ASSESSMENT OF GROUNDWATER QUALITY FOR IRRIGATION PURPOSES FROM FIVE SHALLOW TUBE WELLS UNDER PMKSY IN NATUN KATAHI AND PURAN KATAHI, ASSAM, INDIA

A Project submitted in
Partial Fulfilment of the Requirement for the Award of the Degree of

MASTERS OF TECHNOLOGY
In
CIVIL ENGINEERING
(With Specialization in Water Resource Engineering)
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By

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DECLARATION

I hereby declare that the work presented in the project report "ASSESSMENT OF GROUNDWATER QUALITY FOR IRRIGATION PURPOSES FROM FIVE SHALLOW TUBE WELLS UNDER PMKSY IN NATUN KATAHI AND PURAN KATAHI, ASSAM, INDIA" in partial fulfillment of the requirement for the award of the degree of "MASTER OF TECHNOLOGY" in Civil Engineering (with specialization in Water Resource Engineering), submitted in the Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati – 13 under Assam Science & Technology University, is a real record of my work carried out in the said college under the supervision of Dr. Utpal Kr. Misra, Professor, Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati – 13.

Do hereby declare that this project report is solemnly done by me and is my effort and that no part of it has been plagiarized without citation.

Date: AMLANJYOTI SARMAH

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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CERTIFICATE

This is the certified that the work presented in the project report entitled "ASSESSMENT OF GROUNDWATER QUALITY FOR IRRIGATION PURPOSES FROM FIVE SHALLOW TUBE WELLS UNDER PMKSY IN NATUN KATAHI AND PURAN KATAHI, ASSAM, INDIA " is submitted by Amlanjyoti Sarmah, Roll No: PG/C/23/21, a student of M.Tech 3rd semester, Department of Civil Engineering, Assam Engineering College, to the Assam Science and Technology University in partial fulfillment of the requirement for award of the degree of Master of Technology in Civil Engineering with Specialization in Water Resources Engineering under my guidance and supervision.

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CERTIFICATE FROM HEAD OF THE DEPARTMENT

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ABSTRACT

This study evaluates the quality and suitability of irrigation water from five shallow tube wells under the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) in the villages of Natun katahi and Puran Katahi, Assam based on the criteria outlined in **IS 11624:2019** (Indian Standard for Irrigation Water Quality). Water samples were collected from five shallow tube wells and analyzed for key parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), sodium adsorption ratio (SAR), residual sodium carbonate (RSC), which are critical for determining the impact of water on soil health and crop productivity. The study was mainly focused on those points which were established under the PMKSY (Pradhan Mantri Krishi Sinchayee Yojana) with an objective to identify the efficiency of this scheme in this region. Water samples were collected and tested focusing mainly on the Rabi season. Seasonal variations in water quality were also assessed comparing the results from this study with the results from pre-monsoon season conducted by Central Ground Water Board.

Keywords: *Irrigation, water quality, shallow tube wells, soil health.*

LIST OF FIGURES

LIST OF TABLES

CONTENTS

CHAPTER 1

INTRODUCTION

1.1 GENERAL:

Water is an indispensable resource for agricultural production, playing a vital role in sustaining the livelihood of millions, particularly in agrarian economies such as India. With over 70% of the population dependent on agriculture, efficient irrigation practices have become a cornerstone for ensuring food security. In regions where rainfall is irregular and unpredictable, supplemental irrigation is critical to maintaining agricultural productivity. In such scenarios, shallow tube wells serve as one of the most important irrigation systems, especially in areas where access to large-scale canal irrigation is limited.

Irrigation water quality is determined by a variety of parameters, such as pH, electrical conductivity (EC), total dissolved solids (TDS), sodium adsorption ratio (SAR), residual sodium carbonate (RSC), bicarbonates, Permeability index (PI), Magnesium Ratio (MR) etc.. These parameters collectively influence the impact of irrigation water on soil properties, crop growth, and overall agricultural productivity. Indian standard for irrigation water quality (IS 11624:2019) was incorporated in this study for evaluating irrigation water quality. Regular assessment and monitoring of these parameters are essential to mitigate the potential risks posed by poor-quality irrigation water, particularly in regions that heavily depend on shallow tube wells.

This thesis focuses on assessing the irrigation water quality of shallow tube wells in the Chhaygaon Sub-Division of Assam, with the aim of determining its suitability for agricultural use and providing recommendations for sustainable water management. By analysing key parameters and comparing them against established standards, this study seeks to identify potential risks associated with irrigation practices and offer actionable solutions for farmers. This research will contribute to the sustainable development of agriculture in the region, ensuring both soil health and crop productivity are preserved in the face of growing challenges such as climate change and water scarcity.

1.2 ABOUT PMKSY

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) is a flagship scheme launched by the Government of India in July 2015 to enhance agricultural productivity by improving irrigation infrastructure and water use efficiency. The scheme aims to achieve the vision of "Har Khet Ko

Pani" (water to every field) and "More Crop per Drop" through the judicious use of water resources. PMKSY integrates various existing schemes such as the Accelerated Irrigation Benefit Program (AIBP), Watershed Development Component (WDC), and the On-Farm Water Management (OFWM) program.

The main objectives of PMKSY are to expand the cultivable area under assured irrigation, reduce dependency on monsoon, and enhance water conservation techniques. The scheme encourages the adoption of micro-irrigation systems like drip and sprinkler irrigation to ensure water efficiency. It also emphasizes water harvesting, groundwater recharge, and efficient distribution networks.

PMKSY operates on a decentralized planning and execution model, with active involvement from state governments. Funds are allocated based on the irrigation potential created and performance of the states. By addressing the challenges of water scarcity and inefficient irrigation, PMKSY plays a critical role in ensuring agricultural sustainability and enhancing rural livelihoods, thereby contributing to India's overall food security.

1.3 OBJECTIVES OF THE STUDY

The objective of the project study is given below:

1. To assess the parameters that defines the quality of water for irrigation for 5 PMKSY schemes.
2. To determine the suitability of groundwater for irrigation purposes.
3. To assess the variation of water quality across pre-monsoon and post-monsoon seasons..

CHAPTER 2

LITERATURE REVIEW

Taher et al. (2024) assessed groundwater quality in Western Karbala'a, focusing on developing an irrigation water quality index (IWQI) to classify water suitability for irrigation. Water samples from seven wells were collected over six years (2017-2022) and analyzed for physical and chemical characteristics. The study employed GIS and the Inverse Distance Weighted (IDW) method for data analysis. Findings revealed that IWQI values indicated "High Restriction" in the early years, transitioning to "Severe Restriction" later, highlighting a decline in water quality and underscoring the need for ongoing monitoring to ensure sustainable agricultural practices in the region.

Kamble et.al (2024) conducted a comprehensive assessment of groundwater quality for irrigation suitability in Rajangaon Shenpunji and surrounding areas, Aurangabad, Maharashtra, India. It analyzes 30 water samples collected from various sources, focusing on key parameters such as sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) to evaluate irrigation potential. The study finds that most samples are suitable for irrigation, although some exceed permissible limits due to local geological and anthropogenic influences. The authors suggest remedial actions and artificial recharge techniques to improve water quality, emphasizing the importance of understanding irrigation water quality for enhancing crop yield

Kushwah and Singh (2024) conducted a study on groundwater quality in Mathura, India, provides a comprehensive analysis of hydrochemical factors affecting water suitability for domestic and agricultural use. It highlights significant pollution levels, with 81.25% of sites exceeding fluoride limits and 62.50% for nitrate, indicating serious health risks. The use of multivariate statistical techniques and pollution evaluation indexes effectively categorized sampling sites into varying pollution levels. The findings suggest that the predominant ions render the water unsuitable for irrigation, as confirmed by various classification diagrams. Overall, this research underscores the need for effective water management strategies to ensure sustainable agricultural practices and protect human health

Goswami et.al (2024) conducterd a comprehensive evaluation of groundwater quality in the Biswanath and Sonitpur districts of Assam, India, highlighting significant concerns regarding contamination. The analysis of 56 water samples revealed that while the groundwater is generally suitable for irrigation based on various parameters, high concentrations of arsenic (As) and iron (Fe) pose serious risks for drinking purposes, with 95% and 25% of samples exceeding WHO limits, respectively. The research underscores the need for effective groundwater management and offers valuable insights for farmers and policymakers to address these challenges and promote sustainable agricultural practices in the region

Singh et al. (2023) This study provides a comprehensive assessment of groundwater quality for irrigation, highlighting significant seasonal variations influenced by monsoon dynamics. The research employs indexical, statistical, and machine learning approaches to analyze groundwater samples from intensively cultivated areas, revealing that a high percentage of samples are suitable for irrigation based on various indices. Notably, the study finds that artificial neural networks (ANN) outperform multiple linear regression (MLR) models in predicting groundwater quality. The findings underscore the impact of salinity and anthropogenic factors on water quality, making a valuable contribution to sustainable irrigation practices.

Kalita et.al (2021) The study conducted a thorough assessment of groundwater quality in the western suburb of Jorhat Town, Assam, focusing on its suitability for drinking and irrigation. The researchers evaluated various physicochemical parameters and compared them with Indian Standards for drinking water. The findings revealed that most parameters were within permissible limits, except for iron, while arsenic was detected in some samples. The Water Quality Index indicated that many samples fell into the poor category for drinking purposes, although they were generally suitable for irrigation. The study highlights critical concerns regarding groundwater safety in the region.

Bhat et.al (2018) The paper provides a comprehensive overview of groundwater quality assessment for irrigation, emphasizing its critical role in sustainable development and effective water management. It highlights the often-overlooked importance of water quality, particularly in developing countries, where both quantity and quality are essential for irrigation. The authors discuss how groundwater quality is influenced by natural geochemical processes and human activities, detailing the impact of various physicochemical properties on soil health and crop growth. The paper underscores the detrimental effects of poor-quality water, such as increased sodium levels, which can lead to soil structure degradation and reduced agricultural productivity.

Jain and Vaid (2018) This paper presents a comprehensive assessment of groundwater quality in Nalbari district, Assam, focusing on its suitability for drinking and irrigation. Groundwater samples were collected from 50 locations during pre- and post-monsoon seasons in 2016, revealing that the mean concentration of cations followed the order $Ca^{2+} > Na^{+} > Mg^{2+} > K^{+}$, while anions were $HCO_3^{-} > Cl^{-} > SO_4^{2-} > NO_3^{2-} > F^{-}$. The study utilized various parameters to evaluate drinking water standards and irrigation suitability, finding most samples to be of medium salinity and low sodium adsorption ratio, predominantly belonging to the $Ca–Mg–HCO_3$ hydro chemical facies.

Khanikar et.al (2017) This paper presents a comprehensive hydrogeochemical assessment of groundwater in Dhekiajuli, Assam, highlighting significant concerns regarding arsenic contamination and agricultural suitability. The study identifies high arsenic levels, particularly in the Bachasimalu and Sitalmari regions, with concentrations reaching 44.39 µg/L, raising health risks for local populations relying on this water for irrigation and drinking [1]. The research emphasizes the influence of anthropogenic activities and natural processes on groundwater quality, revealing a correlation between arsenic and iron levels. Overall, the findings underscore the urgent need for monitoring and management strategies to mitigate health hazards associated with arsenic in agricultural practices.

Islam et.al (2017) This study evaluates the irrigation water quality in Faridpur district, Bangladesh, using various indices and statistical methods on 60 groundwater samples. The findings indicate that the groundwater is predominantly of the $Ca-Mg-HCO_3$ type, with 68.33% of samples classified as highly suitable for irrigation. However, 30% of the samples showed low suitability, highlighting potential concerns for agricultural use. The research also reveals extreme concentrations of Na^+ and $Cl^−$, influenced by mineralization and rock-water interactions. The study employs regression models and geostatistical analysis to validate results, aiming to enhance groundwater management for agricultural purposes in the region.

Thockchom et.al (2019) The paper assesses groundwater quality for irrigation in the Manipur valley, highlighting its significance for agriculture, which employs over 22% of the local population. It evaluates various hydro chemical parameters, such as Sodium Absorption Ratio (SAR) and Magnesium Hazard (MH), revealing that a significant portion of groundwater is unsuitable for irrigation due to high salinity and magnesium levels. The study identifies the chemical evolution of groundwater, indicating initial and intermediate stages of ion mixing. Overall, the research provides valuable insights for managing groundwater resources effectively in the region, emphasizing the need for careful evaluation of irrigation water quality.

Chakraborty et.al (2012) This paper presents an innovative approach to assessing the irrigation potential of groundwater using the Ground Water Quality Index (GWQI) tool. By transforming parametric concentrations into qualitative scores, the study simplifies decision-making for water quality evaluation. It identifies electrical conductivity (EC), sodium adsorption ratio (SAR), and residual sodium carbonate (RSC) as key parameters for determining irrigation water quality. The preparation of iso index maps effectively illustrates the irrigation water quality status, revealing that most areas fall under excellent and good categories. Seasonal variations in water quality are also discussed, linking them to groundwater recharge and discharge zones.

Baruah et.al (2011) This study evaluates the suitability of groundwater for irrigation in the tea garden belts of Golaghat District, Assam, India. A comprehensive analysis of 30 groundwater samples was conducted, measuring various parameters such as pH, Electrical Conductivity, and Total Dissolved Solids, among others. The results indicate that most of the analyzed parameters fall within permissible limits for drinking water, suggesting good overall quality. Notably, the Sodium Adsorption Ratio (SAR) values indicate that 26 out of 30 sampling stations are excellent for irrigation, while the Soluble Sodium Percentage (SSP) shows a range from excellent to very bad categories.

Reddy (2013) The paper evaluates the groundwater quality in the semi-arid Bhaskar Rao Kunta watershed, focusing on its suitability for irrigation. It presents a comprehensive analysis of twenty groundwater samples, measuring various physicochemical parameters such as pH, electrical conductivity, and ion concentrations, following APHA standard methods. The results indicate that a significant portion of the samples falls within acceptable salinity and sodium categories, suggesting that the groundwater is generally suitable for irrigation. The study effectively utilizes multiple irrigation quality indexes, concluding that the groundwater quality is favorable for agricultural use in both pre and post-monsoon seasons.

CHAPTER 3

DESCRIPTION OF THE STUDY AREA

3.1 INTRODUCTION

Chhaygaon is a Town and Subdivision in Kamrup District of Assam. In India, a subdivision is a sub-division of a district that is responsible for the administration and revenue collection of a particular area within the district. It is an important part of the local governance structure, and plays a crucial role in the development and administration of its local community. According to census 2011 information the sub-district code of Chhaygaon Block (CD) is 02120. Total area of Chhaygaon subdivision is 471 km². Chhaygaon subdivision has a population of 1,21,628 peoples. Chhaygaon subdivision has a population density of 258.2 inhabitants per square kilometer. There are about 25,411 houses in the sub-district.

3.2 STUDY AREA

The samples were mainly collected from 2 villages in Chhaygaon sub-division- Natun Katahi and Puran Katahi. For this study, 3 schemes were chosen in Puran Katahi and 2 schemes were chosen in Natun Katahi. The location of the schemes is shown below in fig 3.1.

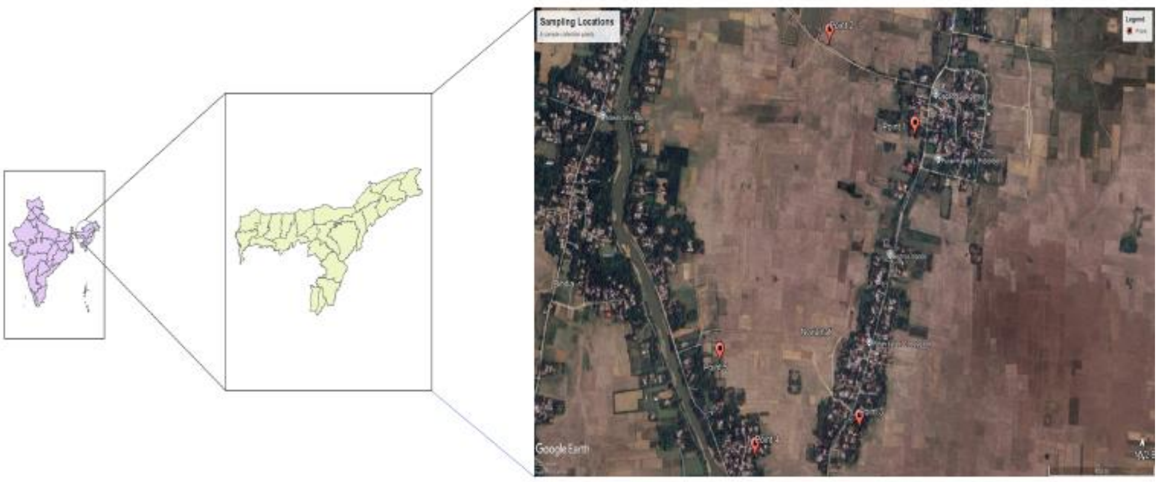


Fig 3.1 Study Area

CHAPTER 4

THEORETICAL BACKGROUND

4.1 INTRODUCTION

Irrigation water quality plays a critical role in determining soil health and agricultural productivity. The suitability of water for irrigation is assessed based on a variety of physical, chemical, and biological parameters that influence plant growth, soil structure, and the long-term sustainability of agricultural practices. The theoretical understanding of these parameters provides a foundation for analyzing the impact of irrigation water on crops and soil systems.

4.1.1 Importance of Irrigation water quality

The quality of irrigation water affects both crop yield and soil fertility. Poor-quality water can result in salinity buildup, nutrient imbalances, and toxicity, which may degrade the soil and reduce its agricultural potential. Monitoring and managing water quality are essential to maintaining sustainable agricultural practices, particularly in regions that depend heavily on groundwater sources like shallow tube wells.

4.1.2 Groundwater as a source of Irrigation

Groundwater is a vital source of irrigation water, particularly in regions where surface water resources are limited or seasonal. It provides a reliable and consistent supply of water, enabling farmers to cultivate crops throughout the year. In areas like the Chhaygaon Sub-Division, shallow tube wells are widely used to extract groundwater for irrigation purposes. The importance of groundwater lies in its accessibility and ability to support agricultural activities even during dry periods. However, excessive reliance on groundwater can lead to issues such as over-extraction, declining water tables, and quality degradation due to increased salinity and contamination. Therefore, sustainable management of groundwater resources is essential for ensuring long-term agricultural productivity.

4.1.3 Indian Standards for Irrigation Water Quality

The Indian Standard (IS 11624:2019) provides guidelines for evaluating the quality of irrigation water. It outlines acceptable ranges for various parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), sodium adsorption ratio (SAR), and residual sodium carbonate (RSC). These standards ensure that irrigation practices do not adversely affect soil health or crop productivity.

4.2 KEY PARAMETERS FOR IRRIGATION WATER QUALITY

Several parameters are used to evaluate the quality of irrigation water. Each parameter has specific implications for soil and crop health.

4.2.1 pH

pH measures the acidity or alkalinity of water and is a critical parameter for irrigation. The optimal pH range for irrigation water is 6.5 to 8.5. Water outside this range can lead to soil pH imbalance, affecting nutrient availability and plant growth.

4.2.2 Electrical Conductivity

EC is a measure of the water's ability to conduct electricity, which directly correlates with its salt concentration. High EC values indicate elevated salinity, which can inhibit plant growth by reducing the availability of water to roots through osmotic stress.

4.2.3 Total Dissolved Solids (TDS)

TDS refers to the total concentration of dissolved salts in water. TDS values below 450 mg/L are considered suitable for irrigation, while higher levels can cause salinity issues, impacting crop yield and soil permeability.

4.2.3 Sodium Adsorption Ratio (SAR)

SAR evaluates the relative proportion of sodium ions to calcium and magnesium ions in irrigation water. High SAR values can lead to soil sodicity, which reduces soil permeability and aeration, negatively affecting root development.

4.2.4 Residual Sodium Carbonate (RSC)

RSC is calculated based on the concentrations of bicarbonates, carbonates, calcium, and magnesium ions. High RSC values can lead to the precipitation of calcium and magnesium, increasing sodium hazards and affecting soil structure.

4.2.5 Permeability Index

The Permeability Index is used to evaluate the suitability of irrigation water for maintaining soil permeability. It is calculated using the formula:

$$PI = \frac{Na + \sqrt{HCO_3}}{Na + Ca + Mg} * 100$$

Where Na, HCO_3, Ca, and Mg are concentrations in meq/L. PI values greater than 75% indicate water that is suitable for irrigation, while lower values may reduce soil permeability and lead to compaction over time.

4.2.6 Magnesium Ratio

The Magnesium Ratio assesses the balance between magnesium and calcium concentrations in irrigation water. It is calculated as:

$$MR = \frac{Mg * 100}{Ca + Mg}$$

Where Mg and Ca are in meq/L. A magnesium ratio exceeding 50% may indicate a dominance of magnesium, which can adversely affect soil structure and fertility by increasing clay dispersion and reducing permeability.

4.3 IMPACT OF POOR-QUALITY IRRIGATION WATER

4.3.1 Soil Salinity

Excessive salts in irrigation water can accumulate in the root zone, leading to salinity stress. The accumulation of salts reduces the osmotic potential of the soil solution, making it difficult for plants to absorb water. As a result, even when soil moisture is sufficient, plants can experience water stress, leading to stunted growth, lower yields, and reduced germination rates. Over time, high salinity can lead to the formation of saline soils, which are less productive and often require costly reclamation efforts. The effects of salinity can also extend to the microbial ecosystem in the soil, disrupting essential processes such as nitrogen fixation and organic matter decomposition. The long-term impact includes a significant reduction in agricultural productivity and land value. Fig 4.1 shows some effects of salinity on soil and crops.

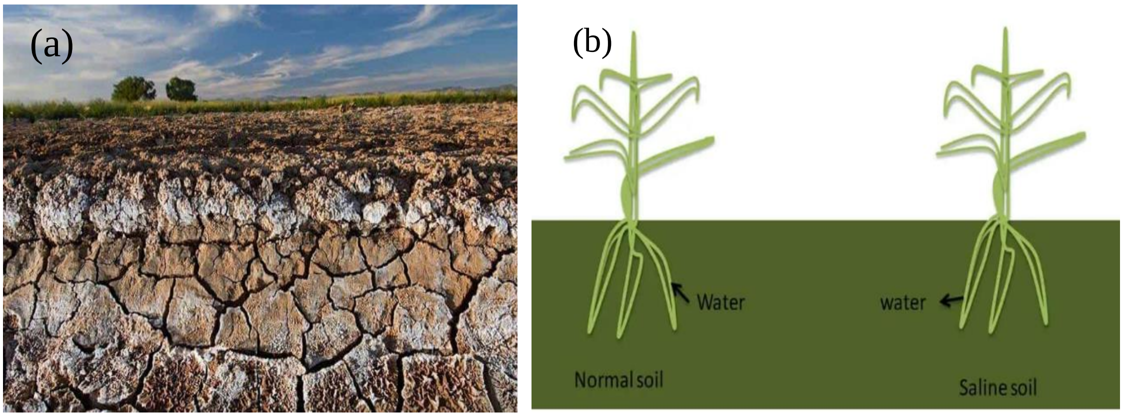


Fig 4.1 (a) Barren land due to salinity (b) Osmotic stress on plants due to excess salinity (Source: (a): doraagri.com;(b): cropnuts.com)

4.3.2 Soil Sodicity

High sodium levels in irrigation water can have a detrimental effect on soil structure. Sodium ions replace calcium and magnesium on soil particles, leading to the dispersion of clay particles. This dispersion reduces soil permeability and aeration, creating compacted layers that are difficult for roots to penetrate. Poor drainage caused by sodicity exacerbates waterlogging, which further restricts oxygen availability to plant roots. Crops grown in sodic soils often exhibit poor growth, chlorosis, and reduced yields. Additionally, sodicity affects the soil's microbial activity, reducing its ability to support nutrient cycling and organic matter decomposition. Over time, sodic soils become increasingly unproductive and challenging to manage, often requiring significant intervention, such as the application of gypsum or organic amendments, to restore soil health. Fig 4.2 shows some effects on sodicity on soil.

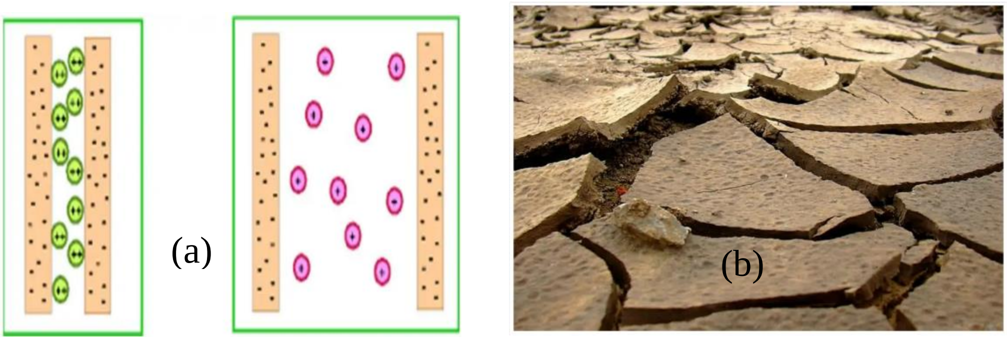


Fig 4.2 (a) Repelling effect of sodium (right) (b) Common sight of sodic soils (Source: cropnuts.com)

4.3.3 Toxicity to crops

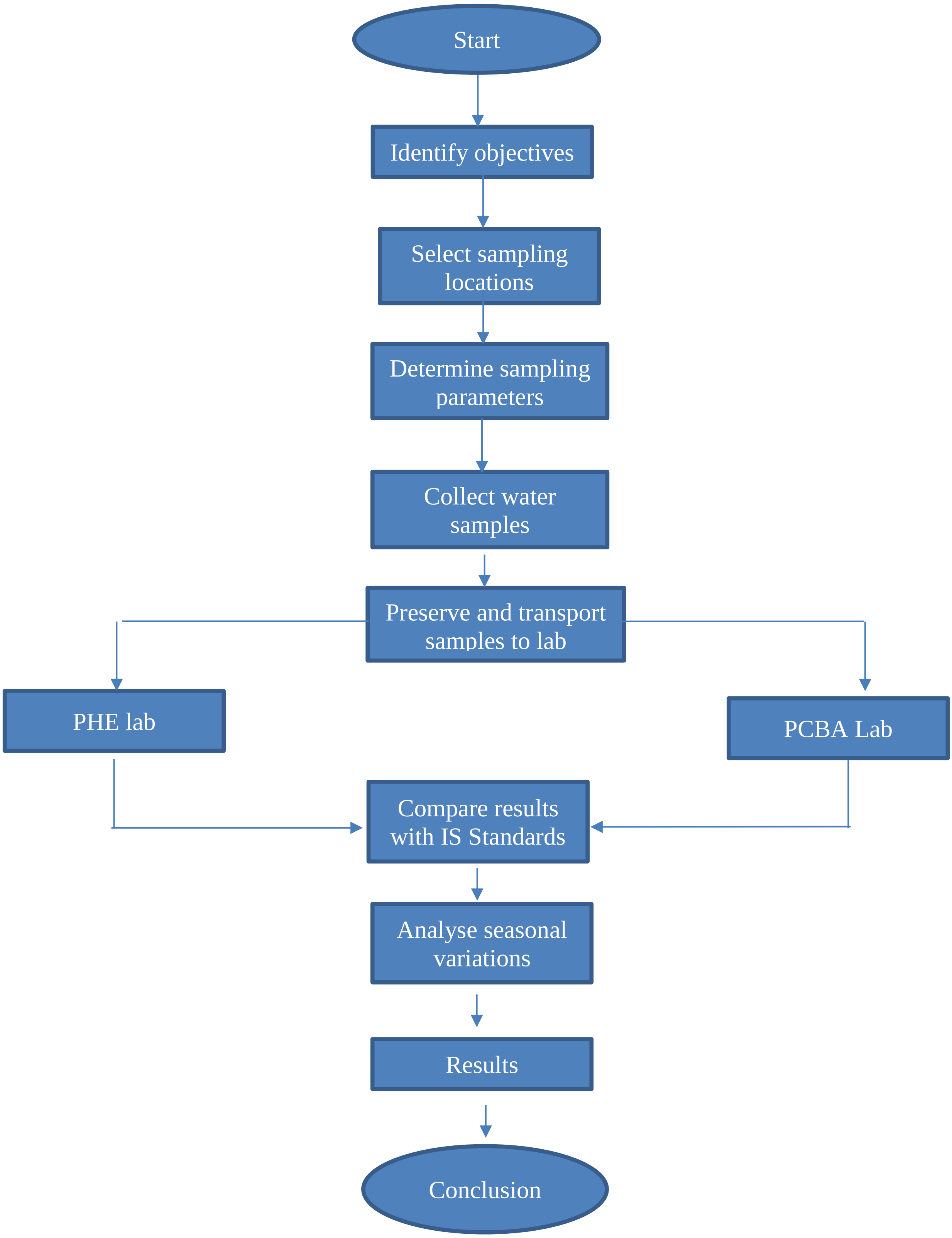
Irrigation water with high concentrations of specific ions, such as sodium, chloride, and boron, can cause toxicity in crops. These ions can accumulate in plant tissues over time, leading to physiological stress and metabolic disruptions. For instance, chloride toxicity can manifest as leaf burn and necrosis, while excessive boron can inhibit cell division and elongation. Sodium toxicity, on the other hand, interferes with the uptake of essential nutrients such as potassium and calcium, leading to nutrient imbalances. The visible symptoms of toxicity, such as leaf discoloration and stunted growth, often reduce the marketability of crops. Furthermore, ion toxicity can lead to the early senescence of leaves, reducing photosynthetic capacity and ultimately affecting overall yield and quality. Managing toxicity requires careful monitoring of water quality and the implementation of strategies such as blending poor-quality water with freshwater or applying foliar sprays to mitigate stress.

4.3.4 Long-Term Soil Degradation

The continuous use of poor-quality irrigation water can lead to severe long-term soil degradation. Salinity and sodicity problems contribute to the loss of soil structure, reducing its ability to retain water and nutrients. Over time, this can result in a decline in soil fertility, limiting the types of crops that can be cultivated. In extreme cases, affected lands become barren and unfit for agriculture. Degraded soils are also more susceptible to erosion, as the weakened structure is less able to resist the forces of wind and water. This erosion not only reduces the productive area but also leads to the loss of valuable topsoil, further exacerbating fertility issues. The economic impact of soil degradation is significant, as it reduces agricultural output and increases the cost of land reclamation and restoration. Sustainable irrigation practices and regular soil testing are essential to prevent long-term degradation and maintain the viability of agricultural lands.

CHAPTER 5

METHODOLOGY



The samples were collected from 5 points as shown in the study area chapter. Some instances during sample collection are shown in the fig 5.1 below.

Fig 5.1: Some moments during sample collection

Some of the tests were conducted in District level public health laboratory, Bamunimaidam and the other tests were conducted in Pollution Control Board Assam, Bamunimaidam. The tests conducted and the instrument used for each test is mentioned in table 5.1 below.

Table 5.1: Methods and instrument adopted for testing

Parameters	Method adopted	Instrument/Technique used	Laboratory
pH	Electrometric method	pH meter	PHE Laboratory, Bamunimaidam
Conductivity	Electrometric method	Conductivity meter	PHE Laboratory, Bamunimaidam
TDS	Electrometric	Conductivity/TDS meter	PHE Laboratory, Bamunimaidam
Alkalinity	Titrimetric method	Titration by H_2SO_4	PHE Laboratory, Bamunimaidam
Sodium	Flame Emission Spectroscopy	Flame Photometer	PCBA Laboratory, Bamunimaidam
Total Hardness	Titrimetric method	Titration by EDTA	PHE Laboratory, Bamunimaidam
Calcium (Ca)	Titrimetric method	Titration by EDTA	PHE Laboratory, Bamunimaidam

5.1 Procedure for each test

The procedure for each test is mentioned below:

5.1.1 pH

The pH was measured using a pH meter. A pH meter measures the difference in electrical potential between a reference electrode and a pH electrode. This difference is related to the solution's acidity or pH. The pH scale ranges from 0 to 14, with 0 being the most acidic and 14 being the most basic. A pH meter is shown in fig 5.2 below.

Fig 5.2: pH meter

5.1.2 Electrical Conductivity (EC)

The EC was measured using a conductivity meter. An electrical conductivity meter measures the electrical conductivity in a solution. The meter used for measuring EC is shown in fig 5.3(a)

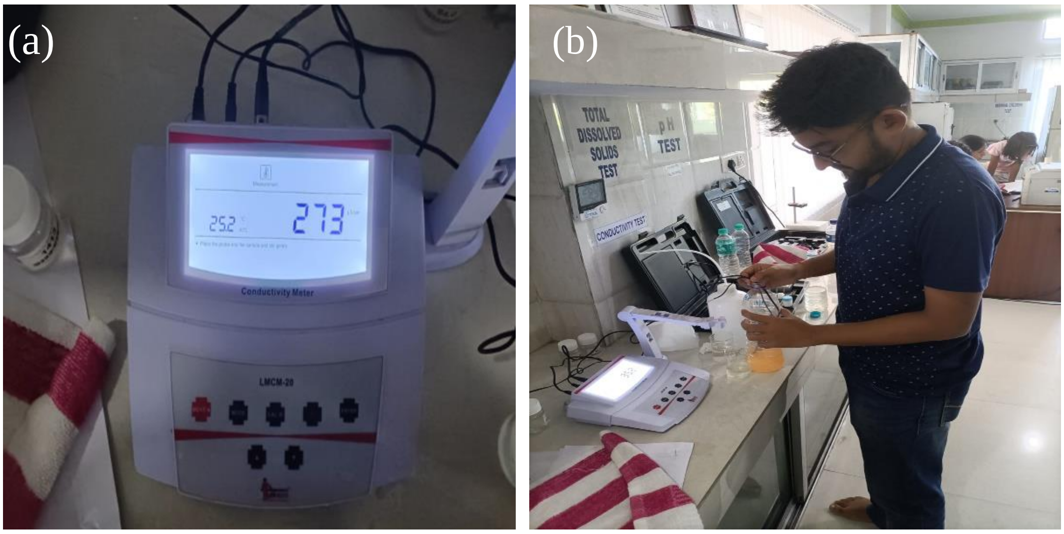


Fig 5.3: (a) EC meter (b) A moment while measuring EC of sample

5.1.3 TDS

The TDS was measured using a TDS meter. The image in fig 5.4 shows the TDS meter.

Fig 5.4: TDS meter

5.1.4 Alkalinity

For measuring alkalinity, the indicator method was used. The test was conducted as per the procedure mentioned in IS 3025 (Part 23): 2023. The procedure is as follows:

i. Pipette 20 ml or a suitable aliquot of sample into 100 ml beaker.

ii. If the pH of the sample is over 8.3, then add 2 to 3 drops of phenolphthalein indicator and titrate with standard sulphuric acid solution till the pink colour observed by indicator just disappears (equivalence of pH 8.3). Record the volume of standard sulphuric acid solution used.

iii. Add 2 to 3 drops of mixed indicator to the solution in which the phenolphthalein alkalinity has been determined.

iv. Titrate with the standard acid to light pink colour (equivalence of pH 3.7). Record the volume of standard acid used after phenolphthalein alkalinity.

5.1.5 Sodium (Na)

The test for Sodium (Na) was conducted as per the procedure mentioned in IS 3025-45(1993). Flame photometer test was used for determining sodium. Some images of the flame photometer and the stock solutions are shown in fig 5. 5..

Fig 5.5 (a) Flame photometer, (b) Stock solutions of sodium of 1, 10 and 100 ppm, (c) A moment while conducting flame photometer test

5.1.6 Total Hardness

The total hardness was estimated using EDTA titrimetric method. The procedure is as follows:

i. Take 25 or 50 ml or well mixed sample in a conical flask.
ii. Then add 1 to 2 ml buffer solution followed by 1 ml inhibitor.
iii. Add a pinch of Eriochrome black T and titrate with standard EDTA (0.01M) till wine red colour changes to blue, then note down the volume of EDTA required
iv. Run a reagent blank. Note the volume of EDTA (B).
v. Calculate volume of EDTA required by sample, C = A – B (from volume of EDTA required in steps (iii & iv).

5.1.7 Calcium (Ca)

The test for calcium was done using EDTA titrimetric method. The procedure is as follows:

i. Take 25- or 50-ml sample in a conical flask.
ii. Add 1 ml NaOH to raise pH to 12.0 and add a pinch of muroxide indicator.
iii. Titrate immediately with EDTA till pink colour changes to purple. Note the volume of EDTA used (A1).
iv. Run a reagent blank. Note the ml of EDTA required (B1) and keep it aside to compare end points of sample titrations.
v. Calculate the volume of EDTA required by sample, C1 = A1 – B1.

This test gives us calcium hardness. The magnesium hardness can be determined by subtracting the calcium hardness from total hardness. The results of the above tests are discussed in the next chapter. Fig 5.6 shows an instance while conducting titration.

Fig 5.6 A moment while conducting titration

CHAPTER 6

RESULTS & DISCUSSION

6.1 LABORATORY OBSERVATIONS

The results of the experiments are tabulated in the table below. Table 6.1shows laboratory tests results of the samples against the point number. From these results, the parameters for assessing irrigation water quality are evaluated.

Table 6.1: Laboratory Results

Point No.	pH	EC (μS/cm)	TDS (mg/l)	Total Alkalinity (mg/l as $CaCO_3$)	Sodium (Na)(m.eq/l)	Total Hardness (mg/l as $CaCO_3$)	Calcium (Ca)(mg/l)
1	7.02	313.5	260.8	27.3	5.42	209.78	46.83
2	6.65	312.6	262.1	21.0	4.74	226.36	50.2
3	7.14	296.4	242.2	32.0	4.04	198.61	43.81
4	7.46	332	245.3	41.1	5.16	192.54	40.26
5	7.68	341.2	255.4	28.6	5.64	215.96	47.86

6.2 CALCULATIONS

6.2.1 Calcium Hardness (as $CaCO_3$)

The calcium hardness is necessary for finding out the magnesium hardness. It can be calculated from Ca^{2+} content by dividing it by 0.4008. It is recorded in table 6.2.

Table 6.2: Calcium and Calcium Hardness

Point No.	Calcium (as Ca^{2+}) (mg/l)	Calcium Hardness (as $CaCO_3$) (mg/l)
1	46.83	116.84
2	50.2	125.25
3	43.81	109.30
4	40.26	100.45
5	47.86	119.41

6.2.2 *Magnesium Hardness (as $CaCO_3$)*

The magnesium hardness is calculated from calcium hardness and total hardness by the following formula as per APHA 3500 – Mg B. The magnesium and magnesium hardness for the samples are shown in table 6.3.

Magnesium Hardness=Total Hardness – Calcium Hardness(mg/l)

Magnesium (as Mg^{2+}) = Magnesium hardness * 0.243 (mg/l)

Table 6.3.: Magnesium and Magnesium Hardness

Point No.	Total Hardness (mg/l as $CaCO_3$)	Calcium Hardness (mg/l as $CaCO_3$)	Magnesium Hardness (mg/l as $CaCO_3$)	Magnesium (as Mg^{2+}) (mg/l)	Magnesium (as Mg^{2+}) (meq/l)
1	209.78	116.84	92.94	22.58	1.85
2	226.36	125.25	101.11	24.56	2.02
3	198.61	109.30	89.30	20	1.64
4	192.54	100.45	92.09	22.37	1.84
5	215.96	119.41	96.55	23.46	1.93

6.2.3 *Carbonate and Bicarbonate concentration*

The carbonate and bicarbonate concentrations can be derived from alkalinity relationships mentioned in IS 3025-51(2001) Part 51. The relationship table is shown in table 6.4.

Table 6.4: Alkalinity Relationships (Source: IS-3025-51(2001) Part 51

Result of Titration	Hydroxide Alkalinity as $CaCO_3$	Carbonate Alkalinity as $CaCO_3$	Bicarbonate Concentration as $CaCO_3$
(1)	(2)	(3)	(4)
P = O	O	O	T
P < 1/2 T	O	2P	T-2P
P = 1/2 T	O	2P	O
P > 1/2 T	2P-T	2(T-P)	O
P = T	T	O	O

where

P = Phenolphthalein alkalinity, and

T = Total alkalinity.

Now, in our case, for all the samples the pH is less than 8.3. Therefore, the alkalinity is only due to bicarbonate ions (HCO_3^-). The calculations for HCO_3^- are shown in table 6.5

Conversion from mg/l as $CaCO_3$ to milliequivalents per liter(meq/l):

$$meq/L = \frac{\frac{\text{mg}}{\text{l}}\ as\ CaCO_3}{\text{Equivalent weight of } CaCO_3}$$

Conversion from meq/l to mg/l

mg/l of HCO_3^-=meq/l * Molecular weight of HCO_3^-

Table 6.5: Total Alkalinity and Bicarbonate concentration

Point No	Total Alkalinity (as $CaCO_3$) (mg/l)	Bicarbonate concentration (in meq/l)	Bicarbonate concentration (in mg/l)
1	27.3	0.546	33.306
2	21.0	0.42	25.62
3	32.0	0.64	39.04
4	41.1	0.822	50.142
5	28.6	0.572	34.892

6.2.4 Sodium Adsorption Ratio (SAR)

The sodium adsorption ratio (SAR) is a water quality parameter that measures the amount of sodium (Na) in water relative to the amount of calcium (Ca) and magnesium (Mg). It is estimated by the following formula:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}}\sqrt{millimole/l}$$

Table 6.6 shows the SAR values estimated for the samples in this study.

Table 6.6: Sodium Adsorption Ratio (SAR) results

Point No.	Na^+(meq/l)	Ca^{2+}(meq/l)	Mg^{2+}(meq/l)	SAR ($\sqrt{millimole/l}$)
1	5.42	2.34	1.85	3.744
2	4.74	2.51	2.02	3.15
3	4.04	2.19	1.64	2.92
4	5.16	2.01	1.84	3.72
5	5.64	2.39	1.93	3.84

6.2.5 Residual Sodium Carbonate (RSC)

Residual sodium carbonate (RSC) is a water quality parameter that measures the amount of sodium in relation to calcium and magnesium. It's used to determine the suitability of water for irrigation and the alkalinity hazard for soil. It is calculated by the following formula:

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$$

where

RSC = Residual sodium carbonate (meq/l),

CO_3^{2-}=carbonate ion concentration (meq/l),

HCO_3^-=bicarbonate ion concentration (meq/l),

Ca^{2+}=calcium ion concentration (meq/l),

Mg^{2+}=magnesium ion concentration(meq/l)

But from previous observations we know that, the carbonate concentration for the samples is 0 and the total alkalinity is only due to bicarbonate ions. Table 6.7 shows the RSC values against the samples

Table 6.7: Residual Sodium Carbonate (RSC) results

Point No.	HCO_3^- (meq/l)	Ca^{2+}(meq/l)	Mg^{2+}(meq/l)	RSC (meq/l)
1	0.546	2.34	1.85	-3.6455
2	0.420	2.51	2.02	-4.11
3	0.64	2.19	1.64	-3.19
4	0.822	2.01	1.84	-3.028
5	0.572	2.39	1.93	-3.748

6.2.6 Permeability

The permeability index is calculated using the formula (Doneen, 1964):

$$PI = \frac{Na + \sqrt{HCO_3}}{Na + Ca + Mg} * 100$$

Table 6.8 records the PI against the points of sample collection.

Table 6.8: Permeability Index (PI) results

Point No	Na^{+}(in meq/l)	Ca^{2+}(in meq/l)	Mg^{2+}(in meq/l)	HCO_3^{-}(in meq/l)	PI(in %)
1	5.42	2.34	1.85	0.546	64.08
2	4.74	2.51	2.02	0.42	58.12
3	4.04	2.19	1.64	0.64	61.5
4	5.16	2.01	1.84	0.82	67.3
5	5.64	2.39	1.93	0.572	64.22

6.2.7 Magnesium Ratio

The Magnesium Ratio is calculated as (Llyod and Heathcote,1985):

$$MR = \frac{Mg * 100}{Ca + Mg}$$

The MR values for the collected samples are tabulated in table 6.9.

Table 6.9: Magnesium Ratio (MR) results

Point No	Ca^{2+}(in meq/l)	Mg^{2+}(in meq/l)	MR
1	2.34	1.85	44.15
2	2.51	2.02	44.59
3	2.19	1.64	42.82
4	2.01	1.84	47.8
5	2.39	1.93	44.67

6.3 DISCUSSIONS

The table 6.10 classifies the samples as suitable or unsuitable for irrigation on the basis of suitability criteria for each parameter.

Table 6.10: Classification of samples based on parameter's suitability criteria

Point No	EC (μS/cm)	TDS	SAR	RSC	PI	MR
	EC<3000 suitable	TDS<1000 suitable	SAR<10 suitable	RSC <1.25 suitable	PI>75% suitable	MR<50 suitable
1	313.5	260.8	3.744	-3.6455	64.08	44.15
2	312.6	262.1	3.15	-4.11	58.12	44.59
3	296.4	242.2	2.92	-3.19	61.5	42.82
4	332	245.3	3.72	-3.028	67.3	47.8
5	341.2	255.4	3.84	-3.748	64.22	44.67

From the above table, it can be seen that the samples satisfy all of the criteria except Permeability Index (PI) as all of them are having a value less than 75%. These low PI values can be attributed to the imbalance in the composition of calcium and magnesium compared to sodium and bicarbonate. These lower values of PI may cause a reduction in soil permeability over time.

The above results are were obtained for post-monsoon season. The seasonal variation of these parameters across pre-monsoon and post-monsoon are also studied.

6.3.1 Seasonal Variation

The seasonal variation of the above parameters was studied across pre-monsoon and post monsoon seasons. The results for pre-monsoon season are reported from a Central Ground Water Board titled "Groundwater Quality in shallow aquifer of Assam". The data for Chhaygaon area is used for comparison heer because our study area falls under the Chhaygaon sub-division. For simplicity we will compare the average of the values obtained in our study and compare it with the already available pre-monsoon results. The parameters of EC, TDS, PI and MR are compared across different seasons. Table 6.11 shows the values recorded for different seasons. Fig shows the variation of the parameters in the form of a column chart.

Table 6.11: Seasonal Variation

Parameters	Pre-Monsoon Results	Post-monsoon results
EC(µS/cm)	407.1	319.14
TDS	268.69	253.16
PI	38.25	63.04
MR	32.68	44.8

We can see that there is a decrease in EC and TDS values in during post-monsoon season. This can be associated with the dilution of groundwater during monsoon. A pictorial comparison is shown in fig 6.1.

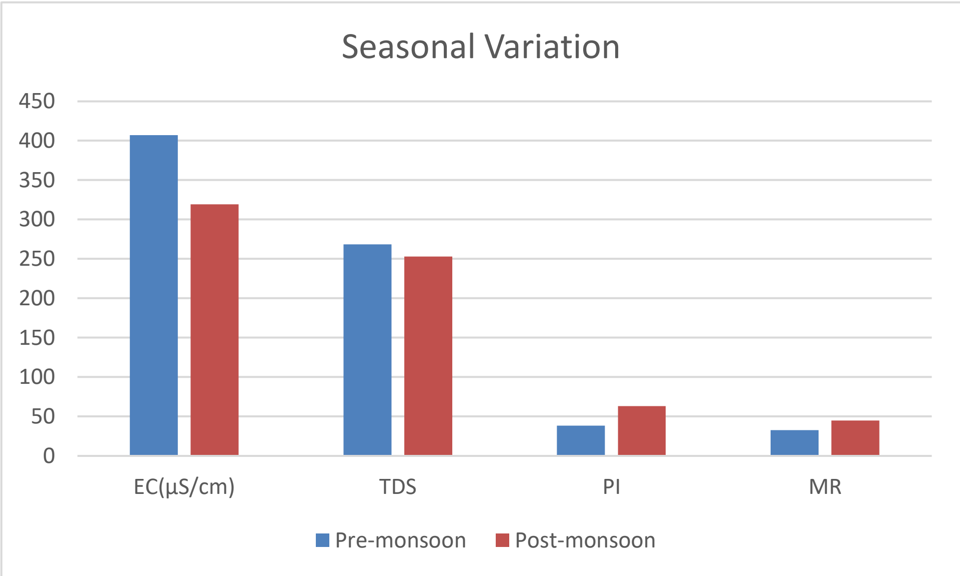


Fig 6.1: Seasonal Variation across pre-monsoon and post-monsoon season

An increase in PI values during post-monsoon may mean the decrease in concentrations of Calcium and Magnesium compared to sodium due to dilution. In the case of Magnesium Ratio, it is clear that the concentration of Calcium decreased more compared to Magnesium during post-monsoon leading to higher values.

CHAPTER 7

CONCLUSION

The assessment of irrigation water quality of five shallow tube wells in the Chhaygaon Sub-Division under PMKSY scheme revealed critical insights into the seasonal variations and the overall suitability of the water for agricultural purposes. The study focused on key irrigation water quality parameters, including pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Permeability Index (PI), and Magnesium Ratio (MR).

The seasonal variation analysis showed that EC and TDS values generally decreased during the post-monsoon season, which can be attributed to groundwater recharge through rainfall and subsequent dilution of dissolved salts. This improvement in water quality during the post-monsoon season makes it relatively more favorable for irrigation. On the other hand, parameters such as the Permeability Index (PI) and Magnesium Ratio (MR) showed an increase in the post-monsoon season. The rise in PI indicates improved permeability conditions in the post-monsoon period, whereas an elevated MR points to higher magnesium levels in relation to calcium, which may have implications for soil structure and crop health over time.

Most of the analyzed parameters were found to be within acceptable ranges for irrigation water, indicating overall suitability for agricultural use in the region. However, the Permeability Index was found to be less than 75% for certain samples, which highlights a potential concern regarding long-term soil permeability and water infiltration. Although no immediate adverse effects may be observed, prolonged use of water with a low PI could lead to compaction and reduced soil productivity.

The seasonal improvement in EC and TDS values suggests that the post-monsoon period is more favorable for irrigation from a salinity perspective. However, the increase in PI and MR during this period underscores the importance of monitoring other aspects of soil and water interaction, especially regarding magnesium's potential impact on soil structure. The study highlights the need for regular water quality monitoring, as well as the adoption of sustainable water and soil management practices to mitigate long-term risks.

In conclusion, while the irrigation water quality in the villages of Natun Katahi and Puran Katahi is largely suitable for agricultural use, certain parameters warrant careful monitoring and management to ensure sustainable agricultural practices. These findings provide a scientific basis for the formulation of irrigation strategies and serve as a valuable reference for future research on water quality and its impact on agriculture in the region.

CHAPTER 8

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