting in bags in the Czech Republic are being recorded too. (eurobagging.com, 2011)

Keywords: waste, biodegradable waste, composting in bags, composting methods, composting process

1. TECHNOLOGICAL PROCEDURE OF COMPOSTING IN BAGS

Composting in polyethylene bags is a convenient alternative to composting in belt pipes at open area mainly due to usability at areas unsecure with respect to water resources, due to minimum amount of odour, aesthetic appearance and non-interference into a composting process after locating biodegradable waste into bags with mechanization (Plíva, 2009). However, producing compost in bags is demanding due to ensuring optimum conditions of composting process, therefore it is necessary to observe the sequence of work stages during the technological procedure which also include intake of composted materials, establish a compost in bags, managing the course of composting process including its finalization and dispatching the produced compost. (eurobagging.com, 2011; Plíva, 2011a)

To have a quality compost, it is necessary to mix raw materials in a correct rate and suitable size. Raw materials homogenised and mixed with a composting machine are placed into composting bags at cemented or paved areas. An accordion-folded bag is put onto a composting machine carrier and it is secured with a rubber-textile rope. (Plíva, 2011a)

To secure aeration of composted mixture inside the bag, a polyethylene hose (PE) is put inside a bag which must be tightened before filling in the bag with composting mixture. Bio-waste is gradually being pushed in with a worm press or a sliding shield from a funnel into a bag. After being filled up, the bag closes tightly and the end of PE hose is fastened to a fan which aerates the mixture. The bag as well as the hose are usable only in one composting process while other technical devices may be used repeatedly. (Plíva, 2011a)

Attle must have convenient moisture of approx 50% before being put into bags because the mixture cannot be moistened after closing the bag (Kalina, 1999). The bag is closed with a special tape. The PE hose is connected to a fan which ensures program-controlled aeration. Thermometers are inserted into the bag to monitor temperatures during the composting process. The length of composting maturing process in bags is 6 – 8 weeks. (crs-marketing.cz, 2010; epristroje.cz, 2016)

After expiration of the period needed for composting process which is determined according to values gained via monitoring, the composting bag is cut open lengthwise. Depending on quality of the compost and on purpose of its use, the compost is then carried away to be used directly or it is transported to another place for subsequent treatment (Kára, 2001). Used bags including PE hoses are passed in for recyclation.

2. COMPOSTING MACHINES AND OTHER EQUIPMENT

A controlled composting process requires using machines, equipment and other facilities (Hohenberger, 1999). These are disposers preparing material for compost attle, loaders for filling up a funnel of a composting machine and for loading finished compost, composting machines for homogenisation and for filling up bags, sifters for sifting finished compost, separators for sorting aggregate waste and other equipment necessary for securing activities related to operating composting plant. (cemaservis.cz, 2013; Plíva, 2011b)

An integral part of effective composting in bags are the following technical equipment: composting bags with the same diameter as composting press, perforated plastic aeration hoses, aeration units, thermometers and hygrometers, aeration air release valves, control unit for the fully automated aeration process, gas analyser and air distribution system outside the bag. (epristroje.cz, 2016)

For composting, bags of the same diameter as composting press are used, or more specifically its filler hole. The bags are mainly made of polyethylene recyclable foil of green colour. To meet their purpose, they have to have high UV stability for at least 3 months which is approximate time of a composting cycle (plasticsystems.cz, 2016). An elemental characteristics of such composting bags is also puncture resistance because composted raw materials contain sharp pieces (Plíva, 2011b). Therefore the wall width is up to 0.9 mm and is made of punc-

Tab. 1. The measured results of temperature and moisture (1st - 20th day)
Tab. 1. Wyniki pomiarów temperatury i wilgotności (dzień 1-20)

Day	Moisture (%)	Temperature (°C)
1	59.8	51.2
3	59.6	62.4
5	59.6	60.3
8	59.5	52.1
12	59.3	48.2
15	59.3	46.7
20	59.3	44.5

Tab. 2. The measured results of temperature and moisture (25th - 55th day)
Tab. 2. Wyniki pomiarów temperatury i wilgotności (dzień 25-55)

Day	Moisture (%)	Temperature (°C)
25	59.2	43.1
30	59.1	41.8
35	59.1	39.2
40	59.0	36.9
45	58.8	33.6
50	58.9	31.3
55	58.7	30.4

ture-resistant material. The width of a filler hole of a composting press, and therefore also a diameter of a composting bag, is 1.5 – 3 m with a standard length of bags from 45 m to 60 m. Bags of a special length are made based on individual requirements. Storage capacity of a 60-meter bag, 1.5 m wide, is about 80 t, 2.4-meter wide has a capacity of 140 t and 3-meter wide has a capacity 175 t of composted material. (crs-marketing.cz, 2010)

3. COMPOSTING IN BAGS AT A SMALL FARM

An owner of a small farm with an area of farmed land of 100 ha in Northern Bohemia (Chomutov region) has been practising bag composting for several years. He decided for that due to necessity of fast and cheap manufacturing of biodegradable waster from his own farm production (e.g. cow-dung, bedding removed at pig raising and beef-raising, remains of old hay and straw, etc.) (Váňa, 2007). Biodegradable waste produced during green vegetation maintenance from two near municipalities are treated except of the two above mentioned farm waste (Habart, 2009). The produced compost is used only for fertilising the owner's own fields because the composting plant is not licensed to sell compost. (Jalovecký, 2012)

A composting machine is used for composting itself as well as other necessary technical equipment and facilities (container carrier; portable chipper which is used for chipping branches, wood and wood waste, handler to manipulate with processed raw materials and finished compost, tractor, chipper, mobile composting plant and spreader) (eurobagging.com, 2011). The farm owner was provided with a grant for purchase of composting machine including other equipment, i.e. mobile composting plant Cernin ltd., type MK 7, serial number 609-11-14, within a grant programme „The programme for rural areas development". This device has the highest technically allowed weight of 4,460 kg and permitted weight of 7,960 kg, maximum weight of mixed rate 3,500 kg, maximum volume of mixed rate is 7 m³, manufacture output of biodegradable waste including filling into bags is 12,5 t·hour-1 and screw press capacity is 14 t·hour-1 (cernin.cz, 2010). Other technical equipment is used to composting in a bag which includes mainly LDPE bags 60 m long, with a diameter of 1.5 m and volume of approximately 100 m3 which are able to contain up to 80 t of material; perforated plastic aeration (fans) hose with bore diameter of 50 mm, 65 m long; aeration unit; electronic scale; hydrometer with integrated thermometer Super Pro Combi, serial number 42142 and tying wire for tying ends of bags. (epristroje.cz, 2016)

Waste of a given ratio of raw materials according to documentation delivered along with the mobile composting plant MK 7 was put into a mixing funnel of the composting plant with the help of a loader (i.e. 50% cut grass, 20% older grass and hay or straw, 20% wood chips a 10% manure and bedding). This mixture was mixed in the funnel for 8 minutes and

Tab. 3. The analyses results of the compost sample (% except for pH and C:N)
Tab. 3. Wyniki analizy próbek kompostu

Dry mass	Organic material	N	P	K	Ca	Mg	S	pH	C:N
40.7	28.4	1.33	0.289	1.39	1.65	0.455	0.27	7.8	10.7

Tab. 4. The results of compost analysis (mg.kg-1).
Tab. 4. Wyniki analizy kompostu – analiza zawartości

As	Cd	Cr	Cu	Hg	Mo	Ni	Pb	Zn
16.4	0.466	24.1	35.6	0.072	1.27	20.0	18.9	113

Tab. 5. Comparison of values of differently produced composts according to the quality characteristics of the compost.
Tab. 5. Porównanie różnie produkowanych kompostów według cech jakościowych kompostu

	Compost 1 (bag)	Compost 2 (belt pipe)	ČSN 46 5735	Order No. 341/08 Coll.
Moisture in %	59.3	49.9	40.0 – 65.0	40.0 – 65.0
Combustibles	28.4	35.9	min. 25.0	min. 25.0
Total nitrogen	1.33	1.9	min. 0.60	min. 0.60
C : N	10.7 : 1	9.0 : 1	max. 30 : 1	**min. 20** (max. 30) **: 1**
pH	7.8	8.5	from 6.0 to 8.5	from 6.0 to 8.5
Indecomposable admixtures	-	2.1	**max. 2.0**	**max. 2.0**

The key to Table 5: Compost 1 (bag) – the compost made in a bag, Compost 2 (belt pipe) – the compost made in belt pipes, Combustibles – observed in dried out sample in %, Total nitrogen – in terms of dried out sample in %, Indecomposable admixtures – in %.

then it was stuffed into a bag. In the given case, the weight of homogenized mixture was 3.8 t.

In the beginning, in the middle and in the end of the filled-up bag, three x-crosses of a diameter 8 × 8 cm were cut off. These cross-shaped holes were used to decrease excess pressure in the bag and at the same time they were used to put in thermometers for measuring moisture and temperature of the composted mixture inside the bag to check the required values of the mentioned factors (Roy, 2013). The temperature and moisture inside the bag were measured with a device SuperPro Combi brand and the measured results of such physical qualities are given in Table 1 and 2.

After eight weeks, the composting process was completed, the bag was cut open lengthwise and the compost was left directly at the place of composting area due to continuing ageing and drying. The resulted compost composition was analysed by company ZKULAB Ltd., Agricultural regional laboratory Malý and Co., Postoloprty, Test record No. ZO - 179. The analysed results of the compost sample are given in Table 3. (Leden, 2016)

Table 4 shows the results of the compost analysis with focus on content of risk features in the produced compost.

The observed results of analysis of compost produced in a bag are marked in the below tables as Compost 1 (a bag) and were compared to values of compost produced from the same raw materials in belt pipes which is marked in the tables as Compost 2 (belt pipes). Compost 2 was produced in an industrial composting plant. The analysed results were given in the Inspection certificate of fertilizer No. 7/2016 which was issued by Central Agricultural Control and Test Institution – Fertilizers Department) and were compared to values given by the following legal provisions: ČSN 46 5735 – Chemical fertilizers; Department of the Environment order No 341/2008 Coll., on details of handling biodegradable waste, as amended; Department of the Environment No. 383/2001 Coll., on details of handling waste, as amended; Department of Agriculture order No 474/2000 Coll., on defining requirements for fertilizers, as amended. Table 5 shows comparison of the below mentioned composts according to quality characteristics of the compost. (Leden, 2016; Řezníček, 2016; Česká soustava norem, 2009; Sbírka zákonů ČR, 2008)

The table clearly shows that the produced composts meet requirements given by ČSN 46 5735 – Chemical fertilizers (Řezníček, 2016). However, it was also observed that in both

Tab. 6. Comparing values of risk features in two differently produced composts with limiting values.
Tab. 6. Porównanie zawartości metali w dwu kompostach i w normach

Element	Compost 1 (bag) (mg·kg-1)	Compost 2 (belt pipe) (mg·kg-1)	Order No 341/2008 Coll. (mg·kg-1)			Order No. 474/2000 Coll. (mg·kg-1)	ČSN 46 5735 (mg·kg-1)	
			I.	**II.**	**III.**		**I.**	**II.**
As	16.4	12	**10**	20	30	20	**10**	20
Cd	0.466	0.613	2	3	4	2	2	4
Cr	24.1	21.8	100	250	300	100	100	300
Cu	35.6	49.9	170	400	500	150	100	400
Hg	0.072	0.115	1	1.5	2	1.0	1.0	1.5
Mo	1.27	1.97	-	-	-	20	5	20
Ni	20.0	16.1	65	100	120	50	50	70
Pb	18.9	32.3	200	300	400	100	100	300
Zn	113	257	500	1 200	1 500	600	300	600
PCB	-	-	0.02	0.2	-	-	-	-
PAH	-	-	3	6	-	-	-	-
Indec. Adm.	-	2.1	**max. 2**	**max. 2**	-	-	-	-

The key to Table 6: Compost 1 (bag) – the compost made in a bag, Compost 2 (belt pipe) – the compost made in belt pipe, Indec.Adm. – Indecomposable admixtures %.

composts produced, there is not sufficient ratio C:N given by the related order (highlighted in red in Table 5). The compost made in a bag has C:N ration 10.7:1 and the compost from a belt pipe 9:1 while the legislation declares the ration of the two elements minimum 20:1 and maximum 30:1. The compost made in a bag, the amount of indecomposable admixtures was not analysed, yet the compost produced by composting in belt pipes contains more indecomposable admixtures than the legislation permits. Table 6 shows amount of risk features of Compost 1 (produced in a bag) and Compost 2 (produced in a belt pipe) and the highest amounts of risk features and elements allowed by effective orders (I, II and III cat. of group 2 for outputs used outside agricultural and forest soil) and limiting values of risk features in fertilizers, assistant soil materials, assistant vegetable agents and substrates according to class I and II.

As Table 6 clearly shows, both composts contain bugger amount of arsenic than provided by Order No. 341/2008 Coll., on details of handling biodegradable waste, as amended, for group 2, class I, and ČSN 46 5735 – Chemical fertilizers for class I. In the in-bag produced compost, the presence of this element was proved in value of 16.4 mg·kg-1 and in the belt-pipe produced compost, it was 12 mg·kg-1 while the limiting value is 10 mg·kg-1. Other admissible values of risk substances were not exceeded. (Řezníček, 2016; Sbírka zákonů ČR, 2008, 2000)

In compost made in belt pipe, bigger amount of indecomposable admixtures was observed than maximum limits in both norms provide. 2.1% was measures while the limit is 2.0% maximum.

During the following compost production in a bag, it will be necessary to increase the content of C:N, namely by setting a convenient ratio of raw materials in a base by adding bigger amount of material containing higher ration of C:N which can be done through increasing the content of hay, straw, wood chips, saw dust and leaves in a compost base, eventually decreasing the amount of raw materials containing higher amount of nitrogen, e.g. liquid manure.

The higher content of arsenic in both produced composts is caused by higher amount of arsenic in the soil in this region and by long-term exposure of the soil to arsenic from combustion gases from nearby heat power plants which burn brown coal (Počerady, Tušimice, Prunéřov, Ledvice) which influences the content of arsenic in individual components of composted materials.

Indecomposable admixtures are substances which cannot decompose during humification (stones, glass, etc.). Decreasing their amount in produced compost can be reached by removing these admixtures from materials forming the base of a compost. (Hlavatá, 2006)

CONCLUSION

It was observed, during realization of in-bag compost production, that its main advantage is lower initial costs than in case of the most widespread method of composting which is composting in belt pipes. Bags can be stored at unconsolidated uncovered surface which decreases initial costs. Although covered surface is needed too, it is only necessary for preparation, event. for short-term storage of biodegradable waste before filling it into bags. Compost production in bags is faster with minimum amount of odour which, together with smaller area needed for bag storage, enables easier rearrangement related to the place where biodegradable waste is located. Unquestionable advantage of in-bag composting is also the fact that composting process is not affected by climatic conditions. Composted materials are not turned over in the course of composting which decreases requirements on human resources during composting process.

The disadvantage of in-bag composting is undoubtedly demanding preparation of composition of composted raw materials including their humidity because after putting raw materials into a bag, it is not possible to interfere in raw material composition. Another disadvantage is disposal of LDPE bags and aeration hoses after the finished composting processed.

Despite all observed imperfections, the compost produced in a bag and in bet pipe can be considered high-quality (Sulzberger, 1996). The benefit of in-bag composting undoubtedly is the speed of quality compost production at lands which do not require any special adjustment. Thus costs for biodegradable waste transportation to the location of composting are decreased which might be considered one of advantages of this composting method compared to composting in belt pipes. Also aesthetic aspect this composting method should be mentioned. In addition, saving human resources and technology during composting in a bag should be stressed because it is not necessary to turn compost over in the course of composting process.

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Kompostowanie w workach polietylenowych

Innowacyjną metodą przetwarzania odpadów biodegradowalnych jest ich kompostowanie w workach, co jest uważane za bardzo korzystną technologię z finansowego i operacyjnego punktu widzenia (Diaz, 2007). Ta metoda kompostowania jest stosunkowo nowa, została opracowana w Niemczech na początku lat siedemdziesiątych, w związku z czym rozprzestrzeniła się również na inne kraje. Obecnie rejestrowane są również próby zastosowania kompostowania w workach w Czechach. (eurobagging.com, 2011)

Słowa kluczowe: odpady, odpady biodegradowalne, kompostowanie w workach, metody kompostowania, proces kompostowania