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## NITROGEN AND ITS FRACTIONS IN COMPOSTS FROM WOOD WASTE

### AZOT I JEGO FRAKCJE W KOMPOSTACH Z ODPADÓW DRZEWNYCH

**Abstract:** Composts produced on the basis of different wood-based industrial waste were analysed for total nitrogen (NT) and its fraction contents. The following nitrogen fractions were separated: water soluble (NWS), hydrolyisable (NH) in sulphuric(VI) acid –  $2.5 \text{ mol dm}^{-3}$  and at the temperature  $105 \text{ }^\circ\text{C}$  during 12 hours and non-hydrolyisable (NNH). Results revealed that tested composts were differentiated by total nitrogen content not only, but also by its content in aqueous and acid extracts. Non-hydrolyisable nitrogen represented from 36.22 % to 53.75 % of composts NT. Next, the percentage share of  $\text{N}_{\text{H}_2\text{O}}$  in NT varied from ca 7.95 % to 11.81 %.

**Keywords:** wood waste, composts, nitrogen fractions

Wood is a widespread raw material utilized in all economic fields. Its acquisition, processing and the production of new tools generate different waste whose mass is estimated for 7.4 million  $\text{m}^3/\text{year}$  [1]. According to Janowicz [2], the amount of industrial biomass from the wood industry is estimated to 6.79 million  $\text{m}^3/\text{year}$ . Such estimations do not generally involve post-used wood (1.44 do 1.68 million  $\text{m}^3/\text{year}$ ) becoming a serious problem. This was the argument formulated for the utilization of wood waste. More and more wood waste are being used for the production of energy, but investigations have also been undertaken towards the recycling of wood-based waste through composting [3–5].

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Wood waste is characterized by the presence of not only wood, but also of several additives. These are among others paints, varnish, resins, glues, foils or biocides. The composting process should create suitable conditions for neutralizing these substances and breaking down lignins, maximally.

These wastes have been frequently discharged at waste landfill. In this context an important problem for composts seems to be not only the assessment of total content of nitrogen and its fractions. As it was reported recently [6, 7], the type of additives to wood waste used for composting significantly influences plant growth.

The paper reports data of investigations dealing with total nitrogen content and its chemical fractions in composts produced from wood waste.

## Materials and methods

Investigations were undertaken on three composts produced from different wood waste consisted of interior plywood waste – IPW, exterior plywood waste – EPW, and fibreboard waste – FW, which were ground to the size < 10 mm before composting. The composting process was performed under field conditions on open heaps of 4–6 m<sup>3</sup> volume. Each heap was trapezoidal and prepared of woven polyethylene mats arranged at the field ground, with the following mixtures:

- Heap 1 – formed of fibreboard waste (FW), representing 65 % of the heap mass (weight basis) of pinewood waste (28 %), highmoor (7 %) and urea (20 kg),
- Heap 2 – formed of interior plywood waste (IPW), representing 85 % of the heap mass and highmoor for 15 % of the whole mass (weight basis),
- Heap 3 – formed of exterior plywood waste (EPW), representing 85 % of the heap mass (weight basis) and 15 % of highmoor and urea (20 kg).

Wood waste used in the current study differed in their carbon and nitrogen contents (Table 1). Each heap was supplied additionally with a biological vaccine (Activit Las) and a proper amount of water. All heaps were mixed up and covered with a black horticultural fibrous mat for reducing water loss.

During the composting process, which lasted 83 months (FW) and 66 months for both IPW and EPW, temperature and moisture and pH were monitored. Water was supplemented to ca 60 % accordingly to moisture levels and aerated by mechanical throwing. The pH of compost varied significantly throughout the whole period of composting and its values were as follows: heap 1: pH from 3.6 to 8.4; heap 2: pH from 4.1 to 7.5; and heap 3: pH from 4.5 to 9.5. Detailed characteristics of composts preparation were reported earlier [8, 9].

The sequential analysis of nitrogen in compost was made on the basis of deionized water extraction and acid hydrolysis. For this purpose, 2 g of compost (d.m.) were transferred into 100 cm<sup>3</sup> centrifuge tubes. Deionized water was added (50 cm<sup>3</sup>), and the tubes were shaken for 2 hours at room temperature. The mixture was further centrifuged and extracts were next transferred to flasks (100 cm<sup>3</sup>). The remains were hydrolyzed for 12 hours in 50 cm<sup>3</sup> 2.5 M H<sub>2</sub>SO<sub>4</sub> at 105 °C.

Tubes were centrifuged and filtered to 200 cm<sup>3</sup> flask and the remains were rinsed twice with deionized water, centrifuged with extracts and transferred to acid ones.

Total nitrogen (TN) of the composts was determined as the sum of N-Kjeldahl (NK) and nitrate nitrogen(V). In aqueous extract, N-Kjeldahl was determined (NKW) and the content of ammonium and nitrate nitrogen(V) expressed as mineral nitrogen ( $N_{\min}$ ). The sum of these forms was considered as aqueous extract total nitrogen (AETN). In the acid extracts (AE) total hydrolysable nitrogen was determined (NTH) as well as the ammonium nitrogen form in extracts (N-NH<sub>4</sub>). The content of non-hydrolysable organic nitrogen (NNH) was calculated as the difference between total nitrogen content and the sum of water soluble and hydrolysable nitrogen. One factorial analysis of variance (STAT), along with the application of the Duncan test were used for the statistical estimation of data at the significance level  $p \leq 0.05$ .

## Results and discussion

Waste considered for composting contain generally differentiated amounts of nitrogen. In order to obtain a proper C:N ratio of the composted material, it is frequently required to make some correction relying on the addition of nitrogen rich or poor components. Materials used for the current composting process were dominated by wood waste, which differed mainly in nitrogen content, but less in carbon (Table 1).

Table 1

Content of total nitrogen and carbon and C : N in wastes selected

| Component                    | Total Nitrogen (NT)         | Total Carbon (CT) | C : N  |
|------------------------------|-----------------------------|-------------------|--------|
|                              | [g · kg <sup>-1</sup> d.m.] |                   |        |
| Fibreboard waste (FW)        | 1.90                        | 479.40            | 252.31 |
| Interior plywood waste (IPW) | 84.10                       | 456.20            | 5.42   |
| Exterior plywood waste (EPW) | 6.20                        | 497.20            | 80.19  |
| Peat                         | 9.40                        | 528.70            | 56.20  |

Special attention should be given mainly to waste classified as interior plywood waste (IPW), which were ca 14 times richer in nitrogen as compared with exterior plywood waste (EPW) and even 44 times as referred to fibreboard waste (FW). These differences are basically attributed to the industrial processing of wood material. In the production of the IPW, urea-formaldehyde resins are used and these are derived from the condensation of urea and formaldehyde under alkaline conditions. This results in a high concentration of nitrogen in the wood products, where this substance is used. On the other hand, phenol-formaldehyde or urea-melamine-formaldehyde resins are used in the production of EPW, which explains their low nitrogen content. Therefore wood-based industrial waste used for the production of composts under study differentiated the chemical composition of these composts. From data reported by Wróblewska et al [7] it appeared, that the chemical composition of the composts differed after 7 or 8 years of composting, with total nitrogen content (NT) in the order: FW – 15.80, IPW – 77.30, and EPW – 27.70 g · kg<sup>-1</sup> d.m. Result reported in Table 2 confirm the differences

between composts in the case of nitrogen content, which varied accordingly: 17.64, 72.31 and 26.25  $\text{g} \cdot \text{kg}^{-1}$  d.m. Total nitrogen contents do not allow establishing a detailed assessment of composts, since nitrogen occurs in different forms and chemical bonds [10] undergoing changes during composting [11, 12].

Table 2

Content of total, hydrolysable and non-hydrolysable of nitrogen in compost from wood wastes [ $\text{g} \cdot \text{kg}^{-1}$  d.m.]

| Compost | Nitrogen |                   |          |                         |         |                         |              |                  |                   |
|---------|----------|-------------------|----------|-------------------------|---------|-------------------------|--------------|------------------|-------------------|
|         | Extract  |                   |          |                         |         |                         | Hydrolysable | Non-hydrolysable | Total of composts |
|         | Water    |                   |          | Acidic                  |         |                         |              |                  |                   |
|         | Total    | N-NO <sub>3</sub> | Kjeldahl | with: N-NH <sub>4</sub> | Total   | with: N-NH <sub>4</sub> |              |                  |                   |
| FW      | 1.604a   | 1.222a            | 0.364a   | 0.070a                  | 6.566a  | 1.855a                  | 8.170a       | 9.470a           | 17.640a           |
| IPW     | 8.542c   | 0.250c            | 8.192c   | 8.025c                  | 37.577c | 10.257c                 | 46.119c      | 26.188c          | 72.307c           |
| EPW     | 2.086b   | 1.582c            | 0.504b   | 0.175b                  | 11.002b | 2.842b                  | 13.162b      | 13.088b          | 26.250b           |

Composts produced from wood-based industrial waste contained not only different amounts of total nitrogen, but also water soluble (NWS), hydrolysable (NH) and non-hydrolysable (NNH) nitrogen forms. These differences are statistically significant and ranged similarly for investigated N forms accordingly to homogenous groups, except for the content of nitrate(V) nitrogen (Table 2). This nitrogen form quantitatively prevailed in aqueous extracts from the FW and EPW. This could be attributed probably to the addition of urea at heap formation. The magnitude of N-NO<sub>3</sub> content relies on the fact, that on average, it represents 77.0 % of N<sub>tot</sub> of aqueous extract of the FW compost, and 73.6 % in the case of the EPW compost (Fig. 2), contrarily to 4.2 % found for the IPW compost. Such high contents of the mentioned nitrogen form may create potential threat of their losses. The causes of this phenomenon remain an open matter of debates. This state may result among others from the addition of urea to the FW and EPW heaps at their formation or possibly from increased mineralization of organic matter, whose

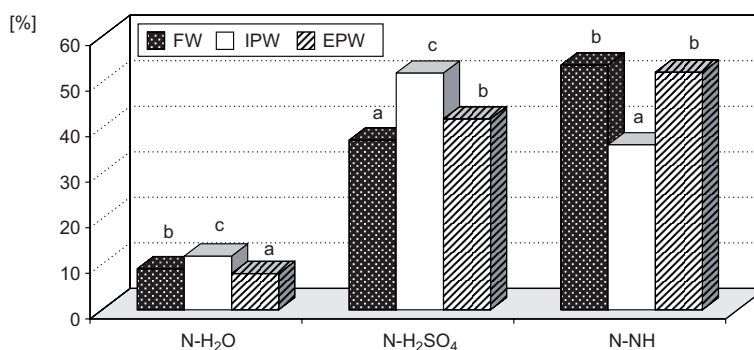


Fig. 1. Percentage share of nitrogen forms in composts

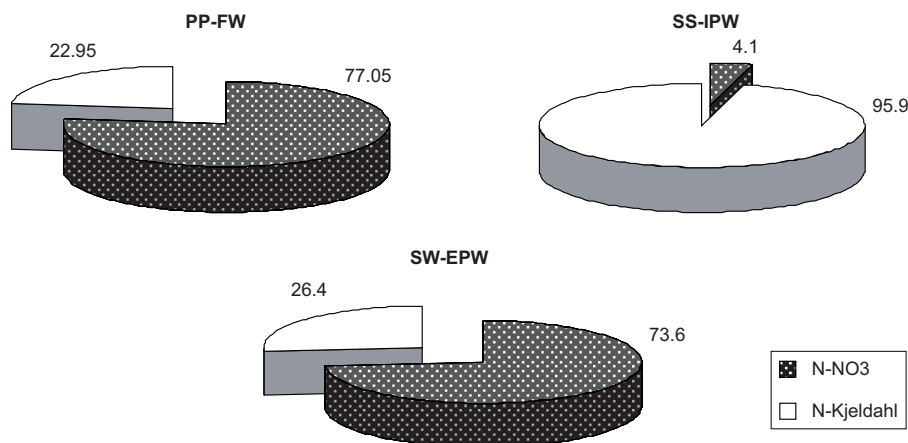


Fig. 2. Percentage share of N-NO<sub>3</sub> N-Kjeldahl in water extracts of composts

effect led to the release of appreciable amounts of nitrogen. Our data reveals that under conditions of the current study, nitrogen was partly built in more resistant organic bonds and at different degrees, accordingly to composts composition. This is supported by the pool of non-hydrolyzable nitrogen (NNH) of the IPW compost as referred to the total N content. The percentage share of this N form was on average 36.2 % (Fig. 1) as compared with 53.7 % for the FW compost and next 52.1 % in the case of the EPW. Furthermore, the intermediary proof of the relatively low stability of nitrogen bonds in the IPW compost, it also their susceptibility for hydrolysis (Table 2).

Under conditions of acid hydrolysis, ca 52 % of nitrogen underwent this process extraction in IPW (Fig. 1); where 37.2 % in the FW and 41.9 % for EPW composts. At a simultaneously high content of total nitrogen ( $72.3 \text{ g} \cdot \text{kg}^{-1} \text{ d.m.}$ ), the easiness of its hydrolysis may exhibit also a toxic effect on plants. Results reported by Wróblewska et al [7] with willow (*Salix alba* L.) grown on a medium consisted of mineral soil mixture and composts of wood-based industrial waste, informed about the occurrence of such possibility. Authors have concluded that under conditions of the addition of the IPW compost, plant growth was significantly reduced. In fact the amounts of N-NO<sub>3</sub> in this compost were significantly lower as referred to those reported for the remaining composts (Table 2). But, despite this, the mineral soil medium with IPW added before starting the trial, contained  $315 \text{ mg} \cdot \text{dm}^{-3}$  for each N-NH<sub>4</sub> and N-NO<sub>3</sub> forms. In the medium containing the EPW compost, these amounts were 7 and  $42 \text{ mg} \cdot \text{dm}^{-3}$  N-NH<sub>4</sub> and N-NO<sub>3</sub>, respectively. This proves undoubtedly about the possible effect of hydrolyzated N from the IPW compost. Results listed in Table 2 indicate that the amount of hydrolyzable nitrogen in this compost represented on average 52 % of investigated nitrogen forms, of which 27.3 % were classified as N-NH<sub>4</sub>. Under soil conditions, this form can be relatively quickly nitrified, but it is not possible to exclude the toxic effect of N-NH<sub>4</sub> over young willow plants, or even the impact of strong salinity of the growth medium.

The negative effect of the interior plywood waste (IPW) compost on the development of willow may result also from the impact of other not investigated compounds, which could have been released during the breakdown of wood or additives used for interior plywood production. All the more so because substances classified as mineral and organic microcontaminants are generally released during wood breakdown and these originate from chemicals used for wood protection [13].

Data of the current investigation have proved that the type and origin of wood-based industrial waste were the main issue during the composting process. This is related to the technology of wood material production as well as the way of their utilization. Under conditions of using resins along with urea, it should be taken into consideration the pool of nitrogen in the waste. Admittedly, interior plywood waste were characterized by very narrow ratio of C:N (5.4 : 1), (Table 1), but the breakdown dynamics of such compost remains a matter of debates. Results of the Table 2, show that the degradation of nitrogen bonds in the compost proceeded quicker as compared with the composts characterised by a lower initial nitrogen content, but with the addition of mineral nitrogen as urea. Based on the fact that high N-NO<sub>3</sub> levels occur in composts with urea addition, future investigations should either reduce its rate or correct it during composting. On the other hand, when using interior plywood waste as a component for composts, one should take in consideration their limited share in the mixture, and on the second hand, the choice of other components, which ensure a higher transformation of nitrogen into organic bonds, hardly soluble.

## Conclusions

1. Under conditions of long-standing of wood-based industrial waste composting, it was found that they differed significantly in terms of total nitrogen as well as other related forms.

2. When using the interior plywood waste for composting, one may take into consideration its naturally high nitrogen content and the properties favourable for the easy hydrolysis of its forms.

3. Urea added to composted mixtures before forming the heaps consisting of fibreboard and exterior plywood waste led to the accumulation of greater amounts of nitrate nitrogen representing in the aqueous extract from 73.7 to 78.7 % of total nitrogen content of this extract.

4. Composting of wood waste rich in nitrogen or with the addition of mineral nitrogen requires organic additives favouring a greater transformation of nitrogen into organic forms hardly hydrolysisable.

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## AZOT I JEGO FRAKCJE W KOMPOSTACH Z ODPADÓW DRZEWNYCH

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**Abstrakt:** Komposty wytworzone z różnych odpadów produkcyjnych tworzyw drzewnych, poddano analizie na zawartość azotu ogólnego i jego frakcji. Wydzielono następujące frakcje azotu: wodnorozpuszczalną (NWR), hydrolizującą (NH) w roztworze kwasu siarkowego(VI) – 2,5 M i temperaturze 105 °C przez 12 godzin – i niehydrolizującą (NNH). Stwierdzono, że komposty różniły się nie tylko zawartością całkowitą azotu, ale również jego zawartością w ekstrakcie wodnym oraz kwaśnym. Azot niehydrolizujący stanowił od 36,22 % do 53,75 % azotu ogólnego kompostów. Z kolei udział azotu wodnorozpuszczalnego w zawartości całkowitej wynosił średnio od 7,95 % do 11,81 %.

**Słowa kluczowe:** odpady drzewne, komposty, frakcje azotu