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त्रिपुरा के सतही जलभृत में भूजल की गुणवत्ता

GROUND WATER QUALITY IN SHALLOW AQUIFER OF TRIPURA

केंद्रीय भूजल बोर्ड

Central Ground Water Board

जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

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FOREWORD

Groundwater serves as an important source for drinking water and irrigation in Tripura. Of late, owing to increased anthropogenic activities as well as geogenic actions groundwater quality issues have posed a threat in the state. Hence it is crucial to have prior information on the groundwater quality available in Tripura for judicious management of this resource.

The Central Ground Water Board, North Eastern Region, regularly monitors the quality, quantity, availability, and non-availability of groundwater in the state through a network of various Groundwater Monitoring Stations (GWMS), mainly representing dug wells. Samples are collected during the month of March/April & November/December every year, following standard practice of collection and analysis.

Sixteen physico-chemical parameters including pH, EC, TDS, turbidity, carbonate and bicarbonate alkalinity, total alkalinity, calcium, magnesium, total hardness, chloride, sodium, potassium, sulphate, nitrate, and fluoride were analyzed for the samples collected within the state. Heavy metals, viz., Iron and Arsenic and radioactive Uranium content of the samples were also being considered for a holistic approach in characterizing the groundwater quality of Nagaland.

The dedicated efforts of the officers of the Board for compiling the data and preparing the report deserve appreciation. This report will help in better understanding the quality aspects of groundwater resources in Tripura and will be a valuable guide for planners, policymakers, administrators, and all other stakeholders to optimize the development and management of this precious resource in the state.

Regional Director
Central Ground Water Board
North Eastern Region

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GENERAL INTRODUCTION

Introduction

Groundwater is an invaluable resource, particularly in regions where surface water is scarce or unreliable. It serves as the primary source for drinking water, irrigation, and industrial use. Ensuring the quality of groundwater is essential for its sustainability and safety.

Globally, groundwater quality varies widely due to natural factors and human activities. Key contaminants, such as pathogens, nitrates, heavy metals, and organic pollutants, pose significant threats to groundwater. Regions experiencing rapid industrialization and urbanization often face severe groundwater pollution due to inadequate waste management and agricultural runoff. While developed countries implement stringent regulations and advanced technologies to manage groundwater quality, developing nations—including parts of Africa and Asia—often struggle with inadequate infrastructure and regulatory enforcement, leading to deteriorating conditions. Contaminated aquifers can pose serious health risks, particularly in communities dependent on groundwater for drinking and irrigation.

In India, one of the largest networks of aquifers in the world provides approximately 60% of its irrigation and 80% of its drinking water supply. However, the quality of groundwater is increasingly jeopardized by over-extraction, pollution from agricultural runoff, industrial discharges, and insufficient sanitation facilities. Research indicates that shallow aquifers, especially in rural and peri-urban areas, are particularly vulnerable to contamination. High levels of nitrates, fluoride, and heavy metals such as arsenic and lead have been documented, with states like Punjab and Haryana facing critical nitrate levels due to extensive fertilizer use, while arsenic contamination is a pressing concern in West Bengal and Assam.

Tripura's unique hydrogeological setting features abundant groundwater resources primarily stored in shallow aquifers formed from alluvial and sedimentary deposits. Nevertheless, groundwater quality in Tripura faces significant challenges that could impact public health and agricultural productivity. Studies have identified varying degrees of contamination in

Tripura's shallow aquifers, including elevated levels of iron, manganese, and, in some areas, fluoride. The main sources of contamination are geological formations, agricultural practices, and occasional industrial discharges. Given the state's reliance on groundwater for drinking and irrigation, monitoring and addressing these quality issues is critical.

Water quality monitoring is vital for ensuring safe drinking water and sustainable agricultural practices. Regular monitoring enables the identification of contaminants, risk assessment, and the implementation of corrective measures. This is especially important in regions like Tripura, where groundwater is integral to daily life. The Central Ground Water Board (CGWB) plays a crucial role in groundwater quality monitoring across India. Established in 1970, the CGWB conducts systematic studies, collects data on groundwater levels and quality, and advises on sustainable management practices. The board engages with local communities to raise awareness about groundwater conservation and pollution prevention. Through extensive sampling and analysis of various parameters, including heavy metals and basic chemical constituents, the CGWB formulates policy recommendations to enhance groundwater management and quality standards.

This report aims to provide a comprehensive overview of the current state of groundwater quality in the shallow aquifers of Tripura, emphasizing the need for ongoing monitoring and proactive management to safeguard this vital resource.

Study area

Tripura, a picturesque and lush green state in north-eastern India, covers an area of 10,491.69 sq. km. It is located between latitudes 22° 56′ 32″ and 24° 31′ 51″ N, and longitudes 91° 09′ 15″ and 92° 19′ 51″ E, with the Tropic of Cancer passing through its southern region. This land-locked state is bordered by Bangladesh on three sides—west, south-southeast, and north—while its north-eastern and eastern boundaries are shared with Assam and Mizoram, respectively. Tripura shares an extensive 856 km (84%) international border with Bangladesh, alongside a 109 km border with Mizoram and a 53 km border with Assam.

Connectivity to other parts of India is facilitated through road, rail, and air. Prior to the partition of India, the road distance from Agartala to Kolkata was under 350 km; however, it now spans approximately 1,700 km via Shillong in Meghalaya, Guwahati in Assam, and Siliguri in West Bengal. National Highway 8 (formerly NH 44), known as the Agartala-

Assam Road, serves as the primary road link to the rest of India through Assam and Meghalaya. Agartala, the state capital, is well-connected to various district towns, sub-divisional headquarters, and block headquarters via state highways and major metalled roads. Additionally, the Sabroom-Agartala-Silchar-Lumding-Guwahati railway line connects Agartala with Guwahati and the broader national railway network. The city is also served by frequent air services, ensuring strong connectivity with other cities across the country.

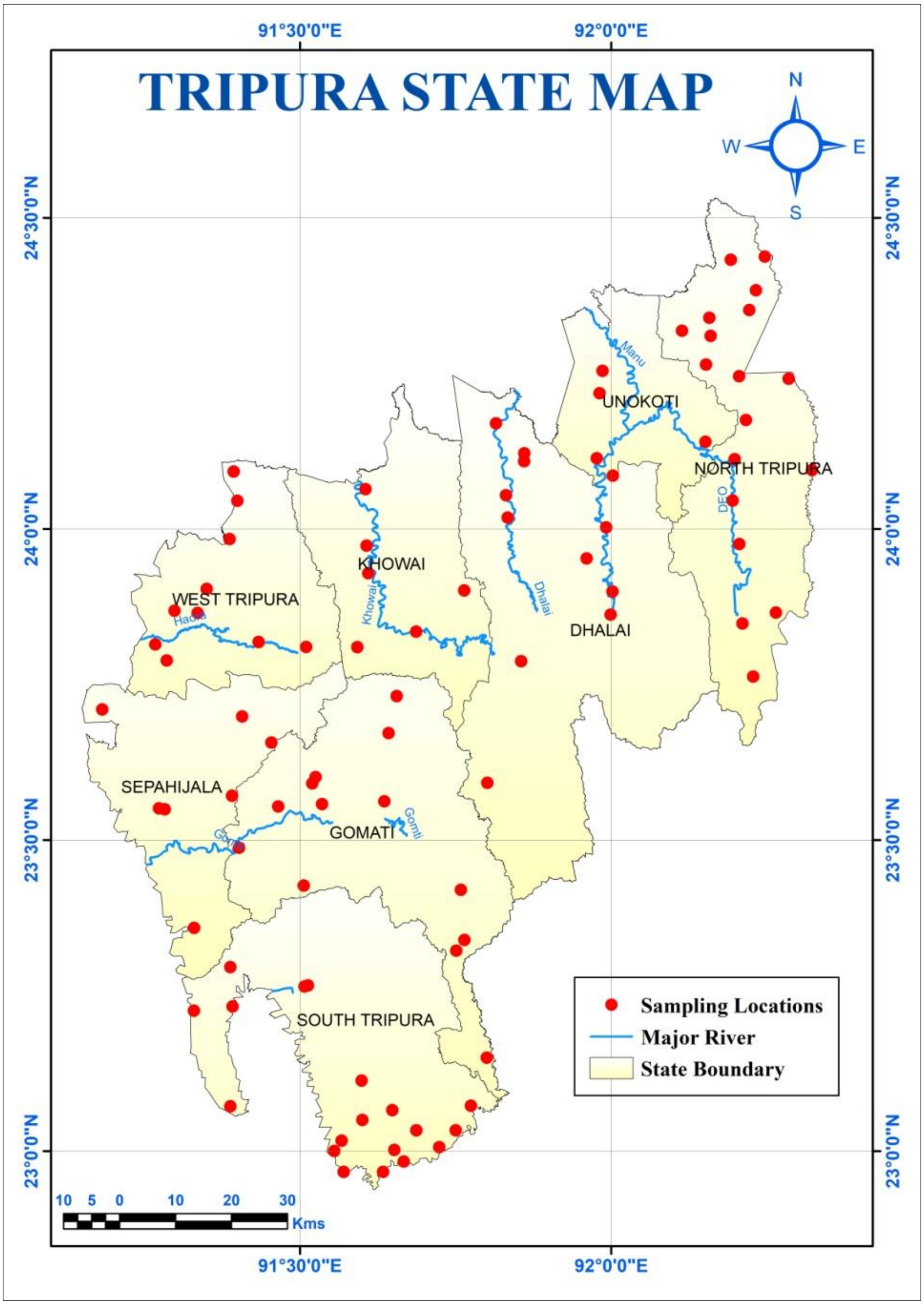


Figure 1. ***Map of Tripura with sampling locations***

Rainfall

The normal rainfall in Tripura follows a distinct pattern typical of the region's monsoon climate. During the pre-monsoon months of April and May, rainfall gradually increases as the state prepares for the onset of the monsoon, with a sharp rise in May. The monsoon season, which lasts from June to September, sees rainfall peaking in July and August, contributing the majority of the annual precipitation. After the monsoon, from October through February, there is a significant decline in rainfall, with particularly low levels in the winter months of December and January. As early spring arrives in February and March, rainfall begins to recover slightly, with pre-monsoon showers becoming more frequent in March.

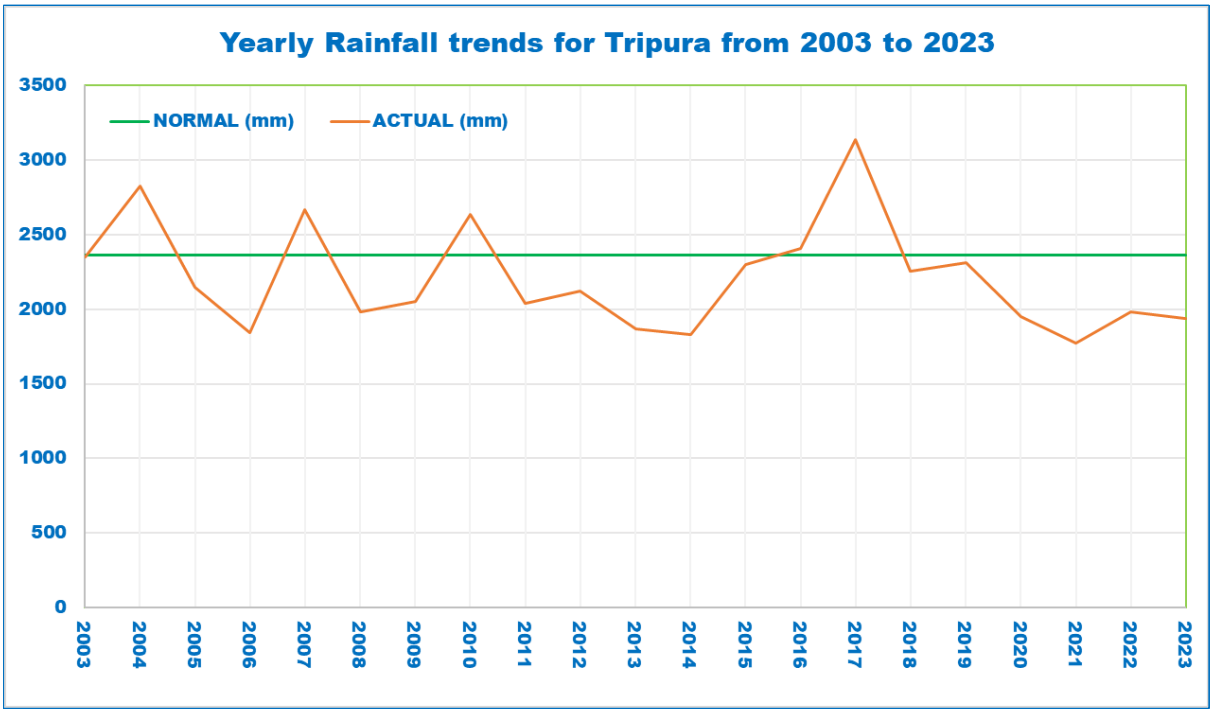


Figure 2. ***20 Years Rainfall trends for Tripura***

The average or normal rainfall for the last 20 years (2003-2023) remains relatively constant across the years, hovering around 2,200-2,500 mm annually. This suggests a fairly stable climatic baseline for rainfall in Tripura. The actual rainfall in Tripura has exhibited cyclical patterns over the past two decades, with alternating peaks and troughs. There have been significant deviations from the normal. The years 2004, 2008, 2011, and 2017 experienced significantly higher rainfall compared to the average, surpassing 3,000 mm in some cases. The periods 2006, 2013, 2015, and 2022 saw a drop in rainfall, falling well below the normal, sometimes dipping close to 1,500 mm.

In the year 2023-24, Tripura experienced an early and intense start to the monsoon, with higher-than-normal rainfall in May and June. The monsoon's peak months of July and August saw actual rainfall closely matching normal levels, though June's rainfall was notably higher than expected. Following the monsoon, rainfall during the post-monsoon months, especially from October to December, was below normal, with November and December being particularly dry. Projections for early 2024 indicate that the below-normal rainfall will persist through January and February, continuing into March, suggesting that Tripura may face a drier winter and early spring than usual.

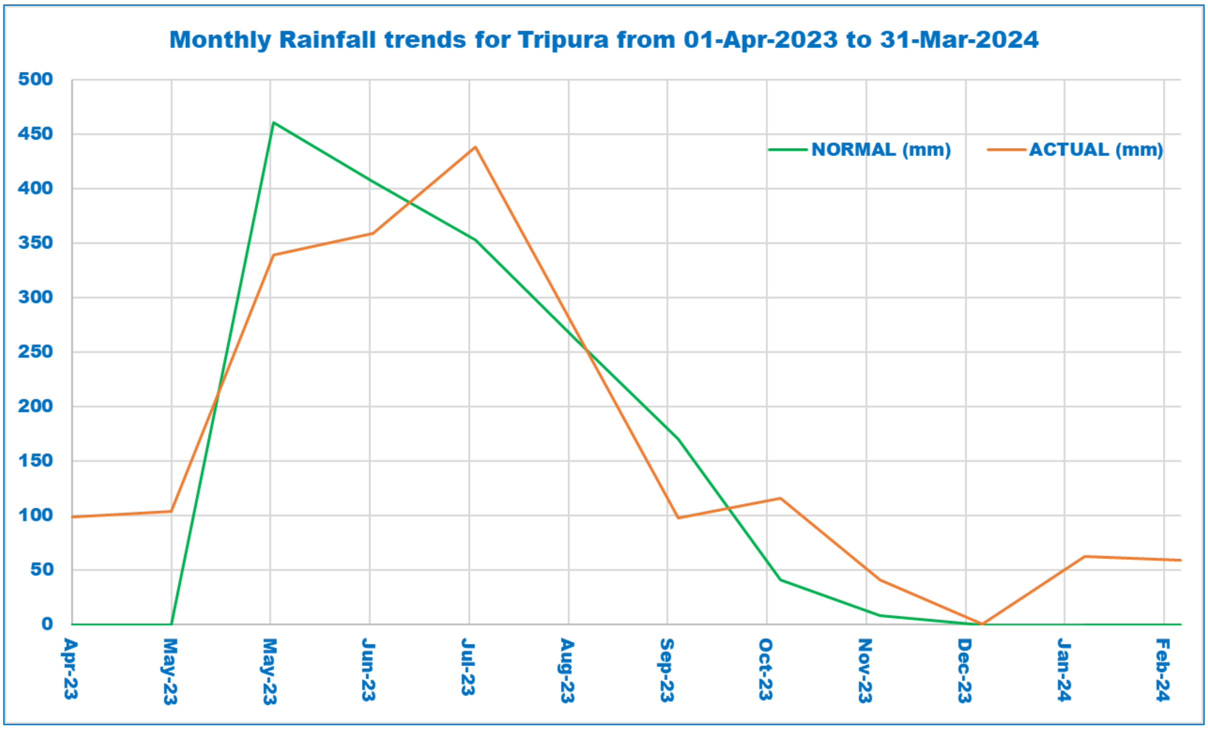


Figure 3. ***Trend for the year 2023-24 for Tripura***

Drainage

The state is characterized by a network of rivers originating from its hill ranges and flowing either northwards or westwards through narrow, terraced valleys. These valleys feature steep erosional scarps along the river banks. The rivers are fed by numerous tributaries from the catchment areas, with surface water flow ranging from 1.05 lakh m^3/km^2 in the Gomati basin to 0.2 lakh m^3/km^2 in the Buri Gang basin. The total annual river flow generated within the state is approximately 793 million cubic meters (MCM).

The Gomati River is the largest and most significant river in Tripura, carrying the maximum volume of water. It originates in the Longtharai and Atharamura ranges and flows through Amarpur and Sonamura before entering Bangladesh. The Manu River, the longest river in Tripura, originates from the Sakhan range and flows into Bangladesh via Kailasahar. The Khowai River flows northwest from the Atharamura Hills and joins the Kushiyara River in Bangladesh.

Tripura's rivers are crucial for the state's hydrology and agriculture. The state is currently harnessing the Gomati River for hydel power generation and has three medium irrigation projects: Gomati in South Tripura, Khowai in West Tripura, and Manu in North Tripura, which support small-scale irrigation. Despite these efforts, a significant volume of water from Tripura's river systems flows into neighboring Bangladesh.

The major rivers in Tripura include the Khowai, Manu, Deo, Juri, Dhalai, Longai, Gomati, Haora, Muhuri, and Buri Gang. The Longai River's catchment area is shared with Mizoram and Assam, while the Feni River's catchment is shared with Bangladesh[3]. The combined flow length of these ten major rivers within the state is about 896 km, and they all ultimately form part of the Meghna basin.

Geology

The geological formation of Tripura is quite fascinating. The state is part of the Indo-Burman ranges, also known as the Purbanchal range, which is a late Tertiary fold mountain belt1. This region is characterized by a series of north-south trending anticlinal ridges and valleys, with elevations ranging from 15 meters in the west to 780 meters in the northeast.

The geology of Tripura primarily consists of sedimentary rocks that were deposited during the Tertiary period, which lasted from about 65 million years ago to the present. These rocks are of marine, mixed, and fluvial origin, indicating a variety of depositional environments influenced by local tectonic movements. The state features several prominent ridges such as Jampui, Sakhantlang, Longtarai, Athramura, and Baramura, which form the watershed for rivers like the Khowai, Haora, Juri, Manu, and others. These geological formations have created a diverse landscape with high relief structural hills, moderately dissected ridges, and low-lying valleys.

Hydrogeology

The semi-consolidated Tertiary formations serve as the primary hydrogeological unit in Tripura. These formations are composed of friable sandstones, clayey sandstones, sandy shales, and shales. The semi-consolidated formations can be subdivided into three main zones. The first zone is located in the central part of areas such as Agartala-Udaipur, Khowai-Amarpur, Ambasa, Kailasker, Kumarghat, and Dharam Nagar syncline valleys, where yield prospects are favorable. In this region, fine to medium-grained sandstones form the principal aquifer. An artesian belt has been identified in western Tripura, with well yields ranging from 1 to 3 m^3/hr, and high autoflow discharge of 54 m^3/hr observed in the Khowai valley. The second zone is made up of unconfined aquifers with moderate regional extent, offering yield prospects of 50-100 m^3/hr. This zone borders the hill ranges and includes the marginal parts of Agartala-Udaipur, Khowai-Amarpur, Kamapur-Ambasa, Kailaskar-Kumarbagh, and Dharam Nagar valleys, though artesian conditions are rare in this zone. The third zone consists of moderately thick, discontinuous aquifers with yield prospects below 50 m^3/hr and is found in the intermontane and smaller valleys. These areas are predominantly occupied by argillaceous formations belonging to the Surma series.

Hydrochemistry

Hydrochemistry is an interdisciplinary science that deals with the chemistry of water in the natural environment. It is essential to study the entire system like atmospheric water (rainwater), surface water and ground water simultaneously in evaluating their hydrochemistry and pollution effect.

The atmosphere is composed of water vapour, dust particles and various gaseous components such as N_2, O_2, CO_2, CH_4, CO, SO_x, NO_x etc. Pollutants in the atmosphere can be transported long distances by the wind. These pollutants are mostly washed down by precipitation and partly as dry fall out. Composition of rainwater is determined by the source of water vapour and by the ion, which are taken up during transport through the atmosphere. In general, chemical composition of rainwater shows that rainwater is only slightly mineralized with specific electrical conductance (EC) generally below 50 µS/cm, chloride below 5 mg/l and HCO_3 below 10 mg/l. Among the cations, concentration of Ca, Mg, Na & K vary considerably but the total cations content is generally below 15 mg/l except in samples contaminated with dust. The concentration of sulphates and nitrates in rainwater may be high in areas near industrial hubs.

Surface water is found extremely variable in its chemical composition due to variations in relative contributions of ground water and surface water sources. The mineral content in river water usually bears an inverse relationship to discharge. The mineral content of river water tends to increase from source to mouth, although the increase may not be continuous or uniform. Other factors like discharge of city wastewater, industrial waste and mixing of waters can also affect the nature and concentration of minerals in surface water. Among anions, bicarbonates are the most important and constitute over 50% of the total anions in terms of milli equivalent per liter (meq/l). In case of cations, alkaline earths or normally calcium predominates.

The downward percolating water is not inactive, and it is enriched in CO_2. It can also act as a strong weathering agent apart from general solution effect. Consequently, the chemical composition of ground water will vary depending upon several factors like frequency of rain, which will leach out the salts, time of stay of rain water in the root-zone and intermediate zone, presence of organic matter etc. It may also be pointed out that the water front does not move in a uniform manner as the soil strata are generally quite heterogeneous. The movement of percolating water through larger pores is much more rapid than through the finer pores. The overall effect of all these factors is that the composition of ground water varies from time to time and from place to place. Before reaching the saturated zone, percolating water is charged with oxygen and carbon dioxide and is most aggressive in the initial stages. This water gradually loses its aggressiveness, as free CO_2 associated with the percolating water gets gradually exhausted through interaction of water with minerals.

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$$

$$H^+ + \text{Feldspar} + H_2O \rightarrow \text{Clay} + H_4SiO_4 + \text{Cation}$$

The oxygen present in this water is used for the oxidation of organic matter that subsequently generates CO_2 to form H_2CO_3. This process goes on until oxygen is fully consumed.

$$CH_2O + O_2 = CO_2 + H_2O$$

(Organic matter)

Apart from these reactions, there are several other reactions including microbiological mediated reactions, which tend to alter the chemical composition of the percolating water.

Methodology

To establish the ground water chemistry of the state, samples from different corners of the states of North Eastern region have been collected during the month of March/April (pre-monsoon) which is generally a dry period, leading to maximum concentration of elements in the water samples. Composite sampling has been adopted to collect water samples to make it a representative sample. The water samples so collected were chemically analyzed. While sampling for groundwater, samples were collected in Polyethylene bottles. Preservative (1:1 HCl solution, pH <2, approx. 2 ml /L sample) were added to each water samples collected for iron analysis and (1:1 HNO_3 solution, pH <2, approx. 2 ml /L sample) were added to each water samples collected for Arsenic analysis at the time of sampling and the containers were sealed. All probable safety measures were taken at every stage, starting from sample collection, storage, transportation and final analysis of the samples to avoid or minimize contamination.

Analysis of samples for other physico-chemical and elemental constituents was carried out as per the standard practice stipulated by APHA, 2024 guidelines (APHA, 2024). The parameters which are concerned other than arsenic is pH, conductivity, turbidity, alkalinity, total dissolved solids, chloride, total hardness, calcium, magnesium, sulphate, nitrate, sodium, potassium, fluoride and iron. The samples were analyzed in Regional Chemical Laboratory, CGWB, NER.

WATER QUALITY CRITERIA

Introduction

The quality of groundwater is determined by a combination of processes and reactions that occur from the time water condenses in the atmosphere to when it is extracted as groundwater. As water moves across and infiltrates land resources, it has a remarkable ability to dissolve and accumulate substances from geological materials, biological processes, and human activities. Urbanization, agricultural practices, and the disposal of municipal and industrial waste significantly influence the characteristics of groundwater. Factors such as climatic conditions, topography, geological formations, and the exploitation or mismanagement of this critical resource further affect its quality, causing variations across different locations.

Water quality criteria and standards are defined based on the intended use of the water. The requirements for water quality differ depending on whether the water is for human consumption, livestock, irrigation, industrial purposes, or other uses. Water quality criteria refer to scientific data that are assessed to provide recommendations for water characteristics suitable for specific uses. On the other hand, water quality standards represent established rules, principles, or measures set by statutory authorities. It is crucial to distinguish between criteria and standards, as they are not synonymous and cannot be used interchangeably. Standards are grounded in criteria, designated uses, implementation methods, and monitoring procedures. Changes in any of these factors may necessitate modifications to the standards. When formulating water quality criteria, the selection of specific water quality parameters is based on the intended use of the water. Sayers et al. (1976, as cited in CGWB & CPCB 2000), identified key water quality parameters relevant to different uses (Table 1).

Table 1. ***Water quality criteria parameters for various uses (Sayers et.al., 1976)***

Public Water Supply	**Industrial Water Supply**	**Agricultural Water Supply**	**Aquatic Life & Wild Life Water Supply**	**Recreation and Aesthetics**
Coliform bacteria, Turbidity, colour, Taste, Odour, TDS, CI, F, SO_4, NO_3, CN, Trace Metals, Trace Organics Radioactive substances	Processing pH, Turbidity, Colour, Alkalinity, Acidity, TDS, Suspended solids, Trace metals, Trace Organics Cooling PH, Temp, Silica, AI, Fe, Mg, Total hardness, Alkalinity/ Acidity Suspended solids, Salinity	Farmstead Same as for public supply Live-stock Same as for public supply Irrigation TDS, EC, Na, Ca, Mg, K, B, Cl and Trace metals	Temp, DO, pH, Alkalinity, Acidity, TDS Salinity, pH, DCOs, Turbidity, Colour, Settleable materials, Toxic substances, Nutrients, Floating materials	Recreations Tem, Turbidity, Colour, Odour, Floating Materials, Settable Materials Nutrients, Coliforms Aesthetics Same as for Recreation and Substances adversely affecting wild life

Water Quality Criteria for Drinking Purpose

To safeguard water from degradation and establish a foundation for improving water quality, various national and international organizations have developed standards, guidelines, and regulations. These include the Bureau of Indian Standards (BIS), the World Health Organization (WHO), the European Economic Community (EEC), the Environmental Protection Agency (EPA) of the United States, and the Inland Waters Directorate of Canada. The Bureau of Indian Standards (BIS), formerly known as the Indian Standards Institution (ISI), first established drinking water standards in 1983, which have been periodically revised and updated. To aid users in making informed decisions regarding water quality, the BIS has prescribed maximum permissible limits, particularly in situations where alternative water sources are unavailable.

The national water quality standards define essential and desirable characteristics that must be evaluated to determine the suitability of water for drinking purposes. The key water quality parameters outlined in the BIS standard (IS 10500: 2012) are summarized in Table 2. These standards serve as a critical reference for ensuring safe and potable water, promoting public health, and guiding water quality management practices.

Table 2. Drinking Water Characteristics (IS 10500: 2012)

S.No.	Parameters	Desirable Limits (mg/L)	Permissible limits (mg/L)
Essential Characteristics			
1	Colour Hazen Unit	5	15
2	Odour	Unobjectionable	-
3	Taste	Agreeable	-
4	Turbidity(NTU*)	1	5
5	pH	6.5-8.5	No Relaxation
6	TotalHardness,$CaCO_3$	200	600
7	Iron(Fe)	1.0	No Relaxation
8	Chloride(Cl)	250	1000
9	Residual Free Chlorine	0.2	1
10	Fluoride(F)	1.0	1.5
Desirable Characteristics			
11	DissolvedSolids	500	2000
12	Calcium(Ca)	75	200
13	Magnesium(Mg)	30	100
14	Copper(Cu)	0.05	1.5
15	Manganese(Mn)	0.1	0.3
16	Sulphate(SO4)	200	400

S.No.	Parameters	Desirable Limits (mg/L)	Permissible limits (mg/L)
17	Nitrate(NO3)	45	No Relaxation
18	PhenolicCompounds	0.001	0.002
19	Mercury(Hg)	0.001	No Relaxation
20	Cadmium(Cd)	0.003	No Relaxation
21	Selenium(Se)	0.01	No Relaxation
22	Arsenic(As)	0.01	No Relaxation
23	Cyanide(CN)	0.05	No Relaxation
24	Lead(Pb)	0.01	No Relaxation
25	Zinc(Zn)	5.0	15
26	HexavalentChromium	0.05	No Relaxation
27	Alkalinity	200	600
28	Aluminum(Al)	0.03	0.2
29	Boron(B)	0.5	2.4
30	Pesticides	Absent	0.001
31	Uranium	0.03	No Relaxation

*__NTU__-Nephelometric Turbidity Unit.

N.B. *The fluoride limits vary with average annual temperature of the areas. Similarly, the limits for magnesium are based on sulphate contents of water. When sulphate content is 250 mg/L or above, the magnesium should be between 30 and 50 mg/L but if sulphate is lower, higher content of magnesium is permissible.*

Water Quality Criteria for Irrigation Purpose

Water quality plays a significant role in irrigated agriculture. Many problems originate due to inefficient management of water for agriculture use, especially when it carries high salt loads. The effect of total dissolved salts in irrigation water (measured in terms of electrical conductance) on crop growth is extremely important. Soil water passes in to the plant through the root zone due to osmotic pressure and the plants root able to assimilate water and nutrients. Thus, the dissolved solid contents of the residual water in the root zone also have to be maintained within limits by proper leaching. These effects are visible in plants by their stunted growth, low yield, discoloration and even leaf burns at margin or top. The safe limits of electrical conductivity for crops of different degrees of salt tolerances under varying soil textures and drainage conditions are presented in Table 3.

Table 3. Safe Limits for electrical conductivity for irrigation water (IS:11624-1986)

S. No.	Nature of soil	Crop Growth	Upper permissible safe limit of electrical conductivity in water (µs/cm at 25°C)
1	Deep black soil and alluvial soils having clay content more than 30%; soils that are fairly to moderately well Drained	Semi-tolerant	1500
		Tolerant	2000
2	Textured soils having clay contents of 20-30%; soils that are well drained internally and have good surface drainage system	Semi-tolerant	2000
		Tolerant	4000
3	Medium textured soils having clay10-20%; internally very well drained and having good surface drainage system	Semi-tolerant	4000
		Tolerant	6000
4	Light textured soils having clay less than10%; soils that have excellent Internal and surface drainage system.	Semi-tolerant	6000
		Tolerant	8000

In addition to problems caused by total amount of salts, some of the specific ions like sodium, boron and trace elements, if present in water in excess, also render it unsuitable for agricultural use.

Effects of Water Quality Parameters on Human Health and Distribution for Various Users

It is essential to ensure that various constituents are within prescribed limits in drinking water supplies to avoid impact on human health (Table 4). Man, life forms and domestic animals are affected by alteration in water quality due to natural or anthropogenic reasons. The effect of these substances depends on the quantity of water consumed per day and their concentration in water.

Table 4. Effects of water quality parameters on human health when used for drinking Purpose

S.No.	Parameters	Prescribed limits IS:10500,2012		Probable Effects
		Desirable Limit	Permissible Limit	
1	Colour (Hazen unit)	5	15	Makes water aesthetically undesirable
2	Odour	Essentially free from objectionable odour		Makes water aesthetically undesirable
3	Taste	Agreeable		Makes water aesthetically undesirable
4	Turbidity (NTU)	1	5	High turbidity indicates contamination/Pollution.
5	pH	6.5	8.5	Indicative of acidic or alkaline waters, affects taste, corrosivity and the water supply system
6	Hardnessa sCaCO3 (mg/L)	200	600	Affects water supply system (Scaling), Excessive soap consumption, and calcification of arteries. There is no conclusive proof but it may cause urinary concretions, diseases of kidney or bladder and stomach disorder.
7	Iron(mg/L)	1.0	No Relaxation	Gives bitter sweet astringent taste, causes staining of laundry and porcelain. Intracesitis essential for nutrition.
8	Chlori de(mg/ L)	250	1000	May be injurious to some people suffering from diseases of heart or kidneys. Taste, indigestion, corrosion and palatability are affected.

S.No.	Parameters	Prescribed limits IS:10500,2012		Probable Effects
		Desirable Limit	Permissible Limit	
9	Residual Chlorine (mg/L) Only when water is Chlorinated	0.20	-	Excessive chlorination of drinking water may cause asthma,colitis and eczema.
10	Total Dissolved Solids-TDS (mg/L)	500	2000	Palatability decreases and may cause gastro intestinal irritation inhuman, may have laxative effect particularly upon transits and corrosion may damage water system.
11	Calcium (Ca) (mg/L)	75	200	Causes encrustation in water supply system. While insufficiency causes a severe type of rickets, excess causes concretions in the body such as kidney or bladder stones and Irritation in urinary passages.
12	Magnesium (Mg) (mg/L)	30	100	Its salts are cathartics and diuretic. High concentration may have laxative effect particularly on new users. Magnesium deficiency is associated with structural and functional changes. It is essential as an activator of many enzyme systems.
13	Copper (Cu) (mg/L)	0.5	1.50	Astringent taste but essential and beneficial element in human metabolism. Deficiency results in nutritional anemia in infants. Large amount may result in liver damage, cause central nervous system

S.No.	Parameters	Prescribed limits IS:10500,2012		Probable Effects
		Desirable Limit	Permissible Limit	
				irritation and depression. In water supply it enhance corrosion of aluminum in particular
14	Sulphate (SO_4) (mg/L)	200	400	Causes gastro intestinal irritation along with Mg or Na, can have acathartic effect on users, concentration more than 750mg/L may have laxative effect along with Magnesium.
15	Nitrate (NO_3) (mg/L)	45	No relaxation	Cause infant methaemoglobin anemia (bluebabies) at very high concentration, causes gastric cancer and affects adversely Central nervous system and cardiovascular system.
16	Fluoride(F) (mg/L)	1.0	1.50	Reduce dental carries, very high concentration may cause crippling skeletal fluorosis.
17	Cadmium(Cd) (mg/L)	0.003	No relaxation	Acute toxicity may be associated with renal, arterial hypertension, itai-itai disease, (a bone disease).Cadmium salt causes cramps, nausea, vomiting and diarrhea.
18	Lead(Pb) (mg/L)	0.01	No relaxation	Toxic in both acute and chronic exposures. Burning in the mouth, severe inflammation of the gastro-intestinal tract with vomiting and diarrhea, chronic toxicity produces nausea, severe

S.No.	Parameters	Prescribed limits IS:10500,2012		Probable Effects
		Desirable Limit	Permissible Limit	
				abdominal pain, paralysis, mental confusion, visual disturbances, anaemia etc.
19	Zinc(Zn) (mg/L)	5	15	An essential and beneficial element in human metabolism. Taste threshold for Zn occurs at about 5mg/L imparts a stringent taste to water.
20	Chromium (Cr^{6+})(mg/L)	0.05	No relaxation	Hexavalent state of Chromium produces lung tumors can produce cutaneous and nasal mucous membrane ulcers and Dermatitis.
21	Boron(B) (mg/L)	0.5	2.4	Affects central nervous system its salt may cause nausea, cramps, convulsions, coma, etc.
22	Alkalinity (mg/L) as $CaCO_3$	200	600	Impart distinctly unpleasant taste may be deleterious to human being in presence of high pH, hardness and total dissolved solids.
23	Pesticides:(mg/l)	Absent	0.001	Imparts toxicity and accumulated in different organs of human body affecting immune and nervous systems may be carcinogenic.
24	Phosphate (PO_4) (mg/L)	No guideline		High concentrate ion may cause vomiting and diarrhea, stimulate secondary hyperthyroidism and bone loss

S.No.	Parameters	Prescribed limits IS:10500,2012		Probable Effects
		Desirable Permissible Limit	Limit	
25	Sodium(Na) (mg/L)	No guidelines		Harmful to persons suffering From cardiac, renal and circulatory diseases.
26	Potassium (K) (mg/L)	No guidelines		An essential nutritional element but its excessive amounts is cathartic
27	Silica(SiO_2) (mg/L)	No guidelines		-
28	Nickel (Ni) (mg/L)	0.02		Non-toxic element but may be carcinogenic in animals, can react with DNA resulting in DNA damage in animals.
29	Pathogens(a) Total coliform (per100ml) (b) Faecal Coliform (per100ml)	nil		Cause water borne diseases like coliform Jaundice, Typhoid, Cholera etc. produce infections involving skin mucous membrane of eyes, ears and throat.
30	Arsenic (mg/L)	0.01	No relaxation	Various skin diseases, Carcinogenic
31	Uranium (mg/L)	0.03	No relaxation	Kidney disease, Carcinogenic

ASSESSMENT OF GROUND WATER QUALITY FOR DRINKING PURPOSES

The physical parameters examined include appearance, color, odor, taste, turbidity, electrical conductivity, and total dissolved solids. The chemical parameters assessed include pH, alkalinity, total hardness, calcium, magnesium, iron, sodium, potassium, nitrate, chloride, fluoride, and sulphate. The results were compared with the drinking water standards set by BIS (IS 10500:2012). The overall chemical quality of water in Tripura for the year 2023-2024 is detailed in Annexure 6.

Drinking water specification

The latest drinking water specifications by the Bureau of Indian Standards (BIS) are outlined in IS 10500: 2012 (Second Revision).

Table 5. Organoleptic and Physical Parameters [BIS, IS 10500]

Sl No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit in the absence of Alternate Source	Method of Test
i)	Odour	Agreeable	Agreeable	Part 5
ii)	pH value	6.5-8.5	No relaxation	Part 11
iii)	Taste	Agreeable	Agreeable	Parts 7 and 8
iv)	Turbidity, NTU, Max	1	5	Part 10
v)	Total dissolved solids, mg/l, Max	500	2 000	Part 16

NOTE — It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under 'acceptable' render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under 'permissible limit in the absence of alternate source' in col 4, above which the sources will have to be rejected.

Table 6. General Parameters Concerning Substances Undesirable in Excessive amounts

Sl No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit in the absence of Alternate Source	Method of Test
i)	Aluminium (as Al), mg/l, Max	0.03	0.2	IS 3025 (Part 55)
ii)	Ammonia (as total ammonia-N), mg/l, Max	0.5	No relaxation	IS 3025 (Part 34)

Sl No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit in the absence of Alternate Source	Method of Test
iii)	Anionic detergents (as MBAS), mg/l, Max	0.2	1.0	Annex K of IS 13428
iv)	Barium (as Ba), mg/l, Max	0.7	No relaxation	Annex F of IS 13428* or IS 15302
v)	Boron (as B), mg/l, Max	0.5	1.0	IS 3025 (Part 57)
vi)	Calcium (as Ca), mg/l, Max	75	200	IS 3025 (Part 40)
vii)	Chloramines (as Cl2), mg/l, Max	4.0	No relaxation	IS 3025 (Part 26)* or APHA 4500-Cl G
viii)	Chloride (as Cl), mg/l, Max	250	1 000	IS 3025 (Part 32)
ix)	Copper (as Cu), mg/l, Max	0.05	1.5	IS 3025 (Part 42)
x)	Fluoride (as F) mg/l, Max	1.0	1.5	IS 3025 (Part 60)
xi)	Free residual chlorine, mg/l, Min	0.2	1	IS 3025 (Part 26)
xii)	Iron (as Fe), mg/l, Max	1.0	No relaxation	IS 3025 (Part 53)
xiii)	Magnesium (as Mg), mg/l, Max	30	100	IS 3025 (Part 46)
xiv)	Manganese (as Mn), mg/l, Max	0.1	0.3	IS 3025 (Part 59)
xv)	Mineral oil, mg/l, Max	0.5	No relaxation	Clause 6 of IS 3025 (Part 39) Infrared partition method
xvi)	Nitrate (as NO3), mg/l, Max	45	No relaxation	IS 3025 (Part 34)
xvii)	Phenolic compounds (as C6H5OH), mg/l, Max	0.001	0.002	IS 3025 (Part 43)
xviii)	Selenium (as Se), mg/l, Max	0.01	No relaxation	IS 3025 (Part 56) or IS 15303*
xix)	Silver (as Ag), mg/l, Max	0.1	No relaxation	Annex J of IS 13428
xx)	Sulphate (as SO4) mg/l, Max	200	400	IS 3025 (Part 24)
xxi)	Sulphide (as H2S), mg/l, Max	0.05	No relaxation	IS 3025 (Part 29)
xxii)	Total alkalinity as calcium carbonate, mg/l, Max	200	600	IS 3025 (Part 23)
xxiii)	Total hardness (as CaCO3), mg/l, Max	200	600	IS 3025 (Part 21)
xxiv)	Zinc (as Zn), mg/l, Max	5	15	IS 3025 (Part 49)

NOTES

1 In case of dispute, the method indicated by '*' shall be the referee method.

2 It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under ‘acceptable’ render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under ‘permissible limit in the absence of alternate source’ in col 4, above which the sources will have to be rejected.

Table 7. Parameters Concerning Toxic Substances.

Sl No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit in the absence of Alternate Source	Method of Test
	Cadmium (as Cd), mg/l, Max	0.003	No relaxation	IS 3025 (Part 41)
	Cyanide (as CN), mg/l, Max	0.05	No relaxation	IS 3025 (Part 27)
	Lead (as Pb), mg/l, Max	0.01	No relaxation	IS 3025 (Part 47)
	Mercury (as Hg), mg/l, Max	0.001	No relaxation	IS 3025 (Part 48)/ Mercury analyser
	Molybdenum (as Mo), mg/l,	0.07	No relaxation	IS 3025 (Part 2)

Sl No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit in the absence of Alternate Source	Method of Test
	Max			
	Nickel (as Ni), mg/l, Max	0.02	No relaxation	IS 3025 (Part 54)
	Polychlorinated biphenyls, mg/l, Max	0.000 5	No relaxation	ASTM 5175* or APHA 6630
	Polynuclear aromatic hydro-carbons (as PAH), mg/l, Max	0.000 1	No relaxation	APHA 6440
	Total arsenic (as As), mg/l, Max	0.01	No	IS 3025 (Part 37)
	Total chromium (as Cr), mg/l, Max	0.05	No relaxation	IS 3025 (Part 52)
	Trihalomethanes:			
	a) Bromoform, mg/l, Max	0.1	No relaxation	ASTM D 3973-85*or APHA 6232
	b) Dibromochloromethane, mg/l, Max	0.1	No relaxation	ASTM D 3973-85*or APHA 6232
	c) Bromodichloromethane, mg/l, Max	0.06	No relaxation	ASTM D 3973-85*or APHA 6232
	d) Chloroform, mg/l, Max	0.2	No relaxation	ASTM D 3973-85* or APHA 6232

NOTES
1. In case of dispute, the method indicated by '*' shall be the referee method.
2. It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under ‘acceptable’ render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under 'permissible limit in the absence of alternate source’ in col 4, above which the sources will have to be rejected.

Table 8. Parameters Concerning Radioactive Substances

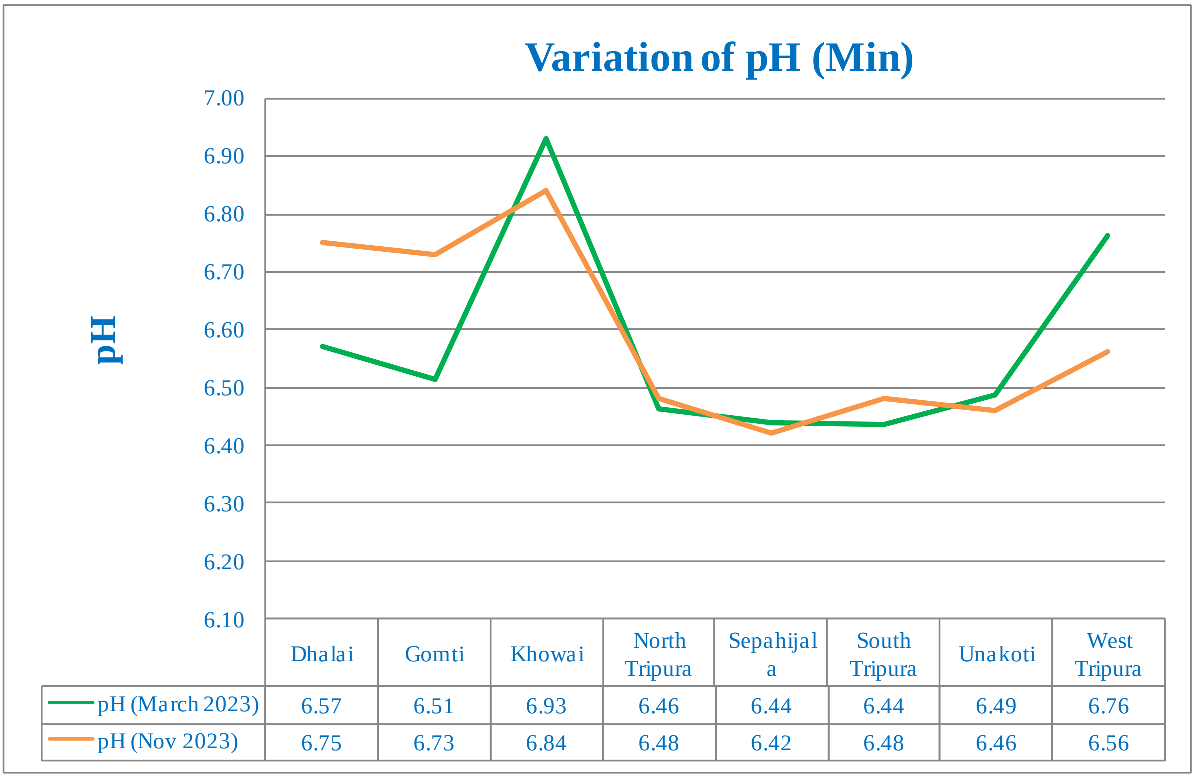
Sl No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit in the absence of Alternate Source	Method of Test
	Radioactive materials:			
	a) Alpha emitters Bq/l, Max	0.1	No relaxation	Part 2
	b) Beta emitters Bq/l, Max	1.0	No relaxation	Part 1

NOTE — It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under ‘acceptable’ render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under ‘permissible limit in the absence of alternate source’ in col 4, above which the sources will have to be rejected.

Ground water quality for domestic purposes

The **Figure 4 and 5** shows the variation in the pH levels across different districts in Tripura during the Pre-Monsoon (March 2023) and Post-Monsoon (November 2023). The first graph illustrates the maximum pH values, while the second graph shows the minimum pH values recorded in each district.

The two graphs represent the minimum and maximum pH values across different districts of Tripura for pre-monsoon and post-monsoon 2023, offering insight into the range of water pH levels across two seasons. The maximum pH are consistently in the alkaline range (above 7.0) across both the seasons, fluctuating between 7.91 (March 2023) and 8.13 (November 2023) in Khowai district and the minimum pH values exhibit a more neutral to slightly acidic range, with values between 6.44 and 6.42 in Sepahijala district during the pre-monsoon and post-monsoon seasons respectively. From March to November, most districts show a slight increase in pH values, particularly in Khowai, which rises from 7.91 to 8.13, and in Gomti, which sees an increase from 7.39 to 7.86. However, a few regions, like North Tripura, show a slight decrease. In contrast, the minimum pH levels do not exhibit as much increase. Noticeably, some areas like Dhalai and South Tripura show only minor shifts, while Sepahijala sees a slight drop in pH, from 6.44 to 6.42. This suggests that maximum pH values tend to rise during November, possibly due to the dissolution of minerals particularly silicate and carbonate minerals present in the sub surface area during the infiltration of rain water.



	Dhalai	Gomti	Khowai	North Tripura	Sepahijala	South Tripura	Unakoti	West Tripura
pH (March 2023)	6.57	6.51	6.93	6.46	6.44	6.44	6.49	6.76
pH (Nov 2023)	6.75	6.73	6.84	6.48	6.42	6.48	6.46	6.56

Figure 4 Variation of Minimum pH in the year

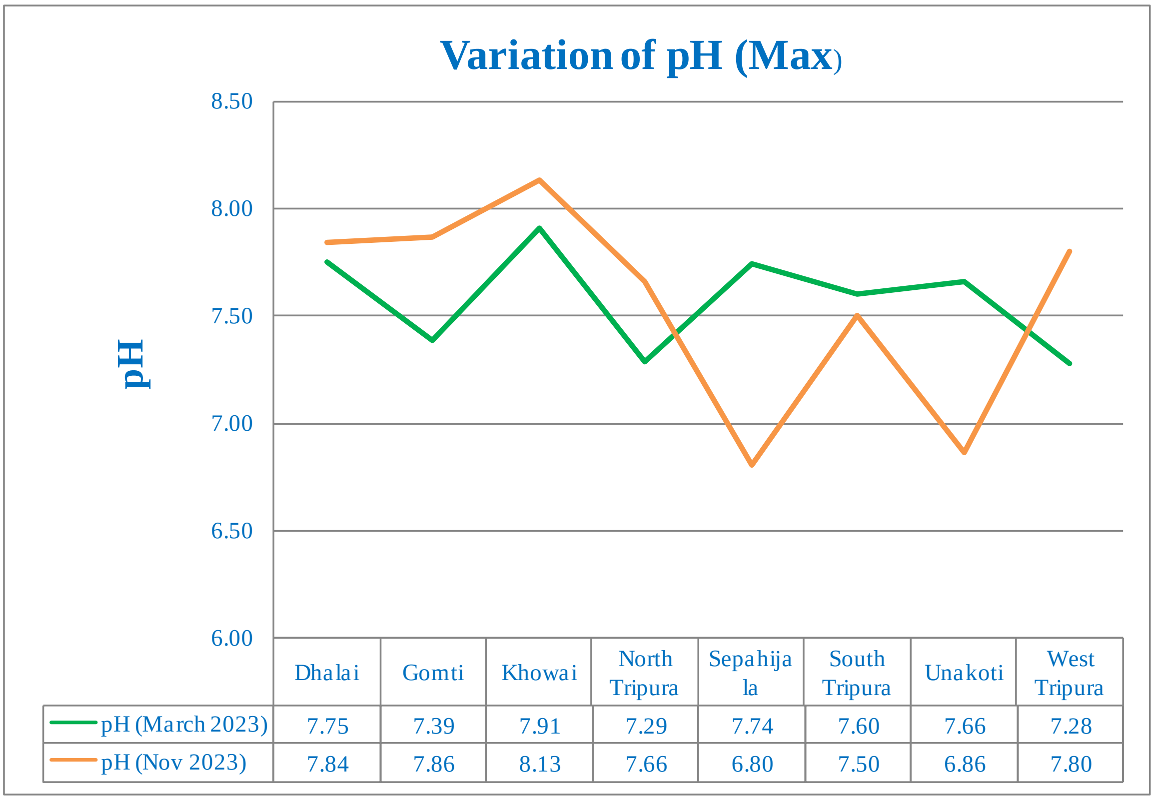


Figure 5 Variation of Maximum pH in the year

The **Figure 6** shows the spatial distribution of electrical conductivity (EC) in Tripura for the pre-monsoon (March 2023-24) and post-monsoon (November 2023-24) seasons, with values generally below 750 µS/cm across all districts, indicating good water quality. Although the Bureau of Indian Standards (BIS) has not set a specific permissible limit for EC in drinking water, an EC value of below 2500 µS/cm is often considered an acceptable threshold. Both maps reveal that the entire state remains under this value, except for the 45 Miles location in Khowai district, where the EC increases from 711 µS/cm in the pre-monsoon season to 766.90 µS/cm in the post-monsoon season. This rise can be attributed to post-monsoon runoff, which can leach salts and other dissolved ions into groundwater, leading to a slight increase in EC at this location due to higher mineral dissolution and concentration.

The statistical analyzed data infer that the water quality in the different districts of Tripura varies significantly. The districts of Dhalai, Khowai, and Sepahijala have the highest EC and TDS values, which suggests that the water in these regions may be more mineral-rich and potentially harder. In contrast, the districts of North Tripura and West Tripura have the lowest EC and TDS values, indicating that the water in these regions may be softer and have lower mineral content.

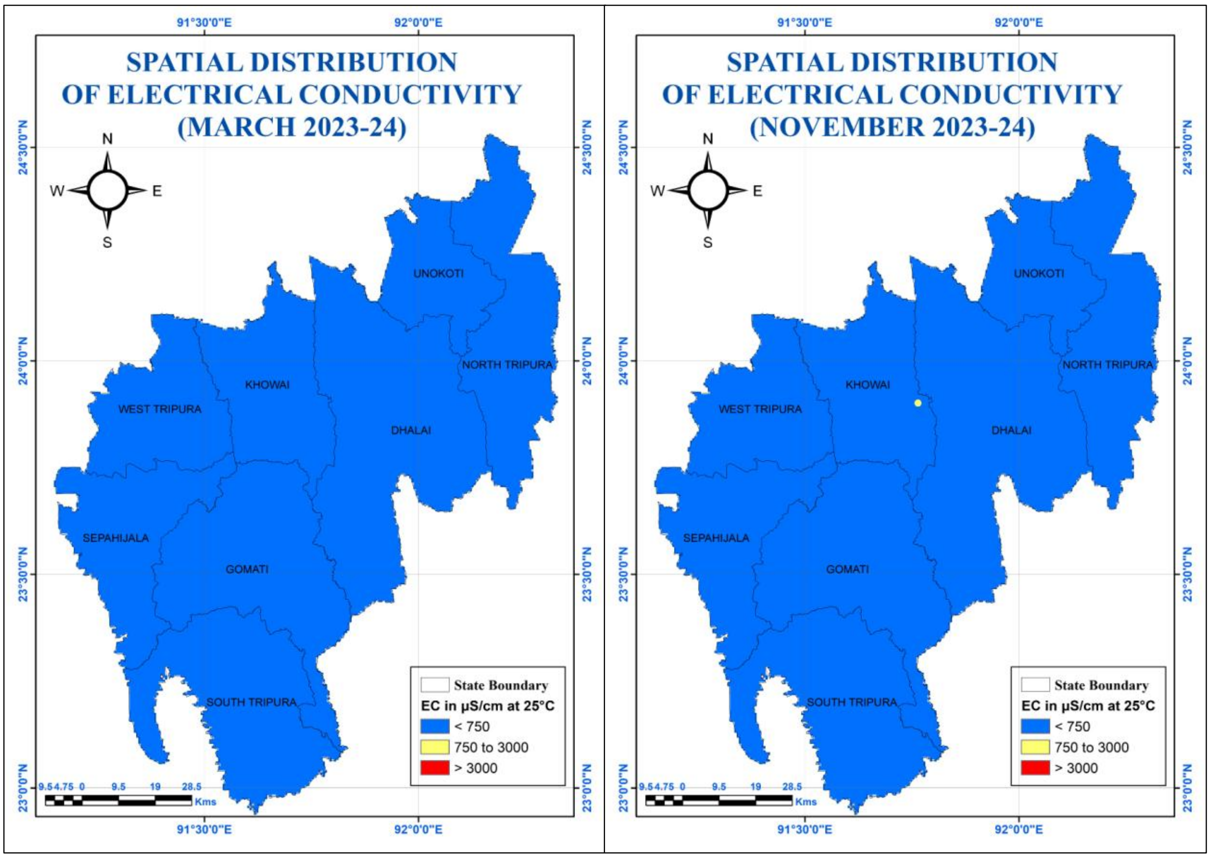


Figure 6 Spatial distribution of Electrical Conductivity (EC) in Tripura

Cations: The districts of Dhalai, Khowai, Sepahijala, and Unakoti have higher ranges of Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) and Total Hardness (TH). These districts are known for having hard water due to the presence of sedimentary rocks and limestone deposits in the region. The groundwater in these districts comes in contact with these rocks and dissolves minerals like calcium and magnesium, resulting in hard water. Sodium and potassium are monovalent cations that are not harmful to human health at normal concentrations. Sodium is important for maintaining body fluid balance, while potassium is essential for muscle and nerve function. However, high levels of sodium can cause water to taste salty and can be harmful to individuals with high blood pressure. The districts of Gomti, North Tripura, South Tripura, and West Tripura have higher ranges of Na+ and K+. These districts are known for having alluvial soils with a high concentration of sodium and potassium. The groundwater in these districts comes in contact with these soils and dissolves sodium and potassium, resulting in elevated levels of these cations in the water.

The **Figure 7** illustrates the locations in Tripura where iron (Fe) concentrations in groundwater exceeded the BIS permissible limit of 1 mg/L during 2023-24, with values ranging from 1.0748 mg/L to 5.0371 mg/L. The highest concentration was recorded at Purba Takka in South Tripura, at 5.0371 mg/L, while the lowest was found at Baishnabpur in the same district, with 1.0748 mg/L. Other notable locations include Krishnapur in North Tripura, with an iron concentration of 2.9772 mg/L, and several sites in the Gomti district, such as Gorjee Bazar and Bampur, where concentrations slightly exceeded 1.9 mg/L. All of these values significantly surpass the BIS's recommended limit of 1 mg/L for iron in drinking water. The elevated levels of iron can be attributed to the region's geological characteristics, particularly the presence of iron-rich minerals in the soil, which leach into the groundwater, especially in areas with lateritic soils. Interestingly, the iron concentration tends to be lower in the post-monsoon season compared to the pre-monsoon period. This reduction is primarily due to dilution by monsoon rains, which flush out some of the dissolved minerals and iron deposits from the soil, temporarily lowering the concentration in groundwater sources. However, in the pre-monsoon season, as the water table recedes, iron concentration increases as a result of reduced water volume and enhanced mineral dissolution from the surrounding geology.

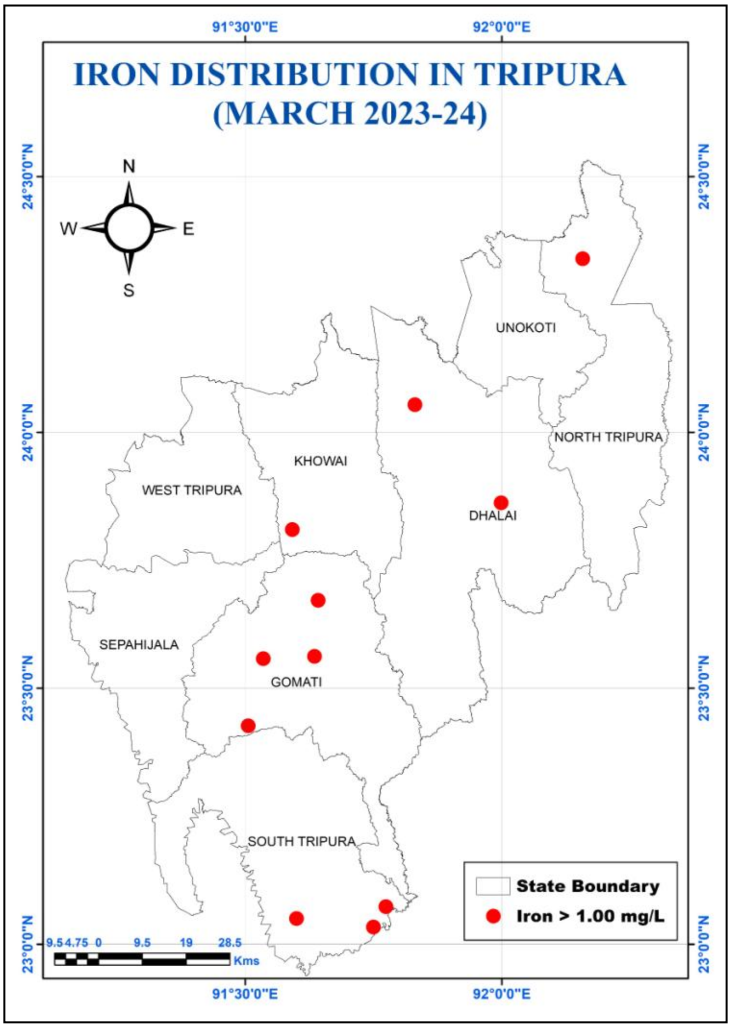


Figure 7 Distribution of Iron across different districts of Tripura

Anions: The anion content of groundwater in Tripura, including chloride (Cl), bicarbonate (HCO_3^-), sulfate (SO_4^{2-}), and fluoride (F^-), remains within the permissible limits set by the Bureau of Indian Standards (BIS), and their concentrations are generally lower in the post-monsoon period compared to the pre-monsoon period. The nitrate (NO_3^-) concentrations in the groundwater of Tripura, particularly in locations like Kanchanbari, Sadhupara, Panisagar, and Madhuban, can be attributed to several scientific factors. During the pre-monsoon season, higher nitrate concentrations, especially in Panisagar (45.73 mg/L) and Madhuban (45.37 mg/L), may be linked to the accumulation of nitrates from natural sources such as organic matter decomposition and limited agricultural inputs, as there is no intensive agricultural activity in the state. The high concentration is further exasperated by the dry conditions preceding the monsoon leading to the high concentration of nitrate ions due to lower water levels. This seasonal reduction in anion concentrations is primarily due to the dilution effect caused by the infiltration of rainwater during the monsoon. Heavy rainfall increases the volume of water in the aquifers, diluting the concentrations of dissolved anions. Rainwater typically contains fewer dissolved ions compared to groundwater, which reduces the overall ion concentration in the post-monsoon season. Moreover, surface runoff during monsoon rains can further wash away soluble salts and minerals, reducing their availability for groundwater recharge. As a result, the natural recharge of aquifers during the monsoon contributes to lower levels of these anions in groundwater in the post-monsoon period, while still maintaining concentrations within safe and acceptable limits.

However, in Kanchanbari and Sadhupara the NO_3^- concentration is observed to be higher in the post-monsoon than in the pre-monsoon season. The increase in nitrate (NO_3^-) concentrations can be attributed to several interrelated factors.

- **Increased Water Table**: Post-monsoon, the groundwater table rises due to the substantial rainfall, leading to a greater availability of water in the soil. This influx of water can help mobilize nitrates that have been present in the soil or groundwater but were previously less accessible during the drier pre-monsoon season.
- **Nitrate Leaching**: During the monsoon, heavy rainfall can result in the leaching of nitrates from surface soils into the groundwater. Even in areas with no intensive agriculture, natural sources such as organic decomposition, wastewater infiltration, and the use of fertilizers in residential gardening or small-scale agricultural practices

can contribute to elevated nitrate levels. The rain can wash these nitrates down into the groundwater, leading to higher post-monsoon concentrations.

- **Dilution and Redistribution**: The physical properties of soil and groundwater systems also play a role. While some areas may experience an overall increase in nitrate levels due to leaching, others might see a dilution effect depending on the surrounding land use and environmental conditions. In some cases, this increased concentration may be localized due to the specific characteristics of the groundwater flow in the region.
- **Seasonal Biological Activity**: Post-monsoon, biological activity tends to increase due to the availability of moisture, which can influence nitrogen cycling. Microbial processes, including nitrification, may be enhanced, contributing to the production of nitrates in the soil that can subsequently percolate into groundwater.

Trend analysis of significant parameters

Trend analysis is necessary in order to determine whether the measured values of the water quality variables increase or decrease during a time period. In this case we have studied 5 years trend of some significant parameters in groundwater of Tripura.

The **Figure 8** shows the trend of Electrical Conductivity (EC) in micro-Siemens per cm over the past five years (2019-20 to 2023-24) across the 8 districts of Tripura, namely Dhalai, Gomti, Khowai, North Tripura, Sepahijala, South Tripura, Unakoti, and West Tripura. In the year 2019-20, represented by the blue line, EC values are relatively low across most districts, indicating lower concentrations of dissolved ions in the water. The following year, 2020-21 (orange line), shows a slight rise in EC, particularly in Khowai and North Tripura. By 2021-22 (grey line), Electrical Conductivity further increases, peaking in Khowai and North Tripura. The year 2022-23 (yellow line) sees the highest spikes in EC, with Gomti and Khowai exhibiting the largest jumps, exceeding 2000 µS/cm. In 2023-24 (light blue line), a decline in EC is observed in most districts, although Gomti and Khowai still show higher values.

Analyzing district-wise patterns, Gomti and Khowai experience significant increases in EC in recent years, especially in 2022-23. North Tripura consistently displays high EC values compared to other districts, though with some fluctuations. Dhalai and South Tripura maintain lower EC levels throughout the years, reflecting stable or low ion concentration in their water systems. Unakoti and West Tripura exhibit modest increases over the years but remain within a lower range compared to districts like Gomti and Khowai.

Table 9 Average Electrical Conductivity for the 5 years across the districts

District	2019-20	2020-21	2021-22	2022-23	2023-24
Dhalai	286.0	315.2	284.0	284.0	216.9
Gomti	396.2	176.6	163.1	163.1	201.9
Khowai	410.0	591.3	342.3	342.3	306.9
North Tripura	339.0	305.8	282.5	282.5	243.6
Sepahijala	225.3	360.3	326.6	326.6	156.0
South Tripura	168.5	176.6	211.9	211.9	166.4
Unakoti	257.7	251.3	235.9	235.9	201.6
West Tripura	181.5	177.5	222.6	222.6	162.2

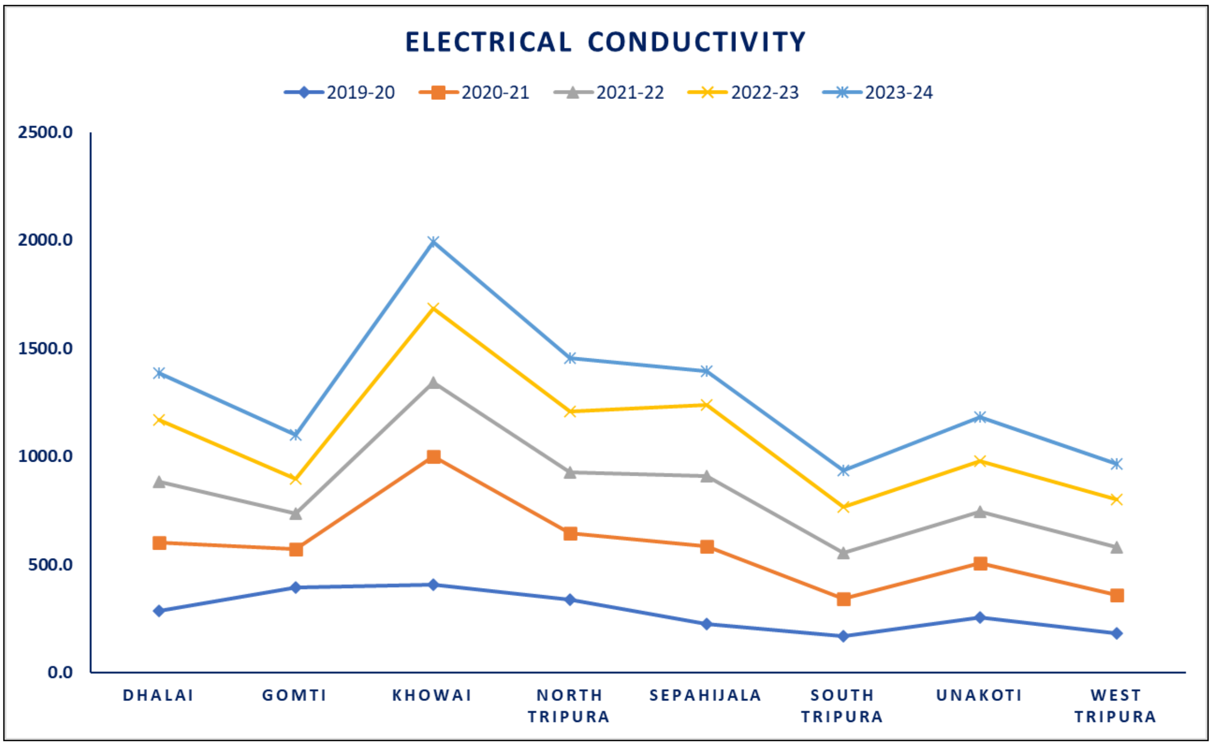


Figure 8 Trend of Eletrical Conductivity in the districts of Tripura

The variations in EC values could be attributed to seasonal effects, such as changes in rainfall and water flow influencing ion concentrations in rivers and water bodies. Additionally, natural factors like geological influences on groundwater composition can also play a role in increasing EC levels.

The **Figure 9** depicts the trend of Nitrate levels (mg/L) across different districts of Tripura over five years (2019-20 to 2023-24). All the recorded nitrate concentrations remain well within the BIS permissible limit of 45 mg/L, reflecting relatively low nitrate pollution. The most noticeable trend is in 2019-20, where districts like Sepahijala and South Tripura show spikes above 20 mg/L, followed by a sharp decline in subsequent years. From 2020-21 to 2023-24, nitrate levels across districts are generally stable, with slight increases in Gomti, Khowai, and West Tripura during 2022-23. Districts such as North Tripura, Unakoti, and Dhalai maintain consistently low nitrate levels throughout the years. The relatively low nitrate concentrations align with the absence of intensive agricultural practices in the region, suggesting minimal fertilizer runoff or nitrate contamination in water sources.

Table 10 Average Nitrate concentration (mg/L) for the 5 years across the districts

District	2019-20	2020-21	2021-22	2022-23	2023-24
Dhalai	3.22	1.37	1.85	1.85	8.71
Gomti	2.74	0.00	2.39	2.39	13.27
Khowai	4.27	3.01	2.48	2.48	8.74
North Tripura	4.26	1.92	2.32	2.32	15.05
Sepahijala	0.66	0.05	1.37	1.37	7.93
South Tripura	1.20	0.36	0.53	0.53	3.75
Unakoti	4.56	0.55	1.91	1.91	8.58
West Tripura	2.43	0.91	2.77	2.77	14.34

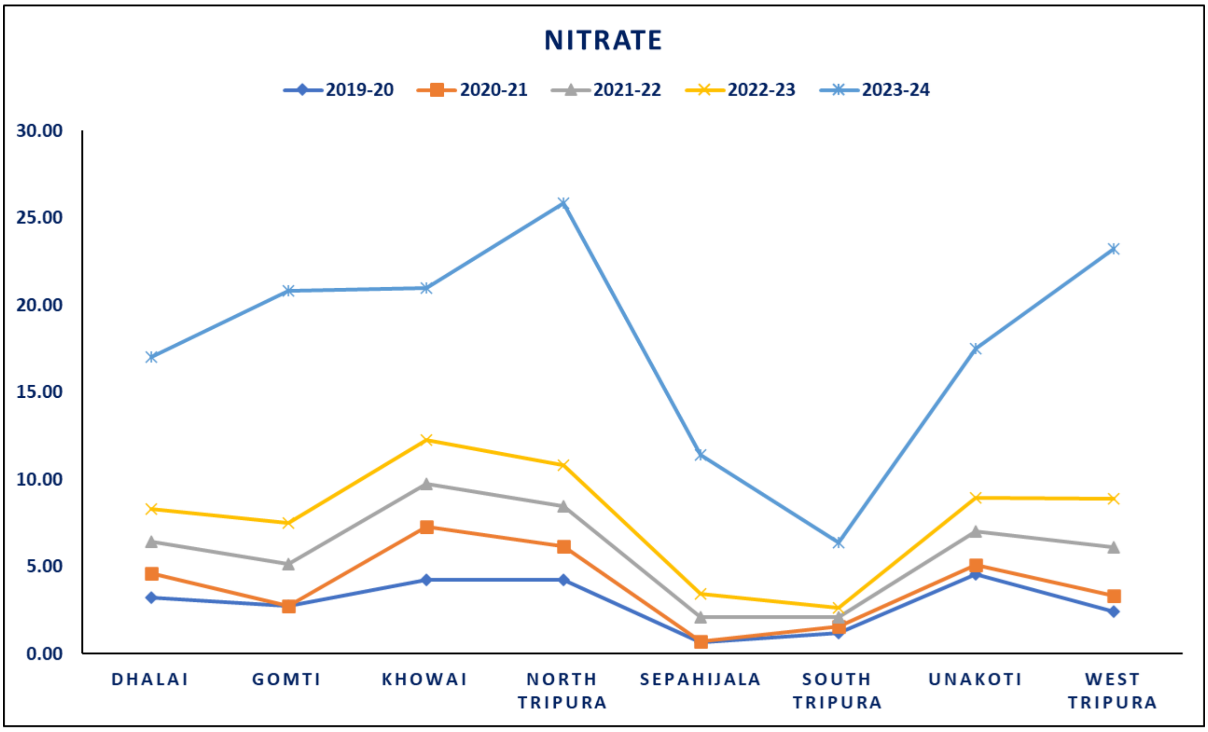


Figure 9 Trend of Nitrate concentration in the districts of Tripura

The **Figure 10** shows the trend of Fluoride levels (mg/L) in different districts of Tripura from 2019-20 to 2023-24. The BIS permissible limit for fluoride in drinking water is 1.5 mg/L, beyond which it can pose health risks such as dental or skeletal fluorosis. Most districts maintain fluoride concentrations within safe limits across the years, except for Khowai, which consistently shows elevated levels, particularly peaking beyond 4 mg/L in 2019-20. A gradual decline in fluoride levels is observed across the years, but Khowai still records the highest values, followed by Gomti.

The elevated fluoride levels in Khowai may be due to geological factors, such as the presence of fluoride-rich minerals in the groundwater. Natural leaching of fluoride from rocks is common in regions with hard rock aquifers, which may explain the persistent high levels. Other districts such as Dhalai, Unakoti, and West Tripura show relatively low and stable fluoride levels, reflecting minimal natural contamination.

Table 11 Average Fluoride concentration (mg/L) for the 5 years across the districts

District	2019-20	2020-21	2021-22	2022-23	2023-24
Dhalai	0.54	0.15	0.48	0.48	0.37
Gomti	0.42	0.14	0.31	0.31	0.19
Khowai	0.84	1.60	0.67	0.67	0.28
North Tripura	0.54	0.20	0.48	0.48	0.29
Sepahijala	0.20	0.31	0.65	0.65	0.07
South Tripura	0.17	0.16	0.45	0.45	0.08
Unakoti	0.51	0.14	0.42	0.42	0.33
West Tripura	0.47	0.13	0.44	0.44	0.10

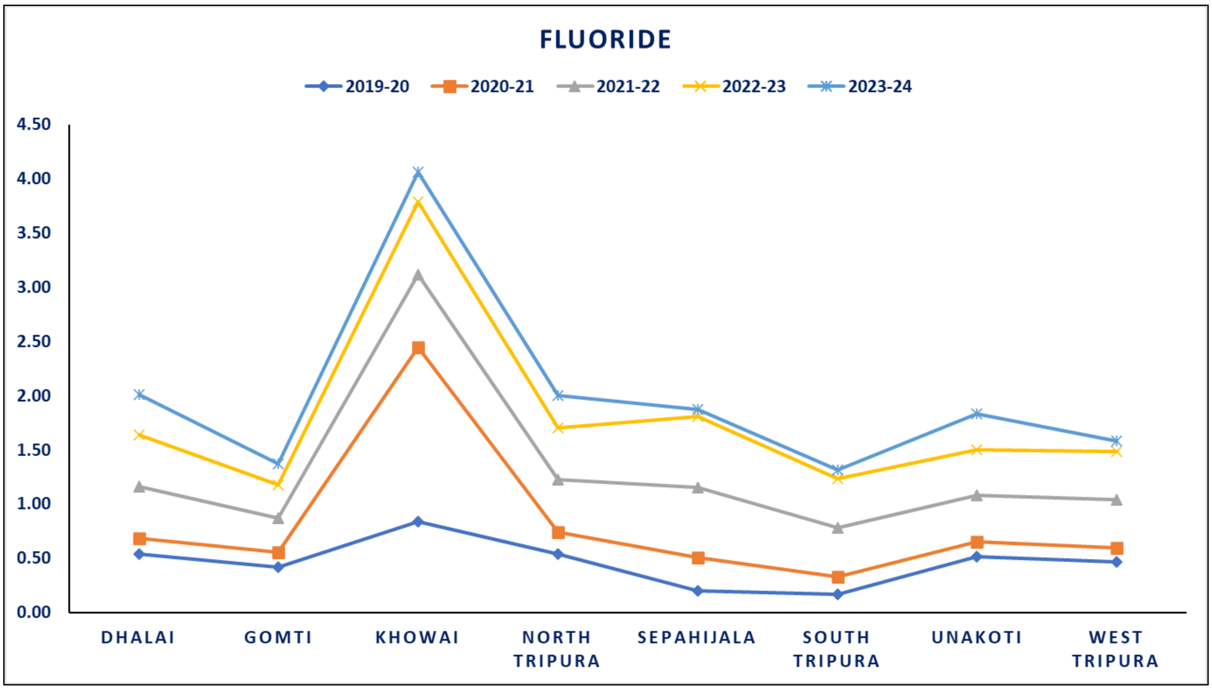


Figure 10 Trend of Fluoride concentration in the districts of Tripura

The **Figure 11** shows iron concentration trends (in mg/L). The Bureau of Indian Standards (BIS) permissible limit for iron in drinking water is 1.00 mg/L. Dhalai consistently exceeds this limit, peaking above 5 mg/L in several years, showing a fluctuating but overall increasing trend. Gomti's iron levels hover around the BIS limit with a slight recent increase, generally below 2 mg/L. Khowai's iron concentration steadily declines post-2021-22, staying below the BIS limit. North Tripura consistently exceeds the limit with peaks close to 5 mg/L in 2023-24, showing a fluctuating but concerning trend. Sepahijala shows fluctuating levels, generally above the limit, with a dip around 2021-22 and a spike in 2023-24. South Tripura has an increasing trend but remains below or near the limit. Unakoti's levels are moderate, often below the limit, with a recent slight increase. West Tripura consistently shows low levels, well below the limit.

Table 12 Average Iron concentration (mg/L) for the 5 years across the districts

District	2019-20	2020-21	2021-22	2022-23	2023-24
Dhalai	0.31	0.53	1.64	1.64	0.61
Gomti	0.79	0.83	1.29	1.29	1.04
Khowai	0.44	0.43	0.85	0.85	0.39
North Tripura	0.16	0.22	0.85	0.85	0.67
Sepahijala	0.49	0.31	1.33	1.33	0.06
South Tripura	0.50	1.42	1.01	1.01	0.64
Unakoti	0.44	1.28	0.28	0.28	0.39
West Tripura	0.42	1.63	1.01	1.01	0.30

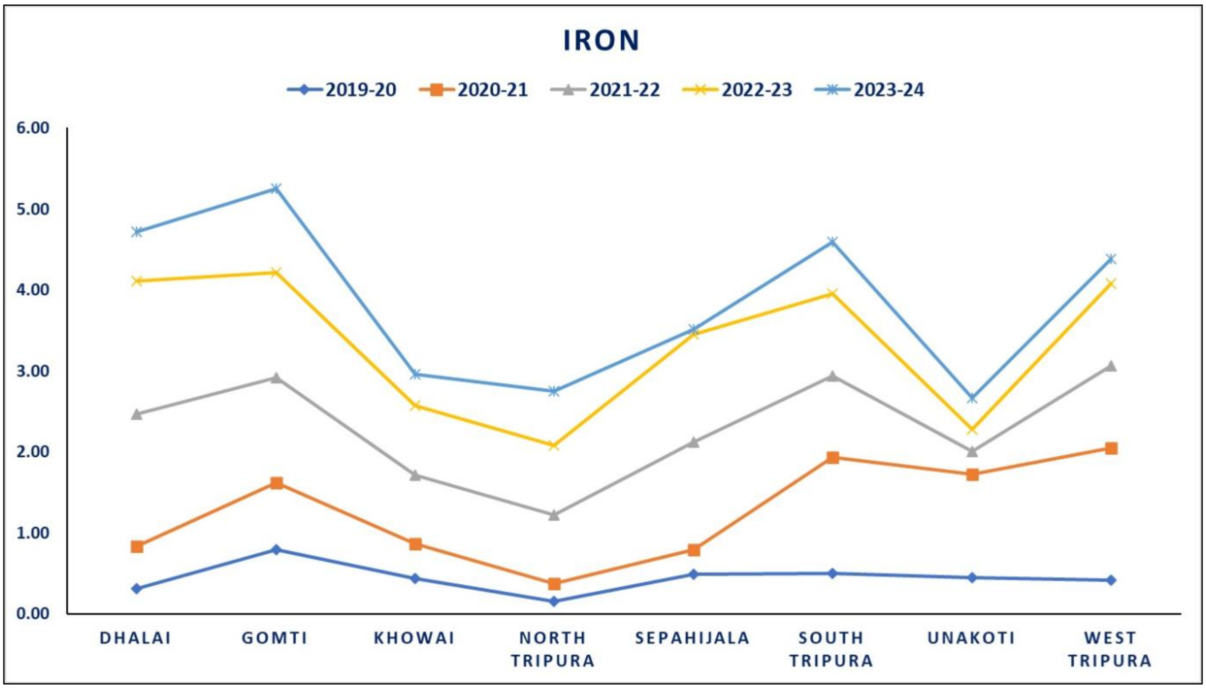


Figure 11 Trend of Iron concentration in the districts of Tripura

The variations in iron levels may be attributed to geological factors and seasonal changes, such as increased leaching during monsoons, leading to higher concentrations in groundwater.

Arsenic levels across all districts remain consistently low (**Table 13)**, with slight variations but staying well below the permissible limit of 0.01 mg/L. The concentrations are relatively uniform, with a small peak in Khowai, where it reaches approximately 0.0005 mg/L. The arsenic levels increase in most districts during the post-monsoon period, with a notable spike in North Tripura, where the concentration rises to around 0.001 mg/L. Other districts, such as Sepahijala and Gomti, show modest increases, while South Tripura, Unakoti, and West Tripura remain relatively unaffected by the seasonal changes. North Tripura district exhibits the highest post-monsoon arsenic concentration, nearing 0.001 mg/L, although still below the BIS limit.

A slight rise is observed in Khowai district in the post-monsoon (**Figure 12**), but the pre-monsoon arsenic concentration is one of the highest among the districts. Dhalai, Gomti, Sepahijala, South Tripura, Unakoti, West Tripura districts show marginal increases during the post-monsoon period, but their arsenic levels remain well below concerning limits. The significant increase in arsenic concentration post-monsoon could be attributed to the leaching of arsenic into groundwater from the soil, particularly in districts like North Tripura. Heavy monsoon rains often lead to the mobilization of arsenic from arsenic-rich geological formations into the aquifers.

Table 13 Average Arsenic concentration (mg/L) for the 5 years across the districts

District	**Pre-Monsoon**	**Post-Monsoon**
Dhalai	0.00022	0.00034
Gomti	0.00016	0.00026
Khowai	0.00036	0.00064
North Tripura	0.00016	0.00062
Sepahijala	0.00019	0.00020
South Tripura	0.00021	0.00018
Unakoti	0.00024	0.00029
West Tripura	0.00027	0.00031

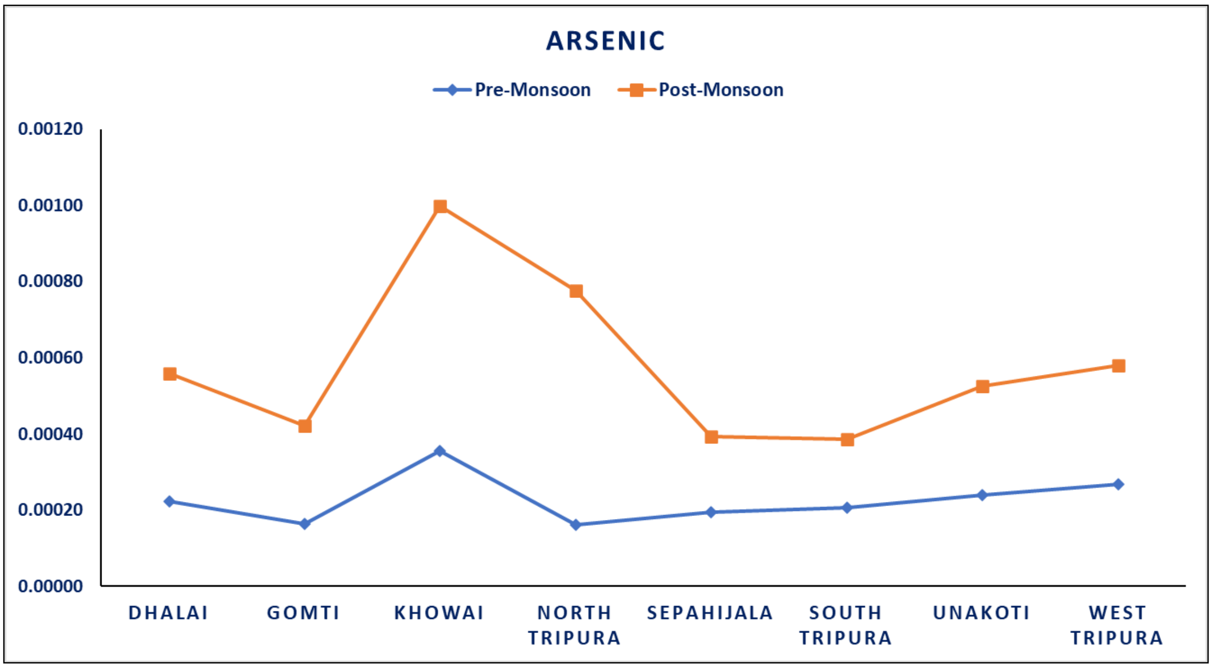


Figure 12 Trend of Arsenic concentration in the districts of Tripura

ASSESSMENT OF GROUND WATER QUALITY FOR FEASIBILTY IN IRRIGATION

The accumulation of soluble salts in soil beyond a certain threshold can lead to a decrease in crop yield. One of the primary reasons behind this reduction in production is the presence of osmotic water stress on plants. The primary sources of soluble salts in agriculture soils are:

- Irrigation water
- Salt deposits in soil
- Drainage water, draining from upper lying to lower lying lands
- Capillary flow of water-especially in shallow water table areas
- Soil reclamation practices and use of fertilizers
- Weathering of soil minerals and
- Precipitation

Suitability of ground water for irrigation purpose is evaluated based on chemical characteristics indicative of their potential to create soil condition hazardous to crop growth and yield. Various indices are used for assessment and classification of ground water into different categories. Some of the widely used criteria are discussed below.

IRRIGATION WATER QUALITY CRITERIA

Salinity based on Electrical conductivity and chlorinity

Electrical conductivity (EC), total dissolved solids (TDS) and chlorinity are used as a measure of salinity of ground water. Water with EC<3000 µS/cm at 25ºC and TDS<1000 mg/L is safe to be used for irrigation purpose. Water parameters that exceed these limits can render it unsuitable for irrigation. Groundwater that spends a longer time in the aquifers and has low mobility tends to become more mineralized, which results in higher levels of electrical conductivity (EC) and total dissolved solids (TDS).Chlorinity in ground water should be below 500 mg/L for being suitable to be used in irrigation.

Sodium hazards

The absolute and relative concentration of sodium and also calcium and magnesium determine the sodium hazard in water used for irrigation purpose. Accumulation of exchangeable sodium results in alkali soil and it is associated with poor tilt and low permeability. Sodium Absorption Ratio (SAR) is recommended by the U. S. Salinity Laboratory since it more accurately depicts the sodium absorbed by the soil. SAR is mathematically calculated as

$$SAR = \frac{Na}{\sqrt{(Ca + Mg)/2}}$$

As per Richards classification water with SAR<10 makes it suitable for irrigation.

Soluble Sodium Percentage (SSP) is another criterion that represents the sodium in water exchanged by calcium by Base Exchange process that decreases the soil permeability.

$$SSP = \frac{Na * 100}{Ca + Mg + Na}$$

Water with SSP<50 are of good quality for irrigation. Besides these two indices, percent sodium (%Na) is another factor in assessing the suitability of irrigation water.

$$\%Na = \frac{(Na + K)}{(Ca + Mg + Na + K)} * 100$$

Kelly's Index (KI) developed in 1951 is another index included in sodium hazard.

$$KI = \frac{Na}{Ca + Mg}$$

Water with KI>1 is considered of poor quality for irrigation.

Effects of bicarbonate ion concentration

The residual alkalinity is denoted by Residual Sodium Carbonate (RSC) as developed by Eaton in 1950. Water containing high concentration of bicarbonate ions, the calcium and magnesium may precipitate as carbonates in the soil. With Ca and Mg precipitates out, the relative proportion of sodium in that water increases. RSC is calculated as shown below:

$$RSC = (HCO_3 + CO_3) - (Ca + Mg)$$

RSC<1.25 is suitable for irrigation, 1.25<RSC>2.50 is marginally suitable and that >2.50 is unsuitable for irrigation.

Permeability

Doneen in 1964 developed Permeability Index (PI). Continuous application of water may affect soil permeability by precipitation of certain elements in the top soil that reduces void space hindering water dynamics. In such case PI of that water gives an idea of the permeability of the top soil.

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

Water with PI>75% is suitable for irrigation.

Magnesium Hazard

The relative proportion of magnesium in water is calculated as Magnesium Ratio (MR) and it was developed by Llyod and Heathcote in 1985. It is formulated as below:

$$MH = \frac{(Mg * 100)}{(Ca + Mg)}$$

The MH>50 is considered unsuitable for irrigation purpose.

US SALINITY Laboratory Diagram/Wilcox plot and Piper Diagram

US SALINITY Laboratory Diagram: One of the most important procedures which have been in use for considerable period of time till date is the one recommended by the U.S. Salinity Laboratory (U. S. S. L. 1954) and is briefly out lined below. The diagram is proposed with the assumption that water is used under average conditions with respect to soil texture, filtration rate, and drainage, quantity of water used, climate and tolerance of corps. The diagram takes into consideration the salinity and sodium hazard of irrigation waters.

Piper Diagram: Hydro-chemical facies are very useful in investigating diagnostic chemical character of water in hydrologic systems. Different types of facies within the same group formations are due to characteristic ground water flow through the aquifer system and effect of local recharge. The types of facies are inter-linked with the geology of the area and distribution of facies with the hydrogeological controls. Hydrochemicalfacies are delineated by plotting percentage reacting value of major ions on tri-linear diagrams know as Piper Diagram

FEASIBILTY FOR AGRICULTURE PURPOSE

The salinity in all the districts of Tripura is low and the water may be categorized as low saline water. All of the samples have Sodium Absorption Ratio (SAR) values below 10, indicating that the groundwater is suitable for irrigation in terms of SAR. However, 25.60% of the groundwater samples in the pre-monsoon and 20.87% sample in the post-monsoon have Soluble Sodium Percentage (SSP) above 50%, which makes them unsuitable for irrigation. The **Table 14 shows** the percentage of water samples falling into different sodium concentration (%Na) categories during the pre-monsoon and post-monsoon seasons. An analysis of the results indicates noticeable seasonal variations in water quality. In the post-monsoon season, the percentage of samples classified as "Excellent" increases from 11.11% to 14.29%, suggesting a slight improvement in water quality due to the dilution effects of rainfall. However, the proportion of samples in the "Good" category decreases from 39.51% in pre-monsoon to 32.97% in post-monsoon. This shift might indicate that some water sources which were previously classified as "Good" either improved to "Excellent" or shifted into the "Permissible" category.

Table 14 Percentage of water samples falling into different sodium concentration (%Na) categories during the pre-monsoon and post-monsoon seasons

Pre-Monsoon (%)	Post-Monsoon (%)	Category
11.11	14.29	Excellent
39.51	32.97	Good
33.33	43.96	Permissible
12.35	7.69	Doubtfull
2.47	1.10	unsuitable

The most significant change is observed in the "Permissible" category, where the share of samples rises from 33.33% before the monsoon to 43.96% afterward. This suggests that many water sources become more suitable for use following the monsoon, likely due to increased water availability and reduced sodium concentration through natural mixing processes. Meanwhile, the "Doubtful" category sees a decline from 12.35% to 7.69%, indicating fewer borderline cases of sodium-related water quality concerns after the monsoon. The reduction in the percentage of samples classified as "Unsuitable" from 2.47% to 1.10% further reinforces the observation that water quality improves post-monsoon.

The **Table 15** provides insights into the seasonal variations in water quality based on the Permeability Index (PI), which is categorized into three classes: Class I (Suitable), Class II (Good), and Class III (Unsuitable). A significant shift in the distribution of samples is observed between the pre-monsoon and post-monsoon periods. Before the monsoon, 69.23% of the samples fall into Class I, indicating that the majority of water sources were highly suitable for use, with a PI greater than 75. However, this percentage drops sharply to 23.46% after the monsoon, suggesting that water quality in this category declines post-monsoon. In contrast, Class II, which corresponds to a PI range of 25-75 and is considered good, shows a substantial increase. The proportion of samples in this category rises from 19.78% in pre-monsoon to 87.65% in post-monsoon. This increase indicates that many water sources experience changes in permeability during the monsoon season, possibly due to enhanced groundwater recharge and mixing processes, which moderate the PI values to fall within this "Good" range. Interestingly, there is a small emergence of samples in Class III (Unsuitable) post-monsoon, rising from 0.00% to 1.23%, suggesting that a few water sources degrade in quality, possibly due to localized contamination or reduced permeability caused by sedimentation during monsoon runoff.

Table 15 Percentage of water samples falling into different Permeability Index (PI) categories during the pre-monsoon and post-monsoon seasons

Pre-Monsoon (%)	Post-Monsoon (%)	Permeability Index (PI)	Category
69.23	23.46	> 75	Class I (Suitable)
19.78	87.65	25-75	Class II (Good)
0.00	1.23	< 25	Class III (Unsuitable)

In the pre-monsoon period, 23.46% of the water samples fall within the suitable range in Magnesium Hazard, but this proportion increases slightly to 27.47% after the monsoon. This marginal improvement suggests that the influx of rainwater during the monsoon helps dilute magnesium concentrations in some water sources, making them more appropriate for agricultural use. Despite this positive change, the majority of samples in both seasons remain in the "Unsuitable for Irrigation" category, with 76.54% in pre-monsoon and 72.53% in post-monsoon. The slight decrease in unsuitable samples after the monsoon indicates that while rainfall provides some relief, magnesium levels remain problematic in most areas. This persistence of high magnesium concentrations could result from factors such as soil mineral content, groundwater recharge patterns, or localized contamination that the monsoon is unable to fully mitigate.

Table 16 Percentage of water samples falling into different Magnesium Hazard (MH) categories during the pre-monsoon and post-monsoon seasons

Suitability	Magnesium Hazard (%)	Pre-Monsoon (%)	Post-Monsoon (%)
Suitable for Irrigation	< 50	23.46	27.47
Unsuitable for Irrigation	> 50	76.54	72.53

The observations in Kelly's Index (**Table** 17) reveal a significant difference in water quality across pre-monsoon and post-monsoon periods. During the pre-monsoon phase, approximately 25.93% of the samples are classified as "Good," indicating relatively favourable conditions for water quality. In contrast, this percentage decreases to 20.88% in the post-monsoon period. Conversely, the proportion of "Poor" quality samples increases from 74.07% pre-monsoon to 79.12% post-monsoon. This shift can be attributed to several factors. The pre-monsoon season often sees lower rainfall and less runoff, allowing for better water retention and reduced contamination. However, with the onset of the monsoon, heavy rainfall can lead to increased surface runoff, which may wash pollutants into water bodies, thereby degrading quality.

Table 17 Percentage of water samples falling into different Kelly's Index (KI) categories during the pre-monsoon and post-monsoon seasons

Kelly's Index	Quality	Pre-Monsoon (%)	Post-Monsoon (%)
< 1	Good	25.93	20.88
> 1	Poor	74.07	79.12

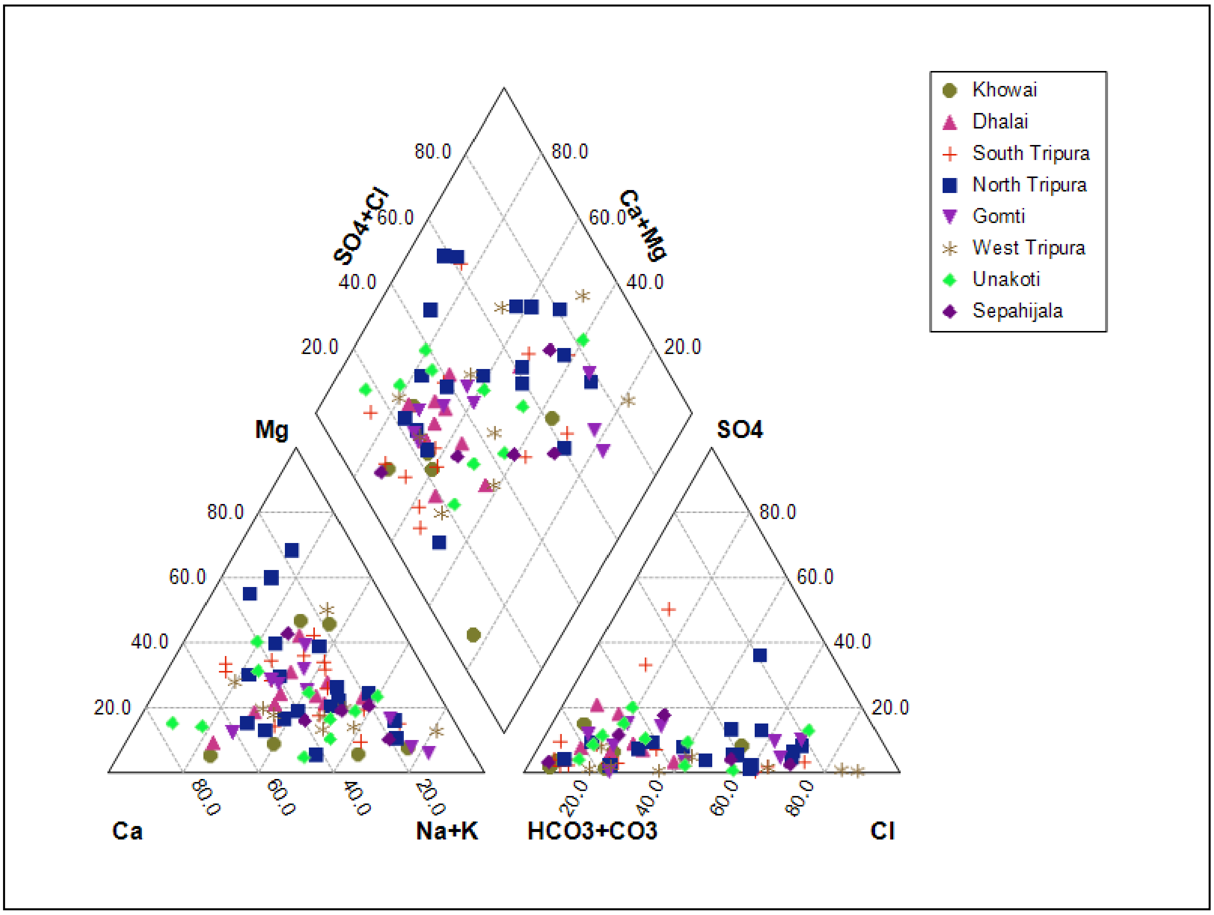


Figure 13 Piper diagram for the state of Tripura

The piper diagram (**Figure 13**) shows that most of the groundwater samples fall within the "no dominant type" category, which means that the concentrations of these three major cations are roughly equal. This may indicate that the water is relatively fresh and has not undergone significant mineralization processes. In the anion triangle, a mix of HCO_3^-+ CO_3^{2-} type and chloride type indicates that the water has a relatively high concentration of these two anions, which may be due to dissolution of minerals or contamination from anthropogenic sources. Overall, when both the cation and anion triangles are taken into consideration, the water is classified as falling into the Magnesium bicarbonate type and the mixed type in the piper diagram.

The US SALINITY Laboratory Diagram shows that most of the analyzed groundwater samples fall in the C1S1 category, which is the lowest level of salinity on the diagram. This means that the water has a low concentration of both sodium and chloride ions, and a low overall TDS. **Figure 14** shows the USSSL diagram of Tripura state.

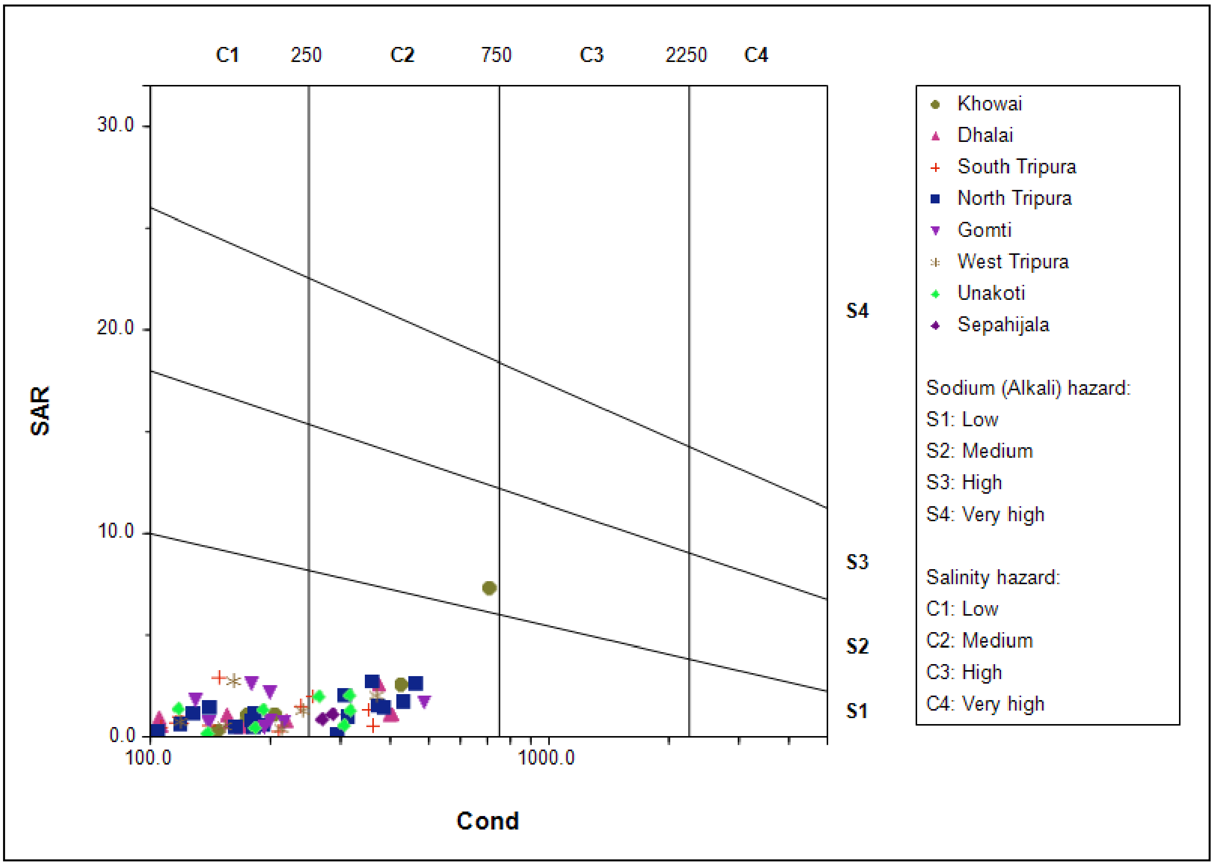


Figure 14 USSL Salinity diagram for the suitability Irrigation

The next most common category for the groundwater samples is C2S1, which is slightly higher in salinity than C1S1, but still relatively low overall. Finally, there is one sample from Khowai district that falls into the C2S2 category, which is slightly higher in salinity than C2S1.

Overall the quality of water tends to improve post-monsoon due to dilution and enhanced recharge, significant concerns remain, particularly with sodium and magnesium concentrations. Therefore, while many sources may be considered permissible or good for irrigation post-monsoon, careful monitoring and management are essential to ensure the continued suitability of groundwater resources for agricultural use.

REMEDIAL MEASURES

Iron/Manganses

a) Oxidation and filtration: Before iron and manganese can be filtered, they need to be oxidized to a state in which they can form insoluble complexes. Ferrous iron (Fe2+) is oxidized to ferric iron (Fe^{3+}), which readily forms the insoluble iron hydroxide complex $Fe(OH)_3$. Manganese (Mn^{2+}) is oxidized to (Mn^{4+}), which forms insoluble (MnO_2). The common chemical oxidants in water treatment are chlorine, chlorine dioxide, potassium permanganate and ozone. The dose of potassium permanganate, however, must be carefully controlled. Too little permanganate will not oxidize all the iron and manganese, and too much will allow permanganate to enter the distribution system and cause a pink color.

Ozone may be used for iron and manganese oxidation. Ozone may not be effective for oxidation in the presence of humic or fulvic materials. If not dosed carefully, ozone can oxidize reduced manganese to permanganate and result in pink water formation as well. Manganese dioxide particles, also formed by oxidation of reduced manganese, must be carefully coagulated to ensure their removal.

A low-cost method of providing oxidation is to use the oxygen in air as the oxidizing agent. Water is simply passed down a series of porous trays to provide contact between air and water. No chemical dosing is required. This method is not effective for water in which the iron is complexed with humic materials or other large organic molecules.

Oxidation and Filtration Method for Fe and Mn Removal from Ground Water In general, manganese oxidation is more difficult than iron because the reaction rate is slower. A longer detention time (10 to 30 minutes) following chemical addition is needed prior to filtration to allow the reaction to take place. Manganese greensand is by far the most common medium in use for removal of iron and manganese through pressure filtration. Greensand is a processed material consisting of nodular grains of the zeolite mineral glauconite. The material is coated with manganese oxide. The ion exchange properties of the glauconite facilitates the bonding of the coating. This treatment gives the media a catalytic effect in the chemical oxidation reduction reactions necessary for iron and manganese removal. This coating is maintained through either continuous or intermittent feed of potassium permanganate.

Anthra/sand (also iron-man sand) are other types of media available for removal of iron and manganese. They consist of select anthracite and sand with a chemically bonded manganese oxide coating.

Electromedia is a proprietary multi-media formulation which uses a naturally occurring zeolite and does not require potassium permanganate regeneration. Finally, macrolite, is a manufactured ceramic material with a spherical shape and a rough, textured surface. The principal removal mechanism is physical straining rather than contact oxidation or adsorption. Each medium has its advantages and disadvantages. Selection of a medium and oxidant should be based on pilot testing in which all necessary design criteria can be determined.

b) Ion Exchange Ion exchange should be considered only for the removal of small quantities of iron and manganese because there is a risk of rapid clogging. Ion exchange involves the use of synthetic resins where a pre-saturate ion on the solid phase (the “adsorbent,” usually sodium) is exchanged for the unwanted ions in water. One of the major difficulties in using this method for controlling iron and manganese is that if any oxidation occurs during the process, the resulting precipitate can coat and foul the media. Cleaning would then be required using acid or sodium bisulfate.

c) Combined Photo-Electrochemical (CPE) Method Different processes, such as electrochemical (EC), photo (UV), and combined photo-electrochemical (CPE) methods are used. A cell containing aluminium electrode as anode, graphite electrode as cathode and UV lamp are used and filled with waste water enriched with iron and manganese as an electrolytic solution. A limited quantity of sodium chloride salt is added to enhance the electric conductivity through the solution. A comparison between different methods was undertaken to evaluate the applied conditions and the efficiency of Fe and Mn removal at different times and initial concentrations. The results revealed that CPE method was the best choice for the simultaneous removal of both iron and manganese in a short time < 10 min.

d) Sequestration is the addition of chemicals to groundwater aimed at controlling problems caused by iron and manganese without removing them. These chemicals are added to groundwater at the well head or at the pump intake before the water has a chance to come in contact with air or chlorine. If the water contains less than 1.0 mg/L iron and less than 0.3 mg/L manganese, using polyphosphates followed by chlorination can be an effective and inexpensive method for mitigating iron and manganese problems. No sludge is generated in this method. Below these concentrations, the polyphosphates combine with the iron and manganese preventing them from being oxidized. Any of the three polyphosphates (pyrophosphate, tripolyphosphate, or metaphosphate) can be used. Applying sodium silicate and chlorine simultaneously has also been used to sequester iron and manganese. However, while this technique is reliable in the case of iron treatment, it has not been found to be effective in manganese control.

CONCLUSION

The comprehensive analysis of groundwater quality in Tripura reveals significant seasonal variations in key parameters such as pH, electrical conductivity (EC), and ion concentrations during the pre-monsoon and post-monsoon seasons of 2023. The data indicate that maximum pH values are predominantly alkaline, particularly in Khowai, while minimum pH levels show stability with a slight decline in Sepahijala. Although EC values generally reflect good water quality, localized spikes, especially at the 45 Miles location in Khowai post-monsoon, highlight concerns regarding mineral concentration due to runoff. Cation concentrations in districts like Dhalai and Khowai point to hard water, influenced by local geology, while softer water is observed in North and West Tripura. Notably, elevated iron levels in areas such as South Tripura exceed the BIS permissible limits, though post-monsoon dilution tends to lower these concentrations. Nitrate levels demonstrate considerable variability, with higher pre-monsoon concentrations linked to natural sources, followed by reductions post-monsoon due to dilution, despite some areas experiencing increases from leaching.

Long-term trends over five years illustrate that while electrical conductivity has generally increased—especially in Khowai and Gomti—with significant fluctuations noted in 2022-23, a decline was observed in 2023-24. Nitrate concentrations remain stable and within permissible limits, indicating minimal pollution, while fluoride levels, particularly in Khowai, consistently exceed safe thresholds, although a gradual decline is noted. Iron concentrations are variable, with Dhalai and North Tripura often surpassing limits, while Khowai shows a decrease. Arsenic levels are low overall, yet post-monsoon spikes in North Tripura necessitate continued monitoring.

The implications for irrigation are clear: while groundwater quality is categorized as low saline with favorable Sodium Absorption Ratio (SAR) values, a concerning proportion of samples exhibit Soluble Sodium Percentage (SSP) above 50%, rendering them unsuitable for agricultural use in both seasons. Post-monsoon improvements are indicated by a rise in samples classified as "Excellent," yet a decline in the "Good" category suggests that while some sources improve, others regress to the "Permissible" category. The Permeability Index (PI) analysis reveals a dramatic decrease in "Suitable" classifications from pre-monsoon to post-monsoon, with an increase in the "Good" class, suggesting improved groundwater recharge. However, a small number of "Unsuitable" samples post-monsoon raises concerns about localized contamination. In terms of magnesium levels, a slight increase in suitable samples is noted post-monsoon, but most remain unsuitable for irrigation, indicating ongoing challenges with soil mineral content and recharge patterns. Kelly's Index shows a decline in "Good" quality samples and a rise in "Poor" classifications after the monsoon, likely due to increased runoff. The Piper diagram further illustrates mixed water quality types, suggesting influences from both natural and anthropogenic sources.

To address these water quality issues, particularly concerning iron, effective management strategies are crucial. Remedial measures such as oxidation and filtration, ion exchange, the Combined Photo-Electrochemical (CPE) Method, and sequestration can significantly enhance water quality by converting dissolved metals into insoluble forms for removal. The selection of appropriate methods should be guided by site-specific conditions and informed by pilot testing. While some improvements in groundwater quality have been observed post-monsoon due to dilution and recharge, significant challenges remain, particularly regarding sodium and magnesium levels. Continuous monitoring and adaptive management strategies will be essential to ensure the long-term sustainability of groundwater resources in Tripura, ultimately ensuring safe and palatable water for all consumers.

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Annexure I

Chemical Quality of Water Samples Collected from GWMS of Tripura during Pre-monsoon Season, 2023-24 (Basic constituents)

District	Location	Source	Turbidity	pH	Conductance	TDS	CO_3^{2-}	HCO_3^-	TA	Cl^-	NO_3^-	SO_4^{2-}	F^-	TH	Ca^{2+}	Mg^{2+}	Na	K
			NTU		µS/cm at 25°C	mg/L												
Dhalai	Abhanga New	DW	0.38	7.06	169.70	110.31	BDL	103.78	103.78	16.57	4.32	6.16	0.01	85.00	30.02	2.41	10.10	3.24
Dhalai	Ambassa	DW	0.59	7.75	158.90	103.29	BDL	85.47	85.47	6.63	5.79	19.79	0.03	65.00	14.01	7.27	13.17	3.00
Dhalai	Chawmanu	DW	1.00	7.19	375.00	243.75	BDL	183.15	183.15	43.09	7.44	15.94	1.00	105.00	20.02	13.34	60.35	3.11
Dhalai	Durga Chowmuhani	DW	0.32	7.05	220.00	143.00	BDL	103.78	103.78	39.77	14.59	4.19	0.32	95.00	28.02	6.05	16.97	2.66
Dhalai	Kali Kumar Para	DW	0.07	6.57	72.30	47.00	BDL	18.31	18.31	16.57	17.17	0.47	0.07	25.00	6.00	2.42	8.01	3.82
Dhalai	Kamalpur	DW	0.40	6.93	156.00	101.40	BDL	91.57	91.57	13.26	4.70	19.58	0.40	60.00	14.01	6.06	18.61	4.79
Dhalai	Lalchari	DW	0.47	6.64	105.60	68.64	BDL	79.36	79.36	6.63	1.01	5.72	0.01	40.00	8.01	4.85	13.22	2.80
Dhalai	Manu New	DW	0.93	7.17	400.00	260.00	BDL	195.36	195.36	49.72	20.03	15.89	0.93	165.00	42.03	14.54	31.52	12.72
Dhalai	Nuna Cherra	DW	0.29	6.86	106.80	69.42	BDL	61.05	61.05	13.26	8.64	6.29	0.01	50.00	8.01	7.28	8.48	2.36
Dhalai	Sindhu Kumar	DW	0.95	6.85	405.00	263.25	BDL	250.30	250.30	39.77	3.43	12.55	0.95	190.00	52.04	14.54	34.54	17.74
Gomti	Bampur	TW	0.13	7.39	200.00	130.00	BDL	152.62	152.62	13.26	2.05	18.13	0.84	100.00	24.02	9.70	17.64	2.46
Gomti	Dewanbari	DW	0.59	6.87	140.50	91.33	BDL	73.26	73.26	13.26	7.08	13.25	0.04	60.00	10.01	8.49	12.27	2.27
Gomti	Dhawajnagar	DW	0.24	6.63	68.20	44.33	BDL	30.52	30.52	13.26	5.96	1.23	0.01	30.00	6.00	3.64	6.70	1.97
Gomti	Gorjee Bazar	DW	0.44	6.51	200.00	130.00	BDL	24.42	24.42	46.40	24.93	8.98	0.00	40.00	8.01	4.85	31.43	9.33
Gomti	Jatanbari	DW	0.11	7.25	179.80	116.87	BDL	30.52	30.52	39.77	9.56	3.65	0.07	15.00	4.00	1.21	23.06	15.73
Gomti	Kankraban	DW	0.45	7.25	193.60	125.84	BDL	103.78	103.78	16.57	9.51	9.26	0.05	90.00	30.02	3.63	9.87	9.38
Gomti	Noabari-2	DW	0.31	7.08	488.00	317.20	BDL	195.36	195.36	59.66	22.36	38.44	0.10	190.00	44.04	19.40	53.57	9.93
Gomti	Ompi colony	DW	0.08	6.98	217.00	141.05	BDL	115.99	115.99	19.89	18.55	0.22	0.42	100.00	24.02	9.70	16.37	8.67
Gomti	Twidu	TW	0.17	6.65	130.30	84.70	BDL	18.31	18.31	23.20	19.46	4.78	0.22	15.00	4.00	1.21	15.87	12.01
Khowai	45 Miles	Artesian Well	0.52	7.91	711.00	462.15	BDL	573.86	573.86	23.20	0.00	6.94	1.10	130.00	36.03	9.69	190.66	1.38
Khowai	Kalyanpur	DW	0.38	7.36	175.80	114.27	BDL	103.78	103.78	16.57	6.07	1.08	0.08	70.00	24.02	2.42	20.25	1.94
Khowai	Kathalbari	DW	0.42	7.33	147.60	95.94	BDL	79.36	79.36	13.26	8.65	5.20	0.08	75.00	28.02	1.20	5.23	10.48

District	Location	Source	Turbidity	pH	Conductance	TDS	CO_3^{2-}	HCO_3^-	TA	Cl^-	NO_3^-	SO_4^{2-}	F^-	TH	Ca^{2+}	Mg^{2+}	Na	K
			NTU		µS/cm at 25°C	mg/L												
Khowai	Khowai	Artesian Well	0.11	7.36	174.00	113.10	BDL	140.41	140.41	6.63	0.16	4.24	0.10	85.00	12.01	13.34	13.84	2.46
Khowai	Pachim Howaibari	DW	0.37	6.93	427.00	277.55	BDL	103.78	103.78	86.18	34.75	17.02	0.07	100.00	34.03	3.62	58.40	39.00
Khowai	Tuimadhu	DW	0.23	7.48	206.00	133.90	BDL	146.52	146.52	9.94	2.84	22.26	0.22	105.00	12.01	18.20	25.54	3.35
North Tripura	Ananda Bazar	DW	0.38	7.02	164.00	106.60	BDL	97.68	97.68	16.57	8.46	2.01	0.38	70.00	22.02	3.63	8.98	7.76
North Tripura	Baghbassa	DW	0.35	6.85	182.00	118.30	BDL	97.68	97.68	23.20	3.10	8.27	0.35	90.00	22.02	8.48	10.18	3.20
North Tripura	Churaibari	DW	0.00	7.16	183.00	118.95	BDL	24.42	24.42	33.15	16.57	36.10	0.00	50.00	12.01	4.85	18.41	6.38
North Tripura	Dataram	DW	0.57	7.13	192.40	125.06	BDL	128.20	128.20	13.26	3.17	12.10	0.57	95.00	18.01	12.13	12.89	2.53
North Tripura	Deocherra	DW	0.15	6.49	128.60	83.59	BDL	42.73	42.73	33.15	13.00	4.27	0.15	45.00	10.01	4.85	17.56	5.87
North Tripura	Dharmanagar	DW	0.34	6.65	119.10	77.42	BDL	79.36	79.36	13.26	7.85	1.68	0.34	50.00	16.01	2.42	9.77	4.88
North Tripura	Kanchanpur	DW	0.27	6.51	465.00	302.25	BDL	79.36	79.36	125.95	14.21	15.92	0.27	115.00	20.02	15.77	64.09	11.06
North Tripura	Krishnapur	DW	0.33	7.20	295.00	191.75	BDL	85.47	85.47	62.98	8.02	8.78	0.33	155.00	24.02	23.05	2.68	9.30
North Tripura	Kunjanagar	DW	0.16	6.58	58.30	37.90	BDL	36.63	36.63	33.15	2.97	1.47	0.16	65.00	8.01	10.92	4.49	0.46
North Tripura	Lalchhara	DW	0.53	7.14	386.00	250.90	BDL	146.52	146.52	79.55	6.73	8.49	0.53	150.00	44.04	9.69	40.10	6.04
North Tripura	Laljuri	DW	0.21	6.82	373.00	242.45	BDL	61.05	61.05	92.81	36.00	8.19	0.21	125.00	34.03	9.69	39.34	1.70
North Tripura	Naba Joypara (Natun Basti)	DW	0.28	7.29	104.80	68.12	BDL	79.36	79.36	33.15	4.10	8.98	0.28	125.00	10.01	24.27	7.40	4.57
North Tripura	Narendra Nagar	DW	0.40	6.97	141.10	91.72	BDL	109.89	109.89	6.63	3.56	3.83	0.40	45.00	16.01	1.21	22.02	1.94
North Tripura	Panisagar	DW	0.13	6.46	308.00	200.20	BDL	30.52	30.52	56.35	45.73	8.70	0.13	50.00	10.01	6.06	32.97	28.74
North Tripura	Rajnagar	DW	0.19	6.66	361.00	234.65	BDL	97.68	97.68	86.18	39.76	1.85	0.19	30.00	14.01	4.85	46.51	29.60
North Tripura	Sabual	DW	0.11	7.21	179.20	116.48	BDL	30.52	30.52	33.15	38.80	10.19	0.11	65.00	10.01	9.70	14.90	4.48
North Tripura	Sanicherra	DW	0.35	6.98	432.00	280.80	BDL	115.99	115.99	86.18	12.83	31.21	0.35	140.00	28.02	16.98	46.44	21.57
North Tripura	Satnala	DW	0.53	6.85	313.00	203.45	BDL	152.62	152.62	43.09	6.11	18.13	0.53	140.00	32.03	14.55	26.14	4.70
Sepahijala	Gongrai	DW	0.48	6.88	67.00	43.55	BDL	18.31	18.31	13.26	13.14	1.29	0.01	15.00	4.00	1.21	12.35	5.99
Sepahijala	Kanthalia Bazar	DW	0.30	7.74	271.00	176.15	BDL	201.46	201.46	6.63	2.37	5.24	0.26	155.00	26.02	21.83	24.09	2.95
Sepahijala	Lalmaibari	DW	0.42	6.54	77.40	50.31	BDL	42.73	42.73	13.26	4.28	11.00	0.01	30.00	6.00	3.64	18.21	3.08
Sepahijala	Rajib Nagar	DW	0.52	6.44	76.40	49.66	BDL	18.31	18.31	26.52	5.76	1.16	0.00	25.00	6.00	2.42	8.73	6.94
Sepahijala	Tufaniamura	DW	0.25	7.53	288.00	187.20	BDL	140.41	140.41	23.20	14.13	18.36	0.05	105.00	30.02	7.27	25.78	22.04
South Tripura	Ananda Bandhu Para	TW	0.90	6.44	57.00	37.05	BDL	36.63	36.63	6.63	2.98	18.65	0.10	20.00	6.00	1.21	13.01	3.96

District	Location	Source	Turbidity	pH	Conductance	TDS	CO_3^{2-}	HCO_3^-	TA	Cl^-	NO_3^-	SO_4^{2-}	F^-	TH	Ca^{2+}	Mg^{2+}	Na	K
			NTU		µS/cm at 25°C	mg/L												
South Tripura	Baishnabpur	DW	0.17	6.75	210.00	136.50	BDL	42.73	42.73	39.77	1.09	0.15	0.21	95.00	24.02	8.48	5.83	4.03
South Tripura	Gaurangar bazar	DW	0.41	6.97	140.50	91.33	BDL	115.99	115.99	6.63	1.01	1.92	0.04	75.00	16.01	8.49	11.02	2.19
South Tripura	Ghorakhappa	DW	0.38	7.37	47.50	30.88	BDL	12.21	12.21	13.26	2.16	0.48	0.10	15.00	4.00	1.21	4.44	3.05
South Tripura	Kalirbazar	DW	0.24	6.92	120.30	78.20	BDL	85.47	85.47	9.94	3.33	7.45	0.01	55.00	10.01	7.28	11.37	2.97
South Tripura	Magroom	DW	0.22	6.67	148.90	96.79	BDL	61.05	61.05	13.26	4.00	66.34	0.19	40.00	8.01	4.85	42.25	1.19
South Tripura	Manubazar	DW	0.32	7.46	239.00	155.35	BDL	164.83	164.83	6.63	4.13	5.55	0.09	95.00	20.02	10.91	33.36	5.30
South Tripura	Michara	DW	0.39	7.33	353.00	229.45	BDL	213.67	213.67	39.77	9.03	6.36	0.10	155.00	48.04	8.47	37.99	7.10
South Tripura	Motu Mogpara	DW	0.62	6.95	116.30	75.60	BDL	97.68	97.68	6.63	0.87	3.51	0.02	55.00	8.01	8.49	11.67	2.05
South Tripura	Purba Takka	DW	0.27	7.60	106.60	69.29	BDL	280.82	280.82	9.94	5.51	24.34	0.20	230.00	56.04	21.82	16.03	3.33
South Tripura	Radhanagar	DW	0.52	7.11	54.30	35.30	BDL	61.05	61.05	9.94	0.00	1.74	0.01	35.00	6.00	4.85	8.42	4.41
South Tripura	Rajnagar	DW	0.36	6.89	118.30	76.90	BDL	91.57	91.57	6.63	0.19	1.77	0.03	55.00	10.01	7.28	16.74	2.67
South Tripura	Sabroom	DW	0.29	7.32	362.00	235.30	BDL	54.94	54.94	16.57	15.36	4.90	0.01	50.00	12.01	4.85	8.56	1.70
South Tripura	Srinagar	DW	0.31	7.03	256.00	166.40	BDL	42.73	42.73	76.24	2.87	4.35	0.01	65.00	14.01	7.27	36.78	8.66
Unakoti	Chandra- moni Kami	DW	0.32	6.94	183.60	119.34	BDL	91.57	91.57	23.20	5.54	11.82	0.32	85.00	20.02	8.49	9.00	6.21
Unakoti	Dumdum	DW	0.22	6.52	78.70	51.16	BDL	61.05	61.05	6.63	5.23	5.22	0.22	30.00	8.01	2.42	12.68	2.93
Unakoti	Gaurnagar	DW	0.12	6.49	266.00	172.90	BDL	30.52	30.52	69.61	35.92	17.29	0.08	60.00	10.01	8.49	34.98	10.98
Unakoti	Jarultali	DW	0.14	6.75	118.10	76.77	BDL	61.05	61.05	26.52	4.28	1.66	0.14	35.00	8.01	3.64	18.45	4.02
Unakoti	Kanchanbari	DW	0.40	6.99	317.00	206.05	BDL	103.78	103.78	76.24	4.21	0.88	0.40	90.00	28.02	4.84	44.18	7.95
Unakoti	Kanchan-cherra	DW	0.53	7.22	192.50	125.13	BDL	97.68	97.68	16.57	11.72	17.44	0.53	55.00	20.02	1.20	22.49	4.64
Unakoti	Karaicherra	DW	0.57	7.15	318.10	206.77	BDL	128.20	128.20	56.35	9.44	17.77	0.57	120.00	28.02	12.12	32.25	11.12
Unakoti	Kumarghat New	DW	0.18	6.81	95.10	61.82	BDL	54.94	54.94	9.94	1.03	14.08	0.18	50.00	10.01	6.06	3.98	2.81
Unakoti	Pancham-nagar	DW	0.31	7.36	139.60	90.74	BDL	109.89	109.89	9.94	5.41	4.02	0.31	90.00	30.02	3.63	3.25	2.10
Unakoti	Pecharthal	DW	0.55	7.66	307.00	199.55	BDL	189.25	189.25	23.20	3.04	22.75	0.55	175.00	58.05	7.25	16.53	2.25
West Tripura	Chandmari	DW	0.45	7.28	162.10	105.37	BDL	12.21	12.21	39.77	31.19	0.42	0.01	15.00	2.00	2.43	24.35	9.14
West Tripura	Gamcha kobra Market	DW	0.03	7.19	25.70	16.71	BDL	12.21	12.21	13.26	3.60	0.40	0.06	20.00	2.00	3.64	2.57	3.45
West Tripura	Ishanpur	DW	0.00	6.90	242.00	157.30	BDL	91.57	91.57	39.77	8.79	3.78	0.03	75.00	22.02	4.84	25.50	16.73
West Tripura	Khumulwng	DW	0.19	6.79	76.30	49.60	BDL	54.94	54.94	6.63	1.61	0.56	0.04	30.00	8.01	2.42	12.54	1.23

District	Location	Source	Turbidity	pH	Conductance	TDS	CO_3^{2-}	HCO_3^-	TA	Cl^-	NO_3^-	SO_4^{2-}	F^-	TH	Ca^{2+}	Mg^{2+}	Na	K
			NTU		µS/cm at 25°C	mg/L												
West Tripura	Madhuban	DW	0.12	6.96	370.00	240.50	BDL	18.31	18.31	86.18	45.37	0.35	0.04	95.00	22.02	9.70	45.40	6.85
West Tripura	Pukua bari	DW	0.00	7.12	153.90	100.04	BDL	97.68	97.68	16.57	8.34	1.87	0.04	70.00	20.02	4.84	9.83	8.32
West Tripura	R.K Nagar	DW	0.21	6.76	96.40	62.66	BDL	61.05	61.05	19.89	1.85	0.28	0.21	30.00	8.01	2.42	15.63	6.32
West Tripura	Sadhupara	DW	0.08	7.21	214.00	139.10	BDL	128.20	128.20	16.57	14.69	10.33	0.43	115.00	30.02	9.69	9.80	5.58

Annexure II

Chemical Quality of Water Samples Collected from GWMS of Tripura during Post-monsoon Season, 2023-24 (Basic constituents)

District	Location	Source	Turbidity	pH	Conductance	TDS	CO_3^{2-}	HCO_3^-	TA	Cl^-	NO_3^-	SO_4^{2-}	F^-	TH	Ca^{2+}	Mg^{2+}	Na	K
			NTU		µS/cm at 25°C	mg/L												
Dhalai	Abhanga New	DW	1.10	7.28	100.60	65.39	0.00	12.21	12.21	39.00	1.44	9.44	0.26	50.00	12.01	4.85	14.17	7.39
Dhalai	Chawmanu	DW	0.80	7.16	338.40	219.96	0.00	24.42	24.42	63.81	0.61	11.54	0.51	80.00	22.02	6.06	27.05	9.70
Dhalai	Durga Chowmuhani	DW	0.60	7.02	183.70	119.41	0.00	18.31	18.31	46.08	5.77	6.44	0.38	85.00	28.02	3.63	7.80	4.90
Dhalai	Durgacherra	DW	0.80	7.08	118.40	76.96	0.00	30.52	30.52	28.36	0.26	8.51	0.34	75.00	26.02	2.41	5.58	2.93
Dhalai	Kali Kumar Para	DW	1.10	6.98	41.75	27.14	0.00	12.21	12.21	39.00	1.68	2.73	0.09	25.00	8.01	1.21	22.95	4.31
Dhalai	Kamalpur	DW	0.70	7.01	138.80	90.22	0.00	18.31	18.31	53.18	0.06	13.05	0.00	90.00	28.02	4.84	10.60	3.56
Dhalai	Manu New	DW	0.60	7.84	425.20	276.38	0.00	30.52	30.52	81.54	5.36	14.14	0.41	170.00	60.05	4.83	8.25	4.70
Dhalai	Much Kumbir Para	DW	0.80	6.94	79.40	51.61	0.00	18.31	18.31	60.27	6.46	1.97	0.00	25.00	4.00	3.64	23.59	19.40
Dhalai	Nuna Cherra	DW	0.80	6.75	63.94	41.56	0.00	12.21	12.21	28.36	0.73	4.52	0.00	30.00	6.00	3.64	10.30	7.39
Dhalai	Sindhu Kumar	DW	0.60	7.80	475.00	308.75	0.00	42.73	42.73	113.44	0.77	9.54	0.52	190.00	62.05	8.47	15.48	8.24
Dhalai	Singinala	DW	0.70	7.36	195.60	127.14	0.00	12.21	12.21	35.45	32.28	10.64	0.00	55.00	14.01	4.85	22.42	4.52
Gomti	Bampur	DW	0.80	7.06	173.80	112.97	0.00	18.31	18.31	53.18	0.13	6.18	0.35	45.00	10.01	4.85	30.01	6.40
Gomti	Dewanbari	DW	4.00	7.47	160.30	104.20	0.00	18.31	18.31	42.54	3.59	11.20	0.15	80.00	26.02	3.63	8.88	5.38
Gomti	Dhawajnagar	DW	0.90	6.89	51.79	33.66	0.00	18.31	18.31	24.82	0.58	4.84	0.33	25.00	8.01	1.21	14.25	8.45
Gomti	Gorjee Bazar	DW	1.10	6.73	355.60	231.14	0.00	18.31	18.31	81.54	9.50	7.85	0.39	95.00	32.03	3.63	30.20	9.42
Gomti	Jalaya	DW	1.30	6.78	161.20	104.78	0.00	18.31	18.31	56.72	2.34	5.66	0.00	50.00	12.01	4.85	15.94	24.78
Gomti	Jatanbari	DW	1.10	7.86	183.30	119.15	0.00	36.63	36.63	56.72	0.08	17.08	0.40	25.00	6.00	2.42	41.80	24.82
Gomti	Joingkami	DW	2.20	6.85	185.50	120.58	0.00	24.42	24.42	39.00	1.75	9.95	0.06	70.00	12.01	9.70	12.88	4.06
Gomti	Kankraban	DW	1.30	7.49	169.50	110.18	0.00	12.21	12.21	56.72	0.31	9.26	0.24	35.00	6.00	4.85	15.88	12.04
Gomti	Noabari-2	DW	0.90	7.28	171.90	111.74	0.00	12.21	12.21	67.36	0.13	10.79	0.41	45.00	8.01	6.06	32.74	12.16
Gomti	Ompi colony	DW	4.00	6.90	279.90	181.94	0.00	30.52	30.52	81.54	3.55	13.42	0.00	140.00	52.04	2.40	11.56	5.90

District	Location	Source	Turbidity	pH	Conductance	TDS	CO_3^{2-}	HCO_3^-	TA	Cl^-	NO_3^-	SO_4^{2-}	F^-	TH	Ca^{2+}	Mg^{2+}	Na	K
			NTU		µS/cm at 25°C	mg/L												
Gomti	Twidu	DW	0.70	7.04	277.50	180.38	0.00	18.31	18.31	113.44	3.63	7.79	0.10	105.00	10.01	19.41	21.38	12.14
Khowai	45 Miles	DW	0.80	6.84	766.90	498.49	0.00	79.36	79.36	56.72	0.75	5.68	1.19	125.00	20.02	18.19	22.16	9.92
Khowai	Kalyanpur	DW	0.80	7.77	163.70	106.41	0.00	12.21	12.21	67.36	3.68	7.75	0.38	70.00	20.02	4.84	21.63	12.32
Khowai	Kathalbari	DW	1.20	7.26	277.60	180.44	0.00	18.31	18.31	63.81	4.18	12.42	0.17	70.00	24.02	2.42	21.61	13.32
Khowai	Khowai	DW	3.00	8.08	276.20	179.53	0.00	18.31	18.31	63.81	4.49	12.56	0.37	90.00	32.03	2.41	25.16	1.99
Khowai	Pachim Howaibari	DW	0.60	8.13	572.70	372.26	0.00	18.31	18.31	113.44	5.21	7.68	0.21	125.00	16.01	20.62	38.22	14.74
Khowai	Tuimadhu	DW	0.70	7.33	240.70	156.46	0.00	24.42	24.42	63.81	2.81	6.05	0.64	115.00	34.03	7.27	8.92	7.20
North Tripura	Ananda Bazar	DW	0.70	7.66	530.20	344.63	0.00	42.73	42.73	81.54	0.93	14.39	0.54	190.00	18.01	35.19	5.02	2.04
North Tripura	Baghbassa	DW	0.80	7.20	123.70	80.41	0.00	18.31	18.31	56.72	0.64	4.27	0.31	65.00	10.01	9.70	14.82	7.56
North Tripura	Churaibari	DW	1.00	6.95	117.80	76.57	0.00	12.21	12.21	38.99	0.30	5.08	0.31	35.00	10.01	2.42	17.88	5.92
North Tripura	Dataram	DW	0.90	6.48	165.50	107.58	0.00	18.31	18.31	53.18	0.00	4.99	0.15	85.00	20.02	8.49	8.74	2.28
North Tripura	Deocherra	DW	1.00	7.32	148.90	96.79	0.00	18.31	18.31	63.81	1.04	6.04	0.30	65.00	8.01	10.92	24.56	9.78
North Tripura	Kanchanpur	DW	0.80	6.80	464.50	301.93	0.00	18.31	18.31	113.44	2.27	9.69	0.44	100.00	20.02	12.13	46.34	18.54
North Tripura	Khedacherra	DW	0.80	7.28	532.90	346.39	0.00	48.84	48.84	134.71	1.61	3.83	0.00	205.00	10.01	43.68	16.10	11.80
North Tripura	Krishnapur	DW	0.90	7.12	375.90	244.34	0.00	18.31	18.31	81.54	2.90	9.03	0.42	125.00	48.04	1.19	9.20	18.50
North Tripura	Kunjanagar	DW	0.90	7.10	72.90	47.39	0.00	18.31	18.31	46.09	0.03	3.88	0.53	55.00	16.01	3.63	20.71	2.62
North Tripura	Lalchhara	DW	0.80	7.12	448.30	291.40	0.00	24.42	24.42	99.26	3.51	6.45	0.47	165.00	34.03	19.40	15.60	6.36
North Tripura	Laljuri	DW	0.90	6.92	410.80	267.02	0.00	18.31	18.31	113.44	6.84	7.11	0.29	130.00	10.01	25.48	30.32	24.24
North Tripura	Naba Joypara (Natun Basti)	DW	1.20	7.23	212.40	138.06	0.00	18.31	18.31	53.18	0.12	5.87	0.41	80.00	12.01	12.13	10.30	7.98
North Tripura	Narendra Nagar	DW	0.90	7.53	152.40	99.06	0.00	12.21	12.21	42.54	1.25	7.63	0.22	40.00	14.01	1.21	4.96	32.48
North Tripura	Panisagar	DW	0.70	7.63	308.20	200.33	0.00	18.31	18.31	53.18	10.67	6.61	0.17	75.00	12.01	10.92	20.39	7.37
North Tripura	Rajnagar	DW	0.90	7.16	93.32	60.66	0.00	12.21	12.21	35.45	3.32	4.74	0.56	35.00	10.01	2.42	19.83	4.73
North Tripura	Sabual	DW	0.90	7.28	172.60	112.19	0.00	18.31	18.31	53.18	2.22	6.65	0.39	65.00	8.01	10.92	16.26	16.12
North Tripura	Sanicherra	DW	0.80	7.13	465.80	302.77	0.00	30.52	30.52	113.44	0.22	10.74	0.46	150.00	20.02	24.26	24.24	16.52
North Tripura	Satnala	DW	0.70	7.21	438.90	285.29	0.00	24.42	24.42	113.44	1.42	7.06	0.37	175.00	12.01	35.19	12.56	9.36
Sepahijala	Gongrai	DW	0.70	6.73	290.30	188.70	0.00	30.52	30.52	42.54	12.24	30.94	0.09	80.00	26.02	3.63	28.55	4.72
Sepahijala	Kanthalia Bazar	DW	0.60	6.78	466.60	303.29	0.00	36.63	36.63	99.26	4.16	19.09	0.45	195.00	54.04	14.54	11.44	6.64

District	Location	Source	Turbidity	pH	Conductance	TDS	CO_3^{2-}	HCO_3^-	TA	Cl^-	NO_3^-	SO_4^{2-}	F^-	TH	Ca^{2+}	Mg^{2+}	Na	K
			NTU		µS/cm at 25°C	mg/L												
Sepahijala	Konaban SC Colony	DW	0.70	6.42	257.40	167.31	0.00	30.52	30.52	46.09	4.64	23.71	0.17	95.00	26.02	7.27	18.70	7.06
Sepahijala	Lalmaibari	DW	0.90	6.42	177.90	115.64	0.00	18.31	18.31	53.18	16.97	19.11	0.31	100.00	18.01	13.34	12.70	6.86
Sepahijala	Rajib Nagar	DW	0.70	6.48	176.00	114.40	0.00	18.31	18.31	28.36	16.23	21.00	0.04	55.00	18.01	2.42	22.35	4.72
Sepahijala	Shivnagar	DW	0.60	6.68	171.50	111.48	0.00	12.21	12.21	60.27	16.34	19.84	0.28	65.00	16.01	6.06	34.21	13.46
Sepahijala	Tufaniamura	DW	0.80	6.80	267.60	173.94	0.00	30.52	30.52	46.09	12.23	27.57	0.55	75.00	20.02	6.06	31.55	9.79
South Tripura	Amli Ghat	DW	0.60	6.89	305.60	198.64	0.00	24.42	24.42	113.44	16.26	35.84	0.15	255.00	46.04	33.96	9.56	4.60
South Tripura	Ananda Bandhu Para	DW	1.00	6.94	152.10	98.87	0.00	18.31	18.31	31.91	1.95	6.73	0.25	55.00	12.01	6.06	8.76	7.02
South Tripura	Baishnabpur	DW	1.00	6.66	152.30	99.00	0.00	18.31	18.31	35.45	1.80	7.07	0.23	45.00	10.01	4.85	12.15	5.73
South Tripura	Barkashari	DW	0.50	6.96	101.10	65.72	0.00	18.31	18.31	39.00	0.03	3.55	0.23	55.00	18.01	2.42	11.06	8.76
South Tripura	Bijaynagar	DW	0.60	6.80	300.90	195.59	0.00	12.21	12.21	99.26	12.40	2.33	0.07	70.00	10.01	10.92	43.10	19.30
South Tripura	Gaurangar bazar	DW	0.70	7.00	97.27	63.23	0.00	12.21	12.21	39.00	0.06	3.21	0.00	50.00	12.01	4.85	10.16	7.97
South Tripura	Ghorakhappa	DW	1.00	6.75	155.30	100.95	0.00	18.31	18.31	42.54	2.13	6.62	0.16	50.00	14.01	3.63	20.26	5.74
South Tripura	Kalirbazar	DW	0.70	6.77	163.50	106.28	0.00	24.42	24.42	60.27	1.24	11.87	0.33	90.00	22.02	8.48	16.34	6.20
South Tripura	Magroom	DW	1.20	6.48	149.00	96.85	0.00	12.21	12.21	39.00	2.06	7.39	0.22	55.00	12.01	6.06	11.98	7.48
South Tripura	Manubazar	DW	0.60	7.24	287.50	186.88	0.00	30.52	30.52	42.54	14.37	42.11	0.36	135.00	46.04	4.83	13.25	5.49
South Tripura	ManurMukh	DW	0.70	7.50	664.40	431.86	0.00	61.05	61.05	60.27	4.28	18.29	0.42	360.00	28.02	20.62	12.26	6.63
South Tripura	Michara	DW	0.80	7.28	668.30	434.40	0.00	67.15	67.15	109.90	4.19	16.83	0.26	150.00	26.02	20.62	34.08	3.89
South Tripura	Motu Mogpara	DW	0.60	7.25	130.70	84.96	0.00	12.21	12.21	60.27	7.23	8.19	0.38	70.00	12.01	9.70	23.15	3.11
South Tripura	Paschim Jalefa EW	DW	0.70	7.07	169.30	110.05	0.00	30.52	30.52	42.54	3.38	1.40	0.35	75.00	24.02	3.63	12.87	3.69
South Tripura	Poangbari	DW	0.60	6.80	198.80	129.22	0.00	18.31	18.31	60.27	6.60	15.12	0.20	95.00	22.02	9.70	12.98	5.16
South Tripura	Purba Takka	DW	0.70	6.90	300.90	195.59	0.00	24.42	24.42	81.54	18.43	26.17	0.19	165.00	40.03	15.76	20.42	5.08
South Tripura	Radhanagar	DW	0.70	6.96	97.93	63.65	0.00	18.31	18.31	60.27	0.08	3.76	0.13	45.00	16.01	1.21	20.90	9.85
South Tripura	Rajnagar	DW	0.50	7.06	99.45	64.64	0.00	12.21	12.21	42.54	0.00	4.32	0.00	55.00	14.01	4.85	5.61	7.34
South Tripura	Sabroom	DW	1.90	6.75	85.68	55.69	0.00	6.10	6.10	28.36	16.60	2.88	0.29	35.00	8.01	3.64	4.85	21.40
South Tripura	Shashi Chandrapur	DW	0.60	6.92	138.30	89.90	0.00	18.31	18.31	39.00	6.98	9.84	0.26	55.00	16.01	3.63	20.01	4.07
South Tripura	Srinagar	DW	0.80	6.66	268.60	174.59	0.00	18.31	18.31	85.08	0.25	4.34	0.12	65.00	22.02	2.42	35.38	2.63
Unakoti	Chandra- moni Kami	DW	0.50	6.49	218.70	142.16	0.00	18.31	18.31	85.08	0.74	17.59	0.24	130.00	38.03	8.48	13.53	8.66

District	Location	Source	Turbidity	pH	Conductance	TDS	CO_3^{2-}	HCO_3^-	TA	Cl^-	NO_3^-	SO_4^{2-}	F^-	TH	Ca^{2+}	Mg^{2+}	Na	K
			NTU		µS/cm at 25°C	mg/L												
Unakoti	Dumdum	DW	1.00	6.55	57.77	37.55	0.00	18.31	18.31	46.09	0.80	5.14	0.07	45.00	8.01	6.06	19.46	5.87
Unakoti	Jarultali	DW	0.70	6.64	140.80	91.52	0.00	18.31	18.31	46.09	4.60	2.16	0.00	40.00	8.01	4.85	14.50	3.98
Unakoti	Kanchanbari	DW	0.80	6.55	250.80	163.02	0.00	18.31	18.31	60.27	29.89	1.88	0.12	85.00	20.02	8.49	25.60	8.84
Unakoti	Kanchan-cherra	DW	0.60	6.46	210.70	136.96	0.00	12.21	12.21	46.08	0.44	14.01	0.30	40.00	8.01	4.85	21.56	10.40
Unakoti	Karaicherra	DW	0.80	6.86	193.30	125.65	0.00	18.31	18.31	42.54	0.58	10.06	0.00	65.00	22.02	2.42	11.89	5.68
Unakoti	Panchamnagar	DW	0.80	6.67	146.00	94.90	0.00	24.42	24.42	42.54	3.51	3.82	0.49	70.00	26.02	1.20	5.31	5.19
West Tripura	A. D. Nagar	DW	0.80	6.77	125.90	81.84	0.00	18.31	18.31	42.54	1.85	28.56	0.08	50.00	12.01	4.85	29.73	5.04
West Tripura	Chandmari	DW	1.50	6.58	395.60	257.14	0.00	36.63	36.63	70.90	12.33	3.08	0.24	55.00	20.02	1.20	28.64	7.16
West Tripura	Gamcha kobra Market	DW	1.50	7.05	17.41	11.32	0.00	12.21	12.21	46.09	0.00	1.93	0.08	75.00	4.00	15.77	1.67	8.64
West Tripura	Ishanpur	DW	1.40	6.56	165.90	107.84	0.00	12.21	12.21	60.27	11.47	2.82	0.00	60.00	22.02	1.20	11.78	9.64
West Tripura	Khumulwng	DW	1.00	6.64	115.00	74.75	0.00	18.31	18.31	60.27	5.61	2.99	0.00	55.00	20.02	1.20	12.43	7.54
West Tripura	Madhuban	DW	0.80	7.09	344.50	223.93	0.00	12.21	12.21	85.08	38.55	0.59	0.00	65.00	14.01	7.27	45.68	13.40
West Tripura	R.K Nagar	DW	1.20	7.40	451.80	293.67	0.00	24.42	24.42	74.45	8.07	9.65	0.41	75.00	24.02	3.63	37.80	11.85
West Tripura	Sadhupara	DW	0.70	6.66	166.60	108.29	0.00	18.31	18.31	21.27	29.15	4.87	0.00	75.00	16.01	8.49	5.17	2.75
West Tripura	Simna	DW	1.10	6.57	143.10	93.02	0.00	18.31	18.31	81.54	3.02	5.79	0.49	50.00	18.01	1.20	29.68	2.85
West Tripura	Tarapur	DW	0.80	7.80	282.40	183.56	0.00	24.42	24.42	63.81	3.77	9.72	0.46	80.00	22.02	6.06	13.72	26.48

केंद्रीय भूजल बोर्ड, उत्तर पूर्वी क्षेत्र

Central Ground Water Board, North Eastern Region

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