MICROFLORA DYNAMICS IN PASSIVE COMPOSTING OF GREEN WASTE

Alexandrina Kostadinova
University of Forestry, Bulgaria, algkbg@gmail.com
Petar Dyakov
University of Forestry, Bulgaria, pdyakov5@gmail.com

Abstract: To determine the microbiological activity, a five-month field experience was carried out by passive composting of green bio-waste resulting from the maintenance of green areas and tree species on the territory of the University of Forestry / Sofia Municipality. The microbiological activity in the different phases of green waste composting was investigated as well as the physical and chemical parameters of the final product were monitored. The results indicate different microbiological activity and composition of microbiocenosis with change of dominant microbial groups.
Keywords: composting, green bio-waste, microorganisms

1. INTRODUCTION

The methods and technologies for the treatment of biodegradable waste are diverse and constantly evolving, and it has been shown in the world that quality compost is only achieved when composting separately collected biodegradable waste [Todorova & Yordanova 2012; Keith, 2002; Raymond, 1975; Chiumenti R. & Chiumenti A, 2006].

Decentralized composting, where applicable, is the most environmentally and economically viable method of treating biodegradable municipal waste. It reduces emissions and costs associated with the transportation of waste and provides a quality product for later use. [Todorova & Yordanova 2012].

The microorganisms involved in the composting process, such as bacteria, fungi and actinomycetes, transform the organic compounds in the plant biomass through the different phases. They are considered chemical destroyers because they alter the chemistry of organic waste. [Ingrid et al 2014]

The Beijing Forestry University conducted studies for a five-month period comparing chemical and microbiological properties of passive aerobic and vermicomposting of green waste. Studies show that the quality of green waste compost is higher in vermicomposting than in aerobic composting. Microorganisms are found to differ in the two types of composting. [Cai et al 2018].

A scientific team from Oman examines the physicochemical and microbiological properties of four types of green waste compost and imported plants. [Saifeldin et al, 2011] During composting, all types of compost exhibit normal physical properties, except for the bad odor of bacteria that reduce sulfur content. [Benito et al, 2003]

A similar study was conducted by a team of Chinese scientists [Cai et al 2018], composting green bio-waste through pre-introduction of bacterial isolates of Bacillus subtilis and Pseudomonas Sp. The composting process takes place within 120 days with an initial C: N ratio of 25-30: 1. Passive composting of green waste was carried out with investigation of various physicochemical parameters. The study specifies a duration of 5.5 months for composting of green waste. The number of most microbial groups increases after the end of the active composting phase, with some populations again decreasing towards the end of the ripening period due to the depletion of specific substrates. [Gazi et al, 2007]

Other authors investigate the effect of compost from active composting of urban green waste on afforestation in Beijing [Tong et al 2018] The results show a significant effect of compost on improving soil properties - increasing organic carbon, phosphorus, potassium, pH . The structure of soil microbiocenosis is also changing - bacterial abundance increases by 12-13%, but the change in bacterial diversity is not significant.

At the University of Innsbruck Austria, anaerobic composting studies on green waste have been carried out [Ingrid et al 2014] The final product identifies Salmonella pathogens and non-degradable organic compounds that the authors propose to mix with fresh raw material or to left to expand.

The effect of compost of rice straw, goat manure and green wastes with added microorganisms on soil properties has been investigated [Jusoh et al, 2013]. The composting process has been proven to last for 90 days, and the compost obtained from artificially imported micro-organisms has better macro and micro indicators, and this result is proven by quantitative values of N, P, K.

The purpose of this study is to monitor the dynamics of microorganisms during the different composting phases of passive aeration of biodegradable green waste.

To achieve this, the most common green wastes were selected and combinations of them were developed, calculated on the basis of an appropriate C / N ratio.

2. MATERIALS AND METHODS

For the purpose of the experiment, a "cold" (passive) method of open composting in 600 cm3 composting was used. The chosen method for the composition and structure of the compost biomass is to stack the starting materials layer by layer without subsequent agitation and aeration [Koff & Lee 2007].

The C / N ratio was calculated on the basis of the literature data on the content of these elements in the waste used by using a specialized calculator. [Chiumenti, 2006, Todorova& Yordanova 2012,]

The microbiological analyzes were performed by the method of dilution and inoculation of solid nutrient media, taking into account the number of columns with forming units in 1g abs dry substrate. In the dynamics are determined the amounts of non-spore-forming bacteria, bacilli, molds, anaerobes, lactobacilli

3. EXPERIMENTAL

The object of the experimental part of the present development is garden (green) waste (20 02 01), as the main raw material for compost production are various types of plant residues obtained from the maintenance of the green areas of the Sofia Municipality and the green areas in the territory of University of Forestry, to which a dead forest cover was added - decaying deciduous leaves mixed with soil from the University of Forestry park. The dead forest floor and soil have been used as activators of the composting process due to the natural biochemical processes of decomposition of organic matter and the presence of soil microorganisms.

The composting inputs used are presented in Table 1, the quantitative values being calculated to achieve a C / N ratio of approximately 30: 1 with literature data.

Tab. 1. Incoming composting waste

Type of waste	Ratio C/N	portions	weight, kg
Grass	19	80	30.80
Leaves	40	35	13.48
Branches	450	2	0.78
Soil	8	14	5.39
total for the sample	Ratio **C/N = 30.01**	**131**	**50.44**

A suitable location is chosen for the placement of the compostor, which provides favorable conditions for the process.

4. EXPERIMENTAL DATA, RESULTS OBTAINED AND DISCUSSION

According to microbiological indicators, passive composting takes place in three phases - mesophilic, ripening and maturing. Monitoring of the dynamics of microorganisms during the different phases of composting during passive aeration of biodegradable green waste is performed in dynamics.

The results of the dynamics of the total microflora / total number of microbes in 1 g absolutely dry substrate / give an idea of the degree of development, respectively. population of germ compost tables. This indicator is important for assessing the degree of destruction of compostable substrates because microorganisms carry out the mineralization of the organic compounds in them. Data on the dynamics of the total microflora, temperature and acidity are presented in Figure 1.

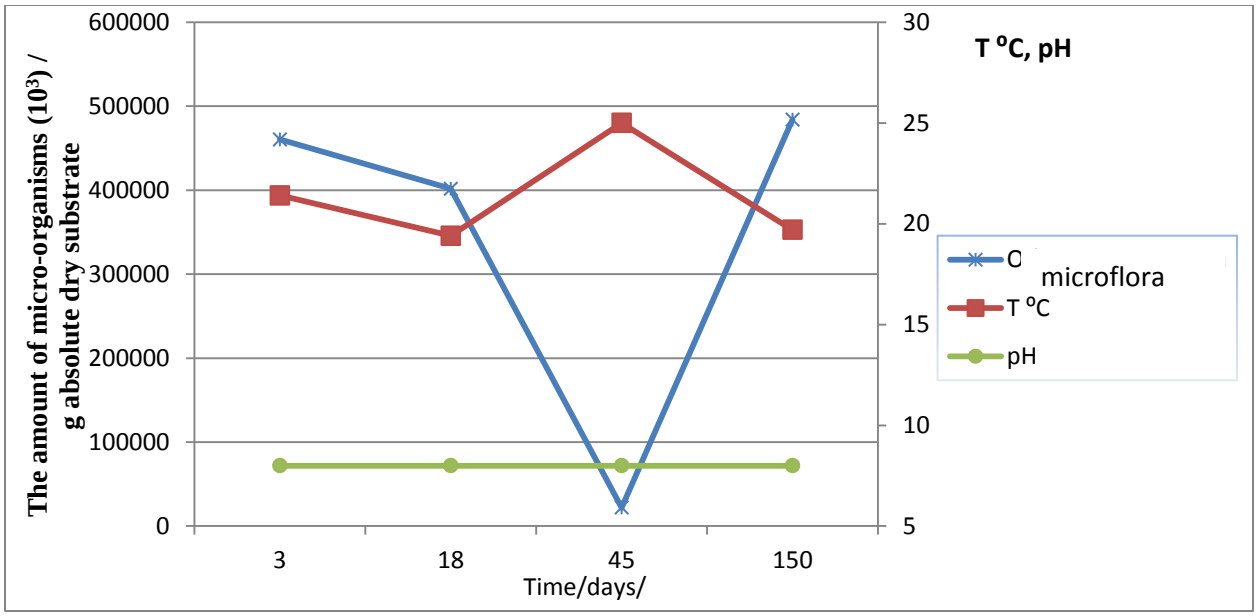

Figure. 1 Dynamics of the total microflora, temperature and pH

In compostable masses, the amount of total microflora decreases smoothly by day 18, after which the multiplication of aerobic microorganisms diminishes extremely until about day 45 of the experiment, due to difficult aeration and anaerobic conditions. During the period from the mesophilic (0-45th day - aerobic phase) to the second, anaerobic phase, the reduction of the amount of total microflora in this way of composting is reduced several times, but is within a high microbial number.

Throughout the period of the experimental setup of passive composting, it is observed that the temperature in the composting mass varies between 20 and 25 ^{0}C, which shows that there are no conditions for the development of thermophilic phase. On the 45th day from the beginning of the process the temperature rises to 25 ^{0}C, which is insufficient for the development of thermophiles. At this point, the total microflora in the compost pile is sharply reduced. This is followed by a slight decrease in temperature and active development of mesophylls, the total microflora increase, with its amount reaching its peak by the 150th day. In the final product, the amount of aerobic heterotrophs is higher than the microbial count at the beginning of the process.

During composting, the pH value in the compost pile does not change, it is about 8 by the end of the process.

In the period around the 45th day, when the decrease in the microbial number for the aerobes was greatest, the quantity of anaerobic bacteria was also counted / Table 2 /.

Table 2. Amount of anaerobic bacteria (x10^3 / g substrate) / 45 days /

Total anaerobes	Ordinary agar bacteria	Chapek-Doxagar-bacteria	MRS agar	Parker Agar
147800	106400	34400	0	7000

The data from this study correlate with the observed limited development of aerobic microorganisms during this study period. It is strongly dominated by anaerobic bacteria. The active development of anaerobes proves an anaerobic phase that "replaces" the standard thermophilic phase. In passive composting, anaerobes that dominate the second phase continue the processes of degradation of organic compounds, albeit at a slower rate.

During the anaerobic phase, a lactobacilli test was carried out to the extent that this group of microbes are optional anaerobes and carry out active fermentation of carbohydrates in composting materials under oxygen deficiency conditions. The data indicate the active development of lactobacilli - 28,000 lactobacilli / 10^3 / g starting substrate, which defines composting as an active process, as well as data on the abundance of obligate anaerobes.

By the end of composting, about 150 days, in the final phases of ripening, the total amount of aerobic microflora reaches and exceeds levels from the first week of development. According to microbiological indicators, 3 phases in the development of microorganisms are outlined, all remaining in the temperature interval for the development of

mesophiles (aerobes and anaerobes). Expectedly, the thermophilic phase is not reached due to difficult aeration in passive composting and a sharp decrease in the volume of compostable materials.
Different quantitative development of the studied microbial groups was observed in the different stages of composting - non-spore-forming bacteria, bacilli, micromycetes / fig. 3 /.

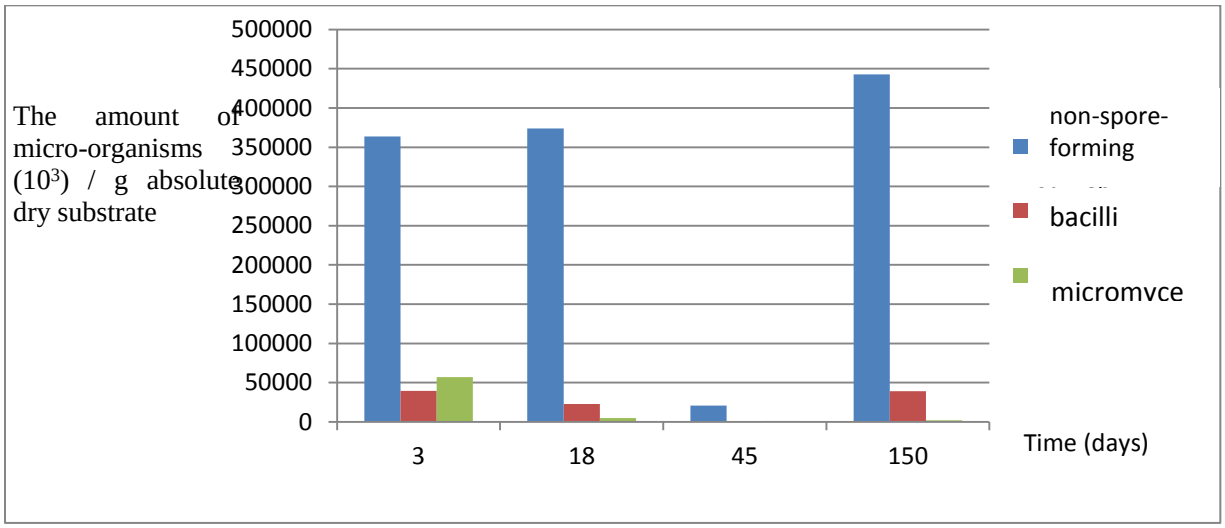

Figure 3 Microflora composition

During all phases, the dominant group of microbes were found to be non-spore-forming bacteria. The quantitative development of these microorganisms shows a sharp decline by the 45th day of sampling and their rapid increase on the 150th day. These microbes, as active destructors, have the highest relative share of the microflora in the whole process of the test. Their participation ranges from 79 to 93% of the total microflora. At the end of the process they have an increased and stable presence and role in maturation, etc. microbiological maturity of the compost. The bacilli have less development, respectively, a smaller role in the processes of decomposition and maturation of compost. The micromycetes are the least developed insofar as they are strictly aerophiles and their development is limited in terms of oxygen deficiency and the found alkaline environmental conditions. It was also found that micromycetes and bacilli were absent in the second, anaerobic phase (day 45).
Data on the quantitative development of microorganisms correlate with the values for the mineralization coefficient, which reflects the rate of degradation of the substrates. / table 3 /

Tab. 3. Mineralization coefficient values

Day	3	18	45	150
Mineralization coefficient	2,44	27,96	0,71	8,49

The data indicate the most active processes of transformation of the compostable material during the 18th day of composting. The results are confirmed by the dynamics of the common microflora. After the 18th day there is a sharp decrease in the number of microorganisms due to the reduction of nutrients in the substrate and the second activation of mineralization in the final stages of the process.

Tab. 4. Values of C, N and pH in the compost obtained

Indicator	C% dry substance	N%	Ratio C/N	pH in water	pHCaCl
Values	12.53	1.144	10.95	7.9	7.2

In the table. 4 shows the values of the C and N elements and their ratio in the finished product. A comparison of the starting data presented in Table 1 for the C: N ratio in the composting stock mixtures and that in the finished product (Table 4/) shows a decrease of 2.75 times the quantitative ratio between C and N in the finished product. The data presented can be seen as a result of the release of the nutrients from the complex organic compounds and their conversion into simpler organic substances as a result of the activity of the micro-organisms in the composting

process. The resulting C: N ratio in the product after composting (10.95) is close to the C: N ratio in humus (10: 1) (Malinova, 2010).

5. CONCLUSIONS

The data from microbiological analyzes for passive composting of green waste can be summarized as follows:

- Passive composting takes place in the absence of a thermophilic phase.
- In the aerobic first and third phases, the main microbial group that carries out the process are non-spore-forming bacteria. The second, anaerobic phase, is dominated by obligate and optional anaerobes, incl. lactobacilli.
- The presence of a starter - soil, activates microbiological processes and the end product is of high microbial count

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