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BIOCOMPOSITE FOR ORGANIC WASTE DEGRADATION

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In the study, the evaluation of organic waste biodegradation with the addition of a biopreparation containing proteolytic, lipolytic and cellulolytic bacteria strains was carried out. The efficiency of the biopreparation was evaluated in a half-technical scale within 3 months of composting and was based on an analysis of protein, fat, carbohydrates content and general bacteria count. The experiment showed that introduction of the biopreparation caused high development of proteolytic, lipolytic and cellulolytic bacteria (early) in the first month of composting. The process was accompanied by a considerable organic compound reduction, especially in proteins and carbohydrates rate. In relation to indigenous microflora, the introduced biopreparation speeded up the process of organic compound mineralization over twicely. A 58% reduction of organic matter was obtained after 3 months.

Key words: biodegradation, biopreparation, organic waste

INTRODUCTION

Due to the development of civilization, vast amount of organic waste is being produced. Its return to the environment is highly desirable, as it is characterized by significant amount of macro- and micronutrients. However, some of the organic waste can not be used directly, and needs improvement in its physical and chemical properties. One way of organic waste utilization is composting with usage of the appropriate biopreparations. Biological methods of decomposition of solid waste and liquid waste are known all over the world. They are regarded, to high extent, as effective, relatively cheap and most environmentally friendly way for utilizing most of the organic waste, in which organic fraction is usually represented by proteins, fats and carbohydrates. However, one of the biggest problems in this kind of process, is a proper choice of micro-organisms, in terms of both quantity and quality, which determines the utilization eff ects of the biopreparation as well as the speed of the

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process. The complete biodegradation of organic waste can not be assumed, as it may contain compounds that can not be decomposed, i.e.: scleroproteids or hemicellulose, but biodegradation of most proteins, fats and carbohydrates in organic waste, originating from for example households seems to be possible (Bujak and Targoński 1998). Organic manure obtained in this process is characterized by better properties in comparison with the initial waste and can be used in agriculture, if its chemical composition (content of heavy metals) and health and sanitary properties are unquestioned.

The objective of the study was the evaluation of organic waste biodegradation with bacterial inoculate containing selected proteolytic, lipolytic and cellulolytic bacteria strains.

MATERIALS AND METHODS

ORGANIC WASTE

In the experiment residual waste from the households was examined. The content of organic matter amounted to ca. 82%, and consisted of the following: ca. 8% of fats, ca. 20% of proteins and ca. 54 % of carbohydrates. For the experiment 40 kg of granular waste was used.

BIOPREPARATION USED IN THE STUDY

In order to prepare the microbiological composite, prior selected and tested strains of lipolytic, proteolytic and cellulolytic bacteria were used. Bacteria were originally isolated from residual waste as well as selected from the Molecular and Experimental Biology Department's own collection. The procedure of strains isolation and selection was presented in the previous publications of the authors (Latała et al. 2004, Latała and Wierzba 2004). Chosen bacteria strains were separately subjected to lyophylisation process in a freeze-dryer type LB-4. Obtained lyophylisates were mixed to formulate biopreparation, used in further studies. Quantitative analysis of the investigated waste, proved that survival rate of bacteria attained 80% after lyophylisation and the number amounted to ca. 10^9 cfu per 1 g of lyophylisate.

Biopreparation composition contained among others: *Bacillus subtilis*, *Bacillus macerans*, *Pseudomonas fluorescens*, *Pseudomonas fragi*, *Serratia liquefaciens*, *Acinetobacter junii*, *Acinetobacter lvoffii*, *Cytophaga* sp..

ORGANIC WASTE BIODEGRADATION

Organic waste biodegradation was conducted in a half-technical scale, in PCV containers of 30 dm^3 capacity. Each of the two containers was filled with 20 kg of homogeneous residual waste (of which the moisture level was 60%), with an addition of 25% of sawdust and brown coal. Next, 0,01% of the biopreparation was added to one of the containers while the other one was a tcontrol reatment (without

biopreparation). The study was conducted for 3 months. The biodegradation efficiency was evaluated on the first day and after 1, 2 and 3 consecutive months of composting. From the total waste matter, representative portions thoroughly mixed were sampled.

MICROBIOLOGICAL AND CHEMICAL ANALYSIS OF THE WASTE

The quantitative bacteriological analysis was performed with a culture-plating method and was based on PN-75/C-04615[1]. General bacteria count (GBC) was determined on different media respectively: general bacteria count on nutrient agar, lipolytic bacteria count on medium with tributyrin, proteolytic bacteria count on agar medium with milk. For cellulolytic bacteria enumeration, index method was applied on Winogradsky medium with blotting stripes. The Most Probable Number (MPN) of bacteria per 1 g of sediment was determined according to the Mc'Crady's tables (Grabińska-Łoniewska 1996). Qualitative analysis included macro- and micro analysis as well as biochemical investigation. Biochemical tests were performed with the aide of a microanalyser mini API (Holt and Krieg 1984). Chemical tests involved: determination of the organic fraction content based on the weight loss on ignition at 550^0C temperature (Ostrowska et al. 1991), determination of the fat compound amount, soluble in the paraffin ether (based on PN-76R-64753), determination of proteins amount (based on PN-76R-64753), determination of carbohydrates amount by means of the anthrone method (Kłyszejko-Stefanowicz 1980).

RESULTS AND DISCUSION

Results of chemical quantitative analysis (during biodegradation process) of residual waste and its organic compounds, as follows: fat compounds, proteins and carbohydrates are presented in table 1 and figures 1 and 2.

Table 1. Chemical analysis during biodegradation process of organic waste

Type of treatment	Time of biodegradation [days]	Amount of organic matter [g/kg dry matter]	Amount of fat compound [g/kg dry matter]	Amount of proteins [g/kg dry matter]	Amount of carbohydrates [g/kg dry matter]
Control treatment	1	824,3	78,3	195,2	514,1
	30	713,1	68,2	172,4	443,1
	60	651,8	62,9	155,2	412,3
	90	593,5	60,7	134,1	371,7
Biopreparation	1	824,3	78,3	195,2	514,1
	30	502,8	63,5	99,9	316,2
	60	421,6	52,8	80,4	269,9
	90	348,5	36,0	68,9	224,7

[1] P – Polish Standards

The highest loss in organic matter obtained after addition of the biopreparation, was noted according to the results, in the first month of the experiment and was equal to 39%. Organic matter content dropped within this time from 824.3 g/kg of d. m. to 502.8 g/kg of d. m. In the following months of biodegradation, the reduction was considerably lower, however regular and after 90 days reached the level of 57.72%. The amount of organic fraction was reduced to 348,5 g/kg of d.m. In the control treatment reduction was twofold - threefold lower than in the one containing the biopreparation, and after 3 months of composting obtained 28% [table 1; Fig. 1, 2]. Similarly, Gostkowska et al. (1996) stated over twofold higher drop in organic matter after bacterial inoculation, in the early stage of biodegradation of tobacco waste, in comparison with the treatments containing natural inoculum. In many authors' opinion (Łatała et al. 2001; Riis et al. 2000) natural microflora supplemented with biopreparations, speeds up the biodegradation process of the component towards which microbes screening was carried.

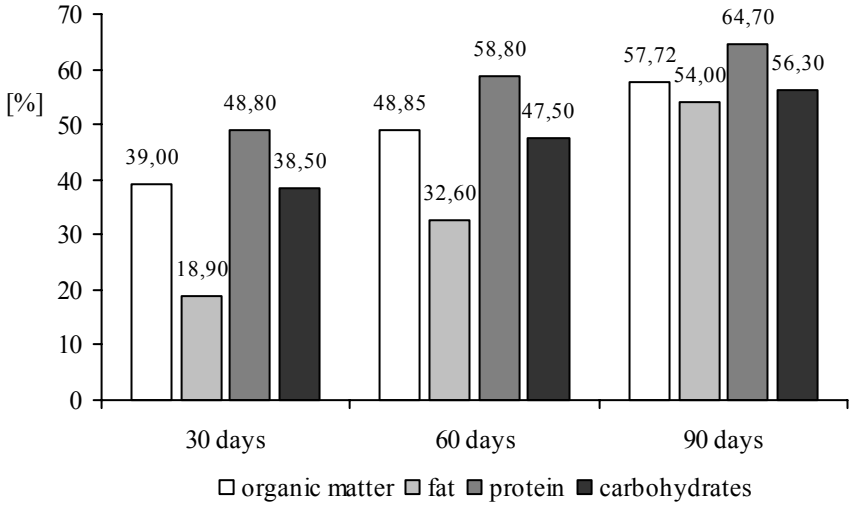

Fig. 1. Reduction of organic matter, fat, proteins, carbohydrates throughout biodegradation process of organic waste with the biopreparation amendment

The residual waste subjected to biodegradation contained 7.83% of fats, 19.52% of proteins and 51.41% of carbohydrates [table 1]. Alongside with the organic matter decrease in waste, the content of respective components was also decreasing. Likewise in this case, the highest reduction was recorded in the first 30 days of composting, after addition of the biopreparation, especially in reference to proteins and carbohydrates, which are assimilated easier than fats. The same tendency was also confirmed by the other authors' reports (Bednarski and Reps, 2001; Latała et al. 2004; Patorczyk-Pytlik et al. 1999).

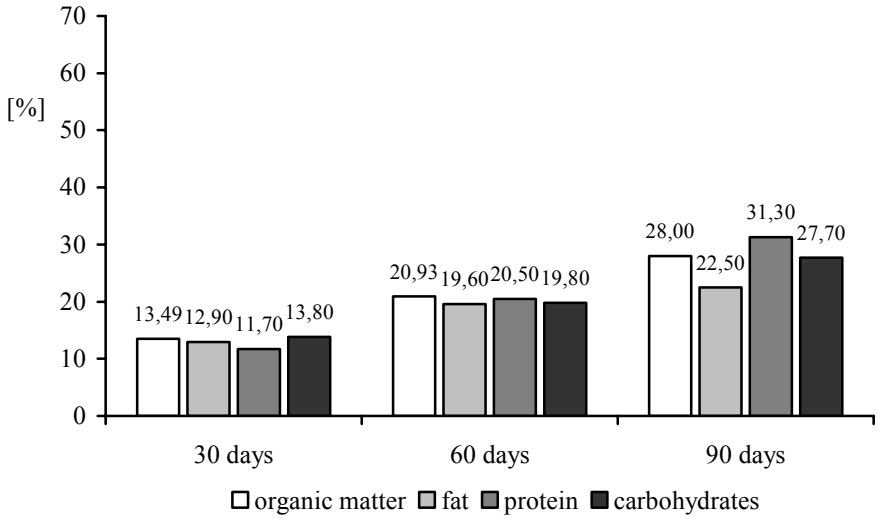

Fig. 2. Reduction of organic matter, fat, proteins, carbohydrates throughout biodegradation process of organic waste without the biopreparation.

The amount of proteins and carbohydrates in waste was decreased to 99.9 g/kg of d. m. and 316.2 g/kg of d. m. respectively, which accounted for 48.8% and 38.5% reduction. The amount was even more decreased after 3 months and reached the following values: 64.7% and 56.3% [table 1; fig. 1 and 2]. Comparable results were stated by Latała et al. (2004) throughout the biodegradation process of household waste with an amendment of different microbiological composites. The protein reduction after 28 days ranged from 40.28% to 58.99%, and the amount of carbohydrates was decreased after 56 days from the level of ca. 59% to ca. 86%. In performed experiment, such a significant loss of carbohydrates in the early stage of biodegradation was caused by the decomposition of simple carbohydrates, in the first place. The hydrolysis of complex carbohydrates had probably occurred no sooner than in the following months, and therefore the process of complete decomposition of carbohydrates proceeded at a slower rate. The amount of fat was being reduced proportionally in the subsequent months and on the last day obtained value of 36.0 g/kg of d. m., which corresponded to the reduction of 54.0%. Similar results (of 50%) were achieved by Bernal et al. (1999) after 56 days of composting sewage sludge with an addition of a bioactivator. However, considerably higher reduction of fat compound was noted by Patorczyk-Pytlik et al. (1999) after 4 months of composting of fat sludge. The result was shaped between 80-90% and depended on the organic component used in the experiment.

Microbiological quantitative studies indicate distinctive tendency in the increase of general bacteria count (GBC), during biodegradation (Fig. 3 and 4). The highest changes were recorded for compost with an addition of biopreparation. After 90 days

bacteria enumeration increased about fiftyfold and reached the level of over 10^8 cfu/g. Corresponding results were observed by Jorgensen et al. (2000) throughout composting process of oil residue with the accessory of biopreparations. Yet, Stuczyński (1992) stated a considerably lower increase in the bacteria enumeration, with the higher final value of GBC (general bacteria count), during mineralization of organic waste in case of bacterial inoculation. The amount of bacteria increased four-fivefold after 2 months of biodegradation and the final count ranged between 10^9–10^{10} cfu/g. Amendment of biopreparation had a beneficial influence on proteolytic, lipolytic and cellulolytic bacteria count during organic waste biodegradation. Systematic growth in their enumeration was noted in the consecutive months with its peak (from about 14-fold to 70-fold) in the first 30 days referring to cellulolytic bacteria. The probable reason for that, was specific temperature conditions in the early stage of the process duration. Studies of many authors (Bujak, Targoński, 1988, Frąk et al., 1998; Szwed, Gostkowska, 1996; Wyczółkowski et al. 1997; Frąk, Bujak etc.) prove that temperature has stimulating effect on the activity of enzymes. As shown in Fig. 3 the composition of waste stimulated rather proteolytic bacteria development. Their share in GBC was the highest throughout the whole process of composting.

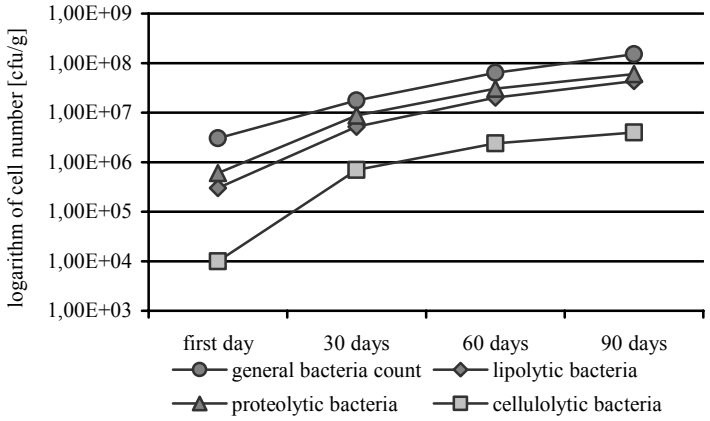

Fig. 3. Changes in bacteria enumeration throughout the biodegradation process of organic waste with the biopreparation amendment

Lower content of lipolytic and cellulolytic bacteria could have resulted from the fact, that the most of lipase and cellulase enzymes are subjected to typical catabolite repression and their production could be inhibited by the presence of easily assimilated carbon sources (Bujak, Targoński, 1988; Trzmiel, 1994). Similar tendencies towards changes in bacteria enumeration were revealed in compost without addition of biopreparation. However, they were definitely more gradual and recorded bacteria amounts were from several to several tenfold lower than after biopreparation inoculation.

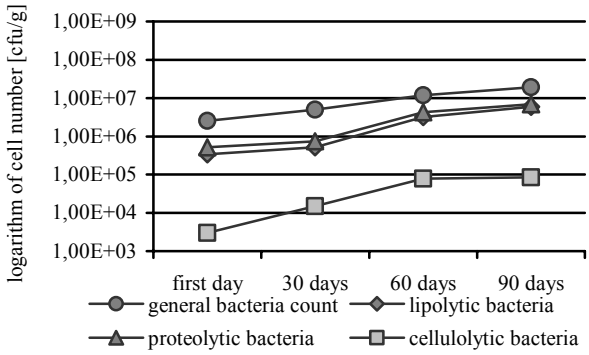

Fig. 4. Changes in bacteria enumeration throughout the biodegradation process of organic waste without biopreparation

SUMMARY AND CONCLUSION

Results obtained in the conducted study as well as results obtained from the earlier experiments of the authors (Latała et al. 2004), indicate significant efficiency of a biopreparation in the range of proteins, fats and carbohydrates decomposition. Reduction obtained after 3 months amounted to: 64.70%, 54.00%, 56.30% (Fig. 1) respectively. In relation to indigenous microflora, introduced biopreparation speeded up the process of organic compound mineralization in waste, over twofold. The highest reduction, especially of proteins and carbohydrates, was recorded after first 30 days of composting. Reduction of organic compound was accompanied by the significant rise in proteolytic, lipolytic and cellulolytic bacteria enumeration. Quantitative and qualitative changes of microflora during composting were characterized by higher dynamic after biopreparation introduction.

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Konsekwencją rozwoju cywilizacyjnego jest powstawanie dużych ilości odpadów organicznych. Ponieważ charakteryzują się one znacznymi zawartościami węgla organicznego oraz makro- i mikroelementów, ich powrót do środowiska jest w pełni pożądany. Niektóre odpady organiczne nie nadają się do bezpośredniego stosowania w rolnictwie, wtedy konieczna jest poprawa ich właściwości fizyko-chemicznych. Jednym ze sposobów utylizacji odpadów organicznych jest ich kompostowanie z wykorzystaniem odpowiednich biopreparatów. Celem prowadzonych badań była ocena biodegradacji odpadów organicznych przy udziale kompozytu bakteryjnego zawierającego wybrane szczepy bakterii proteolitycznych, lipolitycznych i celulolitycznych. Wyniki badań własnych prezentowanych w niniejszej pracy, jak również dane uzyskane z wcześniejszych badań autorów (Latała i wsp. 2004) wskazują na znaczną skuteczność biopreparatu w zakresie rozkładu białek, tłuszczów i węglowodanów w odpadach organicznych. Uzyskana po 3 miesiącach redukcja wynosiła odpowiednio 64,70%, 54,00%, 56,30% (rys. 1). W stosunku do mikroflory autochtonicznej wprowadzony biopreparat ponad dwukrotnie przyspieszał proces mineralizacji związków organicznych w odpadach. Najwyższą redukcję, zwłaszcza białek i węglowodanów odnotowano po pierwszych 30 dniach kompostowania. Redukcji związków organicznych towarzyszył znaczny wzrost liczebności bakterii proteolitycznych, lipolitycznych i celulolitycznych. Zmiany ilościowe i jakościowe mikroflory w trakcie kompostowania charakteryzowały się większa dynamiką po wprowadzeniu biopreparatu.