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Assessment of physical and chemical characteristics of urban solid waste compost before and after microbial consortium enrichment

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Abstract
The global urban waste crisis, driven by the urbanization process, poses many challenges, causing pollution and health risks. Inadequate waste management depletes resources and contributes to climate change. Microbial enrichment in composting aligns with circular economy and sustainable agriculture, accelerating decomposition. The present study was undertaken in 2022 at UAS, GKVK campus, Bangalore to examine urban solid waste compost properties before and after microbial consortium enrichment.

Enriched USWC exhibited enhanced water-holding capacity and reduced pH. After enrichment, soluble salt content rose, while initial organic carbon, C: N ratio, calcium, and magnesium levels were decreased. Nitrogen, phosphorus, and potassium were increased. Sulfur content rose, micronutrient concentrations nearly remained the same after enrichment, while heavy metals (Ni, Pb, Cr) exhibited minimal changes.

Keywords: Urban solid waste compost, consortium enrichment, waste management

Introduction
The surging production of urban solid waste has become an urgent global concern, propelled by rapid urbanization and population growth. The World Bank has forecasted a substantial increase in global waste generation from 2.01 billion metric tons in 2016 to an estimated 3.40 billion metric tons by 2050. Urban solid waste encompasses a varied mix of materials, including organic waste, plastics, paper, metals, and electronic waste. The consequences of this expanding waste production are multifaceted. Improper disposal methods, such as open burning and landfilling, contribute to widespread environmental pollution, releasing harmful substances into the air, soil, and water.

Consequently, this pollution results in soil contamination, negatively influencing ecosystems and potentially compromising agricultural productivity. Health risks are intertwined with inadequate waste management, evident in the proliferation of disease vectors and threats to neighboring communities. Moreover, improper waste disposal leads to resource depletion, with valuable materials suitable for recycling lost.

The decomposition of organic waste in landfills generates methane, a potent greenhouse gas exacerbating climate change. Beyond environmental implications, the accumulation of waste in urban areas influences the aesthetic appeal of the environment, contributing to social issues and diminishing overall quality of life.

The enhancement of microbial activity within urban solid waste presents a promising avenue with profound implications for sustainable waste management and environmental well-being. Urbanization has intensified the formidable challenge of solid waste management, resulting in a significant upsurge in waste generation. Microbial enrichment, a purposeful process involving the introduction of specific strains of microorganisms like bacteria and fungi into the composting of urban solid waste, plays a crucial role in expediting the decomposition of organic materials.

This intentional augmentation optimizes the breakdown of complex compounds and enhances nutrient cycling. The implications are substantial microbial enrichment not only accelerates the composting process but also contributes to the production of high-quality compost. This enriched compost, teeming with beneficial microbes, functions as a potent soil conditioner, fostering enhanced soil fertility, structure, and water retention capacity. Furthermore, the diverse microbial communities introduced during the enrichment process play a pivotal role in suppressing plant pathogens, thereby promoting plant health when the compost is applied to the soil.

Embracing microbial enrichment in urban solid waste composting represents a holistic approach that not only addresses waste management challenges but also aligns with the principles of a circular economy and sustainable agriculture, providing a transformative solution for urban environments grappling with the intricacies of waste disposal. By considering the above, the present investigation is carried out to study the physical and chemical properties of urban solid waste compost before and after enrichment with microbial consortium.

Materials and Methods

The present investigation was undertaken in the Department of Soil Science and Agricultural Chemistry, GKVK campus, UAS, Bangalore, in 2022. The enrichment process involves mixing 2ml of the liquid microbial consortium with 100ml of water for one kilogram of urban solid waste compost. The resulting mixture undergoes thorough blending, and regular watering twice a week to maintain a moisture content range of 60-70%, placed under shade, and allowed a 15-day period for the proliferation of microbial population. Standard protocols outlined in Table 1 were employed to assess various physical and chemical aspects of enriched and unenriched urban solid waste compost. This consortium comprises of *Azotobacter chroococcum*, *Bacillus megatherium*, *Fraturia aurantia*, *Pseudomonas fluorescens*, and *Trichoderma viridae.*

Table 1: Methods followed for analysis of urban solid waste compost before and after enrichment

Parameter	Method	Reference
Physical properties		
MWHC (%)	Keen Raczkowski Cup	Piper, 1966 [14]
Chemical properties		
pH (1:10)	Potentiometry	Jackson, 1973 [7]
EC (dS m^{-1})	Conductometry	Jackson, 1973 [7]
Organic carbon (%)	Wet oxidation	Walkley and Black, 1934 [19]
Total Nitrogen (%)	Kjeldahl distillation method	Piper,1966 [14]
Total Phosphorus (%)	Spectrophotometry	Piper,1966 [14]
Total Potassium (%)	Flame photometery	Piper, 1966 [14]
Total Calcium (%)	Versenate titrimetry	Jackson, 1973 [7]
Total Magnesium (%)	Versenate titrimetry	Jackson, 1973 [7]
Total Sulphur (%)	Turbidometry	Jackson,1973 [7]
Total Fe, Mn, Zn and Cu (ppm)	Atomic Absorption Spectrophotometry	Lindsay and Norvell, 1978 [9]
Total B (ppm)	Azomethane-H	Page *et al.*, 1982 [13]
Total heavy metals (ppm)	Atomic Absorption	Lindsay and Norvell, 1978 [9]

Table 2: Physical and chemical composition of urban solid waste compost (USWC) before and after enrichment

Parameters	Before Enrichment	After Enrichment
	USWC	**USWC**
MWHC (%)	54.11	56.21
pH (1:10)	7.41	7.38
EC (dSm-1)	1.67	1.71
OC (%)	15.54	14.61
C:N ratio	6.16	5.35
N (%)	2.52	2.73
P (%)	2.05	2.24
K (%)	1.46	1.59
Ca (%)	3.25	3.25
Mg (%)	0.85	0.85
S (%)	1.35	1.37
B (mg kg-1)	25.12	26.76
Cu (mg kg1)	102.33	109.35
Mn (mg kg1)	436.80	439.13
Zn (mg kg-1)	188.73	191.20
Fe (mg kg-1)	245.33	253.93
Ni (mg kg-1)	8.93	8.93
Cd (mg kg-1)	ND	ND
Pb (mg kg-1)	11.47	11.46
Cr (mg kg-1)	3.71	3.72

Results and Discussion

The water-holding capacity, as indicated in Table 2, Notably, the moisture content was slightly higher in the enriched urban solid waste compost (USWC) (56.21%) compared to before enrichment. The increase in Water-Holding Capacity (MWHC) observed in enriched USWC is likely a result of reduced bulk density. These results are consistent with the findings of Soumare *et al.* (2003) [16], who reported higher moisture content and lower bulk density in municipal solid waste compost.

Before the incorporation of a microbial consortium, the pH level of USWC registered at 7.41. After the enrichment process, a marginal decline in pH to 7.38 was observed, possibly because of the production of organic acids and phenolic compounds during incubation. Nonetheless, the pH experienced subsequent stabilization over time, likely influenced by the buffering characteristics of humic substances.

The initial soluble salt content in USWC measured 1.67 dSm-1, and post-enrichment, it rose to 1.71 dSm-1. The elevation in electrical conductivity values may be linked to an increased concentration of salts, possibly originating from the decomposition of organic matter, as suggested in the study by Francou *et al*. (2005) [6].

The findings presented in Table 2 reveal that the initial organic carbon (OC) content of USWC was 15.54 percent before enrichment but decreased to 14.61 percent afterward. The overall decline in total carbon after enrichment is likely attributed to carbon loss in the form of carbon dioxide (CO_2). Composting typically entails the breakdown of complex organic matter into simpler compounds, accompanied by the release of CO_2 gas and energy (Adani *et al*., 1997) [1], as carbon serves as an energy source for microorganisms in cell building (Diaz *et al*., 1993) [5].

The carbon-to-nitrogen (C: N) ratio before enrichment for USWC was 6.16, Following 15 days of enrichment, the C: N ratio decreased to 5.35. The decrease in organic carbon content is associated with carbon loss in the form of CO_2, while nitrogen content increases due to the mineralization effect, resulting in a diminished C: N ratio (Lee *et al*., 2002) [8].

Prior to enrichment, the nitrogen (N) content in USWC was 2.52 percent, and it subsequently increased to 2.73 percent. The heightened nitrogen content is associated with the decomposition of complex N-Compounds resulting from the breakdown of labile organic carbon compounds, leading to a reduction in the weight of the composting mass. Additionally, it is theorized that when the loss of biomass and organic matter surpasses the loss of NH3, there is typically an elevation in nitrogen concentration (Bernal *et al*., 1998 and Maleena, 1998) [3, 10].

Prior to enrichment, the phosphorus (P) content in USWC was 2.05 percent, and it later increased to 2.24 percent. The minor increase in phosphorus content observed in enriched compost is probably associated with the introduction of a microbial consortium during compost enrichment. This facilitated efficient mineralization, resulting in an improvement in phosphorus content in urban compost. These results align with the findings reported by Terman *et al*. (1973) [18] and Reddy *et al*. (2000) [15].

Before enrichment, the potassium (K) content in USWC was 1.46 percent, and it rose to 1.59 percent after 15 days of enrichment. The enriched USWC demonstrated a higher potassium content could be linked to swift microbial activity, leading to a reduction in the volume of the material. Manjunatha (2011) [12] similarly observed a higher amount of potassium content in compost enriched with both organic and mineral components.

The calcium (Ca) and magnesium (Mg) content in USWC were 3.25 and 0.85 percent, respectively, before enrichment. Following enrichment, the levels of calcium and magnesium in USWC remained nearly unchanged and did not show improvement.

However, the sulfur (S) content was discovered to be higher after enrichment (1.37%) compared to before enrichment (1.35%). The elevated sulfur concentration was primarily due to the decomposition of organic sulfur components present in the solid wastes (Anand, 2016) [2].

After the enrichment of USWC, there were increased concentrations of all micronutrients compared to before enrichment. The higher levels of micronutrients in USWC are likely due to the organic chelation of micronutrients (Dakshinamurthy and Upendra, 2008) [4].

The assessment of heavy metal concentrations was carried out both before and after enrichment. Cadmium was not detected among the heavy metals. The concentrations of other heavy metals, namely Ni, Pb, and Cr, remained almost unchanged before and after enrichment. This is consistent with the observations of Stillwell and David (1993) [17], who noted that compost prepared from municipal solid waste exhibited lower concentrations of heavy metal elements. Similarly, Manju *et al*. (2013) [11] reported that municipal solid waste compost adhered to Indian standards for heavy metal concentrations.

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