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SHORT COMMUNICATION

Enhancing Compost Production in Saline-Affected Soils Using Halophilic Bacteria and Halophytes for Sustainable Agriculture

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ABSTRACT
Halophilic bacteria, microorganisms that thrive in high-salt environments, have shown significant potential in enhancing soil quality and agricultural productivity, particularly in saline and chemical fertilizer affected soils. This study focuses on to isolate halophilic bacteria, soil samples were collected from pichavaram. The tolerance of halophilic bacterial isolates to varying concentrations of nitrogenous fertilizers, including ammonium sulfate, urea, and potassium chloride. Twenty-six isolates were cultured on halophilic agar with fertilizer concentrations of 10 mM, 50 mM, and 100 mM to evaluate their growth responses. Results indicated diverse tolerance patterns among the isolates. Several strains, such as HO and HY, exhibited high tolerance across all tested concentrations of the fertilizers, showing consistent growth. In contrast, isolates like BQ, BR, and HZ demonstrated complete sensitivity, with no growth observed under any conditions. Ammonium sulfate tolerance was high among some isolates (e.g., BS, HV, HQ), whereas others showed selective tolerance to urea or potassium chloride alone. Morphological and biochemical analyses were performed to identify dominant bacterial strains. The composting process involved using halophytes like Ipomoea I.pes-caprae, Sesuvium portulacastrum and Suaeda maritime in combination with organic waste materials. Halophilic bacteria were introduced to enhance the degradation process under saline conditions. The resulting compost was analyzed for physic chemical parameters, and compared with traditional composts. Results demonstrated that halophilic bacteria accelerated the decomposition of organicmatter in saline environments, improving the compost quality. The use of halophytes contributed additional organic material and nutrients, making the compost suitable for saline-affected soils.
Keywords: *Halophilic bacteria, halophytes, compost preparation, saline environments, soil fertility, sustainable agriculture.*

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INTRODUCTION

The overuse of chemical fertilizers has emerged as significant barriers to sustainable agriculture, particularly in coastal regions and areas with poor soil management [1]. These issues lead to soil degradation, loss of productivity, and long-term environmental harm. Traditional solutions for addressing saline soils, such as chemical amendments and irrigation management, are often costly, labor-intensive, and unsustainable over the long term. As the global demand for more resilient agricultural practices grows, there is a pressing need for innovative, eco-friendly methods to restore and enhance soil health in chemical affected agricultural regions. Mangrove ecosystems, located at the interface of land and sea, are uniquely adapted to survive in extreme environmental conditions such as high salinity, fluctuating water levels, and oxygen-poor soils. These ecosystems not only support a diverse range of flora and fauna but also harbor a rich variety of microorganisms, including halophilic bacteria [2-4]. Halophilic bacteria found in mangrove soils have evolved specialized mechanisms to thrive in hypersaline environments, making them particularly resilient and metabolically versatile. These bacteria play crucial roles in nutrient cycling, organic matter decomposition, and the breakdown of pollutants within the mangrove ecosystem [5]. Their ability to tolerate and even flourish in saline conditions makes them valuable for potential applications in agriculture, especially in the context of bioremediation and soil enhancement in salt-affected areas [6]. The unique properties of halophilic bacteria from mangroves, such as their salt tolerance and enzymatic activity, offer an untapped resource for improving soil health, particularly through the composting process in saline or degraded soils. Harnessing these bacteria could provide an environmentally friendly solution to enhance soil fertility and productivity in areas where traditional agricultural practices are challenged by salinity and chemical contamination. By exploring the application of mangrove halophilic bacteria in compost production, this study aims to leverage their natural resilience and decomposition capabilities to create a more efficient and sustainable method for improving soil quality in saline environments. When Halophiic bacteria combined with halophytes these bacteria offer a natural and sustainable method for improving soil quality, particularly through enhanced composting processes.This study seeks to isolate and characterize halophilic bacteria from saline environments and investigate their potential for improving compost quality in combination with halophytes like *Ipomoea pes-caprae*, *Sesuvium portulacastrum*, and *Suaeda maritima*. By leveraging the decomposition capabilities of these bacteria and the nutrient contributions of halophytes, the research aims to develop a sustainable composting solution for soils affected by salinity and chemical fertilizers [7-10]. This approach could offer a viable alternative for enhancing agricultural productivity in regions facing soil degradation challenges.

MATERIAL AND METHODS

Collection of Samples

Samples were collected from the Pichavaram Mangrove Forest (Lat. 11°20' N; Long. 79°47' E), located on the southeast coast of Tamil Nadu, India.. Samples were obtained at depths of 5–10 cm, where microbial activity is typically concentrated. The samples were stored in sterile containers and transported to the laboratory for further analysis.

Isolation of Halophilic Bacteria

To isolate halophilic bacteria, the soil samples were subjected to serial dilution using sterile saline solutions (0.85% NaCl) and inoculated in Halophilic agar Plates and were incubated at 37°C hours.

Tolerance testing of Halophilic bacteria

To evaluate the tolerance of halophilic bacterial isolates to varying concentrations of nitrogenous chemical fertilizers, halophilic agar medium was prepared and autoclaved to maintain sterility. Three different nitrogenous fertilizers—ammonium sulfate, urea, and potassium chloride were selected as test compounds. Each fertilizer was tested at three concentration levels: 10 mM, 50 mM, and 100 mM.

Isolation & Identification of Halophilic Bacteria

Morphological analysis was conducted by observing colony characteristics such as shape, color, and texture. Gram staining and motility tests were performed. Biochemical tests, including Catalase test, oxidase test, Indole test, Methyl Red and Voges Proskauer test, Citrate utilization test, Starch hydrolysis test, Urease test, H_2S production and Nitrate Reduction were also conducted. Molecular identification of the dominant bacterial strains was performed using 16S rRNA gene sequencing. Genomic DNA was extracted from the isolated bacteria. The 16S rRNA gene was amplified followed by sequencing. The obtained sequences were compared with those in the GenBank database using BLAST to confirm the species of the isolated strains.

Process of Composting

The composting process involved the use of halophytes, specifically *Ipomoea pes-caprae*, *Sesuvium portulacastrum*, and *Suaeda maritima*. These halophytes were collected from coastal regions, cleaned and mixed with organic waste materials, including vegetable scraps and plant residues. Halophilic bacterial strains were introduced into the compost mixture to enhance the degradation process. Physicochemical Analysis of Compost was analyzed for key physicochemical parameters.

RESULTS

Tolerance of Halophilic Bacterial Isolates to Nitrogenous Fertilizers

The tolerance of 26 halophilic bacterial isolates (BO–HZ) to varying concentrations of ammonium sulfate, urea, and potassium chloride was evaluated. The growth responses of the isolates were observed at concentrations of 10 mM, 50 mM, and 100 mM for each fertilizer, as detailed in Table X.

Ammonium Sulfate Tolerance

Among the tested isolates, BO, BS, BV, HO, HQ, HV, HW, HY, and others demonstrated complete tolerance to ammonium sulfate across all concentrations, showing growth at 10 mM, 50 mM, and 100 mM. Other isolates such as BP, BU, and BW exhibited growth at lower concentrations (10 mM) but not at higher concentrations (50 mM or 100 mM). Isolates like BQ, BR, BX, and HZ showed no growth at any concentration of ammonium sulfate, indicating a lack of tolerance to this compound.

Urea Tolerance

Isolates BP, BS, BU, HO, HQ, HT, HY, and others displayed tolerance to urea at all tested concentrations, while isolates such as BO and BW showed partial tolerance, growing only at lower concentrations. Isolates BQ, BR, BX, and HZ did not exhibit any growth at any urea concentration, suggesting these strains are highly sensitive to urea.

Potassium Chloride Tolerance

Complete tolerance to potassium chloride was observed in isolates BP, BS, HO, HT, HY, indicating growth at all concentrations. In contrast, other isolates such as BT, BU, and HV only tolerated potassium chloride at specific concentrations. Isolates such as BQ, BR, BX, and HZ did not exhibit growth across any potassium chloride concentration, suggesting low tolerance or potential toxicity at these levels.

Table 1: Growth Response of Halophilic Bacterial Isolates Under Varying Concentrations of Ammonium Sulphate, Urea, and Potassium Chloride

Halophilic Bacteria	**Ammonium Sulphate**			**Urea**			**Potassium Chloride**		
	10mM	**50mM**	**100mM**	**10mM**	**50mM**	**100mM**	**10mM**	**50mM**	**100mM**
BO	+	+	+	+	-	-	+	-	-
BP	+	-	-	+	+	+	+	+	+
BQ	-	-	-	+	-	-	-	-	-
BR	-	-	-	-	-	-	-	-	-
BS	+	+	+	+	+	+	+	+	+
BT	-	-	-	+	+	+	+	-	-
BU	+	-	-	+	+	+	+	+	-
BV	+	+	+	-	-	-	+	-	-
BW	+	-	-	+	-	-	+	+	-
BX	-	-	-	-	-	-	-	-	-
BY	+	+	+	+	+	+	+	-	-
BZ	-	-	-	-	-	-	-	-	-
HO	+	+	+	+	+	+	+	+	+
HP	-	-	-	+	+	+	+	-	-
HQ	+	+	+	+	+	+	+	-	-
HR	+	+	+	+	+	+	-	-	-
HS	-	-	-	-	-	-	-	-	-
HT	-	-	-	+	+	+	+	+	+
HU	+	-	-	-	-	-	+	+	+
HV	+	+	+	+	+	+	-	-	-
HW	+	+	+	+	+	+	-	-	-
HX	+	+	+	-	-	-	-	-	-
HY	+	+	+	+	+	+	+	+	+
HZ	-	-	-	-	-	-	-	-	_

Table 2: Biochemical Characterization of Selected Halophilic Bacterial Isolates (HO, HY, BS)

Organisms	**Voges proskaur**	**Methyl red**	**Starch hydrolysis**	**Catalase test**	**Urease test**	**Citrate utilization**	**Indole production**	**Nitrate reduction**
HO	+	+	+	+	-	+	-	
HY	-	-			-	+	-	+
BS	+	+	-	+	-	+	-	-

HO was found to be *Advenella kashmirensis* OP63179 HY was found to be *Pseudomonas aeruginosa* 0P763181 BS was found to be *Paenibacillus lautus* OP763179**.**

DISCUSSION

This study explored the potential of halophilic bacteria, particularly those isolated from mangrove ecosystems, in improving soil quality through composting in saline and chemically degraded soils [4]. The results from this investigation suggest that the combined application of halophilic bacteria and halophytes offers a viable, eco-friendly method to enhance soil fertility and productivity in challenging agricultural environments, specifically in regions affected by chemical fertilizer overuse. The study reveal distinct tolerance patterns among halophilic isolates, with some strains exhibiting high tolerance across multiple fertilizers and concentrations (e.g., HO, HY), while others (e.g., BQ, BR, HZ) showed sensitivity to all tested conditions. These results provide insights into the varying capacities of halophilic bacteria to survive under conditions of nitrogenous fertilizer exposure, potentially informing applications in environments with high nitrogenous compound presence. In this study, the introduction of halophilic bacteria significantly improved the efficiency of composting. These bacteria play an essential role in the decomposition of organic matter by secreting extracellular enzymes that break down complex organic compounds, a process that is hindered in high-salt conditions without specialized microbial activity. The inclusion of halophytes in the composting process further bolstered its effectiveness. Halophytes such as *Ipomoea pes-caprae*, *Sesuvium portulacastrum*, and *Suaeda maritima* have evolved to thrive in saline conditions, making them ideal candidates for integration into composting systems in salt-affected regions. These plants contribute not only organic material but also valuable nutrients such as nitrogen, phosphorus, and potassium to the compost, enhancing its nutrient profile [1, 11].

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