Examination of the temperature distribution of compost prisms according to the recipe and the retention time

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SUMMARY

During our research we examined the temperature distribution of compost prisms during two different composting technologies based on different types of wastes with high organic content.

In sewage sludge based compost prism we could measure the horizontal and vertical temperature distribution.

According to the results of the experience we can conclude that the temperature distribution of the prism can be divided into three zones: 1. environmental zone 2. large temperature zone, 3. core-zone.

The vertical distribution of the sewage sludge base compost prism also can be divided into three layers. The temperature of the bottom layer is lower as the temperature of the middle. The top of the prism is adapting to the temperature of the environment.

The vertical distribution of the sewage sludge based compost prism is different in the different points of the width.

Because of the folia-cover we could not measure the horizontal temperature distribution of slaughtered wastes based compost prism.

The vertical distribution was similar as it was in the sewage sludge based prisms. The difference was large between the temperature of the bottom and the middle layer. Thanks to the cover the temperature did not decrease at the top as much as it did at sewage sludge based prisms.

The temperature profile was more homogeny in the beginning and in the end of the degradation independently of the type of the raw materials.

The mixing caused changes in the temperature distribution but it is needed because it ensures the aeration and homogeneity.

Keywords: *composting, sewage sludge, slaughtered wastes, temperature distribution*

INTRODUCTION

Composting – next to biogas production- is one of the potential methods of the utilization of wastes with high organic content. There is a high range of base materials. One part of the base materials can be used directly as an organic fertilizer (such as sewage sludge), or can be used in industrial processes (slaughtered wastes as meat-powder). Unfortunately the utilization of these materials is limited or completely forbidden by the Hungarian legislation or the regulation of the European Union.

And some characteristics of the material that is harmful on the natural and anthropogenic environment – high heavy metal content, patogenity, blight effect, odorous gas emission, etc. – can also be a limitation factor. The deposition of the wastes with high organic matter content is not a solution for this problem too, because the positive properties of the material are not utilized. The harmful effect of the potential base materials can be reduced and dissolved by composting.

Composting is not the same phrase as disposal. During the disposal the harmful effect are reduced or dissolved. Instead of this, composting is a controlled process which gives the possibility to utilize the positive features of the bas materials (Ábrahám, 1980, Petróczki, 2004).

Composting can give the opportunity to recycle that organic matter content of wastes which cannot be utilized any other way (Senesei and Brunetti, 1996).

There are many methods and technologies of composting. During prism composting the base material (mainly sewage sludge) is mixed with materials that improve the construction of the mixture.

The aerated-prism technology is similar to the prism composting technology, but the prism is built on a permeable layer and the system is periodically aerated with ventilators.

The active aerated system is closed, the oxygen is injected with ventilators and the harmful gases (hydrogen-sulphide, ammonia, methane, etc.) are removed with exhausters. According to the construction it can be mixed vertically or horizontally.

During anaerob composting the compost-recipe goes through a fermentation process.

There are agricultural composting processes where the compost-mixture is directly sprinkled out and the seeds are taken into this mixture (lagoons, sludge-bed solutions).

Special technologies are also available. Such as vermiculture process, while the compost mixture is mixed with worm-culture to improve the efficiency of the degradation (Kosobucki et al., 2000).

From the composting technologies mentioned above two technologies became common: the open air prism composting and the active aerated technology. The aerob conditions are perfectly ensured during the active aerated composting technology. At the case of open air prism composting the aeration is periodical and not continuous like as it is at the active aerated technology.

During composting – like during natural humus production - two main processes are going on: degradation and synthesis. To ensure the optimal conditions of the process we need to choose the basic materials correctly, need to optimize the C/N ratio, ensure the oxygen-balance and to settle the correct moisture content and temperature.

During the chose of the raw material we should ensure the optimal nutrient composition, the particle size and distribution – so the aeration. The determination of these parameters gives the possibility to control the microbiological processes effectively (Petróczki and Késmárki, 2003).

The utilization of composts depends on the stability and the maturity. Maturity is the same as physical, chemical and biological stability of the compost (Mathur et al. 1993). The differences in the compost maturity are determined by the transform of the solvable components, of the solvable carbon and C/N ratio and respiration rate of the solvable fraction (Gouleke, 1986).

The basic term to ensure the optimal conditions is the correct chose of the basic materials (Aleksza and Dér, 1998). With the formation of the correct compost recipe and the pretreatment of the raw materials the degradation process can be positively affected and the production of toxic gases can be decreased (Kocsis, 2005).

The correct basic materials and the used composting technology can influence the physical and chemical parameters of the final product too. (Epstein, 1997, Fazekas et al., 2000).

The ratio of the degradation changes during the retention time. In the beginning of the process an intensive degradation starts which causes a larger gas production too. The incorrect formation of the compost-recipes and the not ensured degradation conditions may cause anaerob conditions which produces harmful gases.

The negative changes in the oxygen-balance cause changes in the gas-balance of the compost recipe too. The incorrect aeration may also cause anaerob conditions. That process is called dry-rot. In this situation the aerob microbes oxygenate the organic compounds, carbon-dioxide and simpler compounds arose while heat disengages (Nakasaki and Othaki, 2002). For the thermopile organism 14-17% oxygen rate us optimal (Benedek, 1990). If this value decreases under 10%, the aerob microbiological processes stop.

The researches base on to different types of raw materials and two different composting technologies.

In the first case open air prism composting technology was examined which based on sewage sludge utilization.

During the second part of our work we examined active aerated technology with the utilization of slaughtered wastes.

MATERIALS AND METHODS

During the research we examined the composting procedure of two different deterministic raw materials – with high organic content - , pretreated slaughtered wastes and rotted sewage sludge.

The sewage sludge was composted with open air prism composting technology at the compost plant of A.K.S.D. Ltd. in Debrecen. The size of the prism was 40m long, 2,5m wide and 1,8m high. The retention time was 60 days. The researches were repeated three times. Saw dust, wood-chips, grass-clipping and straw was used as additive in the recipe. 50% of the basic material was sewage sludge.

For the degradation of the slaughtered wastes GoreTex^{TM} covered active aeration composting technology was utilized. The researches were take place at the composting plant of the BátorTRADE Ltd. in Nyírbátor.

The size of the compost prism was the same but the width was 5m. The researches were repeated in three times. The retention time of the composting was only 30 days thanks to the folia cover.

The bone was pretreated and sterilized with 135 °C preheating. We used animal manure, straw, corn-wastes, shiver and hay were used as additives with the slaughter wastes (feather, bone, fur).

At the case of sewage sludge composting the temperature was measured daily in different points of the prism. For the measurement we used a stack-thermometer, which only measures at the bottom part of the stick.

Some of the cross-sections were measured completely and a temperature map was made. Samples were taken from different points of the prism to determine the C/N ratio of the recipe.

In the case of the composting technology of slaughtered wastes the temperature measurement was continuous. The temperature was measured with probes that were built in the prism. We also measure the temperature with a stack-thermometer. The aeration system was automatic and it turned on by the changes of the temperature. Samples were taken form different points of the prism either.

The samples were examined in the laboratories of the Bátor TRADE Ltd. and the laboratories of Debrecen University with CNS element-analizator.

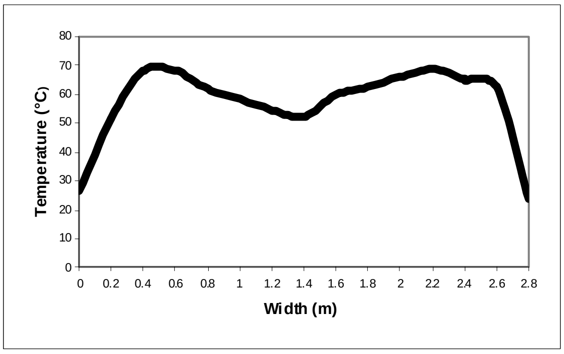
RESULTS AND DISCUSSION

During the researched the temperature was examined related to the retention time and the recipe.

The differences in temperature were examined horizontally and vertically. The temperature distribution was examined during the retention time.

The temperature distribution in sewage sludge based compost can be seen on *figure 1*. The distribution is shown at 1m height level of the prism. The horizontal axis shows the width of the measurement. The figure shows the prism in middle state of the composting process.

Figure 1.:**Temperature changes in the depth of sewage sludge based compost prism**



It can be seen that the compost going through to the middle of the compost prism the temperature increases but in the middle of the prism it decreases. The temperature-profile of the cross-section is completely symmetric. The temperature distribution is almost the same in different height of the compost prism.

According to our measurements the cross section of the compost prism can be divided into three different temperature-zones: the first zone is the boarder zone of the prism, which is determined by the temperature of the environment; the second is the high temperature zone; the third zone is the core where the temperature is lower than it is in the second zone. In the core zone because of the lower temperature an the less aeration the effectiveness of the degradation is lower than it is in the second zone.

The new starter compost prism the temperature profile does not appear. After the starting of the degradation processes the temperature profile evolves.

After the end of the degradation process the temperature of the prism gets close to the temperature of the environment. At this time the moisture content determines the size of the core-zone.

The conformation and examination of the temperature profile may give the basis how to determine the optimal size of the compost prism (with decreasing size of the core).

After mixing the compost prism the cross-section of the prism cannot be divided into temperature zones, but after a few days the layers of temperature evolves.

The vertical temperature distribution of the sewage sludge based compost prism can be seen on *figure 2*.

The black line shows the temperature values at the width of 1.4 m and the grey shows the values measured at 0.6m width.

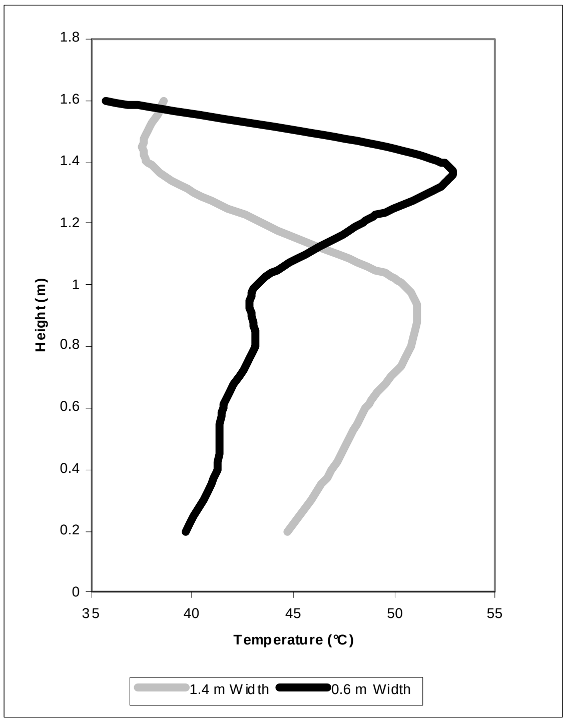
The vertical distribution of the temperature is different at two different widths (in two different temperature zones.

It can be seen on the figure the largest temperature was measured in the top third of the prism at 1.4m width, but at 0.6m width the largest temperature appeared in the middle of the prism.

It is also obvious that independently of the width of the compost prism the temperature decrease going to the bottom of the prism. The largest temperature was measured in the middle of the prism while the top of the prism is adapting to the temperature of the environment.

The vertical temperature distribution – like the horizontal distribution - also changes during the retention time.

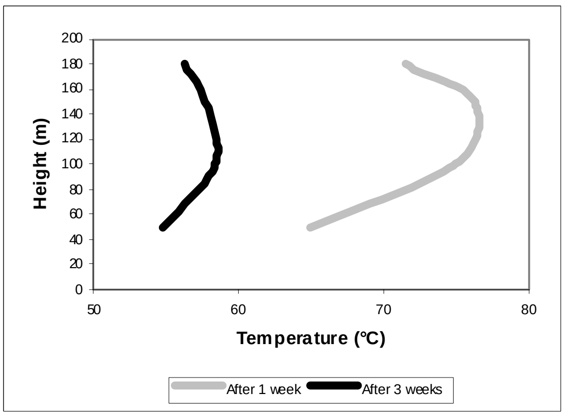
Figure 2.: **Vertical temperature changes in sewage sludge based compost prism**



At the case of slaughtered waste compositing we did not have the possibility to examine and measure the horizontal temperature distribution because of the folia-cover.

So, we examined the vertical distribution that can be seen on *figure 3*.

Figure 3.: **Vertical temperature distribution in slaughtery waste based compost prism due to retention time**



Vertical temperature zones evolve in the prisms based on slaughtered wastes too. In the lower layers of the prism the temperature is lower as it is in the higher ranges. The highest temperature was measured in the middle of the compost prism. The top part of the prism is adapting to the temperature of the environment.

If we compare the temperature profiles measured in different period of the retention time we can conclude that the temperature profile changes during the retention time. One week after the setting of the compost prism not just the temperature was higher but the temperature distribution showed large differences in the distribution-zones. In spite of this three weeks after the setting the temperature distribution was more homogeny in the cross-section of the prism.

The temperature decreased during the retention time which caused an abnormal operation of the automatic aeration system. According to this the made the aeration dependent on time instead of temperature.

CONCLUSIONS

First and last we can conclude that the development of the temperature profile depends on the retention time, the utilized composting technology and the size of the prism. The larger prism does not affect more effective degradation because with the increase of the size of the prism the size of the inner core – with large temperature – increases either.

The effectiveness of the degradation can be increased if the size of the core-zone is decreased to the possibly minimum – if the size of the prism is optimal.

The main goal is to establish an optimal size which decreases the size of the core to the minimum.

During the folia-covered active aeration technology the temperature of the top level did not adapt to the temperature of the environment as it did at open air sewage sludge composting.

Mixing is suggested at the covered technology, because without mixing over-warmed points may appear. Mixing changes the temperature-profile of the prism, but it has a positive effect on the effectiveness of the degradation.

The moisture content of the raw materials also determines the temperature distribution. Large moisture content causes lower temperature. Large moisture content causes larger core-zone in the beginning of the degradation process.

REFERENCES

Aleksza, L. - Dér, S. (1998): A komposztálás elméleti és gyakorlati alapjai. Bio-Szaktanácsadó Bt. Gödöllő.

Benedek P. (1990): Biotechnológia a környezetvédelemben. Műszaki Könyvkiadó. Budapest. 222-236.

Epstein, E. (1997): The science of composting. Technomic Publishing Company Inc. Pennsylvania.

Fazekas, I. - Szabó, Gy. - Szabó, Sz. (2000): A hulladékkezelés jelene és jövője a Tisza menti településeken – Acta Geographica Debrecina 35. 63-72.

Gouleke, G. G. (1986): Compost research accomplishments and needs. BioCycle 27: 470-43.

Kocsis I. (2005): Komposztálás. Szaktudás Kiadó Ház. Budapest. 43-44.

Kosobucki, P. – Chmarzynski, A. – Buszewski, B. (2000): Sewage Sludge Composting, Polish Journal of Environmental Studies Vol. 9

Mathur, S. P. – Owen, G. – Dinel, H. - Schinitzer, M. (1993): Determination of Compost Biomaturity I. Literature Review. Biological Agriculture and Horticulture 10: 65-85.

Nakasaki, K. - Othaki, A. (2002): A Simple Numerical Model for Predicting Organic Matter Decomposition in a Fed-Batch Composting Operation. Journal of Environmental Quality 31. 3: 997-1003.

Petróczki F. – Késmárki I. (2003): A komposztálás jelentősége. Acta Agronomica Óváriensis, 45(2): 203-213.

Senesei, N. – Brunetti, G. (1996): Chemical and Physico-Chemical Parameters for Quality Evaluation of Humic Substances Produced during Composting. The Science of Composting. Blackie Academic & Professional 4, 243-248.