Dynamic of microbial population during composting of organic wastes

Donkova R,, M. Stoichkova, D. Slavov
Institute of soil science "N.Poushkarov"
Corresponding author; email: rada_donkova@Yahoo.com

Abstract

Changes in number of main microorganisms groups during the composting of biowaste were studied. Organic wastes (vegetables, fruits, sawdust, hay, straw, poultry manure, coffee waste, and egg shells) were composted in two type monitored composting system – using 3 composting bins. It was found that bacteria dominated during the termophilic phase, fungi, spore forming and nitrogen fixing bacteria in cooling phase, while actinomycetes and cellulose decomposing microorganisms predominated during the maturation phase. It was concluded that more suitable conditions for composting process were available in closed composting system.

Introduction

On a global scale, the insufficiency of traditional organic manures increased in the last years. At the same time, consideration that approximately two third from the domestic wastes are organic components, brought about the increased studies of their composting. Composting, in fact, is monitored humification of organic wastes. It is a fast, simple and safe method for mass processing of organic wastes allowing their transformation to usable organic manure, in the same time decreasing odours and reducing concentration of animal and plant pathogens in the system. Microorganisms in the compost made the transformation of organic materials (Tuomela M. et al., 2000). They decompose the organic mass to CO_2, H_2O, and humus in an exothermic process (Rynk et al., 1992; Borken et al., 2002). At this process the higher count of microorganisms can transform larger amount of organic matter for a unit of time. Their species and number fully depend on created conditions: nutrient balance of substrates, moisture, aeration, temperature, and pH. This necessitates strict control of the composting process.

The aim of this publication is to announce and discuss the results from the study of composition and dynamic of different microorganisms, participating in the process of home composting in different conditions.

Materials and methods

The following organic materials were used in the study: vegetable and fruit wastes with C/N = 15 : 1, saw-dust -C/N = 52 : 1, hay - C/N = 28,5: 1, straw - C/N = 70 : 1, poultry manure - C/N = 30 : 1, coffee sludge C/N = 24 : 1; egg shells – with C/N = 7 : 1. Microbiological inoculant NOVALUZ COMPOST, produced from ENVENSO (with concentration 10^9 ufc/ml) was included in the study to speed up the process.

The trial was carried out in three bins, suitable for home composting: one closed (200 L) and two open (600 L and 300 L). At first, 200 kg heap was made from all used wastes. The initial C/N ratio of the mixtures was reduced to accept for optimum of 25/1.

The bins were filled up simultaneously after good mixing of the composted materials. In each of them 75 g inoculant was added for 1 m^3. The top was covered with thin layer of poultry manure and after it with about 4 cm moist soil to protect the mixture from drying. The bins were periodically mixed and in case of need water was added to hold up the optimum moisture (60%). Dynamics of changes in number and composition of the microflora were studied during composting. Main taxonomic and physiological groups of microorganisms were determined by the dilution plate method, using selective nutrient media in three replications after respective incubation at 28°C for mesophilic and above 40°C for thermopile microorganisms. The density of microorganisms was recalculated per 1g absolutely dry material. Statistical processing of data was made using ANOVA analysis.

Results and discussion

The presented figures (1 to 7) reflect dynamics in the amount of different microorganisms, participating in the process. Data on figure 1 show that the quantity of mesophilic heterotropheous microorganisms increases after termophilic phase of composting process. These microorganisms in the two open bins reach peak in their growth 38 days after the beginning of composting. In the closed bin this happens earlier and confirms the faster setting of the maturation phase in that bin. This result agrees with the received from Tiquia et al. (2002), namely the quantity of aerobic heterotropheous microorganisms decreases at high temperature, but these microorganisms breed again in maturation phase. Peak in increasing of the thermophilic heterotropheous microorganisms is observed on the 16th day and it is depending directly on the measured temperature. Highest temperatures have been measured in the closed bin because of the lower losses of heat to environment and the smaller influence of the meteorological conditions. The higher temperatures were kept for longest period in the closed bin (9 days), in the 600L open bin – respectively 6 days, and in the open bin of 300L -3 days. In the same range were the established quantities of thermophile microorganisms. Their quantity begins to decrease from the beginning of cooling phase in every one bin (fig.2).

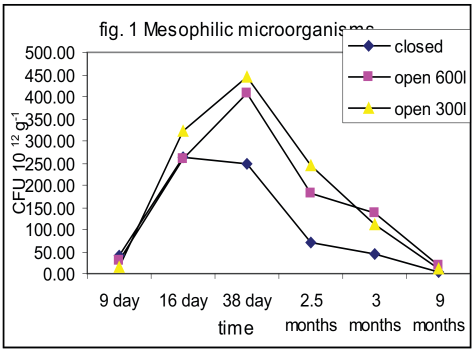


fig. 1 Mesophilic microorganisms

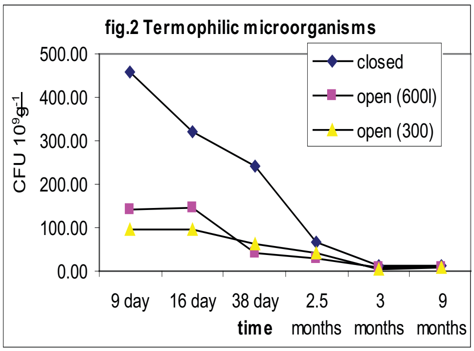


fig.2 Termophilic microorganisms

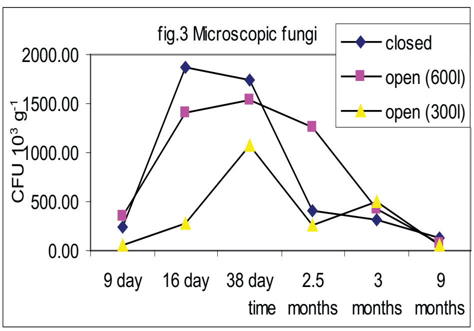


fig.3 Microscopic fungi

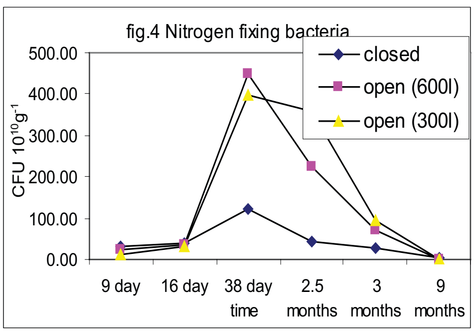
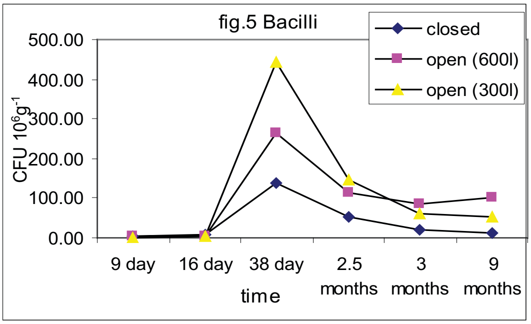


fig.4 Nitrogen fixing bacteria

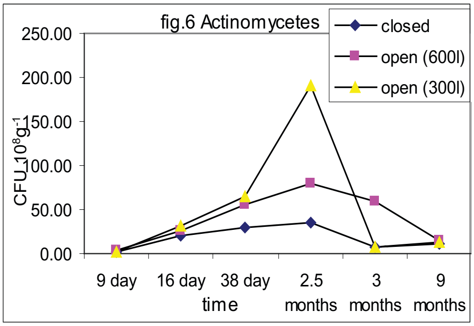
As can be seen from fig. 3, quantity of microscopic fungi in the three systems increases after the end of the termophilic phase, when lower pH values and lowest values of total nitrogen was determined. These data are in compliance with the results of Hoitink et al. (1993), that fungi attack more acid and poor in nitrogen organic residuals. The optimal conditions for these order of microorganisms was observed in the closed bin and the most unfavourable conditions – in the open bin of 300L, in which the highest moisture was measured in this period. These facts can be explained with their sensibility to the low oxygen content and high moisture.

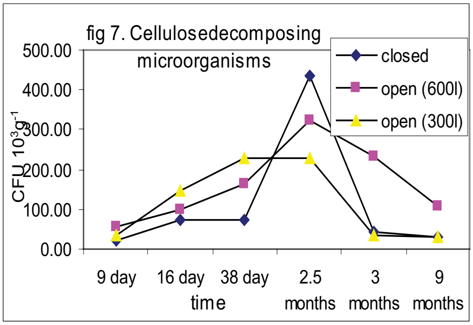
Nitrogen fixing bacteria reach their maximum in the end of cooling phase and the beginning of maturation phase. Their number is small in the closed bin, probably because of decreased access of atmospheric nitrogen in it.



Spore forming bacteria reach their maximum on 38-th day (fig.5), when lowest temperatures and lowest values of nitrogen content have been measured during the cooling phase in the three systems. These microorganisms are less in the open bin (300L), which shows for the more favourable physical characteristics in it.

Data on fig. 6 and 7 show, that in the three bins actinomycetes and cellulose decomposing microorganisms are intensive developing two and a half months after beginning of composting process – at the compost maturation phase, when easily accessible substances have been spent and were followed by the difficulty accessible ones. This confirms the results of others authors (Biddlestone and Gray, 1985; Kelleher et al., 2002; Liang et al., 2003). The more numerous are actinomycetes in the open bin (300L) and cellulose decomposing microorganisms – in the closed bin, in this period of time.





Conclusions

Bacteria dominated during termophilic phase, fungi, bacilli and nitrogen fixing bacteria in cooling phase, while actinomycetes and cellulosedecomposing microorganisms were predominant during the maturation phase.

More suitable conditions for development of composting microorganisms and therefore faster obtaining of qualitative compost were available in closed composting system.

Literature

Biddlestone, A.J. and Gray, K.R., 1985. Composting. In: Comprehensive biotechnology – the principles, applications and regulations of biotechnology in industry, agriculture and medicine. Moo-Yound, M., Ed., Pergamon, Oxford, 1059-1070.

Borken, W., Muhs, A. and Reese, F., 2002. Chanches in microbial and soil properties following compost treatment of degraded temperate forest soils. Soil Biol Biochem 34; 403-412.

Hoitink H.A.J., Boehm M.J. and Hadar Y., 1993. Mechanisms of suppression of soilborne plant pathogens in compost-amended substrates. In: Science and engineering of composting: desigh, environmental, microbiological and utilization aspects. Hoitink H.A.J.&Keener H.J. Eds. Renaissance Publishers, Worthington, Ohio, 601-621.

.Kelleher B.P., Leahy J.J., Henihan A.M., O`Dwyer T.F., Sutton D. and Leahy M.J., 2002. Advances in poultry litter disposal technology-a review. Bioresource Technology, 83: 27-36.

Liang, K. C., Das, R.W., McClendon, 2003. The Influence of Temperature and Moisture Contents Regimes on the Aerobic Microbial Activity of a Biosolids Composting Blend. Bioresource Techn., 86 : 131 – 137.

.Rynk, R., M. van de Kamp, G.B. Wilson, M.E. Singley, T.L. Richard, J.L. Kolega, F.R. Gouin, L.Laliberty, Jr., D. Kay, D.W. Murpy, H.A.J. Hoitink, and W.F. Brinton, 1992. On-Farm Composting Handbook. Northast Regional Agricultural Engineering Service, Ithaca, N.Y., Cornell University, USA, 494.

Tiquia, S.M., Wan, J.H.C., and Tam, N.F.Y. 2002. Microbial population dynamics and enzyme activities during composting. Compost Science &Utilization, Vol. 10, n.2: 150–161.

Tuomela M., Vikman M., Hatakka A. & Itavaara M., 2000. Biodegradation of lignin in a compost environment: a review, Bioresource Technology, Vol. 72, n. 2, 169-183.