TECHNICAL REPORTS: SERIES 'D'

CONSERVE WATER – SAVE LIFE

भारत सरकार

GOVERNMENT OF INDIA

जल संसाधन मंत्रालय

MINISTRY OF WATER RESOURCES

केंद्रीय भूजल बोर्ड

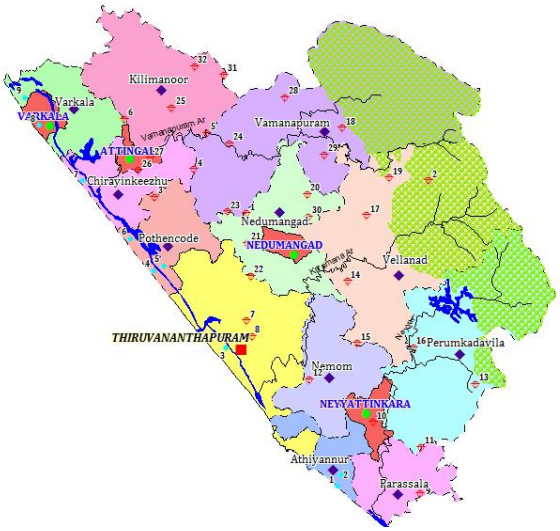
CENTRAL GROUND WATER BOARD

केरल क्षेत्र

KERALA REGION

भूजल सूचना पुस्तिका, त्रिवेंद्रम जिल्ला, केरल राज्य

GROUND WATER INFORMATION BOOKLET OF TRIVANDRUM DISTRICT, KERALA STATE



तिरुवनंतपुरम

Thiruvananthapuram

December 2013

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD

GROUND WATER INFORMATION BOOKLET
OF
TRIVANDRUM DISTRICT, KERALA

रानी वी आर
वैज्ञानिक ग

Rani V.R.
Scientist C

KERALA REGION
KEDARAM, KESAVADASAPURAM
THIRUVANANTHAPURAM – 695 004
TEL: 0471-2442175
FAX: 0471-2442191

BHUJAL BHAVAN
NH-IV, FARIDABAD
HARYANA- 121 001
TEL: 0129-12419075
FAX: 0129-2142524

GROUNDWATER INFORMATION BOOKLET

TRIVANDRUM DISTRICT, KERALA

Contents

List of Tables

List of Figures

List of Annexures

TRIVANDRUM DISTRICT AT A GLANCE

Sl.NO	ITEMS	Statistics
1.	GENERAL INFORMATION	
	i. Geographical Area (sq. km.)	2192
	ii. Administrative Divisions	
	Number of Taluks	4
	Number of Blocks	11
	Number of Panchayats	84
	Number of Villages	92
	iii. Population (As per 2001Census)	3307284
	iv. Normal Annual Rainfall (mm)	1803
2.	GEOMORPHOLOGY	
	Major physiographic Units	Midlands (7.5 to 75 m amsl)
	Major Drainage	Vamanapuram, Neyyar and Karamana
3.	LAND USE (sq.km.) as in 2009	
	a. Forest Area	498.61
	b. Net area sown	1338.62
	c. Cultivable area	1543.88
4.	MAJOR SOIL TYPES	Red loam, alluvium, brown hydromorphic soil and lateritic soil
5.	AREA UNDER PRINCIPAL CROPS (sq.km.)	56.68
6.	IRRIGATION BY DIFFERENT SOURCES as in 2009	
	Private wells	22.78
	Tubewells/Borewells	0.18
	Tanks/ponds	3.41
	Canals	36.31
	Other sources	2.90
	Net Irrigated area	65.58
7.	NUMBER OF GROUNDWATER MONITORING WELLS OF CGWB as in 2011	
	No. of dug wells	56
	No of Piezometers	23
8.	PREDOMINANT GEOLOGICAL FORMATIONS	Crystallines and Alluvium
9.	HYDROGEOLOGY	
	*Major Water bearing formation *Pre-monsoon depth to water level as in April 2011 *Post-monsoon depth to water level as in Nov 2011	Fractured crystallines, Alluvium 1.26 – 20.34 m bgl 1.05 – 22.86 m bgl

10.	GROUNDWATER EXPLORATION BY CGWB	
	No. of wells drilled as in March 2011 EW OW PZ SH	 32 01 09 02
	Depth range (m)	19.6 – 200.5
	Discharge (liters per minutes)	12 – 1200
	Storativity (S)	
	Transmissivity (m^2/day)	0.54 – 232.4
11.	GROUNDWATER QUALITY	
	Type of water	Alkaline
12	DYNAMIC GROUNDWATER RESOURCES (as in March 2009) MCM	
	Net annual ground water availability	304.74
	Annual Ground Water Draft	171.00
	Projected Demand for Domestic and industrial Uses upto 2025	146.99
	Stage of Ground Water Development	56%
13	AWARENESS AND TRAINING ACTIVITY	
	Mass Awareness Programmes organized	4
	Date	07/02/2005, 22/03/2005 09/02/2012,10/02/2012
	Place	Trivandrum
	No: of participants	400 each
14.	EFFORTS OF ARTIFICIAL RECHARGE& RAIN WATER HARVESTING	
	Projects completed by CGWB (No.& Amount spent)	1, Rs. 3 lakh
	Projects under technical guidance of CGWB (Numbers)	
15.	GROUNDWATER CONTROL AND REGULATION	
	Number of OE Blocks.	Nil
	Number of Critical Blocks	Nil
	Number of blocks notified	Nil
16.	MAJOR GROUNDWATER PROBLEMS AND ISSUES	Over-exploitation

GROUND WATER INFORMATION BOOKLET OF TRIVANDRUM DISTRICT, KERALA STATE

1.0 INTRODUCTION

Trivandrum, the southern most district of Kerala State, is situated between North latitude of 8° 16' 59" and 8° 49' 59" East longitude of 76° 28' 59" and 77° 16'59", covers a geographical ambience of 2192 sq. km which house the capital city of Kerala State and falls in Survey Of India degree sheets 58 D and H. The district stretches 76 kms along the shores of Lakshadweep Sea on the west, bordered by Kollam district on the north and with Tirunelveli and Kanyakumari districts of Tamil Nadu on the east and south respectively.

Trivandrum is the anglicised form of the word "Thiruvananthapuram" and the city and several other places in the district loom large on ancient traditions, folklore and culture. The political and cultural history possessed by the district made it some respect independent from the rest of other districts of Kerala State.

Administratively, the Trivandrum district can be broadly grouped into 4 talukas viz., Trivandrum, Neyyatinkara, Chirayinkil and Nedumangad consisting of 11 blocks, 84 panchayats, 4 municiplaities and 1 corporation. An index map of the district is shown in **Figure 1.**

As per provisional 2011 census data, the total population of the district is 33,07,284 with a population density of 1509 persons/ sq.km. Earlier census details revels that majority of the population reside in rural areas. As per census 2001, the rural and urban population as percentage to the total population are 66.21% and 33.78% respectively. The literacy rate of the district is 92.66.

Physiographically, the district has a very rugged topography which is present in the coastal city of Trivandrum and towns like Vizhinjam, Varkala and Edavai. Three distinctive topographic units can be identified in the district from west to east – (1) lowland (coastal plains), (2) midlands and (3) highlands. The low land or coastal plain are seen in areas between Trivandrum and Anjego and between Vizhinjam and Poovar. The occurrence of crystallines at Veli, Kovalam and Vizhinjam and laterite cliff sections at

Poovar and Varkala are conspicuous land forms within the coastal plains which is quite narrow and the maximum width is 5 kms. 60% of the district comes under the midland unit which is occupied by valleys and hillocks making an undulating topography. The highly rugged terrain in the eastern part of the district represents the highland where the elevation goes upto 1869m above mean sea level (Agasthya mala). Among the 4 taluks, only Neyyatinkara Taluk stretches through all the three regions. Chirayankeezh and Trivandrum taluk lies in the midland and lowland region, while the Nedumangad taluk lies in the midland and highland region.

The important rivers draining the district are *Neyyar, Karamana*, *Vamanapuram*, *Mamom* and *Ayirur*, which form three main drainage basins such as Neyyar, Karamana and Vamanapuram basin. The *Neyyar* River with catchments of 497 sq.km originates from Agasthya hills at about 1860 m above msl and joins Lakshadweep sea near Poovar which is perennial with dendritic drainage pattern. Neyyar Irrigation Project constructed across this river irrigates southern parts of Trivandrum district and adjoining Kanya Kumari district of Tamil Nadu state. The other major river of the district is *Karamana* River, which is also perennial in nature and exhibits dendritic pattern, which originates from Chemmunjimalai at 1717 m above msl and joins the Lakshdwep Sea near Pachallur with a total catchment area of 703 sq.km. The dam constructed across the *Karamana* River at Aruvikkara and Peppara provides drinking water for the Trivandrum City. *Vamanapuram, Mamom* and *Ayirur* River form the Vamanapuram drainage basin with a total catchment area of 867 sq.km. It also originates from the Chemmunji Malai at about 1860 m above mean sea level and flows in a north-westerly direction and then to south-west before emptying into the sea.

A number of backwaters are seen along the western parts of the district viz. Poovar Kayal, Poonthura Kayal, Vellayani Kayal, Veli Kayal, Kadinamkulam Kayal, Anchuthengu Kayal and Edava-Nadayara Kayal. Among this only Vellayani Kayal is freshwater lake which is supplying water to major portion of Nemom block.

Though the district houses the state capital, the industrial development in the area is negligible. The land use pattern shows that major portion of the area is under agriculture, which is followed by forest. 64.27% and 22.7% respectively are the distributions of

agriculture land and forest in the district. Irrigation is mainly by surface water. The total area irrigated by canals is 36.31 sq.km, which is about 53.7% of the total irrigated area. The land utilisation pattern shows that net area sown is 1338.62 sq.km while area under forest cover is 498.61 sq.km.

Agriculture constitutes the main source of economy and about 15 types of crops are being cultivated in the district. Paddy is the main dry land crop. The crop is mainly grown in rain fed condition excepting along the ayacut area of Neyyar Irrigation project, which falls in Neyyatinkara Taluk. Coconut is one of the most important crops of the district which are mainly grown along the coastal places and the slopes of midland hills. Rubber, tea, cardamom, coffee are grown on the higher contour area of midland and Western Ghats. Other crops, which are grown in the district, are banana, pepper, cashew and arecanut..

Central Ground Water Board has carried out Systematic Hydrogeological Survey in the district during 1974-75 and 1980-81. Later the same area was covered under Reappraisal Hydrogeological survey during 1997-98 and 2004-05. In 1983-88, the SIDA assisted Coastal Kerala Ground Water Project of CGWB has carried out detailed hydrogeological studies with exploration in the district. In addition to the routine work, CGWB has also taken up a number of short-term investigation studies, exploration and geophysical activities in the district.

2.0 RAINFALL AND CLIMATE

The district has a climate that borders between tropical savanna climate and tropical monsoon climate. In a broad sense, it can be said that the district experience a tropical monsoon climate. The annual variation of mean air temperature at Trivandrum district is from 21^{o} C to 34^{o} C. The humidity is high and rises about 90% during the monsoon season.

The average annual rainfall of the district is 2035mm. It is significant that the district gets benefits of both monsoon – southwest monsoon and northeast monsoon. The district is characterised by very high precipitation which is spread over very few wet days and a long dry season (December- May) and a marked gradient from the eastern hilly region to the sea rapidly re-conveying the rainfall back to the sea through short, fast, west flowing

rivers. Trivandrum is the first city along the path of southwest monsoon and gets its showers by end of May/beginning of June. The district also gets rain from receding northeast monsoon which hits the district by October. The southwest monsoon contributes more than the northeast monsoon to the total rainfall in the district. The dry season sets by December in the district. December, January and February are the coldest months while March, April and May are hottest. The normal rainfall of the district is 2001.6 mm. The normal monthly rainfall in mm for the year 2011 is given below.

Table 1: Normal Monthly Rainfall – 2011

Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
19	21	33	150	186	329	240	141	161	276	184	63	1803

Table 2: Monthly rainfall in Trivandrum district for the period 2006 – 2011

Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
January	19	0	0	5	108	44
February	0	2	25	0	0	71
March	69	4	276	60	73	15
April	100	213	158	45	109	170
May	496	197	90	207	217	80
June	444	349	116	183	237	272
July	437	307	286	204	235	99
August	389	177	181	87	119	83
September	380	279	203	183	114	131
October	430	328	364	119	414	140
November	259	214	195	346	326	242
December	40	12	38	43	188	169
Total	**3063**	**2082**	**1932**	**1483**	**2141**	**1516**

The monthly rainfall data for the period 2007 - 2011 shows that during 2007 and 2010 rainfall was above normal rainfall.

The coastal area receives less rainfall when compared to the eastern region and moreover there is a sharp increase in rainfall from south to north. Even if the district receives both monsoons, a delay or failure of the monsoon often causes drought conditions in the district.

3.0 GEOMORPHOLOGY AND SOIL TYPES

The landforms of the district are carved out by a combination of marine, fluvial and denudational processes. The landforms can be categorised into three units viz. lowlands, midlands and highlands. Lowlands are formed by a combination of marine ad fluvial activities and represented all along the coastal plain, which stretches a length of 78 km, and are characterised by gently sloping terrain. The main landforms are sandy and rocky beaches, coastal cliff and sand ridges. Major portion of the district was formed by denudational activities, which includes both midlands and highlands. The area with an elevation of 7.5 to 75 m above msl with low or moderate slope (< 25%) can be categorised as midlands. Landforms with steep slopes and elevation of more than 75 m above msl can be grouped under highland. This highly rugged terrain is characterised by thick vegetation with NW- SE trending ridges, narrow valleys with steep slopes, rocky cliff and escarpments, which mainly occurs in the eastern part of the district.

The major types of soil found in Trivandrum district are red loams, coastal alluvium, riverine alluvium, lateritic soil, brown hydromorphic soil and forest loam. Most predominant soil in the district is lateritic soil and is mainly found along the midland, which are mostly reddish brown to yellowish red in colour. Brown hydromorphic soils are mostly confined to valley bottom in the midland and low lying areas of coastal strip which exhibits characters like gray horizon, mottling streaks, hard, organic matter deposition, iron and manganese concretions etc. Red loamy soils are highly porous, friable and low in organic matter, which is mainly seen in southern part of the district. The lowland area is dominated by alluvium, which are sandy loam to clayey loam in texture. Coastal alluvium is mainly found along the coastline while river alluvium is found along the banks of rivers and their tributaries. The eastern part of the district is characterised by fluvial loams, which are the products of weathering of crystalline rocks. These soils are dark reddish brown to black with loam to silty loam texture. As per the recent survey by ICAR ten types of soil are present in the district.

4.0 GROUND WATER SCENARIO

4.1 Hydrogeology

Trivandrum district is characterised by the outcrops of crystalline rocks of Archaean age in the eastern part and is overlain by sedimentary formations ranging in the age from Miocene to Recent along the western coast. Based on the water bearing properties, the entire district can be broadly classified into crystalline formation and sedimentary formation. The crystallines include khondalites, charnockites, migmatites and intrusives occur at shallow or deep with or without fractures. Whereas sedimentary formation comprise the (1)Recent alluvium that occur along the coastal plain and in the valleys and are mainly composed of sand and clay (2) Tertiary formation such as Warkali, Quilon and Vaikom beds and (3) laterites which occur as a capping over crystallines. Central Ground Water Board has drilled 32 exploratory wells in crystallines such as khondalites and garnetiferous-biotite gneiss and 9 exploratory wells in soft rocks to delineate the aquifer geometry and quality of formation water. The wells drilled in khondalites were in the depth range of 98.8-200.5 m bgl and the discharge ranges from 30 to 1200 lpm. Exploratory drilling revealed the presence of 5-7 aquifer groups within the depth range of 200 m in the district. The transmissivity ranges from 0.94 to 9.03 m^2/day. The wells drilled in the garnetiferous-biotite gneiss were in the depth range of 172.6-200 m bgl and the yield ranges from 12-420 lpm. The bore wells tapping NNW, NE, NW lineaments in the district gives high yield. The transmissivity of the wells drilled in garnetiferous-biotite gneiss ranges from 0.54 to 16.84 m^2/day. The locations of the wells drilled in hard rocks are shown in **Figure 1** and the details are given in **Annexure IA**.

In the sedimentary formation nine wells were constructed and very good yields have been encountered from the granular zones of Tertiary formations down to maximum depth of 109 m bgl. The Warkalai formation has a limited potential in the Trivandrum district. The wells drilled in the sedimentary formation were in the depth range of 19.6 to 109 m bgl tapping 4 to 5 potential zones. The discharge of the wells is in the range of very low to 6.91 lps and transmissivity value ranges from 69.76 to 232.4 m^2/day. Recent alluvium formation is thinner or absent towards the northern parts of the district. The maximum thickness of alluvium is 18 m, which is encountered at Chakkai. Exploratory drilling in

the sedimentary basins along the coast has indicated that these formations are potential in the area between Trivandrum and Anjego but the quality of ground water from deeper aquifers in this section is extremely saline and hence majority of the wells has been abandoned. The details of the wells drilled in soft rocks are given in **Annexure IB** and the locations are shown in **Figure 1**.

In Trivandrum district groundwater occurs in all the geological formations from Archaean crystallines to Recent alluvium under phreatic as wells under semi-confined condition. In weathered crystallines and in shallow sedimentary formations groundwater occurs under phreatic condition while semi-confined condition exists in deep fractured crystalline rocks and laterites. In shallow crystalline formations, groundwater occurs in the highly weathered and fairly deep and interconnected well-jointed parts. While deep fractures in deeper crystalline rocks form major potential aquifers that may be harnessing water from the semi-consolidated weathered product, laterite, lying over it.

In order to get a realistic picture about the groundwater conditions in Trivandrum district, Central Ground Water Board has established 79 Ground Water Monitoring Wells (GWMW's- as on 31/03/2012) which includes 56 dug wells and 23 piezometers tapping various formations. The locations of these GWMW's are given in **Figure 1**. These ground water monitoring wells are monitored four times a year and for the qualitative analysis, water samples has been collected during premonsoon (April) monitoring. Depth to water level in the district as a whole varies from 1.26 to 20.34 m bgl and 1.05 to 22.86 m bgl during pre-monsoon and post-monsoon (2011)respectively. The analysis of decadal average water level data reveals that water level ranges from 1.90 to 15.03 m bgl during premonsoon while the average water level ranges from 0.82 to 18.22 m bgl during postmonsoon period. In major portion of the district, the depth to water level ranges between 5-10 m bgl during pre-monsoon while it ranges from 2-5 m bgl during post monsoon.

The spatial distribution of depth to decadal average ground water level (2002-2011) for pre-monsoon and post-monsoon is shown in **Figure 2** and **Figure 3** respectively. From the figure, it is clear that deeper water level of more than 10 m bgl is encountered in

southern blocks especially Athiyannur, and parts of Nemom, Neyyatinkara and Thiruvananthapuram Corporation and in Varkala block in the south. The deeper water levels in these areas can be highly correlated with the physiographic set up of the area. These are the areas where thick laterite cliffs are exposed.

Seasonal fluctuation indicates that in major portion of the district, there is rise in water level in the range of 0-5 m except few isolated patches. An analysis of the data shows that the depth to water level during pre-monsoon and post-monsoon is minimum in alluvium and maximum in laterites. This may be due to the fact that since alluvium occurs in the discharge zone hence water level is shallow and fluctuation is less. The high fluctuation shown by wells tapping laterite can be attributed to the cavernous and porous nature of laterite, by which it gets easily recharged by a heavy showers and due to the same porous nature water easily drains off from the aquifer as subsurface run off. The long term trend analysis (2002-2011) shows that the water level during pre and post-monsoon indicates a rising as wells as falling situation. Some of the wells in Trivandrum Urban area show a decline in water level in a higher magnitude when compared to the previous decade. The hydrogeology map of Trivandrum district is shown in **Figure 4**.

4.2 Ground Water Resources

The Ground Water Resource of the district has been assessed based on Ground Water Resource Estimation Methodology –97 (GEC- '97) by considering administrative block as the assessment unit by excluding hilly regions and is computed based on the data available as on March 2009. The net groundwater availability of the Trivandrum district is 304.74MCM whereas the gross groundwater draft of the district is 171.01 MCM, thus keeping a balance of 133.73 MCM for future ground water development. The stage of ground water development is **56.12%**. Out of 12 blocks (prior to reorganisation of blocks), five are 'Semi critical' and nine are 'Safe'. Athiyanuur, Nedumangad, Nemom, Parassala and Trivandrum blocks in Trivandrum district falls in semi-critical category **(Figure 5).**

Table 3: Block-wise Groundwater Resource as on 31.03.2009

Block Name	Net Annual Ground Water Availability (MCM)	Existing Gross Ground Water Draft for irrigation (MCM)	Existing Gross Ground Water Draft for all uses (MCM)	Allocation domestic industrial upto next 25 years (MCM)	Net Ground Water Availability for future irrigation development (MCM)	Stage Ground Water Development (%)	Category
Athiyannur	16.61	4.65	14.4	10.93	1.04	86.66	Semi-Critical
Chirayinkil	19.44	1.85	12.35	11.79	5.82	63.55	Safe
Kazhakuttom	21.9	3.91	14.28	11.6	6.39	65.19	Safe
Kilimanur	26.35	2.19	13.26	12.41	11.75	50.31	Safe
Nedumangad	17.37	17.26	12.19	11.73	3.91	70.19	Semi-critical
Nemom	19.8	1.99	15.16	14.77	3.05	76.57	Semi-critical
Parassala	16.66	5.66	14.09	9.45	1.56	84.55	Semi-critical
Perumkadavila	36.44	3.62	16.22	14.12	18.7	44.51	Safe
Trivandrum	23.74	3.3	19.25	17.89	2.55	81.13	Semi-critical
Vamanapuram	47.26	3.65	14.15	11.77	31.83	29.94	Safe
Varkala	18.59	2.37	11.72	10.49	5.73	63.09	Safe
Vellanad	40.6	4.96	13.94	10.07	25.27	34.33	Safe
Total	**304.74**	**39.85**	**171.01**	**147**	**117.9**	**56.12**	

The ground water development in northern and eastern parts of the district are less than 100% and are categorised under safe category indicating the presence of potential aquifer which can be harnessed. Hence further ground water development can be taken up safely and more wells can be constructed. While further development in five blocks in southern and central parts of the district viz., Athiyannur, Parassala, Nedumangad, Nemom and Trivandrum requires a control in the development due to more exploitation of ground water.

While comparing the draft for all uses for 1999, 2004 and 2009, it is very clear that the gross groundwater draft has decreased from 178.79 MCM, 185.79 MCM to 171.01 MCM respectively during the past yrs. The Chirayinkil block was under over-exploited category during 1999 estimation while in the 2004 computation it falls under critical category. As per the Ground water Resource Estimation on 2009, the Chirayankil block is categorised under "Safe" Category. The marginal decline in the gross ground water draft may be due to decrease in irrigation draft consequent upon the reduction in the area under irrigated crops, increase in population and variation in rainfall.

4.3 Ground Water Quality

The ground water quality of unconfined aquifer in the district is monitored through the 56 dug wells established by CGWB. The ground water samples are being collected during premonsoon monitoring and subjected to detailed chemical analysis. The groundwater in the district is generally potable except in few locations such as areas adjacent to the seacoast, backwaters and area polluted by industrial effluents. In the coastal plain and areas adjacent to the backwaters, the electrical conductivity is greater than 1000 μS/cm. Similarly the chloride content is also high in the same location. The water is generally alkaline in nature. Along the eastern hills and foothills, due to heavy rainfall and step gradient flushing is a regular process and the water samples show less electrical conductivity value. All the major constituents are within the permissible limit. The groundwater is suitable for domestic and drinking purposes. Studies reveal that areas adjacent to Kadinakulam lake particularly the land sandwiched between the sea and backwaters are more prone to sea water ingress. Some of the wells tapping coastal alluvium shows high salinity and can be attributed due to over-pumping. The studies reveal that the quality of ground water in the shallow as well as deep -Tertiary aquifers are good particularly in Pulluvila basin. While the chemical quality of ground water in the area north of Chakai is not good and the bore wells constructed in the area has been abandoned due to poor quality.

4.4 Status of Ground Water Development

The main groundwater abstraction structures for domestic and agricultural purposes are dug wells, bore wells and tube wells. In the crystalline and lateritic terrain the groundwater is developed through dug wells and bore wells while along the coastal alluvium the groundwater is developed through dug wells, filter point wells and tube wells. Filter point wells are more suitable and economic in the alluvial area in comparison with the dug wells and tube wells. This can be constructed in areas where the saturated thickness exceeds 5 m and the diameter of these wells is about 0.5 to 0.8 m. Generally the highlands are not suitable for groundwater development through dug wells due to limited thickness of weathering.

During the past few years the construction of private tube wells and bore wells has increased tremendously. The tube wells and bore wells are the main structures to obtain large quantities of ground water supply whereas dug wells are used for limited quantity of groundwater. Tube wells and bore wells constructed by Kerala water Authority (KWA) cater to the drinking water needs of the district. The KWA is developing the resources through 3152 nos of tube wells and bore wells for the water supply in rural and urban areas in addition to surface water. Majority of the tube wells are in rural areas (96%). The rural water supply uses groundwater as the source whereas the urban area depends on surface water or both.The urban water supply in Trivandrum district is mainly from the dams constructed across Karamana river at Aruvikkara and Peppara. The freshwater lake at Vellayani also forms the source for the drinking water to the Nemom block. Besides this, majority of the households in the district have their own dug wells and bore wells.

Irrigation in Trivandrum district is mainly by means of surface water. A major surface irrigation scheme is Neyyar Irrigation Project, which irrigates an area of 1165 ha in southern part of the Trivandrum district and 3725 ha in Kanya Kumari district of Tamil Nadu state. The total area irrigated by canals is about 18.55 sq.km, which is about 61.4% of the total irrigated area. Besides this, there is minor irrigation through dug wells, bore wells and dug cum bore wells. The dug wells located along the valleys of midlands and

hilly area and tube wells/ bore wells located along the lineament yield water for irrigation even in the summer months.

The potential aquifers of fractured crystalline rocks can be tapped through tube wells / bore wells, which may be of medium or deeper depth. The deep tube wells have depth range from 200 to 300 m and the diameter ranges from 6 to 12 inches. The bore wells in Khondalites vary in depth from 1.1 to 20 m bgl. The wells in Upper Teritaries such as Warkalli, Quilon and Vaikom beds do not yield adequate water due to topography and limited saturated thickness. The depth of the wells in these formations generally varies from 15 to 30 m bgl.

The most potential aquifer in the area is alluvial deposits, which are composed of sand and clays. The depth of the wells ranges from 2 to 6 m bgl and is developed by shallow tube wells and filter point wells. The average yield is about 10 to 60 m^3/day.

5.0 GROUNDWATER MANAGEMENT STRATEGY

5.1 Ground Water Development

There is scope for further groundwater development for irrigation in majority of the blocks of the district where the stage of development is low. Groundwater development should be coupled with management of rainwater and surface water. The existing water resources and dug wells, ponds and streams should be protected and conserved. Rainwater harvesting and artificial recharge schemes should be practiced. In Trivandrum district, there are about 31 springs which are perennial source for drinking water. These springs originate from sedimentaries and crystallines and shows good discharge. The quality of spring water is potable and hence this can be used effectively for drinking water supply schemes, which in turn reduce the stress on groundwater.

Direct rotary would be suitable for drilling in alluvial areas. In coastal alluvium, fully lined dug wells with an average diameter of 1.5 m are feasible. While comparing the different types of well, filter point wells are found to be more economically feasible in coastal alluvium. The parapet wall of dug wells is to be constructed with light material so that collapse during heavy rainfall can be avoided. Deep tube wells are not feasible in alluvium.

In the case of hard rocks, deep tube wells are feasible but it should be site specific and depending upon the terrain. The construction of any sort of abstraction structures should be done with proper technical guidance, especially in Khondalite where fractures may be filled with clay. In the case of boreholes, perforated casing pipes can be inserted up to the bottom because of caving tendency in khondalite terrain. Majority of the fractures are confined within 150 m bgl. Hence construction of tube wells can be restricted within this depth.

In the case of laterites, the wells should be design in such a fashion that water should be harnessed from the unconsolidated (laterite) formation. And if happens to encounter underlying laterite/hard rocks boundary, there is a fair chance to well collapse due to litho margin clay.

An essential part of management of the resource is the proper spacing of abstraction structures. The spacing between shallow tube wells should be kept 225 m and for deep tube wells the spacing between the well should be kept 800m.

5.2 Water Conservation and Artificial Recharge

The increase in abstraction structures in the district warrants a systematic and planned response through more effective Ground Water Regulation and more intensive artificial recharge and conservation measures. The blocks showing significantly low ground water availability when compared to draft are Athiyannur, Parassala,Nemon Trivandrum and Nedumangad. In order to check the declining trend, artificial recharge to groundwater is required. The non-committed monsoon run-off can be utilised as a source for artificial recharge. Topography of the area are suitable for construction of various artificial recharge structures such as percolation ponds, check dams, contour bunding, trenching, pitting, terrace cultivation and sub-surface dykes. CGWB has constructed 5 Water Conservation Structures in Trivandrum district and the details are given in **Table 4**.

Table 4: Water Conservation Structures by CGWB

S.No.	District/Block	Location	Type of Construction Structures
1.	Trivandrum, Chirayinkil Block	Ayilam	Subsurface dyke
2.	Trivandrum, Chirayinkil Block	Ayandikadavu	Tidal regulator
3.	Trivandrum, Neyyattinkara Muncipality	Mampazhakara	Subsurface dyke
4.	Trivandrum, Trivandrum Rural	Government Secretariate	Recharge pits (3 Nos)
5.	Trivandrum, Manikkal Panchayat, Vamanapuram Block	Thalayil-Mottakkavu	Subsurface dykes

In Trivandrum district about 2100 numbers of tank/ponds were present. The maximum number of ponds is seen in Vamanapuram block and minimum number of ponds is in Trivandrum block. Chenkal pond is the largest pond in Trivandrum district. A large number of ponds, tanks and other abstraction structures in the district are filled up with silt, clay and hence sufficient recharge is not taking place in the aquifers. Hence these should be cleaned, desilted and protected since these structures are good for water conservation and recharge.

Due to lateral spread of urbanisation, groundwater is vulnerable quantitatively and hence it is very necessary to take up artificial recharge schemes in urban area. The most feasible structure is the roof top rainwater harvesting technique. Such schemes can arrest the decline in groundwater levels and improve groundwater quality. Recharge pits and trenches are ideal structures for Rainwater harvesting. Roof water can be used for recharge the dug wells, bore wells and tube wells.

In Athiyanuur, Parasala and Nemom blocks subsurface dykes, recharge ponds and pits can be constructed. Many quarry ponds are present in and around vizhinjam, kovalam areas. The unused quarry ponds can be effectively used for rainwater harvesting structures. The feasible artificial recharge structures in each block are shown in **Figure 6**.

6.0 GROUNDWATER RELATED ISSUES AND PROBLEMS

6.1 Over-Exploitation

With the adoption of modern drilling techniques, construction of bore wells has become a common practice in the district to meet domestic as wells as agriculture needs. This increase in tube wells resulted in more groundwater draft from potential aquifers of Athiyannur, Parasala, Nemom, Nedumangad and Trivandrum blocks. These scenario leads to over-exploitation in these blocks.

The other groundwater issue in Trivandrum district is the pollution due to waste disposal particularly around Vilapilsala where the waste disposal factory resides. The E.Coli content is very high in this area whereas the other constituents are within the desirable limit. Other important issue is the water marketing mainly seen during summer months due to heavy withdrawal resulting in decline of water table.

7.0 AWARENESS & TRAINING ACTIVITY

A mass awareness programme on water conservation techniques was held on 7th February 2005 at Mascot hotel, Trivandrum. About 300 persons participated in the programme.

Two days water management training programme was held on 1st and 2nd February 2005 at Thycaud Guest house, Trivandrum. About 100 persons participated in the programme. Three days training on Rainwater harvesting was also conducted.

The World Water day Celebration on 22nd March was organised in association with CWC and NWDA during 2005, 2006 and 2007. This programme was well attended by 300 people.

Two days water management training programme for the tribal area was held on 8th and 9th February 2012 at Vidura, Trivandrum. About 150 persons participated in the programme. One day mass awareness programme on water conservation techniques was also held at Vidura on 10th February 2012.

8.0 RECOMMENDATIONS

1. Groundwater resource in less development blocks are recommended for further development especially along the valleys by means of large diameter wells.
2. In the case of crystallines the depth of tube well can be restricted within 150 m since majority of fractures are within this depth.
3. It is necessary to regulate the construction of all groundwater abstraction structures. Prior permission should be sought from Central Ground Water Authority for constructing any type of groundwater harnessing structures.
4. In order to avert the declining trend of water levels in urban areas of the district, groundwater management structures such as roof top rainwater harvesting system and recharge structures should be constructed which in turn augment the groundwater reservoir.
5. Mass Awareness Programme should be conducted in the district by giving emphasis to over-exploitation and its consequences and need for its effective/economic use.
6. A number of springs are available in the district usually emerging from bedding planes between sandstone and clay horizons which has not been developed so far effectively. Hence, attention may be given for the proper development of springs as they form perennial sources of drinking water.
7. Along the entire coast of the district, considerable quantity of ground water is escaping to the sea as inevitable losses due to sub surface outflow. This may be arrested by constructing subsurface structures at suitable points.
8. The wells tapping coastal sandy alluvium near to Kadinakulam kayal shows a high salinity indicating that an equilibrium stage has been reached. Hence further development in this area may be stopped to prevent the sea water ingress into the unconfined aquifer.
9. Micro level study is recommended in semi-critical blocks to gather more realistic picture of ground water development and to study the scope for future

development and regulatory measures to be taken in such areas to control over exploitation of ground water resources.

10. Site-specific artificial recharge schemes to be adopted in the district for the effective management and conservation of ground water resources.

Figure 1: Index map of Trivandrum District, Kerala

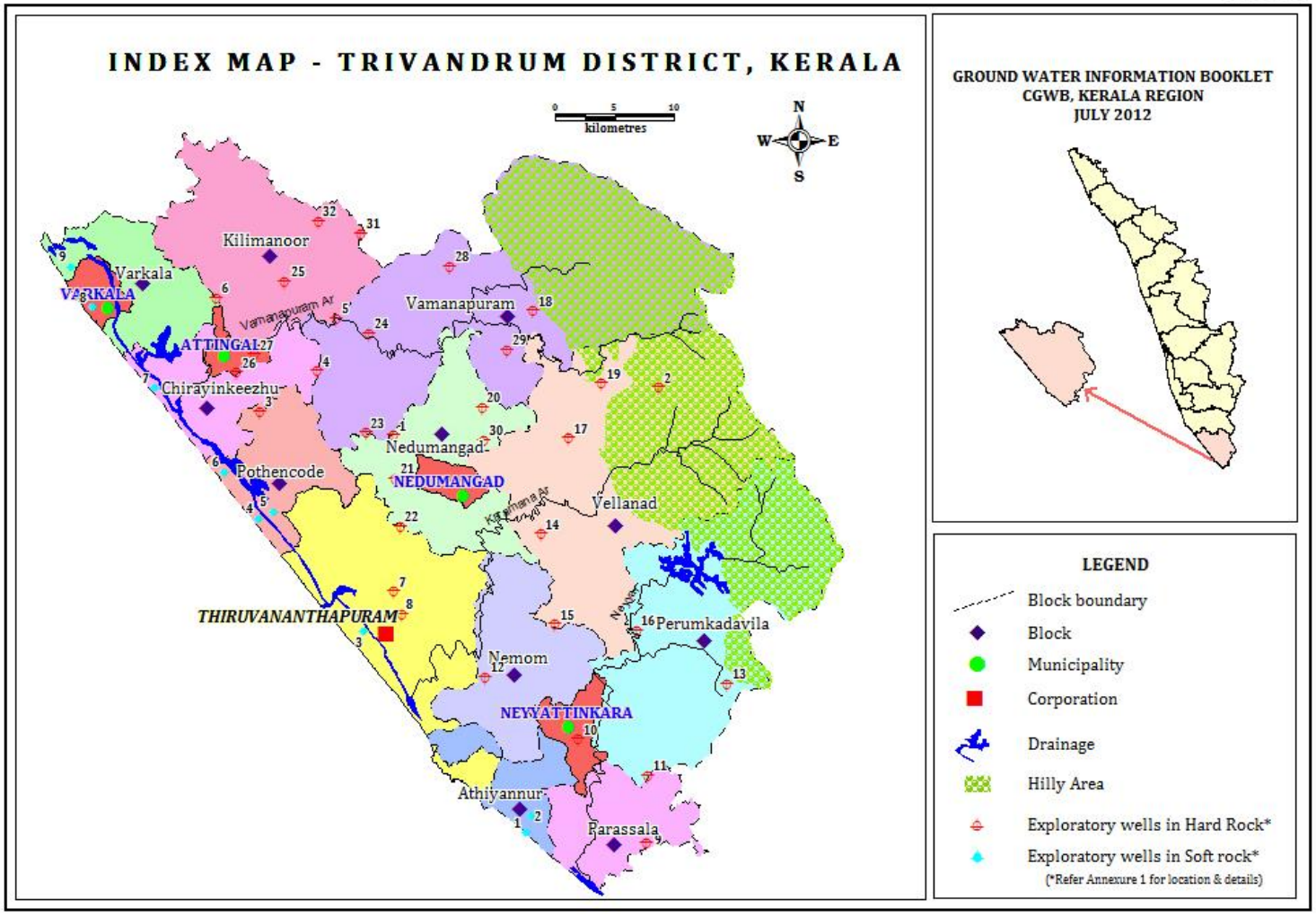


Figure 2: Depth to Decadal Average Water Level (Premonsoon April 2002-11)

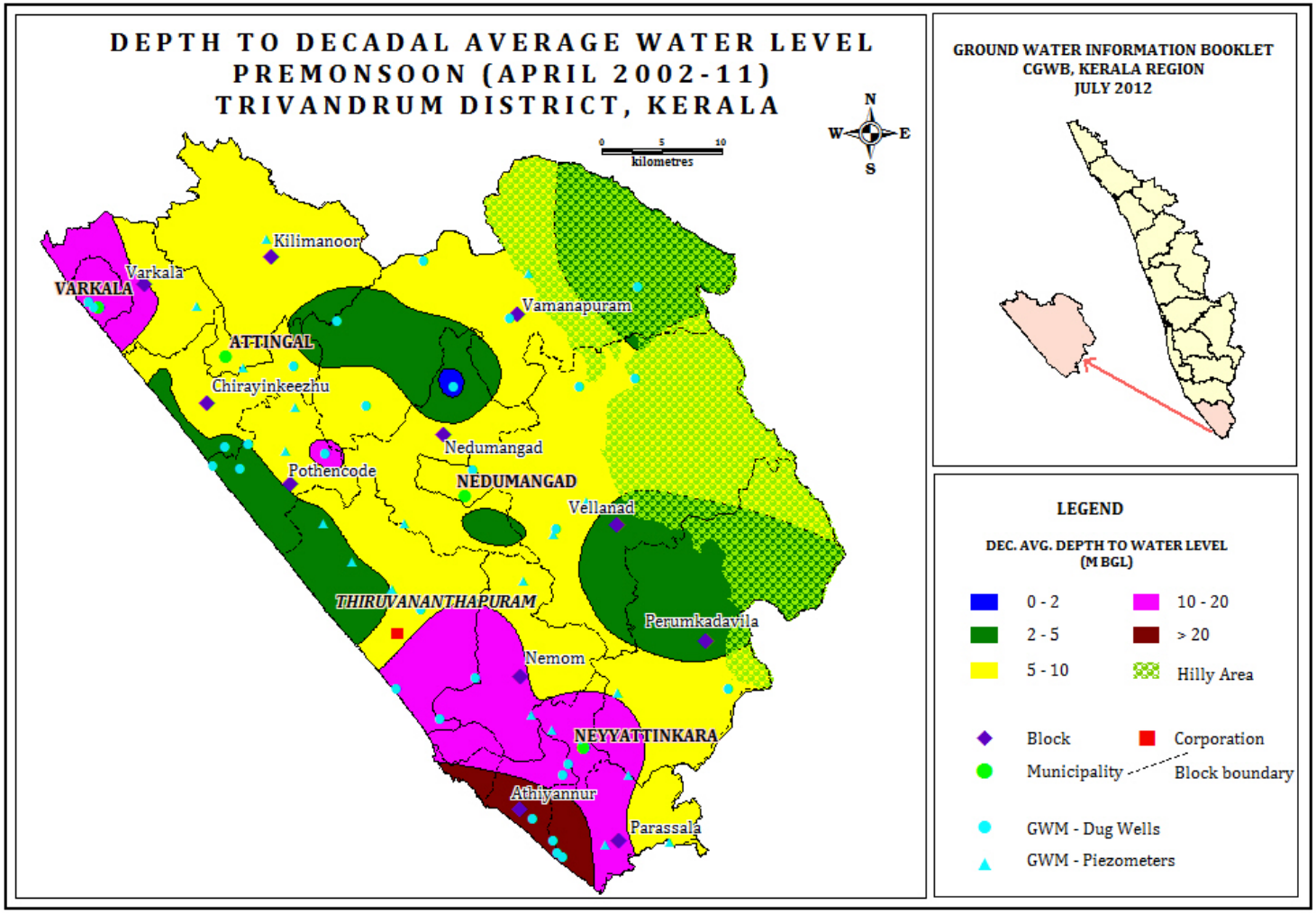


Figure 3: Depth to Decadal Average Water Level (Post monsoon Nov 2002-11)

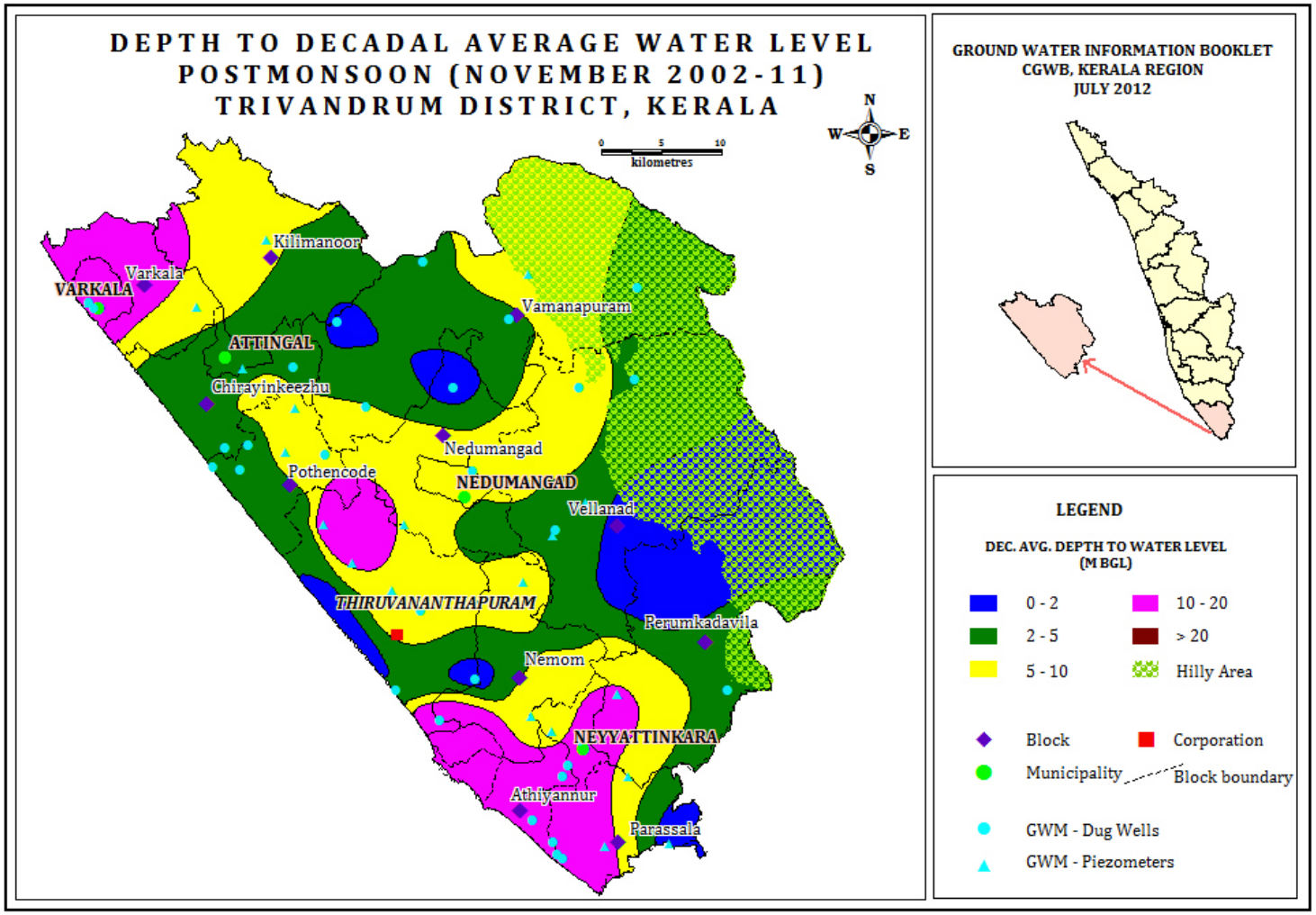


Figure 4 : Hydrogeology of Trivandrum District, Kerala State

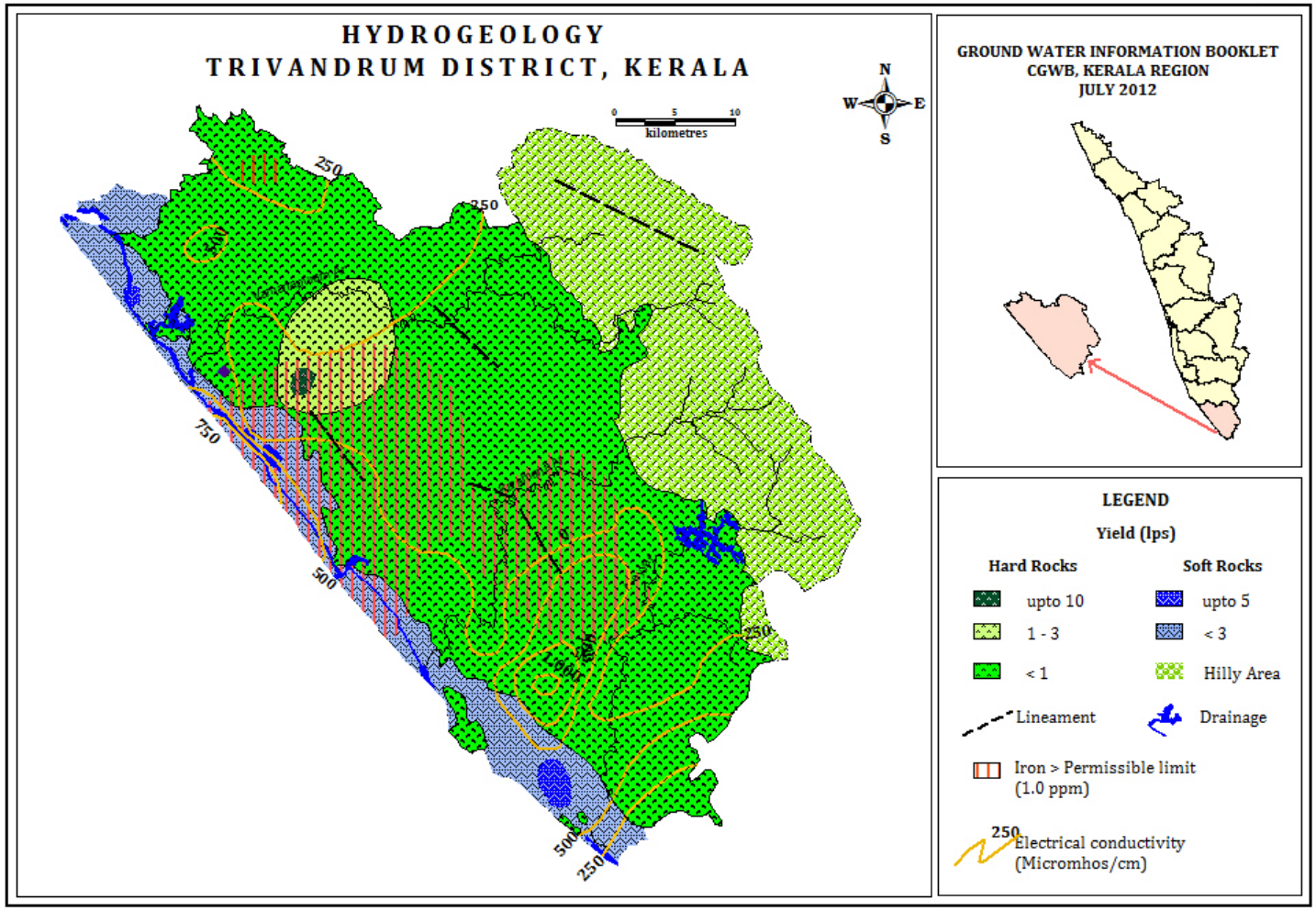


Figure 5: Categorisation of Blocks in Trivandrum District

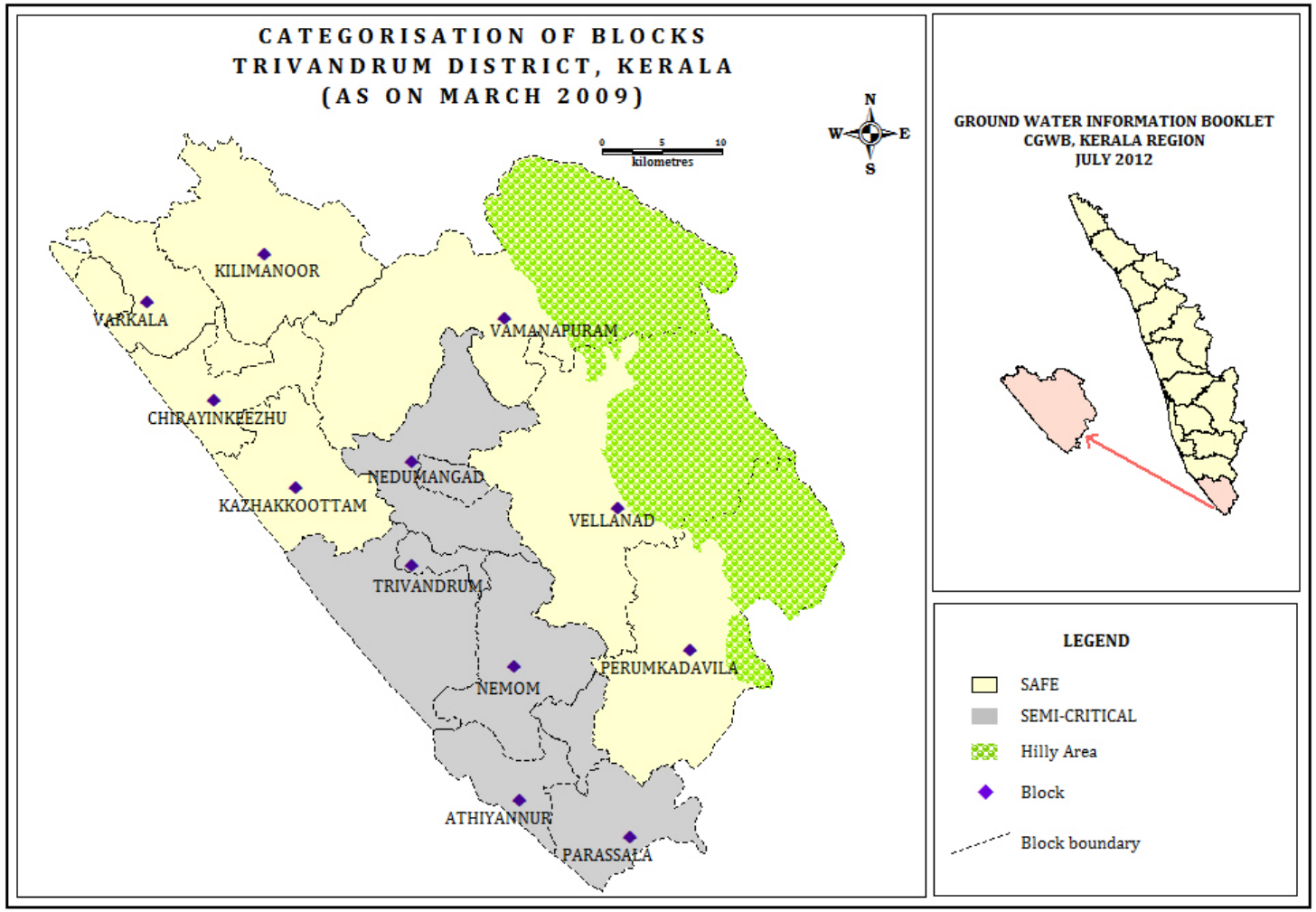
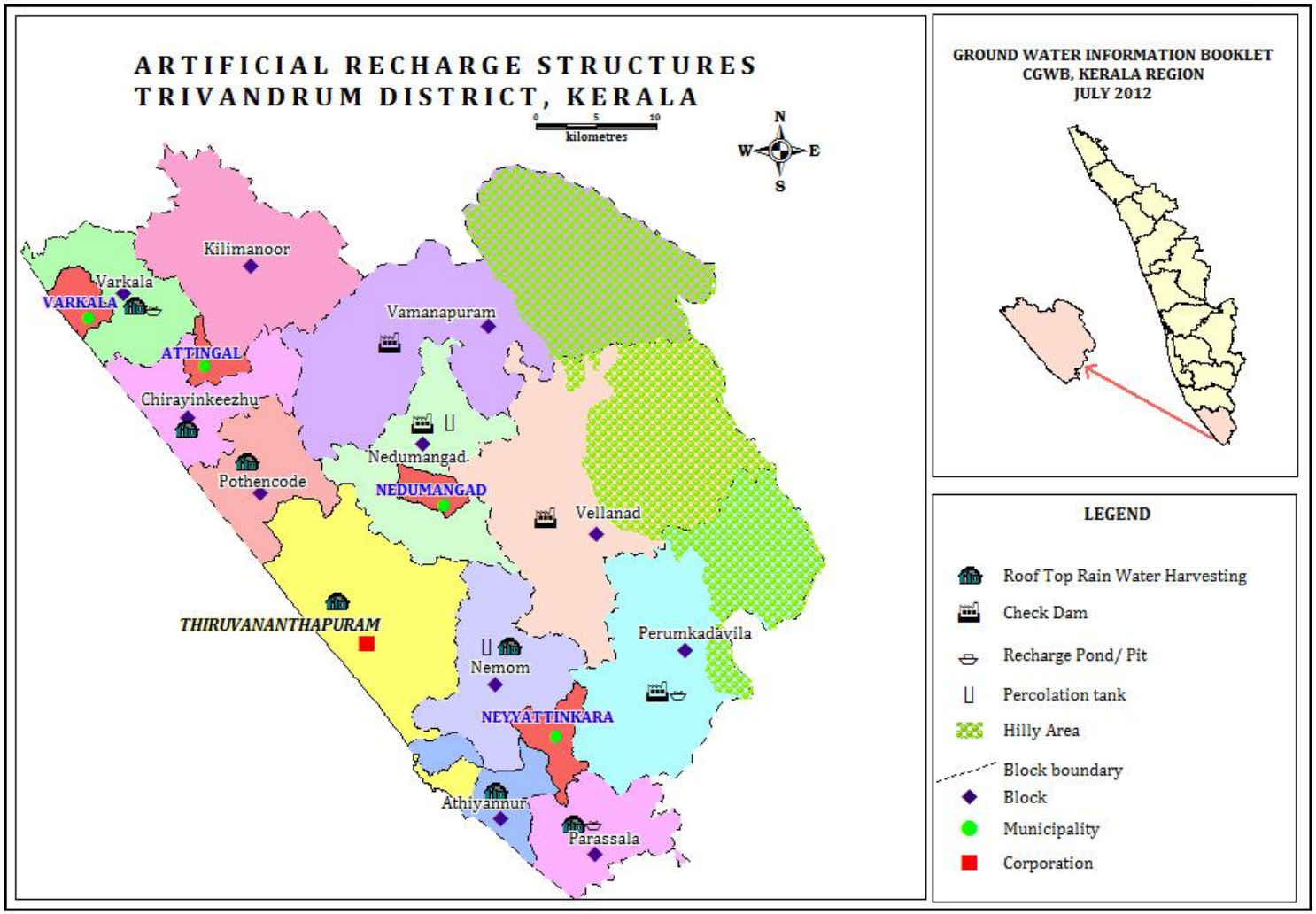


Figure 6: Artificial Recharge Structures proposed in Trivandrum District



Annexure-1A: Details of wells drilled in hard rock areas of Trivandrum District

Sl. No	Location	Year of construction	Depth drilled (mbgl)	Major lithology encountered	Fracture zones with yield lpm	SWL mbgl	Discharge (lps)	Draw down (m)	T m^2/day	EC Microseimens/cm	Cl ppm
1	Vempayam	1986-87	200.53	Khondalite	54.09/30, 88/60, 130/90, 160/144	10.54	2.40	32.48	0.93	460	11
2	Vidura	1986-87	200.53	Khondalite	35/30, 103.5/60, 122.33/90	6.56	1.50	31.89	0.94	220	7
3	Korani	1986-87	183.29	Khondalite	22.4/30, 42.9/120, 84/180, 103.5/300, 122/390, 152.8/500, 175/1200	5.36	20.00	18.89	9.03	510	14
4	Chemburu	1986-87	191.0	Khondalite	54/30, 88.2/120, 123/204, 164.4/270	14.92	5.00	24.19	1.17	230	13
5	Vamanapuram	1986-87	200.53	Khondalite	14.17/30, 76.61/120, 107.09/324, 130.0/390	12.5	8.33	24.91	4.63	640	131
6	Thottakkad	1986-87	200.53	Khondalite	4.4-13/30	20.42	0.50		NA	460	14
7	Pattom	2005-06	200	Garnetiferous biotite gneiss	30-33, 75-78	11.85	0.20		-	185	8.5
8	Palayam	2005-06	200	Garnetiferous biotite gneiss	78-80, 119-122 192-194	2.35	1.50	33	0.54	334	26
9	Chenkavila	2005-06	68.3	Khondalite	39-41 62-68.30	12.18	3.00	16.45	4.59	425	20

10	Neyyattinkara	2005-06	129.3	Khondalite	31.70-36.70, 47.00-50.00, 57.00-59.00, 75.00-77.50	2.67	6.00	31.24	5.54	275	11
11	Dhanuvachapuram	2005-06	161.8	Khondalite	36.80-39.00, 49.00-53.00	11.43	1.50	25.67	1.13	260	14
12	Nemam	2005-06	200	Khondalite	44.00-47.00, 148-150, 193-196	3.09	0.30			459	18
13	Vellarada	2005-06	200	Khondalite	44.00-46.00, 74.00-77.00	2.32	1.30	36	1.04	140	8.5
14	Vellanad	2005-06	200	Khondalite	89.00-92.00, 135-137	4.79	0.50			413	20
15	Kollode	2005-06	200m	Khondalite	16.40-19.50, 38.00-41.00, 75.00-77.00	6.53	2.40	23.14	1.2	105	7.1
16	Kuravara	2005-06	98.8	Khondalite	9.00-12.00, 40.00-44.00, 77.00-87.00	1.02	5.00	21.4	2.59	391	8.5
17	Malayadi	2005-06	172.6	Garnetiferous gneiss	40.00-42.00 102-104 172.5-172.6	3.35	7.00	17.02	16.84	364	5.7

18	Peringamala	2005-06	200	Khondalite	13.50-15.00, 142-146	1.75	1.50	30	0.9	212	7.1
19	Vithura	2005-06	200	Khondalite	26.00-29.00, 35.00-41.00	0.65	3.00		6.03	234	4.3
20	Attukal	2006-07	200	Khondalite	77.00-78.00	17.75	0.50			297	7.1
21	Vettinad	2006-07	200	Khondalite	16.00-19.00 129-132	1.4	1.50	28.5	1.46	430	27
22	Mannanthala	2006-07	200	Khondalite	12.00-14.00 182-184	4.26	1.00			228	7.1
23	Meenera	2006-07	80.5	Khondalite	38.00-40.00 74.00-80.50	8.85	1.00			272	8.5
24	Melattumuzhi	2006-07	144.5	Charnockite/ Gabbro	53.00-56.00 105-108 144-144.5	5.19	10.00	12.21	17.58	398	20
25	Nagarur	2006-07	141.5	Khondalite	22.00-24.00 90.00-93.00 105-109	5.14	7.00	17.3	5.89	258	8.5
26	Mamam	2006-07	200	Khondalite	29.00-32.00 76.00-80.00 123-126 157.5-160	2.8	7.00	14	9.54	314	7.1
27	Avanavancherry	2006-07	62.2	Khondalite	19.00-22.00 29.00-32.00	-	0.50			292	17

28	Bharathannur	2006-07	200	Khondalite	10.50-14.00-dry 38.00-41.00-dry 166-168	2.4	0.30			332	17
29	Nanniyode	2006-07	52	Pegmatite vein/ Khondalite	42.00-48.00	2.24	1.50	22.45	6.45	360	9.9
30	Anad	2006-07	200	Leptynite	17.00-20.00 92.00-94.00 160-163	1.16	3.00	25.75	4.65	371	9.9
31	Tholikuzhy	2006-07	125	Khondalite	24.50-26.50 123.50-125.00	7.45	10.00	18.41	6.41	464	7.1
32	Thattathumala	2006-07	200	Khondalite	16.00-19.00 35.00-38.00 62.00-65.00	4	0.20			233	5.7

Annexure-1B: Details of wells drilled in soft rock areas of Trivandrum District

Sl. No	Location	Depth drilled (m bgl)	Depth constructed m bgl	Major lithology encountered	Depth to bedrock if found	Zones encountered	Zones tapped	Static water level (mbgl)	Discharge lps	Drawdown (m)	T m^2/day	E.C micro seimen/cm	Cl (ppm)	Remarks
1	Pallam 1994	100.75	66	Clay, sand	88		28-38, 59-64, 72-78, 85-88	0.64	6.91		NA	430		
2	Pulluvila 1976	120.29	103.63	Laterite, clay, sand	112.8	56.5-62.3, 91.6-101.9	56.5-62.3, 91.6-101.9	49.23	6.3	2.57	232.4	460	1.45	
3	Chakkai 1976	100.5	57	Clay, sand	97.5	42-54, 60-79		NA	NA	NA	NA	Top - 4127, Bottom - 6485	NA	Slim hole
4	Meenamkulam 1976	49.3	30.4	Sand & clay	45.7	6.4-13.7, 19.5-28.95	19.8-28.95, (Warkalai)	NA	1.66	NA	NA	18120 to 19320	665.7	Abandoned due to poor discharge
5	Chittattumukku 1976	51.82	30.4	Laterite, clay, sand	42.7	12-15, 33-36	19.8-28.95, (Warkalai)	NA	NA	NA	69.76	NA	NA	Slim hole
6	Pudukurichi 1976	92.35	19.6	Clay, sand	88	7.15-17, 76-82	13.47-16.6, (Warkalai formation)	NA	NA	NA	NA	11330 to 26000	97.29	Abandoned due to poor discharge

7	Anjengo 1976	103.2	70	Laterite, clay, sand, lithomargic clay	100.6	8-17, 46-54, 57 - 68	57 - 67	NA	Freeflo w	NA	NA	31080 to 43740	14496	Artescean water is saline.
8	Varkala 1976	75.3	69	Laterite, clay, sand			56.4-62.5	49.93	6.31		232.4	70		
9	Edavai 1998	121.9	109	Laterite, clay, sand	106.7	73-79, 91-103	73.0-79.0, 91.0-106.0	NA	Very low	NA	NA	NA	NA	Abandone d due to poor discharge

Annexure-2: Chemical Analysis Data of GWMW in Trivandrum District

Sl:No	Location	pH	EC	TH	Ca	Mg	Cl	F	NO_3
			µs/cm	<----------conc. In mg/L---------->					
1	Amboori	7.43	119	14	5.6	0	18	0.12	20
2	Anjengo	8.75	162	52	13	4.9	14	0.27	2.9
3	Aruvikara	7.01	59	8	2.4	0.49	8.5	0.14	0.37
4	Attingal	7.11	110	12	4	0.49	13	0.15	0.76
5	Balaramapuram	-	918	108	38	2.9	171	0.45	106
6	Chirayinkil	7.81	373	26	5.6	2.9	77	0	5.1
7	Edavai	7.28	376	36	11	1.9	54	0	51
8	Kadakkavur	7.37	512	96	20	11	68	0	67
9	Kallambalam	-	591	42	15	0.97	107	0.49	44
10	Kallar	7.87	70	12	3.2	0.97	7.1	0.18	3.7
11	Kallikkad	4.9	331	12	4	0.49	68	0.14	8.4
12	Kattakkada	6.32	339	42	9.6	4.4	61	0.28	19
13	Kazhakuttam	8.24	508	102	31	5.8	39	0.17	67
14	Kochuveli	-	247	16	4.8	0.97	17	0.2	9.8
15	Korani	8.02	230	26	8.8	0.97	28	0.26	3.4
16	Madavur	7.52	120	8	3.2	0	17	0.28	7.6
17	Mannanthala	7.17	247	18	3.2	2.4	40	0.21	19
18	Maruthamoola	7.38	141	20	5.6	1.5	16	0.09	14
19	Murukumpuzha	8.68	181	54	18	1.9	17	0	2.2
20	Nedumangad	-	161	10	3.2	0.49	27	0.25	0.98
21	Neyyattinkara	7.54	252	24	5.6	2.4	36	0.3	42
22	Palode	-	129	14	3.2	1.5	13	0.05	13
23	Panavoor	-	120	12	4.8	0	16	0.23	2.8
24	Pangode	7.45	314	32	7.2	3.4	50	0.19	50
25	Parassala	8	918	118	25	14	181	0.47	5.4
26	Perumathura	8.68	1014	278	94	11	142	0.4	57
27	Perumgur	-	237	12	3.2	0.97	44	0.21	8.3
28	Perumkuzhi	8.05	258	60	19	2.9	21	0.35	0.77
29	Perunkadavila	7.6	87	16	2.4	2.4	13	0.15	0.41
30	Pirappankod	7.35	78	10	3.2	0.49	8.5	0.08	5.9
31	Ponmudi	6.98	67	12	2.4	1.5	9.9	0.22	11
32	Poovar II	8.08	394	72	15	8.3	57	0.13	0.82
33	Pothenkod	7.3	167	20	4.8	1.9	23	0.26	29
34	Pozhiyoor	8.15	1711	190	20	34	391	0.18	3.6
35	Pudukurichi	-	1483	220	68	12	327	0.4	68
36	Puvar	8.25	1013	120	24	15	185	0.47	51
37	Vamanapuram	-	310	30	7.2	2.9	48	0.08	4.9
38	Varkala	8.11	268	36	11	1.9	47	0.15	12
39	Vellanad	-	60	8	1.6	0.97	8.5	0.35	3.4
40	Vellarada	7.99	585	68	20	4.4	106	0.13	48
41	Vellayani	7.81	94	10	1.6	1.5	21	0.42	5.5

42	Vidura	6.76	136	28	7.2	2.4	16	0.26	32
43	Sasthanthala	6.49	113	6	2.4	0	20	0.06	13
44	Chittagode	7.36	292	34	8	3.4	48	0.28	23
45	Nagapuram	7.12	112	18	4	1.9	24	0.42	4.1
46	Athazhamangalam	6.94	83	8	1.6	0.97	17	0.25	5.3
47	Vempakal	8.18	125	30	10	0.97	9.9	0.31	0.45
48	Kulathur	7.46	81	16	5.6	0.49	9.9	0.23	0.04
49	Thonnakkal	7.11	148	34	8.8	2.9	21	0.09	24