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INTENSITY OF SEWAGE SLUDGE COMPOSTING PROCESS WITH DIFFERENT ADDITIONS ON THE BASIS OF DEHYDROGENASES ACTIVITY AND THE SUCCESSION OF SELECTED BACTERIA GROUPS*

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Abstract. The problem of sewage sludge composting is the subject of many scientific investigations. If the process of composting runs properly, a consequent dominance of determined types and groups of microorganisms in connection with the successive changes in temperature occurs. In this paper, changes in the number of mesophilic and thermophilic bacteria were examined in the process of composting sewage sludge together with all sorts of additions. Influence of the differences in the composition of compost on bacteria development dynamics was also examined. Colonies of bacteria isolated on selective culture mediums were the base for determining the total number of bacteria in the compost. Relation between the activity of dehydrogenases and the number of mesophilic and thermophilic bacteria was also examined. It was estimated that the composition of compost and pH did not interact with the number of mesophilic and thermophilic bacteria during the composting process. Existence of relation between the decrease in the number of microorganisms and the increase in T (temperature) was observed. On the basis of the obtained results, it was also found that the activity of dehydrogenases positively correlated with the number of mesophilic bacteria.

Key words: bacteria, bioreactor, compost, dehydrogenase, sewage sludge

INTRODUCTION

Composting represents the sum of microbiological processes taking place in oxygen conditions, and their final product is humus [Wong and Fang 2000]. Next to humus, there also develop significant amounts of carbon dioxide and heat. Temperature reached during the composting process exerts a significant influence on the quality of the obtained compost [Taiwo et al. 2004]. Temperature is responsible for the liquidation of pathogenic microorganisms [Czekała et al. 2006], larvae, insects, and weed seeds.

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Inside the compost heap, its oxygenation and moisture are directly connected with temperature.

According to Błaszczyk [2007], the composting process takes place in four stages. The first stage represents the mesophilic phase, where the temperature ranges from 25 to 45°C. It is connected with the quick growth of microorganisms, which take advantage of the easily degradable organic matter, such as sugars or aminoacids.

The successive stage of composting includes the thermophilic phase, where the temperature quickly increases and may reach even 70-80°C. Significant amounts of moisture in this phase evaporate from the composted material, while the pH value increases to the level of 7.5-9. This phase exerts a key effect on the change in the succession of microorganisms. Spore-forming mesophylls remain at that time in the state of anabiosis, while not spore-forming mesophylls perish. On the other hand, there proliferate thermophilic microorganisms.

In the phase of cooling down, temperature gradually decreases to 40°C, mainly as a result of thermophilic microorganisms succession. In this phase, there comes primarily the degradation of cellulose and hemicelluloses, and consequently the compost mass decreases by a half.

The last phase in the composting process is the cold phase, when the compost ripens.

Thermophilic microorganisms gradually lose their activity to the advantage of the mesophilic microorganisms. This phase ends the composting process, and the humus obtained in it represents the final product of the whole process.

Thus, the microorganisms are the key element of the composting process. They utilize simple organic compounds as the sources of energy. Combined organic compounds are also decomposed in order to satisfy the energetic needs and to gain construction components [Marx et al. 2001]. During composting in the bioreactor, the basic role is played by the oxygen mesophilic bacteria. The course of the composting process, the length of the phases and the reached temperature can be controlled to a significant degree by such factors as the intensity of aeration or irrigation [Dach et al. 2003]. However, the succession of bacteria takes place at definite temperatures and it indicates the correctness of the composting process course.

The determination of the activity of dehydrogenases is, next to temperature monitoring and measurement of CO_2 release or of the control of the microorganisms, a succession representing a successive valuable instrument used for the control of the intensity of the composting process course. The activity of dehydrogenases is directly connected with the activity of microorganisms [Piotrowska-Cyplik et al. 2007].

Dehydrogenases represent enzymes from the oxydoreductases occurring in the cytoplasm and organelles of living organisms. Their task is to catalyze the oxygenation reaction of organic compounds, and they perform this function by disconnection of electrons and protons from the organic compounds [Eiland et al. 2001].

The objective of the presented studies was the control of the intensity of the composting process of sewage sludge with additions (straw, sawdust, and disintegrated and not disintegrated bark) on the basis of the activity of dehydrogenases and the succession of selected groups of bacteria. In the presented experiment, it was assumed that temperature will be the main factor conditioning changes in the number of meso- and thermophilic bacteria and in the level of dehydrogenases activity. The increase in temperature will increase in the composts the domination of thermophilic bacteria, decrease the number of mesophilic bacteria, and slow down the metabolic processes of microorganisms defined on the basis of dehydrogenases activity.

MATERIAL AND METHODS

The experiment was established in laboratory conditions in 2007. The studies were carried out in four bioreactors of 125 dm^3 capacity and equipped with electronic sensors for the constant recording of some process parameters (temperature, carbon dioxide, methane, ammonia and oxygen). Materials for the studies were thoroughly mixed in a container in weight proportion in relation to dry matter. The microbiological and chemical analyses are presented in Tables 1 and 2.

Table 1. Number of microorganisms (cfu·g^{-1} d.m.) and dehydrogenases activity (µmol TPF·g^{-1} d.m. of material·5 h^{-1}) in biowaste used in the experiment

Tabela 1. Liczba mikroorganizmów (cfu·g^{-1} s.m.) i aktywność dehydrogenaz (µmol TPF·g^{-1} s.m. materiału·5 h^{-1}) w odpadach użytych w doświadczeniu

Kind of microorganisms Rodzaj bakterii	Sewage sludge Osad ściekowy	Straw Słoma	Sawdust Trociny	Disintegrated bark Kora rozkruszona	Not disintegrated bark Kora nierozkruszona
cfu·g^{-1} d.m. of material – cfu·g^{-1} s.m. materiału					
Mesophilic bacteria Bakterie mezofilne	$163.00 \cdot 10^5$	$53.00 \cdot 10^5$	$1.00 \cdot 10^5$	$8.01 \cdot 10^5$	$1.50 \cdot 10^5$
Thermophilic bacteria Bakterie termofilne	$2.25 \cdot 10^3$	$1100.00 \cdot 10^3$	$0.01 \cdot 10^3$	$2.26 \cdot 10^3$	$1.33 \cdot 10^3$
µmol TPF·g^{-1} d.m. of material·$5h^{-1}$ – µmol TPF·g^{-1} s.m. materiału·$5h^{-1}$					
Dehydrogenases activity Aktywność dehydrogenaz	8.33	1.16	1.14	5.00	2.22

Table 2. The contents of biowaste in the composts

Tabela 2. Zawartość odpadów w kompostach

Chamber Komora	Sewage sludge Osad ściekowy	Straw Słoma	Sawdust Trociny	Disintegrated bark Kora rozkruszona	Not disintegrated bark Kora nierozkruszona	C : N initial C : N początkowe	C : N final C : N końcowe
	%						
K1	55	5	–	20	20	12.4	10.56
K2	55	5	20	–	20	12.9	13.20
K3	40	5	40	–	15	18.2	14.17
K4	40	5	30	25	–	19.0	14.01

The experiment was conducted with a constant air flow amounting to 4 L·min^{-1} in the chambers. The material in bioreactors was composted for 672 hrs (28 days), while compost samples were taken from all chambers at the same time depending on the actual temperature of the composted material.

On microbiological selective medium, using plate method, the number of colony forming units (cfu) of mesophilic and thermophilic bacteria was established. The number of mesophilic bacteria was determined on simple nutritive agar by incubation of plates at 26°C for 48 hrs [Kańska et al. 2001]. Thermophilic bacteria were determined on 3% nutritive agar. Plates were incubated for 24 hrs at 55°C [Kańska et al. 2001].

Furthermore, in the sampled composted material, the activity of dehydrogenases was identified by the spectrophotometric method using as substrate 1% TTC (triphenyl-

tetrazole chloride), after a 24-hour incubation at 30°C, with a 485 nm wave length. Enzymatic activity was expressed in μmol TPF·g^{-1} d.m. of compost·5 h^{-1} [Thalman 1968].

Statistical analysis applied in the presented experiment consisted in the calculation of the mean number of microorganisms in given compost, terms of analyses, standard deviations, and the LSD values were carried out basing on the Statistica 8.0 program.

RESULTS AND DISCUSSION

The analyses of the obtained result presented in Tables 3 and 4 and in Figure 1 indicate that the main factors exerting an effect on the changes in the number of the studied microorganisms, as well as on the activity of dehydrogenases, were the changes in temperature taking place during the composting process.

According to Ishii et al. [2000], temperature changes during composting condition the succession of microorganisms understood as changes in the quantitative and qualitative composition of microorganisms. On the other hand, Sundberg et al. [2004] informed that the reason for the changes in the limit value of the growth temperature (exerting an effect on the resistance of microorganisms to the action of high temperatures) can be the pH value of the environment or the chemical composition of the breeding substrate.

Data presented in Table 3 indicates that on the day of the experiment establishment, the greatest number of mesophilic bacteria occurred in compost 2, and it introduced 812.39 cfu·10^4·g^{-1} d.m. After 24 hours from the moment of the experiment establishment, there followed an increase in the number of mesophilic microorganisms in all the composted masses, which was most visible in chambers K3 and K4. Also in the successive term of analysis (III – after 48 hrs), further proliferations of the discussed bacteria cells were recorded connected with another temperature increase (by 19-33 degrees) in the composted materials, in relation to term I. Furthermore, analogically, as in the previous term (II), the highest number of mesophilic bacteria was recorded in K3 and K4 composts, which, in relation to K1 and K2 composts, contained in their composition an amount of sewage sludge lower by 15% and a 30-40% content of sawdust (Table 2). Furthermore, those composts (K3 and K4) were characterized by a higher C/N proportion oscillating within 18.2 and 19.

One can suppose that the addition of that structure-creating material represented by sawdust provided advantageous conditions for the development of mesophilic bacteria and thereby contributed to quicker heating of the materials subjected to the composting process (Fig. 2). In composts K2, K3 and K4, containing sawdust in their composition, already in the 72nd hour of the composting process, an increase in temperature to the values of 67-79°C was observed. In turn, in the material composted in chamber 1, the development of the thermophilic phase was recorded 24 hours later (term V). With the appearance of thermophilic conditions in the composted masses (term IV and V), a distinct decrease in the discussed bacteria was noted.

Table 3. The number of mesophilic bacteria in composts
Tabela 3. Liczba bakterii mezofilnych w kompostach

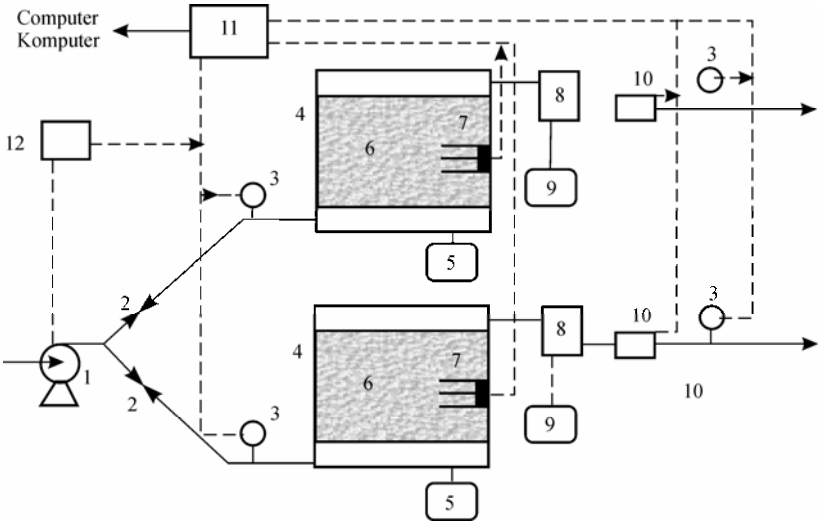
Kind of compost Rodzaj kompostu	Temperature of compost Temperatura kompostu °C	cfu·10^4·g^{-1} d.m.	Standard deviation Odchylenie standardowe

I term – beginning of experiment – I termin – początek eksperymentu				
K1		10	248.81	88.30
K2		10	812.39	171.25
K3		12	181.15	60.77
K4		12	235.96	60.81
$LSD_{0.05} – NIR_{0,05}$	192.76	$LSD_{0.01} – NIR_{0,01}$	252.43	
II term – after 24 h – II termin – po 24 h				
K1		20	808.98	166.75
K2		27	802.68	175.70
K3		24	1418.73	391.05
K4		25	3478.38	100.50
$LSD_{0.05} – NIR_{0,05}$	494.39	$LSD_{0.01} – NIR_{0,01}$	647.41	
III term – after 48 h – III termin – po 48 h				
K1		29	2117.75	307.38
K2		43	7328.50	208.73
K3		36	14277.73	1445.92
K4		37	37465.10	2541.55
$LSD_{0.05} – NIR_{0,05}$	3094.96	$LSD_{0.01} – NIR_{0,01}$	4052.92	
IV term – after 72 h – IV termin – po 72 h				
K1		44	529.49	7.62
K2		79	25.29	3.06
K3		68	12.89	1.19
K4		67	23.73	0.53
$LSD_{0.05} – NIR_{0,05}$	8.72	$LSD_{0.01} – NIR_{0,01}$	11.42	
V term – after 96 h – V termin – po 96 h				
K1		80	1.79	0.40
K2		71	1.25	0.30
K3		69	7.86	2.40
K4		72	2.09	0.36
$LSD_{0.05} – NIR_{0,05}$	2.60	$LSD_{0.01} – NIR_{0,01}$	3.41	
VI term – after 672 h – VI termin – po 672 h				
K1		47	44.69	0.84
K2		36	39.86	3.18
K3		50	31.35	1.45
K4		45	25.15	7.68
$LSD_{0.05} – NIR_{0,05}$	8.90	$LSD_{0.01} – NIR_{0,01}$	11.66	

Table 4. The number of thermophilic bacteria in composts
Tabela 4. Liczba bakterii termofilnych w kompostach

Kind of compost Rodzaj kompostu	Temperature of compost Temperatura kompostu	$cfu \cdot 10^3 \cdot g^{-1}$ d.m.	Standard deviation Odchylenie standardowe

		°C		
I term – beginning of experiment – I termin – początek eksperymentu				
K1		10	22.09	5.93
K2		10	3160.70	1134.78
K3		12	71.54	26.26
K4		12	17.92	3.66
$LSD_{0.05} – NIR_{0,05}$	794.76	$LSD_{0.01} – NIR_{0,01}$	1040.76	
II term – after 24 h – II termin – po 24 h				
K1		20	218.83	69.97
K2		27	45.17	10.16
K3		24	50.96	27.06
K4		25	48.35	17.41
$LSD_{0.05} – NIR_{0,05}$	81.56	$LSD_{0.01} – NIR_{0,01}$	106.81	
III term – after 48 h – III termin – po 48 h				
K1		29	988.28	199.66
K2		43	5112.91	695.78
K3		36	3213.19	1945.85
K4		37	3210.50	2198.22
$LSD_{0.05} – NIR_{0,05}$	3174.83	$LSD_{0.01} – NIR_{0,01}$	4157.52	
IV term – after 72 h – IV termin – po 72 h				
K1		44	1241.89	177.39
K2		79	26622.90	5865.47
K3		68	24576.95	5294.23
K4		67	47314.58	4346.99
$LSD_{0.05} – NIR_{0,05}$	9471.00	$LSD_{0.01} – NIR_{0,01}$	12402.50	
V term – after 96 h – V termin – po 96 h				
K1		80	9637.99	1466.27
K2		71	5987.49	1208.04
K3		69	10569.11	1196.72
K4		72	42199.49	6712.71
$LSD_{0.05} – NIR_{0,05}$	7432.18	$LSD_{0.01} – NIR_{0,01}$	9732.62	
VI term – after 672 h – VI termin – po 672 h				
K1		47	14402.38	2222.22
K2		36	31639.26	1071.54
K3		50	29723.13	8864.63
K4		45	1861.32	526.10
$LSD_{0.05} – NIR_{0,05}$	12665.88	$LSD_{0.01} – NIR_{0,01}$	9732.62	



1 – pump – pompa
2 – flow regulator – regulator przepływu
3 – flow meter – miernik przepływu
4 – isolated chambers – izolowane komory
5 – drained liquids container – zbiornik na odcieki
6 – composted mass – kompostowana masa
7 – sensors array – zespół czujników
8 – air cooling system – system schładzania powietrza
9 – condensate container – zbiornik na skropliny
10 – multiple gas sensor array – system analizy gazów
11 – 32-channel recorder – 32-kanałowy mikroprocesorowy rejestrator sygnałów pomiarowych
12 – air pump steering system – system sterowania pompą powietrza

Fig. 1 Schematic diagram of the bioreactor
Rys. 1. Schematyczny diagram bioreaktora

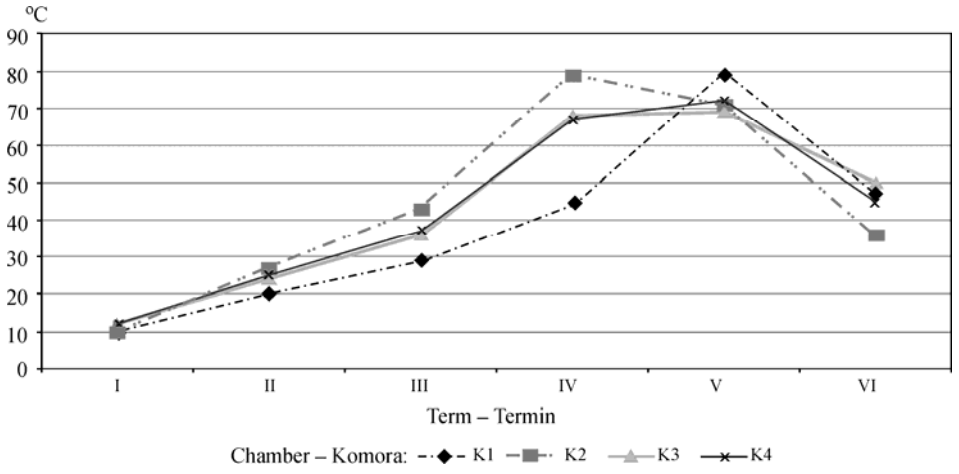


Fig. 2. Changes in temperature in the biowaste during the composting process
Rys. 2. Zmiany temperatury w odpadach podczas procesu kompostowania

During the composting process, the pH value oscillated between 6.8 and 8.8. Furthermore, it was found that in the majority of terms, independently of the composition of the composts, the pH showed similar values (Fig. 3). Therefore, one can infer that one of the factors limiting the development of mesophilic bacteria was the temperature increase and not the pH value. Also Strom [1985] informed that one of the main factors conditioning the succession of microorganisms in the composting process is changes in the temperature values.

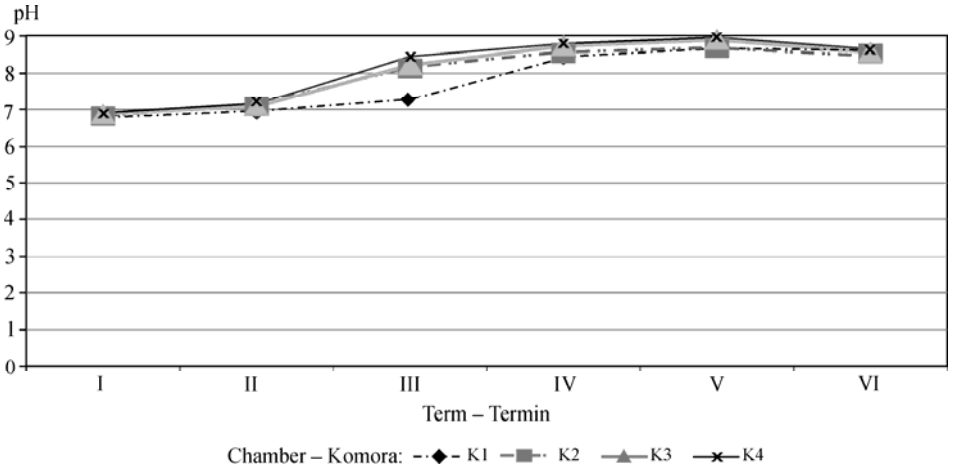


Fig. 3. Changes in pH in the biowaste during the composting process
Rys. 3. Zmiany pH w odpadach podczas procesu kompostowania

According to Ishii et al. [2000], in the mesophilic composting phase, there dominated such bacteria types as: *Pseudomonas, Achromobacter*, *Acinetobacter*, *Bacillus*, *Cellulomonas*, *Commomonas*, *Clostridium*, *Flavobacterium* and *Staphylococcus.*

In the passing from the mesophilic phase to the thermophilic one, the dominating bacterial component in the compost became the species from *Bacillus* genus. Strom [1985] gave a very detailed succession of the particular species. At the temperature of 49-55°C, among the species belonging to *Bacillus*, there dominated *Bacillus coagulans* and *Bacillus circulans*. At temperatures in the range of 55-65°C, there dominated *Bacillus stearothermophillus* over *Bacillus coagulans*, *Bacilllus brevis* and *Bacilllus sphaericus*.

In the cooling down phase, when the temperature fell to 30°C, in the compost there occurred bacteria from the genera *Sphangobacterium* and *Alcaligens*, *Clostridium fervidus*. In the last phase, where the temperature is lower than 30°C, bacteria were observed which did not belong to the *Arthrobacter* genus [Ishii et al. 2000].

Additionally, the development of bacteria during the experiment could have been limited as a result of the depletion of easily decomposable organic matter. Another factor which could have limited the increase in the number of bacteria could have been the accumulation of substances with antibiotic character produced by fungi and *Actinomycetes* or by the competition for food [Sidhu et al. 2001]

A repeated increase in the number of mesophilic bacteria in all composts was recorded in the last term after 672 hours of composting (i.e. after 28 days). This

phenomenon was caused most probably by the decrease in temperature to the values of 36-50°C.

Analogically as in the case of mesophilic bacteria, the greatest number of thermophilic bacteria on the day of the experiment establishment was recorded in compost K2 (Table 4). After 24 hours of the composting process (term III), oscillations were recorded in the number of the discussed bacteria, depending on the type of the composted material. The successive 24 hours of the composting process and the further increase in temperature in the composted materials caused an intensive proliferation of thermophilic bacteria. The presented dynamics of microorganism increase was recorded at that time in compost K1, which was characterized by the lowest C : N proportion at the moment of the experiment establishment and by the absence of sawdust in its composition (Table 2). Further continuation of the process contributed in term IV to a repeated increase in temperature in the composted materials to the values of 44-79°C and to a strong proliferation of the discussed microorganisms, particularly in composts K2, K3 and K4. In K1 compost, the development of the thermophilic phase took place at a slower rate, and it also caused a shift in time regarding the proliferation intensity of the thermophilic bacteria cells. In term V (after 96 hrs), the number of microorganisms in the discussed compost was several times higher than 24 hours earlier (term IV), while in the remaining composts, the proliferation was significantly decreased. The reduction in the number of bacteria occurring in composts at the highest temperatures of the thermophilic phase was observed also by Finstein and Morris [1975] in their studies.

In term VI, after the decrease in temperature to the values of 36-50°C, a repeated increase in the number of bacteria was found in the composted materials.

According to Storm [1985] and Nakasaki et al. [1985], the most intensive increase in thermophilic bacteria number takes place at temperatures from 50 to 60°C.

In turn, from the studies of Błaszczyk [2007], it follows that temperatures higher than the mentioned ones favour the development of a few bacteria species only, i.e. the high temperatures are favourable mainly to bacteria from the *Hydrogenoabacter* and *Thermophillus* genera.

Analysis of the activity level of dehydrogenases in the biowaste subjected to the composting process (Fig. 4), it was found that on the day of the experiment establishment (term 1), the highest level of enzymatic activity occurred in compost K4. The 24-hour composting process caused a slight increase in dehydrogenases in materials composted in chambers K1 and K3, while a decrease in their activity was found in compost K4 and was particularly visible in chamber K2.

One can suppose that the differences in the activity of the discussed enzymes were at that time connected with a different content of easily degradable organic matter in the composts, since the pH values or temperature values in the II term of the analyses in the composted materials showed similar values.

With the start of the thermophilic phase (term IV), a violent decrease in dehydrogenases activity levels was recorded in the majority of composts. Only in the material composted in chamber K1, the decrease in the activity in that term was not great, and it was most probably caused by slower heating of the compost.

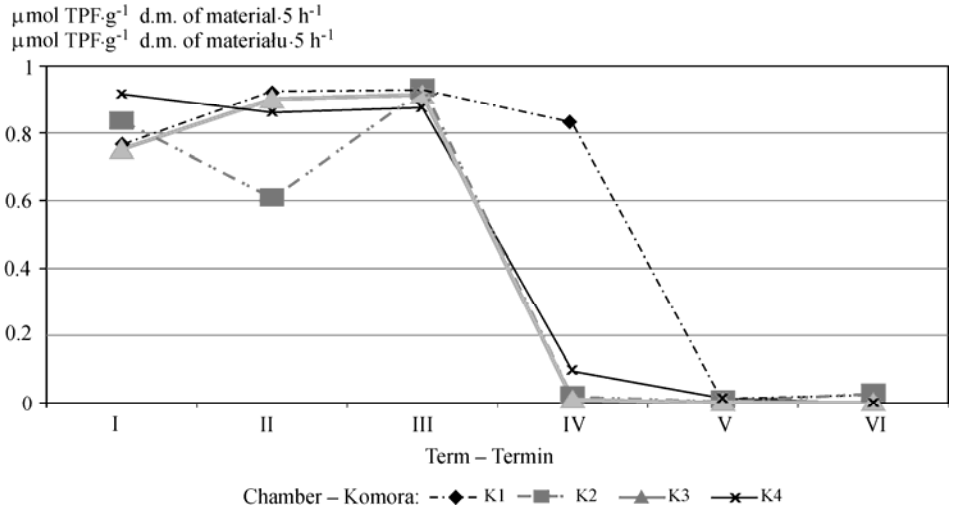


Fig. 4. Changes in dehydrogenases during the composting process
Rys. 4. Zmiany dehydrogenaz podczas procesu kompostowania

In the two latter terms of studies (V and VI), the activity of dehydrogenases was maintained at a similar low level in all the composting combinations. According to Piotrowska-Cyplik et al. [2007], low level of dehydrogenases activity in the final stage of the composting process is connected most probably with the depletion of organic substances in the composts. On the basis of the data presented in Table 5, it was found that the activity of dehydrogenases showed a dynamics very similar to that referring to the changes in the number of mesophilic bacteria. These observations overlap with the conclusions of Tiquia [2002], who found that dehydrogenases activity is a reflection of the physiological state of different groups of microorganisms in the compost.

Table 5. Pearson correlation coefficient between the number of chosen groups of microorganisms (cfu·g^{-1} d.m. of compost) and dehydrogenases activity (µmol TPF·g^{-1} d.m. of material·5 h^{-1}) in composts
Tabela 5. Współczynnik korelacji Pearsona między liczbą wybranych grup bakterii (cfu·g^{-1} s.m. kompostu) a aktywnością dehydrogenaz (µmol TPF·g^{-1} s.m. materiału·5 h^{-1}) w kompostach

Combination Kombinacja	Correlation coefficient – Współczynnik korelacji	
	mesophilic bacteria x dehydrogenases activity bakterie mezofilne x aktywność dehydrogenaz	thermophilic bacteria x dehydrogenases activity bakterie termofilne x aktywność dehydrogenaz
K1	0.67	-0.95
K2	0.70	-0.70
K3	0.56	-0.86
K4	0.48	-0.70

CONCLUSIONS

1. Composting process contributed to the reduction in the number of mesophilic bacteria. In the case of thermophilic bacteria, an inverse situation was recorded.

2. Changes in the number of mesophilic and thermophilic bacteria depended to a high degree on the temperature and not on the qualitative composition of materials used for composting or on the pH value, which during the experiment reached the optimal values for their development.

3. Absence of sawdust for the composting of biowaste in chamber K1 (55% of sewage sludge + 5% straw + 20% of not disintegrated bark + 20% of disintegrated bark) contributed to slower heating of the material.

4. The highest mean number of mesophilic and thermophilic bacteria in the analysed experimental composts was recorded in compost K4 (40% of sewage sludge + 5% of straw + 30% of sawdust + 25% of not disintegrated bark).

5. The highest mean level of dehydrogenases activity was found in compost K1 (55% sewage sludge + 5% straw + 20% not disintegrated bark + 20% disintegrated bark).

6. Activity of dehydrogenases in all composts correlated positively only with the number of mesophilic bacteria.

REFERENCES

Błaszczyk M.K., 2007. Mikroorganizmy w ochronie środowiska [Microorganisms in environment protection]. PWN Warszawa [in Polish].

Czekała J., Dach J., Wolna-Maruwka A., 2006. Wykorzystanie bioreaktora do badań modelowych kompostowania osadu ściekowego [Use of bioreactor for model examinations of sewage sludge composting]. Woda – Środowisko – Obszary Wiejskie 6(2), 29-40 [in Polish].

Dach J., Jędruś J., Adamski M., Kowalik I., Zbytek Z., 2003. Bioreaktor do badań procesów rozkładu materiałów organicznych [Bioreactor for the examination of the decomposing processes of organic matter]. J. Res. Appl. Agric. Eng. 48, 4-9 [in Polish].

Eiland F., Klame M., Lind A.M., Baath E., 2001. Influence of initial C/N ratio and microbial composition during long term composting of straw. Microb. Ecol. 41, 272-280.

Finstein M.S., Morris N.L., 1975. Microbiology of municipal solid waste composting. Adv. Appl. Microbiol. 19, 113-151.

Ishii K., Fukui M., Takii S., 2000. Microbial succession during a composting process as evaluated by denaturing gradient gel electrophoresis analysis. J. Appl. Microbiol. 89, 768-777.

Kańska Z., Grabińska-Łoniewska A., Łebkowska M., Żechowska E., 2001. Ćwiczenia laboratoryjne z biologii sanitarnej [Sanitary biology laboratory exercise]. Oficyna Wydawnicza Politechniki Warszawskiej [in Polish].

Marx M.C., Wood M., Jarvis S.C., 2001. A microplate fluorimeteric assay for the study of enzyme diversity in soils. Soil Biol. Biochem. 33, 1633-1640.

Nakasaki K., Sasaki M., Shoda M., Kubota H., 1985. Change in Microbial Numbers during Thermophilic Composting of Sewage Sludge with Reference to CO_2 Evolution Rate. Appl. Environ. Microbiol. 49(1), 37-41.

Piotrowska-Cyplik A., Cyplik P., Czarnecki Z., 2007. Measurement of dehydrogenase activity and traditional metod of microorganisms Mount estimation as indicators of microorganisms activity in compost from municipal sewage sludge. J. Res. Appl. Agric. Eng. 52(4), 22-26.

Sidhu J., Gibbs R.A., Ho G.E., Unkovich I., 2001. The role of indigenous microorganisms in suppression of *Salmonella* regrowth in composted biosolids. Water Res. 35(4), 913-920.

Storm P.F., 1985. Effect temperature on bacterial species diversity in thermophilic solid-waste composting. Appl. Environ. Microbiol. 50, 899-905.

Sundberg T., Smars T., Jönsso H., 2004. Low pH as an inhibiting factor in the transition form mesophilic to thermophilic phase in composting. Biores. Technol. 95, 145-150.

Taiwo L.B., Oso B.A., 2004. Influence of composting techniques on microbial succession, temperature and pH in a composting municipal solid waste. African J. Biotechnol. 4, 239-243.
Thalmann A., 1968. Zur Methodik der Bestimmung der Dehydrogenase Aktivität in Boden Mittels Triphenyltetrazoliumchlorid (TTC). Landwirtsch. Forsch. 21, 249-258 [in German].
Tiquia S.M., Judy J.H.C., Tam N.F.Y., 2002. Microbial population dynamics and enzyme activities during composting. Compost Sci. and Utiliz. 10(2), 150-161.
Wong J.W.C., Fang M., 2000. Effects of lime addition on sewage sludge composting process. Water Res. 34(15), 3691-3698.

INTENSYWNOŚĆ PROCESU KOMPOSTOWANIA OSADU ŚCIEKOWEGO Z RÓŻNYMI DOMIESZKAMI NA BAZIE AKTYWNOŚCI DEHYDROGENAZ I NASTĘPSTWA WYBRANYCH GRUP BAKTERII

Streszczenie. Problem kompostowania osadu ściekowego jest przedmiotem wielu badań naukowych. Podczas prawidłowo przebiegającego procesu kompostowania – na skutek zmian temperatury – występuje dominacja określonych typów i grup mikroorganizmów. W doświadczeniu badano zmiany liczby bakterii mezofilnych i termofilnych w procesie kompostowania osadu ściekowego z różnymi domieszkami. Analizowano wpływ różnic składu kompostu na dynamikę rozwoju bakterii. Kolonie bakterii wyizolowanych na pożywkach selekcyjnych stanowiły podstawę do ustalenia całkowitej liczby bakterii w kompoście. Zbadano także stosunek między aktywnością dehydrogenaz a liczbą bakterii mezofilnych i termofilnych. Skład kompostu i pH nie wpływały na liczbę bakterii mezofilnych i termofilnych podczas procesu kompostowania. Zaobserwowano związek między zmniejszeniem liczby mikroorganizmów a wzrostem T (temperatura). Na podstawie otrzymanych wyników ustalono, że aktywność dehydrogenaz korelowała dodatnio z liczbą bakterii mezofilnych.

Key words: bakterie, bioreaktor, dehydrogenaza, kompost, osad ściekowy

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