



Diversity, Environmental Adaptability, and Functional Potential of Salt-Tolerant Phosphate-Solubilizing Bacteria from Coastal and Mangrove Soils of Diu, India

Harsh Limbani, Nikul Chavada*

OM College of Science and PG Center, Junagadh, Gujarat, India

*Corresponding author: mahirpatle@gmail.com

Received: 03-02-2026; Accepted: 25-02-2026; Published: 13-03-2026

© Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License

<https://doi.org/10.55218/JASR.2026170301>

ABSTRACT

Coastal and mangrove ecosystems represent unique ecological niches that support diverse and stress-adapted microbial communities. The present investigation aimed to isolate and characterize phosphate-solubilizing bacteria (PSB) from coastal and mangrove soils of Diu, India, and evaluate their adaptability under varying environmental conditions. Soil samples collected from four ecologically distinct coastal sites yielded twenty-one morphologically diverse bacterial isolates using selective media. All isolates demonstrated phosphate-solubilizing capability on Pikovskaya's agar and were Gram-positive, indicating their resilience in saline environments. Environmental factors significantly influenced phosphate solubilization efficiency. Acidic conditions (pH 5) enhanced solubilization, whereas alkaline conditions reduced activity, although some isolates exhibited tolerance. Moderate salinity (1–2.5%) supported optimal activity, confirming halotolerance, while higher salinity reduced efficiency without completely inhibiting bacterial function. Temperature also played a critical role, with maximum solubilization observed at 37 °C, indicating mesophilic adaptation. Biochemical characterization revealed metabolic versatility, including enzyme production and oxidative stress tolerance. These findings highlight the ecological importance of PSB in phosphorus cycling and their potential role in improving nutrient availability in salt-affected soils. The study demonstrates that coastal and mangrove soils serve as valuable reservoirs of agriculturally beneficial microorganisms, offering promising candidates for eco-friendly biofertilizer development and sustainable crop production in saline and coastal agro ecosystems.

Keywords: Phosphate-solubilizing bacteria, Coastal soil, Mangrove ecosystem, Halotolerant bacteria, Biofertilizer, Phosphorus solubilization, Salinity stress, Sustainable agriculture.

INTRODUCTION

Soil salinization is one of the most serious threats to global agriculture, affecting more than 20% of irrigated land and significantly reducing crop productivity, particularly in arid, semi-arid, and coastal regions [1]. In India, approximately 6.7–7.0 million hectares of agricultural land are affected by salinity, mainly due to climate change, seawater intrusion, poor irrigation practices, and industrial activities [2]. Salinity disrupts soil structure, reduces microbial diversity, and causes osmotic and ionic stress, which ultimately impairs plant physiological processes such as nutrient uptake, photosynthesis, and growth [3, 4]. Among essential nutrients, phosphorus (P) availability is particularly affected in saline soils due to precipitation, adsorption, and reduced solubility.

Phosphorus is a vital macronutrient involved in energy transfer, ATP synthesis, nucleic acid formation, and membrane stability. Although agricultural soils contain large amounts of total phosphorus, only about 0.1% is available to plants in soluble forms such as H_2PO_4^- and HPO_4^{2-} [3]. Furthermore, 70–90% of applied phosphate fertilizers become immobilized through reactions with calcium, iron, and aluminum, forming insoluble complexes and reducing fertilizer

efficiency [7, 8]. Excessive fertilizer application also contributes to environmental problems such as eutrophication, soil degradation, and biodiversity loss [5]. Therefore, improving phosphorus bioavailability through sustainable and environmentally friendly approaches is essential for future agriculture.

Phosphate-solubilizing bacteria (PSB) have gained increasing attention as eco-friendly biofertilizers due to their ability to mobilize insoluble phosphorus through the production of organic acids, phosphatases, and chelating compounds [9]. In addition to phosphorus solubilization, PSB promote plant growth by producing phytohormones such as indole-3-acetic acid (IAA), siderophores, ACC deaminase, and exopolysaccharides, which enhance nutrient uptake and improve plant tolerance to abiotic stresses including salinity [6-10]. These beneficial traits make PSB promising candidates for sustainable agricultural applications.

Coastal and mangrove ecosystems represent unique ecological niches characterized by high salinity, fluctuating environmental conditions, and nutrient limitations. Microorganisms inhabiting these environments possess specialized adaptive mechanisms and

metabolic versatility, enabling them to survive under extreme stress conditions while actively participating in nutrient cycling [10, 12]. Salt-tolerant PSB isolated from coastal environments have demonstrated significant potential in enhancing phosphorus availability and improving crop growth under saline conditions [11]. However, the diversity and functional potential of phosphate-solubilizing bacteria from coastal and mangrove soils of India remain insufficiently explored. Therefore, the present study aims to isolate and characterize salt-tolerant phosphate-solubilizing bacteria from coastal and mangrove soils and evaluates their potential for sustainable biofertilizer development and improved phosphorus availability in saline agro ecosystems [13].

MATERIALS AND METHODOLOGY

Study Area and Soil Sample Collection

Soil samples were collected from four ecologically distinct salt-affected coastal and mangrove locations of Diu, India, influenced by tidal activity and seawater intrusion. The sampling sites included Fudam Bird Sanctuary center (20.7256° N, 70.9557° E), mangrove intertidal mudflat zone (20.7200° N, 70.9600° E), Brancavara Creek mangrove fringe (20.7108° N, 70.8672° E), and coastal mangrove patches near Diu town (20.7140° N, 70.9822° E). Non-rhizosphere soil samples were collected aseptically from a depth of 1–20 cm using sterile spatulas and transferred into sterile polyethylene bags.

The samples were transported to the laboratory under refrigerated conditions and stored at 4 °C until. Further microbiological analysis [14, 15].

Isolation of Phosphate-Solubilizing Bacteria

Phosphate-solubilizing bacteria (PSB) were isolated using the serial dilution and spread plate technique on Pikovskaya's agar medium. The composition of the medium (g/L) was: yeast extract (0.5), dextrose (10.0), calcium phosphate (5.0), and ammonium sulfate (0.5), potassium chloride (0.2), magnesium sulfate (0.1), manganese sulfate (0.0001), ferrous sulfate (0.0001), and agar (15.0). Soil samples were serially diluted in sterile distilled water, and appropriate dilutions were spread on Pikovskaya's agar plates supplemented with tricalcium phosphate (TCP) as an insoluble phosphorus source [15, 16]. The plates were incubated at 30 ± 1 °C for 2–3 days. Colonies exhibiting clear halo zones around them were considered phosphate solubilizers. These colonies were selected, purified by repeated streaking, and maintained on nutrient agar slants at 4 °C for further study [16].

Qualitative Screening for Phosphate Solubilization

Qualitative phosphate solubilization activity was evaluated using the spot inoculation method on Pikovskaya's agar plates. Pure bacterial cultures were spot inoculated at the center of agar plates and incubated at 30 ± 1 °C for 7–10 days [20]. The formation of a clear halo zone around the colony indicated phosphate solubilization. The diameter of the colony and solubilization zone was measured at 24-hour intervals for up to 6 days.

Phosphate solubilization efficiency (SE) was calculated using the formula:

$$SE (\%) = (Z / C) \times 100$$

Where:

Z = Diameter of solubilization zone (mm) C = Diameter of bacterial colony (mm)

Isolates producing solubilization zones greater than 5 mm were selected for further analysis.

Quantitative Estimation of Phosphate Solubilization

Quantitative estimation of phosphate solubilization was carried out in Pikovskaya's broth supplemented with tricalcium phosphate (0.3 g/100 mL). Each flask containing 100 mL sterile broth was inoculated with 1 mL of actively growing bacterial culture and incubated at 37 °C for 5 days on a rotary shaker. Uninoculated broth served as the control [17]. After incubation, the cultures were centrifuged at 10,000 rpm for 30 minutes to obtain clear supernatant. Soluble phosphorus content in the supernatant was determined colorimetrically at 410 nm using KH_2PO_4 as the standard [12].

Optimization of Physiological Parameters

The effect of environmental factors on phosphate solubilization efficiency was evaluated using Pikovskaya's agar medium. The isolates were incubated at different temperatures (20, 37, and 50°C), pH levels (6, 7, and 9), and salt concentrations (1%, 2.5%, and 5% NaCl). All plates were incubated at 28–30 °C, and solubilization zones were measured to determine optimal conditions for phosphate solubilization.

Morphological and Biochemical Characterization

Selected PSB isolates were characterized based on morphological, physiological, and biochemical properties according to standard microbiological methods described in Bergey's Manual of Systematic Bacteriology [18] and standard microbiology laboratory manuals. Pure cultures were maintained on nutrient agar slants and preserved at 4 °C.

Biochemical Characterization of PSB Isolates

Indole test

Bacterial isolates were inoculated into peptone water and incubated at 37 °C for 24–48 hours. After incubation, Kovac's reagent was added. Formation of a cherry-red ring indicated a positive result.

Methyl red test

Isolates were inoculated into MR broth and incubated at 37 °C for 24–48 hours. Addition of methyl red indicator producing red color indicated positive mixed acid fermentation.

Voges–proskauer test

Isolates were grown in VP broth and incubated at 37 °C for 24–48 hours. After incubation, Barritt's reagents A and B were added. Development of pink or red color indicated acetoin production.

Citrate utilization test

Isolates were inoculated on Simmons citrate agar slants and incubated at 28–30°C for up to 7 days Color change from green to blue indicated positive citrate utilization.

Motility test

Motility was determined by the hanging drop method using fresh bacterial cultures. Directional movement indicated motile bacteria.

Triple sugar iron (TSI) test

Isolates were inoculated on TSI agar slants and incubated at 37 °C for 24 hours. Sugar fermentation patterns, gas production, and H₂S formation were recorded.

Catalase test

A drop of 3% hydrogen peroxide was added to fresh bacterial culture. Immediate bubble formation indicated catalase-positive isolates.

Oxidase test

Oxidase activity was determined using oxidase reagent discs. Development of dark purple color indicated positive oxidase activity.

Carbohydrate fermentation test

Isolates were inoculated into carbohydrate fermentation broth containing glucose, lactose, or sucrose and incubated at 37 °C for 24–48 hours. Acid and gas production were recorded based on color change and gas formation in Durham tubes.

RESULTS AND DISCUSSION

Isolation and Occurrence of Phosphate-solubilizing Bacteria

Soil samples collected from four ecologically distinct coastal environments of Diu, including mangrove intertidal mudflat, estuarine mangrove fringe, coastal mangrove patches, and bird sanctuary soil, yielded a total of twenty-one morphologically distinct bacterial isolates capable of phosphate solubilization (Fig 1).

All isolates demonstrated visible growth on Pikovskaya's agar medium, confirming their ability to utilize insoluble phosphate sources. The widespread occurrence of phosphate-solubilizing bacteria (PSB) across all sampling sites indicates their ecological significance in phosphorus cycling within coastal and mangrove ecosystems (Table 1).

The recovery of PSB from diverse ecological niches subjected to varying degrees of salinity, tidal influence, and organic matter deposition suggests strong adaptive capability of these microorganisms under fluctuating environmental conditions. These findings highlight mangrove-associated soils as important reservoirs of functionally significant phosphate-mobilizing microbial populations [19].

Morphological and Gram staining characteristics

The isolates exhibited considerable variation in colony morphology, indicating phenotypic diversity among the PSB population. Most isolates formed small colonies, while a few isolates such as PDP-4, CDP-9, and FDP-12 produced larger colonies, suggesting differences in growth rate and metabolic activity. Colony shape was predominantly irregular, although some isolates exhibited circular colonies. Surface texture varied from smooth to rough, reflecting differences in extracellular polymer production and surface characteristics [24,25]. Colony elevation was mainly raised, with a few flat colonies observed. Pigmentation was predominantly white or off-white, while some isolates produced yellow pigmentation,

indicating variability in pigment synthesis and possible ecological adaptation (Table 2).

Gram staining analysis revealed that all isolates were Gram-positive, indicating the predominance of Gram-positive phosphate-solubilizing bacteria in coastal soils of Diu. This group of bacteria is well known for their stability, stress tolerance, and efficient nutrient cycling capability in soil ecosystems [21].

Effect of pH on phosphate solubilization

Phosphate solubilization by bacterial isolates was significantly influenced by environmental pH. Under acidic conditions (pH 5), several isolates demonstrated enhanced solubilization activity, with isolates 4, 9, 12 exhibiting the highest solubilization indices by Day 3.

This suggests that acidic conditions favor organic acid production, which enhances phosphate solubilization.

Under neutral conditions (pH 7), most isolates exhibited moderate phosphate solubilization activity, although certain isolates such as isolate 10 and isolate 4 showed comparatively higher efficiency. In contrast, alkaline conditions (pH 9) significantly reduced solubilization efficiency in most isolates, although some isolates demonstrated limited tolerance and maintained measurable activity.

These findings indicate that acidic to neutral conditions are more favorable for phosphate solubilization, while alkaline conditions impose metabolic constraints. (Graph 1)

Effect of Salt Concentration on Phosphate Solubilization

All isolates demonstrated phosphate solubilizing ability under varying salt concentrations (1%, 2.5%, and 5%), confirming their halo tolerant nature. At 1% salt concentration, isolates exhibited moderate to high

Table 1: Strain Identification Code

Strain No.	Identification code
1	FDP – 01
2	CDP – 02
3	MDP – 03
4	PDP – 04
5	CDP – 05
6	CDP – 06
7	FDP – 07
8	MDP – 08
9	CDP – 09
10	FDP – 10
11	CDP – 11
12	FDP – 12
13	MDP – 13
14	MDP – 14
15	CDP – 15
16	PDP – 16
17	PDP – 17
18	FDP – 18
19	CDP – 19
20	MDP – 20
21	FDP – 21

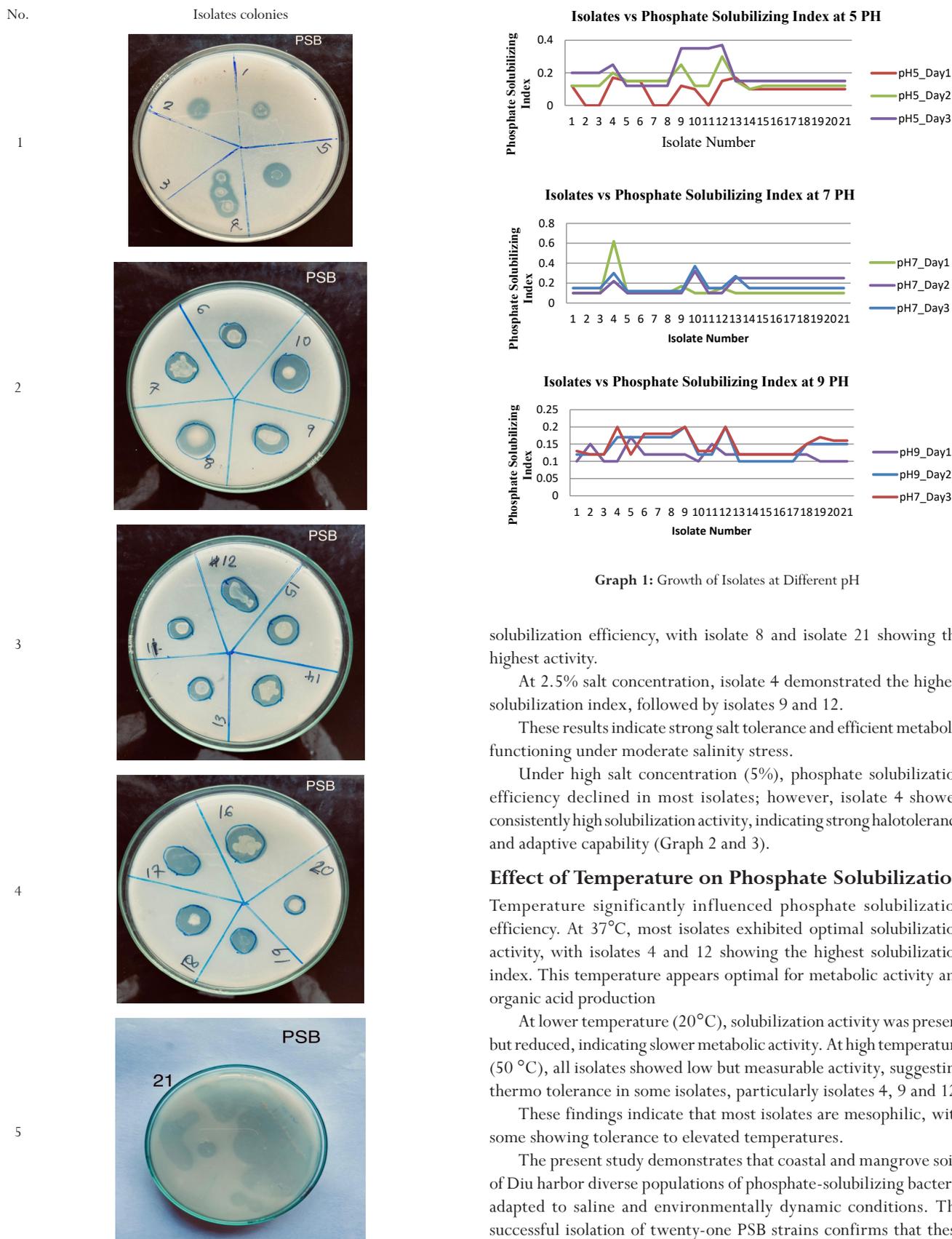


Fig 1: Isolates Colonies

Graph 1: Growth of Isolates at Different pH

solubilization efficiency, with isolate 8 and isolate 21 showing the highest activity.

At 2.5% salt concentration, isolate 4 demonstrated the highest solubilization index, followed by isolates 9 and 12.

These results indicate strong salt tolerance and efficient metabolic functioning under moderate salinity stress.

Under high salt concentration (5%), phosphate solubilization efficiency declined in most isolates; however, isolate 4 showed consistently high solubilization activity, indicating strong halotolerance and adaptive capability (Graph 2 and 3).

Effect of Temperature on Phosphate Solubilization

Temperature significantly influenced phosphate solubilization efficiency. At 37°C, most isolates exhibited optimal solubilization activity, with isolates 4 and 12 showing the highest solubilization index. This temperature appears optimal for metabolic activity and organic acid production

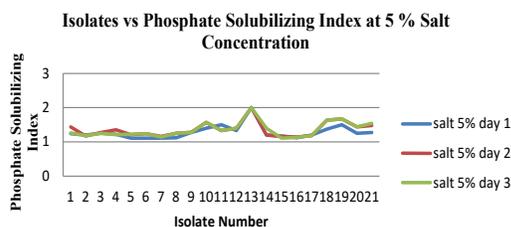
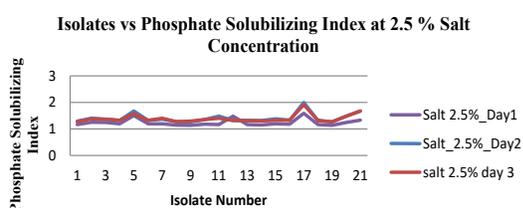
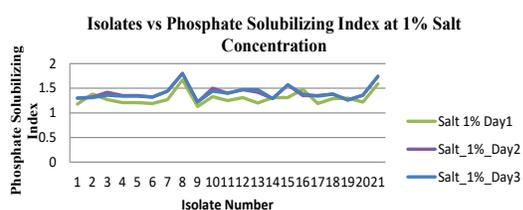
At lower temperature (20°C), solubilization activity was present but reduced, indicating slower metabolic activity. At high temperature (50 °C), all isolates showed low but measurable activity, suggesting thermo tolerance in some isolates, particularly isolates 4, 9 and 12.

These findings indicate that most isolates are mesophilic, with some showing tolerance to elevated temperatures.

The present study demonstrates that coastal and mangrove soils of Diu harbor diverse populations of phosphate-solubilizing bacteria adapted to saline and environmentally dynamic conditions. The successful isolation of twenty-one PSB strains confirms that these ecosystems are important reservoirs of beneficial microorganisms involved in phosphorus cycling [22, 23].

Table 2: Colonies characteristics of Isolates

Colony number	Colony shape	Shape	Elevation	Texture	Consistency	Pigmentation	Growth on pikovaskya agar media	Gram staining
FDP – 01	Small	Round	Raised	Smooth	Moist	White	Yes	Gram +ve
CDP – 02	Small	Round	Flat	Smooth	Moist	White	Yes	Gram +ve
MDP – 03	Small	Round	Raised	Smooth	Moist	Off White	Yes	Gram +ve
PDP – 04	Small	Round	Raised	Smooth	Moist	White	Yes	Gram +ve
CDP – 05	Small	Irregular	Flat	Smooth	Moist	White	Yes	Gram +ve
CDP – 06	Small	Irregular	Flat	Rough	Moist	Yellow	Yes	Gram +ve
FDP – 07	Small	Irregular	Raised	Rough	Moist	Off white	Yes	Gram +ve
MDP – 08	Small	Irregular	Raised	Rough	Moist	Yellow	Yes	Gram +ve
CDP – 09	Small	Irregular	Flat	Smooth	Moist	White	Yes	Gram +ve
FDP – 10	Small	Irregular	Raised	Smooth	Moist	White	Yes	Gram +ve
CDP – 11	Small	Irregular	Flat	Smooth	Moist	White	Yes	Gram +ve
FDP – 12	Large	Irregular	Raised	Smooth	Moist	White	Yes	Gram +ve
MDP – 13	Large	Irregular	Raised	Rough	Moist	White	Yes	Gram +ve
MDP – 14	Small	Irregular	Raised	Rough	Moist	White	Yes	Gram +ve
CDP – 15	Small	Irregular	Flat	Smooth	Moist	Yellow	Yes	Gram +ve
PDP – 16	Small	Irregular	Raised	Rough	Moist	Yellow	Yes	Gram +ve
PDP – 17	Small	Irregular	Raised	Rough	Moist	White	Yes	Gram +ve
FDP – 18	Small	Irregular	Raised	Rough	Moist	Off White	Yes	Gram +ve
CDP – 19	Large	Irregular	Raised	Rough	Moist	Off White	Yes	Gram +ve
MDP – 20	Small	Round	Flat	Rough	Moist	White	Yes	Gram +ve
FDP - 21	Small	Irregular	Flat	Rough	Moist	Off White	Yes	Gram +ve



Graph 2: Growth of Isolates at Different Salt Concentration

Mangrove and coastal ecosystems are characterized by high salinity, tidal fluctuations, and organic matter accumulation, which promote microbial diversity and nutrient transformation[26].

The presence of PSB in these environments suggests their essential role in maintaining phosphorus availability and supporting plant productivity under nutrient-limited conditions.

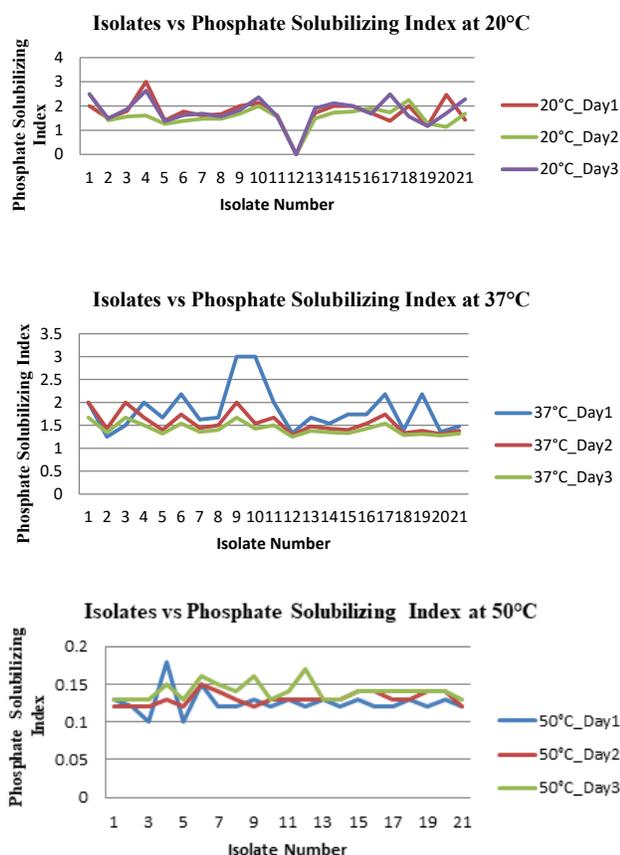
The predominance of Gram-positive bacteria observed in this study is consistent with previous reports indicating that Gram-positive genera such as *Bacillus* and *Streptomyces* dominate in saline and stressed environments due to their ability to form resistant structures and tolerate osmotic stress [23]. These bacteria are known to produce organic acids, phosphatases, and chelating compounds that facilitate phosphate solubilization

Environmental factors such as pH, salinity, and temperature significantly influenced phosphate solubilization efficiency [24].

Acidic conditions enhanced solubilization activity, likely due to increased organic acid production and reduced pH in the surrounding medium, which promotes dissolution of insoluble phosphate complexes [18].

Salinity stress reduced phosphate solubilization in most isolates; however, several isolates demonstrated strong halotolerance, indicating adaptive mechanisms such as osmotic regulation, compatible solute accumulation, and efficient enzyme functioning under saline conditions [25].

Similarly, temperature influenced metabolic activity, with optimal solubilization observed at 37 °C, which is typical for



Graph 3: Growth of Isolates at Different Temperature

mesophilic bacteria. The ability of certain isolates to maintain activity at elevated temperature and salinity highlights their ecological resilience and potential application in extreme environments [28].

Overall, the diversity and functional capability of PSB isolated in this study demonstrate their ecological importance and potential utility in improving phosphorus availability in salt-affected soils.

CONCLUSION

The present study confirms that coastal and mangrove soils of Diu, India harbor diverse and metabolically versatile phosphate-solubilizing bacteria capable of functioning under saline and environmentally stressful conditions.

A total of twenty-one Gram-positive bacterial isolates demonstrated effective phosphate solubilization, indicating their important role in phosphorus cycling and nutrient transformation in salt-affected ecosystems.

Environmental factors such as pH, salinity, and temperature significantly influenced solubilization efficiency, with optimal activity observed under acidic pH, moderate salinity, and mesophilic temperature conditions.

The ability of several isolates to tolerate high salinity and temperature highlights their ecological adaptability and potential for application in saline agricultural soils.

These findings suggest that coastal PSB represent promising candidates for development of eco-friendly Biofertilizer aimed at

improving phosphorus availability, enhancing soil fertility, and supporting sustainable agriculture in coastal and salt-affected regions.

REFERENCES

1. Hiu-Ping Li, Qing-Qing Han, Qiong-Mei Liu, Ya-Nan Gan, Christopher Rensing, Windell L. Rivera, Qi Zhao, Jin-Lin Zhang, Roles of phosphate-solubilizing bacteria in mediating soil legacy phosphorus availability, *Microbiological Research*, Volume 272, 2023
2. Khuong, Nguyen Quoc, Dat, Le Tien, Xuan, Ly Ngoc Thanh, Quang, Le Thanh and Nghia, Nguyen Khoi. "The potential of phosphorus-solubilizing purple nonsulfur bacteria in agriculture: Present and future perspectives" *Open Agriculture*, vol. 9, no. 1, 2024, pp. 20220328. <https://doi.org/10.1515/opag-2022-0328>
3. Saranya, K., Sundaramanickam, A., Manupoori, S., & Kanth, S. V. (2022). Screening of multi-faceted phosphate-solubilising bacterium from seagrass meadow and their plant growth promotion under saline stress condition. *Microbiological research*, 261, 127080.
4. NAVDEEP, S. B. (2023). *EFFECT OF PHOSPHORUS AND PHOSPHORUS SOLUBILIZING BACTERIA (PSB) ON SOIL PHOSPHORUS AVAILABILITY, YIELD AND NUTRIENTS UPTAKE BY SUMMER GREEN GRAM 3705* (Doctoral dissertation, JAU JUNAGADH).
5. Dey, G., Banerjee, P., Sharma, R. K., Maity, J. P., Etesami, H., Shaw, A. K., ... & Chen, C. Y. (2021). Management of phosphorus in salinity-stressed agriculture for sustainable crop production by salt-tolerant phosphate-solubilizing bacteria—A review. *Agronomy*, 11(8), 1552.
6. Iftikhar, A., Aijaz, N., Farooq, R., Aslam, S., Zeeshan, A., Munir, M., ... & Shiraz, A. (2023). Beneficial role of phosphate solubilizing bacteria (PSB) in enhancing soil fertility through a variety of actions on plants growth and ecological perspective: An updated review. *Journal of Xi'an Shiyou University, Natural Science Edition*, 19(9), 520-547.
7. Maity, J. P., Banerjee, P., Sharma, R. K., Etesami, H., Bastia, T. K., ... & Chen, C. Y. (2024). Characterization of halotolerant phosphate-solubilizing rhizospheric bacteria from mangrove (*Avicennia* sp.) with biotechnological potential in agriculture and pollution mitigation. *Biocatalysis and Agricultural Biotechnology*, 55, 102960.
8. Janati, W., Bouabid, R., Mikou, K., Ghadraoui, L. E., & Errachidi, F. (2023). Phosphate solubilizing bacteria from soils with varying environmental conditions: Occurrence and function. *PLoS One*, 18(12), e0289127.
9. Sun, X., Wang, W., Yi, S., Zheng, F., Zhang, Z., Alharbi, S. A., ... & Kuzyakov, Y. (2024). Microbial composition in saline and alkaline soils regulates plant growth with P-solubilizing bacteria. *Applied Soil Ecology*, 203, 105653.
10. Wang, X., Li, Z., Li, Q., & Hu, Z. (2025). Alleviation of Plant Abiotic Stress: Mechanistic Insights into Emerging Applications of Phosphate-Solubilizing Microorganisms in Agriculture. *Plants*, 14(10), 1558.
11. Zhang, T., Wang, X. L., Zhou, J., Zhou, W., & Zhou, S. Q. (2025). Construction of phosphate-solubilizing microbial consortium and its effect on the remediation of saline-alkali soil. *Microbial Ecology*, 88(1), 11.
12. Joshi, G., Kumar, V., & Brahmachari, S. K. (2021). Screening and identification of novel halotolerant bacterial strains and assessment for insoluble phosphate solubilization and IAA production. *Bulletin of the National Research Centre*, 45(1), 83.
13. Salsabila, N., Fitriatin, B. N., & Hindersah, R. (2023). The Role of Phosphate-Solubilizing Microorganisms in Soil Health and Phosphorus Cycle: A Review. *Int. J. Life Sci. Agric. Res*, 2, 281-287.
14. Ughamba, K. T., Ndukwe, J. K., Lidbury, I. D., Nnaji, N. D., Eze, C. N., Aduba, C. C., ... & Anumudu, C. K. (2025). Trends in the application of phosphate-solubilizing microbes as biofertilizers: implications for soil improvement. *Soil Systems*, 9(1), 6.
15. Tian, J., Ge, F., Zhang, D., Deng, S., & Liu, X. (2021). Roles of

- phosphate solubilizing microorganisms from managing soil phosphorus deficiency to mediating biogeochemical P cycle. *Biology*, 10(2), 158.
16. Mikiciuk, G., Miller, T., Kisiel, A., Cembrowska-Lech, D., Mikiciuk, M., Łobodzińska, A., & Bokszczanin, K. (2024). Harnessing beneficial microbes for drought tolerance: a review of ecological and agricultural innovations. *Agriculture*, 14(12), 2228.
 17. El-Saadony, M. T., Saad, A. M., Mohammed, D. M., Fahmy, M. A., Elesawi, I. E., Ahmed, A. E., ... & El-Tarabily, K. A. (2024). Drought-tolerant plant growth-promoting rhizobacteria alleviate drought stress and enhance soil health for sustainable agriculture: A comprehensive review. *Plant Stress*, 14, 100632.
 18. Jia, J., de Goede, R., Li, Y., Zhang, J., Wang, G., Zhang, J., & Creamer, R. (2025). Unlocking soil health: Are microbial functional genes effective indicators?. *Soil Biology and Biochemistry*, 204, 109768.
 19. Babar, S., Baloch, A., Qasim, M., Wang, J., Wang, X., Li, Y., ... & Jiang, C. (2024). Unearthing the soil-bacteria nexus to enhance potassium bioavailability for global sustainable agriculture: A mechanistic preview. *Microbiological Research*, 288, 127885.
 20. Kaur, H., Mir, R. A., Hussain, S. J., Prasad, B., Kumar, P., Aloo, B. N., ... & Dubey, R. C. (2024). Prospects of phosphate solubilizing microorganisms in sustainable agriculture. *World Journal of Microbiology and Biotechnology*, 40(10), 291.
 21. Walsh, M., Schenk, G., & Schmidt, S. (2023). Realising the circular phosphorus economy delivers for sustainable development goals. *NPJ Sustainable Agriculture*, 1(1), 2.
 22. Luo, X., Wang, R., Nabi, M., Tan, L., Wu, Z., & Xiao, K. (2024). A review on the phosphorus bioavailability of thermal treated sewage sludge. *Journal of Environmental Chemical Engineering*, 12(6), 114783.
 23. Sadiq, F. K., Anyebe, O., Tanko, F., Abdulkadir, A., Manono, B. O., Matsika, T. A., ... & Bello, S. K. (2025). Conservation agriculture for sustainable soil health management: A review of impacts, benefits and future directions. *Soil Systems*, 9(3), 103.
 24. Zhang, M., Hu, J., Zhang, Y., Cao, Y., Rensing, C., Dong, Q., ... & Zhang, J. (2025). Roles of the soil microbiome in sustaining grassland ecosystem health on the Qinghai-Tibet Plateau. *Microbiological Research*, 128078.
 25. Akplo, T. M., Kouelo Alladassi, F., Zoundji, M. C. C., Faye, A., Hernández, M., Yemadje, P. L., ... & Houngnandan, P. (2025). Phosphate solubilization and mobilization: bacteria–mycorrhiza interactions. *Letters in Applied Microbiology*, 78(8), ovaf105.
 26. KHUONG¹, N. Q., NGUYEN¹, T. T. K., NGOC¹, V. O. Y. E. N., TRONG¹, N. D., QUANG¹, L. T., THU¹, L. E. T. H. I. M. Y., & THANG¹, L. A. C. A. O. (2025). Storage of biofertilizers containing potassium-solubilising purple nonsulfur bacteria, *Cereibacter sphaeroides* M-SI-09, *Rhodopseudomonas thermotolerans* M-So-11 and *Rhodopseudomonas palustris* M-So-14. *Crop Research*, 60(5), 381-391.
 27. Cheng, Y., Narayanan, M., Shi, X., Chen, X., Li, Z., & Ma, Y. (2023). Phosphate-solubilizing bacteria: Their agroecological function and optimistic application for enhancing agro-productivity. *Science of The Total Environment*, 901, 166468.
 28. Xie, X., Gan, L., Wang, C., & He, T. (2024). Salt-tolerant plant growth-promoting bacteria as a versatile tool for combating salt stress in crop plants. *Archives of Microbiology*, 206(8), 341.
 29. Egamberdieva, D., Eshboev, F., Shukurov, O., Alaylar, B., & Arora, N. K. (2023). Bacterial bioprotectants: biocontrol traits and induced resistance to phytopathogens. *Microbiology Research*, 14(2), 689-703.

HOW TO CITE THIS ARTICLE: Limbani H, Chavada N. Diversity, Environmental Adaptability, and Functional Potential of Salt-Tolerant Phosphate-Solubilizing Bacteria from Coastal and Mangrove Soils of Diu, India. *J Adv Sci Res*. 2026;17(3): 1-7 **DOI:** 10.55218/JASR.2026170301