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IN-VESSEL COMPOSTING: II. GRASS CLIPPINGS

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Abstract: In the present study, in-vessel aerobic composting was evaluated in terms of impact on stabilization of grass clippings (GC). The composting period was 22 days. The temperature, carbon (C), total Kjeldahl nitrogen (TKN), C/N ratio, cellulose, volatile solids (VS), moisture, pH, electrical conductivity (EC), total coliform (TC), fecal coliform (FC), heavy metals and radioactivity were investigated and the kinetics of degradation of organic matter was found during composting. The reaction rate constant of degradation of VS was found as 0.0372 day^{-1}(R^2 = 0.99). The VS decreased from 88.78 % to 83.51 % at the end of the process. The GC reached maximum temperature of 62°C within 1 day. C decreased from 49.32 % to 46.39 % while TKN decreased from 2.94 to 2.69 %. C/N ratio that was 16.78 at the beginning increased to 17.25. Cellulose increased after 22 days. pH increased from 5.97 to 8.26 and EC decreased from 1006 to 942 µS/cm. Coliforms decreased during composting. The obtained composts contained heavy metals under the standards related to heavy metal. At the end of the composting process α-radioactivity greatly decreased and also the β-radioactivity decreased. ^{40}K and ^{137}Cs concentrations were also determined. In-vessel aerobic composting was effective to reduce TC, FC, α-and β-radioactivity in GC used. According to these parameters, if such composts are used in soil, a risk for human health could not arise.

Key Words: Waste, Composting, Aerobic composting, Grass clippings, In-vessel composting.

Reaktörde Kompostlaştırma: II. Çim Kırpıntıları

Özet: Mevcut çalışmada reaktörde aerobik kompostlaştırma, çim kırpıntılarının stabilizasyonu üzerine olan etkisi bakımından değerlendirilmiştir. Kompostlaştırma süresi 22 gün olmuştur. Kompostlaştırma süresince sıcaklık, karbon (C), toplam Kjeldahl azotu (TKN), C/N oranı, selüloz, uçucu katı, nem, pH, elektriksel iletkenlik, toplam koliform (TC), fekal koliform (FC), ağır metaller ve radyoaktivite araştırılmış ve organik madde bozunmasının kinetikleri bulunmuştur. Uçucu katı bozunmasının reaksiyon hız sabiti 0.0372 gün^{-1} (R^2 = 0.99) olarak bulunmuştur. Uçucu katı, proses sonunda % 88.78' den % 83.51'e azalmıştır. Çim kırpıntıları 1 gün içerisinde 62°C'lik en yüksek sıcaklığa ulaşmıştır. TKN % 2.94'den % 2.69'a azalırken karbon % 49.32'den % 46.39'a azalmıştır. Başlangıçta 16.78 olan C/N oranı 17.25'e artmıştır. Selüloz 22 gün sonra artmıştır. pH 5.97'den 8.26'ya artmış ve elektriksel iletkenlik 1006'dan 942 µS/cm'e azalmıştır. Kompostlaştırma esnasında koliformlar azalmıştır. Elde edilen kompostlar ağır metal ile ilişkili standartların altında ağır metal içermişlerdir. Kompostlaştırma prosesinin sonunda α-radioaktivitesi büyük oranda azalmıştır ve β-radioaktivitesi de azalmıştır. ^{40}K ve ^{137}Cs konsantrasyonları da tespit edilmiştir. Reaktörde aerobik kompostlaştırma, kullanılan çim kırpıntılarındaki TC, FC, α ve β-radioaktivitelerini azaltmada etkili olmuştur. Bu parametrelere göre böyle kompostların toprakta kullanılması durumunda insan sağlığına bir risk oluşturmayacaktır.

Anahtar Kelimeler: Atık, Kompostlaştırma, Aerobik kompostlaştırma, Çim kırpıntıları, Reaktörde kompostlaştırma.

1. INTRODUCTION

It is well known that fresh organic materials should not be applied to soil until they have been sufficiently biostabilized, because application of immature organic materials to soil may cause severe damage to plant growth due to nitrogen starvation and production of toxic metabolites (Zucconi et al.,

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1981; Fang and Wong, 1999). Composting of organic waste has become widely developed to yield a product that provides more fertilization and is safer than the raw material for agricultural recycling. Composting leads to the biotransformation of raw organic matter into a more stable product, rich in humic substances (Amir et al., 2006). The stabilization process considerably reduces odour emissions, and dries up the waste making it easier to handle and transport (Hanajima et al., 2006).

This is the second part of the study which evaluated in-vessel aerobic composting. In this part, aeobic composting was evaluated in terms of impact on stabilization of grass clippings. This valuable biostabilization process may be a solution for waste problem and on the other hand prevent the damages caused by raw organics.

2. MATERIAL AND METHODS

The compost reactor that was made of fiberglass and covered with glass wool for insulation was with internal diameter of 30 cm and height of 50 cm. Schematic diagram of the composting system is given in the first part of this study. The GC were obtained from football field of the Fırat University campus. Two kilograms of biological treatment sludge from the activated sludge treatment plant of the Elazıg city was added as inoculum. Two kilograms of sawdust from a carpenter's shop was used to increase the porosity and carbon content of the mixtures. The composting period was 22 days. The reactor was turned before taking every sample. Determination of moisture, VS, cellulose, TKN, C, pH, EC, temperature, TC, FC, heavy metals (Cr, Cd, Zn, Mg, Cu, Co, Fe, Ni, Mn) and radioactivity is given in the first part of this study.

3. RESULTS AND DISCUSSION

3.1.Temperature

Changes in temperatures during composting were given in Figure 1. The thermometer heights mentioned in the figure are from top to the bottom of the reactor. Decreases and increases in temperatures during first 7 days were due to the mixing of the wastes. Temperatures decreased during mixing the wastes and increased again after the mixing. Similar to this situation, Eklind and Kirchmann (2000) reported the short-term temperature fluctuation caused by temperature decline in connection with weighing and sampling during composting of organic household waste. In our study, the GC reached maximum temperatures of 62°C within 1 day and thermophilic phase ended after 7 days. Then, the temperatures decreased to mesophilic values.

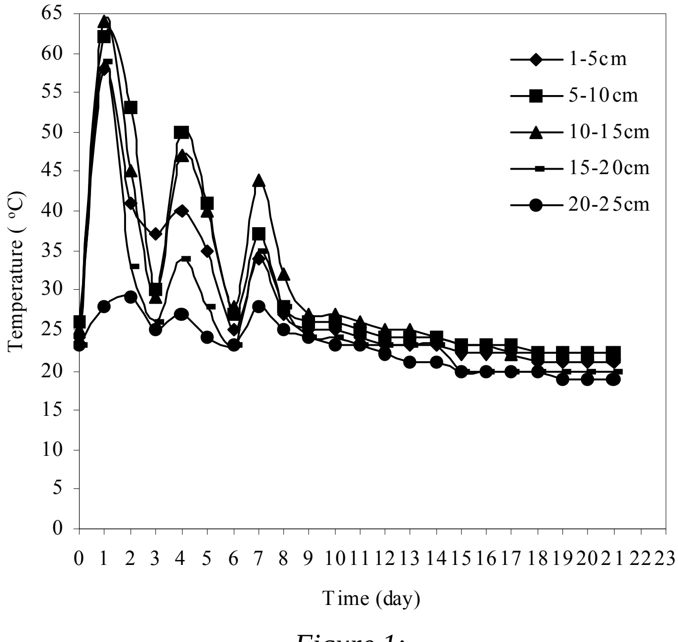

Figure 1:
Changes in temperatures during composting.

3.2. pH and EC

At the beginning of the composting process, pH value was 5.97 (Figure 2). The pH values increased with thermophilic phase. Similar to our result, a sharp increase was reported at the first day by Zorpas and Loizidou (2008). In their study that dealt with the production of compost from dewatered anaerobically stabilized primary sewage sludge and sawdust, during the first day pH increased to nine due to the presence of ammonia (Zorpas, 1999 Zorpas, A.A. 1999. Development of a methodology for the composting of sewage sludge using natural zeolite. PhD Thesis. National Technical University ofAthens, Greece.Zorpas, 1999).

EC values decreased from 1006 to 942 µS/cm (Figure 3). Changes in EC values were as a result of the changes in solution rates of salts. The salt level of the compost is important because of the effects those can be seen in soils. So, the salt levels of the composts and soil should be known and possibility of negative effects of salt on soil should be considered (Zorpas and Loizidou, 2008). Similar pattern to our result were reported by Marhuenda-Egea et al. (2007). When they composted mixtures of grape stalk, grape marc, exhausted grape marc and sewage sludge, the initial EC value (4.21 dS/m) decreased to 1.94 dS/m at day 130.

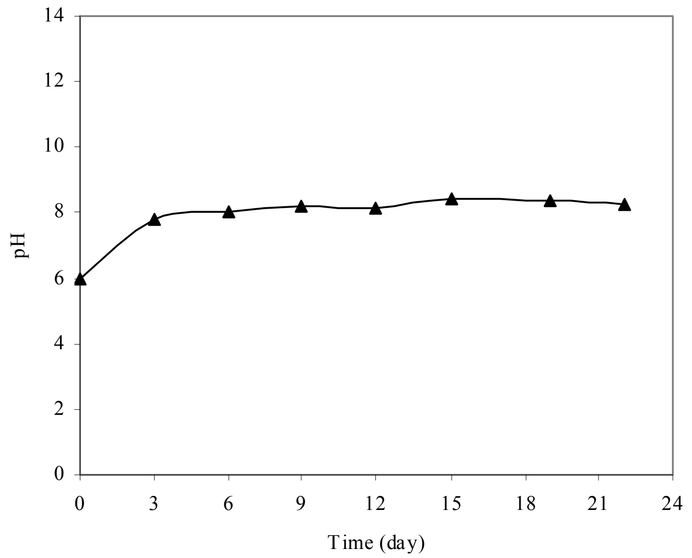

Figure 2:
Changes in pH contents during composting.

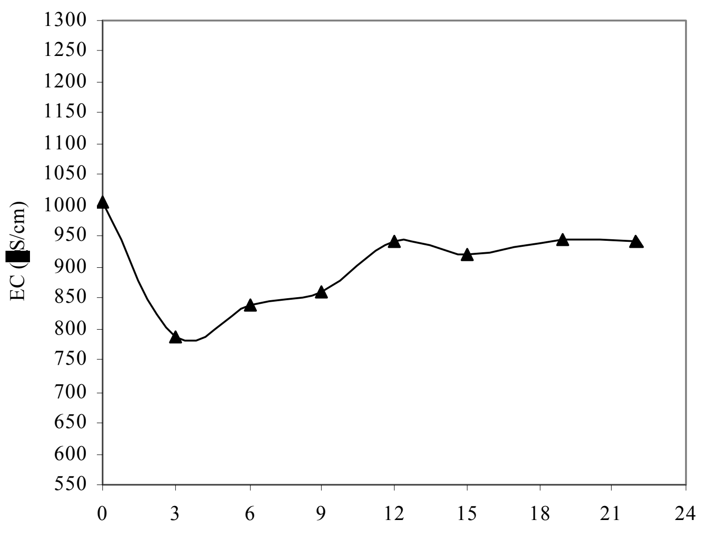

Figure 3:
Changes in EC contents during composting.

3.3. Carbon, TKN, C/N, Cellulose

Carbon decreased from 49.32 to 46.39 % (Figure 4). This could be due to the fact that a great fraction of the carbon consumed by the microorganisms is converted into carbon dioxide, which is released, while the rest is combined with hydrogen in microbial cell metabolism (Breindenback, 1971; Ferrer et al., 2001). Higher losses than our result were reported by Larney et al. (2006) and Tiquia et al. (2002). In the study of Larney et al. (2006), carbon losses were 66.9 % with composting (Larney and Hao, 2007). With solid pig manure, Tiquia et al. (2002) reported C losses of 64% for turned compost windrows which were significantly higher than 50% for unturned windrows.

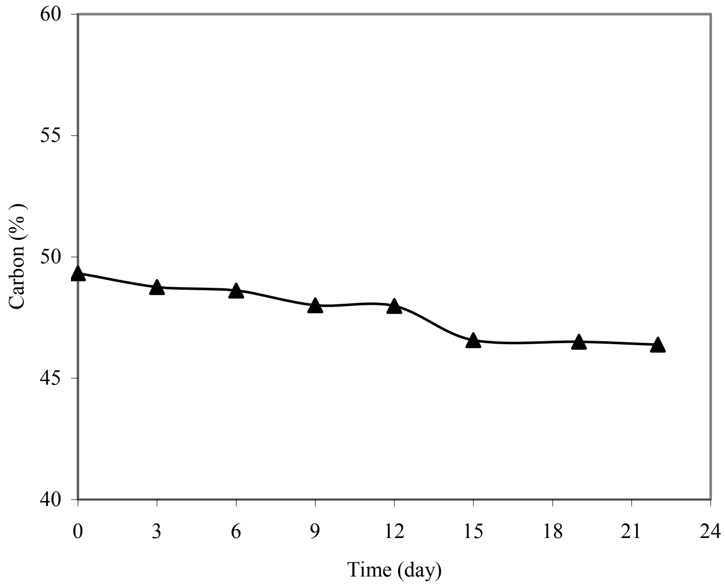

Figure 4:
Changes in carbon contents during composting.

TKN values decreased from 2.94 to 2.69 % (Figure 5). As our result, in the composting study of Tiquia and Tam (2000), at day 49, the organic N decreased in the chicken litter piles, due to ammonification of organic N to NH_3 (Tiquia and Tam, 2000).

C/N ratio that was 16.78 at the beginning increased to 17.25 (Figure 6). In the study of Tiquia and Tam (2000), as composting proceeded, the C/N ratio of the chicken litter increased. This pattern was consistent with our result. Increases in C/N ratio had been reported also during composting of sewage sludge (Morisaki et al., 1989) in which increasing C/N values occurred during composting due to vigorous NH_3 volatilization (Tiquia and Tam, 2000).

Cellulose content increased at the end of the composting process (Figure 7). Similarly, Eklind and Kirchmann (2000) were reported that during composting of organic household waste with litter amendments (leaves and sphagnum peat) and without litter amendments (control) cellulose contents increased.

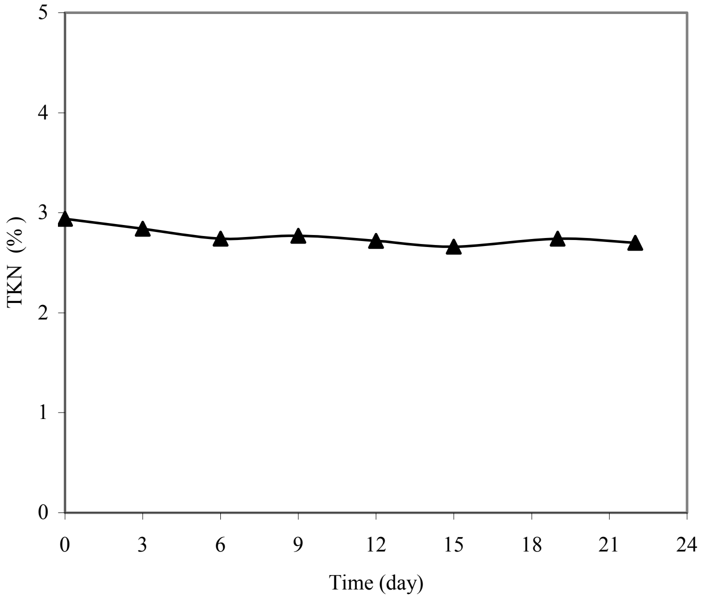

Figure 5:
Changes in TKN contents during composting.

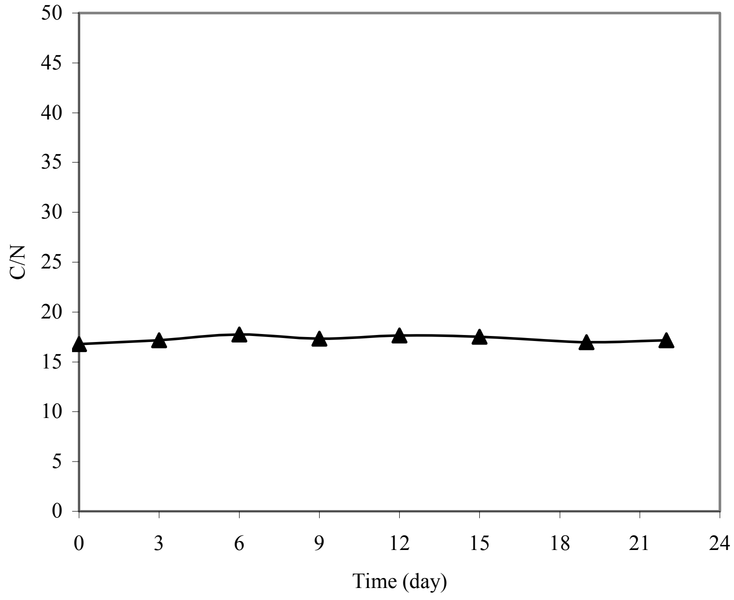

Figure 6:
Changes in C/N during composting.

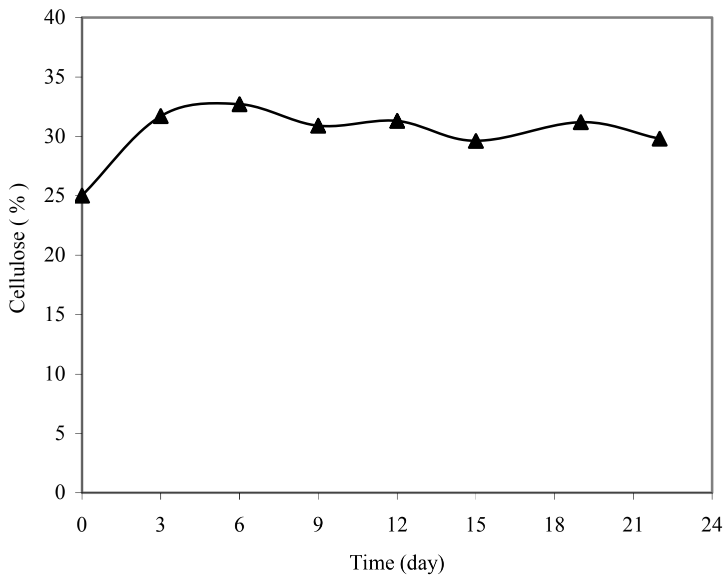

Figure 7:
Changes in cellulose contents during composting

3.4. Moisture and VS

Moisture values were given in Figure 8. GC had the appropriate moisture values for sufficient composting during the process. After the thermophilic phase moisture decreased and then stay stabile after day 12. Similar to our result, in the study of Said-Pullicino et al. (2007), during the active phase the moisture content decreased from 56.5 % to 38.8 % (at day 28) with most of the reduction occurring during the first 6 days, primarily due to matrix turning, positive aeration and temperature elevation.

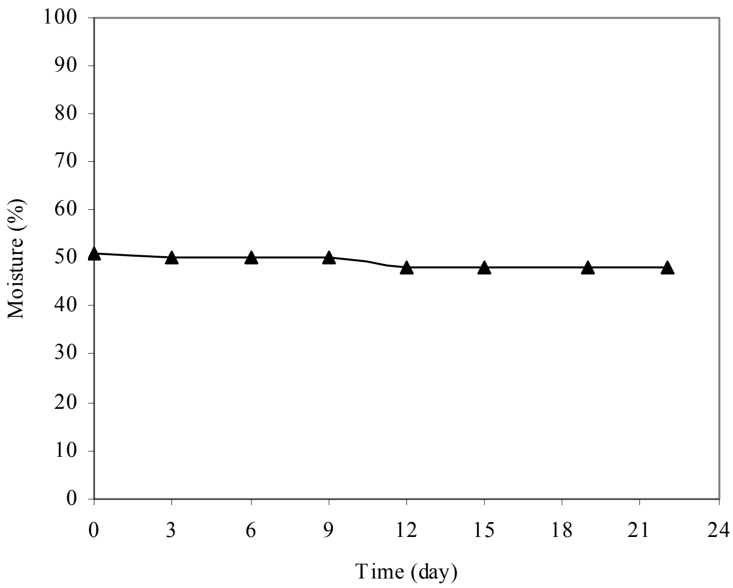

Figure 8:
Changes in moisture contents during composting.

The VS decreased from 88.78 % to 83.51 % at the end of the process (Figure 9). The VS degradation could be expressed as first-order kinetics. The reaction rate constant of VS degradation was 0.0372 day^{-1} (R^2 = 0.99). Contrary to our result higher organic matter loss were reported by Kulcu and Yaldız (2007). In their study, the organic matter loss was calculated as 67.23 after 21 days incubation for 47.5 % goat manure, 47.5 % wheat straw and 5 % pine cones.

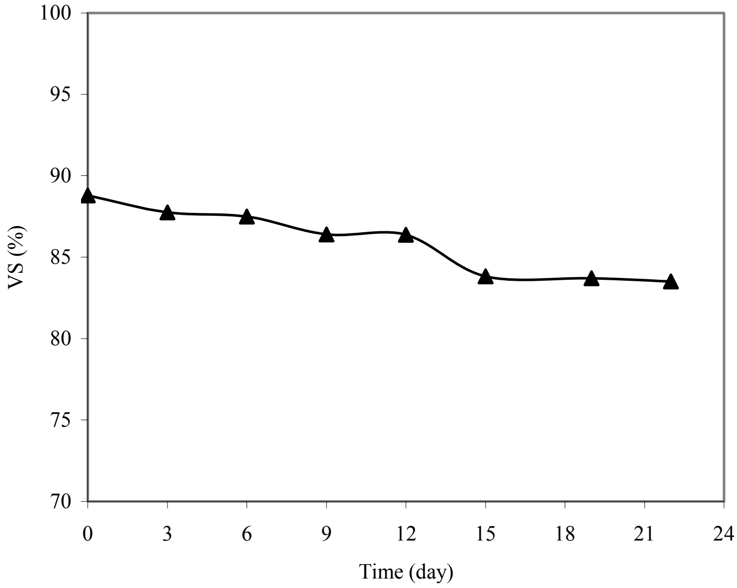

Figure 9:
Changes in VS contents during composting.

3.5. TC and FC

Similar to the findings of first part of this study, a decrease in TC and FC was also observed at the end of this process (Figure 1 and 2). As seen from Figure 10 and 11, at thermophilic phase both of the TC and FC significantly declined because of the high temperatures.

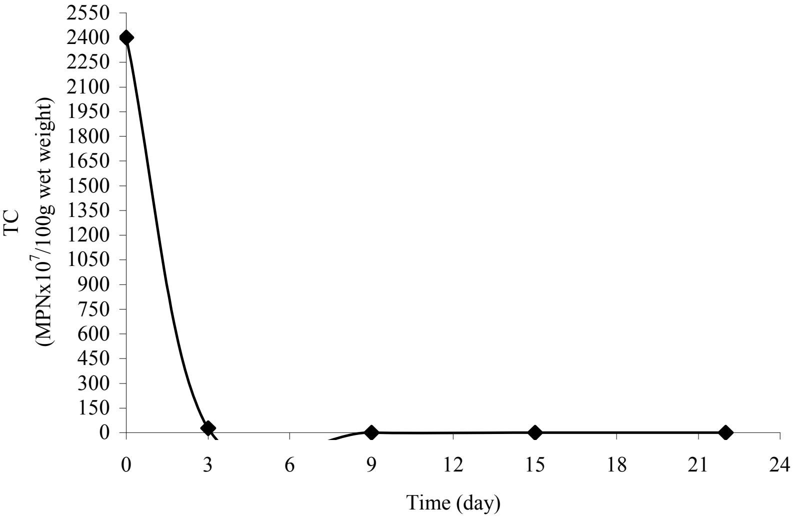

Figure 10:
TC numbers during composting.

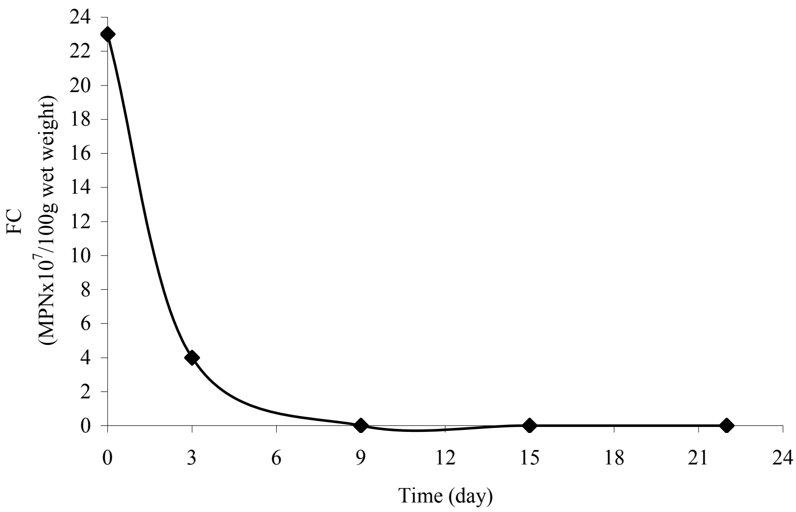

Figure 11:
FC numbers during composting.

3.6. Heavy Metals

Heavy metal contents of the compost were given in Table I. Similar to the findings of first part of this study, heavy metal concentrations of the final composts were below the limits established by several legislations and the values obtained by our study were also below the values given by Regulation of Control of Soil Pollution for stabilized treatment sludges those used in soil in Turkey.

Table I. Heavy metal contents of the compost (mg/kg)

	Cr	Cd	Zn	Mg	Cu	Co	Fe	Ni	Mn
GC Day 0	17.2	*	250.3	509.3	22.775	6.35	2448.45	14.80	121.73
GC Day 22	22.4	*	280.2	1126.2	34.450	9.05	3092.78	17.35	169.73

* Below detection limit

3.7. Radioactivity

The α radioactivity in the GC composts was exist and the β-radioactivity decreased at the end of the composting process, similar to the findings of first part of this study (Table II). Also, potassium activity was decreased in range of 11%. The measured concentration of ^{137}Cs in studied samples was very low. This study indicated that gross alpha and gross beta radioactivity in GC could be reduced by in-vessel aerobic composting.

Table II. The radioactivity levels of raw materials and obtained compost

Sample	Gross α-radioactivity (Bq/g)	Gross β-radioactivity (Bq/g)	^{137}Cs (Bq/g)	^{40}K (Bq/g)
GC Day 0	0.4946 ± 0.0175	0.0277 ± 0.0004	0.0040 ± 0.0002	0.981
GC Day 22	0.3263 ± 0.0165	0.0271 ± 0.0006	0.0062 ± 0.0003	0.869

4. CONCLUSIONS

C/N ratio that was 16.78 at the beginning increased to 17.25. The increase in C/N ratio is an undesired situation because of the loss of nitrogen due to NH_3 volatilization. In spite of this, the final value of the C/N ratio was suitable for application of the compost to the soil. The contents of cellulose increased at the end of the process. pH values increased at the end of the composting process. EC values decreased from 1006 to 942 μS/cm. GC had the appropriate moisture values for sufficient composting during the process. The VS decreased from 88.78 % to 83.51 %. The reaction rate constant of VS degradation was 0.0372 day^{-1} (R^2 = 0,99).

As a result of the study, it can be said that in vessel-aerobic composting of GC that do not have high economical value would be suitable from the point of waste management and the usage of the obtained compost on agricultural soils would be a solution for the environmental problem caused by the huge amounts those thrown away.

5. ACKNOWLEDGEMENT

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