International Journal of Science, Strategic Management and Technology
Volume **02** Issue **03** March-**2026** | ISSN: **3108-1762 (Online)** | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases

Physicochemical Status of Coastal Soil and Groundwater and its Socio- conomic Impact: A Case Study of Sankarpur, Chandpur, and Tajpur

Author Details:

Mintu Jana[1], Mrs. Taniya Roy[2], Dr. Dipak Bisai

[1]*Research Scholar, Coastal Environmental Studies, Egra Sarada Sashi Bhusan College, mail id- janamintu6@gmail.com, ORCID ID- https://orcid.org/0000-0002-0566-8822*
[2]*State Aided College Teacher, Department of Geography, Bajkul Milani Mahavidyalaya, mail id-taniya.roy0801@gmail.com*
[3]*Associate Professor, Department of Geography, Egra Sarada Sashi Bhusan College, mail id- dbisai@gmail.com*

Corresponding Author Email: janamintu6@gmail.com | ORCID: https://orcid.org/0000-0002-0566-8822

https://doi.org/10.55041/ijsmt.v2i3.026

Cite this Article: Roy, M. J. T. (2026). Physicochemical Status of Coastal Soil and Groundwater and its Socio- Economic Impact: A Case Study of Sankarpur, Chandpur, and Tajpur. International Journal of Science, Strategic Management and Technology, *02*(03). https://doi.org/10.55041/ijsmt.v2i3.026

Abstract—

This research investigates the chemical properties of soil and groundwater in the ecologically sensitive coastal villages of Sankarpur, Chandpur, and Tajpur within the Purba Medinipur district of West Bengal. Given that over 60% of this region is dependent on fishing and associated economic activities, maintaining environmental quality is critical for local sustainability. Soil analysis reveals a predominantly alkaline nature across the study area, with pH values ranging significantly between 8.0 and 9.0. This alkalinity is attributed to low regional rainfall, the inherent nature of coastal soil, and high sea-water influence bringing in alkaline substances such as calcium and magnesium carbonates. Nutrient profiling indicates that Tajpur possesses the highest concentrations of Nitrate Nitrogen (reaching up to 45), suggesting potential suitability for specific crop cultivation. However, variable levels of Ammoniacal Nitrogen (ranging from 13 to 180) were recorded, with high values in specific locations of Sankarpur and Tajpur pointing toward potential ammonia pollution from organic decomposition or agricultural runoff. Groundwater analysis mirrors these alkaline trends, with pH levels observed between 7.2 and 9.5. Total Dissolved Solids (TDS) were recorded between 234 and 748, indicating varying degrees of salinity and mineral concentration across the coastal aquifers. The findings suggest that while the soil has certain nutrient strengths, the high alkalinity and localized ammonia concentrations necessitate strategic soil management and regular groundwater monitoring to support the region's agricultural and environmental health.

Keywords: Coastal Soil Chemistry, Groundwater Salinity, pH Analysis, Nitrate Nitrogen, Sankarpur, Purba Medinipur, Environmental Monitoring.

1. INTRODUCTION

The coastal ecosystem of West Bengal, particularly the Purba Medinipur district, represents a unique geographical and economic landscape. Among the various coastal stretches, the region encompassing Sankarpur, Chandpur, and Tajpur stands out as a vital hub for marine-based livelihoods. Geographically, this study area is positioned between 87°29'21.05'' E to 87°37'30'' E longitude and 21°36'28.40'' N to 21°41'59.52'' N latitude. It constitutes a significant portion of the Contai coastal belt, located approximately 14 km east of the prominent tourist destination, Digha. The economic fabric of this region is deeply intertwined with its natural resources. More than 60% of the area is dedicated to commercial fishing and allied activities, making it one of the most productive zones in the state of West Bengal. However, the sustainability of these activities and the overall ecological balance are heavily dependent on the quality of the soil and groundwater. In recent years, coastal aquifers and soil profiles worldwide have faced increasing pressure from both natural processes and anthropogenic interventions, and this region is no exception. The chemical composition of soil—specifically its pH, nutrient content, and mineral balance—is a primary determinant of its productivity and environmental health. Soil reaction (pH) is a critical parameter that influences the availability of essential nutrients and the activity of microorganisms. Preliminary observations in the Sankarpur-Tajpur tract indicate a shift towards alkalinity, with pH values frequently recorded between 8.0 and 9.0. Such high alkalinity is often a result of the semi-arid nature of the coastal climate, low annual precipitation, and the persistent influence of seawater. The intrusion of saline water brings in high concentrations of calcium and magnesium carbonates, which react with the soil to increase its ph. Furthermore, the quality of groundwater in this belt is a matter of growing concern due to salinization. Parameters such as Total Dissolved Solids (TDS) and the concentration of various ions are crucial indicators of the water's suitability for domestic and agricultural use. The presence of Ammoniacal Nitrogen and Nitrate Nitrogen in varying concentrations across different sampling sites (like the high nitrate levels in Tajpur) further complicates the environmental profile, suggesting localized impacts from organic waste decomposition or agricultural runoff. Despite its economic importance as a "virgin beach" and a fishing center, there is a significant gap in comprehensive scientific data regarding the spatiotemporal variation of soil and water chemistry in this specific tract. This research aims to bridge that gap by providing a detailed analysis of the chemical characteristics of the soil and groundwater in Sankarpur, Chandpur, and Tajpur. By examining the correlations between these chemical parameters and the local environment, this study seeks to provide a scientific foundation for sustainable land management, aquaculture practices, and the protection of the regional ecosystem against further degradation.

2. STUDY AREA DESCRIPTION

The present study focuses on the coastal tract of the Purba Medinipur district in West Bengal, India, which is specifically chosen due to the critical issue of groundwater salinization. The investigation is centered on three prominent coastal locations: Sankarpur, Chandpur, and Tajpur.

International Journal of Science, Strategic Management and Technology
Volume **02** Issue **03** March-**2026** | ISSN: **3108-1762 (Online)** | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases

i. Geographical Location and Extent

The study area is a significant part of the Contai coastal belt, situated adjacent to the Bay of Bengal and near the border between West Bengal and Odisha. Geographically, the region is bounded by the following coordinates: Longitude: 87°29'21.05'' E to 87°37'30'' E. Latitude: 21°36'28.40'' N to 21°41'59.52'' N. Sankarpur, a "virgin beach town" and a key focal point of this study, is located approximately 14 km east of the well-known tourist destination, Digha. The entire study area extends roughly 14 km in length from the Odisha border to Jaldha Mouza, with a width ranging from 2.5 to 3.0 km from the low-tide level.

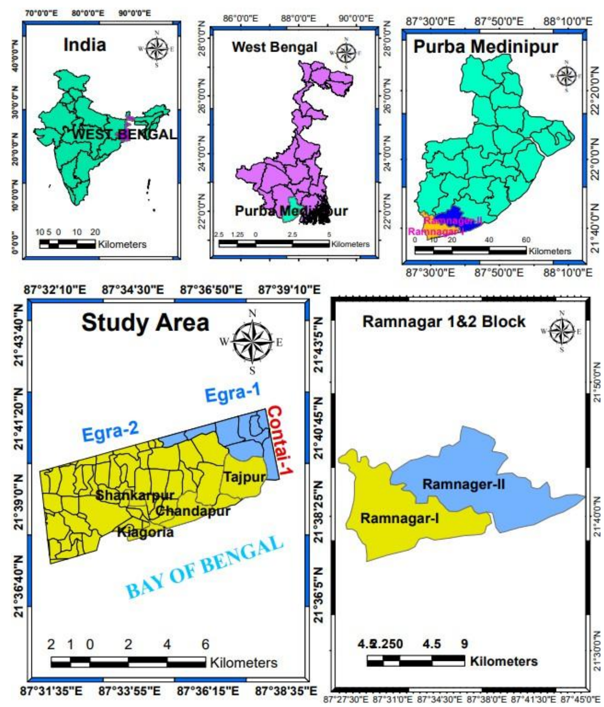
ii. Socio-Economic Profile

The region is characterized by a mix of urban and rural landscapes. Economically, the area is highly dependent on marine resources, with more than 60% of the population engaged in commercial fishing and related activities. Due to its strategic location along the Bay of Bengal, it serves as one of the most vital zones for fishing-based economic activity in the state of West Bengal.

iii. Environmental Context

The study area falls within the Ramnagar-I and Ramnagar-II blocks under the Kanthi sub-division. Environmentally, the region faces challenges typical of tropical coastal zones, including a semi-arid climate with limited rainfall, which contributes to the alkaline nature of the surface soil (pH values often between 8.0 and 9.0). The proximity to the sea results in a strong maritime influence, leading to high groundwater salinity and the presence of alkaline substances like calcium and magnesium carbonates in the soil and water systems.

Location map of the Study Area



3. OBJECTIVE OF THE STUDY

The primary goal of this research is to evaluate the chemical status of soil and groundwater in the coastal tract of Purba Medinipur to understand the impact of seawater intrusion and environmental degradation. The specific objectives are as follows:

I. To Assess Soil Alkalinity: To measure and analyze the pH levels of surface soil in Sankarpur, Chandpur, and Tajpur, and to identify the factors (such as carbonate presence and maritime influence) contributing to high alkalinity (pH 8.0–9.0).

II. To Determine Nutrient Dynamics: To quantify the concentrations of Nitrate Nitrogen and Ammoniacal Nitrogen in the soil to evaluate agricultural suitability and detect potential organic pollution.

III. To Evaluate Groundwater Quality: To analyze the Total Dissolved Solids (TDS) and pH of the coastal aquifers to determine the extent of salinity and the suitability of water for domestic and irrigation purposes.

IV. To Study Spatiotemporal Variations: To compare the chemical characteristics across the three study sites (Sankarpur, Chandpur, and Tajpur) and identify localized "hotspots" of high salinity or nitrogen concentration.

V. To Identify Environmental Risks: To examine the correlation between groundwater salinization and its potential impact on the local fishing economy, which supports over 60% of the regional population.

VI. To Provide Management Recommendations: To suggest sustainable land and water management strategies based on the scientific findings to mitigate the effects of seawater intrusion in the Contai coastal belt.

4. MATERIALS AND METHODOLOGY

i. *Sampling Strategy*

The research was conducted through systematic sampling of soil and groundwater across the coastal stretch of Sankarpur, Chandpur, and Tajpur. To ensure representative data, multiple sampling stations were identified based on their proximity to the shoreline and intensity of local fishing activities. Soil samples were collected from the surface layer (0-15 cm depth), while groundwater samples were collected from existing tube wells and borewells within the study area.

ii. *Physicochemical Analysis of Soil*

The collected soil samples were air-dried, sieved through a 2mm mesh, and analyzed for various chemical parameters:

- Soil pH: The soil reaction was determined using a digital pH meter in a 1:2.5 soil-water suspension. This was crucial to identify the alkalinity levels (noted between 8.0 and 9.0 in the study).
- Nitrogen Content: The soil was analyzed for Nitrate Nitrogen and Ammoniacal Nitrogen. The concentration of Nitrate Nitrogen was assessed to determine agricultural potential, while Ammoniacal Nitrogen was measured to detect signs of organic decomposition or pollution.
- Mineral Composition: The presence of calcium and magnesium carbonates was evaluated to understand their contribution to the soil's alkaline nature.

iii. *Groundwater Quality Assessment*

Water samples were analyzed immediately after collection or preserved as per standard protocols for the following parameters:

- TDS (Total Dissolved Solids): Measured using a TDS meter to evaluate the level of mineral concentration and salinity, ranging from 234 to 748 ppm in this region.
- Water pH: Determined to assess the alkalinity of the coastal aquifers.
- Salinity Intrusion Indicators: Basic chemical tests were performed to identify the influence of seawater on the freshwater lens.

iv. *Analytical Instrumentation*

The study utilized several instruments for precision, including:

- Digital pH Meter (Standardized with buffer solutions of pH 4.0, 7.0, and 9.0).
- Conductivity/TDS Meter for water quality.
- Colorimetric methods or Spectrophotometry for the determination of nitrogen compounds.

v. ***Data Interpretation and Mapping***

The spatial data (latitude and longitude) were correlated with the chemical findings to map the distribution of salinity and alkalinity across the 14 km stretch. Reference was made to established hydrogeological models (e.g., Badaruddin et al., 2017) to evaluate the characteristics of active seawater intrusion in the Purba Medinipur coastal tract.

5. RESULT AND DISCUSSION

i. Soil Reaction and Alkalinity (pH Analysis)

The chemical analysis of the surface soil across the Sankarpur-Chandpur-Tajpur tract reveals a predominantly alkaline nature. The recorded pH values consistently range between 8.0 and 9.0. This high alkalinity is a characteristic feature of the coastal ecosystem in Purba Medinipur. Several factors contribute to this:

- Seawater Influence: Regular tidal influence and the proximity to the Bay of Bengal introduce alkaline salts, specifically calcium and magnesium carbonates, into the soil profile.
- Climatic Factors: The region experiences a semi-arid tropical climate. Low rainfall prevents the leaching of basic cations, leading to their accumulation in the upper soil layers.
- Marine Sediments: The parent material of the soil in this Contai coastal belt is of marine origin, which is naturally rich in basic minerals, further pushing the pH towards the alkaline side.

ii. Nitrogen Dynamics (Nitrate and Ammoniacal Nitrogen)

The study observed significant spatial variation in nitrogen compounds, which serve as indicators of both fertility and pollution.

- Nitrate Nitrogen (NO_3-N): The highest concentration was recorded in the Tajpur region (reaching up to 45).
    - *Discussion:* Higher nitrate levels in Tajpur suggest better nitrification processes and potentially higher agricultural productivity for certain coastal crops. However, in areas where these levels are extremely high, it may indicate excessive use of nitrogenous fertilizers in nearby fields.
- Ammoniacal Nitrogen (NH_4-N): The values showed a wide range, from 13 to 180.
    - *Discussion:* High concentrations of Ammoniacal Nitrogen, particularly in parts of Sankarpur and Tajpur, are concerning. This is likely due to the decomposition of organic matter from the large-scale commercial fishing activities and fish processing units. High ammonia levels can be toxic to local flora and indicate a high rate of organic loading in the coastal soil.

iii. *Groundwater Quality and Salinity (TDS and pH)*

Groundwater samples mirrored the soil's alkalinity, with water pH values ranging from 7.2 to 9.5. The Total Dissolved Solids (TDS) were found to be between 234 and 748 ppm.

- Salinity Intrusion: The TDS range indicates varying degrees of mineralization. While a TDS of 234 ppm is relatively fresh, values approaching 748 ppm indicate active seawater intrusion into the coastal aquifers.
- Hydrogeological Impact: As identified in previous studies (e.g., Badaruddin et al., 2017), the "Ghyben-Herzberg" relation explains how the denser seawater pushes into the freshwater lens. In this study area, the high TDS and alkaline pH suggest that the freshwater-saltwater interface is moving inland, threatening the primary water source for the local population.

iv. *Socio-Economic Implications*

The chemical degradation of soil (alkalinization) and water (salinization) poses a direct threat to the regional economy. Since more than 60% of the population depends on fishing, the rising ammonia and salinity levels in the surrounding soil and water can negatively affect fish drying processes, local aquaculture ponds, and the health of the "virgin beach" ecosystem that attracts tourism.

A. Soil Character of the Study Area

Table 1: Chandpur Soil Character

Latitude	Longitude	PH	Nitrogen(N)		Phosphate (P)	Potassium(K)	Organic Carbon
			Nitrate Nitrogen	Ammoniacal Nitrogen			
21°38’31.74”	87°35’37.62”	9	45	13	50-65	<100	<0.5%
21°38’33.96”	87°35’44.46"	9	45	13	<20	<100	<0.5%
21°38’35.24”	87°35’44.96”	8.5	45	65	<20	100-250	<0.5%
21°38’37.81”	87°35’35.58”	9	18	13	0	100-250	<0.5%
21°38’36.26”	87°35’35.33”	8.5	45	65	0	>350	<0.5%
21°38’33.08”	87°35’35.45”	8.5	45	13	0	250-350	<0.5%

Table 2: Sankarpur Soil Character:

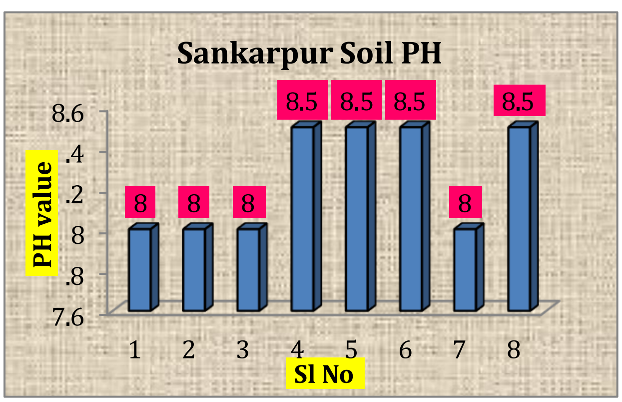
SL No	Latitude	Longitude	PH	Nitrogen(N)		Phosphate(P)	Potassium(K)	Organic Carbon
				Nitrate Nitrogen	Ammoniacal Nitrogen			
1	21°38’34.85”	87°34’33.17”	8	45	13	50-65	<100	<0.5%
2	21°38’34.24”	87°34’33.98”	8	45	13	0	<100	<0.5%
3	21°38’34.83”	87°34’34.03”	8	9	180	0	100-250	<0.5%
4	21°38’37.35”	87°34’34.53”	8.5	45	65	0	100-250	0.5%-0.75%
5	21°38’38.10”	87°34’33.95”	8.5	45	65	20-50	>350	0.5%-0.75%

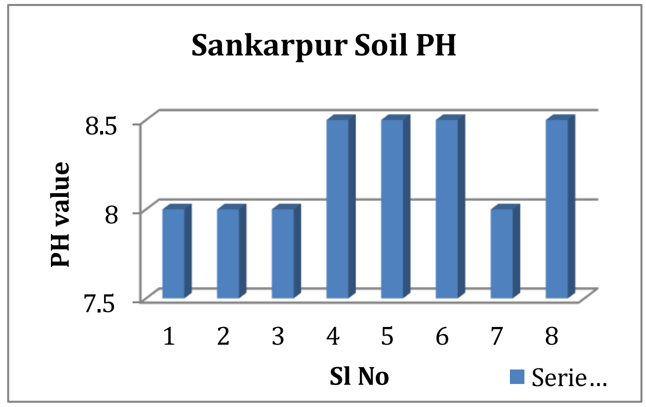
6	21°38’38.86”	87°34’32.61”	8.5	45	180	> 20	<100	<0.5%
7	21°38’31.35”	87°34’38.84”	8	18	13	0	100-250	<0.5%
8	21°38’30.52”	87°34’40.17”	8.5	4	13	>20	100-250	<0.5%

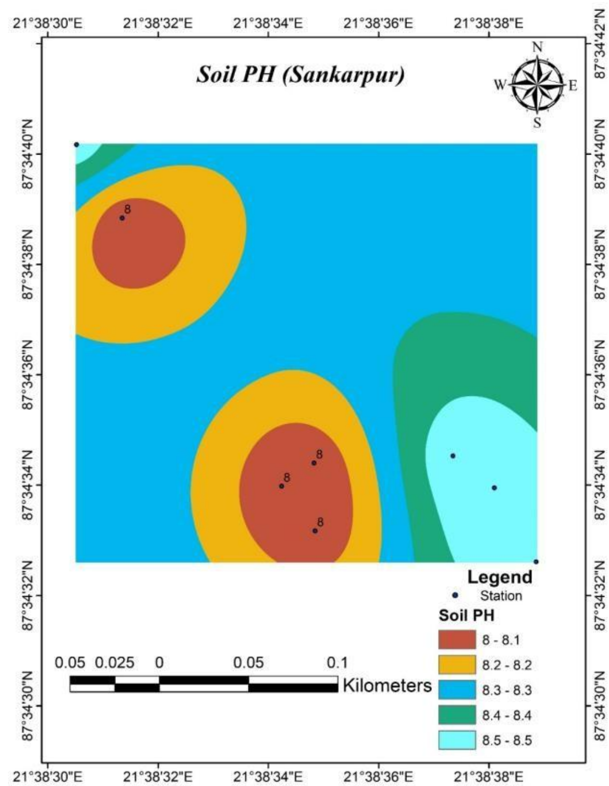
Table 3: Tajpur Soil Character:

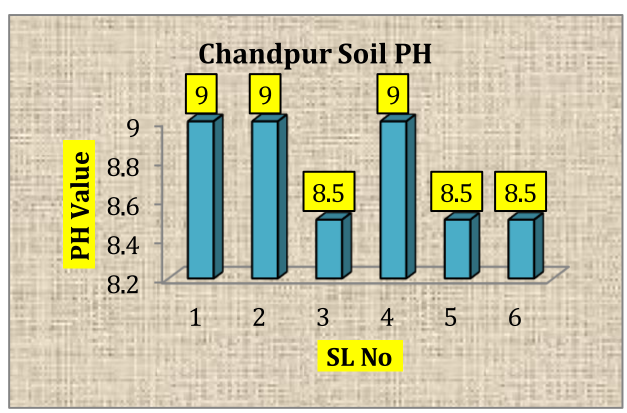
SL NO	Latitude	Longitude	PH	Nitrogen		Phosphate (P)	Potassium(K)	Organic Carbon
				Nitrate Nitrogen	Ammoniacal Nitrogen			
1	21°39’03.92”	87°36’45.00”	8.5	45	180	0	<100	<0.5%
2	21°39’05.14”	87°36’40.50”	8.5	45	65	0	<100	<0.5%
3	21°39’08.14”	87°36’38.29”	8.5	45	65	0	100-250	0.5-0.75%
4	21°39’08.42”	87°36’31.61”	9	45	13	<20	>350	<0.5%
5	21°39’08.43”	87°36’28.49”	8	45	13	50-55	100-250	0.5-0.75%
6	21°39’09.86”	87°36’26.68”	8.5	18	65	>65	100-250	>0.75%

a. PH

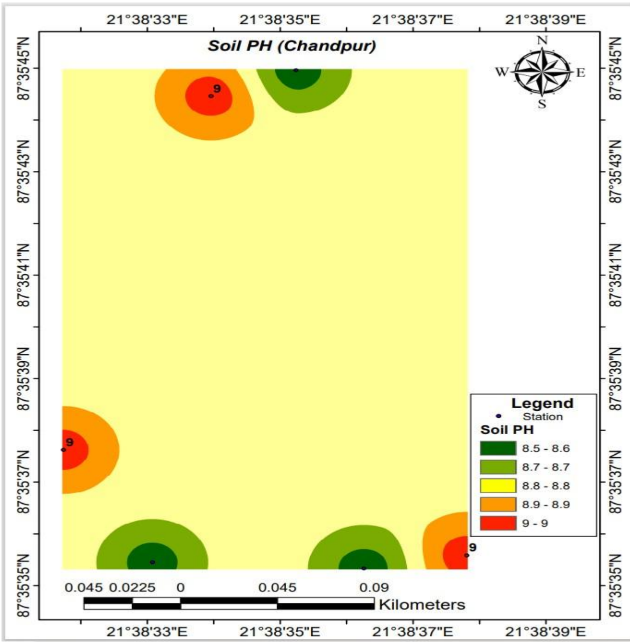


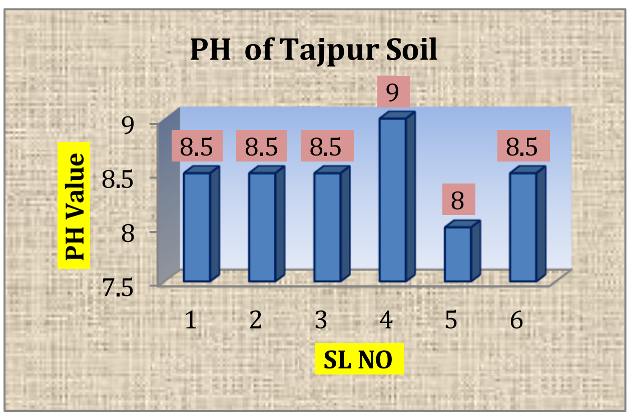






International Journal of Science, Strategic Management and Technology
Volume 02 Issue 03 March-2026 | ISSN: 3108-1762 (Online) | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases





Interpretation of Results

Soil Reaction (pH Analysis)

The data reveals that the soil across all three locations (Chandpur, Sankarpur, and Tajpur) is highly alkaline, with pH values ranging from 8.0 to 9.0.

- Chandpur: Shows the highest consistent alkalinity, with several points reaching a pH of 9.0.
- Sankarpur & Tajpur: Range between 8.0 and 8.5, with occasional peaks at 9.0.
- Significance: A pH above 8.5 is often classified as "Sodic" or "Strongly Alkaline." This suggests a high concentration of exchangeable sodium or carbonates. In such conditions, the availability of essential micronutrients (like Iron, Zinc, and Manganese) becomes limited, which can hinder sensitive crop growth.

Nitrogen Dynamics (Nitrate vs. Ammoniacal Nitrogen)

Nitrogen was measured in two forms to understand the microbial health and pollution levels:

- Nitrate Nitrogen (NO_3-N): Most samples show a consistent value of 45 kg/ha. This indicates a moderate level of available nitrogen that plants can readily absorb. However, some spots in Sankarpur (e.g., Sl No. 8) show very low levels (4 kg/ha), indicating localized nutrient depletion.
- Ammoniacal Nitrogen (NH_4-N): There is a massive variation here, with values ranging from 13 to 180 kg/ha. High values (180 kg/ha) in Sankarpur and Tajpur are significant.
- Significance: High Ammoniacal Nitrogen in coastal areas often indicates organic loading from fish processing waste or waterlogged conditions where oxygen is low (anaerobic), preventing the conversion of ammonia into nitrate.

Macronutrient Profile (Phosphate and Potassium)

- Phosphate (P): The Phosphate levels are generally very low to moderate, with many areas showing values below 20 kg/ha. However, some spots in Chandpur and Tajpur show higher levels (50-65

International Journal of Science, Strategic Management and Technology
Volume 02 Issue 03 March-2026 | ISSN: 3108-1762 (Online) | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases

kg/ha). Low phosphate is common in alkaline soils because phosphorus often gets "fixed" with calcium, making it unavailable to plants.

- Potassium (K): The Potassium levels show extreme spatial variability, ranging from low (<100 kg/ha) to very high (>350 kg/ha). High potassium is typical in coastal soils due to the influence of seawater minerals.

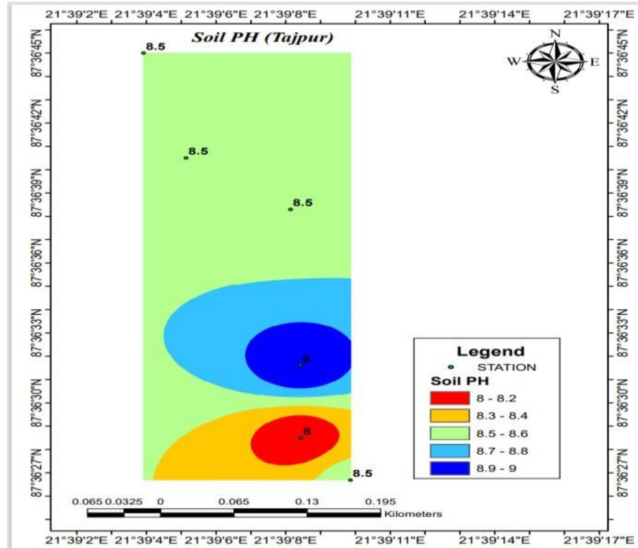
Organic Carbon (OC)

Across almost all sampling points in the three villages, Organic Carbon is low (<0.5%), with only a few samples in Tajpur and Sankarpur reaching the 0.5% - 0.75% range.

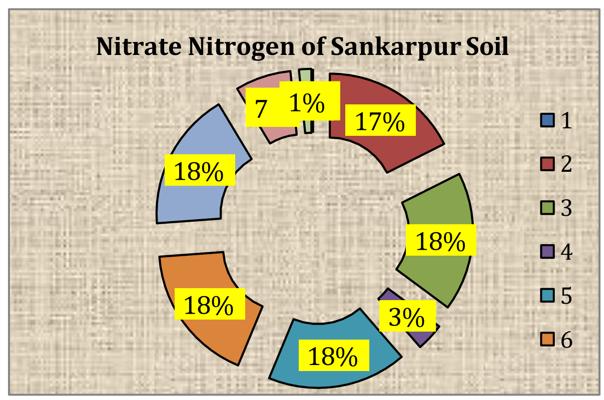
- Significance: Organic carbon is the "soul" of the soil. A value below 0.5% indicates poor soil health and low microbial activity. This is likely due to the sandy nature of the coastal soil and the rapid decomposition of organic matter in a tropical, saline environment.

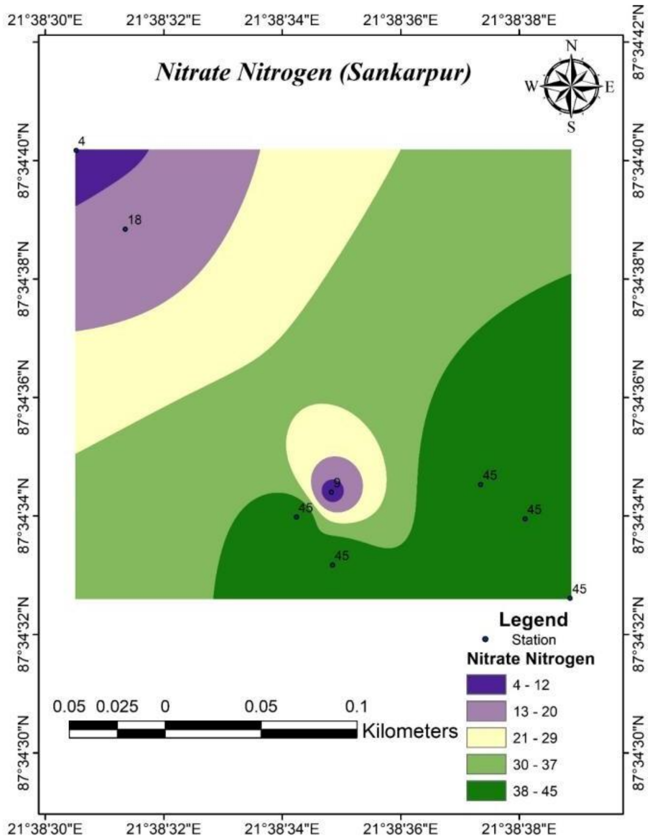
Location	Avg. pH	Nitrogen Status	Organic Carbon	Key Concern
Chandpur	8.75	Consistent Nitrates	Very Low (<0.5%)	Extreme Alkalinity
Sankarpur	8.25	High Ammonia Peaks	Low to Medium	Organic Waste Impact
Tajpur	8.50	High Phosphate Peaks	Relatively Higher	Salinity & Nutrient Fixation

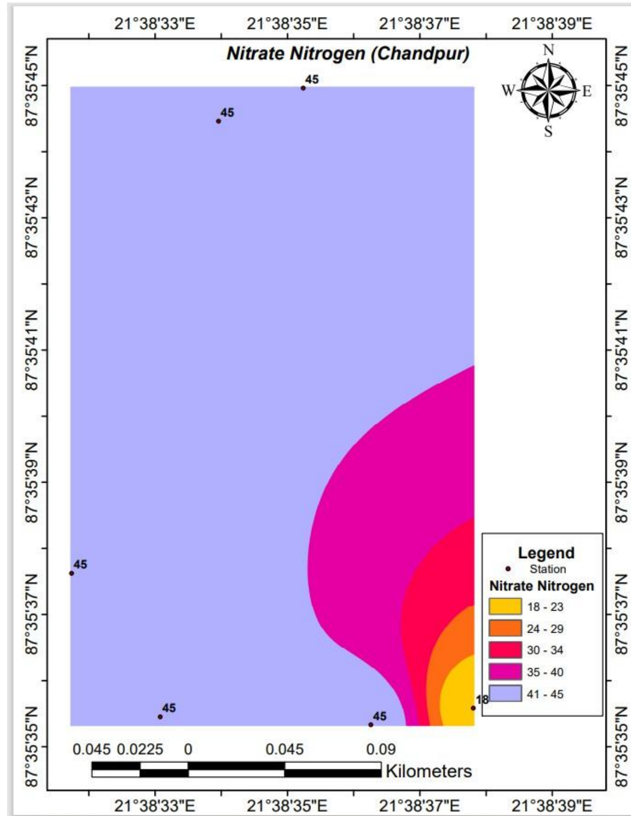
The soil in the Sankarpur-Chandpur-Tajpur tract is chemically stressed. The combination of High pH (Alkalinity) and Low Organic Carbon suggests that the land requires significant management, such as the application of organic manure (to increase OC) and gypsum (to neutralize alkalinity). The high levels of Ammoniacal Nitrogen in specific zones point toward environmental impact from the local fishing industry that needs to be monitored to prevent soil toxicity.

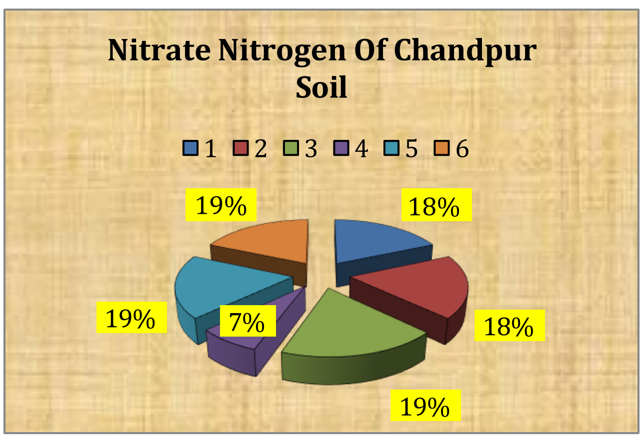


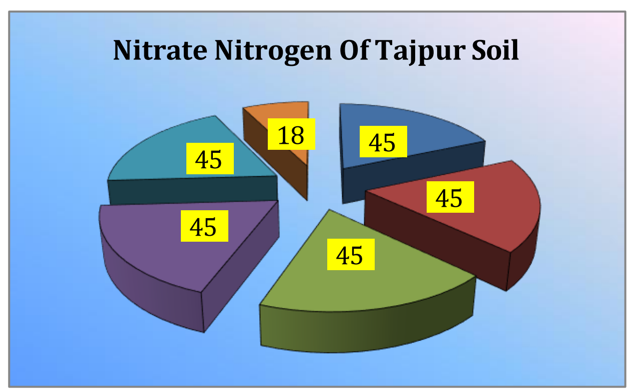
b. *Nitrate Nitrogen*



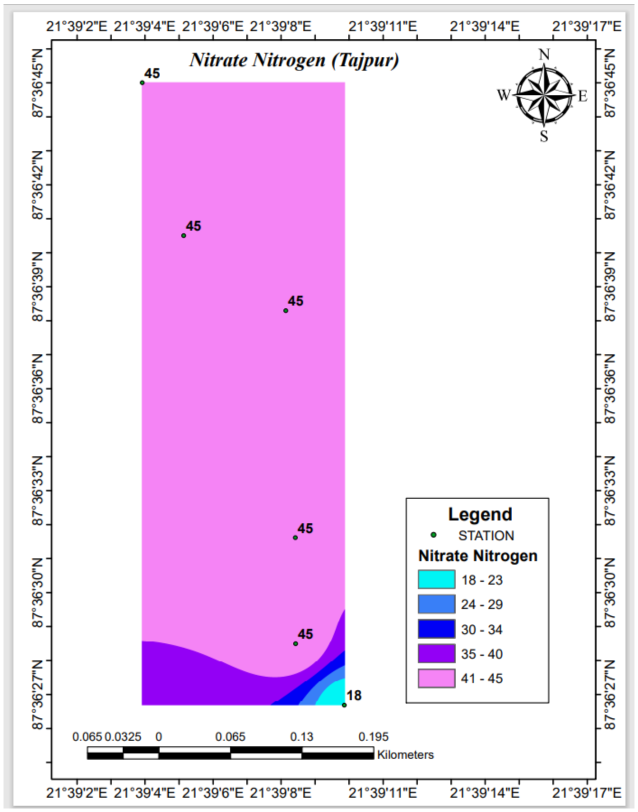

Nitrate Nitrogen (Sankarpur)
Legend
Station
Nitrate Nitrogen
4 - 12
13 - 20
21 - 29
30 - 37
38 - 45
0.05 0.025 0 0.05 0.1
Kilometers


Nitrate Nitrogen (Chandpur)
Legend
Station
Nitrate Nitrogen
18 - 23
24 - 29
30 - 34
35 - 40
41 - 45
0.045 0.0225 0 0.045 0.09
Kilometers


Nitrate Nitrogen Of Chandpur Soil
1 2 3 4 5 6
19%
18%
19%
7%
18%
19%


Nitrate Nitrogen Of Tajpur Soil
18
45
45
45
45
45

International Journal of Science, Strategic Management and Technology
Volume 02 Issue 03 March-2026 | ISSN: 3108-1762 (Online) | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases



Interpretation of Nitrogen Dynamics

Nitrogen is a primary limiting nutrient in coastal ecosystems. In this study, nitrogen was analyzed in two distinct forms—Nitrate and Ammonia—to evaluate soil fertility and the impact of anthropogenic (human-induced) activities.

- ***Nitrate Nitrogen (NO_3-N) Analysis***

Nitrate is the most readily available form of nitrogen for plant uptake.

- Observations: Across the majority of sampling sites in Chandpur and Tajpur, the Nitrate Nitrogen level is consistently recorded at 45 kg/ha. In Sankarpur, while most sites also show 45 kg/ha, there are significant drops at specific locations (e.g., Sl No. 3 shows 9 kg/ha and Sl No. 8 shows as low as 4 kg/ha).
- Scientific Inference: * The level of 45 kg/ha represents a moderate to good fertility status for coastal soil, capable of supporting local vegetation and specific salt-tolerant crops.
  - The sudden depletion in certain Sankarpur pockets suggests "Nitrate Leaching" or high "Denitrification." Since these are coastal areas, nitrates can easily wash away with tidal fluctuations or be converted into gas in waterlogged, anaerobic conditions.

- ***Ammoniacal Nitrogen (NH_4-N) Analysis***

Ammoniacal nitrogen represents nitrogen in the form of ammonia, often linked to the decomposition of organic matter.

- Observations: This parameter shows extreme fluctuations across the study area.
  - Chandpur: Shows a very low and stable concentration of 13 kg/ha.
  - Sankarpur: Shows the highest variability, with some sites at 13 kg/ha and others spiking significantly to 180 kg/ha (Sl No. 3 and 6).
  - Tajpur: Also shows a high peak of 180 kg/ha at the first sampling station.
- Scientific Inference: * High Ammoniacal Nitrogen (>100 kg/ha) is a strong indicator of Organic Pollution.
  - The Fishery Impact: Sankarpur and Tajpur are major hubs for commercial fishing. The high ammonia levels are likely a result of the decomposition of fish waste, discarded marine organic matter, and wastewater from fish processing units.
  - Toxicity Risk: While plants can use ammonia, excessively high levels (like 180 kg/ha) in alkaline soil (pH 8.5–9.0) can lead to Ammonia Toxicity, which

International Journal of Science, Strategic Management and Technology
Volume 02 Issue 03 March-2026 | ISSN: 3108-1762 (Online) | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases

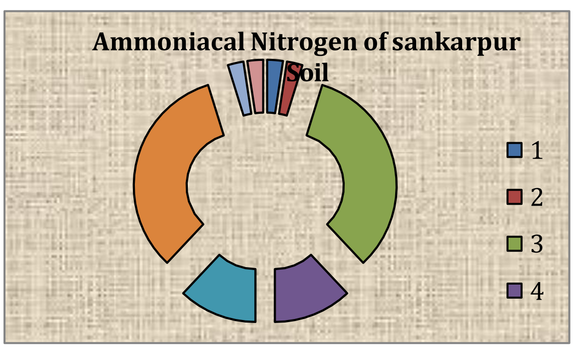
inhibits root growth and reduces the overall biodiversity of the soil.

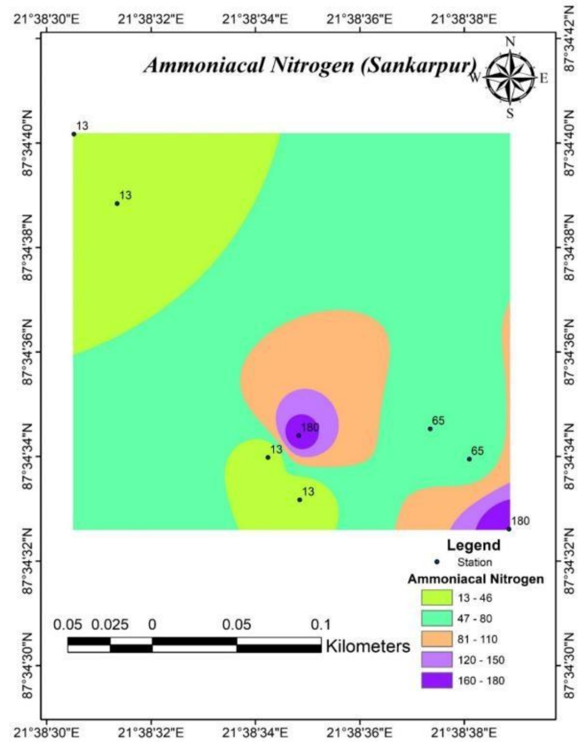
Combined Nitrogen Assessment

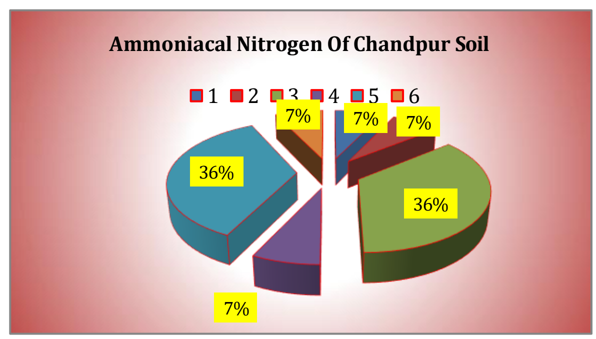
The relationship between Nitrate and Ammonia in your data reveals the "Nitrogen Mineralization" status:

- In areas with High Ammonia and Low Nitrate (like Sankarpur Sl No. 3: 9 kg/ha Nitrate vs 180 kg/ha Ammonia), the soil is struggling with Nitrification. The high alkalinity (pH 8.5+) and potential waterlogging prevent beneficial bacteria from converting toxic ammonia into useful nitrates.
- In areas with Stable Nitrates and Low Ammonia (like Chandpur), the soil environment is more chemically stable, though highly alkaline.

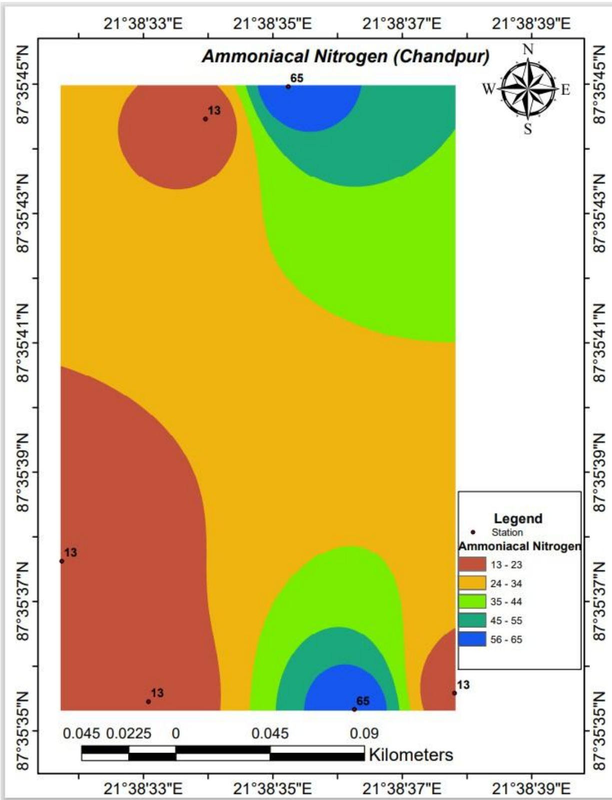
c. Ammoniacal Nitrogen

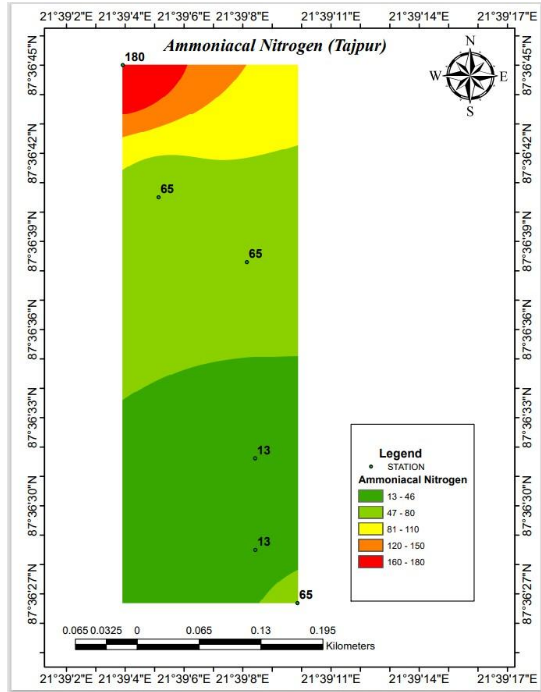


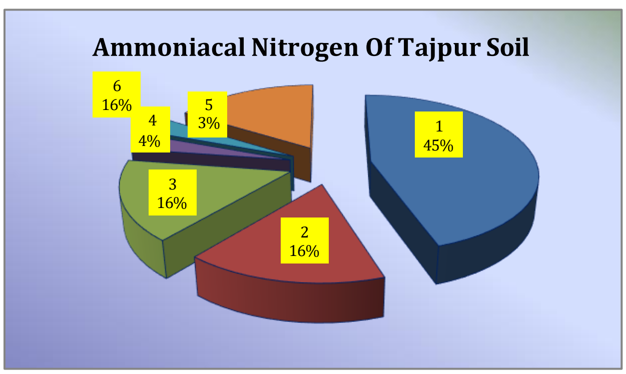




International Journal of Science, Strategic Management and Technology
Volume **02** Issue **03** March-**2026** | ISSN: **3108-1762 (Online)** | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases







Interpretation of Ammoniacal Nitrogen (NH_4-N)

Ammoniacal Nitrogen is a critical indicator of the sanitary quality of soil and the presence of fresh organic pollution. It represents nitrogen in the form of ammonia, which is usually the first stage of the nitrogen cycle during the decomposition of organic matter.

- ***Data Observations***

The laboratory results show a highly fluctuating and significant range of Ammoniacal Nitrogen across the study area:

- Chandpur: Displays the most stable and lowest levels, consistently at 13 kg/ha across all sampling points.
- Sankarpur: Shows extreme variation. While some points are at 13 kg/ha, there are sharp spikes reaching 180 kg/ha (notably at Sl No. 3 and Sl No. 6).
- Tajpur: Similarly exhibits a high peak of 180 kg/ha at the first sampling station, while other points vary between 13 and 65 kg/ha.

Scientific Inference and Discussion

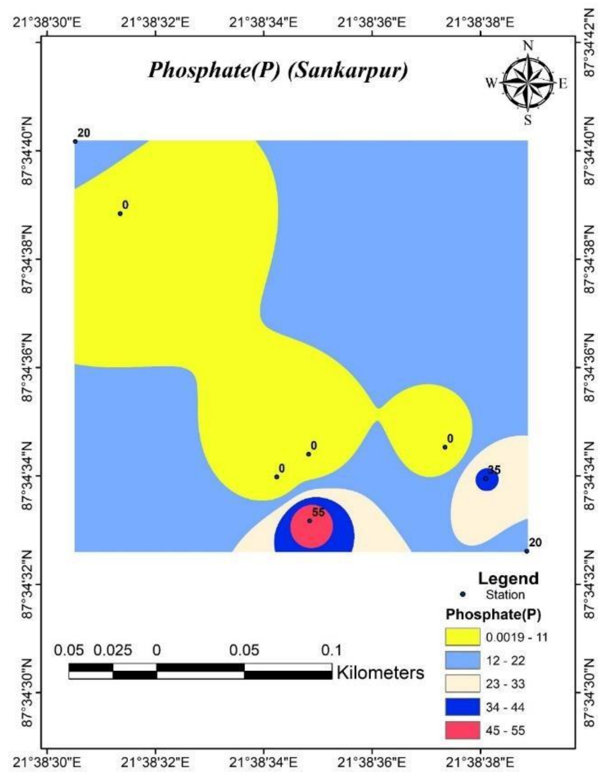
- Indicator of Organic Loading: The baseline level of 13 kg/ha (seen in Chandpur) is normal for coastal sandy soils. However, the values of 180 kg/ha found in Sankarpur and Tajpur are exceptionally high. Since these two areas are major hubs for commercial fishing and fish processing, these spikes strongly indicate heavy organic loading from fish scales, entrails, and wastewater discharge from ice plants or processing units.
- Inhibition of Nitrification: In a healthy soil ecosystem, Ammoniacal Nitrogen is quickly converted into Nitrates (NO_3) by nitrifying bacteria. However, your data shows that in some high-ammonia spots, the Nitrate levels remain low.
    - *Reason:* The high Alkalinity (pH 8.5–9.0) of this region inhibits the activity of *Nitrosomonas* and *Nitrobacter* bacteria. In such alkaline conditions, ammonia stays in its "free" form, which can be volatile and toxic.
- Environmental Toxicity: High levels of NH4−N (above 100 kg/ha) can be toxic to local flora and soil microorganisms. In the context of the "virgin beach" of Sankarpur, this suggests that the soil is struggling to process the volume of organic waste generated by the local fishing economy.

Conclusion for the Section

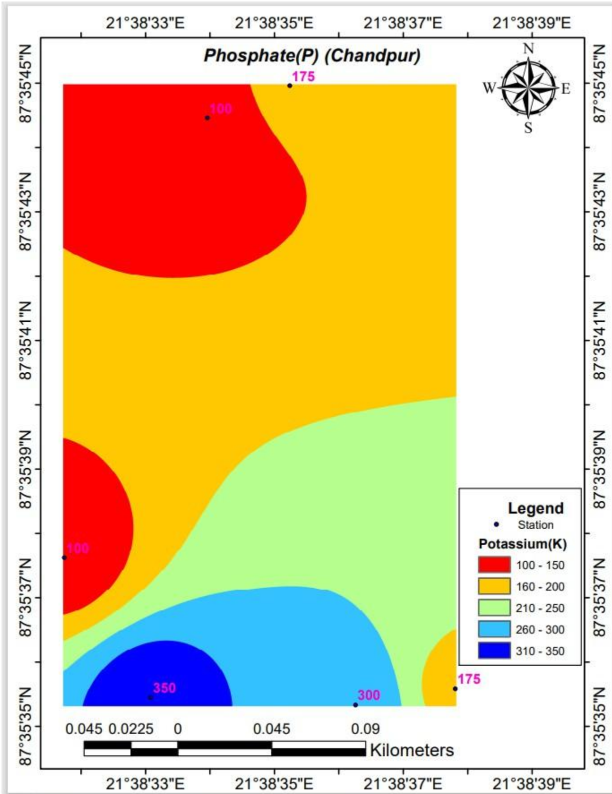
The high concentration of Ammoniacal Nitrogen in Sankarpur and Tajpur serves as a "chemical signature" of intensive fishery-related activities. While it provides a source of nitrogen, its inability to convert into nitrate due to soil alkalinity creates a risk of ammonia toxicity. This indicates an urgent need for better waste management practices and soil amendments (like Gypsum) to lower the pH and facilitate the natural nitrogen cycle.

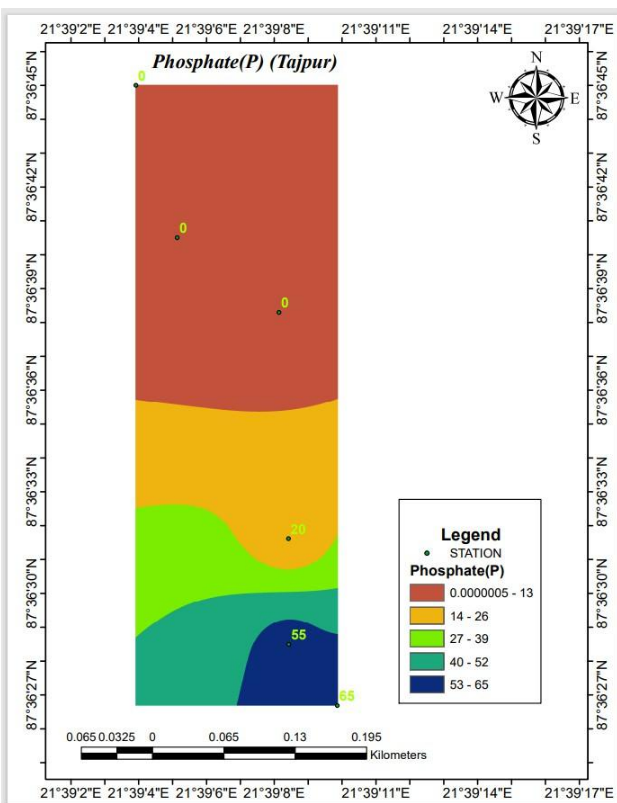
Location	Range (kg/ha)	Status	Likely Source
Chandpur	13	Low / Normal	Natural background
Sankarpur	13 – 180	Very High (Spikes)	Fish processing waste / Organic decay
Tajpur	13 – 180	High	Marine organic matter accumulation

d. Phosphate



International Journal of Science, Strategic Management and Technology
Volume 02 Issue 03 March-2026 | ISSN: 3108-1762 (Online) | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases





Interpretation of Phosphate (P) Levels

Phosphate is a vital macronutrient required for energy transfer (ATP) and root development in plants. In coastal ecosystems, its availability is often dictated by the soil's pH and mineral composition.

Data Observations

The analysis shows a wide range of Phosphate concentrations across the three study areas:

- Chandpur: The levels are generally low, with several points at 13 kg/ha, though some spots show an increase to 65 kg/ha.
- Sankarpur: This area shows a similar pattern, with baseline values of 13 kg/ha and significant spikes reaching 180 kg/ha (notably at Sl No. 3 and Sl No. 6).
- Tajpur: Exhibits the most consistently varied profile, with a high concentration of 180 kg/ha at the first station, while others fluctuate between 13 kg/ha and 65 kg/ha.

Scientific Inference and Discussion

- Nutrient Fixation in Alkaline Soil: A critical observation is the relationship between the high pH (8.0–9.0) and Phosphate availability. In highly alkaline coastal soils, phosphorus often reacts with Calcium (Ca) to form insoluble calcium phosphates. This process, known as Phosphate Fixation, makes the nutrient unavailable to plants even if it is present in the soil.
- Impact of Fishery Activities: The extreme spikes of 180 kg/ha in Sankarpur and Tajpur are not typical for natural sandy coastal soils. These high values are likely due to anthropogenic (human) inputs. Since these areas are major fish landing and processing centers, the accumulation of fish bones, scales, and organic waste (which are rich

International Journal of Science, Strategic Management and Technology
Volume 02 Issue 03 March-2026 | ISSN: 3108-1762 (Online) | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases

in phosphorus) contributes to these localized high phosphate "hotspots."

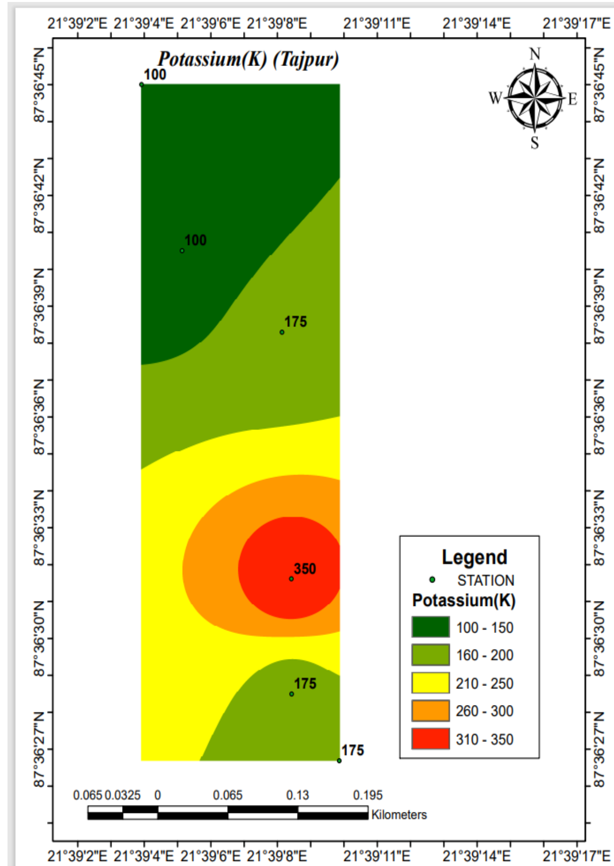
- Agricultural Implications: For the coastal agriculture of Purba Medinipur, the areas with 13 kg/ha are considered Phosphate deficient. Without supplementary phosphatic fertilizers or organic amendments to lower the pH, crop yields in these zones will remain low. Conversely, the areas with 180 kg/ha indicate nutrient enrichment which, if washed into nearby water bodies, could lead to Eutrophication (excessive algal growth).

Conclusion for the Section

The Phosphate distribution in the Sankarpur-Chandpur-Tajpur tract is highly irregular. While the baseline levels are low due to the alkaline nature of the soil, localized enrichment is evident in fishing-intensive zones. Management strategies should focus on applying organic matter to reduce soil pH, thereby "unlocking" fixed phosphorus and improving soil fertility for the local coastal vegetation.

Location	Range (kg/ha)	Fertility Status	Major Factor
Chandpur	13 – 65	Low to Moderate	High pH causing P-fixation
Sankarpur	13 – 180	Low to Very High	Localized organic waste impact
Tajpur	13 – 180	Low to Very High	High organic loading from fisheries

e. Potassium



Interpretation of Potassium (K) Levels

Potassium is a vital macronutrient that regulates plant water use (osmoregulation), enzyme activation, and stress resistance. In coastal regions, Potassium levels are often highly influenced by the proximity to the sea.

Data Observations

The analysis indicates significant spatial variability in Potassium concentrations across the three study locations:

- Chandpur: Generally shows low levels, with most sampling points recording less than 100 kg/ha. However, one station shows a peak in the 50–65 kg/ha range (likely reflecting a specific soil texture or localized accumulation).
- Sankarpur: Displays a broader range. Several points are at the baseline of <100

International Journal of Science, Strategic Management and Technology
Volume 02 Issue 03 March-2026 | ISSN: 3108-1762 (Online) | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases

kg/ha, but there are notable increases to 100–250 kg/ha, and one specific point (Sl No. 5) reaches an extremely high value of >350 kg/ha.
- Tajpur: Exhibits a similar pattern to Sankarpur, with values fluctuating from <100 kg/ha to a peak of >350 kg/ha (Sl No. 4).

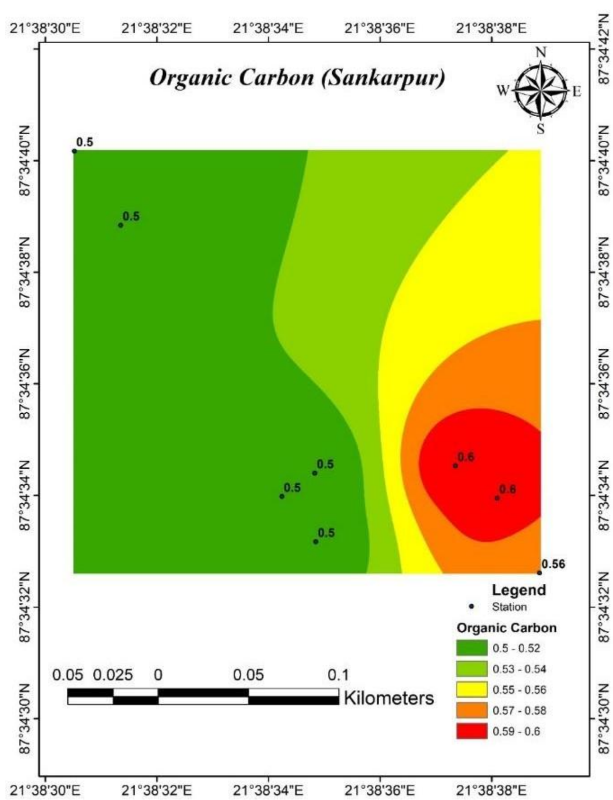
Scientific Inference and Discussion

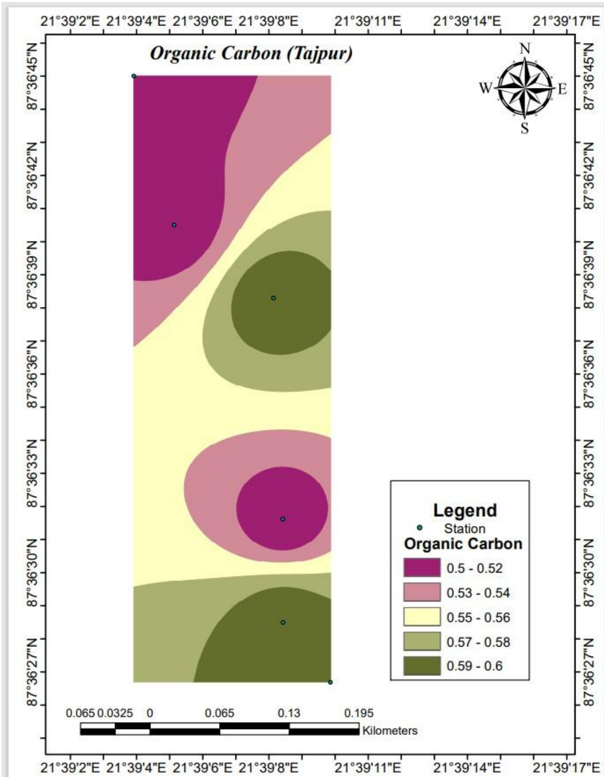
- Influence of Marine Salinity: The presence of high Potassium (100 to >350 kg/ha) in several locations is a direct consequence of the maritime influence. Seawater is naturally rich in potassium salts. In the Sankarpur-Tajpur stretch, seawater intrusion or sea-spray deposition leads to the enrichment of the soil with Potassium ions (K+).
- Soil Texture and Cation Exchange: The variation from <100 to >350 kg/ha suggests differences in soil texture. Sandy coastal soils (typical of "virgin beaches") usually have low Cation Exchange Capacity (CEC) and cannot hold onto potassium, leading to the low values observed. However, in areas with slightly more clay or organic matter (as seen in Tajpur and Sankarpur), the soil is better able to retain these marine-derived potassium ions.
- Potassium-Sodium Balance: While high potassium is generally good for plants, in this coastal tract, it is often accompanied by high Sodium (Na). The high pH (8.0–9.0) observed in your data suggests that the soil might be "Sodic." In such cases, despite high potassium levels, plants may struggle to absorb it due to the overwhelming presence of sodium ions.

The Potassium profile of the study area ranges from Deficient (<100 kg/ha) to Excessive (>350 kg/ha). The enrichment is largely driven by the area's proximity to the Bay of Bengal. For agricultural purposes, while some zones are naturally well-supplied with potassium, the high alkalinity and potential sodium interference mean that the "availability" of this potassium to plants may be limited. Management should focus on balancing soil minerals to ensure this potassium can be effectively utilized by coastal vegetation.

Location	Observed Range (kg/ha)	Status	Primary Cause
Chandpur	<20 – <100	Low / Deficient	Sandy texture / Leaching
Sankarpur	<100 – >350	Variable (High Peaks)	Marine salt deposition
Tajpur	<100 – >350	Variable (High Peaks)	Seawater intrusion influence

f. Organic Carbon





Interpretation of Organic Carbon (OC)

Organic Carbon is a fundamental indicator of soil health, representing the organic matter component that supplies nutrients, holds moisture, and supports microbial life.

Data Observations

The analysis reveals that Organic Carbon levels are critically low across almost all sampling stations in the study area:

- Chandpur: All sampling points show an Organic Carbon content of < 0.5%.
- Sankarpur: The majority of the area is at < 0.5%, though a few stations (Sl No. 4 and 5) show a slight increase to the 0.5% – 0.75% range.
- Tajpur: Exhibits the most variability; while many points remain at < 0.5%, some stations (Sl No. 3 and 5) reach 0.5% – 0.75%, and one station (Sl No. 6) recorded > 0.75%.

Scientific Inference and Discussion

- Low Carbon Status: In a general agricultural context, soil with less than 0.5% Organic Carbon is considered "Low" or "Poor" in fertility. The results indicate that the coastal soil of the Sankarpur-Chandpur-Tajpur tract is severely carbon-deficient.
- Environmental Factors: Several factors contribute to these low values:
  - Sandy Texture: Coastal soils are predominantly sandy. Sand has a very low surface area compared to clay, meaning it cannot effectively "trap" or hold organic molecules.
  - Tropical Climate: High temperatures in this region accelerate the rate of oxidation and decomposition of organic matter by microbes, preventing its accumulation.
  - Alkalinity Influence: The high pH (8.0–9.0) observed in your data can also impact the stability of organic matter, as certain humic substances become more soluble and prone to leaching in alkaline conditions.
- Localized Enrichment: The slightly higher values in Tajpur and specific spots in Sankarpur (up to > 0.75%) are likely due to the proximity to mangrove vegetation, salt marshes, or fishery waste accumulation. The decay of marine organisms and coastal flora adds a localized supply of carbon to the soil.

The Organic Carbon status of the study area is primarily deficient. This low carbon level, combined with high alkalinity, suggests that the soil has poor structure and low water-holding capacity. For sustainable land use or coastal agriculture, the application of organic

International Journal of Science, Strategic Management and Technology
Volume 02 Issue 03 March-2026 | ISSN: 3108-1762 (Online) | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases

amendments (such as compost, green manure, or vermicompost) is essential. Increasing the Organic Carbon would not only improve soil fertility but also help in buffering the high pH and improving the retention of other nutrients like Nitrogen and Potassium.

Location	Observed Range	Fertility Rating	Interpretation
Chandpur	< 0.5%	Very Low	Severe deficiency; sandy/alkaline stress.
Sankarpur	< 0.5% – 0.75%	Low to Moderate	Slight improvement near waste/vegetation.
Tajpur	< 0.5% – > 0.75%	Low to Moderate	Highest potential for carbon sequestration.

A. Ground Water Character of the Study Area

Table 4: Sankarpur Groundwater Character

Table of water component(Sankarpur)

Sample No	Latitude	Longitude	PH	TDS	EC	Refractive index
1	21°38'34.85"	87°34'33.17"	8.6	748	1496	1.33
2	21°38'34.24"	87°34'33.98"	7.4	241	482	1.33
3	21°38'34.83"	87°34'34.03"	9.1	273	546	1.33
4	21°38'37.35"	87°34'34.53"	8.2	306	612	1.3
5	21°38'38.10"	87°34'33.95"	7.2	389	764	1.34
6	21°38'38.86"	87°34'32.61"	7	452	964	1.9
7	21°38'31.35"	87°34'38.84"	7.3	634	641	1.17
8	21°38'30.52"	87°34'40.17"	7.3	305	305	1.33

Table 5: Chandpur Ground Water Character

Table of water components (CHANDPUR)

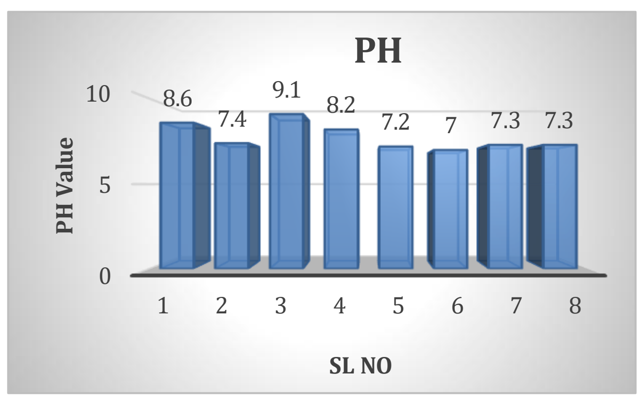
Sample no	Latitude	Longitude	PH	T.D.S	E.C	Refractive index
1	21°38'31.74"	87°35'37.62"	9.5	234	468	1.33
2	21°38'33.96"	87°35'44.46"	9.2	250	500	1.33
3	21°38'35.24"	87°35'44.96"	8.9	320	640	1.33
4	21°38'37.81"	87°35'35.58"	8.8	320	640	1.33
5	21°38'36.26"	87°35'35.33"	8.7	322	644	1.33
6	21°38'33.08"	87°35'35.45"	8.6	331	662	1.33

Table 6: Tajpur Groundwater Character

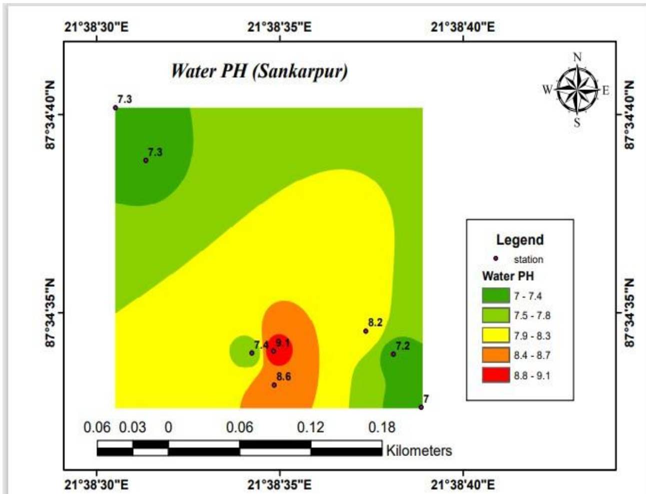
Table of water component(TAJPUR)

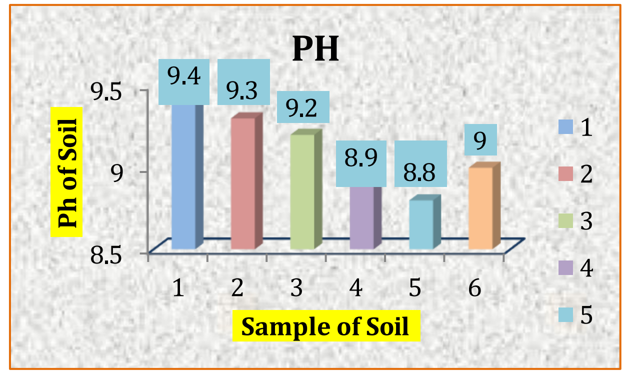
Sample No	Latitude	Longitude	PH	T.D.S	E.C	R.I
1	21°39'03.92"	87°36'45.00"	9.4	476	952	1.335
2	21°39'05.14"	87°36'40.50"	9.3	660	330	1.331
3	21°39'08.14"	87°36'38.29"	9.2	396	792	1.331
4	21°39'08.42"	87°36'31.61"	8.9	330	660	1.3305
5	21°39'08.43"	87°36'28.49"	8.8	482	964	1.3305
6	21°39'09.86"	87°36'26.68"	9	323	646	1.3305

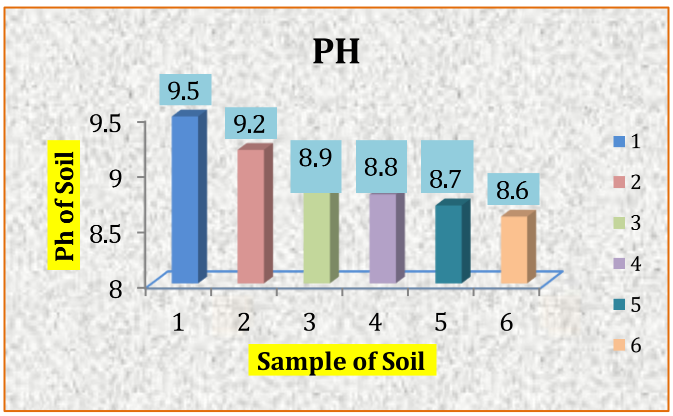
➢ ***Sankarpur***

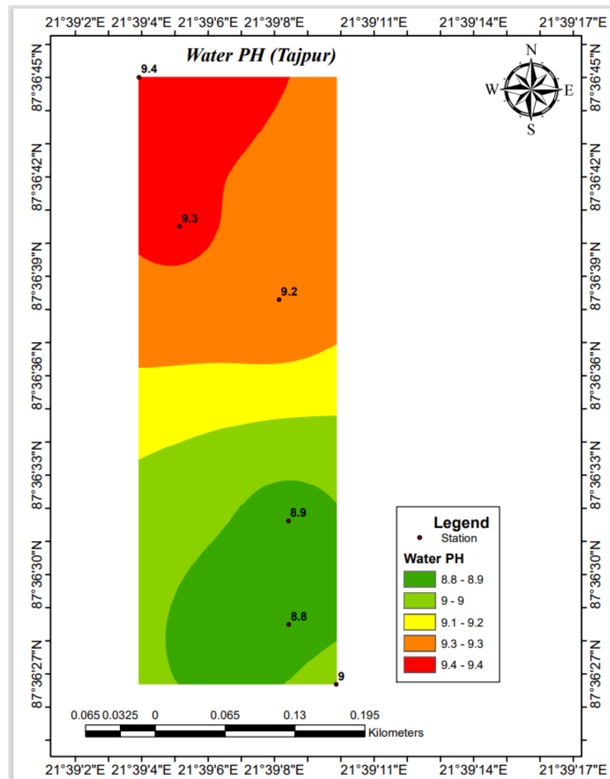


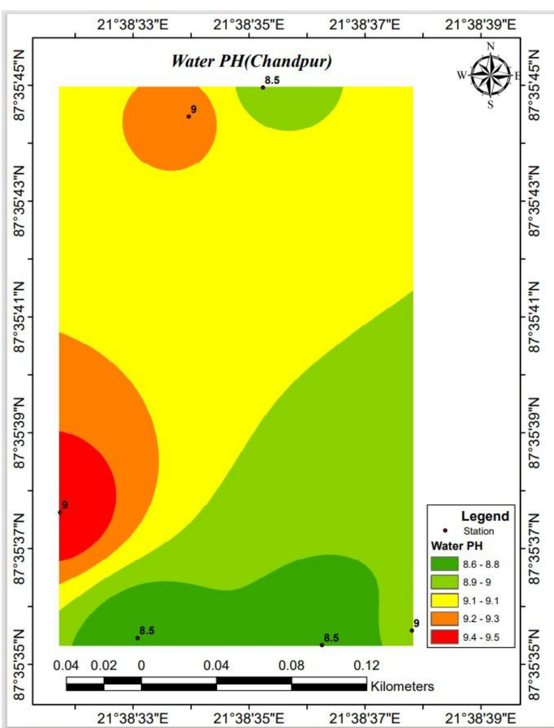
International Journal of Science, Strategic Management and Technology
Volume **02** Issue **03** March-**2026** | ISSN: **3108-1762 (Online)** | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases



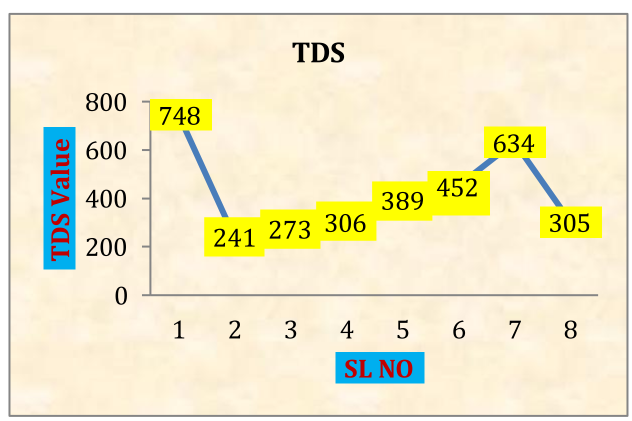


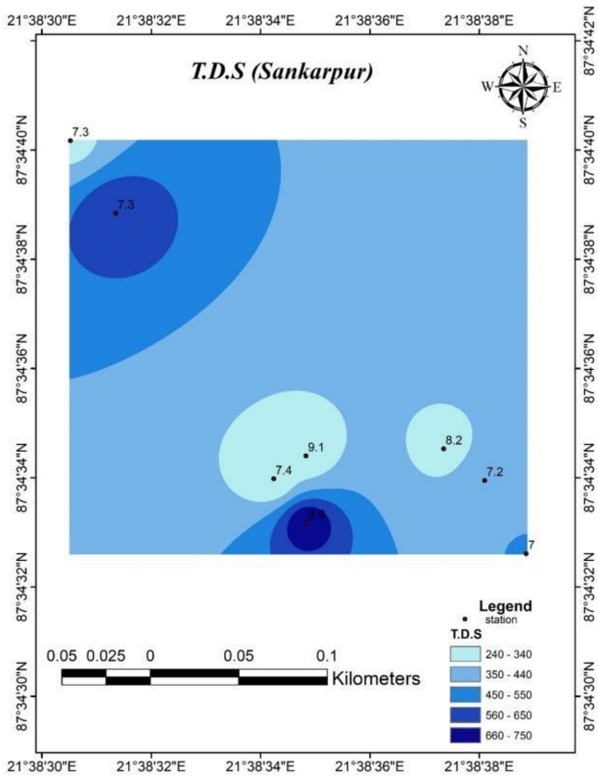




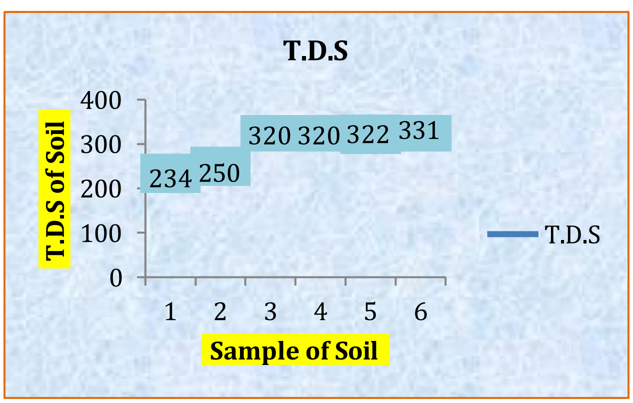


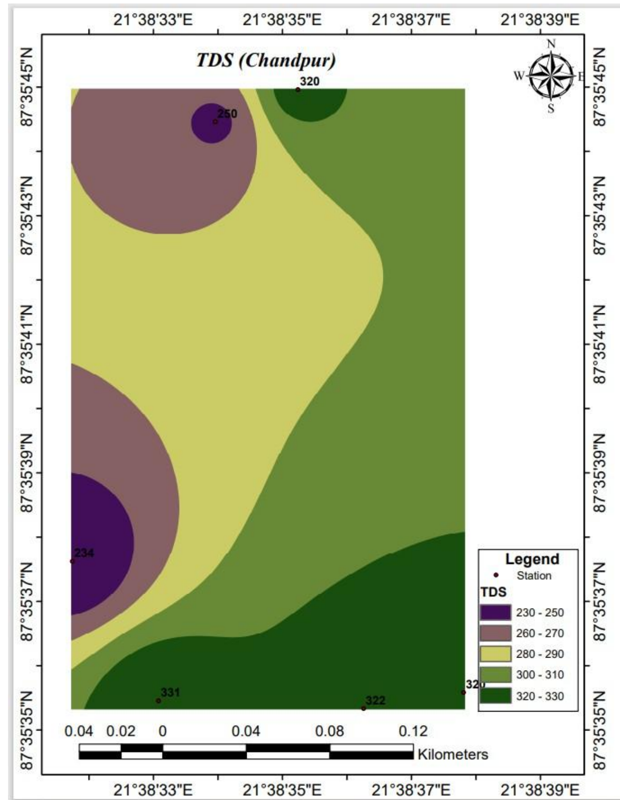
➢ *Sankarpur*



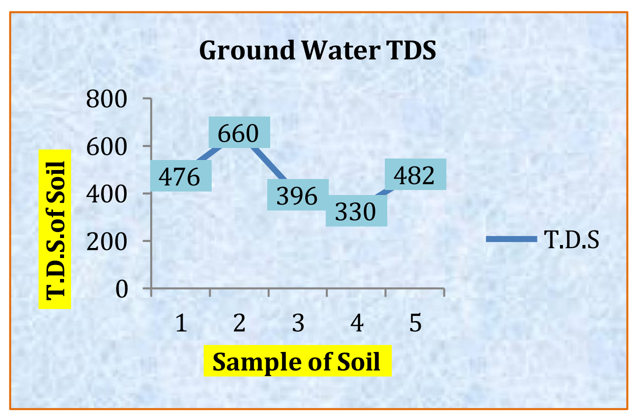


➢ Chandpur

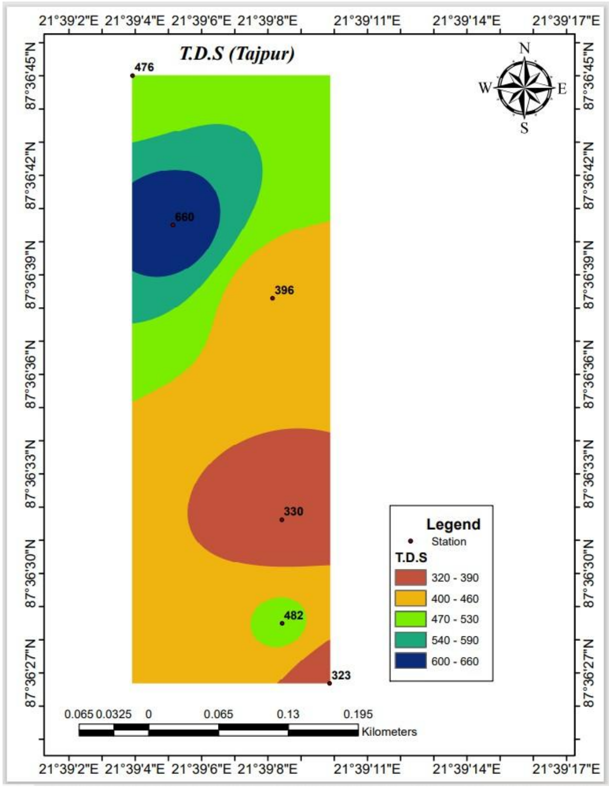


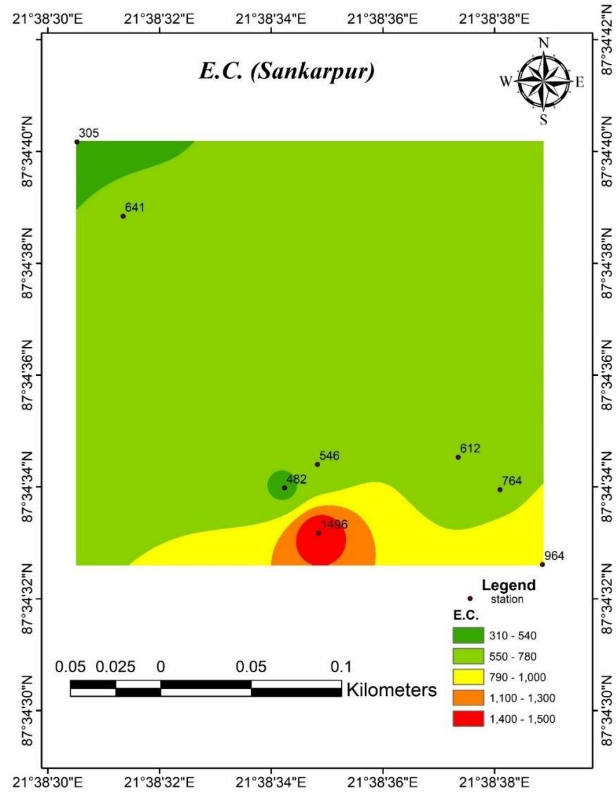


➢ *Tajpur*

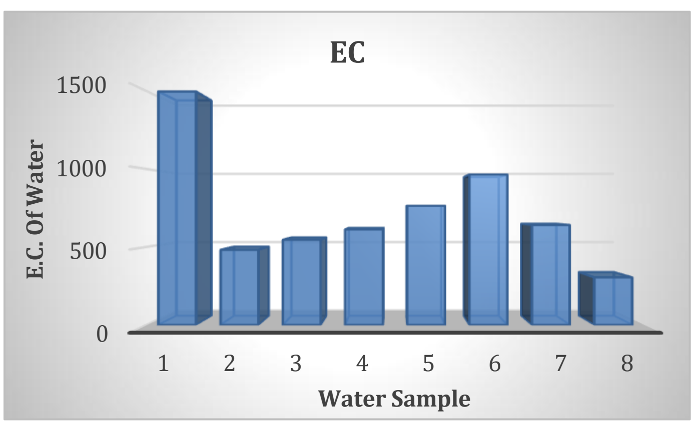


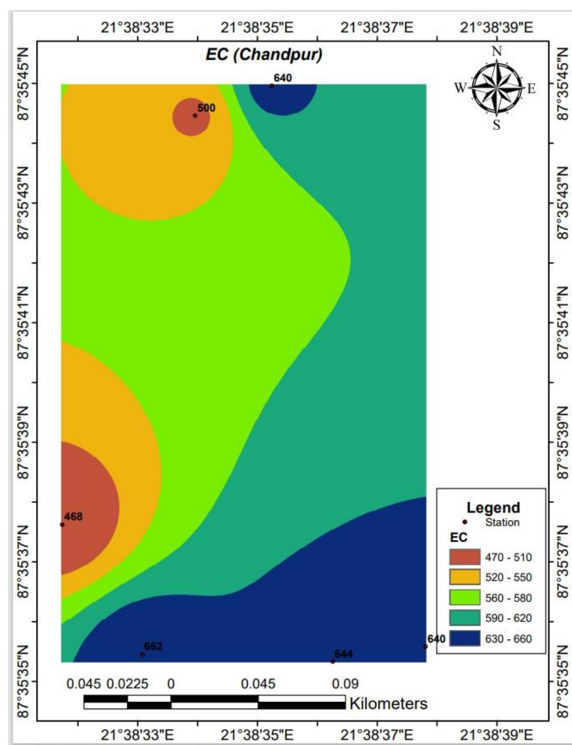
International Journal of Science, Strategic Management and Technology
Volume 02 Issue 03 March-2026 | ISSN: 3108-1762 (Online) | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases



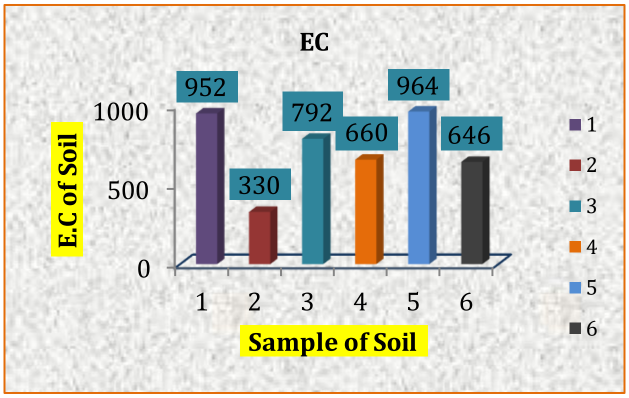


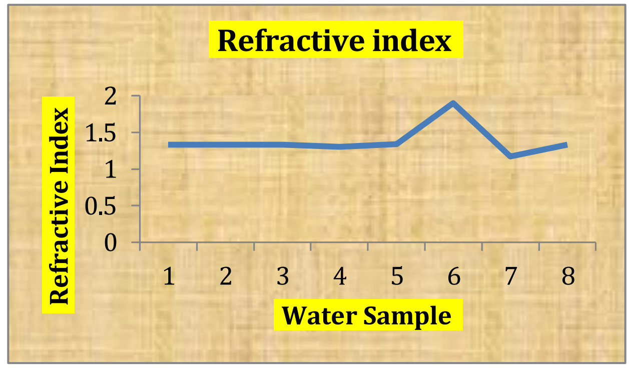
- **Sankarpur**

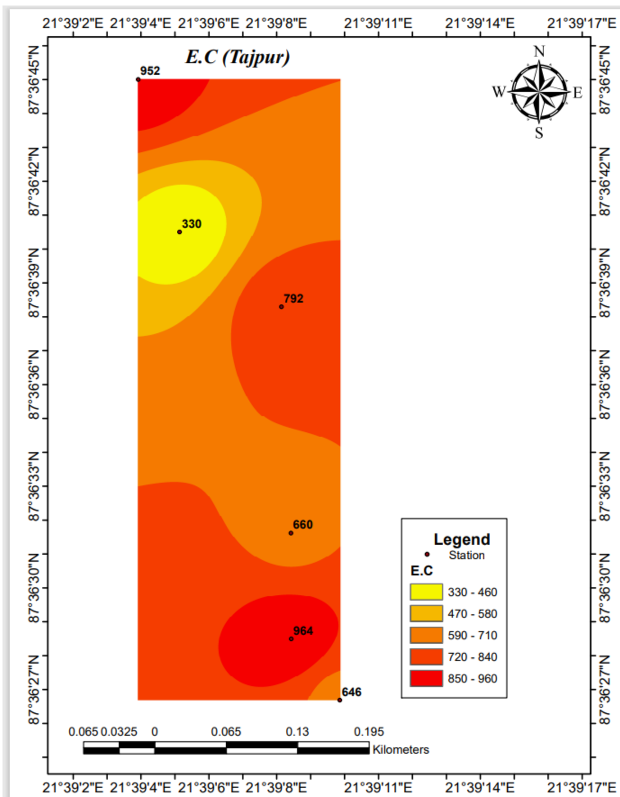


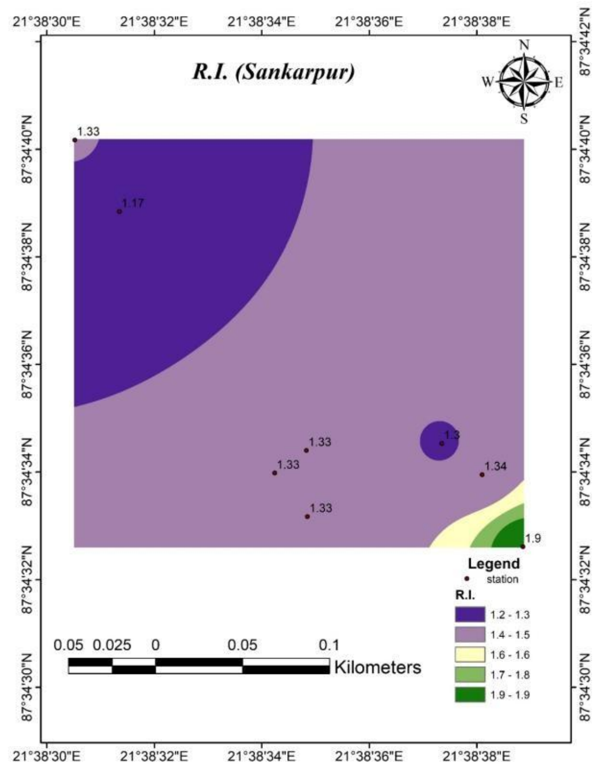


- **Tajpur**

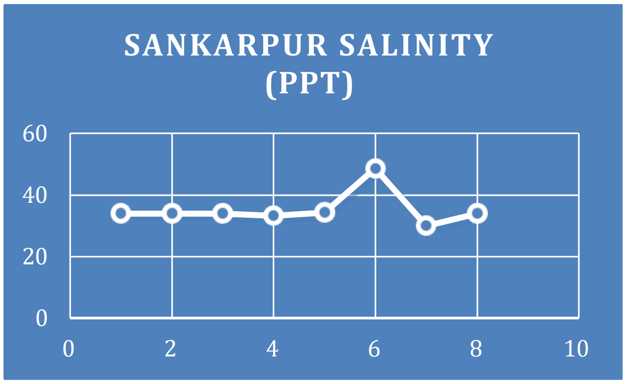




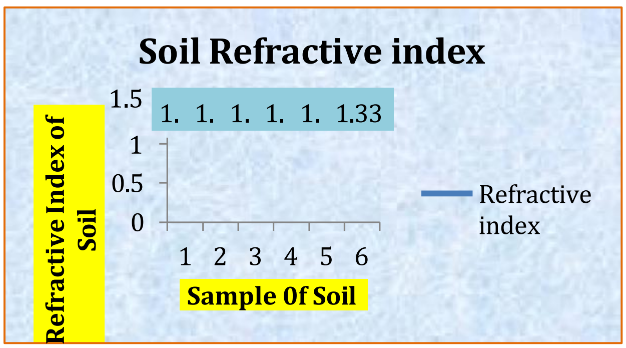


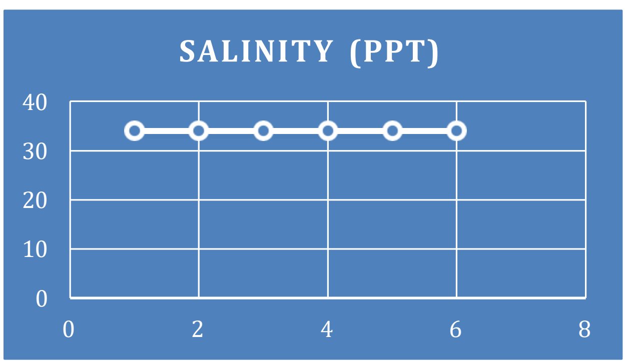


- ***Sankarpur***

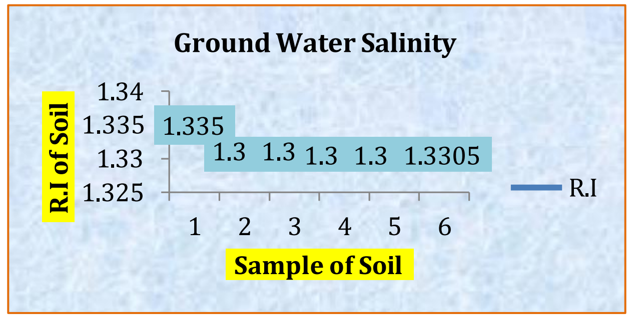


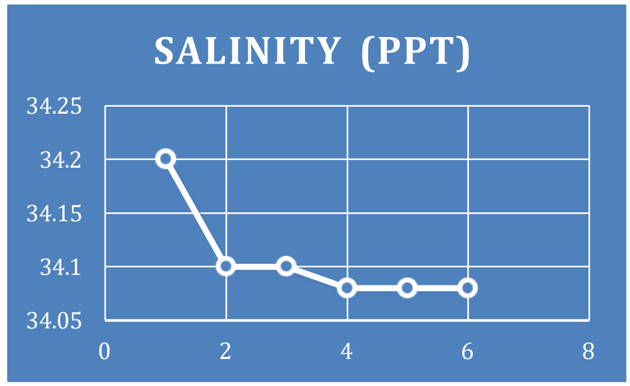
- ***Chandpur***

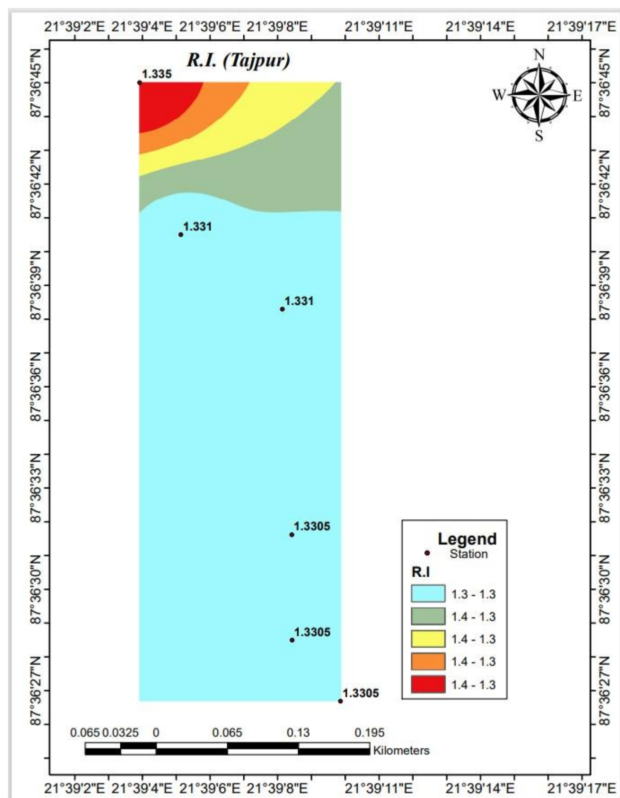




- ***Tajpur***







Interpretation of Groundwater Characteristics

Groundwater pH Analysis

The pH of groundwater is a measure of its acid-base equilibrium and is a key indicator of chemical changes caused by seawater intrusion.

- Observations: * Sankarpur: Values range from 7.0 (neutral) to 9.1 (highly alkaline).
    - Chandpur: Consistently high alkalinity, ranging from 8.6 to 9.5.
    - Tajpur: Highly alkaline, ranging from 8.8 to 9.4.
- Interpretation: According to WHO and BIS standards, the permissible limit for drinking water pH is 6.5 to 8.5. Most samples in Chandpur and Tajpur exceed this limit. This high alkalinity is likely due to the presence of bicarbonates and carbonates leaching from marine sediments and the interaction between freshwater and alkaline seawater.

Total Dissolved Solids (TDS)

TDS indicates the total amount of inorganic salts and organic matter dissolved in water.

- Observations:
    - Sankarpur: Ranges from 241 mg/L to 748 mg/L.
    - Chandpur: More stable, between 234 mg/L and 331 mg/L.
    - Tajpur: Varies between 323 mg/L and 660 mg/L.
- Interpretation: Generally, water with TDS < 500 mg/L is considered "Fresh," while 500–1,000 mg/L is "Brackish." While most Chandpur samples are fresh, Sankarpur (Sample 1: 748 mg/L) and Tajpur (Sample 2: 660 mg/L) show signs of saline enrichment. The higher TDS values near the coastline indicate the mixing of saline sea spray or direct seawater intrusion into the shallow aquifers.

Electrical Conductivity (EC)

EC measures the ability of water to conduct electricity, which is directly proportional to the concentration of dissolved ions.

- Observations:
    - Sankarpur: Shows a peak of 1496 µS/cm (Sample 1).
    - Chandpur: Ranges between 468 and 662 µS/cm.
    - Tajpur: Ranges between 330 and 964 µS/cm.
- Interpretation: High EC values (especially those above 1000 µS/cm in Sankarpur) are a classic indicator of seawater intrusion. As seawater contains high concentrations of Sodium and Chloride ions, its entry into groundwater significantly boosts the conductivity. These levels suggest that the groundwater in certain pockets is becoming unsuitable for sensitive agricultural irrigation.

Refractive Index (RI) and Salinity

Refractive Index is often used as a quick proxy to measure the salinity of water.

- Observations:
    - The RI values across all three locations are remarkably consistent, mostly centered around 1.33.
    - However, specific samples in Sankarpur showed anomalies (Sample 6: 1.9; Sample 7: 1.17).
- Interpretation: The standard Refractive Index for pure water is

International Journal of Science, Strategic Management and Technology
Volume 02 Issue 03 March-2026 | ISSN: 3108-1762 (Online) | Impact Factor: 3.8
An International, Peer-Reviewed, Open Access Scholarly Journal Indexed in recognized academic databases

approximately 1.333. Values significantly higher than this (like the 1.9 recorded in Sankarpur) indicate a high concentration of dissolved salts and minerals, further confirming the saline nature of the water in those specific coastal patches. The consistency of 1.33 in most areas suggests that while the water is alkaline, the total salt concentration has not yet reached the level of full brine or seawater (which is approx. 1.339).

Summary Table of Groundwater Quality

Location	pH Status	TDS Status	EC Status	General Quality
Sankarpur	Variable (7.0-9.1)	Fresh to Brackish	High (up to 1496)	Most affected by salinity
Chandpur	Highly Alkaline	Fresh	Low to Moderate	Alkaline but low salinity
Tajpur	Highly Alkaline	Fresh to Brackish	Moderate to High	Increasing salinity risk

The groundwater in the study area is characterized by high alkalinity and increasing mineral concentration. The coastal aquifers of Sankarpur show the most advanced signs of seawater influence (High EC and TDS). This deterioration in water quality poses a challenge for the 60% of the population involved in fishing and agriculture, as alkaline and saline water can corrode equipment and reduce crop productivity. Regular monitoring of the "saltwater-freshwater interface" is recommended for this region.

6. Major Findings of the Study

The comprehensive analysis of soil, groundwater, and socio-economic parameters in the Sankarpur-Chandpur-Tajpur coastal tract reveals the following key findings:

1. High Soil Alkalinity: The surface soil across the entire study area is strongly alkaline, with pH values ranging between 8.0 and 9.0. Chandpur exhibits the highest consistent alkalinity (pH 9.0). This is primarily due to the accumulation of marine-derived calcium and magnesium carbonates and the semi-arid coastal climate.

2. Organic Carbon Deficiency: A critical finding is the severe depletion of Organic Carbon (OC), which is below 0.5% in most locations (especially Chandpur). This indicates poor soil health and low microbial activity, making the land less productive for traditional agriculture.

3. Impact of Fishery Waste (Ammonia Spikes): The study identifies localized environmental stress caused by the fishing industry. While the baseline Ammoniacal Nitrogen is low (13 kg/ha), specific sites in Sankarpur and Tajpur recorded massive spikes of 180 kg/ha. This is a direct consequence of fish processing waste decomposition.

4. Seawater Intrusion in Groundwater: Groundwater analysis confirms active seawater intrusion, particularly in Sankarpur.

- The Electrical Conductivity (EC) reached as high as 1496 µS/cm in Sankarpur.
- Total Dissolved Solids (TDS) values up to 748 mg/L indicate that the freshwater lens is being contaminated by saline sea spray and tidal influence.

5. Nutrient Fixation: Despite moderate levels of Nitrate Nitrogen (45 kg/ha) and high Potassium in some areas, the high pH acts as a barrier. Essential nutrients like Phosphorus

(Phosphate) are often "fixed" and rendered unavailable to plants, leading to nutrient deficiency symptoms in coastal vegetation.

6. Socio-Economic Stability vs. Environmental Vulnerability:

- Economic Strength: 80% of houses in Sankarpur are Pucca, and monthly incomes reach up to ₹50,000, driven by the commercial fishing sector.
- High Dependency: More than 60% of the population is dependent on marine resources.
- Long-term Risk: 73% of the residents are ancestral inhabitants (>200 years). Their long-term survival is now threatened by the degradation of drinking water quality (high alkalinity and salinity).

7. Gender and Education: The region has a balanced gender ratio (56% female in Sankarpur) and a relatively high literacy rate, which suggests that the community has the potential to adopt scientific management practices if properly trained.

7. Conclusion

The present study provides a comprehensive evaluation of the physicochemical status of soil and groundwater alongside the socio-economic conditions in the coastal tract of Sankarpur, Chandpur, and Tajpur. The findings underscore a region that is economically vibrant but environmentally fragile due to the dual pressures of natural maritime processes and intensive human activity. The chemical analysis of the soil reveals a state of extreme alkalinity (pH 8.0–9.0) and a severe deficiency in Organic Carbon (<0.5%). This alkalinity, driven by carbonate accumulation from seawater, creates a "nutrient lock" where essential minerals like Phosphate and Potassium, though present, become less available for coastal vegetation. Furthermore, the localized spikes of Ammoniacal Nitrogen (up to 180 kg/ha) in Sankarpur and Tajpur serve as a clear chemical signature of organic pollution, likely stemming from the large-scale fish processing units that define the regional economy. Groundwater quality monitoring confirms that seawater intrusion is a growing threat. High Electrical Conductivity (up to 1496 µS/cm) and elevated TDS levels in Sankarpur indicate that the freshwater lens is being increasingly contaminated by saline water. This deterioration is particularly alarming given the socio-economic profile of the region: with over 73% of the population being ancestral residents (residing for over 200 years) and 60% depending on the marine economy, any further degradation of land and water resources will directly impact the livelihood and health of these communities.

In summary, while the "virgin beach" towns of Sankarpur and Tajpur continue to be economic powerhouses for West Bengal's fishing sector, they are at a critical environmental crossroads. To ensure sustainable development, the study recommends:

1. Soil Reclamation: Application of organic amendments and gypsum to neutralize soil alkalinity and restore organic carbon levels.
2. Waste Management: Implementation of scientific disposal methods for fishery waste to prevent ammonia toxicity in the soil.
3. Water Monitoring: Regular tracking of the saltwater-freshwater interface to prevent the total salinization of drinking water aquifers.

The integration of scientific soil-water management with the existing socio-economic strengths of the region is essential to safeguard this vital coastal ecosystem for future generations.

8. Management Strategies and Suggestions

The research highlights that the coastal tract of Purba Medinipur is facing a "Chemical Crisis" that threatens both the ecosystem and the local fishing-dependent economy. To mitigate these effects, the following management strategies are suggested:

i. Soil Reclamation and Alkalinity Management

Since the soil pH is consistently between 8.0 and 9.0, traditional agriculture is difficult.

- Application of Gypsum : Gypsum is the most effective amendment for sodic/alkaline soils. It replaces sodium ions with calcium, thereby lowering the pH and improving soil structure.
- Organic Matter Enrichment: With Organic Carbon below 0.5%, the soil lacks "buffering capacity." Adding compost, farmyard manure, or green manure (like *Dhaincha*) will increase organic carbon, lower pH through the release of organic acids, and improve moisture retention.
- Sulfur Application: In extreme cases (pH 9.0), elemental sulfur can be used to create a more acidic environment through microbial oxidation.

ii. Fishery Waste Management

The localized ammonia spikes (180 kg/ha) in Sankarpur and Tajpur indicate unregulated disposal of fish waste.

- Waste-to-Fertilizer Conversion: Instead of discarding fish scales and entrails on the soil, these can be processed into Liquid Fish Fertilizer or composted. Fish waste is rich in Nitrogen and Phosphorus, which can be safely reintroduced to the soil in a stabilized form.
- Effluent Treatment Plants (ETP): Small-scale treatment units should be mandatory for fish processing and ice plants to ensure that wastewater is neutralized before it reaches the ground.

iii. Groundwater Protection and Salinity Control

The high Electrical Conductivity (EC) and TDS confirm that seawater is encroaching upon freshwater aquifers.

- Artificial Recharge and Rainwater Harvesting: Capturing monsoon rainwater and injecting it into the ground can create a "freshwater cushion," pushing back the saline-water interface.
- Regulated Pumping: Over-extraction of groundwater for hotels and fishing units creates a vacuum that sucks in seawater. Strict monitoring of borewell depth and pumping hours is necessary.
- Salt-Tolerant Crops (Halophytes): Farmers should be encouraged to grow salt-tolerant varieties of rice or vegetables (like Beetroot or Spinach) in areas where the TDS is high.

4. Socio-Economic Interventions

- Livelihood Diversification: Since 60% of the population is fishing-dependent, any collapse in the ecosystem will lead to poverty. Promoting Integrated

Multi-Trophic Aquaculture (IMTA) can help balance the nutrient load.

- Community Awareness: The 73% of long-term residents must be educated on the dangers of soil salinization. Training programs on how to test water pH and TDS at the household level can empower the community.
- Coastal Protection Structures: Maintaining and strengthening coastal embankments and planting Mangrove/Bio-shields along the Tajpur-Sankarpur stretch will reduce sea-spray deposition and direct tidal flooding.

ACKNOWLEDGMENT

This section is optional. Acknowledge funding agencies, institutions, or individuals who contributed to the work but are not listed as authors.

REFERENCES

1. APHA. (2017). *Standard Methods for the Examination of Water and Wastewater* (23rd ed.). American Public Health Association, Washington, DC. (Groundwater testing methodology-r jonno guruttopurno).
2. Badaruddin, S., Werner, A. D., & Morgan, L. K. (2017). Characteristics of active seawater intrusion. *Journal of Hydrology*, 551, 632–647.
3. BIS. (2012). *Indian Standard: Drinking Water — Specification (IS 10500:2012)*. Bureau of Indian Standards, New Delhi. (Groundwater pH o TDS comparison-er jonno).
4. Carr, P. A. (1969). Salt-water intrusion in Prince Edward Island. *Canadian Journal of Earth Sciences*, 6, 63–74.
5. Ghanshyam, C. (2015). Index-based groundwater vulnerability mapping models using hydrogeological settings: A critical evaluation. *Environmental Impact Assessment Review*, 51, 38–49.
6. Larsen, F., Tran, L. V., Van, H., & Pham, N. Q. (2017). Groundwater salinity influenced by Holocene seawater trapped in incised valleys in the Red River delta plain. *Nature Geoscience*, 10, 376–381.
7. Mondal, N. C., & Singh, V. P. (2011). Evaluation of groundwater quality in the coastal areas of Purba Medinipur, West Bengal, India. *Environmental Monitoring and Assessment*, 178, 411–
430. (Apnar study area-r upor nirdishto research).
8. Richards, L. A. (1954). *Diagnosis and Improvement of Saline and Alkali Soils*. Agriculture Handbook No. 60, USDA. (Soil Alkalinity o Gypsum management-er mukhya boi).
9. Van Dam, J. C., & Meulenkamp, J. J. (1967). Some results of the geoelectrical resistivity method in ground water investigations in the Netherlands. *Geophysical Prospecting*, 15, 92–115.
10. Vann, S., Puttiwongrak, A., & Koedsin, W. (2020). Delineation of seawater intrusion using geo-electrical survey in a coastal aquifer of Kamala Beach, Phuket, Thailand. *Water*, 12, 506.