PRELIMINARY COMMUNICATION

Changes in C/N ratio and some chemical properties during decomposition of hazelnut husk under field conditions

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Abstract
The changes in some chemical properties were investigated during the decomposing of hazelnut husk under the field condition for decomposition itself at Eastern Black Sea Region, Northern Anatolia, Turkey. The changes in C/N ratio, pH, electrical conductivity and nutrient contents (N, P, K, Ca, Mg, Fe, Cu, Zn and Mn) were also monitored. The results obtained showed that the nutrient contents and electrical conductivity of hazelnut husk increased significantly with increase in the period of decomposition and it was highest at the end of two years than initial of decomposition period. In general, the pH was near slightly acidic. After 3 months of decomposing, the pH non-changed and then gradually increased by the end of the decomposing. The initial C/N ratio was 55.7 in hazelnut husk. After the 24 month period, the final C/N ratio was reduced to 22.6 in decomposed hazelnut husk. It was evident that the degradation of organic matter increased by an occurred in the microflora and its enzymatic activities.

Key words: C/N ratio, decomposing, electrical conductivity, hazelnut husk, nutrient, pH

Introduction
Large amounts of hazelnut husk are produced every year. Land application provides a way to recycle these wastes as resources in the Eastern Black Sea Region of Turkey (Kızılkaya, 2005). However, high C/N ratio and unstable components like organic compounds and available nutrient contents in hazelnut husk limit their direct land application. Typically, hazelnut husks can be burned or left as waste in the hazelnut field after the harvesting process, which can cause environmental pollution. Another alternative hazelnut husk management method is animal feed. Because of the enormous amount of hazelnut husk in Turkey, there is a need for other sustainable ways to manage hazelnut husk (Kızılkaya, 2008). Decomposing provides an economical and environment-friendly approach to organic waste treatment (Hu et al., 2011). Easily degradable components of hazelnut husk are decomposed into stable organic and inorganic components during the treatment (Kızılkaya and Hepşen, 2007). Decomposing is also advantageous as it reduces the volume and mass of solid wastes by approximately 50 percent (Fialho et al., 2010). Decomposed products can be used as a nutrient source for plant growth and/or as soil conditioner to improve soil structure, increase soil organic content, and regulate soil microbial activity (Kızılkaya and Hepşen, 2007; Farrell and Jones, 2009)

Although the effects of hazelnut husk on soil fertility and some soil properties have been investigated, there is little information available in the literature about the characteristics of organic matter decomposition during decomposing of hazelnut husk under field conditions. This study thus aims to help fill this gap by investigating changes in C/N ratio and some
properties such as pH, electrical conductivity, and nutrient contents (N, P, K, Ca, Mg, Fe, Cu, Zn, Mn) of hazelnut husk during composting.

**Material and methods**

Hazelnut husk was collected from plantation flora, transported to Akçatepe village, Ordu in Turkey, and left under field conditions for decomposing itself into raw material used to prepare natural composts. Hazelnut husk was stacked vertically. The stack used for decomposing was 150 x 75 x 90 cm (length x width x height). The stack was non-closed and allowed to decompose. However, stacking also presents non-compaction, temperature control, and airflow challenges which must be overcome. Because hazelnut husk receives no mixing stack, raw materials must be mixed well.

During decomposition under field conditions, hazelnut husk samples were collected at time intervals of 1, 2, 3, 4, 5, 6, 7, 12 and 24 months to determine the changes in C/N ratio and some chemical properties. After sampling, hazelnut husk samples were dried and sieved to less than 0.05 mm. All determinations of C/N ratio and chemical properties were performed for each sample in triplicate, and all values reported are averages of the three determinations expressed on an oven-dried sample basis at 105°C for 48 h.

**Measurement of C:N ratio:** Total nitrogen (N) in hazelnut husk was estimated by digestion and subsequent measurement by the Kjeldahl method. Total carbon (C) content was determined by the dry ashing procedure. The C/N ratio was calculated by dividing the percentage of organic carbon by the percentage of total nitrogen (Jones, 2001).

**Measurement of some chemical properties:** Selected chemical properties were determined by the following methods: pH and EC (electrical conductivity) were determined by shaking 10 gr hazelnut husk in 100 ml distilled water (1/10, w/v) for 30 minutes, and both parameters were measured by digital pH and EC meters; nutrient contents (P, K, Ca, Mg, Fe, Zn, Cu and Mn) were determined by HNO₃-HClO₄ wet digestion. After digestion, the nutrient contents were determined by atomic absorption spectrophotometer and spectrophotometer (Jones, 2001).

**Statistical Analysis:** All data were analyzed using Statistical Package for the Social Sciences (SPSS) version 11.0. Analysis of variance (ANOVA) was carried out using one-factor randomized complete plot design; where significant F-values were obtained, differences between individual means were tested using the Least Significant Difference (LSD) test, with a significance level of P<0.01. The asterisks, *, ** and *** indicate significance at P<0.05, P<0.01, and P<0.001, respectively.

**Results and discussion**

Hazelnut husks required for decomposing studies were collected from Ordu, Turkey. The samples were characterized for various parameters. Hazelnut husk has an acidic pH (5.81), with an electrical conductivity of 1.93 dS.m⁻¹. The hazelnut husk contained 53.88% organic C and total N of 0.97%. Its C/N ratio was wide-ranging, with an average value of 56:1. The hazelnut husk was found to contain 0.343% P and 2.193% K. In addition, hazelnut husk contained other macro and micro nutrients such as Ca, Mg, Fe, Cu, Zn and Mn which are agronomically important (Table 1).

<table>
<thead>
<tr>
<th>C:N</th>
<th>pH</th>
<th>EC, dSm⁻¹</th>
<th>N, %</th>
<th>P, %</th>
<th>K, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>55.71</td>
<td>5.81</td>
<td>1.93</td>
<td>0.97</td>
<td>0.343</td>
<td>2.193</td>
</tr>
</tbody>
</table>

Table 1. Some properties of hazelnut husk used in the present study
Considerable variations in the selected properties, namely C/N ratio, pH, EC and nutrients of hazelnut husk, were found at different points in the decomposition period. Statistically significant variations were found in all chemical parameters. The analysis of variance of the results obtained in our experiment at the periodic sampling times showed that all of the abovementioned properties of hazelnut husk were also affected by the decomposing period (Table 2).

| Property | F-value | LSD $\alpha=0.01$ | Property | F-value | LSD $\alpha=0.01$
|----------|---------|-------------------|----------|---------|-------------------
| C:N ratio | 5814864*** | 0.018 | Ca | 154.714*** | 0.011 |
| pH | 15042705118*** | 0.005 | Mg | 31.750*** | 0.009 |
| EC | 4816.385*** | 0.029 | Fe | 1220.720*** | 4.242 |
| N | 1026.100*** | 0.019 | Cu | 1180.902*** | 0.586 |
| P | 148.632*** | 0.010 | Zn | 1201.461*** | 2.135 |
| K | 1.049 ns | --- | Mn | 1146.291*** | 1.681 |

Changes in C/N ratio and N
The changes in C/N ratio and N content during the decomposition period are shown in graph 1. A significant reduction of C/N ratio in the hazelnut husk was observed. Irrespective of decomposition period, there was a significant difference in C/N ratio in the hazelnut husk. The C/N ratio decreased significantly with the increase in the period of decomposition; from 53.4 at 30 days, it dropped to its lowest point (22.6) at the end of two years. The C/N ratio in the initial 6 months of decomposing was above 30, which may be toxic and could cause damage to plants (Tiquia et al., 1996). Huag (1980) reported that C/N ratio below 20 for decomposted material is ideal for nursery plant production. Therefore, after two years of decomposing, the product of hazelnut husk can become a good fertilizer. There was a significant increase in total nitrogen content with the increase in the period of decomposition. Nitrogen content increased from 0.97% at the start of the decomposition period to a maximum of 1.38% at 24 months. The increase of total nitrogen content during the decomposing process may be caused by the activity of microorganisms which use nitrate to grow and produce cells in an organism, or nitrogen fixing nitrogen from the environment during the degradation of cellulose in the material culture (Yamada and Kawase, 2006).

Changes in pH and EC
Seasonal changes in pH and electrical conductivity (EC) that occurred in the stack during the composting period (24 months) are shown in graph 2. The starting pH value was 5.81. After 3 months of decomposing, the pH remained at 5.80, after which it gradually increased to 6.85 at the end of 24 months. This increase could be attributed to the
degradation of protein contained in hazelnut husk, which resulted in the production of ammonia. Ammonia reacted with H₂O to form NH₄⁺ and free OH⁻ causing the increase of pH. With the evolution of the decomposition, the organic nitrogen was almost completely converted into NH₄⁻-N. The accumulated NH₄⁻-N was partly released into the air and partly converted into NO₃⁻-N (Tiquia and Tam, 2000; Hu et al., 2011). The free NH₄⁻-N also probably reacted with magnesium and phosphate to form struvite at optimal conditions. Removal of NH₄⁻-N resulted in a slight decrease of pH at the end of the decomposition, as shown in graph 2. Electrical conductivity increased with the increase in the period of decomposition. The maximum increase of EC was recorded at 24 months (3.29 dSm⁻¹). This increase could be explained by the organic matter loss which occurred due to an increase in mineral cation concentration attenuated by salts.

Changes in nutrients
The nutrients examined in this study are phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), zinc (Zn) and manganese (Mn). Irrespective of decomposition period, a significant difference was found in nutrient contents of hazelnut husk. The nutrient contents increased significantly with the increase in the period of decomposition, and were highest at the end of two years (Graph 3). The increased nutrients may be a result of the microorganism’s activity which used nutrients in their growth and cell creation. In addition, the increase of nutrients during the decomposing period is enough to turn hazelnut husk into fertilizer. The increasing value of nutrients during the decomposition period may be caused by (i) loss of organic fraction as carbon monoxide (Hamoda et al., 1998), and (ii) respiration of microorganisms.
Conclusion
The results showed that the hazelnut husk as agricultural residue is suitable for composting and/or decomposing itself under field conditions. The decomposition of hazelnut husk is continuously occurring, and decomposed hazelnut husk can be used as a fertilizer at the end of two years. After two years, the final decomposed hazelnut husk can be considered good quality material based on the Turkish compost standard. However, the long decomposition period is not suitable and not economic for farmers. Although decomposing appears to be a very attractive option, further research is needed to establish its economic feasibility. Results indicate that the reuse of agricultural residue as decomposing material can be an environment-friendly and sustainable method to reduce the environmental pollution caused by the burning and leaving of hazelnut husks.

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References