REFLECTANCE AS A POSSIBLE METHOD TO DETERMINE MIXING RATE AND HOMOGENEITY OF COMPOST PRISMS

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Abstract
The mixing rate of the compost raw materials basically determines the procedure of degradation. in most cases, in practice the real mixing ratio is not equal with the counted ratio - which based on the C/N ratio – and the check of the fulfilled mixing is not possible.
The homogeneity of the prism is also one of the fundamentals of the effective degradation process. There is no available method to determine the homogeneity of the compost prism.
During our research we examined the reflectance values of different compost mixtures where sewage sludge and rape-straw were used as raw materials.
According to our results we built up a regression model which gives the ability to determine the mixing rate (in 5% margin of error) and makes possible to check the homogeneity of the prism together with the access of immediate action.

Keywords: sewage, sludge, composting, reflectance, homogeneity

INTRODUCTION

As a part of the national wastewater treatment and sewerage program larger and larger areas are connected to the sewerage system which indicates the increase of the amount of waste water and the capacity of the local and regional purification plants. The increased amount of wastewater positively affects the amount of produced sewage sludge too.

The depositing directive of the European Union orders the diminishing of the amount of the deposited organic wastes – like sewage sludge. This directive accelerated the spread and improvement of the composting technologies. With the eastern expansion of the EU the market of by-products of waste treatment technologies also expanded. There is a large demand for high-class quality organic fertilizers.

Sewage sludge is a great raw material for composting because its advantage characteristics do not change during the degradation (Tamás, 1998), but the utilization may be limited by its high heavy metal content (Tamás, 1990; Simon et al., 2000; Kovács and Füleky, 2007).

Sewage sludge composting is not only a waste disposal technology. It is a treatment technology which decreases the volume of sewage sludge, stabilizes its organic-matter content and gives a final product with great preferences (Uri et al.; 2005; Kanat et al. 2006; Banegas et al., 2007).

The utilization of the composts is determined by their stability and maturity. Maturity is equal with the physical, chemical and biological stability of the compost. (Mathur et al., 1993). The different maturity states is based on the changes of organic components, especially the solvable components, the solvable carbon fraction, C/N and the respiration rate – that can be linked to the solvable organic matter content (Gouleke, 1986.)

The effectiveness of composting is basically determined by the amount and quality of the additive materials (straw, wood-clipping, grass-clipping, etc.). Next to the additives the homogeneity of the prism, the particle distribution, the moisture content, the oxygen-balance and the C/N ratio affects the quality of the final product (Petróczki and Késmárki, 2003; Guardia et al., 2008).

The determination of the optimal degradation process is based on the correct chose of the raw materials (Aleksza and Dér, 1998). The degradation process, and the amount and intensity of the produced toxic gases is influenced by the mixing rate of the raw materials and the pretreatment technologies (Kocsis, 2005; Smith and Hughes, 2004).

The homogeneity of the prism also influences the velocity of the degradation and the effectiveness of the procedure (Golueke and Diaz, 1996).

In homogeny compost prisms the intensity of the degradation is equable in the whole prism independently of the size of the prism. The set of homogeny circumstances is difficult, the increase of the number of mixing is essential, but it means larger costs too (Amlinger et al., 2004)

The determination of homogeneity is also not easy, because there is no available elaborated method that gives an acceptable result. Mainly the particle distribution is used to determine the homogeneity (Haug, 1993).

The particle distribution gives good basics for the determination of homogeneity, but large number of samples and large amount of sample-materials are needed. The analyzing of the sample is not cost-effective and needs time.

During the chosen of the raw materials mainly 50% is sewage sludge in the mixture. The other 50% are the additives, such as saw dust, wood-clipping, grass-clipping, straw. After the predetermination of the mixing rate the real mixing rate is improper (Cekmecelioglu et al., 2005).

The aim of this paper is to introduce a new simple method that gives the possibility to check the true mixing rate. With this new method we can examine the homogeneity of the prism that occurs immediate action.

During the research we used sewage sludge and rape-straw mixture. After a mixing range we concluded the real mixing rate by the reflectance values of the samples.

MATERIALS AND METHODS

During our research we used sewage sludge and rape straw as raw materials to establish the different compost mixtures. With the utilization of the raw materials we made a mixing series, in which we increased the rate of the rape-straw with 10% of the whole volume. The mixing was fulfilled 2 times with 3 times repetition (6 series in total). The mixing series is shown on figure 1.

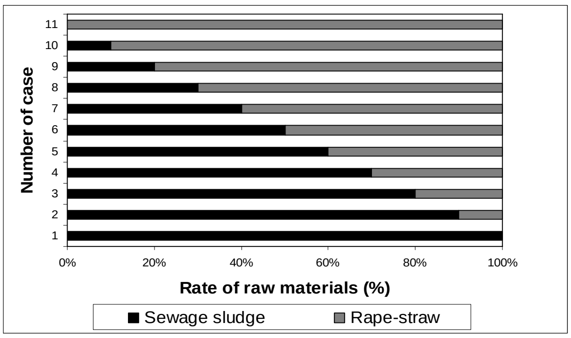

Fig. 1: The set mixing series

During our research instead of the rate of mass we used the rate of volume because in practice the mixing is based on the rate of volume.

To determine the reflectance we used ALTA II. on-field, portable spectrometer. The function of the equipment is based on the differences of voltage. On the bottom part of the equipment there are different colored bulbs to generate different color spectrums (Burai et al., 2008). The equipment measures in the following color spectrums (table 1.).

Table 1.

The measurable color spectrums and wave-length

Color	Light Wavelength
Blue	470 nm
Cyan	525 nm
Green	560 nm
Yellow	585 nm
Orange	600 nm
Red	645 nm
Deep Red	700 nm
Infrared 1	735 nm
Infrared 2	810 nm
Infrared 3	880 nm
Infrared 4	940 nm

To count the reflectance next to the voltages – measured on the different wave-lengths – a so-called dark voltage is needed. Dark voltage is measured in the basic state of the equipment – without setting the wave-length – on a white paper. The standard measurements should be done on white paper too on each wave-lengths. The reflectance values of each sample are counted with the following equation (figure 2).

$$R = \left[\frac{\text{Sample voltage - Dark voltage}}{\text{Standard voltage - Dark voltage}} \right] *100$$

Fig. 2: Equation to count reflectance

The comparison of the wet and dry samples was also a part of our research. For drying drier cabin was used with 105 °C temperature.

SPSS 15 statistical software was used for the evaluation of the data.

RESULTS AND DISCUSSION

During our research we examined the changes of reflectance values depending on the mixing rates.

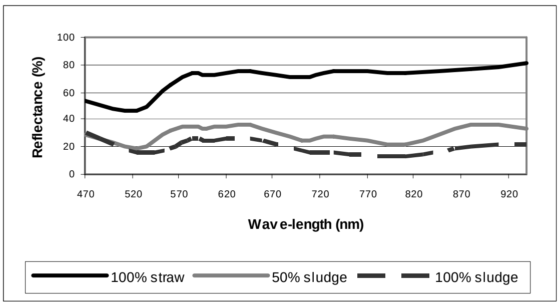

Fig. 3: Changes of reflecatance depending on the mixing rates

Figure 3. shows the reflectance values of 100% sewage sludge 50-50% sludge and rape-straw and 100% rape-straw ratios. The wave-length spectrums are shown on the horizontal axis, and the vertical axis shows the reflectance values. It can be seen that the greater rate of rape-straw resulted greater reflectance value on each wave length.

We examined that the reflectance values how change on the different wave lengths depending on the mixing rates.

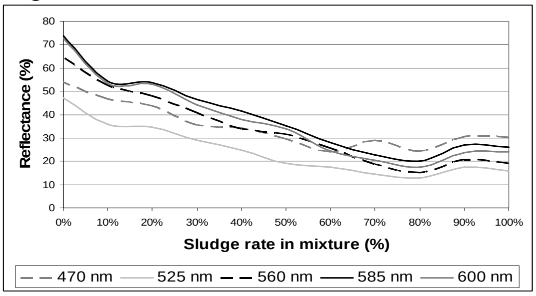

Fig. 4: Reflectance values of different mixing rates on different wave-lengths

Figure 4. shows changes of reflectance values on different wave-lengths in between 470-600 nm interval according to the ratio of sewage sludge. The figure shows that with the increase the rate of sludge the reflectance decrease on each wave-length. It is difficult to make the differences between the reflectance values of the different mixing rates on each wave lengths so we made statistical analysis to find those spectrums, where the reflectance values can be disjoined. Based on the Tukey-test we can conclude that in the infrared spectrums (spectrums between 735-940 nm wave-lengths) 7 groups can be disjoined from the 11 different mixing rates significantly. We have also to say that 70-100% sewage sludge rate is in the same group, so on none of the wave-length there is no significant difference between the reflectance values of 70, 80, 90 and 100% sewage sludge ratios, these mixing rates cannot be disjoined.

During our research we analyzed the differences between the reflectance wet and the dry samples too.

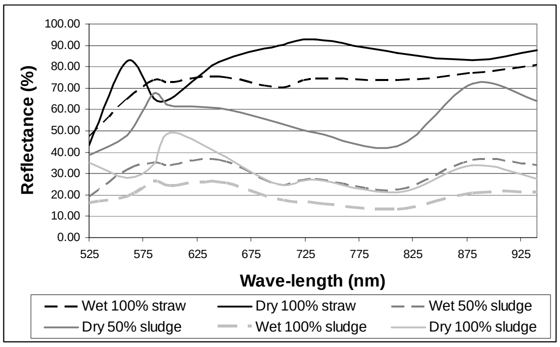

Fig. 5: Reflectance values of wet and dry samples according to the wave-length

Figure 5. shows the reflectance-lines of dry and wet samples in the cases of 100% sewage sludge, 50-50% sludge and rape-straw and 100% rape-straw mixing ratios. It can be seen that the reflectance values of the dry samples is higher than the values of wet samples in each cases.

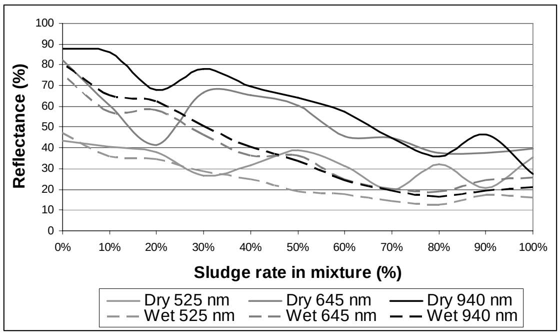

Fig. 6: Reflectance values of wet and dry samples on different wave-lengths

The trend is similar if we examine the reflectance values of the different wave-lengths according to mixing rate (figure 6.). The values of dry samples are lower here too. The reflectance is decreasing with the increase of the sludge rate in mixing in the cases of dry samples too. But the decrease is more fluent, no waves in the lines. According to the Tukey-test in the cases of dry samples also the utilization of infrared spectrum is suggested for the evaluation of the samples (between 735-940 nm wave-lengths).

After the graphical representation we made regression analysis between the wet and dry samples. According to that the moisture content negatively influences the reflectance values, which is confirmed by the 0.62 r2 value. The regression analysis also confirms that the reflectance values of dry samples are higher independently by the wave-length spectrums.

After the mixing spectrums we examined that if it is possible to use the reflectance measurement method to determine the mixing rate of unknown mixed samples. For this we used a regression analysis with the use of determined wave lengths. After the regression analysis we can make a regression equation with which we can determine the starting mixing rate with the utilization of reflectance values. Handling the wave-length each by each did not give an applicable and usable solution. According to this and the experiences of the statistical analysis, handling of more wave-lengths together in a regression analysis we can build up an equation that can be used. In our regression model we used those infrared spectrums that were given as a result in Tukey-test.

The r2 value of the regression analysis was 0.646 which is adoptable. According to the table of coefficients (table 2.) we can set that the coefficient values of each wave-length are inside the pre-determined 5% significance level, so the regression model is applicable. The regression model is satisfied with the boundary conditions (homogeneity, normal distribution, independence of the values).

Table 2

Coefficients values of the regression model

Model		Unstandardized Coefficients		Stand. Coeff.	t	Sig.
		B	Std. Error	Beta	B	Std. Error
1	(Cons)	85,939	1,407		61,073	,000
	735 nm	,395	,088	,312	4,473	,000
	810 nm	-,939	,106	-,694	-8,822	,000
	880 nm	-,183	,076	-,148	-2,407	,016
	940 nm	-,341	,086	-,281	-3,963	,000

Based on table 2 we can set the following equation:

Sample mixing rate = 85,539+0,395(mr735)-0,939*(mr810)-0,183*(mr880)-0,341*(mr940)*

where:

mr735: measured reflectance at 735 nm

mr810: measured reflectance at 810 nm
mr880: measured reflectance at 880 nm
mr940: measured reflectance at 940 nm

During the check of the given reflectance equation we concluded that if the sewage sludge content is larger than 60% the equation did not give acceptable result (similarly like the Tukey-test). If the sewage sludge rate was lower than 60% the counted mixing rate had a difference in only 5% boundary limit which gives the ability to use the model.

CONCLUSIONS

The determined mixing rate of the compost raw materials basically affects the composting process. In practice the mixing rate is not equal with the calculated mixing rate (which based on the C/N ratio) and there is no available and effective method to check the mixing rate.

The examined new method - which is based on reflectance measurements - may give a possibility to check the mixing rate and to examine the homogeneity of the compost prism.

According to the results of our experiment we can conclude that infrared color spectrums are the most adaptable to examine sewage sludge - rape straw compost mixtures. But if the sewage sludge rate is larger than 60% there is no significant difference on none of the wave-lengths. This is not influence deterministically the applicability of the measuring method because in practice – to reach the largest effectiveness – the rate of sewage sludge is always lower than 50%.

The increase of the rate of rape-straw brings out the increase of the reflectance.

The moisture content influences the reflectance negatively, so after the drying process the reflectance increase. The method can be used with wet and dry samples too, but in the case of wet samples there is no need for the drying process, so samples can be examined directly taken from the prism.

Using statistical analysis we can build up a model which gives the possibility to determine the mixing rate of unknown samples after reflectance measurements. The regression equation can be used in 5% error limit. With the equation we can examine the compost homogeneity by measuring the reflectance of samples taken from different parts of the prism, so it gives the ability of immediate action.

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