

Identifying Nitrogen Content in Soil Enriched with Hair-Based Compost

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ABSTRACT

Hair waste, an organic material commonly found in municipal solid waste, decomposes slowly due to its high keratin content. On average, individuals shed between fifty and hundreds of hairs daily, while barbershops generate significant amounts of this waste. Given that hair is rich in nitrogen—a nutrient essential for plant growth—this study aims to determine the nitrogen levels in soil mixed with decomposed hair. Hair was collected, treated, and left to decompose for four months. The nitrogen content in the soil-hair mixture was analyzed using the Kjeldahl method and measured with a spectrophotometer. Results indicate that the presence of decomposed hair significantly increases nitrogen levels in the soil, suggesting that decomposed hair has the potential to enhance soil fertility and serve as an organic fertilizer

Keywords: *natural fertilizer; hair; hair waste; agriculture, kjeldahl*

INTRODUCTION

Over the past few decades, Malaysia has undergone rapid industrialization and urbanization, resulting in a significant increase in the generation and complexity of municipal solid waste (MSW). In 2022, Malaysia disposed of more than 30,000 tons of MSW daily, approximately 1.17 kg of waste per capita (Malaysia Waste Management Solutions, 2022). Samsudin and Don (2013) stated that landfilling is Malaysia's most widely used waste treatment method, with many sites operating as open dumping areas. According to the National Solid Waste Department, Malaysia has 165 landfills, eight sanitary landfills, and three inert landfills by 2022. Local environmental experts have forecasted that without intervention, there will be no available space by 2050 (Malaysia Waste Management Solutions, 2022).

Among the types of municipal solid waste, hair waste is often overlooked even though humans shed between 50 to 100 strands of hair daily. The disposal and potential uses of cut hair vary, with applications including wigs, fertilizers, and ropes (Gupta, 2014). Nevertheless, hair waste is still commonly disposed of in landfills or burned in incinerators worldwide. Burning hair waste releases gases such as nitrous oxide, sulfur dioxide, and carbon dioxide, contributing to greenhouse gas emissions. Furthermore, human hair contains keratin, a protein that is resistant to degradation due to cross-linking by disulfide bonds making hair waste slow to decompose (Chilakamarry et al., 2021). Consequently, hair waste would occupy the landfills for a long period.

Ruiz (2024) has raised questions regarding whether hair is biodegradable. Human hair comprises complex structures that include proteins, amino acids, lipids, elements, and

pigments (Robbins, 2012). It is made up of chemical elements, including carbon, oxygen, nitrogen, hydrogen, and sulfur. Nitrogen indeed plays an important role in crop plants after carbon, hydrogen, and oxygen. Each strand of hair contains approximately 16% nitrogen compounds, aligning with plant nutrient needs and suggesting the potential of hair waste as a natural fertilizer for agriculture.

Gupta (2014) expressed concern about hair waste disposal, noting that products made from hair waste may exacerbate solid waste issues, particularly if their disposal requires toxic chemicals. Moreover, the disposal of hair inside plastic bags that sit in landfills can produce methane, a powerful greenhouse gas. Therefore, this study aims to identify if the hair can be decomposed or not, as well as to assess the nitrogen levels in decomposed hair in soil.

MATERIALS AND METHODS

Sample Collection

Human hair waste for this study was collected from a barber shop that was to be disposed of. The waste was gathered in plastic bags.

Sample Preparation

The collected hair was washed using tap water and dried to remove any physical contaminants. The hair was then soaked into 50 ml keratinase solution suitable for 150 grams for four days to break down the keratinase structure. This step is crucial to assist in the decomposition of hair in the next step.

Hair Decomposition

The prepared hair was mixed with domestic waste at a 3:1 ratio. The mixture was placed in soil to undergo natural decomposition. After four months, the soil samples were collected from three different areas within the decomposed area, labeled as Sample A. Additionally, samples were also taken from three different areas of the undecomposed area known as Sample B which acts as the standard soil.

Elemental Analysis

The total nitrogen (N) and protein content in decomposed hair were fully analyzed using Automatic Distillation System VAPODEST 500 Nitrogen/Protein Determinators (C. Gerhardt GmbH & Co. KG). This instrument performs Kjeldahl nitrogen determination automatically through a three-step approach, digestion, distillation, and titration. The sample mixture was digested using a mixture of concentrated sulphuric acid and salicylic acid. The mixture was then heated for 10 minutes in a digester at 300°C. Once the tubes cooled to room temperature, a catalyst containing 15 g of potassium sulfate (K_2SO_4) and 0.04 g of copper sulfate ($CuSO_4$) was added. The tubes were then returned to the digestion block and heated for four hours until the samples became clear. The samples were then allowed to cool to room temperature before being removed from the digestion block. Three hundred mL of

distilled deionized water was then used for titration. The titration is then calculated to identify the amount of nitrogen and protein content in the soil (Wanda, 2003).

RESULTS AND DISCUSSION

After four months, no hair samples were detected in the soil, indicating that the hair had fully decomposed within this period. While previous studies have reported that hair typically decomposes in soil over 1 to 2 years, this study found that decomposition occurred in a shorter duration. Soaking hair with keratinase is recommended to further facilitate the decomposition process.

The samples that were analyzed using the Kjeldahl method have determined the total nitrogen and protein as percentage dry weight as shown in Table 3.1. The results indicate that the average nitrogen and protein levels in area A (nitrogen: 0.128 and protein: 0.800), which contains a decomposed mixture of decomposed hair and domestic waste, were higher than those in area B, which contained no hair (nitrogen: 0.016 and protein: 0.100). This suggests that nitrogen from the mixture of decomposed hair and other domestic waste contributed to an increase in soil nitrogen level.

Table 3.1. Nitrogen and Protein Levels (% Dry Weight) in Soil Samples from Area A and Area B

Area	Sample	Weight (g)	Nitrogen %	Protein %
A	A1	1.027	0.153	0.956
	A2	1.012	0.131	0.818
	A3	1.050	0.125	0.781
	Mean	1.031	0.128	0.800
B	B1	1.1930	0.014	0.085
	B2	1.0990	0.015	0.092
	B3	1.1050	0.016	0.099
	Mean	1.102	0.016	0.100

The composting process for organic matter returns valuable nutrients to crop plants with the assistance of a microbial community (Ho et al., 2022). During this process, certain chemicals are released, including carbon dioxide (CO₂), ammonia (NH₃), and sulfate ion (SO₄²⁻), through four stages: mesophilic, thermophilic, cooling, and maturation (Ho et al., 2022). These stages explained the longer duration required for chemical release and the level of temperature during decomposition. However, factors such as pH of the compost, the C/N ratio, moisture, and oxygen availability were not controlled in this study, which could influence the decomposition duration.

As this study identified the higher nitrogen level in decomposed soil, organic fertilizer can be produced through this method. This aligns with the global goals of Sustainable Development Goal (SDG) 12, which focuses on responsible consumption and production. By utilizing human hair, an often overlooked and renewable resource, it is postulated that fertilizer may contribute to the sustainable management of natural resources (Target 12.2) by preventing harmful buildup in landfills and reducing environmental pollutants (Target

12.4). Additionally, the fertilizer helps significantly reduce waste generation by repurposing hair for agricultural use, transforming it into a valuable resource for improving soil health (Target 12.5).

CONCLUSION

This study demonstrates that soil enriched with domestic waste and decomposed hair exhibits significantly higher nitrogen content than standard soil. These findings highlight the potential to repurpose hair waste, thereby reducing its contribution to landfills by employing the method suggested in this study, which shortens the decomposition duration. This approach aligns with the focus of Malaysia on reducing the waste in landfills as stated in Sustainable Development Goal Target 12.4.

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