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Organic amendments to restore soil fertility and improve its chemical and physical characteristics

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Abstract
Soil degradation from excessive chemical inputs and unsustainable farming practices has led to a decline in soil health globally. Organic amendments like compost offer a promising alternative, enhancing soil structure, microbial diversity, and nutrient cycling. This study evaluates the effect of compost-derived from kitchen waste and organic residues-on key soil parameters such as pH, NPK availability, Total Dissolved Solids (TDS), starch degradation, and Water Holding Capacity (WHC). Laboratory and field analyses showed that compost significantly improved microbial proliferation, nutrient bioavailability, and water retention. Spectrophotometric analysis confirmed enhanced starch degradation, indicating heightened microbial enzymatic activity. The findings suggest compost as a sustainable soil management strategy, capable of enhancing fertility and reducing dependence on synthetic fertilizers.

Keywords: Compost, pH, NPK availability, Total Dissolved Solids (TDS) and water holding capacity (WHC)

1. Introduction

Soil health is the foundation of productive agriculture and ecological resilience. The degradation of soils through erosion, nutrient depletion, and overuse of chemical fertilizers has disrupted microbial communities and nutrient cycling. Organic amendments such as compost restore biological activity and nutrient balance by providing organic matter, beneficial microbes, and essential nutrients. Compost, composed of decomposed organic waste, serves as a slow-release nutrient source and improves physical properties like soil texture and moisture retention. It stabilizes pH and promotes enzymatic processes vital to nutrient transformations. Notably, microbial communities introduced or stimulated by compost play critical roles in carbon and nitrogen cycling, phosphorus solubilisation, and organic matter decomposition.

Different types of compost can have varying effects on soil properties and microbial communities. The most common types include

1. **Green Waste Compost:** Derived from plant-based materials such as grass clippings, leaves, and vegetable scraps, green waste compost is rich in carbon and essential nutrients. It improves soil structure, enhances microbial diversity, and gradually releases nitrogen, phosphorus, and potassium.
2. **Manure-Based Compost:** Produced from animal waste such as cow, horse, or poultry manure, this type of compost is highly nitrogen-rich and promotes microbial-activity. However, proper composting is essential to reduce pathogens and prevent nutrient imbalances that can lead to excessive nitrogen runoff.
3. **Vermi-compost:** Created through the digestion of organic matter by earthworms, vermi-compost is known for its high microbial content and enzymatic activity. It enhances soil aeration, moisture retention, and nutrient availability, making it particularly beneficial for improving soil microbial health.
4. **Soil pH** is a crucial parameter influencing microbial activity and nutrient availability.

Compost applications can help regulate soil pH, neutralizing acidic or alkaline conditions and creating an optimal environment for microbial proliferation and plant growth. The NPK (nitrogen, phosphorus, and potassium) content in compost-amended soils is essential for plant nutrition. Compost acts as a slow-release fertilizer, providing these macro-nutrients gradually as organic matter decomposes. Nitrogen supports leafy growth, phosphorus is vital for root development and energy transfer, and potassium enhances overall plant metabolism.

This study investigates how compost influences soil pH, nutrient levels (NPK), TDS, starch decomposition, and WHC. Understanding these dynamics is essential to developing sustainable agricultural practices that balance productivity with ecological health.

Objectives

- To evaluate the effect of compost amendments on soil physical properties.
- To investigate changes in chemical properties of compost-treated soil.

2. Materials and Methods

2.1 Compost Preparation

Compost was prepared using kitchen waste (vegetable peels, fruit waste), dry leaves, coco peat, and neem powder. Materials were layered and regularly turned to ensure aeration. Neem acted as a natural insecticide and decomposition enhancer. The compost matured over 2-3 months in summer and 3-5 months in winter.

2.2 Soil Sampling and Setup

Agricultural soil was divided into two groups: one mixed with compost (1:1 ratio) and a control without compost. Samples were subjected to chemical, physical, and biological tests to evaluate differences.

2.3 Analytical Methods

pH: 10g of soil-compost mix was dissolved in 50 mL distilled water, stirred, and filtered. The pH was measured using a digital meter.

2.4 Calculating the amount of NPK in the compost amended soil

A-Nitrogen (N): A. Nitrogen (N) Test-Kjeldahl Method

- **Take a Sample:** Weigh 0.5g of the soil-compost mixture.
- **Digest the Sample:** Add sulfuric acid and a catalyst, then heat until the solution is clear.
- **Neutralize and Distill:** Add sodium hydroxide, then distill to collect ammonia in boric acid solution.
- **Titrate:** Add acid drop by drop until the color changes, which shows the amount of nitrogen.
- **Calculate the Nitrogen Content:** Based on the amount of acid used.
- Determined via the Kjeldahl method, Organic N was converted to ammonium, distilled, and titrated.

B. Phosphorus (P) Test-Vanadomolybdate Method

- **Take a Sample:** Weigh 1g of the soil-compost mixture.
- **Extract Phosphorus:** Add nitric acid and sulfuric acid and heat.
- **Add Reagents:** Mix with ammonium molybdate and ammonium vanadate to form a yellow color.
- **Measure with Spectrophotometer:** Check the color intensity at 400-420 nm wavelength.
- **Compare with a Standard Chart:** To find out how much phosphorus is present.

C. Potassium (K) Test-Flame Photometry Method

- **Take a Sample:** Weigh 1g of the soil-compost mixture.
- **Extract Potassium:** Mix with distilled water, then filter.
- Assessed using the Vanado molybdate colorimetric method at 400-420 nm absorbance.
- **Compare with a Standard Chart:** To determine the potassium content.

TDS: 50g soil mixed with 100 mL distilled water. The extract was filtered and analyzed using a TDS meter.

Starch Analysis: Presence tested using iodine (I_2-KI) solution. Quantified using spectrophotometry at 620 nm against a starch standard curve.

Water Holding Capacity: Calculated using the formula:

WHC (%) = [(Wet weight-Dry weight)/Dry weight] × 100

3. Results

3.1 Compost Characteristics

Mature compost appeared dark brown, with a crumbly texture and earthy smell. The presence of worms indicated microbial richness and effective aerobic decomposition.

3.2 pH

The pH of the compost-amended soil was 7.0-ideal for most crops. This neutral condition supports nutrient solubility and microbial growth.

Table 1: pH of the sample.

SL. No.	SAMPLE (liquid)	pH
1.	Mixture of soil + compost	7.0

3.3 NPK Content

Table 2: Amount of NPK in the sample

SL. No.	Parameter	Unit	Result	Method
1	Nitrogen	% by wt	0.12	FCO, 1985
2	Total Phosphorous	mg/kg	840.84	FCO, 1985
3	Potassium (K)	Mg/100g	220.83	FCO, 1985

3.4 Total Dissolved Solids (TDS)

The TDS measured 406 mg/L, indicating a moderate level of dissolved salts and nutrients, supporting microbial and plant functions without risk of salinity.

Table 3: Total Dissolved Solids (TDS) in the sample

SL. No.	Sample (liquid)	TDS
1.	Mixture of soil + compost	406 mg/L.

3.5 Starch Analysis: The iodine test produced a purple-black coloration, confirming starch presence. Spectrophotometric analysis yielded an OD of 0.900 at 620 nm. This corresponds to active enzymatic degradation by amylase-producing microbes, confirming high microbial activity in compost-amended soils.

Table 4: Result of Iodine Test

SL. No.	Sample	Result
1.	Solution of soil with compost	Purple-black color

3.6 Water Holding Capacity

Dry soil weighed 20 g; saturated soil weighed 28.35 g. WHC = [(28.35-20)/20] × 100=41.75%.

This high WHC supports drought resilience and nutrient retention.

Table 5: Result of Starch test

Sl. NO	Volume of working standard (ml)	OD at 620 nm
1	0	0
2	0.2	0.125
3	0.4	0.448
4	0.6	0.660
5	0.8	0.731
6	1	0.975
7 (unknown)	0.85	0.900

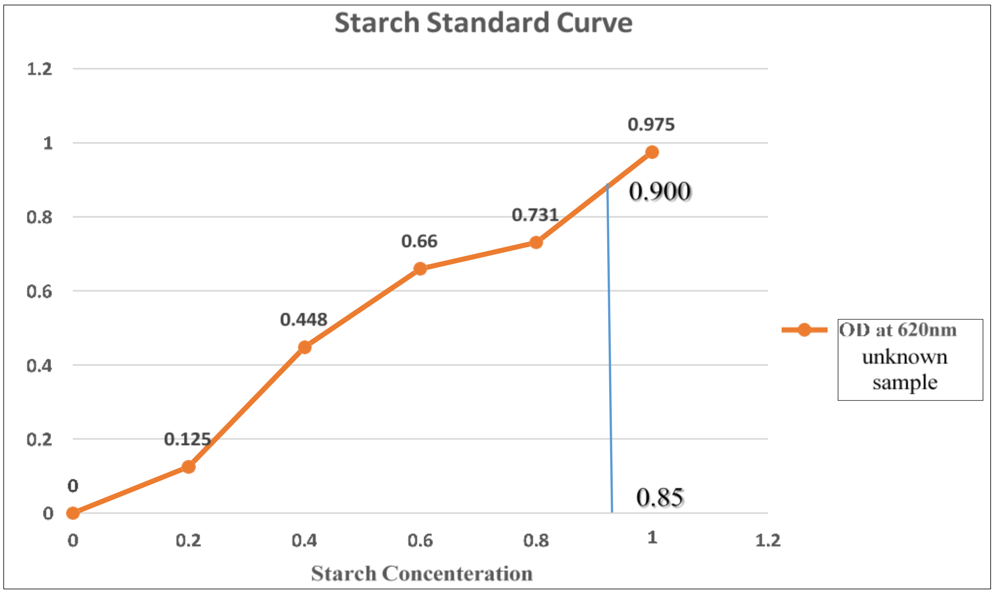

Fig 1: Graph of starch standard curve

4. Discussion

Soil Reaction (pH)

Compost helps buffer soil acidity by neutralizing excess H^+ ions through microbial by products and calcium carbonate. Neutral pH (6.5-7.5) enhances nutrient availability, enzymatic activity, and microbial diversity.

Nutrient Enrichment

- **Nitrogen:** Slowly released as compost decomposes, supporting continuous plant and microbial needs. Additional support from nitrogen-fixing microbes is beneficial.
- **Phosphorus:** Solubilized by phosphate-solubilizing bacteria present in compost. Its high availability aids root development and plant metabolism.
- **Potassium:** Released from organic matter and held by improved soil CEC, increasing uptake efficiency and reducing leaching.

Enhanced Microbial Activity

Enzymes like amylases, ureases, and dehydrogenases are stimulated by compost, accelerating organic matter breakdown and nutrient mineralization. Starch degradation is a strong indicator of microbial health.

TDS and Water Balance

Moderate TDS reflects optimal solute levels, aiding nutrient uptake. Compost's organic matrix retains water while improving porosity, making it particularly valuable in arid and degraded soils.

Long-term Benefits

Continued compost application improves:

- Soil structure and aeration
- Resistance to erosion
- Crop yields
- Microbial resilience under environmental stress
- These benefits support regenerative agriculture and carbon sequestration goals.

5. Conclusion

Compost amendments significantly enhance soil physicochemical and biological properties. The findings show improved pH stability, nutrient retention, microbial activity, and water retention. Compost supports sustainable farming by reducing dependency on chemical fertilizers and fostering a healthier, biologically active soil ecosystem. This study advocates the use of compost as a cost-effective, eco-friendly amendment to regenerate soils and promote sustainable agriculture. Future research should assess the long-term impacts of different compost types on various soil profiles and crop systems.

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