Název: RACIONÁLNÍ POUŽITÍ HNOJIV
Sborník z konference
konané na ČZU v Praze dne 1. 12. 2022

Autor: kolektiv autorů

Lektoři: prof. Ing. Jiří Balík, CSc., dr. h. c.
prof. Ing. Václav Vaněk, CSc.
prof. Ing. Daniela Pavlíková, CSc.
prof. Ing. Pavel Tlustoš, CSc., dr. h. c.

Do tisku připravil: doc. Ing. Michal Jakl, Ph.D.

Vydavatel: Česká zemědělská univerzita v Praze
Fakulta agrobiologie, potravinových a přírodních zdrojů
Katedra agroenvironmentální chemie a výživy rostlin

Adresa vyd.: Česká zemědělská univerzita v Praze, Kamýcká 129, 165 00 Praha – Suchdol

Tiskárna: powerprint s.r.o., Brandejsovo náměstí 1219/1, 165 00 Praha – Suchdol

Náklad: 200 výtisků

Počet stran: 178

Rok vydání: 2022

Vydání: první

Dopor. cena: neprodejné

ISBN 978-80-213-3226-3

9 788021 332263 >

Racionální použití hnojiv – Sborník z 28. mezinárodní konference

ČESKÁ ZEMĚDĚLSKÁ UNIVERZITA V PRAZE
Katedra agroenvironmentální chemie a výživy rostlin

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE
Department of Agroenvironmental Chemistry and Plant Nutrition

Sborník z 28. mezinárodní konference

RACIONÁLNÍ POUŽITÍ HNOJIV

zaměřené na problematiku hnojení rostlin v době hospodářské krize

Proceedings of the 28th International Conference on

REASONABLE USE OF FERTILIZERS

dedicated to the fertilization of plants in times of economic crisis

ČZU v Praze
1. 12. 2022

ČESKÁ ZEMĚDĚLSKÁ UNIVERZITA V PRAZE
Katedra agroenvironmentální chemie a výživy rostlin

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE
Department of Agroenvironmental Chemistry and Plant Nutrition

---

Sborník z 28. mezinárodní konference

RACIONÁLNÍ POUŽITÍ HNOJIV

zaměřené na problematiku hnojení rostlin v době hospodářské krize

Proceedings of the 28th International Conference on

REASONABLE USE OF FERTILIZERS

dedicated to the fertilization of plants in times of economic crisis

ČZU v Praze
1. 12. 2022

CHANGES IN MINERAL NITROGEN DURING VERMICOMPOSTING OF HYDROLYZED CHICKEN FEATHER RESIDUES

(Změny minerálního dusíku při vermikompostování hydrolyzovaných zbytků kuřecího peří)

Bayu Dume, Aleš Hanč, Pavel Švehla, Pavel Míchal

Czech University of Life Sciences Prague, Faculty of Agrobiology, Food, and Natural Resources, Department of Agroenvironmental Chemistry and Plant Nutrition, Kamýcká 129, 165 00 Prague – Suchdol, Czech Republic; gari@af.czu.cz

Abstract

The objective of this study was to assess the changes in mineral nitrogen dynamics during vermicomposting of hydrolysed chicken feather residues (HCFR). The experiment included four treatments with three replications at different mixing ratios of HCFR and pelletized wheat straw (PWS): (T1) 25%HCFR+75%PWS (w/w) with earthworms, (T2) 25% HCFR+75% PWS (w/w) without earthworms, (T3) 50% HCFR +50% PWS (w/w) with earthworms, and (T4) 50% HCFR+ 50% PWS (w/w) without earthworms. The experiment was carried out for 120 days using *Eisenia andrei*. The N-NO_3^- content increased from 111 to 562 mg/kg (T1), from 111 to 679 mg/kg (T2), from 80 o 391 mg/kg (T3), and from 80 to 343 mg/kg (T4). The N-NH_4^+ content decreased from 1578 to 130 mg/kg (T1), from 1578 to 664 mg/kg (T2), from 1067 to 101 mg/kg (T3), and from 1067 to 184 mg/kg (T4). Observed changes in particular N-species content resulted mainly from biodegradation of organic matter and from nitrification process. Also the influence of denitrification process and ammonia volatilization cannot be excluded.

Key words: N dynamics; biofertilizer; compost; organic matter; N fertilizer

Chicken feathers produced in large quantities by the poultry industry are hazardous to the natural environment due to their poor digestibility and potential as a source of microbiological pathogens. This waste, on the other hand, contains valuable plant nutrients that can be recovered and used to improve soil fertility and agricultural productivity. Feathers are the most common waste by-product of chicken poultry, and their production is steadily increasing [1]. Every year, approximately 8.5 billion tons of chicken feathers are produced as a by-product of chicken meat production. The accumulation of such massive quantities of resistant to biological degradation feathers causes environmental pollution and feather protein waste generation [2]. The majority of the feathers are disposed of in dumps, landfills, and incinerators. These handling methods may pollute the environment by emitting greenhouse gases [3]. Furthermore, these methods have been limited due to a lack of land and high costs [4]. Attempts have been made to find alternative

uses for chicken feathers, such as biofertilizers [5], biofuels [6], and thermoplastics [7].

Feathers are rich in protein because they contain more than 90% keratin (w/w) [8]. The keratin protein is made up of an insoluble, highly stable structure that is cross-linked by disulfide, hydrogen, and hydrophobic bonds and tightly packed into a supercoiled polypeptide in the form of α-helix (-keratin) and -sheets (-keratin) [9]. Due to its indigestibility by soil microorganisms, feather waste is as a slow-release nitrogen (N) fertiliser. Hydrolytic degradation of feathers could provide an appropriate substrate for vermicomposting [10]. In previous studies on vermicompost of hydrolysed chicken feather residue (HCFR), researchers have not considered changes in mineral forms of nitrogen during vermicomposting of HCFR. Therefore, the objective of this study was to assess the changes in mineral nitrogen dynamics during vermicomposting of HCFR.

Material and methods

Experimental setup

The experiment included four treatments with three replications at different mixing ratios of HCFR and PWS: (T1) 25% HCFR+ 75% PWS (w/w) with earthworms, (T2) 25% HCFR+75% PWS (w/w) without earthworms, (T3) 50% HCFR +50% PWS (w/w) with earthworms, and (T4) 50% HCFR+ 50% PWS (w/w) without earthworms. To avoid earthworm mortality and to allow earthworms to return to optimum condition for earthworm treatments, the 3 L of substrate containing earthworms (126 pieces/L and a weight of earthworm biomass was 24 g/L of substrate) was placed into the tray from the side. The vermicomposting process was carried out at a constant temperature of 22 °C. By spraying the surface with water every 2 days, the moisture level of the material was kept at around 70–80% of the wet mass throughout vermicomposting. The experiment was carried out at the experimental station of the Faculty of Agrobiology, Food, and Natural Resources in Červený Újezd, Czech University of Life Sciences Prague. Granofyt Ltd provided dried PWS with a diameter of 10 mm.

Analysis of nitrogen forms (TN, N-NO_3^-, N-NH_4^+)

Representative samples of about 150 g wet weight of treated were taken on days 0, 30, 60, 90, and 120, frozen at -25 °C, lyophilised, and ground to analyse total nitrogen [TN], nitrate nitrogen [N-NO_3^-], and ammonium nitrogen [N-NH_4^+]. For TN determination, the CHNS Vario MACRO cube analyzer was used. The levels of available N-NO_3^-, and N-NH_4^+ were extracted using the CAT solution (0.01 mol/L $CaCl_2$ and 0.002 mol/L diethylene triamine pentaacetic acid [DTPA] at a 1:10 ratio (w/v) [11].

Statistical analyses

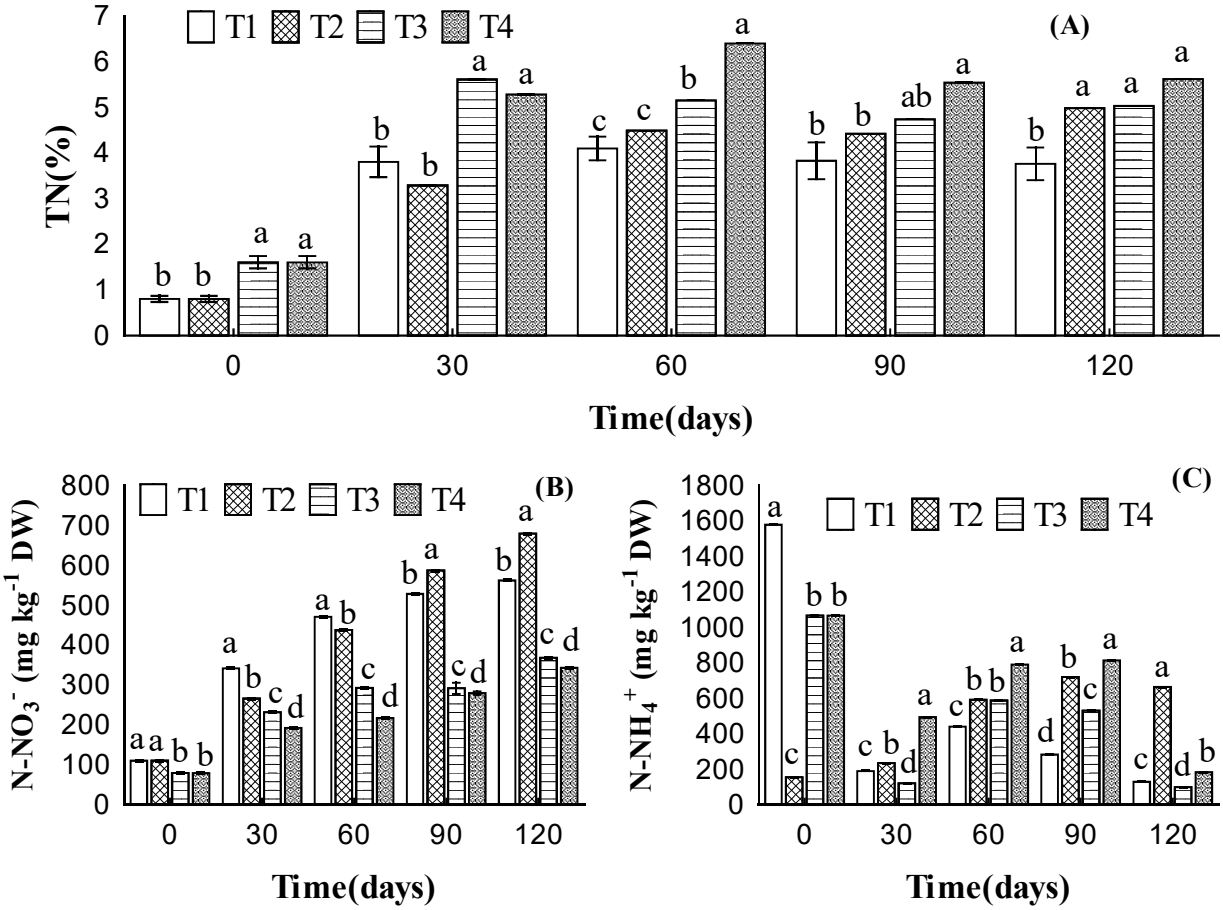
The statistical analyses were carried out using STATISTICA 12 software (StatSoft, Tulsa, USA). The means of the three replicates were used to calculate all

of the results. Analysis of variance (ANOVA) was used to test the significant sources of variation, and the following Tukey HSD test was used to compare the treatment means if the factors' effect was significant at ($p < 0.05$).

Results and discussion

TN increased significantly ($p < 0.05$) with vermicomposting times and among the treatments compared with initial values (Fig. 1A).

1. TN (A) N-NO_3^-(B) and (N-NH_4^+ (C) among the treatments at different times of processes. The bars indicate the standard deviations of the mean (n=3). Different letters indicate significant differences among the treatments (*p<0.05*)



There were higher TN values recorded in treatments without earthworms than vermicompost and the vermicompost recovers less mineral nitrogen than the control treatments at the end of experiments. This finding was consistent with the findings of Pigatin *et al.* [12] who found that during vermicomposting of various agricultural residues using *E. fetida* for 60 days, TN increased by 19.5% – 152% and Pramanik *et al.* [13] found vermicomposting using *E. fetida* for 85 days also increased the TN content in tea prunings (30.5%–51.29%).

The trends of N-NO_3^- and N-NH_4^+ contents for the treatments are shown in Fig. 1B, C. The N-NO_3^- content increased from 111 to 562 mg/kg (T1), from 111 to 679

mg/kg (T2), from 80 to 391 mg/kg (T3), and from 80 to 343 mg/kg (T4). The N-NH_4^+ content decreased from 1578 to 130 mg/kg (T1), from 1578 to 664 mg/kg (T2), from 1067 to 101 mg/kg (T3), and from 1067 to 184 mg/kg (T4). The nitrate content increased in all treatments, regardless of earthworm presence or absence owing to the conversion of ammonia to nitrate *via* oxidation by nitrifying bacteria [14]. The N-NO_3^- leve s were increased during vermicomposting, in line with [15], who found a decrease in N-NH_4^+ and an increase in N-NO_3^- during the vermicomposting of sewage sludge. The changes in different N-species content were caused by a set of different process. Increase of TN content in dry matter was induced by mineralization of organic matter. Signification proportion of N-NH_4^+ was converted to N-NO_3^- during the nitrification process. Certain portion of N-NH_4^+ could be also volatilized in the form of NH_3. Also nitrogen loss as the consequence of N-NO_3^- conversion to N_2 within denitrification process cannot be excluded.

Conclusion

Vermicomposting of HCFR resulted in N-NH_4^+ content decrease accompanied the N-NO_3^- content increase where mainly nitrification process seems to be responsible for this observation. TN content in dry matter significantly increased in all treatments as the consequence of mineralization of organic matter. Also the denitrification process and NH_3 volatilization could influence N-species distribution. The significance of particular processes on nitrogen balance should be verified within subsequent research.

Financial support for this work was provided by the Technological Agency of the Czech Republic under the project number TN010000048 and by the Ministry of Agriculture of the Czech Republic under the NAZV project number QK1910095.

References

[1] A.G. Paul, *et al.*, *Glob. Ecol. Biogeogr.* 2012, *21*, 64.
[2] A. Gousterova, *et al.*, *Lett. Appl. Microbiol.* 2005, *40*, 335.
[3] M.N. Acda, *Philipp. J. Sci.* 2010, *139*, 161.
[4] E.V.Tonkova, *et al.*, *Int. Biodeterior. Biodegrad.* 2009, *63*, 1008.
[5] W.I.A. Saber, *et al.*, *Res. J. Microbiol.* 2010, *5*, 21.
[6] M.A. Abdoli, *et al.*, *Int. J. Environ.Res.* 2014, *8*, 139.
[7] A. Ullah, *et al.*, *Biomacromolecules* 2011, *12*, 3826.
[8] C.M. Williams, *et al.*, *Poultry Sci.* 1991, *70*, 85.
[9] A.A. Onifade, *et al.*, *Bioresour. Technol.* 1998, *66*, 1.
[10] A. Gousterova, *et al.*, *Biotechnol Biotech.* 2003, *17*, 140–145.
[11] *The British Standards Institution and European Standards (BSI EN)*, 2001.
[12] L.B.F. Pigatin, *et al.*, *Int. J. Recycl. Org. Waste Agric.* 2016, *5*, 55.
[13] P. Pramanik, *et al.*, *Ecol. Eng.* 2016, *97*, 410–415.
[14] B. Lv, *et al.*, *Bioresour. Technol.* 2018, *268*, 408.
[15] S. Hait *et* V. Tare, *Ecotox. Environ. Safe.* 2012, *79*, 214.