Effect of bio-technological agents on the composting process and gaseous emissions production from the composting process

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Abstract: In the contribution are presented results of two experiments with utilisation of bio-technological agents Bacteriocomposter Plus and Bio-Algeen G40. The effect of these agents on the course of the composting process and emissions production from the composting was investigated. The experiment was also carried out with utilisation of biofilter. The emissions measuring was carried out by the continual method utilising the measuring apparatus INNOVA MULTIGAS (monitor 1312) Multipoint Sampler 1309 INNOVA. The results of the experiments have confirmed that the bio-technological agents have effect on the reduction of the emissions production from the composting activity.

Keywords: controlled microbial composting; biofilter; gas emissions; compost; bio-technological agents

According to the Annex No. 2 of the Governmental Decree No. 353/2002 determining the emission limits and other conditions for operation of other air pollution stationary resources also such activities belong to the stable livestock breeding which are connected with the animal excrements handling including areas for crop production. Therefore even the composting plant can be included into the devices serving for the animal excrements processing (Plíva *et al.* 2004a).

For all agricultural resources of pollution is valid the specific emission limit for ammonia on level of general emission limit (= 50 mg/m^3) and specific emissions limit for volatile substance = 50 OUER/m^3. The general emission limit for volatile substances for the composting plants is 50–100 OUER/m^3 on the filter output or 5–20 OUER/m^3 on the composting plant boundary.

In some cases the many gases release during the composting process what is caused by the composted raw materials decomposition. In consequence of this the process generates odour in the fillings surrounding. On the market is available a lot of bio-technological means reducing or even removing the odour after their application as recommended by the producers.

Besides this ability some of them are acting as the composting process stimulator and thus the number of compost turning is reduced.

MATERIAL AND METHODS

The measuring was carried out at the Reserch Institute of Agricultural Engineering (RIAE) experimental composting plant located in the Research Institute of Crop Production (RICP) premises consisting of area 60 × 10 m.

The compost temperature and oxygen content were measured by the digital thermometer with the necking-down probe of firm Sandberger, the oxygen content was found out by the apparatus of firm ASEKO.

Description of used agents

Bacteriocomposter Plus – determined for acceleration of crop waste composting by aerobic way. It consists of selective adapted microbial cultures mixed

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Table 1. Compost heaps raw material composition

Heap No.		Raw material composition 21. 6. 2004	Volume (m^3)	Percentage share (%)	Volume weight of sample (kg/m^3)	
					21. 6. 04	1. 7. 04
1	1/2 covered	application of agent Bio-Algeen G40				
	1/2 uncovered	3 l G40 + 150 l H_2O			1 581.67	638.33
	24.6.	application 3 l G40 + 150 l H_2O				
	25.6.	application 3 l G40 + 150 l H_2O				
	28.6.	application 3 l G40 + 150 l H_2O				
		farmyard manure	4	50		
		grass	4	50		
		Σ	8	100		
2	1/2 covered					
	1/2 uncovered	control heap			482.22	628.33
		farmyard manure	4	50		
		grass	4	50		
		Σ	8	100		
3	1/2 covered	application of agent Bacteriocomposter Plus				
	1/2 uncovered	1 kg of agent + 50 l H_2O			591.67	632.67
		farmyard manure	4	50		
		grass	4	50		
		Σ	8	100		

with enzymes, emulgators, yeast containing mainly vitamins of group B and growth factors, inorganic resources of N and P, zoeletium acting as sorbent and material for living micro-organisms, physiological factor Nall and micro-nutrients, immobilisation in the preparation. The agent is acting as "starter" and "accelerator" of the composting process.

Bio-Algeen G40 – hydrolysis plant of the brown sea algae contains amino acids, peptides, organic acids, minerals, and vitamins. The agent supports development of micro-organisms, accelerates bio-degradable processes and reduces H_2S and NH_3 emissions.

Verification of the bio-technological agents effectiveness on the composting process course and gaseous emissions production

In June 2004 has started an experiment at the composting plant with a scope to verify effect of the bio-technological agents on the gaseous emissions production, composting process course and final product quality. For this purpose was utilised technology of the controlled microbial composting in the belt heaps – aerobic controlled composting (Jelínek *et al.* 2002, 2004).

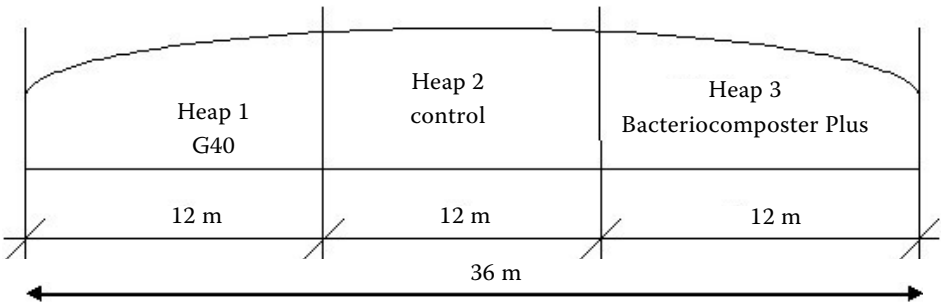

Figure 1. Heap dislocation and size

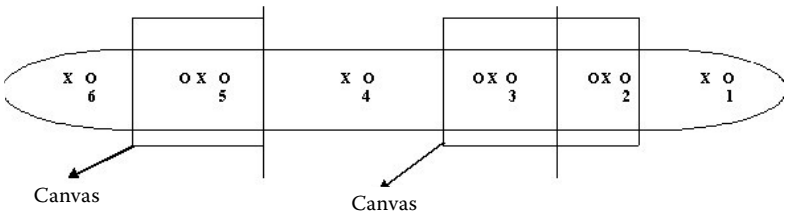

Figure 2. Scheme of emissions. temperature and oxygen measuring points

x – measuring point of temperature and oxygen

o – emissions measuring point

After the experiment implementation was established one filling containing three heaps of identical raw material composition. The heap 1 was treated by the bio-technological agent Bio-Algeen G40, the heap 2 served as controlling and the heap 3 was treated by the bio-technological agent Bacteriocomposter Plus. Each heap was divided into two halves of which one always was covered by the fabrics Top Tex. Each heap was measured for gaseous emissions, temperature and oxygen content.

The emissions measuring was carried out by the measuring device INNOVA MULTIGAS (monitor 1312) Multipoint Sampler 1309 INNOVA (Jelínek & Pecen 2003). Measured was the NH_3, CO_2, CH_4, H_2S content. The measuring was performed from 24. 6. 2004 to 1. 7. 2004. The measuring sensors were removed from the heap during the compost turning and inserted again after the turning finishing (about 1.5 h).

The raw material composition of the compost heaps is presented in Table 1. The scheme of heaps distribution and size is shown in Figure 1, scheme of emissions measuring points, temperature and oxygen in Figure 2.

Verification of the bio-technological agents effectiveness on production of gaseous emissions from the composting process with utilisation of bio-filter

In September 2004 was established an experiment at the composting plant with objective to find out effect of the bio-technological agents on gaseous emissions production from composting with utilisation of the bio-filter. For this purpose was utilised technology of the controlled microbial composting in the belt heaps – aerobic controlled composting.

The compost filling has contained one heap covered by the air-tight canvas. The heap raw material composition is presented in Table 2.

The compost temperature and oxygen content were measured regularly. The compost temperature was measured by the digital thermometer with the necking-down probe of the firm Sandberger, oxygen content was found-out by the measuring apparatus of the firm ASEKO.

The gases emissions measuring passing through the bio-filter was implemented by the measuring apparatus INNOVA MULTIGAS (monitor 1312) Multipoint Sampler 1309 INNOVA. Measuring of NH_3, CO_2, CH_4, H_2S content also was carried out.

The bio-filter consists of the large-volume container, perforated bottom and inlet pipeline and partition walls. For the experiment purpose the whole space was divided into three chambers. For the chambers charge was used wooden bark moisturised to about 60%. The two chambers charge were treated by the bio-technological agents Bio-Algeen G40 (charge 2) and Bacteriocomposter Plus (charge 1). The central chamber charge has not been treated – controlling.

The gas emissions were measured in five measuring points:

S1 – in the compost heap,

S2 – in the compost inlet pipeline,

S3 – in the bio-filter chamber without bio-technological agent application,

S4 – in the bio-filter chamber with the bio-technological agent Bacteriocomposter Plus application,

S5 – in the bio-filter chamber with the bio-technological agent Bio-Algeen G40 application.

The charges composition of the bio-filter individual chambers is presented in Table 3.

Table 2. Compost heaps raw material composition

Heap No.	Raw material composition	Volume (m^3)	Percentage share (%)	Volume weight of compost sample (kg/m^3)
	pig manure	6	30	
1	grass	10	50	
	chopped material	4	20	267.62
Σ		20	100	

Table 3. Bio-filter charge

Chamber	Charge	Volume weight (kg/m^3)	Porosity (%)	Moisture (%)
Charge 1	wooden bark – 0.33 kg Bacteriocomposter + 10 l H_2O	328.33	61.68	57.3
Charge 2	wooden bark – 0.12 l Bio-Algeen G40 + 10 l H_2O	333.33	57.85	60.3
Control	wooden bark without application – control	333.33	63.33	60.1

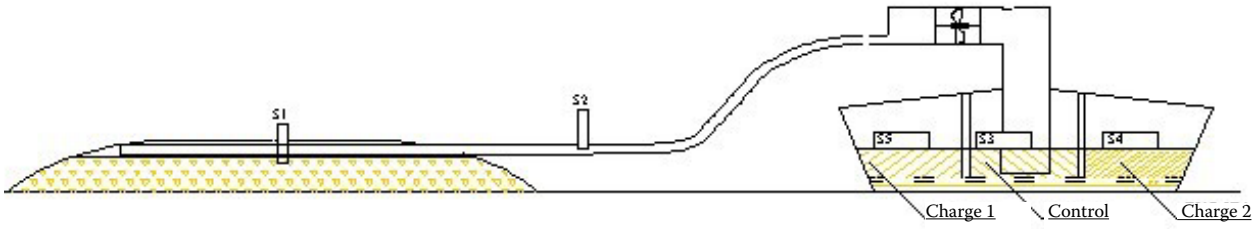

Figure 3. Bio-filter scheme

The bio-filter and gaseous emission measuring points scheme is presented in Figure 3.

RESULTS

Verification of the bio-technological agents effectiveness on the composting process course and gaseous emissions production

In the course of the composting process was provided also visual and sensuous evaluation of the filling heaps. In the heap 1 and 2 was found increased occurrence of small flies, in the heap 3 their occurrence was slightly lower.

The temperature reached relative low values in all heaps, only the heap 1 has showed higher temperature at the beginning of the composting process. This was probably caused by the fact that the composted raw materials were matured (degraded) and the composting process had passed with a lower intensity.

The oxygen content was almost identical in all the heaps and the values were constant in the course of the composting process.

The compost samples were taken during the experiment establishing and its finishing. The sample analysis was carried out in the agrarian laboratory in RIAE in Prague (Tables 4 and 5).

On the basis of the finished compost agrarian chemical analysis can be stated that the heap 3 treated by the agent Bacteriocomposter Plus and the control heap 2 have varied from the requirements of the standard ČSN 46 5735 "Industrial composts

Table 4. Compost agrarian – chemical analysis (24. 6. 2004, Agrarian laboratory RIAE)

	Moisture (%)	Combustible substances (% d.m.)	N (% d.m.)	pH
Heap 1 (agent Bio-Algeen G40)	48.83	45.25	1.97	8.47
Heap 2 (control)	45.77	42.38	1.97	8.29
Heap 3 (agent Bacteriocomposter Plus)	53.92	42.63	1.85	8.38
Qualitative signs according to ČSN 46 5735	40.0–65.0	min. 25	min. 0.60	6.0–8.5

Table 5. Compost agrarian – chemical analysis (1. 7. 2004, Agrarian laboratory RIAE)

	Moisture (%)	Combustible substances (% d.m.)	N (% d.m.)	pH
Heap 1 (agent Bio-Algeen G40)	42.10	36.15	1.75	8.66
Heap 2 (control)	33.47	20.72	1.61	9.02
Heap 3 (agent Bacteriocomposter Plus)	34.45	27.3	1.58	8.71
Qualitative signs according to ČSN 46 5735	40.0–65.0	min. 25	min. 0.60	6.0–8.5

in the qualitative sign-moisture". The control heap 2 also does not meet the demand for the combustible substances content. The heap 3 treated by the agent G40 complies with all the qualitative signs as specified by the standard ČSN 46 5735, except for pH-value.

On the basis of the emission measuring results was found out that the agent Bio-Algeen G40 reduced the NH_3 emissions production by 72%, CO_2 emissions by 40%, CH_4 by 72.28% and H_2S emissions by 35.24% compared with a value measured in the control heap (without agent application).

The agent Bacteriocomposter Plus reduced the NH_3 emission production by 66.53%, CH_4 emissions by 73.89%, H_2S emissions by 16.96%, CO_2 emissions have increased by 57% in comparison with a value measured in the control heap. The CO_2 emissions increasing can be caused by the agent incorrect application.

The CH_4 emissions measured values from 28. 6. 2004 are presented in Figure 4.

Verification of the bio-technological agents effectiveness on production of gaseous emissions from the composting process with utilisation of bio-filter

The results of measuring have proved that the bio-filter reduced in comparison with the production

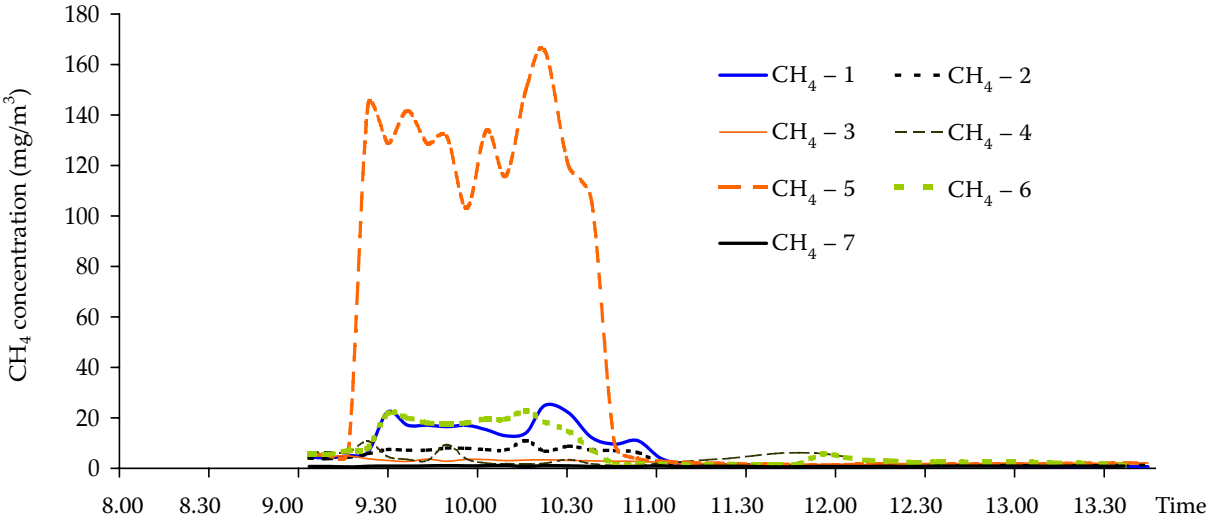

Figure 4. Graph of CH_4 concentration values measured on 28. 6. 2004

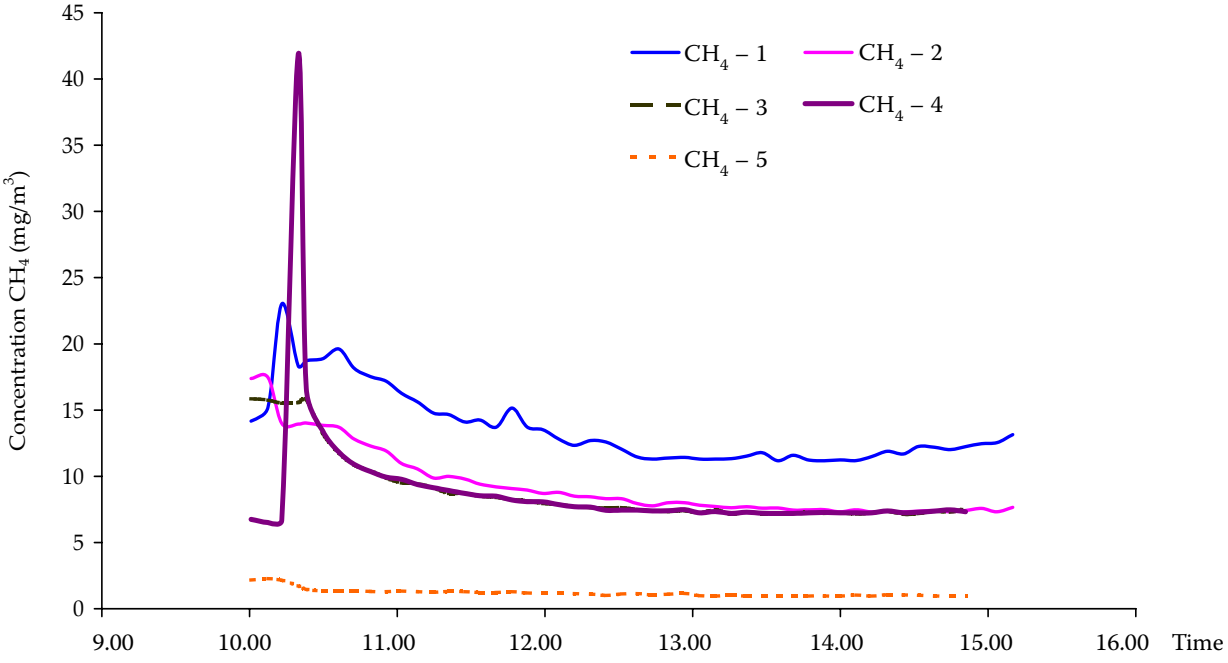

Figure 5. Graph of CH_4 concentration values measured on bio-filter on 27. 9. 2004

Table 6. Qualitative signs of finished compost (Agrarian laboratory RIAE)

Sample	Moisture (%)	Combustible substance (% d.m.)	N (% d.m.)	C:N
Finished compost	35.98	61.12	1.71	17.87
Qualitative signs according to ČSN 46 5735	40.0–65.0	min. 25	min. 0.60	max. 30

of gaseous emissions from the compost heap the CH_4 emissions by 86.6%, CO_2 emissions by 80.83%, H_2S emissions by 68.46% and NH_3 emissions by 83.20%.

In the bio-filter part with application of the agent Bacteriocomposter Plus the CH_4 emissions were reduced by 42.3%, CO_2 emissions by 48.79%, H_2S emissions by 23.1% and NH_3 emissions by 75.15%. The graph of the CH_4 concentration values course from 27. 9. 2004 is presented in Figure 5.

High reduction of CO_2 emissions was probably caused by using the optic filter with infrared wavelength 4.5 μm for measurement. There was perhaps N_2O presence in the compost heap, which molecules have resonance frequency near resonance frequency of CO_2 molecules. Therefore for the next measurement was chosen the optical filter with infrared wavelength 4.4 μm.

On the basis of agrarian-chemical analysis of the finished compost samples can be stated that the produced compost meets the requirements of the standard ČSN 46 5735 (Table 6) in the all qualitative signs.

DISCUSSION

An important role in the environmental policy has currently been played by the Kyoto Protocol on climatic changes (Jelínek & Kollárová 2004). The biomass is known for a long time as partial substitution of fossil fuels. At present exists a new look on the climatic changes stoppage. More significant role is played by organic matter fixed in soil (Plíva *et al*. 2004b).

A strong motivation for the organic fertilizer application is effort to fix organic carbon in the soil (sequestration) and thus reduce the CO_2 content in atmosphere.

Other potential advantage is a fact, that the organic fertilizers improve the soil fertility, increase water collection, reduce the crop pathogen occurrence (it leads to the pesticides consumption reduction), and soil erosion reduction. It is difficult to appreciate these externalities but they can lead to the considerable energy consumption reduction what could play an important role in a future.

These facts are still more and more accepted as a stimulus for environmental policy. The thematic strategy for soil protection published by the European Commission emphasises importance of the carbon sequestration in the soil.

The controlled microbial composting on the belt heaps is a technology applicable particularly for small-size agricultural enterprises but also for community and municipal composting plants.

One of many problems preventing the more large extension of that technology into practice is odour from the compost fillings what is a problem especially in the cases when the composting plant in situated nearby the human settlements. The problem is serious also for a reason of subjective odour receptivity and evaluation.

CONCLUSIONS

The submitted results of the research have proved that the bio-technological agents can be utilised for reduction of NH_3, CO_2, CH_4, H_2S emissions. Their application is suitable mainly in the case when for various reasons it is not possible to provide correct course of the composting process and thus also the odour reduction by regular heaps turning.

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Abstrakt

Kollárová M., Altmann V., Jelínek A., Češpiva M. (2006): **Vliv biotechnologických přípravků na průběh kompostovacího procesu a produkci plynných emisí z kompostovacího procesu**. Res. Agr. Eng., **52**: 145–151.

V příspěvku jsou prezentovány výsledky dvou experimentů při použití biotechnologických přípravků Bakteriokompostér Plus a Bio-Algeen G40. Byla zkoumána účinnost těchto přípravků na průběh kompostovacího procesu a produkci emisí z kompostovací činnosti. Experiment byl proveden také s použitím biofiltru. Měření emisí bylo provedeno kontinuální metodou měřícím přístrojem INNOVA MULTIGAS (monitor 1312) Multipoint Sampler 1309 INNOVA. Výsledky experimentů potvrdili, že biotechnologické přípravky mají vliv na snížení produkce emisí z kompostovací činnosti.

Klíčová slova: řízené mikrobiální kompostování; biofiltr; emise plynů; kompost; biotechnologické přípravky

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