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Examination and comparison the effects of extraction time and temperature for compost tea

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Abstract: Composting represents an efficient technology that enables the effective utilization of by-products and waste materials. Moreover, it proves to be highly suitable for processing raw materials and converting them into fertilizers that would not be recommended for direct application without undergoing pre-processing. This is particularly crucial in the case of poultry manure, which possesses potentially hazardous properties and necessitates pre-treatment. One increasingly prevalent form of compost is known as compost tea, which involves the immersion of compost in water. In this experiment, compost tea or compost solution were created using a product called composted and pelletized poultry litter (CPPL). Four compost:water ratio (CWR) (1/2.5, 1/5, 1/10, 1/20) were applied, along with three different extraction durations (24, 48, and 72 hours) and three distinct extraction temperatures (20 °C, 35 °C, and 50 °C). Since the 1/10 and 1/20 ratios were found to be the best for subsequent applicability and spreadability, their content parameters were measured further. After elimination of the experiment, the most important nutrients (nitrogen content (nitrate and ammonium), phosphorus and potassium) were determined. The results showed that the nutrient content was highest for all four parameters at the extraction temperature of 35 °C. For example, while at 20 and 50°C the NO_3^- content ranged from 263 to 768 mg/l and from 210 to 534 mg/l, at 35 °C it ranged from 498.33 to 2636.67 mg/l, irrespective of the mixing ratio and extraction time. If the extraction temperature is not taken into account, the nutrient content increased with the increase of the extraction time, so that the highest values were measured at 72 hours extraction time obviously. The data measured in the present experiment will serve as a basis for subsequent experiments with different indicator plants, investigating the effect of compost when applied as a solution.

Keywords: compost tea, nutrient content, poultry litter

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Introduction

Poultry manure is a valuable source of nutrients, especially nitrogen, and is widely used in agriculture as an organic fertiliser and soil conditioner. Its application, however, requires careful pre-treatment procedures to avoid negative effects on crop production and environmental pollution (Dede & Ozer, 2018). A tried-and-true technique for handling organic waste and byproducts is composting. Under conditions of sufficient moisture and oxygen, the organic matter of the waste and by-products is converted into humus-like material throughout the biological process, breaking down into simple components (CO_2, H_2O, SO_4, NO_3) (Alexa & Dér, 2001; Ayilara et al., 2020; Epstein, 2017; Sulzberger, 2006; Tawfik et al., 2023; Xu et al., 2023). Composting technology plays an important role in sustainable agriculture, as many studies have shown. Researchers highlight the importance of composting for greenhouse gas reduction, waste

Table 1: Parameters of the composted and pelletized poultry litter.

Compost/water ratios	1/2.5, 1/5, 1/10, 1/20
Extraction times	24, 48, and 72 hours
Extraction temperatures	20 °C, 35 °C, and 50 °C

Internet1: https://bio-fer.hu/bio-fer-natur-extra/

recovery and environmental sustainability. They also highlight the economic, social and environmental benefits of composting, contributing to sustainable development and extending the life of landfills (Adekunle et al., 2010; Boldrin et al., 2009; Dastpak et al., 2020; Kiss et al., 2021; Marmolejo-Rebellón et al., 2020; Onwosi et al., 2020; Pergola et al., 2018, 2020; Sangamithirai et al., 2015; Sequi, 1996; Zakarya et al., 2018).

Due to its unfavourable qualities (high nitrogen, fiber, and moisture content), there is limited literature available on the composting of poultry manure. According to Georgakakis and Krintas (2000), the Hosoya composting system is excellent for composting byproducts with undesirable qualities, such as poultry manure. According to Hosoya (1996), Csiba and Fenyvesi (2012), and Szabó (2016), this technique, which is based on fermentation and drying, ultimately produces granulated material with a dry matter content of 80–85% (CPPL). Granulated products have the advantage that the heat treatment kills pathogenic bacteria, weed seeds, and hazardous ammonia fumes (Gaál, 2011).

Compost tea, also known as compost slurry, is a compost use that is becoming more and more popular. By extracting compost with water, a liquid form of the product known as compost tea is created (Al-Dahmani et al., 2003; Morales-Corts et al., 2018; Zaccardelli et al., 2018). According to Scheuerell and Mahaffee (2002) and Ingham (2005), compost teas can be made with or without aeration and with or without the addition of ingredients to promote microbial life. According to several studies (Edwards et al., 2006; Kim et al., 2015; Pane et al., 2016; Pilla et al., 2023; Radovich & Arancon, 2011; Shaban et al., 2015; Shrestha et al., 2011; Sujesh et al., 2017), compost solutions can be a valuable source of microbial biomass (bacteria, filamentous fungi, yeasts, etc.), organic matter, organic acids, soluble mineral nutrients, and plant growth regulators (González-Hernández et al., 2021; Scheuerell & Mahaffee, 2002; Wang et al., 2023). Compost tea research is becoming more popular due to the variety of compost teas and the growth of organic and sustainable farming (González-Hernández et al., 2021; Gorliczay et al., 2021; Litterick et al., 2004). Litterick et al. (2004) studied the mitigating effect of compost tea on phytopathogenic damage in grapes, potatoes, tomatoes, cucumbers, apples and roses. Research by Hargreaves et al. (2009) also found that compost tea provided most of the micro- and macronutrients in leaf fertilisation, better than compost from ruminant manure or even synthetic fertilisers. In the present study, the nutrient content of compost tea produced from composted and pelletized poultry litter (CPPL) was examined depending on extraction time and temperature.

Materials and methods

The raw material of the compost tea was composted and pelletized poultry litter (CPPL). The parameters of the CPPL are reported in Table 1.

In the experiment 4 compost/water ratios (CWR), 3 extraction temperatures and 3 dif-

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Table 2: Parameters of the composted and pelletized poultry litter.

Compost parameters	Value
Moisture content (m/m%)	12
pH	7.2
TDS (m/m%)	73
Nitrogen (m/m%)	5.5
Phosphorus (m/m%)	3
Potassium (m/m%)	2.5
Ca (m/m%)	6
Mg (m/m%)	0.5
S (m/m%)	1
B (mg/kg)	31.4
Fe (mg/kg)	545
Mn (mg/kg)	374
Mo (mg/kg)	3.66
Zn (mg/kg)	367
Cu (mg/kg)	53.3

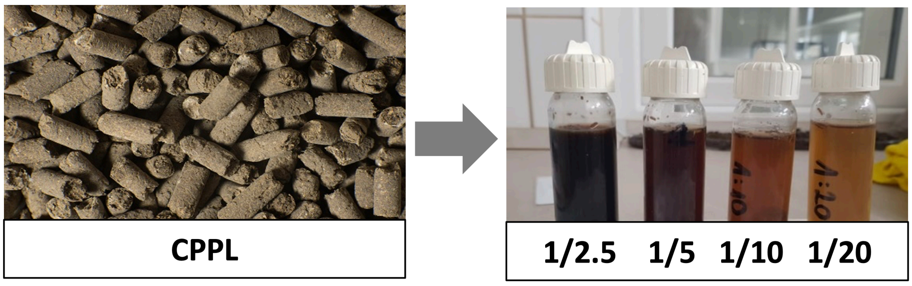

Figure 1: The CPPL and the compost teas/solutions in different mixing ratios.

ferent extraction times were used to make the differences as comparable as possible (Table 2).

After mixing the solutions, they were placed in an incubator at the given temperature for a given time. After the extraction time, the solutions were centrifuged (Figure 1).

For centrifuged samples nitrogen forms (nitrate, ammonium), phosphorus and potassium content were measured with a PF-12 Plus photometer and Visocolor ECO reagents. Measurements were performed in 3 replicates.

Statistical analysis of the data was carried out using R software. The normal distribution of the data was tested using the Shapiro-Wilk test. Since the data were found to be normally distributed, the Duncan test was used to quantify statistical differences at 5% significance level ($p = 0.05$). By comparing the factors (three different extraction times (24, 48, 72 hours), three different extraction temperatures (20, 35, 50 °C), and two different compost-to-water mixing ratios (1:10, 1:20)) to each other, the experiment was based on a multifactorial analysis, not just a three-factor one. Through multifactorial analysis, we assessed how each factor and their potential interactions contributed to the variability in the experimental results.

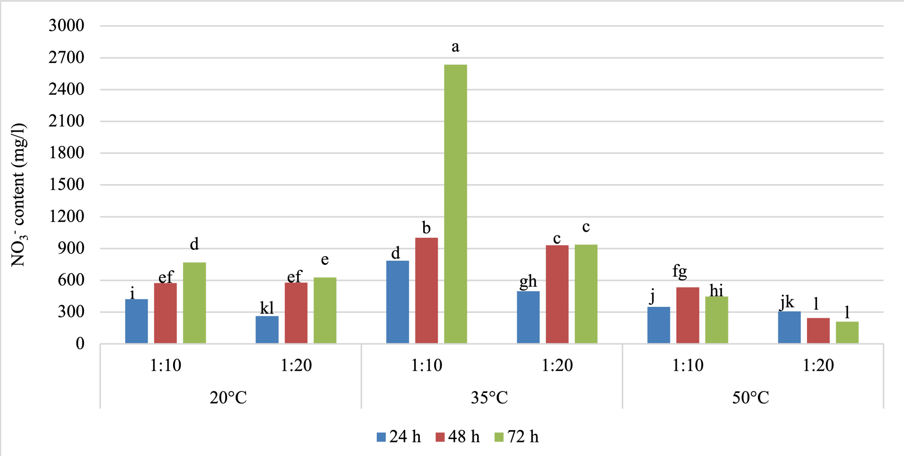

Figure 2: Nitrate content of compost tea prepared of composted and pelletized poultry litter (CPPL) at various compost:water ratios (1:10; 1:20), extraction temperatures (20, 35 and 50 °C) and extraction times (24, 48 and 72 hours). The letters above the columns indicate the different statistical groups.

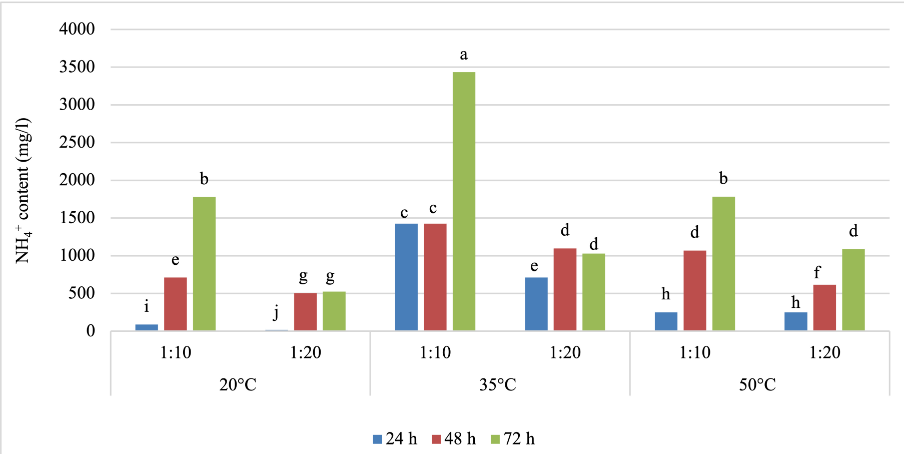

Figure 3: Ammonium content of compost tea prepared of composted and pelletized poultry litter (CPPL) at various compost:water ratios (1:10; 1:20), extraction temperatures (20, 35 and 50 °C) and extraction times (24, 48 and 72 hours). The letters above the columns indicate the different statistical groups.

Results

Nitrogen forms of compost tea

Among the nitrogen forms, the changes in nitrate and ammonium content were examined depending on various compost:water ratios (1:10, 1:20), extraction temperatures (20, 35 and 50 °C) and extraction times (24, 48 and 73 h). Figure 2 shows the trend in nitrate content.

Comparing the ratios, on average the more concentrated 1:10 solution has a higher nitrate concentration. For extraction temperatures of 20 and 35 °C, in general, the nitrate content increases with increasing extraction time and this is significantly detected in almost all cases. However, this trend is not observed at 50 °C. At the 1:10 ratio, the NO_3

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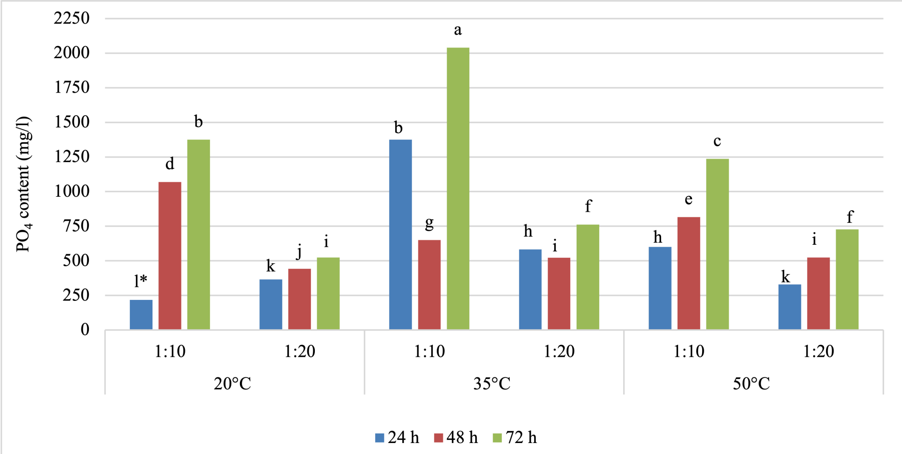

Figure 4: Phosphorus content of compost tea prepared of composted and pelletized poultry litter (CPPL) at various compost:water ratios (1:10; 1:20), extraction temperatures (20, 35 and 50 °C) and extraction times (24, 48 and 72 hours). The letters above the columns indicate the different statistical groups.

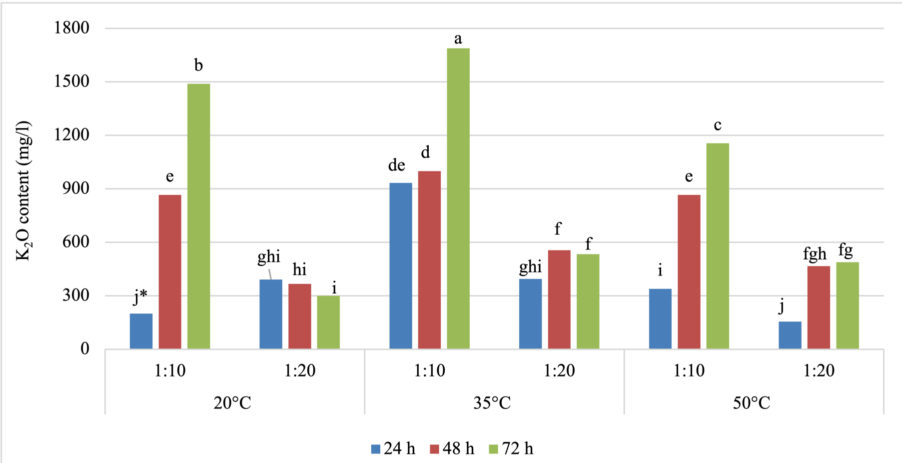

Figure 5: K_2O content of compost tea prepared of composted and pelletized poultry litter (CPPL) at various compost:water ratios (1:10; 1:20), extraction temperatures (20, 35 and 50 °C) and extraction times (24, 48 and 72 hours). The letters above the columns indicate the different statistical groups.

content of the 72 hours solution was lower than that of the 48 hours solution, whereas at the 1:20 ratio the nitrate concentration decreases with increasing extraction time.

The biggest jump is observed for the 35 °C 1:10 solutions, where a NO_3 content of 1000 mg/l was measured at 48 hours, while at 72 hours it was around 2600 mg/l. The highest value was observed in the latter solution. The lowest values were measured for the 50 °C extraction time at a ratio of 1:20 (regardless of the extraction time).

Figure 3 shows the trend in ammonium content. In the case of ammonium, the effect of extraction time on nutrient content was evident not only for solutions extracted at 20 °C and 35 °C, but also at 50 °C, as the ammonium content increased with increasing extraction time. Significant increases in nutrient content (other than the 35 °C 1:10 treat-

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ment) were also detected. In all but one of the treatments, solutions extracted for 72 hours had the highest values. As in the case of nitrate, the highest value was observed in the solution extracted at 35 °C for 72 hours at a ratio of 1:10. But in general, solutions with more concentrated ratios had higher ammonium contents.

Phosphorus content of compost tea

Also for phosphorus (Figure 4), the highest values were observed for solutions extracted for 72 hours, regardless of the extraction temperature and mixing ratio. As the extraction time increased, the nutrient content also increased for extraction times of 20 °C and 50 °C. For the 35 °C extraction time, the PO_4 content decreased at 48 hours compared to 24 hours and increased again at 72 hours. The highest values, as for nitrate and ammonium, were observed for the 1:10 solution extracted at 35 °C for 72 hours. Regarding the comparison of ratios for PO_4 content, as before, the more concentrated 1:10 solution had higher nutrient content, regardless of extraction time and temperature.

Potassium oxide content for the compost tea

The evolution of K_2O content was also generally characterized by a parallel increase in nutrient content with increasing extraction time (Figure 5). An exception to this was the 20 °C 1:20 adjustment, where the potassium content showed the opposite trend, i.e. decreased with increasing extraction time. The increase in nutrient content with extraction time was also significantly detectable in most cases.

The highest values were measured at the 72 hours setting, where the 1:10 setting at 35 °C was found to be the most prominent, as was the case for the other nutrients. For both the 20 and 50 °C settings, the higher value was measured in the 1:10 72 hours extraction time setting. In the case of potassium oxide, it can be said that the more dilute solutions with a compost:water ratio of 1:20 had lower nutrient content.

Discussion

In the realm of nutrient management, nitrogen (N), phosphorus (P), and potassium (K) stand out as the three most crucial macronutrients. These essential elements play a vital role in various plant processes, contributing to their overall health, productivity, and resilience (BassiriRad, 2005; Marschner, 2011). Nitrogen, a key component of amino acids and chlorophyll, is essential for protein synthesis, photosynthesis, and stress resistance. Plants primarily absorb nitrogen in the form of ammonium (NH_4^+) and nitrate (NO_3^-). The availability of these forms is crucial for optimizing plant growth and development (Bernhard, 2010; Cechin & de Fátima Fumis, 2004; S.-X. Li et al., 2013; Song et al., 2021). Phosphorus is an indispensable element for energy transfer, cellular signaling, and root, flower, and fruit development. It forms the backbone of adenosine triphosphate (ATP), the energy currency of cells, and is involved in nucleic acid synthesis. Adequate phosphorus nutrition ensures healthy plant growth and reproductive success (H. Li et al., 2015; Bechtaoui et al., 2021; Johan et al., 2021). Potassium, often referred to as the "quality element," plays a multifaceted role in plant physiology. It regulates water balance, enzyme activation, and carbohydrate and mineral transport. Moreover, potassium bolsters plant defense mechanisms against pests, diseases, and environmental stresses (Hasanuzzaman et al., 2018; Sardans & Peñuelas, 2021). In conclusion, nitrogen, phosphorus, and potassium, the NPK trio, are indispensable nutrients for plant growth and productivity. Their presence is paramount for optimizing plant health, resilience, and overall yield. This is why these three macroelements were investigated in the first round of this research.

Summarizing the results, it can be said that the nutrient content was significantly highest for all four parameters at the extraction

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temperature of 35 °C and over a longer extraction time, more nutrient dissolved from the compost. It is important to note that although nitrogen, phosphorus and potassium are important nutrients for plants, excessive amounts can be harmful. Excessive levels of nitrate and phosphorus in soil or water, for example, can cause environmental problems such as water pollution or environmental imbalances. Therefore, nutrient management in agriculture needs to be monitored to ensure sustainable crop production and to minimise the environmental impact.

In the selection of the application in crop production, not only the nutrient content of the compost tea was considered, but also, for example, cost factors and energy aspects. Accordingly, solutions with a 1:10 ratio, extracted at 35 °C for 48 hours, were selected for further application and applied at a tenfold dilution.

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