

PRODUCTION AND CHARACTERIZATION OF MINERAL-ENRICHED NADEP COMPOSTS FOR ENHANCED SOIL FERTILITY

Aim: Production and characterization of NADEP composts using aquatic weeds as substrates and enriched with different minerals, were conducted to evaluate its feasibility for agricultural purpose

Study Design: The experiment was carried out using a completely randomized design comprising 12 treatments and three replications.

Place and Duration of Study: The experiment was conducted at the model organic Farm of the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani, Kerala Agricultural University, between December 2023 and January 2024.

Methods: Aquatic weeds, *Limnocharis flava* and *Eichhornia crassipes*, were collected from Vellayani lake and mixed with banana pseudostem in different proportions for compost preparation. Once the compost reached maturity, it was enriched with minerals such as calcium apatite and epsom salt. The resultant compost was then analyzed for its physical, chemical, and biological properties.

Results: The NADEP compost, made from a 1:1 mixture of *L. flava* and *E. crassipes* and enriched with calcium apatite and epsom salt, was found to be the most effective treatment. It showed higher levels of macro and micronutrients, an ideal C: N ratio, improved enzyme activity, and a significant microbial load.

Conclusion: NADEP composting has emerged as a highly effective and environmentally sustainable approach to producing high-quality compost in a prompt and efficient way. This method transforms aquatic weeds, such as *Limnocharis* and *Eichhornia crassipes*, which pose a threat to aquatic ecosystems, into valuable compost, thereby promoting effective waste management and advancing sustainable agricultural practices.

ABSTRACT

Keywords: NADEP Compost, organic farming, composting, *Limnocharis flava*; *Eichhornia crassipes*; calcium apatite, epsom salt, zeolite.

1. INTRODUCTION

Human interventions have brought about soil degradation and soil fertility continues to decline due to factors such as the excessive application of fertilizer inputs which have adverse effects on soil's physical, chemical and biological properties. Therefore, the strategy for this problem certainly has to be the adoption of integrated nutrient management and organic agricultural practices. These practices are beneficial for the restoration and preservation of soils as well as for higher crop yields. Integrated organic farming, which aims at sustainability as well as the use of agricultural

chemicals, is quite useful not only in enhancing environmental conservation but also in the health and well-being of mankind and nature.

Aquatic weeds are recognized as one of the major hindrances to farming ecosystems, as they negatively affect the crops and water quality. Composting technologies tend to decompose waste materials and improve the ecosystem as well as the soil, increase agricultural output, and make nutrients easily available. Aquatic weeds like *L. flava* are efficiently composted utilizing a variety of techniques, such as vermicomposting and the use of *Pleurotus florida*, to produce high-quality compost with a high nutritional content [1]. Aquatic weed biomass can be managed effectively by composting it, which turns it into nutrient-rich compost that promotes environmentally friendly farming practices [2].

Different kinds of composting, like vermicomposting, bokashi composting, and NADEP composting, are all methods that can be used for the preparation of compost from aquatic weeds. Of these methods, NADEP composting is gaining popularity among the farming community. It is an aerobic composting technique developed by Sri Narayan Deotao Pandharipande (also called Nadep Kaka), a farmer in Maharashtra, India. This approach incorporates various organic substances, which are biologically active in generating high-quality compost [3]. NADEP composting works differently as it does not follow the practices of traditional composting that require the frequent turning of the compost tank for aeration and also regular watering. As a result, this method is found to be the most effective way to generate compost during the dry season and is also useful at any time of the year when moisture is scarce [4].

A permanently built tank is required for the production of NADEP composts. The filling of the tank follows a specific pattern. The first layer is filled with substrates, followed by the second layer filled with cow dung, and the final layer is plastered with soil. By plastering the compost tank, the process is optimized for efficient decomposition while retaining valuable nutrients and moisture essential for healthy soil enrichment. Therefore, by using composting techniques like the NADEP method, we can effectively manage aquatic weeds and produce high quality compost in a specified period of time.

2. MATERIALS AND METHODS

2.1 Production and characterization of enriched NADEP compost

NADEP Compost was prepared in NADEP tanks using two commonly available aquatic weeds, *Limnocharis flava* (S₁) and *Eichhornia crassipes* (S₂). Banana pseudostem were added to the aforesaid aquatic weeds in a 1:1 ratio. Aquatic weeds from Vellayani Lake and banana pseudostem collected from Model Organic Farm, College of Agriculture, Vellayani were used to produce composts at the same farm. After the composting process was over, enrichment was carried out using minerals viz. calcium apatite and epsom salt. In all the treatments zeolite was added at 0.5 per cent. The study was carried out using 12 different treatments which are given below.

Table 1. Treatment details of the resultant enriched NADEP compost

T ₁	Yellow velvet leaf (<i>Limnocharis flava</i>) + Banana pseudostem (1:1) enriched with calcium apatite
T ₂	Yellow velvet leaf (<i>Limnocharis flava</i>) + Banana pseudostem (1:1) enriched with epsom salt
T ₃	Yellow velvet leaf (<i>Limnocharis flava</i>) + Banana pseudostem (1:1) enriched with calcium apatite+ epsom salt
T ₄	Water hyacinth (<i>Eichhornia crassipes</i>) + Banana pseudostem (1:1) enriched with calcium apatite
T ₅	Water hyacinth (<i>Eichhornia crassipes</i>) + Banana pseudostem (1:1) enriched with epsom salt
T ₆	Water hyacinth (<i>Eichhornia crassipes</i>) + Banana pseudostem (1:1) enriched with calcium apatite+ epsom salt
T ₇	Yellow velvet leaf (<i>Limnocharis flava</i>) + Water hyacinth (<i>Eichhornia crassipes</i>) (1:1) enriched with calcium apatite
T ₈	Yellow velvet leaf (<i>Limnocharis flava</i>) + Water hyacinth (<i>Eichhornia crassipes</i>) (1:1) enriched with epsom salt
T ₉	Yellow velvet leaf (<i>Limnocharis flava</i>) + Water hyacinth (<i>Eichhornia crassipes</i>) (1:1) enriched with calcium apatite+ epsom salt
T ₁₀	Yellow velvet leaf (<i>Limnocharis flava</i>) + Water hyacinth (<i>Eichhornia crassipes</i>) + Banana pseudostem (1:1:1) enriched with calcium apatite
T ₁₁	Yellow velvet leaf (<i>Limnocharis flava</i>) + Water hyacinth (<i>Eichhornia crassipes</i>) + Banana pseudostem (1:1:1) enriched with epsom salt
T ₁₂	Yellow velvet leaf (<i>Limnocharis flava</i>) + Water hyacinth (<i>Eichhornia crassipes</i>) + Banana pseudostem (1:1:1) enriched with calcium apatite+ epsom salt

The composting process was completed over a period of 75 days. Following this zeolite was added to each treatment (T₁-T₁₂) at the rate of 0.5 per cent.

2.2 Statistical Analysis

NADEP compost was produced and characterized using a completely randomized design (CRD).

An F-test was performed in the ANOVA to assess the significance of the treatments, and the critical difference (CD) was calculated. Data analysis was carried out using the R package 'grapesagri1'.

3. RESULTS AND DISCUSSION

3.1. Proximate constituents the of resultant mineral enriched NADEP composts

The highest value of cellulose was observed in T₁₁ which is NADEP compost prepared from 1:1:1 mixture of *L. flava*, *E. crassipes* and banana pseudostem enriched with epsom salt and followed by T₅, T₁₀, T₆ and T₁₂. *E. crassipes* exhibited the highest cellulose content, up to 118.12 per cent, which was subsequently used for ethanol production [5]. NADEP compost prepared from 1:1:1 mixture of *L. flava*, *E. crassipes* and banana pseudostem enriched with epsom salt recorded the highest lignin content and was found on par with T₁₀, followed by T₂, T₁₂ and T₁. The cellulose and lignin content of different treatments is shown in fig (1).

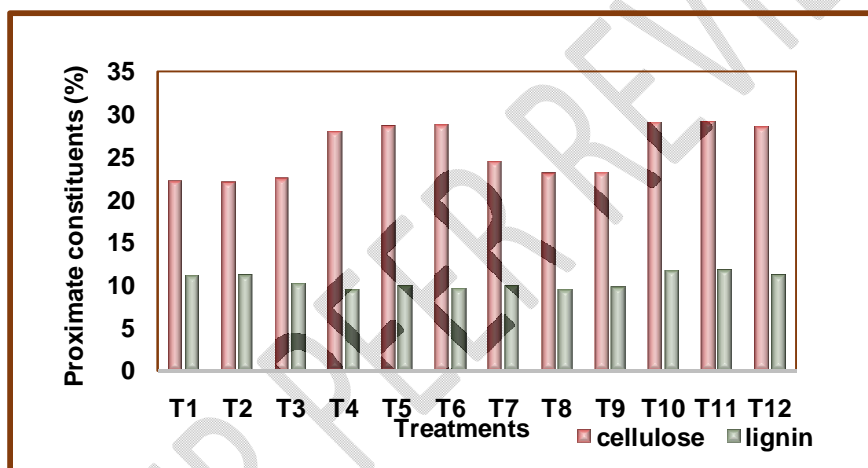


Fig 1. Cellulose and lignin content of mineral enriched NADEP compost

3.2 Physical properties of the resultant enriched NADEP composts.

The physical properties of the mineral enriched NADEP compost are shown in Table 2. Physical properties such as moisture content and bulk density were analyzed. The moisture content of the resultant NADEP composts varied from 25.40 per cent to 32.98 per cent. The highest moisture content was found in T₃, which is NADEP compost prepared from a 1:1 mixture of *L. flava* and banana pseudostem enriched with calcium apatite and epsom salt. The variations in moisture content between the compost samples could be linked to differences in the compost pile's temperature throughout the composting process [6]. Treatment 9 showed the lowest bulk density (0.26 gcm⁻³), which might be due to the higher organic matter content of the compost [7].

Table 2. Physical properties of the resultant enriched NADEP compost

Treatments	Bulk Density (Mg m^{-3})	Moisture content (%)
T ₁	0.380	32.530
T ₂	0.350	32.800
T ₃	0.370	32.980
T ₄	0.370	25.397
T ₅	0.347	27.800
T ₆	0.360	28.000
T ₇	0.310	27.800
T ₈	0.313	29.840
T ₉	0.260	29.800
T ₁₀	0.387	28.120
T ₁₁	0.370	29.600
T ₁₂	0.380	30.800
SEm(\pm)	0.009	0.38
CD(0.05)	0.026	1.108

3.3. Electro Chemical Properties of the Resultant Enriched NADEP Composts

The electro-chemical properties of soil such as pH and EC, are shown in table 3. Mature compost generally had a pH range of 6.5 to 8, while immature compost was typically more acidic [8]. The pH of the resultant enriched NADEP compost varied from 6.87 to 7.28. The highest pH was observed in T₁ (7.24), which was NADEP compost prepared from a 1:1 mixture of *L. flava* and banana pseudo stem enriched with calcium apatite.

The EC value of the compost is an important parameter as it reflects the salinity level, which directly affects plant growth. The highest EC value was found highest in T₁₂, NADEP compost prepared from a 1:1:1 mixture of *L. flava*, *E. crassipes*, and banana pseudo stem enriched with calcium apatite and epsom salt.

Table 3. Electrochemical properties of the resultant enriched NADEP compost

Treatments	pH	EC (dSm ⁻¹)
T ₁	7.28	1.45
T ₂	6.87	1.56
T ₃	7.13	1.67
T ₄	7.17	1.48
T ₅	6.92	1.56
T ₆	7.00	1.69
T ₇	7.17	1.56
T ₈	6.99	1.72
T ₉	7.22	1.76
T ₁₀	7.03	1.78
T ₁₁	6.89	1.65
T ₁₂	7.14	1.80
SEm(±)	0.084	0.023
CD(0.05)	2.44	0.066

3.4. Chemical properties of the resultant mineral enriched NADEP compost

The organic matter content of mineral enriched NADEP composts was significantly influenced by the choice of substrates. T₇, (NADEP compost prepared from 1:1 mixture of *L. flava* and *E. crassipes* enriched with calcium apatite) exhibited the highest organic matter content, which was on par with T₁, followed by T₉, T₄, and T₁₀. As the composting process progressed, organic matter was broken down into minerals as microorganisms degraded proteins, cellulose, and hemicellulose, utilizing 60-70 per cent of the carbon while immobilizing 30-40 per cent. Total Organic Carbon (TOC) serves as a key metric for evaluating compost maturity [9]. The macro and micronutrient contents of the composts are shown in Table 4. The mineral enriched NADEP compost, prepared from a 1:1 mixture of *L. flava* and *E. crassipes* and enriched with calcium apatite, showed higher total nitrogen and phosphorus levels. In contrast to other composting methods, this process minimizes nitrogen loss through volatilization, denitrification, leaching, and immobilization. The potassium content was found highest in T₁. The elevated potassium content in these composts is primarily due to the banana pseudostem, which contains significantly higher potassium levels compared to *L. flava* [10].

Table 4. Total organic carbon, primary and secondary nutrient content of mineral enriched NADEP composts

Treatments	Total organic carbon (%)	Total N (%)	Total P (%)	Total K (%)	Ca (%)	Mg (%)	S (mg kg ⁻¹)
T ₁	35.79	3.22	0.51	2.39	0.35	0.14	22.50
T ₂	32.12	2.80	0.37	1.64	0.28	0.22	28.00
T ₃	30.70	2.80	0.59	2.20	0.37	0.27	29.50
T ₄	34.47	2.89	0.44	2.39	0.31	0.13	15.50
T ₅	31.20	2.56	0.52	1.95	0.26	0.23	21.50
T ₆	32.70	2.70	0.60	2.15	0.33	0.24	24.00
T ₇	35.90	3.31	0.61	1.85	0.29	0.13	21.75
T ₈	32.11	2.80	0.50	1.74	0.25	0.22	28.50
T ₉	34.77	3.03	0.62	1.80	0.32	0.26	30.00
T ₁₀	32.78	2.95	0.57	2.35	0.34	0.14	18.00
T ₁₁	31.33	2.64	0.51	2.05	0.28	0.23	23.17
T ₁₂	31.43	2.89	0.59	2.10	0.38	0.28	25.34
SEm(±)	0.703	0.032	0.006	0.035	0.006	0.004	0.452
CD(0.05)	2.053	0.094	0.019	0.103	0.016	0.011	1.318

The micronutrient content of the resultant mineral enriched NADEP compost is found maximum in T₉ (NADEP compost prepared from 1:1 mixture of *L. flava* and banana pseudostem enriched with calcium apatite and epsom salt), followed by T₆, T₇ and T₁₀. The increase in micronutrient concentration in the final compost might be due to the reduction in compost mass, resulting in a higher proportion of micronutrients like iron, zinc, copper, and manganese in the remaining material. Similarly, aquatic weeds like *L. flava* and *E. crassipes* contained more micronutrients than banana pseudo stem [11].

Table 5. Micronutrient content of mineral enriched NADEP composts

Treatments	Fe (%)	Mn (mg kg ⁻¹)	Zn (mg kg ⁻¹)	Cu (mg kg ⁻¹)
T ₁	1.19	141.49	51.00	22.49
T ₂	0.95	131.00	31.60	21.50
T ₃	1.25	157.00	53.00	24.50
T ₄	1.20	153.00	43.49	18.99
T ₅	1.05	142.00	28.00	17.00
T ₆	1.37	171.00	45.10	21.00
T ₇	1.28	156.00	52.80	23.00
T ₈	1.19	144.50	43.40	21.99
T ₉	1.40	179.00	56.19	26.00
T ₁₀	1.20	148.00	43.29	17.50
T ₁₁	0.97	159.00	26.40	13.99
T ₁₂	1.25	169.96	44.70	21.00
SEm(±)	0.022	2.209	0.706	0.259
CD(0.05)	0.065	6.448	0.706	0.756

3.5. Biological properties of the resultant mineral enriched NADEP compost

Microorganisms play a key role in composting by decomposing organic matter and releasing CO₂, CH₄, and N₂O at different stages of the process [12]. The decomposition of organic materials into stable end products is facilitated by the sequential development of microbial communities, with bacteria, fungi, and actinomycetes playing key roles at different stages of the process [13]

The bacterial and fungal population was found highest in T₉ which is the mineral enriched NADEP compost, prepared from a 1:1 mixture of *L. flava* and *E. crassipes* and enriched with calcium apatite. Actinomycetes play a key role in organic matter decomposition, inhibit plant pathogens in the rhizosphere, and produce extracellular enzymes that enhance crop production. The NADEP compost prepared from 1:1 mixture of *L. flava* and banana pseudostem enriched with calcium apatite and epsom salt showed the highest population of actinomycetes.

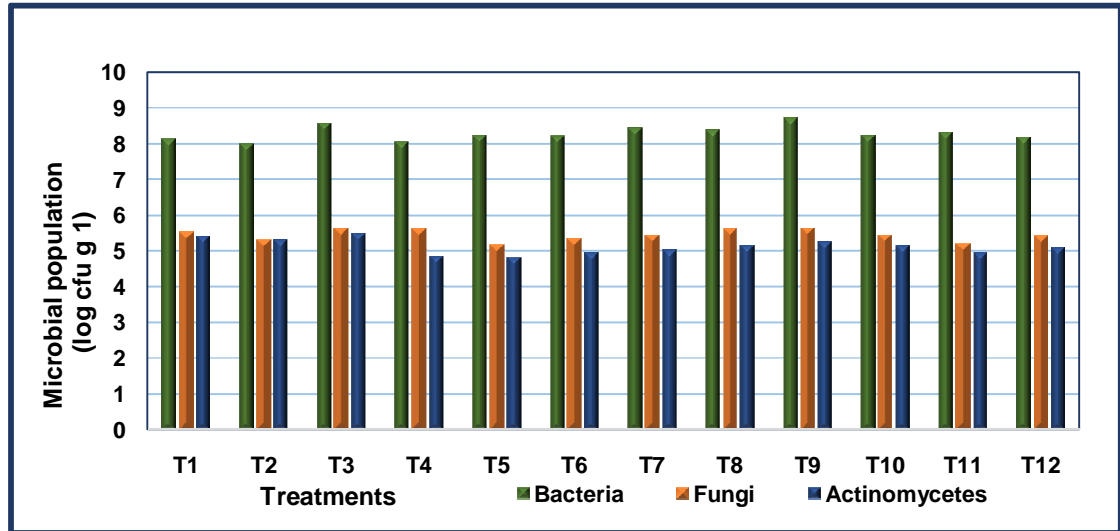


Fig 2. Microbial population of mineral enriched NADEP compost

The C: N ratio is crucial in composting as it affects microbial activity, decomposition rates, nutrient balance, and temperature regulation. The mean values of the C: N ratio ranged from 9.59 to 11.92. An ideal C: N ratio of around 25:1 to 30:1 provides microorganisms with a balanced supply of nutrients for growth, leading to faster and more efficient decomposition [14]. A decrease in the C: N ratio, resulting from a reduction in organic carbon and an increase in total nitrogen, was noted during the decomposition of organic matter [15] [16].

Carbon dioxide evolution serves as an effective indicator of compost maturity because it directly reflects microbial respiration and biological activity. As microorganisms decompose organic matter, they release CO₂. Tracking CO₂ emissions offers valuable information about microbial activity, which tends to decline as compost matures, indicating stabilization and readiness [17]. The higher value of CO₂ evolution was observed in T₉ which is NADEP compost prepared from a 1:1 mixture of *L. flava* and *E. crassipes* enriched with calcium apatite and epsom salt (5.13 mg CO₂ g⁻¹).

Enzymatic activities can be used as indicators of composting progress and maturity, as their decline typically corresponds with a reduction in available organic compounds and increased compost stability [18]. NADEP compost prepared from 1:1 mixture of *L. flava* and *E. crassipes* enriched with calcium apatite and epsom salt) recorded the highest dehydrogenase activity.

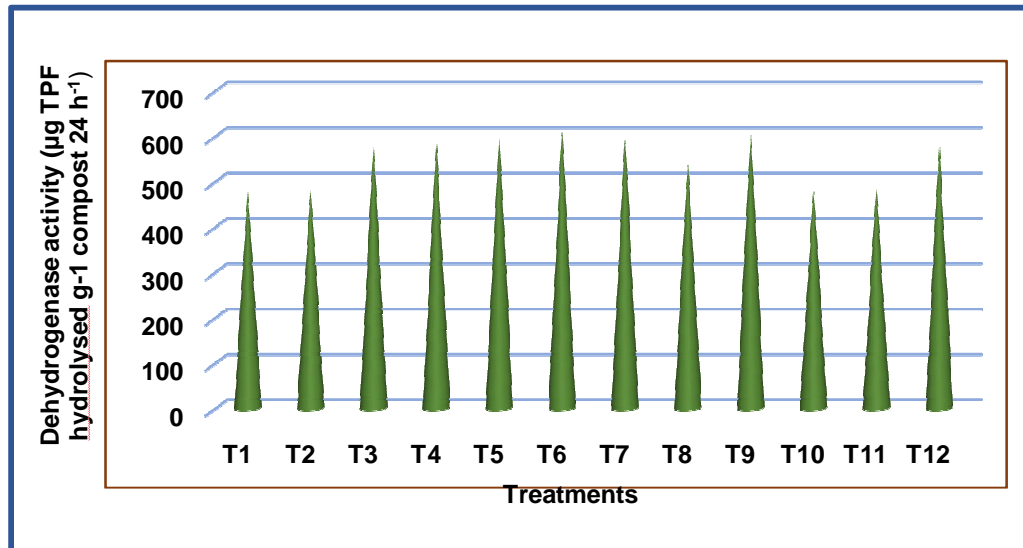


Fig 3. Dehydrogenase activity of mineral enriched NADEP compost

4. CONCLUSION

Based on a thorough evaluation of physical, chemical, and biological parameters, it was determined that the NADEP compost created with a 1:1 mixture of *L. flava* and *E. crassipes*, enriched with calcium apatite and epsom salt, was the most effective treatment. This composition not only shows considerable promise as an organic fertilizer but also provides a sustainable alternative to chemical fertilizers, significantly promoting plant growth and enhancing overall soil health. Moreover, implementing such organic methods can aid environmental sustainability by minimizing chemical runoff and enhancing soil biodiversity.

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