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GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI
Department of WR, RD and GR
CENTRAL GROUND WATER BOARD

SPRING STUDIES AND ITS MANAGEMENT IN JAMPUI HILLS, NORTH TRIPURA DISTRICT

(AAP 2021-22)

NORTH EASTERN REGION
GUWAHATI
January, 2023

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(AAP 2021-22)

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NORTH EASTERN REGION
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EXECUTIVE SUMMARY

Springs are the major source of fresh water specially in the mountainous areas. These springs are the main source of water for a large population of communities living in the hilly area of Tripura. The objective of the study is to know the locations of the springs, their present status and sustainability for rural drinking water, quality aspect and future scope of development and lastly to recommend the suitable management plan.

Spring studies and its management in Jampui Hill range, North Tripura was carried out covering an area of 471.86 km^2. The study area includes Jampui hill block and parts of Dasda and Damcherra blocks. The Jampui Hills stretch from North to South and are bordering Damcherra block in the north, Dasda block in the west and south and Mizoram state in the east.

The average topographic elevation is 560m amsl and the highest point in Tripura is in Jampui Hill range at 930m amsl at Betlingchhip. The hill range is drained by Juri and Deo river which are dendritic to sub-dendritic in pattern. The streamlet drain either into the river Juri in the west or into river Langai in the east. In the Jampui hill the main geomorphic feature is steep flanked hill range. The western flank of Jampui Range is steeper than the eastern flank. The climate of the state is characterized by moderate temperature and high humid atmosphere. The average annual rainfall over the state is 1911 mm.

The area is occupied mainly by the semi consolidated Bhuban and Bokabil Formation of Surma Group of Tertiary age. The formation comprised mainly of hard compact sandstone, shale, silt and mudstone occurring on the anticlinal hill range. The yield potential is very limited due to superficial thickness of sediments.

Springs have been classified into various types depending upon various criterion like rock structure and discharge. On the basis of geological structure of the formation, three types of springs are identified viz, contact, depression and fracture spring. On the basis of discharge, the springs are classified as per Meinzer classification which falls in Fourth to Eight order. The discharge of the springs during the pre-monsoon and post monsoon season varies from 0.024 lpm to 6 lpm and 0.3 to 1200 lpm respectively.

Most springs show fluctuation in the rate of discharge. Fluctuations are in response to rainfall. The discharge measurement indicates the springs of Jampui hill are of seasonal nature. The discharge pattern is deeply co relatable with rainfall pattern, the discharge is highest in monsoon period and the discharge decreases gradually in post monsoon and become lowest in pre-monsoon whereas some springs dried up.

The result of chemical analysis shows that ground water quality in the area is potable and range of all the chemical constituents are within the permissible limit set by BIS, 2012. The quality of groundwater in the study area in general is acceptable for domestic and irrigation use. The spring water at Shantipur has a Fluoride value of 1.7 mg/l which is above the during post monsoon. In general electrical conductivity (EC) varies from 34.51 to 232.40 µS/cm. The content of iron in ground water ranges from 0.13 to 1.43 mg/L. Turbidity varies from BDL to 1 NTU. The other constituents are well within the permissible limit for drinking purpose.

There is a need to restore and preserve the spring from drying up. Supplementing the natural groundwater recharge, by first identifying the recharge area of the aquifers feeding the spring and then taking up artificial recharge works like digging trenches and ponds to catch the surface flow and enhance the infiltration forms the rejuvenation plan. It also involves the maintenance and protection of catchment of the spring and the spring head to ascertain that there is no danger of pollution to ensure safe water. It involves land use management and control from anthropogenic interference in the springshed.

1. INTRODUCTION

1.1 GENERAL

In pursuance of Annual Action Plan (AAP) 2021-2022 of the Central Ground Water Board (CGWB), North Eastern Region (NER), Guwahati, under Special Studies, Springs of Jampui Hill Range, North Tripura District, was selected for the study, covering an area of 471.86 km² falling in the Survey of India Toposheet no. 83D/7, 83D/8, 84A/5. The study area includes Jampui hill block and parts of Dasda and Damcherra blocks.

1.2 OBJECTIVE:

The present study was carried out with an objective to inventory springs in the area, identifying the spring type, their occurrence and distribution, to access the geochemistry of spring water and worked out the management plan for sustainable development of the area. This is the first time spring studies being carried out by CGWB in this area.

1.3 LOCATION, EXTENT AND ACCESSIBILITY

Jampui Hill is a part of the Mizo hills (Lushai Hills) range located in the North Tripura district in Tripura. The Jampui Hills stretch from North to South and are bordering Damcherra block in the north, Dasda block in the west and south and Mizoram state in the east extending between 23° 39′ 7.2″ to 24° 14′ 13.2″ N Latitude and 92° 9′ 10.8″ to 92° 19′ 44.4″ E Longitude. The average topographic elevation is 560m amsl and the highest point in Tripura is in Jampui Hill range at 930m amsl at Betlingchhip.

There are 10 small villages in Jampui hills range three blocks included and most of the inhabitants are the Mizo community. The villages are (from North to South) Vaisam, Hmawngchuan, Hmunpui, Tlaksih, Vanghmun, Behliangchhip, Bangla Zion, Tlangsang, Sabual and Phuldungsei, Paschim Bandarima, Shantipur. Vanghmun is the headquarters of Jampui R.D Block and there is a police station too. Besides these, UBI Bank and State Cooperative Bank have their branches functioning at Vanghmun. The population of the ranges

The whole of Jampui hills falls within Kanchanpur sub-division under North Tripura district with its headquarters located at Dharmanagar. There is a black topped road to Jampui Hills which is being developed to make it an interstate highway connecting with Mizoram. The nearest village, Hmunpui is 23 km (Approx) far from Kanchanpur, the Sub-Divisional Headquarters.

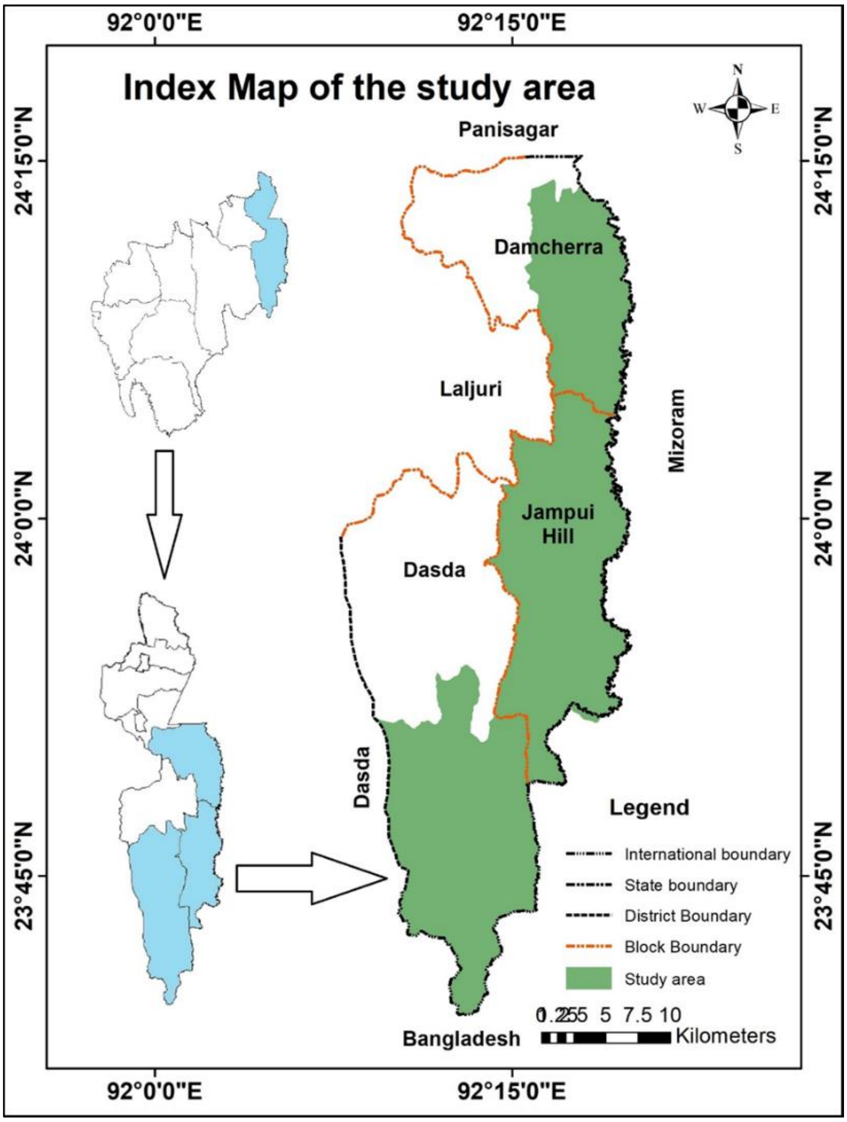

Figure 1: Map of the Study Area for the Spring Inventory

1.4 DEMOGRAPHY

The population of the study area dependent on springs is around 20,402 (as per 2011 census). The projected population till 2021 is 24,315.

Table 1: Demography of the study area (Jampui Hill range) dependent on Springs (2011 Census)

Village Name	ST	SC	OBC	Minority	UR	Total
Jampui Hills	11715	0	0	0	0	11715
Parts of Damcherra	3006	7	38	38	22	3111
Parts of Dasda	4029	769	702	0	76	5576
Total	**18750**	**776**	**740**	**38**	**98**	**20402**

1.5 CLIMATE & RAINFALL

The climate of the state is characterized by moderate temperature and high humid atmosphere. Winter sets in November and lasts till the end of February. Summer season starts from March and lasts upto May and is followed by Southwest monsoon lasting till September. Generally, the maximum summer temperature ranges from 35^{0}C to 40^{0}C and average minimum temperature in winter nights is recorded at 6^{0}C.

The state receives rainfall from Southwest Monsoon. The average annual rainfall over the state is 1911 mm. The intensity of rainfall increases from SW to NE in the state. In North Tripura district normal monsoon rainfall is 1387 mm and normal annual rainfall is 1940 mm.

Table 2: Rainfall (mm) in Dharmanagar & Kanchanpur station

Months (2021)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dharamnagar	0	0	139	39.6	196.5	232.5	307.7	329.3	191.2	113.4	0	100.4
Kanchanpur	2.2	0	69	73.2	157.2	173.8	617	475.8	244.2	113.4	0	103.4

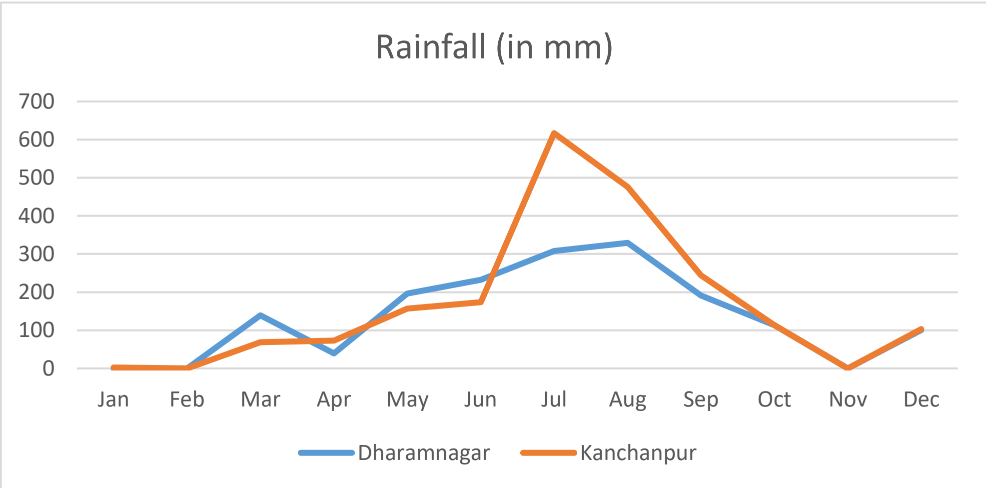

Figure 2: Rainfall (mm) graph of Dharmanagar & Kanchanpur station for the year 2021

1.6 CORRELATION OF RECHARGE WITH RAINFALL OF SPRING:

Most springs show fluctuation in the rate of discharge. Fluctuations are in response to rainfall. The discharge measurement indicates the springs of Jampui hill are of seasonal nature. The discharge pattern is deeply co-rrelatable with rainfall pattern, the discharge is highest in monsoon period and the discharge decreases gradually in post monsoon and become lowest in pre-monsoon whereas some springs dried up. The rainfall along with discharge of the springs are tabulated at Table no.3.

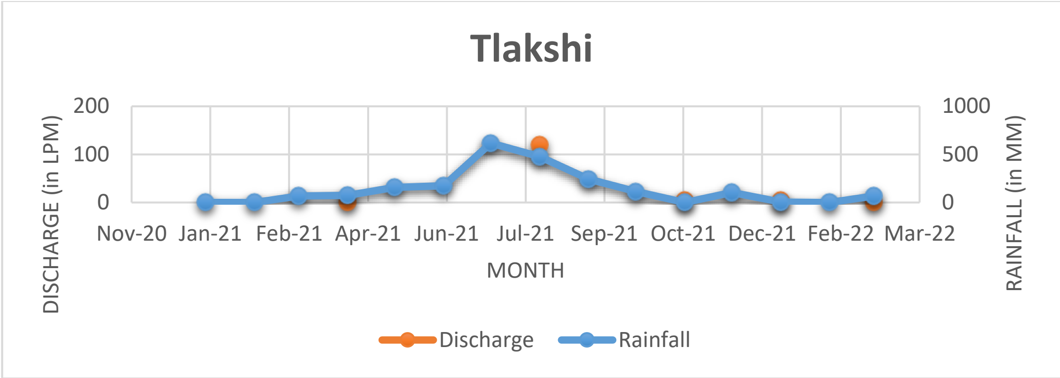

Figure 3: Discharge (lpm) of Tlakshi Spring vs Rainfall (mm) Kanchanpur station for the year 2021

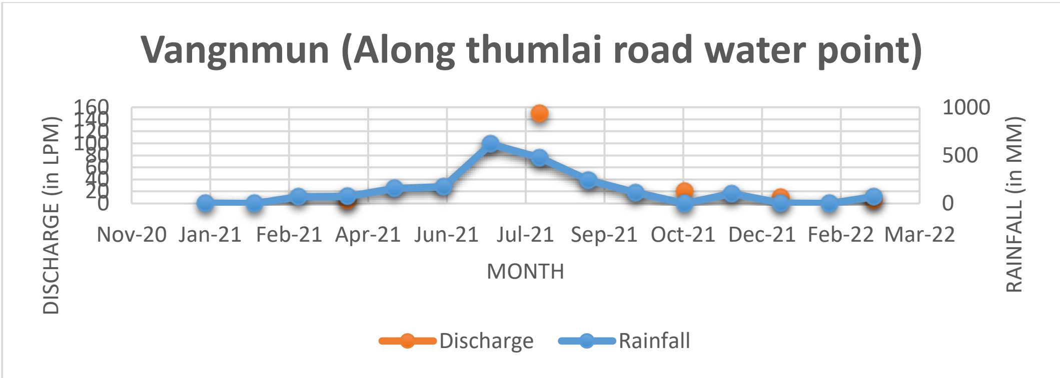

Figure 4: Discharge (lpm) of Vangnmum Spring vs Rainfall (mm) Kanchanpur station for the year 2021

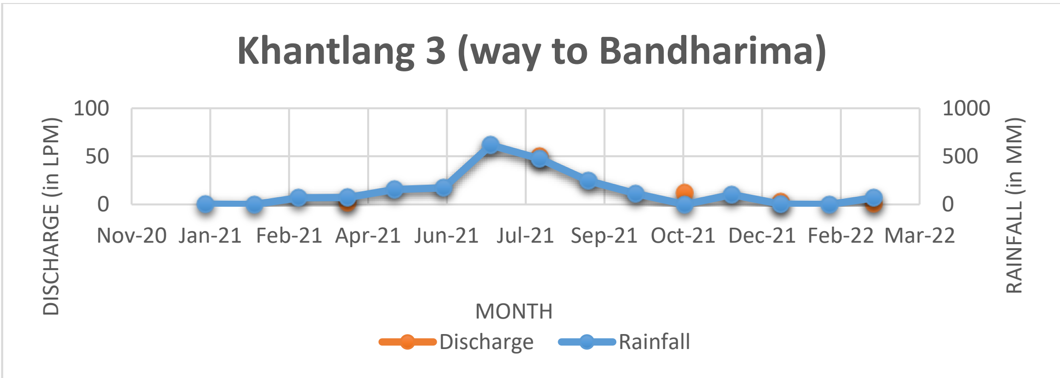

Figure 5: Discharge (lpm) of Khantlang 3 Spring vs Rainfall (mm) Kanchanpur station for the year 2021

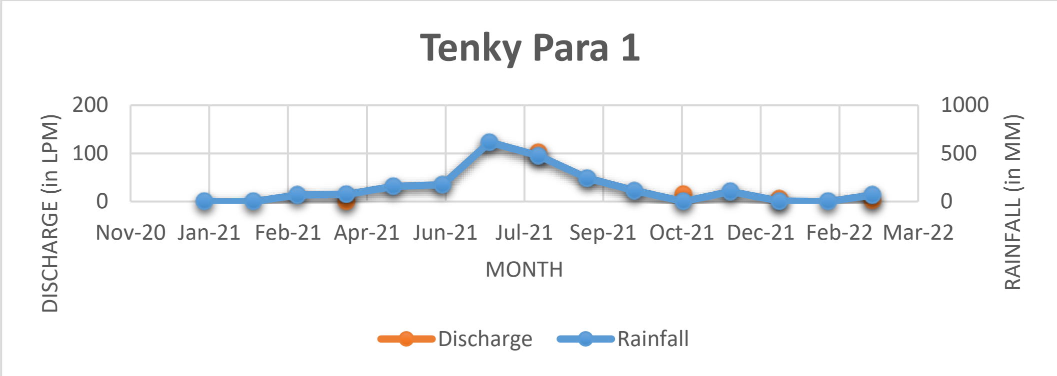

Figure 6: Discharge (lpm) of Tenky Para 1 Spring vs Rainfall (mm) Kanchanpur station for the year 2021

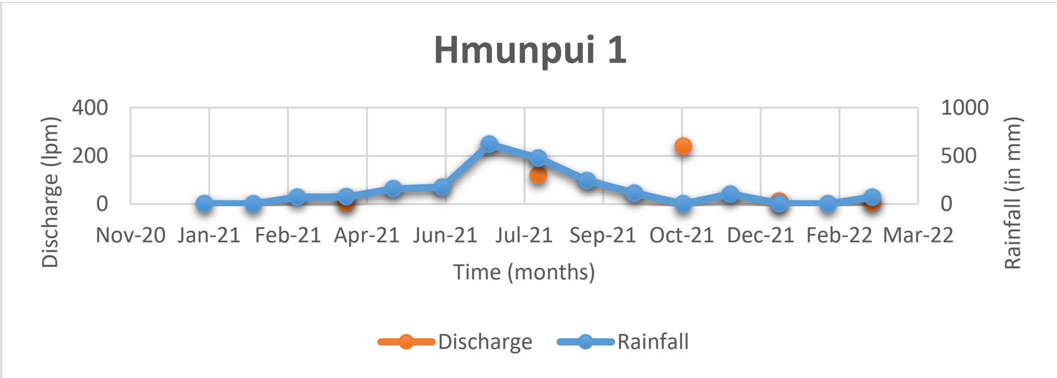

Figure 7: Discharge (lpm) of Hmunpui 1 Spring vs Rainfall (mm) Kanchanpur station for the year 2021

Table 3: Rainfall vs discharge of some of the Springsl

Month	Rainfall (mm)	Khantlang 3 (way to Bandharima)	Hmuanchang 2 (below water storage tank)	Sabual	Vaisum 4 (Way to Damcherra)	Along Thumlai Road water point	Tenky para 1	Tlaksih 1	Hmunpui 1	Hmunpui 2
		Discharge (lpm)								
Apr-21	73.2	1.5	1.5	1.5	1.0002	4.998	1.0002	1.0002	4.98	9.6
Aug-21	475.8	49.98	900	75	30	150	102.6	120	120	2700
Nov-21	0	12.00	6.00	6.00	3.53	20.00	15.00	4.98	240.00	1200.0
Jan-22	3.8	2.55	0.86	2.86	7.31	10.00	5.81	4.00	12.29	23.08
Mar22	68.6	1	1	1.5	2.74	6	2.65	1	5	6

1.7 GEOMORPHOLOGY

The geomorphology of the state of Tripura is characterized by a succession of hill ranges and valleys of meridional and sub-meridional trends. The hill ranges are actually box-like anticlines with relatively compact and resistant older rock units exposed in the narrow crests, whereas the valleys are flat synclines with younger and softer rock units exposed in the wide troughs. The folded belt constitutes the frontal sub-belt of the Assam-Arakan geosynclinal basins being separated on the east by the inner mobile sub-belt of the Mizoram consisting of tight linear folds. The geomorphology map is shown at figure 8.

The area can be divided into two distinct units on the basis of drainage pattern and topography. These are (i) Juri and Deo river valley (ii) parts of Jampui hill range with the Bongsul hill. In both the unit, the topography and drainage is related to geological structures and lithology.

- **(i)** The Juri-Deo valley is drained by a number of streams and streamlets which are dendritic to sub-dendritic in pattern
- **(ii)** In the Jampui-Bangsul hill the main geomorphic feature is steep flanked hill range. The western flank of Jampui Range is steeper than the eastern flank. The maximum elevation in the mapped area is 650 m above M.S.L. The height gradually decreases towards the north and the hill terminates north of village Vaisum.
- **(iii)** Hill crest are narrow and sharp particularly in the south.

1.8 STRUCTURE

Tectonically, the area comprises a sub-parallel, arcuate, elongated, doubly plunging folds arranged en-echelon pattern and trending in an average north-south direction with slight convexity to the west (Kher and Ganju, 1984). The folds are characterized by tight and narrow, box like anticlines alternating with broad flat synclines. The anticlines forming ridges are symmetrical and traversed, in most cases, by north-south longitudinal reverse faults.

The microscopic folds are varied in style. They are preserved mostly in the thinly laminated multilayer of silt-shale alternations of both Bhuban and Bokabil Formations. Two types are common sharp crested and disharmonic. Parallel (concentric) folds, overturned, recumbent and box folds are confined to the eastern sector.

1.9 DRAINAGE:

In the hills, the drainage pattern is rather pinnate. In the flanks the stream follows a straight N-S course for some distances, along faults, then take sharp bends either westerly or easterly to meet Deo, Juri or Langai. To the north of Jampui, the drainage is roughly northerly, along the plunge of the anticline. The streamlet drain either into the river Juri in the west or into river Langai in the the east. The pattern of the drainage is sub-dendritic. The river Langai follows a roughly north-south course along the narrow valleys between Janpui Range in the west and Hachheck Tlang (Range) in the east. The drainage map is at figure 9.

The course of Langai is also fault-controlled. Course of the river Deo upto Laljuri village is controlled by N-S trending faults. Juri River originates from the western flank of Jampui Range, takes a bend along the nose of Bongsul hill and then follows a NNW course within steeply dipping fault zone upto village Jalabasa and further north.

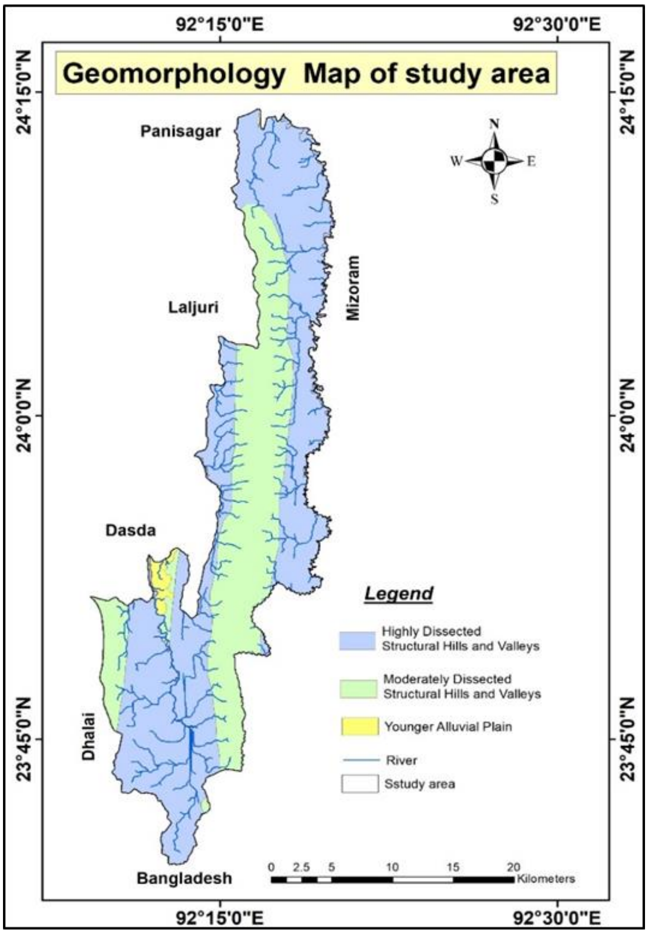

Figure 8: Geomorphology Map of the study area

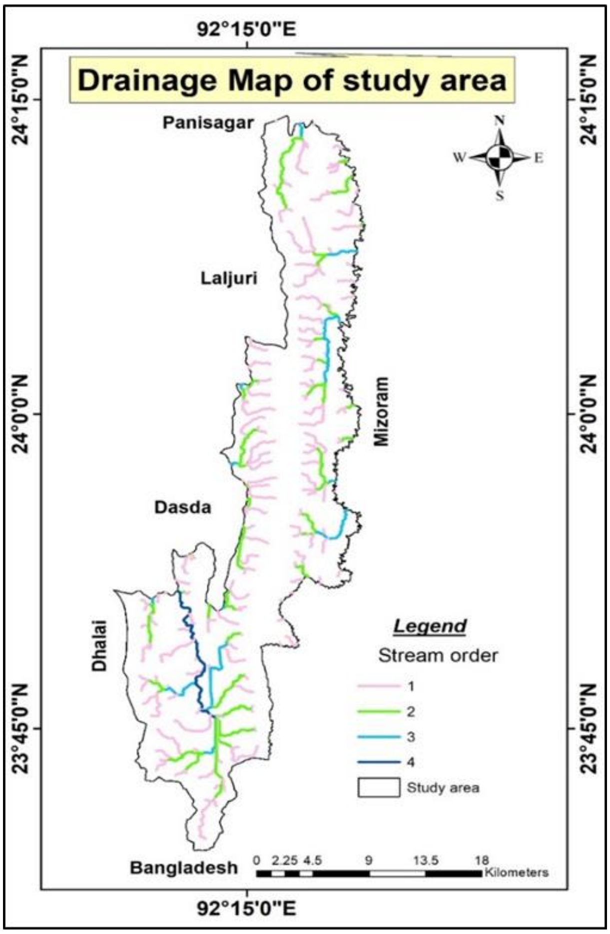

Figure 9: Drainage Map of the study area

1.10 LAND USE

The slope of Jampui Hills is more than 40 degrees and the entire block is stretched in a linear pattern with roads in the middle and houses on both sides. There has been immense change / shift in the agricultural practices from Orange orchards to beetle nut cultivation.

1.11 SOIL COVER

The study area is covered with the reddish yellow brown sandy soils. This soils occurring in ridge tops and sloping flanks of the hill ranges, are highly susceptible to erosion. Due to continuous erosion and chemical weathering of the bed rock, the finer fractions of the soil mantle have been leached down to the lower horizons of the soil profile, leaving the residual littered with a layer of coarse silty or fine sandy material of reddish brown hue. The surface colour of these soils is usually found to be yellowish brown to dark brown sandy nature. The red loam and sandy loam soils are associated with the intermountain valleys and the forest cover of undulating uplands. These soils are largely of residual nature are generated under forest environment (figure 10.).

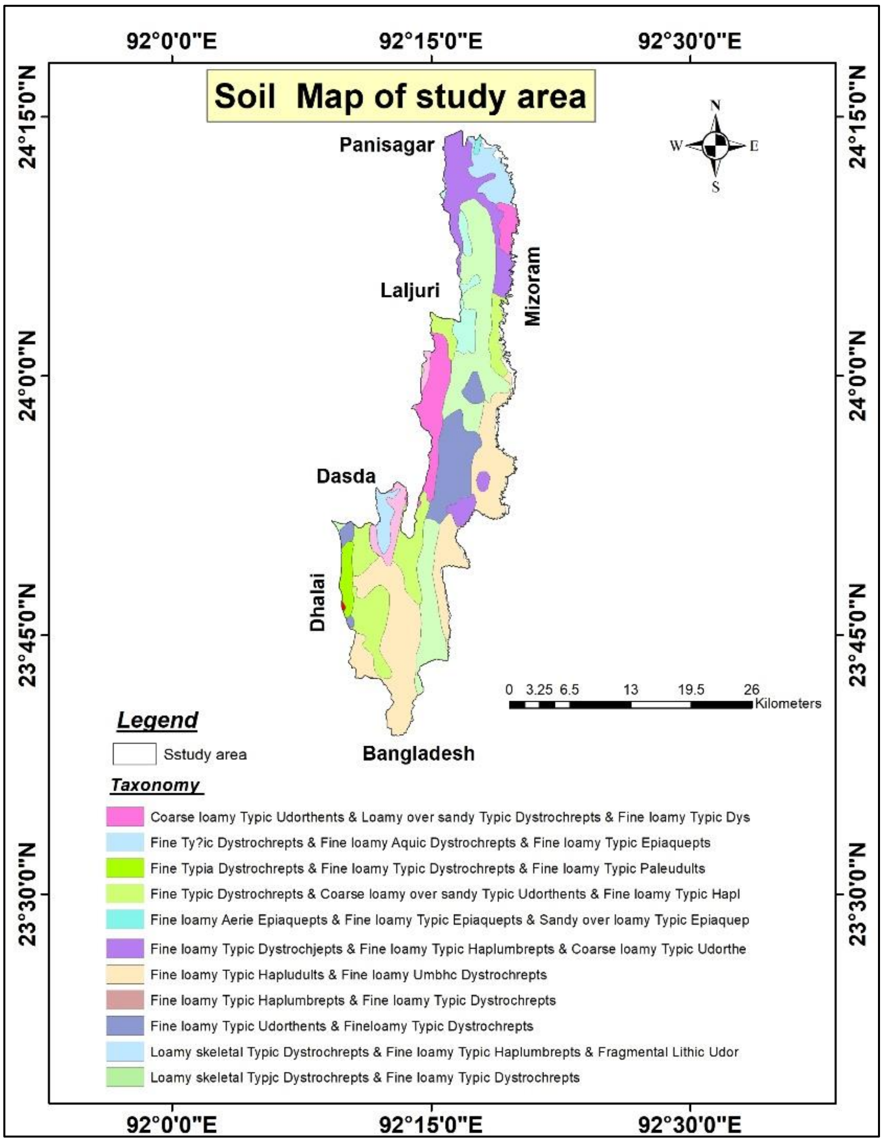

Figure 10: Soil Map of the study Area

1.12 SLOPE ANALYSIS AND ASPECT:

The slope direction of recharge zone of each of the springs is determined using aspect map prepared in Arc GIS. Slope type is also determined to divide the respective catchment into various slope categories ranging from 0 to 60° (figure 11).

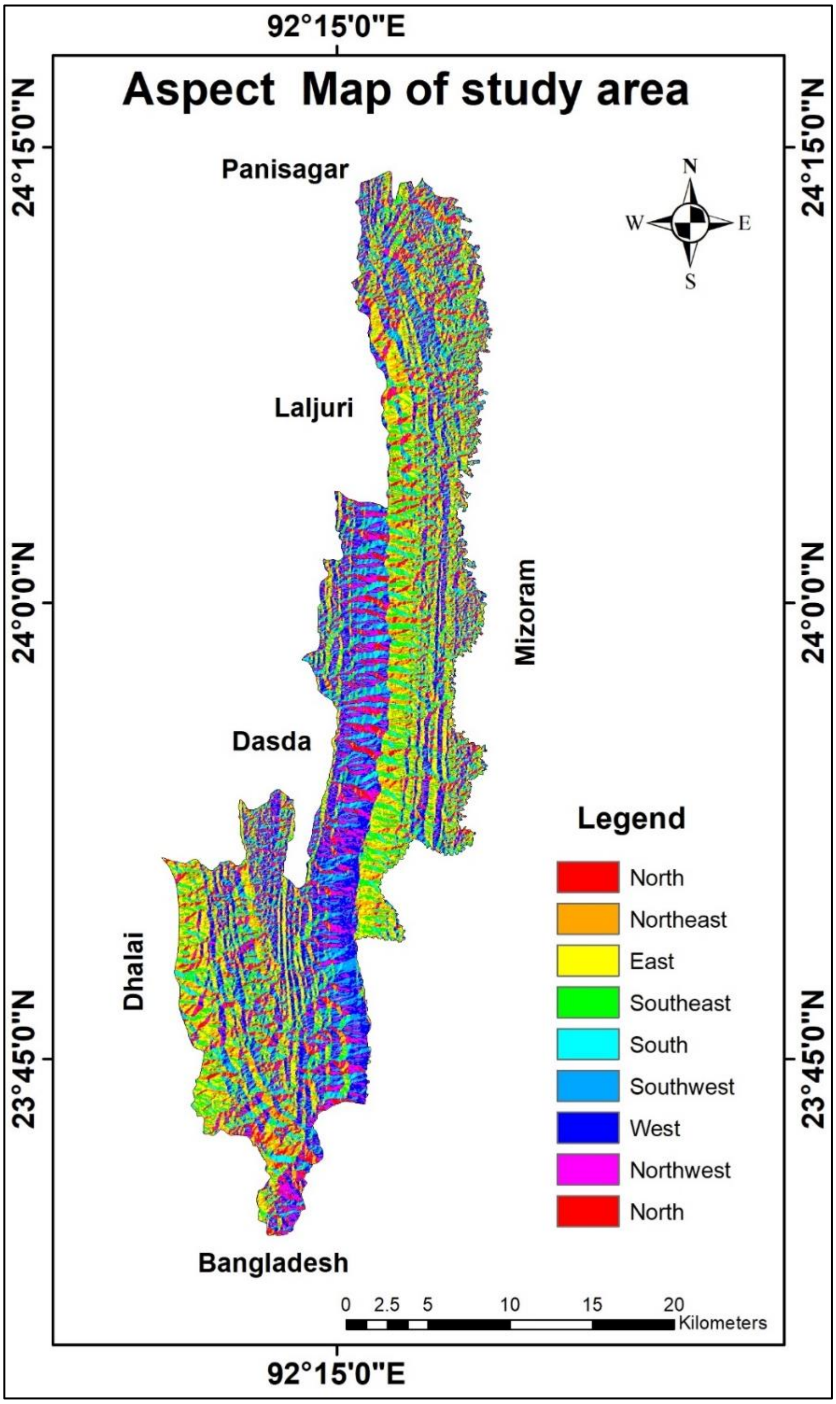

Figure 11: Aspect Map of the study area

1.13 GEOLOGY

Geologically the state of Tripura is occupied by sedimentary formations of Recent to Tertiary age. Stratigraphycally the state is divided into 4 units i.e Alluvial formation, Dupitila formation, Tipam formation and Surma formation (Bokabil and Bhuban) depicted at figure 12.

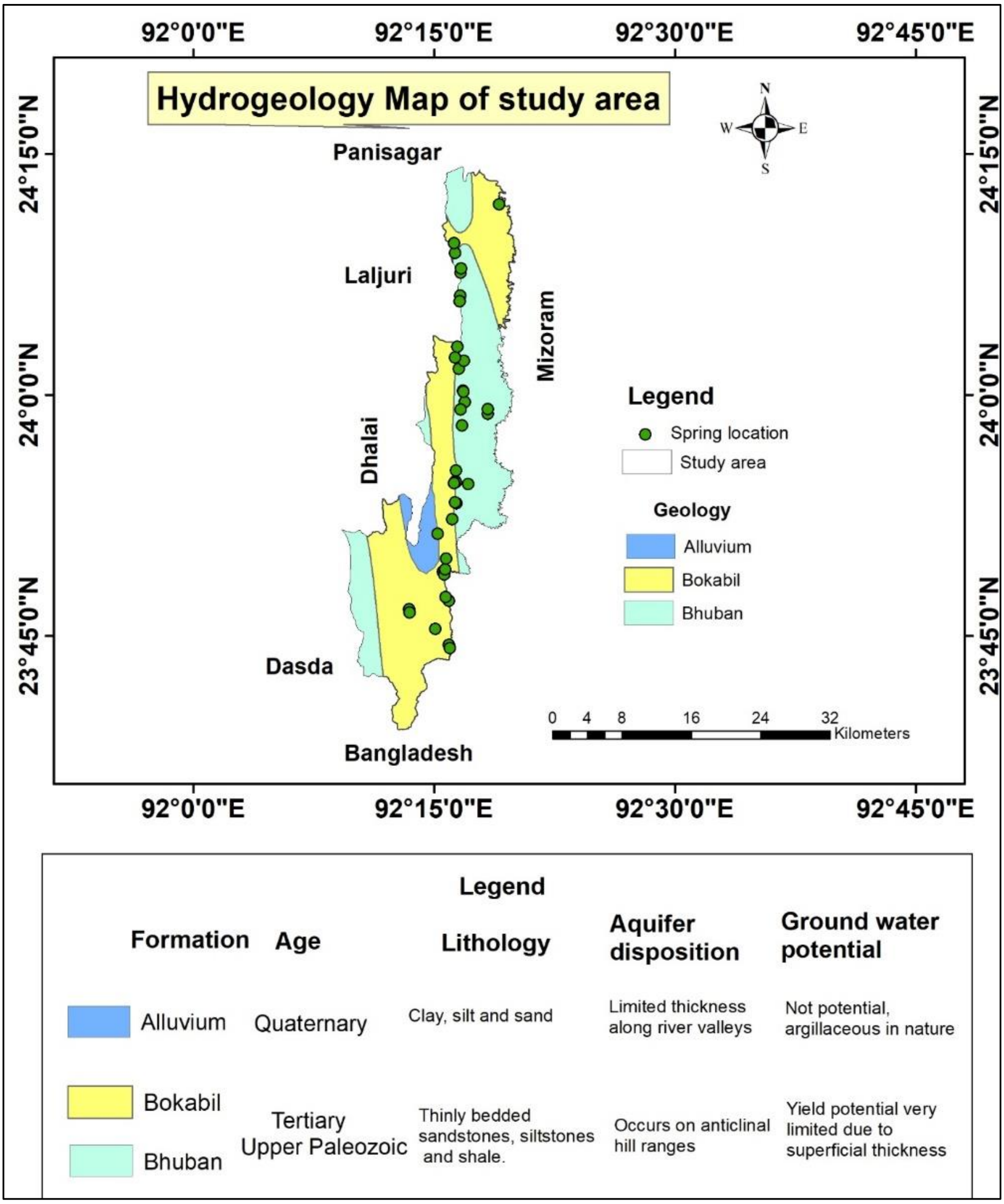

Figure 12: Hydrogeological Map of the study area

The study area consisting of sedimentary rocks of Bokabil & Bhuban Formation of Surma Group.

Table 4: Geology of the study area

Age	Group	Formation	Lithology
Tertiary	Surma	Bokabil	Sandstone: Thinly laminated, bedded sandstone and silt (repetition) with ferruginous materials, medium to coarse micaceous sandstone with mudstone
		Bhuban	Shale/Sandstone: Intruded, hard compact, both massive and well-bedded sandstone, dark to olive shale repeated (exposed in core of anticlines)

2. SPRING INVENTORY

Spring is concentric discharge of ground water on the surface. Water from spring moves downhill through soil, cracks or from any depression present in rock and comes out of the ground by natural pressure. The amount, or yield, of available water form springs may vary with the time of year and rainfall. Springs are the major source of fresh water specially in the mountainous areas. These springs are the main source of water for a large population of communities living in the hilly area of Tripura. During the pursuance of the field study 40 numbers of springs were inventoried and 35 numbers were monitored periodically covering Jampui hill block, parts of Dasda and Damcherra block (figure 12). The discharge of the spring was monitored periodically {Datasheet (Discharge)}. The objective of the study is to know the locations of the springs, their present status and sustainability for rural drinking water, quality aspect and future scope of development and lastly to recommend the suitable management plan. The discharge of the springs during the pre-monsoon and post monsoon season varies from 0.024 lpm to 6 lpm and 0.3 to 1200 lpm respectively.

The details of the springs are as follows:

2.1 Shantipur 1:

The spring is located on the Right Hand Side while coming from Ananda bazar at an elevation of 130.3 m amsl. The slope of hill is 60 to 70° and aspect is towards northeast. Laminated layered weathered shale formation with thick vegetation cover the area and water from the spring is stored in the storage tanks. The water is being used for drinking and domestic purpose.

2.2 Shantipur 2 (Paschim Bandrima):

The spring is located on the Right Hand Side while coming from Ananda bazar at an elevation of 121.3m amsl. The slope of hill is 60 to 70° and aspect is towards northeast. Laminated layered weathered shale formation with thick vegetation cover the area and water from the spring is stored in the storage tanks. The water is being used for drinking and domestic purpose.

Figure 13: Shantipur-2 Spring

2.3 Khantlang 1:

The spring is located on the RHS of the road towards Paschim Bandarima approximately 150 m downslope. The spring is located at an elevation of 650.9 m amsl. The slope is 60 to 70° and aspect is towards west. The rock type consisting of consolidated fractured sandstone formation. The spring is used for drinking & domestic purpose. Beetle nut plantation observed at the top of spring.

Figure 14: Khantlang-1 spring

2.4 Khantlang 2:

The spring is located on the RHS of the road towards Paschim Bandarima just beside the water storage pumping unit, at an elevation of 652.6 m amsl. The slope is 60 to 70° and aspect is towards west. The lithology of the area consisting of fractured sandstone formation. The consistency of the flow is variable reduced during lean period (December to January) and it gets dried during pre-monsoon period (March – April). Approximately 40 families dependent on this spring for drinking and domestic uses.

2.5 Khantlang 3:

The spring is located on the Left hand side while coming from Vangmun at an elevation of 380.2m amsl. Slope is 60 to 70° and aspect is towards southwest. Consolidated sandstone of fractured nature present at the area with forested thick vegetation. The spring is used for drinking & domestic purpose.

Figure 15: Khantlang 3 spring

2.6 Zomuantlang 1:

The spring is located on the RHS of the road towards Vahnmun approximately 250 m downslope. The spring is located at an elevation of 671 m amsl. The slope is 40 to 50° and aspect is towards northeast. The rock type consisting of consolidated bedded sandstone formation of fractured nature. The spring is primarily used for domestic purpose. Dense vegetation. Jhum cultivation (Paddy) is being observed at the Right side of spring.

Figure 16: Zomuantlang 1 spring

2.7 Zomuantlang 2:

The spring is located on the RHS of the road towards Vahnmun approximately 300 m downslope. The spring is located at an elevation of 680 m amsl. The slope is 40 to 50° and aspect is towards northeast. The rock type consisting of weathered sandstone and soil. The spring is primarily used for domestic purpose.

Figure 17: Zomuantlang 2 spring

2.8 Phuldungsei 1:

The spring is located on the RHS of the road towards Vahnmun approximately 300 m downslope at an elevation of 835 m amsl. The slope is 50 to 60° and aspect is towards west. The area consisting of consolidated sandstone formation fractured in nature. The spring is used for drinking and domestic purpose.

Figure 18: Phuldungsei 1 spring (pre-monsoon)

Figure 19: Phuldungsei 1 spring (post-monsoon)

2.9 **Phuldungsei 2 :**

The spring is located on the RHS of the road towards Vahnmun approximately 200 m downslope. The spring is located at an elevation of 835 m amsl. The slope is 40 to 50° and aspect is towards northeast. The rock type consisting of consolidated sandstone formation fractured in nature. The spring is being used for drinking and domestic purpose.

Figure 20: Phuldungsei 2 spring

2.10 **Phuldungsei** 3:

The spring is located LHS of the road on the way to Betliansib (the highest peak of Jampui hills range.) below the TSR camp approximately 100 m downslope, at an elevation of 867.8 m amsl. The slope is 60 to 70° and aspect is towards northeast. The area consisting of weathered sandstone with soil Unit. The spring is used for domestic purpose.

Figure 21: Phuldungsei 3 spring

2.11 **Phuldungsei 4**:

The spring is located on the LHS of the road next to church while coming from vanghmun, located at an elevation of 828 m amsl. The slope is 50 to 60° and aspect is towards east. The area consisting of consolidated sandstone covered with surface soil. The spring is used for domestic purpose.

Figure 22: Phuldungsei 4 spring

2.12 **Phuldungsei** 5:

The spring is located on the LHS of the road while coming from vanghmun below BSNL tower approximately 300 m downslope at an elevation of 844.6 m amsl. The slope is 60 to 70° and aspect is towards north east. Lithologically the area consisting of consolidated sandstone covered with surface soil. The spring water is used for drinking and domestic purpose.

2.13 **Sabual**:

The spring is located on the RHS of road towards Vanghmun approximately 1 km downslope from the road located at an elevation of 724.6 m amsl. The slope is 50 to 60° and aspect is towards southeast. The area consisting of consolidated fractured sandstone formation. The spring is primarily used for drinking and domestic purpose.

Figure 23: Sabual spring

2.14 **Tenkypara** 1:

The spring is located on the RHS of road while towards vanghmun approximately 300 to 400 m downs from the road at an elevation of 700.2 m amsl. The slope is 50 to 60° and aspect is towards east. The area consisting of Consolidated sandstone covered with surface soil. The spring is primarily used for drinking and domestic purpose.

Figure 24: Tenkypara 1 spring

2.15 **Tenkypara** 2:

The spring is located adjacent to the road on the LHS towards Vanghmun at an elevation of 763.3 m amsl. The slope is 60 to 70° and aspect is towards east. The area consisting of consolidated sandstone with sediments. The spring is used for domestic purpose.

2.16 **Tlangsang** 1:

The spring located on the RHS of road towards vanghmun approximately 700 to 800 m downslope next to the Tlangsang Training Academy teachers residence at an elevation of 609.4 m amsl. The slope is 50 to 60° and aspect is towards east. The area consisting of consolidated sandstone covered with surface soil. A check dam is constructed on downslope to collect spring water. This water is then supplied to the Tlangsang training academy and nearby habitation for drinking & domestic purpose.

Figure 25: Tlangsang 1 spring

2.17 **Tlangsang** 2:

The spring is located LHS of the road next to the shop with Tlangsang village entry point approximate 600 m away downslope from road, at an elevation of 746.8 m amsl. The slope is 50 to 70° and aspect is towards east. The area consisting of consolidated sandstone formation. The spring is used for drinking & domestic purpose.

Figure 26: Tlangsang 2 Spring

2.18 **Tlangsang** 3:

The spring is located on the RHS of the road next to the church approximately 200m downslope towards Vnghmun at an elevation of 740.8 m amsl. The slope is 50 to 60° and aspect is towards east. The area consisting of fractured consolidated sandstone beds. The spring is used for drinking & domestic purpose.

Figure 27: Tlangsang 3 spring

2.19 **Tlangsang** 4:

The spring is located RHS of the road next to the Tlangsang ICDS centre is approximate 200 m downslope from the road, at an elevation of 738 m amsl. The slope is 50 to 70° and aspect is towards east. The area consisting of consolidated sandstone formation. The spring is used for drinking & domestic purpose.

Figure 28: Tlangsang 4 spring

2.20 **Tlangsang** 5:

The spring is located on the RHS of road while coming from vanghmun below the bus stop approximately 350-400 m downslope at an elevation of 272 m amsl. The slope is 60 to 70° and aspect is towards east. The spring is used for drinking & domestic purpose.

Figure 29: Tlangsang 5 spring

2.21 **Belianchip**:

The spring is located on the RHS of road towards the Belianchip view point below vehicle repairing workshop approximately 200 m downslope at an elevation of 649.4 m amsl. The slope is 45 to 50° and aspect is towards east. The lithology consisting of consolidated Sandstone formation. The spring is used for domestic purpose.

Figure 30: Belianchip spring

2.22 **Hmunpui1**:

The spring is located on LHS of road towards Vanghmun just beside the main road approximately 100 m elevation at elevation of 491.2 m amsl. The slope is 50 to 60° and aspect is towards east. The area consist of consolidated Sandstone formation. The spring is used for domestic purpose.

Figure 31: Hmunpui 1 spring

2.23 Hmunpui 2:

The spring is located on the LHS of road towards Vanghmun just adjacent to the main road at an elevation of 347.6 m amsl. The slope is 70 to 80° and aspect is towards east. Lithologically the area contains consolidated sandstone with surficial soil. The spring is used for drinking & domestic purpose.

Figure 32: Hmunpui 2 spring

2.24 Along Thumlai Road water point:

The spring is located on RHS of road while coming from Eden tourist lodge just adjacent to the main road at an elevation of 467.3 m amsl. The slope is 50 to 60° and aspect is towards east. The area consist of consolidated sandstone formation of fractured nature. The spring is primarily used for drinking and domestic purposes.

Figure 33: Along the Thumlai road water front

2.25 Ruchokon:

The spring is located on RHS of the road towards Vanghmun approximately 250 m downslope at an elevation of 546 m amsl. The slope is 50 to 60° and aspect is towards east. The area consists of consolidated sandstone of fractured nature. The spring is used for domestic purpose only.

Figure 34: Ruchokon Spring

2.26 Tlakshi 1:

The spring is located below the Tlakshi church on the RHS of the motorable road approximately 250 m downslope, at an elevation of 574 m amsl. The slope is 60 to 70° and aspect is towards east. The rock type of the area is unconsolidated sandstone. Used for drinking & domestic purpose.

Figure 35: Tlakshi 1 spring

2.27 Hmuanchang 1:

The spring is located beside the road approximately 300 m downslope at an elevation 537.3 m. The rock type of the area is fine grained sandstone, grey in colour and fractured nature. The spring is being used for drinking and other domestic purposes.

Figure 36: Hmuanchaang 1 spring

2.28 Hmuanchang 2:

The spring is located beside the road approximately 200 m downslope from the water storage pumping unit at an elevation of 529.7 m amsl. The slope is 60 to 70° and aspect is towards east. The rock type of the area is unconsolidated sandstone. The spring is primarily used for drinking and domestic purposes.

Figure 37: Hmuanchang 2 spring chamber

Figure 38: Hmuanchang 2 spring

2.29 Vaisum 1:

The spring is located beside the road RHS on the way to Vaisum village approximately 250 m downslope inside the premise of water storage pumping unit at an elevation of 435.7 m amsl. The slope is 60 to 70° and aspect is towards east. The rock type of the area is consolidated sandstone covered with unconsolidated soil. The spring is primarily used for drinking and domestic purposes only.

Figure 39: Vaisum 1 spring

2.30 Vaisum 2:

The spring is located just adjacent to the main road on the LHS on the way to Damcherra at an elevation of 431.5 m amsl. The slope is 60 to 70° and aspect is towards east. The rock type of the area is unconsolidated sediments covering consolidated. The spring is being used by locals for drinking and other domestic purposes.

Figure 40: Vaisum 2 spring

2.31 Vaisum3:

The spring is located just beside the main road on the LHS towards Damcherra an elevation of 276.4 m amsl. The slope is 60 to 70° and aspect is towards east. The rock type of the area is consolidated sandstone. The spring is primarily used for drinking and domestic purposes only.

Figure 41: Vaisum 3 spring

2.32 Vaisum 4:

The spring is located just beside the main road on the LHS towards Damcherra an elevation of 229.6 m amsl. The slope is 60 to 70° and aspect is towards east. The rock type of the area is unconsolidated sandstone. The spring is being used by locals for drinking & domestic purposes.

2.33 Khakchang Para:

The spring is located just beside the main road on the RHS towards Damcherra an elevation of 77.7 m amsl. The slope is 60 to 70° and aspect is towards east. The rock type of the area is Consolidated sandstone covered with thin layer of unconsolidated soil. The spring is being used by locals for drinking & domestic purposes.

Figure 42: Khakchang Para spring

2.34 Vahnmun 1:

The spring is located just beside the main road on the RHS towards Tribal guest House approximately 200 m downslope at an elevation of 560.1 m amsl. The slope is 60 to 70° and aspect is towards east. The rock type of the area is Consolidated sandstone covered with thin layer of sediments. The spring is being used by locals for domestic purposes.

2.35 Vahnmun 2:

The spring is located just beside the main road on the RHS opposite od PNB bank of Vahnmun village approximately 300 m downslope at an elevation of 644.5 m amsl. The slope is 60 to 70° and aspect is towards east. The rock type of the area is unconsolidated sediments. The spring is primarily used for drinking and domestic purposes only.

Figure 43: Vahnmun 2 spring

Figure 44: Vahnmun 2 spring chamber

3. SPRING CLASSIFICATION

Spring describe as concentrated discharge of ground water appearing on the surface as flowing water (Todd, 1995, p-48). Seepage areas are which indicate a slower movement of ground water to the ground surface. Spring are fed by aquifers system i.e. the types of rock present in that area, which stores and transmits water to those springs. Rocks of various type show different properties which are characteristics of their process of formation. All these properties influences behaviour of spring. Accordingly, springs have been classified into various types depending upon various criterion like rock structure, discharge, temperature, and variability. Bryan (Bryan, 1919) divided all springs into (1) those resulting from gravitational forces and (2) those resulting from non-gravitational forces. Under the former are included volcanic springs (associated with volcanic rocks) and fissure springs (resulting from extending to greater depth in earth's crust).

3.1 CLASSIFICATION BASED ON NATURE OF HYDRAULIC HEAD:

3.1.1 On the basis of hydraulic head i.e. the pressure head of the formation:

(a) Gravity Spring: This type of spring emerges where water table cuts the surface under unconfined condition. They are also called descending spring.

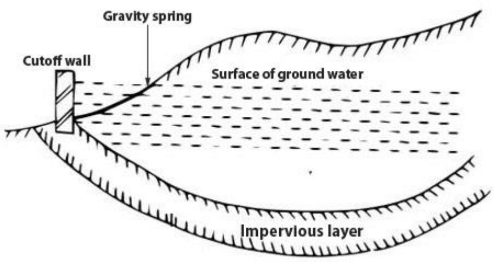

Figure 45: Gravity Springs

(b) Artesian Spring: This type of spring emerges under pressure surface under confined condition of the aquifer. They are also called ascending or rising spring.

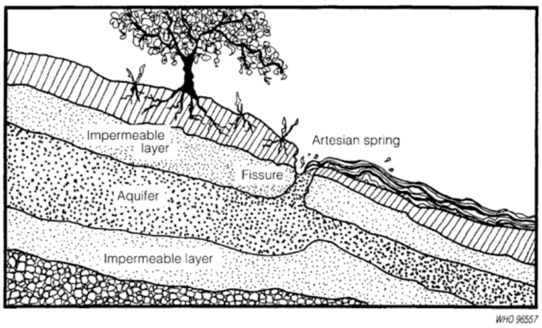

Figure 46: Artesian Spring

3.1.2 Classification based on geology: On the basis of geological nature i.e. the geological structure of the formation:

(a) Depression Spring: They are formed when the water table intersects the topography. In this type of spring the discharge may vary depending upon the position of water table of that area. As the Springs are formed because of earth's gravitational pull they are named depression or gravity springs. These are usually found along the hillside and cliffs.

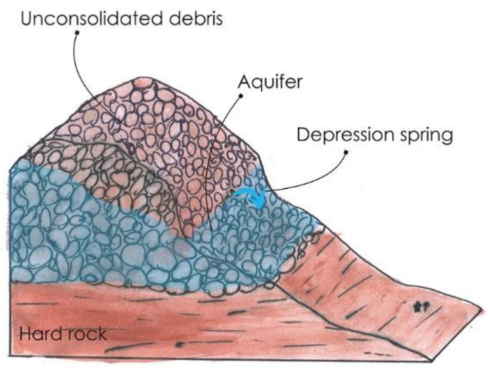

Figure 47: Graphical representation of a Depression spring

(b) Contact Spring: This kind of springs formed at the contact zone where relatively permeable rock formation overlies rock formation of low permeability. As a result, water comes out from such contact as flow. They are known as contact spring.

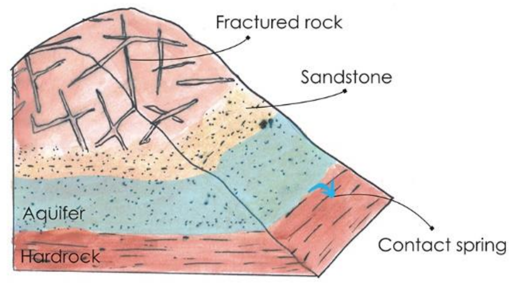

Figure 48: Graphical representation of a Contact spring

(c) Fracture Spring: Springs of this type occur due to presence of permeable fracture zones in rocks of less permeability. Groundwater moves mainly through porous fracture zones that constitute the porosity and permeability of aquifers. Springs are formed where these fractures intersect the ground surface.

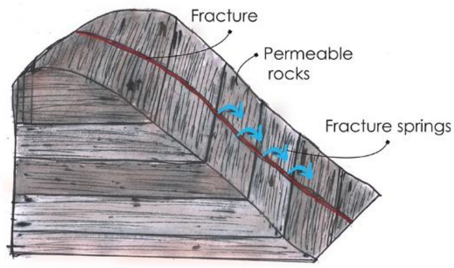

Figure 49: Graphical representation of a Fracture spring

(d) Fault Spring: Faulting may also sometimes give rise to conditions in which groundwater (at depth) under hydrostatic pressure (such as in confined aquifers) can move up along such fault openings to form a spring.

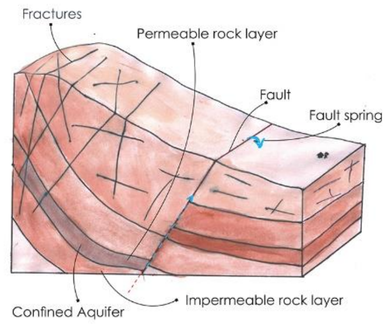

Figure 50: Graphical representation of a Fault spring

(e) Karst Spring: The term 'Karst' is derived from a Slavic word that means barren, stony ground. It is also the name of a region in Slovenia near the border with Italy that is well known for its sinkholes and springs. Geologists have adopted karst as the term for all such terrain. Cavities are formed in carbonates rocks (limestones, dolomites, etc.) due to dissolution of rock material by chemical reaction. Water moves through these cavities and openings to form a spring or a system of springs.

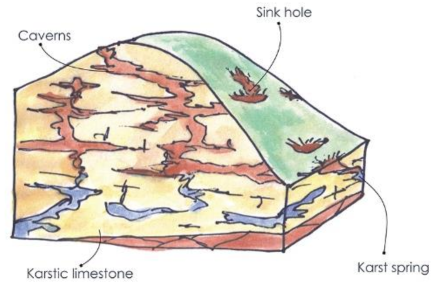

Figure 51: Graphical representation of a Karst spring

3.2 CLASSIFICATION BASED ON DISCHARGE:

Meinzer proposed a classification scheme by discharge to define magnitude of spring. The spring discharge depends on the area contributing to the recharge of the aquifer and the rate of recharge. Mostly spring discharge fluctuate in the rate of discharge in response to the periods ranging from minutes to years, depending on geologic and hydrologic conditions.

3.3 FIELD FINDINGS:

The classification in both the cases has been carried out for the 35 springs which were approachable. The remaining springs although inventoried, but were not approachable.

3.3.1 Based on Nature of Hydraulic Head:

Table 5: Different types of springs inventoried in the study area based on Hydraulics

Sl No.	Spring Types	Nos	Names	Lithology/Resons
1	Contact spring	6	Khakchnagpara, Phuldungsei 4, Tlangsang 1, Vaisum 1, Behliangchip and Tlangsang 2	Contact between unconsolidated soil and semi-consolidated sandstone.
2	Depression spring	12	Hmuanchang 2, Phuldungsei 3, Phuldungsei 5, Santipur, Paschim Bandarima, Tenky para1, Tlaksih 1, Tlangsang 5, Vahnmun 1, Vahnmun 2, Vaisum 4 , Zomuantlang 2	Unconsolidated sediments
3	Fracture spring	17	Hmuanchang 1, Hmunpui 1, Hmunpui2, Khantlang1, Khantlang 2, Khantlang 3, Phuldungsei 1, Phuldungsei 2, Ruchukon, Sabual, Tenky para 2, Thumlai Road water pioint, Tlangsang 3, Tlangsang 4, Vaisum 2, Vaisum 3 Zomuantlang 1.	Bedded sandstone
	Total	35		

3.3.2 Based on Discharge:

On the basis of discharge, springs of Jampui Hills are classified as per Meinzer classification given in the table below:

Table 6: Classification of Springs by Discharge (After Meinzer)

Sl. No.	Magnitude (Order)	Numbers of Spring	Names
1	4th	1	Hmunpui 2
2	5th	6	Hmuanchang 2, Hmunpui 1, Tlangsang 1, Vaisum 1, Vaisum 3, Zomuantlang 2
3	6th	18	Behliangchip, Khakchnagpara,, Khantlang 1, Khantlang 2, Khantlang 3, Phuldungsei 2, Ruchukon, Sabual, Paschim Bandarima, Tenky para1, Thumlai Road water pioint, Tlaksih 1, Tlangsang 2, Tlangsang 4, Vahnmun 2, Vaisum 2, Vaisum 4, Zomuantlang 1
4	7th	9	Hmuanchang 1, Phuldungsei 1, Phuldungsei 4, Phuldungsei 5, Santipur, Tenky para2, Tlangsang 3, Tlangsang 5, Vahnmun 1
5	8th	1	Phuldungsei 3
	Total	35	

4. HYDROCHEMISTRY

Hydrochemistry is a field that integrates various disciplines to study the chemical composition of natural waters, focusing on understanding the dynamics of composition changes influenced by chemical, physical, and biological processes within the surrounding environment. The primary objective of hydrochemistry is to assess the chemical quality of groundwater and determine its suitability for specific purposes, such as domestic and irrigation use.

To achieve this, the study area involved in the research collected spring water samples for analysis. These samples were then subjected to thorough examination at the Regional Chemical Laboratory of the Central Ground Water Board, located in the North Eastern Region, Guwahati.

The analysis conducted at the laboratory encompassed a range of scientific techniques and methodologies. The chemical composition of the spring water samples was assessed, examining parameters such as pH (a measure of acidity or alkalinity), electrical conductivity (a measure of ion concentration), total dissolved solids (TDS), and various ions including cations (positively charged ions) and anions (negatively charged ions). The presence and concentration of elements, such as heavy metals (e.g., iron, arsenic, uranium), were determined to identify potential contaminants.

Additionally, the laboratory likely employed advanced instruments and analytical techniques, such as spectrophotometry, ion chromatography, atomic absorption spectroscopy, to achieve accurate and precise measurements of the chemical constituents present in the spring water samples.

4.1 QUALITY OF SPRING WATER

The research study involved the collection of spring water samples from a diverse range of spring sources. In order to assess the quality of the water, analyses were conducted on various parameters, including basic characteristics, heavy metal content, iron levels, as well as arsenic and uranium concentrations. The samples were collected twice, once during the month of November 2021 and again in March 2022, representing pre-monsoon and post-monsoon periods respectively.

A statistical summary was generated to provide an overview of the physico-chemical properties of the spring water samples obtained from different groundwater abstraction structures within the study area. This summary aimed to capture the essential features of the dataset and enable the identification of any potential variations between the pre-monsoon and post-monsoon periods (Table).

The concentration of all analyzed parameters remained within the permissible limits established by the Bureau of Indian Standards (BIS), indicating that the overall quality of the spring water was within acceptable levels. However, it is worth noting that the post-monsoon samples collected from Shantipur exhibited an elevated fluoride concentration, surpassing the BIS permissible limit.

The inclusion of scientific terminology and concepts in the study allowed for a comprehensive analysis of the spring water samples. By examining a range of physico-chemical parameters, such as pH, conductivity, dissolved oxygen, turbidity, and total hardness, the researchers were able to gain insights into the composition and characteristics of the water samples. Additionally, the assessment of heavy metal content, including iron, arsenic, and uranium, provided valuable information regarding potential contaminants and their levels in the spring water.

Table 7: Summarized results of analysis of groundwater samples collected during March 2022 and November 2021.

S. no	Chemical constituents (concentrations in mg/L) except pH and EC)	Water Samples from Springs			
		Pre monsoon		Post monsoon	
		Min	Max	Min	Max
1	pH	**6.0**	8.4	7.47	8.64
2	EC (µS/cm) at 25°C	45.48	456.7	34.51	232.40
3	Turbidity(NTU)	BDL	0.22	BDL	1.00
4	TDS	30.02	301.42	19.66	136.60
5	CO_3	0	9	0.00	9.00
6	HCO_3	24.42	305.24	24.42	189.25
7	TA (as $CaCO_3$)	24.42	314.24	24.42	189.25
8	Cl-	7.09	35.45	7.09	49.63
9	SO_4	0.07	8.42	0.10	18.99
10	NO_3	0.06	16.56	0.00	13.66
11	F-	0.01	0.11	0.33	**1.70**
12	Ca	2.00	70.056	2.00	30.02
13	Mg	1.21	15.76	1.21	14.56
14	TH (as $CaCO_3$)	15	205	15.00	125.00
15	Na	4.32	29.91	1.19	34.39
16	K	0.04	29.16	0.11	10.40
17	Fe			0.13	1.43
18	U (ppb)	BDL	0.16	BDL	1.239
19	As (ppb)			BDL	0.359

4.2 GRAPHICAL PLOT

4.2.1 Piper diagram

Within the field of hydrogeology and groundwater analysis, the utilization of a Piper plot, also referred to as a trilinear diagram, serves as a highly effective tool for visualizing the relative abundance of ions present in groundwater. This diagram allows for a comprehensive representation of the water's chemical composition and aids in the classification of sample points into distinct fields.

In general, the sample points plotted on the Piper diagram can be classified into six fields, namely:

1. Ca-HCO3 type: Characterized by the predominance of calcium (Ca) and bicarbonate (HCO3) ions.

2. Na-Cl type: Dominated by sodium (Na) and chloride (Cl) ions.

3. Ca-Mg-Cl type: Exhibiting significant concentrations of calcium, magnesium (Mg), and chloride ions.

4. Ca-Na-HCO3 type: Marked by the presence of calcium, sodium, and bicarbonate ions.

5. Ca-Cl type: Demonstrating the prevalence of calcium and chloride ions.

6. Na-HCO3 type: Highlighting the abundance of sodium and bicarbonate ions.

However, in the context of the present study, the water types observed were limited to the first four types mentioned above.

Analyzing the results derived from the Piper plot, it becomes evident that during the post-monsoon period, approximately 62.8% of the spring water samples in the study area fall within the left quadrant, which represents calcium bicarbonate (Ca-HCO3) waters. This water type is commonly associated with shallow fresh groundwater. Additionally, 14.2% of the samples fall into the Calcium Sulfate water category, 22.8% are classified as Sodium bicarbonate waters, and 2.8% are categorized as sodium chloride water.

In contrast, during the pre-monsoon period, the distribution of water types in the study area exhibited some variations. Approximately 44% of the samples fell within the calcium bicarbonate quadrant, indicating a decrease compared to the post-monsoon period. Sodium bicarbonate water accounted for 48% of the samples, showcasing an increase. Moreover, 4% of the samples were classified as Calcium Sulfate water, and another 4% were identified as sodium chloride water.

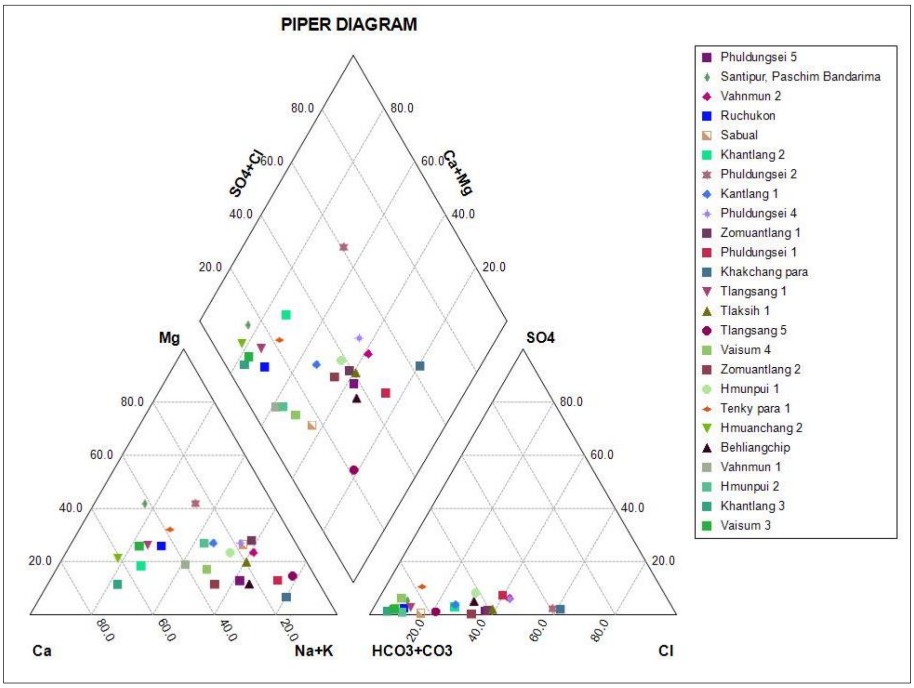

Figure 52: Piper diagram showing groundwater type for the Pre Monsoon Samples

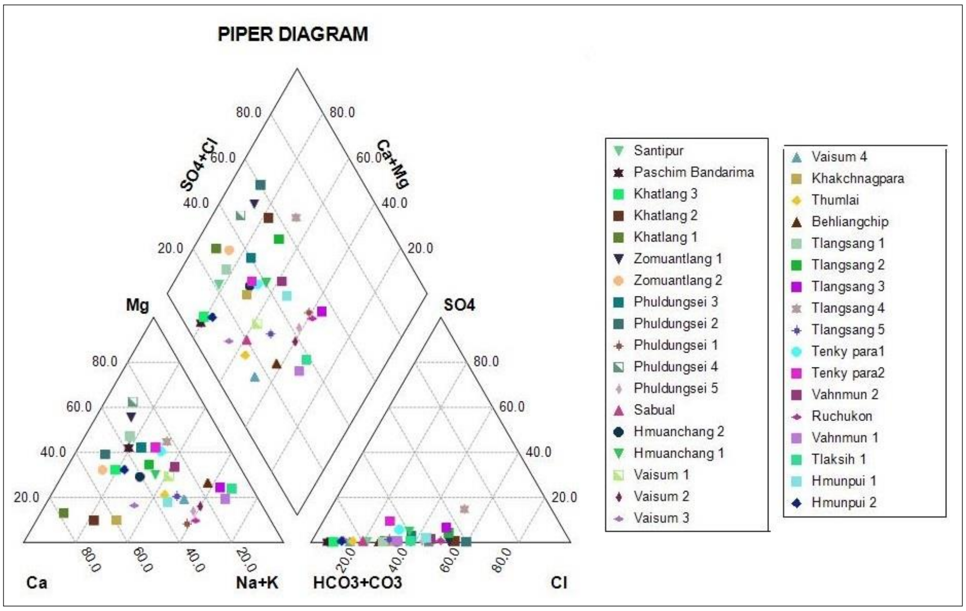

Figure 53: Piper diagram showing groundwater type for the Post Monsoon Sample.

4.2.2 Giggenbach Triangle

The Giggenbach triangle is a widely used method in hydro-geochemistry that enables the assessment of the degree of attainment of water-rock equilibrium in natural water systems. This graphical plot, named after its developer Werner Giggenbach, provides valuable insights into the chemical evolution of water as it interacts with the surrounding rock formations.

The Giggenbach triangle diagram consists of three vertices representing major cations, namely sodium (Na+), calcium (Ca2+), and potassium (K+), as well as three major anions, namely chloride (Cl-), bicarbonate (HCO3-), and sulfate (SO42-). These vertices form a triangle within which water samples can be plotted based on their chemical composition, specifically the concentrations of these major ions.

All the samples of the study area fall within the "immature water" zone in the Giggenbach triangle, it indicates that the water has not reached a state of complete equilibrium with the surrounding rock formations. This suggests that the dissolution of minerals in the rocks has not been followed by sufficient equilibration with the water.

The concept of maturity in the context of water-rock equilibrium refers to the extent to which the water composition reflects the chemical composition of the rocks it has interacted with. Mature water has undergone extensive interactions with the rocks, leading to the dissolution of minerals and the attainment of chemical equilibrium.

In contrast, immature water implies that the water-rock interactions have been limited or insufficient to achieve equilibrium. This can be due to several factors, such as limited contact time between the water and rocks, the presence of unreactive minerals, or preferential reactions occurring in the aquifer.

When all the samples fall within the immature water zone in the Giggenbach triangle, it suggests that the water composition does not reflect a complete exchange of ions between the water and the rocks. This may be due to factors such as short residence time in the aquifer, rapid groundwater flow, or the presence of relatively unreactive minerals.

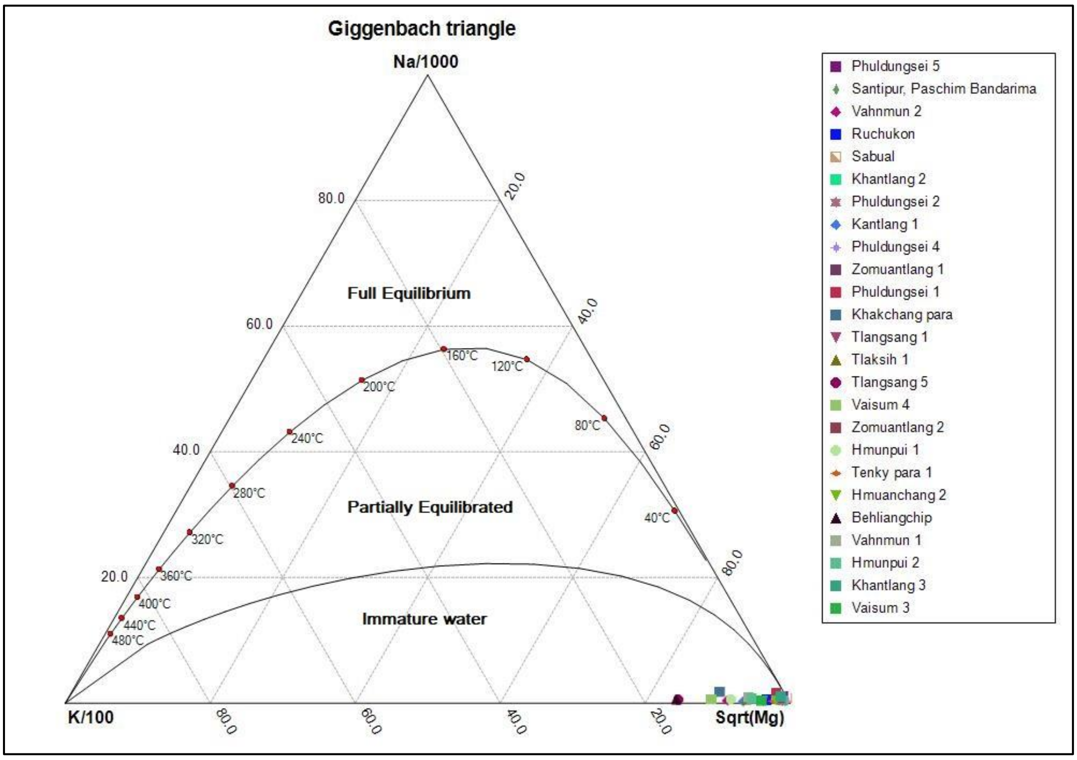

Figure 54: Giggenbach triangle showing immature character of spring water (Post Monsoon)

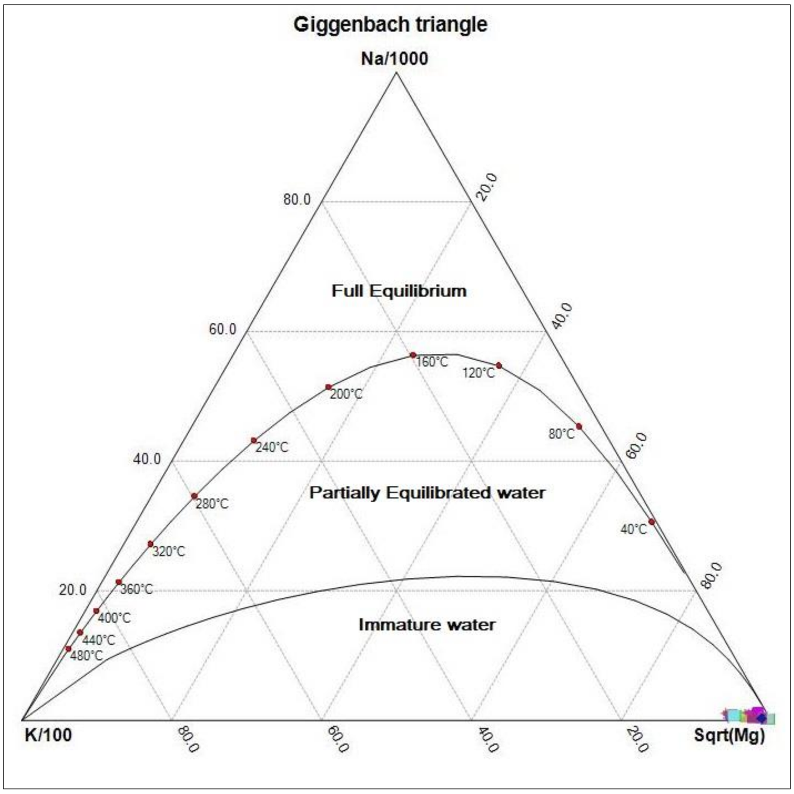

Figure 55: Giggenbach triangle showing immature character of spring water (Post Monsoon)

4.2.3 SAR vs Electrical Conductivity in Wilcox Plot

The irrigation classification diagram developed by the US Salinity Laboratory Staff (1954) is a valuable tool that relates specific conductance (a measure of electrical conductivity) and sodium adsorption ratio (SAR) to assess the suitability of water for irrigation purposes. This diagram, commonly referred to as Figure 35, provides insights into the potential hazards associated with sodium and salinity levels in water used for irrigation.

Analyzing the results within the framework of the irrigation classification diagram, it becomes apparent that during the post-monsoon period, all the collected samples fall within the "low sodium (alkali) hazard" category (C1) and the "low salinity hazard" category (S1). This indicates that the sodium concentration and overall salinity of the water samples are relatively low, posing minimal risks to soil quality and crop growth when used for irrigation purposes.

Furthermore, during the pre-monsoon period, approximately 20% of the samples are classified as falling under the "low sodium and medium salinity hazard" category. This suggests that these samples exhibit low levels of sodium, mitigating the risk of soil alkalinization, but exhibit moderate levels of salinity. While the salinity may have a minor impact on soil and crops, it is within a range that can still be managed effectively.

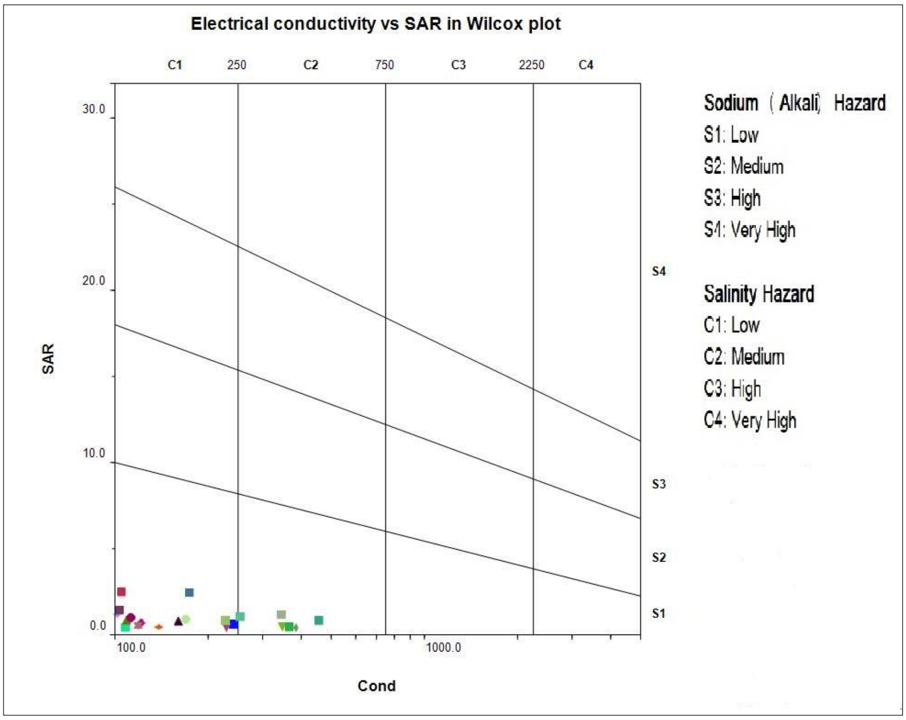

Figure 56: US salinity diagram showing the viability of water for irrigation purposes (Pre Monsoon spring samples)

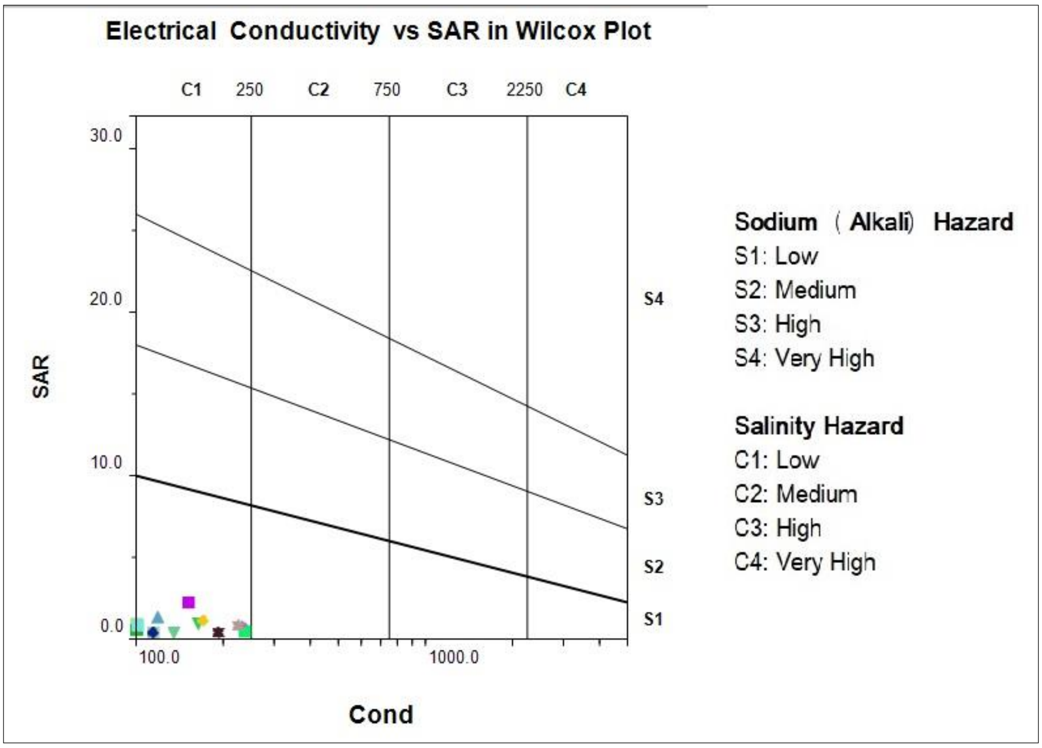

Figure 57: US salinity diagram showing the viability of water for irrigation purposes (Post Monsoon springs samples)

4.3 GROUND WATER SUITABILITY FOR VARIOUS USES

4.3.1 Suitability of ground water for Drinking and Domestic use

The result of chemical analysis shows that ground water quality in the area is potable and range of all the chemical constituents are within the permissible limit set by BIS (2012). The quality of groundwater in the study area in general is acceptable for domestic use. The concentration of calcium, magnesium, nitrate, sulphate etc. in ground water is well within the acceptable limits of Bureau of Indian Standards (BIS, 2012).

Very low or very high pH is not favorable for the growth of organisms and is not fit for animal and human consumption. The pH values of the spring water ranges from 7.47 to 8.64 during post monsoon and 6 to 8.4 during pre monsoon. The BIS (2012) has recommended acceptable range of pH from 6.5 to 8.5 for domestic use. Soda ash (sodium carbonate) and sodium hydroxide may be injected into a water system to raise the pH of water to near neutral.

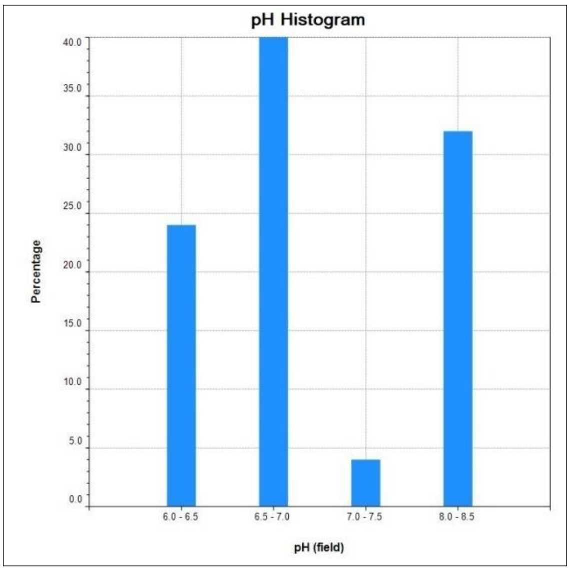

Figure 58: pH Histogram, Spring Samples (Pre Monsoon)

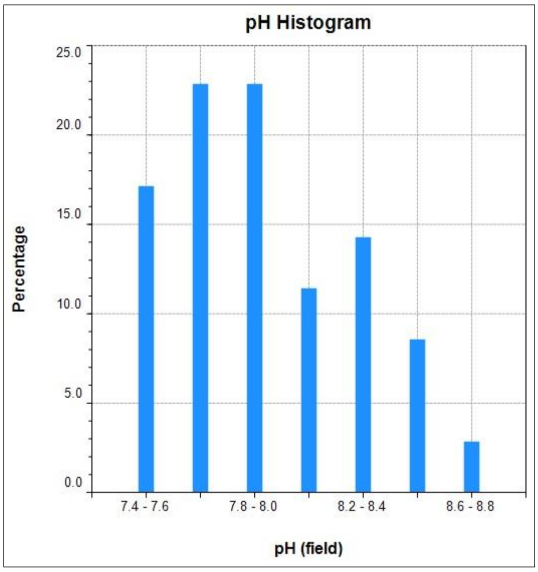

Figure 59: pH Histogram, Spring Samples (Post Monsoon)

The spring water at Santipur has a Fluoride value of 1.7 mg/l which is above the permissible limit of 1.5 mg/l during post monsoon otherwise all spring water of the area is acceptable for domestic use in view of Fluoride concentration. A very famous defluoridation technique is the Nalgonda technique. This technique involves the addition of the following chemicals in sequence: aluminum salt, lime, bleaching powder, followed by rapid mixing, then coagulation, sedimentation, filtration, and disinfection. The amount of the aluminum salt added depends on the alkalinity and concentration of fluoride in the water under treatment. The Nalgonda technique is very versatile and has been successfully used for water purification at the individual as well as community levels.

In general electrical conductivity (EC) varies from 34.51 to 232.40 µS/cm. The content of iron in ground water ranges from 0.13 to 1.43 mg/L. Turbidity varies from BDL to 1 NTU. The other constituents are well within the permissible limit for drinking purpose.

4.3.2 Suitability of ground water for Irrigation use

In general, spring water in the area is suitable for irrigation and industrial purposes. Wilcox diagram shows that 100% of samples during post monsoon fall under low sodium and low salinity hazard. The spring water can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Low sodium water can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium.

4.4 SPRING DISINFECTION

During the survey it is noticed that the spring tab chambers are not properly cleaned periodically. As a result, algal growth (moss) inside the spring has developed inside the wall of the spring tab chamber. Therefore, time to time bacteriological test and periodical chlorination of each spring are needed.

Springs are often contaminated with bacteria during construction or maintenance. All new and repaired water systems should be disinfected using shock chlorination. If bacterial contamination occurs on a regular basis because of surface sources above the spring, continuous chlorination may be necessary.

The following are the steps to disinfect spring-fed water systems with chlorine:

1. Remove debris and sediment from the spring box and distribution system. Scrub all interior surfaces with a strong chlorine solution (1 gallon of liquid chlorine laundry bleach per 10 gallons of water). It may be ensued to wear gloves and other appropriate protective clothing
2. Disinfect the spring box by first allowing it to fill with fresh spring water. If the spring flow is small enough, plug the outlet pipe and add chlorine to the spring box to obtain the 200-part-per-million chlorine concentration as described above. Hold the chlorinated water in the spring box for at least 12 hours. Keep the overflow pipe open. If the flow rate is too high to retain water in the spring box, feed the chlorine solution into the spring box continuously for at least 12 hours.
3. Disinfect the water distribution system including pressure tanks, storage tanks, pipelines, valves, and faucets by pumping chlorinated water through the system. Open all faucets until a strong chlorine odour is detected at each one. Close the faucets to allow the chlorine solution to remain in the system for at least 12 hours.
4. Open all valves and faucets to allow fresh spring water to flow through the system until no chlorine odour or taste can be detected.
5. Test the spring water for bacterial contamination 24 hours after chlorine has been removed from the spring and household system.

Continuous chlorination is necessary if bacterial contamination continues after repeated shock chlorinations. In this system, equipment is used to feed chorine continuously in sufficient amounts to kill bacteria. Chlorine must be in contact with water at least 1 to 5 minutes to kill all bacteria. At the end of this time, a chlorine residual of about 3 to 5 ppm should remain to indicate that the disinfection is complete. Typical chlorine feed rates are about 1 cup of 5 percent laundry bleach per 300 gallons of water. This rate depends on water temperature, pH, and pumping rate. Use an inexpensive chlorine residual kit to determine if the feed rate should be increase of decreased to obtain the proper chlorine residual.

5. SPRING WATER MANAGEMENT PLAN:

Spring plays a vital role in sustenance of life of hilly people. The community living in mountain since time immemorial considers spring water as the purest & scared water and it is respected. In some parts they protect it by construction of temple and shrine in those places even today some places have those structures preserved.

5.1 MAJOR ISSUES:

(a) Major problems identified in the hilly terrain is land degradation. In Jampui hill area, the practice of Jhum cultivation is there which involve forest fires and therefore most of the forested lands were burned and used for beetle nut cultivation. This leads to serious soil erosion in that areas and cause landslide problem.

(b) Road construction in the area is going on which aggravates the problems. Activities for controlled soil erosion and reclamation of eroded stretches are urgently required and communities should be encouraged to take up suitable measures such as vegetative barriers, contour bund, engineer structure like gabion, loose boulder, check dam.

(c) The water supply in hills and mountain is mostly spring dependent. However, due to fluctuating discharge it is observed during lean periods the discharge decreases and water shortage occur. To maintain consistency of the flow throughout the year conservation of spring and its supply to the downstream along with its management is necessary.

(d) Major factors responsible for declining discharge of a spring indicating that the spring needs rejuvenation are as follows:

(e) Indiscriminate deforestation in the recharge area and catchment area.

(f) Erratic rainfall in space and time.

(g) Forest fire in the recharge area, mainly during the summer season.

(h) Grazing and trampling by cattle in the recharge area.

(i) Erosion of the top, fertile soil.

(j) Other anthropogenic factors like construction of roads & buildings in the recharge area.

5.2 MANAGEMENT PLAN:

The two-fold management plan is to be given one recharging the aquifers through soil and water conservation structures in the area by identifying hydro-geological assessment & aquifers and other by participatory approach.

The proposed spring serves as one of the major source of water for the inhabitants in the area. The spring water is collected using tankers to be supplied for various household uses. It has a discharge of 150 lpm during post monsoon season and the discharge declines in the lean period with a discharge of 6 lpm. There is a need to restore and preserve the spring from drying up. Supplementing the natural groundwater recharge, by first identifying the recharge area of the aquifers feeding the spring and then taking up artificial recharge works like digging trenches and ponds to catch the surface flow and enhance the infiltration forms the rejuvenation plan. It also involves the maintenance and protection of catchment of the spring and the spring head to ascertain that there is no danger of pollution to ensure safe water. It involves land use management and control from anthropogenic interference in the springshed.

5.2.1 Spring development

Proper spring development helps to protect the water supply form contamination. The objective of spring development is to collect the flowing water underground to protect it from surface contamination and store it in a sanitary spring box.

A spring is developed by collecting the water that flows out of a spring or seep in a pipe to a watering trough. A spring can be developed in several different ways but generally the steps are:

a) Dig into the hillside to find the source of the spring or seep.
b) Put down gravel and perforated pipe to collect the water.
c) Build a dam of compacted soil, plastic sheeting, or concrete downstream from the gravel and allow to force the water into the pipe.
d) Run the pipe to a spring box to settle out dirt and sand.
e) Run a pipe from the spring box to a watering trough.

5.2.2 Concentrated spring development:

These springs occur along hillsides in mountain and piedmont areas at points where groundwater emerges naturally from openings in rock. These are the easiest springs to develop and protect from contamination. Proper development for concentrated springs consists of intercepting water underground in its natural flow path before it reaches the land surface. Concentrated spring found in valleys or other low areas is termed as low-area spring.

To develop a concentrated spring following steps are required:

a) Dig upslope from the spring outlet to a point where flowing water is at least 3 feet underground or where rock is encountered.
b) Install a rock bed to form an interception reservoir. On the down slope side, install a cutoff wall of concrete or plastic. The cutoff wall may not be necessary for a low-area spring, where the spring box may serve as the collector.

c) Insert a collector pipe low in the cutoff wall to guide water into the spring box. As much as possible, prevent water from backing up behind the wall.

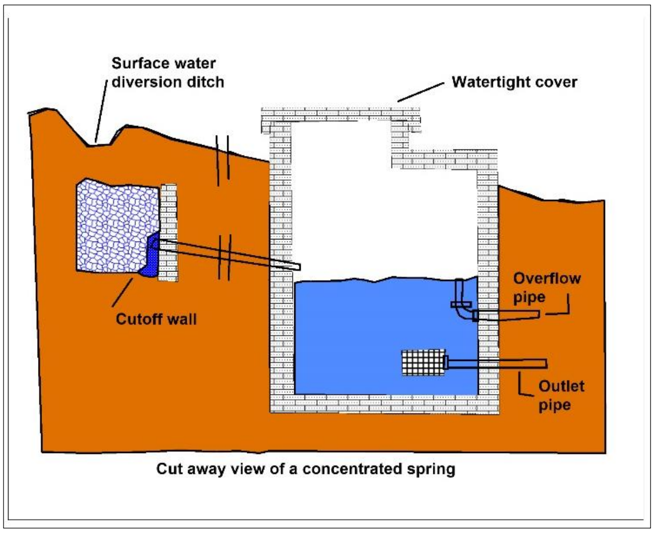

Figure 60: Cut-away view of a concentrated spring

5.2.3 Seepage spring development:

These generally occur where groundwater "*seeps*" from the soil over large areas. The development process for seepage springs consists of intercepting flowing groundwater over a wide area underground and channeling it to a collection point as shown in the figure below. Because seepage springs collect water over large areas, they are more difficult to protect from surface water contamination than concentrated springs.

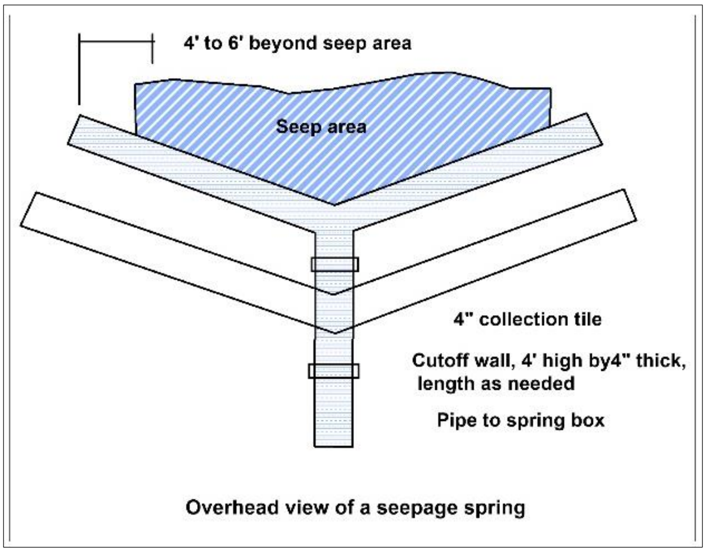

Figure 61: Overhead view of a seepage spring

Following steps are required to develop a *seepage spring*:

a) Dig test holes uphill from the seep to find a point where the impervious layer below the water-bearing layer is about 3 feet underground. Water flows on top of this layer in sand or gravel toward the surface seep.

b) Dig a 2-foot-wide trench across the slope to a depth of 6 inches below the water-bearing layer and extending 4 to 6 feet beyond the seep area on each side. Install a 4-inch *collector tile* and completely surround the tile with gravel.

c) Connect the collector tile to a 4-inch line leading to the spring box. The box inlet must be below the elevation of the collector tile.

d) The spring box should be watertight (most are made of reinforced concrete) and have a tight-fitting cover. It should be at least 4 feet tall and should extend at least 1 foot above ground level when buried. The size of the spring box depends on the amount of storage needed. Typically, it should be at least 3 square feet, which would provide storage of 511 litre with water standing 2 feet deep. If the size were increased to 4 feet square, the amount of storage would increase to 240 gallons with water standing 2 feet deep.

e) The spring box should have an *outlet pipe* and an *overflow pipe*. The overflow pipe should be screened and located below the collector pipe or tile so that water will not back up behind the spring.

5.3 CONCLUSION:

Agriculture, though not much, is still the main occupation of the poor rural people. Only 3% of the total geographical area is sown. Whatever cultivation is practiced is shifting or Jhum cultivation. In this district, there is no maior or medium irrigation project. There are only few minor irrigation schemes in the Block. The existing irrigation schemes are based mainly on surface water.

Water level is found to occur between 2 to 15 m bgl. Ground water is found to occur under confined to semi-confined conditions with low yield of 5-15 m hr. Water level is found to rest between 2 and 4 m bgl.

Spring is a concentrated discharge of ground water appearing at the ground surface as flowing water. The study was carried out to know the genesis of springs and their present status of utilization for rural drinking water and agriculture, quality aspect with further scope of development. During the study 48 springs covering all the blocks were studied. The discharge of the springs was monitored in different seasons. The nearby rock type study was also carried out accompanied by discussion with local people to know the genesis of the springs. It is observed that topographic, contact and fracture springs are prevalent in this district. Proper spring development helps protect the water supply from contamination.

During the study it is observed that how far the rural people are presently dependent on spring water for their drinking water and irrigation purpose. Though no such data is available with the state govt. that how many household is supplied by using springs or how much cultivated area is irrigated through spring water but, field observation reviles that a good number of people are dependent on spring water both for their drinking water and for agricultural purpose.

To know about the chemical quality of the spring water samples were collected and analysis shows that except iron, all other parameters are within desirable limit for all useful purposes. Iron content is as much as 2 mg/lt as observed in one spring at Sakwing village under Mawkyrwat block. Spring water should be tested before and after heavy rains each year for bacteria, pH, turbidity, and conductivity to determine if surface-water contamination is a problem. Springs are often contaminated with bacteria during construction or maintenance. All new and repaired water systems should be disinfected using shock chlorination. In a good number of springs tab chamber algal growth has been observed inside the chamber which needs periodical cleaning.

5.4 RECOMMENDATIONS:

1. Each spring, whether seasonal or perennial, should be given due importance. During lean period when rural villagers suffer from water crises a very low discharge spring can cater a part of their daily water requirement.
2. Long term spring discharge trend analysis shows that, the spring discharge shows a declining trend. It is observed in some localities that in the upstream side of the spring catchment deforestation, construction of house as well as agricultural practice are going on and thereby loss of soil cover is prevalent. It is required to stop, at least by a forestation. Therefore, spring catchment area should be developed and protected.
3. Dhara Vikas is a government sponsored program to increase the discharge of springs in rural Sikkim. It is modeled with the idea of protecting a spring's catchment area and to provide recharge of its aquifer by installation of trenches in barren lands and drains in cultivated land, gives rainwater a place to rest and percolate down into the ground water. Here a spring catchment area is traditionally developed by the villagers for its sustainable use. In the upstream of the spring small ponds like structures needs to be constructed to store the surface and rainwater. On way the stored water is recharging the ground water and the nearby spring in the downstream is getting direct benefit and thereby running throught the year. If scientific method as recommended in the Dhara Vikash programme is blended with the traditional approach and replicated in the district, rural people are sure to get benefit of it. But, development efforts should be spend first on the springs that affect the largest number of people as to more efficiently allocate government money.
4. Spring water should be tested before and after heavy rains each year for bacteria, pH, turbidity, and conductivity to determine if surface-water contamination is a problem. During survey it is noticed that spring tab chambers are not properly cleaned periodically. As a result algal growth (moss) has developed inside the wall of the spring tab chamber.
5. Time to time bacteriological test and periodical chlorination of each spring are needed. Now-a-days PHED, Govt. of Meghalaya is having district level chemical laboratory. Owner of each spring need not require running for a long distance to analyse water.

6. The sustainability of spring depends on awareness of community as well as their active participation during as well as after spring development for their periodical maintenance and monitoring. It may not be possible for any government to take necessary attention in time for individual springs. Therefore, formation of a village committee with proper training is needed.

6. DATASHEETS (Location)

Table 8: The spring Inventory Data Sheets along with locations

Sl No.	Location	Spring ID	District	Block	Approach	Longitude	Latitude	Type of Spring	Land cover	Lithology
1	**Behliangchip**	TS-22	North Tripura	Jampui Hill	Below the vehicle Workshop	23°58'6.26''	92°16'42.55''	Contact / Fracture	Forest	Consolidated sandstone covered with unconsolidated soil
2	**Hmuanchang 1**	TS-15	North Tripura	Damcherra	RHS of the road towards Vaisum 300 m downslope	24°6'11.45''	92°16'35.68''	Fracture	Betel nut Plantation	Fine grained sandstone, grey in colour
3	**Hmuanchang 2**	TS-14	North Tripura	Damcherra	Below the Water Storage Tank	24°5'50.84''	92°16'34.36''	Depression	Betel nut and Banana plantation	Unconsolidated sandstone
4	**Hmunpui 1**	TS-34	North Tripura	Jampui Hill	LHS of road towards Vanghmun	24°3'0.88''	92°16'26.60''	Fracture	Forest	Consolidated sandstone
5	**Hmunpui 2**	TS-35	North Tripura	Jampui Hill	LHS of road towards Vanghmun	24°2'20.46''	92°16'17.12''	Fracture	Forest	Consolidated sandstone
6	**Khakchnagpar a**	TS-20	North Tripura	Damcherra	RHS towards Damcherra from Khedacherra	24°11'52.4''	92°19'01.6''	Contact / Fracture	Forest and Bamboo groove	Consolidated sandstone covered with thin layer of unconsolidated soil
7	**Khantlang 1**	TS-5	North Tripura	Dasda	RHS of the road towards Paschim Bandarima	23°44'26.37''	92°15'54.71''	Fracture	Betel nut Plantation	Consolidated sandstone
8	**Khantlang 2**	TS-4	North Tripura	Dasda	Behind the Water Storage Tank	23°44'13.86''	92°15'57.64''	Fracture	Bamboo groove	Consolidated sandstone
9	**Khantlang 3**	TS-3	North Tripura	Dasda	Way to Bandharima	23°45'26.37''	92°15'2.84''	Fracture	Forest	Consolidated sandstone
10	**Phuldungsei 1**	TS-10	North Tripura	Jampui Hill	RHS of the road towards Vahnmun	23°48'59.67''	92°15'31.51''	Fracture	Shrubs and bushes	Consolidated sandstone
11	**Phuldungsei 2**	TS-9	North Tripura	Jampui Hill	RHS of the road towards Vahnmun	23°48'59.77''	92°15'38.07''	Fracture	Forest	Consolidated sandstone

12	**Phuldungsei 3**	TS-8	North Tripura	Jampui Hill	(below TSR Outpost on the way to Betling Sib)	23°48'49.32''	92°15'37.29''	Depression	Forest	Unconsolidated sediments
13	**Phuldungsei 4**	TS-11	North Tripura	Jampui Hill	LHS of the road next to church while coming from vanghmun	23°49'8.27''	92°15'40.98''	Contact	Betel nut Plantation	Consolidated sandstone covered with surface soil
14	**Phuldungsei 5**	TS-12	North Tripura	Jampui Hill	LHS of the road while coming from vanghmun below BSNL tower	23°49'49.27''	92°15'43.34''	Depression	Forest	Consolidated sandstone covered with surface soil
15	**Ruchukon**	TS-31	North Tripura	Jampui Hill	RHS of the road towards Vanghmun	24°0'12.31''	92°16'47.70''	Fracture	Bamboo groove	Consolidated sandstone
16	**Sabual**	TS-13	North Tripura	Jampui Hill	RHS of road towards Vanghmun	23°52'16.44''	92°16'6.63''	Fracture	Forest	Consolidated sandstone
17	**Santipur**	TS-1	North Tripura	Dasda	Right Hand Side from Ananda bazar to Jampui	23.777758°	92.223739°	Depression	Bamboo groove and banana	Unconsolidated sediments
18	**Shantipur, Paschim Bandarima**	TS-2	North Tripura	Dasda	Right Hand Side from Ananda bazar to Jampui	23.774120°	92.224406°	Depression	Forest	Unconsolidated sediments
19	**Tenky para1**	TS-28	North Tripura	Jampui Hill	RHS of road while towards vanghmun	23°53'15.59''	92°16'21.60''	depression	Shrubs and bushes	Consolidated sandstone covered with surface soil
20	**Tenky para2**	TS-29	North Tripura	Jampui Hill	LHS towards Vanghmun	23°53'19.92''	92°16'17.29''	Fracture	Forest	Consolidated sandstone with unconsolidated sediments
21	**Thumlai Road water pioint**	TS-21	North Tripura	Jampui Hill	RHS of road while coming from Eden tourist lodge	23°59'33.5''	92°16'54.38''	Fracture	Bamboo / forest groove	Consolidated sandstone
22	**Tlaksih 1**	TS-33	North Tripura	Jampui Hill	below the Tlakshi church on the RHS of the motorable road	24°2'5.38''	92°16'38.93''	depression	Forest	Unconsolidated sediments
23	**Tlangsang 1**	TS-23	North Tripura	Jampui Hill	RHS of road towards Vanghmun	23°55'18.58''	92°16'20.28''	Contact	Forest	Consolidated sandstone covered with surface soil

					below Tlangsang academy					
24	**Tlangsang 2**	TS-24	North Tripura	Jampui Hill	LHS of the road next to the shop in Tlangsang village	23°54'38.50''	92°16'18.06''	Contact/Fr acture	Forest	Consolidated sandstone
25	**Tlangsang 3**	TS-25	North Tripura	Jampui Hill	RHS of the road next to the church	23°54'34.05''	92°16'19.66''	Fracture	Forest	Consolidated sandstone
26	**Tlangsang 4**	TS-26	North Tripura	Jampui Hill	RHS of the road next to the Tlangsang ICDS centre	23°54'30.16''	92°16'13.17''	Fracture	Betel nut and bamboo Plantation	Consolidated sandstone
27	**Tlangsang 5**	TS-27	North Tripura	Jampui Hill	RHS of road while coming from Vanghmun	23°54'28.21''	92°16'66.00''	Depression	Forest	Weathered sandstone
28	**Vahnmun 1**	TS-32	North Tripura	Jampui Hill	Below Tribal Guest House	24°0'15.34''	92°16'47.17''	Depression	Betel nut Plantation	Unconsolidated soil
29	**Vahnmun 2**	TS-30	North Tripura	Jampui Hill	Below the Village, opposite PNB ATM	23°59'6.10''	92°16'37.98''	Depression	Betel nut Plantation	Unconsolidated soil
30	**Vaisum 1**	TS-16	North Tripura	Damcherra	RHS on the way to Vaisum village	24°7'37.85''	92°16'37.15''	Contact	Bamboo groove	Consolidated Sandstones covered with Unconsolidated soil
31	**Vaisum 2**	TS-17	North Tripura	Damcherra	LHS on the way to Damcherra	24°7'52.13''	92°16'40.12''	Contact/Fr acture	Areca nut plantation	Unconsolidated sediments covering Consolidated sandstone
32	**Vaisum 3**	TS-18	North Tripura	Damcherra	LHS on the way to Damcherra	24°8'50.05''	92°16'16.95''	Contact/Fr acture	Forest	Consolidated sandstone
33	**Vaisum 4**	TS-19	North Tripura	Damcherra	LHS on the way to Damcherra	24°9'27.86''	92°16'13.65''	Depression	Forest	Unconsolidated sandstone
34	**Zomuantlang 1**	TS-6	North Tripura	Dasda	RHS of the road towards Vahnmun	23°47'10.68''	92°15'54.51''	Fracture	Forest	Consolidated sandstone
35	**Zomuantlang 2**	TS-7	North Tripura	Dasda	RHS of the road towards Vahnmun	23°47'24.81''	92°15'42.39''	Depression	Banana plantation	Unconsolidated sediments
36	**Darkwang**	TS-36	North Tripura	Jampui Hill	Darkwang village water source	23° 51' 21.86''	92° 15' 12.33''	Depression	Forest	Consolidated sandstone covered with surface soil

37	**Thumlai para 1**	TS-37	North Tripura	Jampui Hill	beside Thumlai para road	23° 58' 49.39''	92° 18' 18.85''	Fracture	cane	Consolidated sandstone covered with surface soil
38	**Thumlai para 2**	TS-38	North Tripura	Jampui Hill	beside Thumlai para road	23° 59' 7.15''	92° 18' 18.82''	Fracture	Bamboo groove	Consolidated sandstone covered with surface soil
39	**Tlaksih 2**	TS-39	North Tripura	Jampui Hill	LHS of the road towards Hmunpui	24° 1' 38.10''	92° 16' 31.80''	depression	Betelnut and banana plantation	Unconsolidated sediments
40	**Tlaksih 3**	TS-40	North Tripura	Jampui Hill	RHS of the road towards Hmunpui	24° 2' 7.9''	92° 16' 50.26''	Fracture	Betelnut Plantation	Consolidated sandstone

7. DATASHEETS (Discharge)

Table 9:: The spring Inventory Data Sheets along with measured discharge in ltr/sec

Sl No.	Location	Spring ID	Block	Type of Spring	Spring Discharge in ltr/sec				
					Apr-21 (Q)	Aug-21	Nov-21	Jan-22	Mar-22
1	**Behliangchip**	TS-22	Jampui Hill	Contact / Fracture	0.003	1.000	0.017	0.050	0.025
2	**Hmuanchang 1**	TS-15	Damcherra	Fracture	0.017	Not approachable due to plant overgrowth	0.033	not measurable	dry
3	**Hmuanchang 2**	TS-14	Damcherra	Depression	0.025	15.000	0.100	0.014	0.017
4	**Hmunpui 1**	TS-34	Jampui Hill	Fracture	0.083	2.000	4.000	0.205	0.083
5	**Hmunpui 2**	TS-35	Jampui Hill	Fracture	0.160	45.000	20.000	0.385	0.100
6	**Khakchnagpara**	TS-20	Damcherra	Contact / Fracture	Not measurable	0.166	0.150	0.010	0.003
7	**Khantlang 1**	TS-5	Dasda	Fracture	0.002	0.580	0.025	0.008	0.000
8	**Khantlang 2**	TS-4	Dasda	Fracture	Dry	0.400	0.087	0.010	0.003
9	**Khantlang 3**	TS-3	Dasda	Fracture	0.025	0.833	0.200	0.043	0.017
10	**Phuldungsei 1**	TS-10	Jampui Hill	Fracture	0.006	not measurable	0.050	0.050	0.025
11	**Phuldungsei 2**	TS-9	Jampui Hill	Fracture	0.004	1.016	0.017	0.017	0.017
12	**Phuldungsei 3**	TS-8	Jampui Hill	Depression	0.006	Not measurable	Dry	0.008	Dry
13	**Phuldungsei 4**	TS-11	Jampui Hill	Contact	Not measurable	Not measurable	0.025	0.050	0.050
14	**Phuldungsei 5**	TS-12	Jampui Hill	Depression	0.003	Not measurable	0.025	0.067	0.058
15	**Ruchukon**	TS-31	Jampui Hill	Fracture	0.017	2.000	0.083	0.003	0.017
16	**Sabual**	TS-13	Jampui Hill	Fracture	0.025	1.250	0.100	0.048	0.025
17	**Santipur**	TS-1	Dasda	Depression	Not measurable	0.014	0.007	Dry	Dry
18	**Shantipur, Paschim Bandarima**	TS-2	Dasda	Depression	Not measurable	0.025	1.000	0.176	0.029
19	**Tenky para1**	TS-28	Jampui Hill	Depression	0.017	1.710	0.250	0.097	0.044
20	**Tenky para2**	TS-29	Jampui Hill	Fracture	dry	0.133	0.033	0.008	Not measurable

21	**Thumlai Road water pioint**	TS-21	Jampui Hill	Fracture	0.083	2.500	0.333	0.167	0.100
22	**Tlaksih 1**	TS-33	Jampui Hill	Depression	0.017	2.000	0.083	0.067	0.017
23	**Tlangsang 1**	TS-23	Jampui Hill	Contact	dry	2.000	1.000	0.176	0.011
24	**Tlangsang 2**	TS-24	Jampui Hill	Contact/Fracture	0.003	0.250	0.083	0.067	Dry
25	**Tlangsang 3**	TS-25	Jampui Hill	Fracture	0.003	Not approachable due to plant overgrowth	0.067	Not measurable	Not measurable
26	**Tlangsang 4**	TS-26	Jampui Hill	Fracture	0.002	1.320	0.025	0.167	Dry
27	**Tlangsang 5**	TS-27	Jampui Hill	Depression	0.017	Not approachable due to plant overgrowth	0.133	0.047	0.050
28	**Vahnmun 1**	TS-32	Jampui Hill		0.017	Not approachable due to plant overgrowth	0.033	not measurable	dry
29	**Vahnmun 2**	TS-30	Jampui Hill	Depression	0.002	1.500	0.083	0.083	0.017
30	**Vaisum 1**	TS-16	Damcherra	Contact	dry	5.000	0.050	Not measurable	Not measurable
31	**Vaisum 2**	TS-17	Damcherra	Contact/Fracture	0.003	1.500	0.008	0.083	Dry
32	**Vaisum 3**	TS-18	Damcherra	Contact/Fracture	0.017	5.000	0.006	0.008	0.008
33	**Vaisum 4**	TS-19	Damcherra	Depression	0.017	0.500	0.059	0.122	0.046
34	**Zomuantlang 1**	TS-6	Dasda	Fracture	0.050	Not approachable due to plant overgrowth	0.200	0.083	0.050
35	**Zomuantlang 2**	TS-7	Dasda	Depression	dry	20.000	0.667	0.017	0.042
36	**Darkwang**	TS-36	Jampui Hill	Depression	0.025	Road not approachable			
37	**Thumlai para 1**	TS-37	Jampui Hill	Fracture	dry	Not approachable due to road construction			
38	**Thumlai para 2**	TS-38	Jampui Hill	Fracture	0.003	Not approachable due to road construction			
39	**Tlaksih 2**	TS-39	Jampui Hill	Depression	0.083	Not approachable due to plant overgrowth			
40	**Tlaksih 3**	TS-40	Jampui Hill	Fracture	0.004	Not approachable due to plant overgrowth			

8. DATASHEETS (Water Quality)

Table 10: Water Quality of the spring Sample in the Pre Monsoon season

Location	ID	District	pH	EC (µS/cm) at 25°C	TDS	CO_3	HCO_3	Measured Alkalinity	Cl	SO_4	NO	F	Ca	Mg	Measured Hardness	Na	K	Fe
					mg/ltr													
Shantipur 2, Paschim Bandarima	TS-2	North Tripura	7.42	384.80	253.97	0	158.73	158.73	10.64	7.59	0.40	0.05	26.02	15.76	130	10.56	2.19	
Khantlang 3	TS-3	North Tripura	8.35	456.70	301.42	9	305.24	314.24	10.64	3.14	0.98	0.11	70.06	7.25	205	26.79	2.06	
Khantlang 2	TS-4	North Tripura	6.96	108.40	71.54	0	48.84	48.84	10.64	1.51	4.68	0.08	12.01	2.42	40	6.18	1.14	
Khantlang 1	TS-5	North Tripura	6.77	85.06	56.14	0	48.84	48.84	10.64	1.95	0.22	0.03	6.00	3.64	30	4.32	12.92	
Zomuantlang 1	TS-6	North Tripura	6.87	103.60	68.38	0	48.84	48.84	17.73	0.96	0.37	0.03	4.00	4.85	30	17.92	2.25	
Zomuantlang 2	TS-7	North Tripura	6.81	71.11	46.93	0	36.63	36.63	10.64	0.07	0.39	0.03	6.00	1.21	20	10.31	1.23	
Phuldungsei 2	TS-9	North Tripura	6.87	119.20	78.67	0	24.42	24.42	21.27	1.08	16.56	0.02	6.00	6.07	40	7.8	2.22	
Phuldungsei 1	TS-10	North Tripura	6.70	104.90	69.23	0	48.84	48.84	21.27	5.24	5.89	0.01	4.00	2.43	20	25.46	1.8	
Phuldungsei 4	TS-11	North Tripura	6.79	101.80	67.19	0	36.63	36.63	17.73	3.34	2.11	0.01	4.00	3.64	25	13.71	0.74	
Phuldungsei 5	TS-12	North Tripura	6.82	45.48	30.02	0	30.52	30.52	10.64	0.51	1.40	0.03	4.00	1.21	15	11	0.5	
Sabual	TS-13	North Tripura	6.96	84.72	55.92	0	61.05	61.05	7.09	0.18	1.03	0.02	4.00	3.64	25	14.76	0.04	
Hmuanchang 2	TS-14	North Tripura	8.33	348.30	229.88	3	219.78	222.78	10.64	4.29	0.36	0.02	46.04	9.69	155	12.48	5.56	
Vaisum 3	TS-18	North Tripura	8.32	366.00	241.56	6	219.78	225.78	10.64	4.09	0.06	0.04	40.03	12.12	150	12.46	13.52	
Vaisum 4	TS-19	North Tripura	8.35	228.20	150.61	6	128.20	134.20	7.09	7.81	0.39	0.07	20.02	6.06	75	16.05	29.16	
Khakchang para	TS-20	North Tripura	6.48	174.20	114.97	0	36.63	36.63	35.45	1.54	0.32	0.03	4.00	1.21	15	21.75	10.82	
Behliangchip	TS-22	North Tripura	6.60	160.60	106.00	0	61.05	61.05	17.73	3.66	0.60	0.05	8.01	2.42	30	9.7	28.52	
Tlangsang 1	TS-23	North Tripura	8.33	229.70	151.60	6	115.99	121.99	10.64	3.21	0.11	0.05	26.02	8.48	100	9.27	10.74	
Tlangsang 5	TS-27	North Tripura	6.47	112.90	74.51	0	67.15	67.15	10.64	0.68	1.21	0.04	2.00	2.43	15	8.63	27.96	
Tenky para 1	TS-28	North Tripura	6.41	138.70	91.54	0	79.36	79.36	7.09	8.42	0.33	0.03	12.01	6.06	55	7.54	5.25	
Vahnmun 2	TS-30	North Tripura	6.35	121.70	80.32	0	36.63	36.63	17.73	3.36	2.83	0.02	4.00	3.64	25	7.75	17.68	
Ruchukon	TS-31	North Tripura	8.42	242.70	160.18	3	152.62	155.62	10.64	3.40	1.22	0.02	24.02	8.48	95	13.28	9.11	

Vahnmun 1	TS-32	North Tripura	8.34	345.80	228.23	9	219.78	228.78	10.64	3.37	0.14	0.11	34.03	9.69	125	29.91	17.48	
Tlaksih 1	TS-33	North Tripura	6.30	109.20	72.07	0	36.63	36.63	14.18	0.88	5.48	0.03	4.00	2.43	20	8.58	9.57	
Hmunpui 1	TS-34	North Tripura	6.08	169.90	112.13	0	73.26	73.26	21.27	7.53	0.61	0.02	10.01	6.06	50	14.22	21.12	
Hmunpui 2	TS-35	North Tripura	8.41	254.60	168.04	6	146.52	152.52	10.64	1.07	7.80	0.07	20.02	10.91	95	23.17	17.45	

Table 11: Water Quality of the spring Sample in the Post Monsoon season

Location	ID	District	pH	EC (µS/cm) at 25°C	TDS	CO_3	HCO_3	Measured Alkalinity	Cl	SO_4	NO	F	Ca	Mg	Measured Hardness	Na	K	Fe
					mg/ltr													
Santipur 1	TS-1	North Tripura	8.30	135.40	77.14	3.00	103.78	106.78	17.73	0.15	0.00	1.70	16.01	12.13	90.00	7.17	3.39	0.17
Santipur 2, Paschim Bandarima	TS-2	North Tripura	8.55	193.30	110.30	9.00	158.73	167.73	7.09	0.16	0.00	1.10	22.02	14.55	115.00	9.72	5.51	0.70
Khantlang 3	TS-3	North Tripura	7.80	238.10	136.60	0.00	189.25	189.25	10.64	0.17	0.00	0.89	30.02	12.12	125.00	11.74	3.65	0.65
Khantlang 2	TS-4	North Tripura	7.85	61.64	35.15	0.00	24.42	24.42	17.73	0.17	0.00	0.83	14.01	1.21	40.00	4.55	1.25	0.13
Khantlang 1	TS-5	North Tripura	7.66	53.02	30.14	0.00	30.52	30.52	7.09	0.17	0.00	0.73	12.01	1.21	35.00	1.19	0.69	0.18
Zomuantlang 1	TS-6	North Tripura	7.69	77.91	44.52	0.00	42.73	42.73	28.36	0.18	0.00	0.63	10.01	10.92	70.00	4.39	1.28	0.74
Zomuantlang 2	TS-7	North Tripura	7.83	54.35	30.98	0.00	36.63	36.63	10.63	0.18	0.00	0.54	10.01	3.64	40.00	3.05	0.11	0.33
Phuldungsei 3	TS-8	North Tripura	7.67	89.04	50.74	0.00	48.84	48.84	17.73	1.76	0.00	0.49	8.01	6.06	45.00	6.46	0.40	1.20
Phuldungsei 2	TS-9	North Tripura	7.60	77.70	44.22	0.00	24.42	24.42	21.27	0.10	3.89	0.44	10.01	4.85	45.00	2.69	0.23	1.43
Phuldungsei 1	TS-10	North Tripura	7.57	78.12	44.49	0.00	36.63	36.63	21.27	0.39	0.00	0.38	8.01	1.21	25.00	12.58	6.48	0.46
Phuldungsei 4	TS-11	North Tripura	7.54	59.85	34.28	0.00	36.63	36.63	17.73	0.13	0.00	0.47	6.00	8.49	50.00	2.68	0.27	0.34
Phuldungsei 5	TS-12	North Tripura	7.47	34.51	19.66	0.00	24.42	24.42	10.64	0.15	0.00	0.47	4.00	1.21	15.00	8.81	1.45	0.65
Sabual	TS-13	North Tripura	7.66	43.57	24.82	0.00	48.84	48.84	7.09	0.20	6.27	0.50	6.00	4.85	35.00	8.22	5.06	0.27
Hmuanchang 2	TS-14	North Tripura	8.20	99.90	56.90	0.00	73.26	73.26	21.27	0.16	0.00	0.56	14.01	6.06	60.00	10.79	2.11	0.42
Hmuanchang 1	TS-15	North Tripura	8.15	164.40	94.54	0.00	91.57	91.57	31.91	5.78	2.06	0.41	16.01	8.49	75.00	17.91	2.29	0.41
Vaisum 1	TS-16	North Tripura	8.20	100.60	57.34	0.00	79.36	79.36	17.73	0.20	1.82	0.52	10.01	6.06	50.00	14.61	2.90	1.35
Vaisum 2	TS-17	North Tripura	7.91	65.01	37.01	0.00	48.84	48.84	17.73	0.18	0.00	0.46	6.00	2.42	25.00	15.33	3.22	0.16
Vaisum 3	TS-18	North Tripura	8.64	232.40	133.90	9.00	158.73	167.73	14.18	2.00	0.00	0.71	30.02	6.05	100.00	19.92	7.12	1.04
Vaisum 4	TS-19	North Tripura	8.21	119.10	67.43	0.00	103.78	103.78	10.64	0.27	6.11	0.49	12.01	4.85	50.00	21.31	6.64	0.37
Khakchnagpara	TS-20	North Tripura	7.69	40.88	23.07	0.00	42.73	42.73	10.64	0.25	0.00	0.54	12.01	1.21	35.00	5.09	3.59	0.44
Thumlai Rd Water Point	TS-21	North Tripura	8.53	170.80	97.96	9.00	140.41	149.41	17.73	0.55	0.00	0.61	20.02	7.27	80.00	22.68	10.40	0.32
Behliangchip	TS-22	North Tripura	8.47	78.15	44.60	9.00	67.15	76.15	17.73	0.30	5.46	0.37	6.00	6.07	40.00	23.07	3.57	0.74
Tlangsang 1	TS-23	North Tripura	8.16	115.10	65.94	0.00	79.36	79.36	17.73	0.28	0.00	0.43	12.01	9.70	70.00	6.49	0.59	0.51
Tlangsang 2	TS-24	North Tripura	7.80	100.90	57.55	0.00	42.73	42.73	28.36	3.01	1.82	0.33	10.01	6.06	50.00	8.87	2.55	0.26

Tlangsang 3	TS-25	North Tripura	7.52	152.20	86.47	0.00	61.05	61.05	39.00	6.91	13.66	0.34	6.00	7.28	45.00	34.39	2.84	0.23
Tlangsang 4	TS-26	North Tripura	8.19	226.50	129.10	0.00	54.94	54.94	49.63	18.99	13.40	0.37	12.01	14.56	90.00	17.62	4.58	0.41
Tlangsang 5	TS-27	North Tripura	7.59	57.42	32.51	0.00	42.73	42.73	10.64	0.62	1.25	0.45	6.00	2.42	25.00	5.57	9.17	0.36
Tenky para1	TS-28	North Tripura	7.96	73.53	42.09	0.00	61.05	61.05	17.73	4.15	0.00	0.44	8.01	7.28	50.00	9.54	3.01	0.23
Tenky para2	TS-29	North Tripura	7.98	83.95	47.95	0.00	61.05	61.05	14.18	6.99	0.00	0.49	8.01	7.28	50.00	8.02	3.04	0.44
Vahnmun 2	TS-30	North Tripura	7.70	70.58	40.06	0.00	42.73	42.73	21.27	0.87	0.00	0.37	6.00	4.85	35.00	8.45	5.02	0.95
Ruchukon	TS-31	North Tripura	7.56	50.78	28.70	0.00	30.52	30.52	17.73	0.31	2.42	0.35	6.00	1.21	20.00	13.02	2.75	0.44
Vahnmun 1	TS-32	North Tripura	7.82	47.19	26.94	0.00	61.05	61.05	17.73	0.33	2.53	0.51	4.00	3.64	25.00	19.04	9.34	0.72
Tlaksih 1	TS-33	North Tripura	7.72	65.98	37.36	0.00	48.84	48.84	17.73	0.34	0.00	0.37	2.00	3.64	20.00	14.92	8.42	0.33
Hmunpui 1	TS-34	North Tripura	8.02	101.60	57.58	0.00	61.05	61.05	28.36	1.66	0.00	0.41	12.01	3.63	45.00	12.64	9.23	0.38
Hmunpui 2	TS-35	North Tripura	8.22	114.60	65.05	0.00	91.57	91.57	7.09	0.35	0.00	0.42	14.01	6.06	60.00	6.56	2.68	0.60

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tude: 23.818951
gitude: 92.261336
tude: 23.908388
gitude: 92.270201
vation: 739.33±27 m
uracy: 13.5 m
tude: 23.903804
gitude: 92.271514
tude: 24.097475
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uracy: 6.8 m
tude: 23.74059
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vation: 502.08±11 m
uracy: 12.9 m