CONSERVE WATER – SAVE LIFE

भारत सरकार

GOVERNMENT OF INDIA

जल संसाधन मंत्रालय

MINISTRY OF WATER RESOURCES

केंद्रीय भूजल बोर्ड

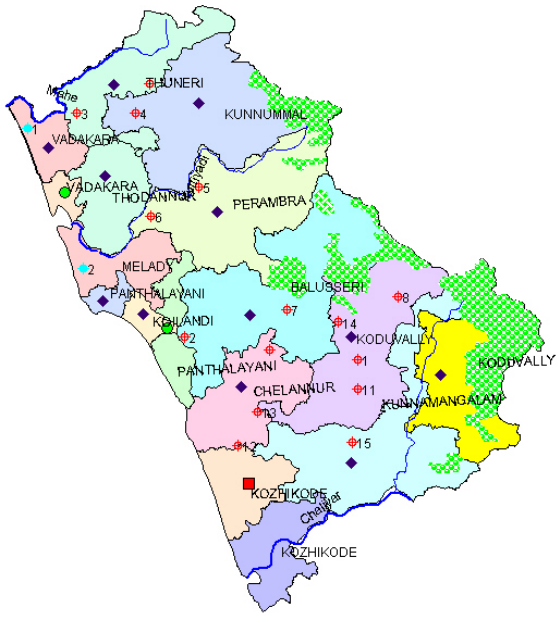
CENTRAL GROUND WATER BOARD

केरल क्षेत्र

KERALA REGION

भूजल सूचना पुस्तिका, कोष़िकोड जिल्ला, केरल राज्य

GROUND WATER INFORMATION BOOKLET OF KOZHIKODE DISTRICT, KERALA STATE



तिरुवनंतपुरम

Thiruvananthapuram

December 2013

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD

GROUND WATER INFORMATION BOOKLET
OF
KOZHIKODE DISTRICT, KERALA

ए रवि
वैज्ञानिक ग
A. Ravi
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- 2419075
FAX: 0129- 2142524

GROUND WATER INFORMATION BOOKLET
OF
KOZHIKODE DISTRICT, KERALA

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXURES

DISTRICT AT A GLANCE

Sl. No.	ITEMS	STATISTICS
1.	**GENERAL INFORMATION**	
	i) Geographical area, km^2	2344
	ii) Administrative Divisions (As on 31-03-2009) Number of Tehsil / Block Number of Panchayat/Villages	 3 / 12 77 / 117
2.	**GEOMORPHOLOGY**	
	Major physiographic units	Lowland, Midland and Highland
	Major Drainages	Chaliyar, Kuttiadi, Mahe, Kadalundi, Kallayi and Korapuzha
3.	**LAND USE (ha) as on 2009**	
	a) Forest area	41386
	b) Net area sown	232307
4.	**MAJOR SOIL TYPES**	Alluvial soil**,** laterite soil and forest loam.
5.	**AREA UNDER PRINCIPAL CROPS, has on 2009**	210905
6.	**IRRIGATION BY DIFFERENT SOURCES as on 2009 (Areas (ha) and Number of Structures)**	
	Wells (Dug wells &Tube wells / Bore wells)	2561
	Tanks / Ponds	419
	Canals	2237
	Other Sources	780
	Net Irrigated area	5997
	Gross Irrigated area	-
7.	**NUMBER OF GROUNDWATER MONITORING WELLS OF CGWB (as on 31-3-2011)** No. of dug wells No. of piezometers	55 32 23
8	**PREDOMINANT GEOLOGICAL FORMATIONS**	Archaean Crystalline formation (Gneiss, Charnockite), Tertiary sedimentary formation, Sub-Recent laterite and Recent coastal Alluvium.

9.	**HYDROGEOLOGY** Major Water bearing formation	Weathered fractured crystalline formations; semi consolidated Tertiary formations, laterites and Recent alluvium.	
	Depth to water level (Premonsoon, April 2011), mbgl	0.73 to 16.11	
	Depth to water level (Post monsoon, Nov. 2011),mbgl	0.26 to 10.62	
	Long term water level trend in 10 years (2002-2011)	Rise – 0.01-0.72 Fall – 0.03 – 2.56	
10.	**GROUND WATER EXPLORATION BY CGWB (2011)**		
	No. of wells drilled (EW, OW, PZ, SH, Total)	EW – 17, PZ –23, SH – Nil. Total – 40.	
	Depth range, m	30 to 200	
	Discharge, lpm	10- 1020	
	Transmissivity, m^2/day	8.52 to 104.00	
11.	**GROUND WATER QUALITY**		
	Presence of chemical constituents more than permissible limits	Quality is good. Major chemical constituents lie within the permissible limits.	
12.	**DYNAMIC GROUNDWATER RESOURCES (as in March 2009), MCM**		
	Annual Replenishable Ground Water Resources	347.38	
	Net Annual Groundwater draft	189.72	
	Projected demand for Domestic and Industrial uses in 2025	157.93	
	Stage of Ground Water Development, %	54.61	
13.	**AWARENESS AND CAPACITY BUILDING** Mass Awareness Programmes organized No. of Participants	Nil	
	Water Management Training Programmes organized	2 programmes	
	Date	2005	2008
	Place	Kozhikode	Kozhikode
	No. of Participants	85	95
14	**EFFORTS OF ARTIFICIAL RECHARGE & RAINWATER HARVESTING**		
	Projects completed by CGWB (No & Amount spent)	Nil	
	Projects under technical guidance of CGWB (Numbers)	Nil	

15	**GROUND WATER CONTROL AND REGULATION**	
	Number of Over Exploited blocks	Nil
	Number of Critical blocks	Nil
	Number of Semi-Critical blocks	2
	Number of safe blocks	10
	Number of notified blocks	Nil
16	**MAJOR GROUND WATER PROBLEMS AND ISSUES**	Decline in water level, water scarcity, and salinity ingress in coastal aquifers.

GROUND WATER INFORMATION BOOKLET OF KOZHIKODE DISTRICT, KERALA STATE

1.0 INTRODUCTION

The district of Kozhikode is one of the coastal districts of Kerala. Kozhikode district is bounded on the north by Kannur district, on the east by Wayanad district, on the south by Malappuram district and on the west by Lakshadweep Sea. It lies between North latitudes 11º 08' and 11º 50' and East longitudes 75 º 30' and 76 º 8'. It is falling in parts of Survey of India Toposheets 58 A and 49 M.

The district has an areal extent of 2344 sq.km and is accessible by road, rail and air. The national highway (NH -17) connecting Cochin with Mangalore passes through the district. The district headquarters – Kozhikode is well connected by road with the rest of the state. The Trivandrum-Mangalore-Mumbai railway is passing through the district. The Kozhikode airport, which operates several international flights to Gulf countries, is situated at Karipur in Malappuram district, which is very close to Kozhikode city. The political history of Kozhikode is a story of treacherous and ill-conceived conspiracies hatched by the Western powers. The district houses Kappad beach (16 km north of Kozhikode) which is famous as the place where Vasco Da Gama the leader of a trade mission from Portugal first landed in Kerala in May 1498.

1.1 Administration

The district is divided into 3 taluks and 12 developmental blocks and 77 panchayats for administrative purposes. The district has one corporation (Kozhikode) and two Municipalities namely Quilandy and Badagara. It has a total of 117 revenue villages. Out of the total area of 2344 Sq. Kms 336 Sq. Kms fall under urban area and the remaining 2008 Sq. Kms falls under rural area. The Index map of Kozhikode district is depicted in the **Figure- 1**

The district has a total population of 30, 89,543 persons as per 2011 census. As in the case of many other districts of Kerala, the female population exceeds the male population and in Kozhikode District for every 1000 males there are 1097 females. The density of population is 1318. The decadal population (2001-2011) growth rate of the district is 7.31%. The district has a literacy rate of 95.24 % as per 2011 census.

1. 2 Drainage & Irrigation

The district is drained by six rivers of which one is of medium nature and all others are minor ones

namely *Chaliyar, Kuttiyadi, Mahe, Kadalundi, Kallayi and Korapuzha*. The Chaliyar River is a medium river and originates at a height of 2066 m amsl in Ilambalari hills of Western Ghats of Gudallur district, Tamil Nadu. The Chaliyar drains in to Beypore estuary. It is a sixth order stream with a length of 169 km. At its upper reaches it is formed by *Punnurpuzha, Pandiyur, Karimpuzha, Cherupuzha, Kanhirampuzha, Kurumbanpuzha, Vathatpurampuzha & Iruvantipuzha*. At its lower reaches near Cheruvannur, it is flowing as a broad river developing inlets.

The *Kuttiadi* River originates at a height of 1334 m amsl on the western slopes of Wayanad plateau. The river is also known by the name of Murat River. It has a length of 75 km and flows through Badagara and Quilandy taluks. It flows in northerly direction at first then bends and takes southwesterly direction of flow. At Turaiyur it is joined by the Agalapuzha. Further it takes a "U" turn and flow northwesterly direction as the Murat River developing lagoons and joins the sea at Kottakkal near Badagara. The river is dammed at Kakkayam for the hydroelectric project and the tail end waters of the project are stored at Peruvannamamuzhi, for irrigation.

The Mahe River originates at a height of 910 m amsl at Vanchimagate hills of Wayanad in Western Ghats and flows in the northeastern corner of the district. The course is forming northern boundary of the district. Near its lower reaches it bends and turns at Kariyad and flow in northwesterly direction and join the sea at Mahe.

The Kadalundi River formed by the union of Olipuzha and Veliyarpuzha has a length of 130 km. It enters the district at near its mouth of flow with only 14 km length in the district.

The Kallayi River has a length of 22 km. It originates at Cherukulathur, which is at a height of 45 m amsl and drains the district, joining the sea near Kozhikode. It is connected by man-made Buckingham Canal with the river Chaliyar.

The Korapuzha is a small river with a length of 40 km formed by the union of Agalapuzha and Punnurpuzha. It drains into the Arabian Sea at Elathur

There is only one major irrigation project in the district namely the Kuttiyadi irrigation project across the Kuttiyadi River. The Kuttiyadi irrigation project (KIP) partially completed in 1972 comprises a main dam 35.5m high across Kuttiyadi at Peruvannamuzhi form a reservoir of storage capacity 113.28 MCM for regulating the yield from the catchment below the Kuttiyadi hydel dam and the tail waters of Kuttiyadi power station. Besides the major irrigation schemes, the district is

irrigated by number of minor irrigation schemes, lift irrigation schemes, community irrigation schemes, wells and tanks.

1.3 Works carried out by CGWB

The Central Ground Water Board carried out systematic and reappraisal hydrogeological surveys in the district by Shri P. Lakshminarayanan, Shri V. Dhinagaran (1988-89 & 1990-91), Shri K. Balakrishnan (1998-99) and Dr. V. S. Joji (2004-05). Under the Exploratory drilling programme the Central Ground Water Board carried out drilling in hard rock areas and sedimentary areas of the district during 1994 to 1999. 15 exploratory wells were drilled in hard rock area with depth ranging from 114 to 200 m and in sedimentary areas at Badagara and Melady. Periodical water level and water quality monitoring is being carried out in the district by CGWB and State Groundwater Department.

2.0 RAINFALL AND CLIMATE

Kozhikode district experienced annual rainfall of 3698 mm in the year 2006. The high rainfall areas in the district are Kakkayam dam site and Kakkayam Power House. Kakkayam dam site has been experiencing more than 4500 mm of annual rainfall since 2000. It has been noticed that rainfall displays an increasing trend towards northeastern areas of the district.

The climate of the area is divided in to four seasons – summer, South West Tropical Monsoon period, North East Tropical Monsoon period and winter. The SW and NE monsoons mainly contribute rainfall in the area with 82.77 % of the rainfall. In 2006 during winter (January to March), summer (April and May), SW tropical monsoonal (June to October) and NE tropical monsoonal seasons, Kozhikode district received 0.49%, 16.74%, 72.15% and 10.63% rainfall respectively. The month of June experiences maximum rainfall. The months of July, August and October also receive heavy rainfall. The agricultural activity of the district depends on the onset of SW tropical monsoon. The Annual Rainfall in Kozhikode district, Kerala (2006-2011) is given in **Table-1**

Table: 1 Annual Rainfall in Kozhikode district, Kerala (2006-2011)

Month	Rainfall (mm) during					
	2006	2007	2008	2009	2010	2011
January	6	11	0	10.10	7.1	0
February	0	10	0	00.30	0.3	0
March	12	16	272	102.70	0	1
April	13	109	68	42.90	143.3	131
May	606	606	854	226.70	249.9	91
June	811	382	419	443.20	1094.5	1176
July	694	1153	409	983.40	897.8	870
August	547	753	450	335.80	368.9	669
September	616	720	614	533.00	321.1	610
October	279	439	13	296.10	495.1	205
November	105	106	6	236.10	280	215
December	9	1	0	107.20	13.9	5
Total	**3698**	**4306**	**3105**	**3348**	**3873**	**3973**

2.1 Other meteorological parameters

The various meteorological parameters other than rainfall are briefed below.

2.2 Temperature

The minimum temperature ranges between 22 and 25.8º C and the maximum between 28.2 and 32.9º C. The temperature reaches its peak in the month of April and attains minimum in January.

2.3 Relative Humidity

The relative humidity ranges from 74 to 92 % during morning hours and from 64 to 89% in evening hours. The monsoon months record high humidity.

2.4 Wind speed

The wind speed ranges from 8.1 to 12.6 km/h. The maximum wind speed is during April and minimum in November.

2.5 Potential Evapotranspiration

The annual Potential Evapotranspiration (PET) is 1505.7 mm. The monthly PET ranges from 92.9 to 170.2 mm. The PET is less than the rainfall during May to November and hence the possibility of recharge to ground water regime is more during these months.

3.0 GEOMORPHOLOGY AND SOIL TYPES

The physiographic divisions of Kozhikode district are low land (<7.6 m amsl), mid land (7.6 to 76 m amsl) and high land (above 76 m amsl). The highest elevation of the district is 1935 m amsl at Nilamala in northeastern corner of the district.

The low land extends as a narrow stretch of land lying along the coast from South Kadalundi to North Mahe. The height of the plain is less than 7.6 m amsl. The plain is interrupted by steep laterite cliffs and rock outcrops. The low land forms 6.7% of the total area of the district.

The midland area lies at a height between 7.6 and 76 m amsl. It may be further classified into low rolling terrain and moderately undulating terrain. The low rolling terrain has a slope of less than 15%. It consists of rolling laterite hills surrounded by valleys. The valleys are flood plain alluvium and red loamy soil. The moderately undulating terrain covering large area of the district has a slope between 15 and 25%. In addition to the agricultural crops of paddy and coconut, cash crops like rubber and arecanut are cultivated.

Area with elevation above 76 m amsl is called the highland. It is in the eastern part of the district. The area is prone to landslides and land slips and comprises of steep slopes and barren rocks.

The landform units identified in Kozhikode are alluvial plain, flood plain, valley fill, linear ridge, hillcrest, sloping terrain, rocky slope (scarp face) and hilly terrain. The flood plain and valley fill are the major fluvial landforms whereas moderately sloping terrain, highly sloping terrain, rocky slope (scarp face), linear ridge and hillcrest are major denudational landform units. The fluvial and gently sloping terrains are promising zones of groundwater. Denudational landforms are unproductive zones.

The soils of the district are alluvial soil, lateritic soil and forest loam. Alluvial soil is seen mostly along the coastal plain and valley. They are coastal alluvial soil and river alluvial soils. They are excessively drained to moderately drained and are of sandy to clayey textures. Majority of the area under riverine alluvium was once occupied by paddy cultivation. But those areas are now utilised for the cultivation of various crops especially plantain. The riverine alluvium contains moderate organic matter, nitrogen, phosphorous and potash.

Lateritic soil is derived from the laterite under tropical climate with alternate wet and dry conditions. It is reddish in colour and well drained gravelly to clayey. They are found mostly along the midland portion of the district. The organic matter in the soil is very less with moderate

nitrogen, phosphorous and potash. The pH of soil ranges between 5.5 and 6.5 and texture is clayey loam to silty loam with 5 to 20% coarse fragments. Laterites on high grounds are more compact when compared to the low-lying areas.

Forest loam is deep or very deep and well drained loamy to clayey textures. They are rich in organic matter, nitrogen and humus. Forest loam is dark reddish brown in colour formed by weathering under forest cover with loamy to silty loam texture. The pH of the soil ranges between 5.3 and 6.3 and is slightly acidic in nature.

4.0 GROUNDWATER SCENARIO

Groundwater occurs in the weathered and fractured portions of crystalline formations and alluvial formations in the district. Phreatic conditions exist in weathered formation and are mostly developed by dug wells for domestic and irrigation purposes. Semi-confined to confined conditions exist in deep fractures where storage and movement of groundwater is mainly controlled by the fracture system. Deep bore wells with high yield are located along fractures / lineaments.

4.1 Hydrogeology

The district is mainly underlain by crystalline rocks. The Weathered, Fissured and Fractured crystalline rocks, laterite and alluvium are the major hydrogeological formations occurring in the district.

Groundwater occurs under phreatic condition in weathered crystallines and under confined to semi-confined conditions in deeper crystalline formations. Dug wells are the suitable abstraction structures in this area. The depth to water level varies from 0.73 (Tamarasseri) to 16.11 m bgl (Kozhikode) during pre monsoon (April, 2011) and from 0.26 to 10.62 m bgl during post monsoon (November, 2011). The yield of dug wells in phreatic formations ranges between 5 and 10 m^3/day with pumping duration ranging from less than 1 to 4 hours in a day. The open dug wells are used for domestic purposes and their yield reduces during drought periods.

The deep fractures, in crystalline rocks form potential aquifers and ground water is abstracted through bore wells. Semi confined to confined condition exists in the case of water occurring in deep fractures. The fractured deeper aquifers were explored down to a depth of 200 m by CGWB. The depth of casing ranges from 7.00 to 30.5 m bgl. The potential fractures occur between 10.60 and 169.2 m bgl. In the bore wells, fracture zones are found to vary between 50.20 and 169.2 m

bgl. The details of EW drilled in the district by the Central Ground Water Board are given in **Annexure I.** The quality of water in hard rock aquifer is good.

In deeper crystalline aquifers fractures are feasible locations for bore wells. High yielding wells can be located along fracture zones identified by proper hydrogeological and geophysical studies. The depth of bore wells drilled by CGWB in the district varies from 114 to 200 m bgl with yield in the range of 10 to 1020 LPM. The yield of bore wells in hornblende biotite gneiss varies between 10 and 402 LPM and that in biotite gneiss varies between 150 and 410 LPM. The highly fractured potential aquifer among the crystalline rocks is hornblende-biotite gneiss. The yield of bore wells in Charnockite varies between 82 and 286 LPM. Exploration drilling by CGWB has revealed occurrence of deep potential fractures between 70 and 151 m bgl along lineaments. The maximum discharge observed from these wells is around 1020 LPM (**Annexure I**). Drilling in the fractured hard rocks indicate that the NE-SW fractures in the biotite gneisses are the most potential fractures in the district. They are followed by the NS fractures. The over burden thickness is maximum in hornblende biotite gneiss and is generally in the range of 10.5 to30.0 m and for biotite gneiss from 14.50 to 19.50 m and for charnockites 8.00 – 20.90.

The midland terrain of Kozhikode is generally covered by very porous laterite and forms potential phreatic aquifers along topographic lows and valleys. The depth to water level ranges around 2.11 to 16.86 m bgl in pre-monsoon and around 0.33 to 11.84 m bgl in post-monsoon and are developed by open dug wells. The depth of wells ranges between 7.06 and 18.06 m bgl. The yield of the dug wells ranges between 5 and 10m^3 / day.

The alluvium consists of sand, silt and clay, its thickness varies between 2 and 8 m and the ground water occurs under phreatic condition. There are two types of alluvium - riverine and coastal. Coastal alluvium occurs in the western part of district and the riverine alluvium occurs along river courses. The abstraction structures in alluvium are dug wells and filter point wells wherever the saturated sand thickness is 4 m or more. The depth of wells ranges between 3.14 and 9.12 m bgl. The depth to water level ranges from around 2.00 to 6.63 m bgl in pre-monsoon period and from 0.99 to 4.03 m bgl in post-monsoon period. The yield of wells ranges between 30 and 80 m^3/day.

The Tertiaries occurring in the district are the Vaikom bed and these are occurring below the alluvium and have been encountered at shallow depths in the narrow coastal strip of the district. The thickness and extent of Tertiary beds is very limited with poor ground water potential.

The CGWB monitors the depth to water level in the wells four times in a year and have collected

historical data. The Seasonal fluctuation of the water table is due to variation in the rainfall, evapotranspiration, withdrawals for irrigation and other purposes, base flow, seepage from surface water bodies etc. The Decadal depth to water level in the Ground Water Monitoring Wells of CGWB during pre and post monsoon periods are shown in **Figure 2 & Figure 3** respectively and a generalized hydrogeological map of Kozhikode district is shown in **Figure 4**.

A study of fluctuation in water level over the past decade (2002-2011) in the pre-monsoon has indicated that, the water level has shown a declining trend in parts of south / south-eastern parts of the district whereas it shows rising trend in the northern parts of the district. The district has recorded a maximum fall in water level 2.56 m at Kozhikode (decadal mean 2002-2011 Vs 2012 April) and a maximum rise of 0.72 m at Ramanattukara. The rise in water-level is of less than 1m. The long term trend of pre-monsoon water level for the last 10 years (2002-2011) indicates a falling trend in areas at Kozhikode, Balussery, Quilandy etc. The rising trend is seen at Beypore, Thamarasseri, Mukkali, and Kakkayam etc. Since the trend of water level during the pre-monsoon indicates development, it can be seen that this is of insignificant nature and does not cause any concern.

The analysis of the post-monsoon trend of water level also does not show any trend which needs caution. Some areas showing declining trends include Kozhikode, Balussery, Chemencheri etc, but around 33 % of the locations of GWMWs experienced rising trend.

4.2 Groundwater Resources

The ground water resources assessment is based on Groundwater Resource Estimation Methodology 1997 (GEC-'97). Groundwater recharge from rainfall in different blocks during monsoon ranges between 17.43 and 51.12 MCM and that of non-monsoon 0.32 and 2.49 MCM respectively. Existing gross groundwater draft for irrigation ranges between 1.46 and 8.82 for different blocks. The groundwater draft for domestic and industrial use ranges between 6.70 and 26.09 MCM in the blocks. As in March 2009 Balusseri and Kunnamangalam are categorized as semi critical and the rest of the blocks as safe. The existing gross ground water draft all uses ranges between 8.24 (Thodanur) to 31.12 MCM (Kozhikode). The existing gross ground water draft all uses during 2009 in Kozhikode district is 189.72 MCM against the net annual ground water availability of 347.38 MCM. Block wise ground water resources and categorization of ground water development of the blocks as on 31st March 2009 are furnished below in **Tables 2 respectively** and a map showing categorization of blocks is shown in **Figure 5**.

Table 2: Dynamic Ground Water Resources of Kozhikode District, Kerala (As in March 2009)

Sl. No.	Block	Net Annual GW Availability	Existing Gross GW Draft for irrigation	Existing Gross GW Draft for domestic and industrial water supply	Existing Gross GW Draft for all uses	Stage of GW develop-ment	Categorisation of blocks
1	Badagara	16.03	1.46	8.22	9.68	60.37	Safe
2	Balusseri	26.10	8.59	12.32	20.92	80.11	Semi-Critical
3	Kozhikode	37.70	5.03	26.09	31.12	82.53	Safe
4	Chevayoor	24.51	4.00	11.08	15.08	61.53	Safe
5	Koduvally	47.59	5.81	13.92	19.73	41.45	Safe
6	Kunnummel	26.37	3.67	10.09	13.76	52.19	Safe
7	Kunnamangalam	31.17	8.82	17.62	26.44	84.82	Semi-critical
8	Meladi	31.25	3.14	6.70	9.85	31.51	Safe
9	Panthalayani	36.38	2.60	9.23	11.83	32.51	Safe
10	Perambra	36.00	4.49	8.47	12.96	35.99	Safe
11	Thodannur	16.79	1.47	6.78	8.24	49.09	Safe
12	Tooneri	17.44	2.92	7.19	10.11	57.97	Safe
Total		**347.38**	**52.00**	**137.71**	**189.72**	**54.61**	

The stage of groundwater development in the district of Kozhikode during 2009 is 54.61 %, leaving scope for further development. At present about 52.00 MCM of groundwater is used for irrigation out of the net annual groundwater availability of 347.38 MCM. A balance of about 137.45 MCM is left for future irrigation developments. This shows the vast scope for irrigation using groundwater.

4.3 Groundwater Quality

The quality of water from shallow and deep aquifers in the district is good for domestic and irrigation purposes. The electrical conductivity (EC) is a measure of mineralization in water and it depends on degree of weathering and mineralization. The EC of water samples collected from shallow aquifer of GWMW ranges between 50 (Punnasserri) and 661 (Kozhikode) µS/cm at 25°C. The pH value of water ranges from 6.29 to 8.29 indicating neutral to alkaline and occasionally acidic nature. Total hardness of water samples ranges between 12 and 155 mg/l as $CaCO_3$ shows soft nature of the water.

The qualitative studies indicate that the cations and anions are within the permissible limit. The water from the shallow aquifers is good and potable. As per the drinking water standards of Bureau of Indian Standards (BIS) all the major chemical constituents including fluoride in the groundwater of Kozhikode district is within the permissible limit and is suitable for all purposes. The chemical quality of water sample analyses of GWMS in Kozhikode district is given in- **Annexure- II.**

The quality of water from deep aquifers also indicates that the water is suitable for drinking water purposes and various parameters are within the permissible limits prescribed by Bureau of Indian Standards.

The tube wells, dug wells, tanks/ponds and public taps are employed for urban and rural water supply in the district of Kozhikode. The public taps are the main means of water supply followed by dug wells, tanks/ponds and tube wells.

4.4 Status of groundwater development

The groundwater is mostly used to irrigate the standing paddy crops during fag end of the season and some cash crops and vegetables after the monsoon. During the SW and NE monsoon period from June to November, no irrigation is required. The main ground water abstraction structures used for irrigation are dug and bore wells. The yield of dug wells located along the valleys and in alluvium is higher than that in weathered crystallines. The yield of dug wells varies from less than 500 to 10,000 LPH and can sustain pumping for a period of less than an hour to 3 hours. Mostly centrifugal pumps of 1 to 3 HP are installed in shallow irrigation wells. The cost of construction of dug wells in alluvium and valley fills comes to around Rs. 25,000/- including the cost of pump set. In weathered crystalline it may go up to Rs. 30,000/-.

The tube wells, dug wells, tanks/ponds and public taps are employed for urban and rural water supply in the district of Kozhikode. The public taps are the main means of water supply followed by dug wells, tanks/ponds and tube wells.

5.0 GROUNDWATER MANAGEMENT STRATEGY

Kozhikode district with the three physiographic units of low, mid and high lands needs different water management strategies accordingly. Implementation of water management strategies and recharge structures are to be designed and promoted with people's active participation at grass root level to make it a grand success.

The high lands have high run off rate and also more sensitive to vagaries in climatic conditions, hence need more attention in the implementation of water conservation and recharge structures. There are numerous soil conservation structures like contour bunding, terrace cultivation, gully plugging etc, which act as water recharge structures in high lands. The wide network of drainage developed by the rivers in the district has numerous ideal locations for check dams, which may act as water conservation and recharge structures.

The artificial recharge structures suitable for Kozhikode district are percolation tanks, gully plug, check dams, sub-surface dykes and roof top rainwater harvesting. Rainwater harvesting for groundwater recharge as well as for storage in tanks for drinking water purpose can be promoted by popularizing the techniques on water harvesting especially in the northeastern areas of the district.

Percolation tanks are suitable for areas with valley fill, colluvium and highly weathered rocks. Check dams can be constructed across small streams with gentle slope with permeable beds and such sites are available in all the blocks except the Kozhikode, Badakara and Meladi.

Sub-surface dyke along gently slopping wide valleys with narrow out let are effective groundwater conservation structures at different areas of Balusserri, Kunnummal, Tooneri, Koduvalli and Kunnamangalam blocks.

A large number of springs (46 numbers) in the district can be developed for drinking water supply. The springs in Kozhikode district are not effectively utilised for drinking water supply. Desiltation of tanks / ponds may augment the groundwater recharge. The rainwater harvesting and other water conservation and recharge structures can be popularised through mass awareness programmes and training programmes.

Dug well recharge can be practiced in Badakara, Meladi, Panthalayani, Chelavoor and Kozhikode blocks. In areas with high degree of urbanisation with less land holdings, people can practice rainwater harvesting using storage tanks.

Gully plugs are suitable for all high land areas with local break in slope especially in the high land terrains of Koduvally, Perambra, Tooneri, Kunnummal and Balusserri blocks.

5.1 Groundwater Development

On the basis of groundwater development the blocks are categorised into over exploited, critical, semi-critical and safe. Stage of groundwater development in different blocks of the district ranges

between 31.51 and 84.82 %.

The common abstraction structures in all the blocks of Kozhikode district are open dug wells and bore wells fitted with hand pumps. The groundwater development reported maximum in Kunnamangalam (84.82 %) and minimum in Meladi (31.51%) among the 12 revenue blocks. The ground water draft is mainly used for drinking and irrigation purposes in all the blocks. A spurt in the construction of bore wells in the district has been reported in recent years. Bore wells are mainly used for irrigation purpose.

5.2 Water Conservation and Artificial Recharge

As Kozhikode is covered by a good drainage net work formed by Chaliyar, Kuttiadi, Mahe, Kadalundi, Kallayi and Korapuzha and their tributaries, the district is suitable for the implementation of various Minor Irrigation (MI) schemes such as lift irrigation, diversion weirs, vented cross bars (VCB), check dams, irrigation tanks/ ponds. The minor irrigation schemes are utilized for integrated paddy field development, Western Ghat Development, vegetable cultivation and drought mitigation.

The artificial recharge schemes proposed by CGWB are gully plug, desilting and renovation of ponds and tanks, subsurface dyke and check dam and roof top rainwater harvesting etc. The artificial recharge schemes viable in the blocks are shown in **Figure-6**

6.0 GROUNDWATER RELATED ISSUES AND PROBLEMS

The major problems noticed in the district are water scarcity, decline in water level and localized pollution etc.

Water scarcity is a severe problem during the drought period in many blocks especially those bordering Wayanad district namely Tooneri, Kunnummal, Perambra, Balusserri, Koduvalli and Kunnamangalam. The people of the high land areas are walking far distances for fetching drinking water. Decline in water level is observed at many places in the district.

Rainwater-harvesting structures have been constructed in a number of places. Most of these are storage tanks for collection of rainwater falling on rooftops. They are doing only storage rather than recharge to groundwater system. Now most of the structures require renovation for the proper storage. Most of the tanks and ponds in the district are filled with silts and waste materials. The ponds in the district are not recharging water into ground water system due to siltation.

Direct pumping of water from rivers is very common in the district especially by those people residing on the banks of rivers. The river water is exploited by constructing infiltration galleries to large wells and the galleries are open to the river channel.

Localized pollution is reported from many areas in the district, especially from effluent and sewage discharges from factories and hotels.

7.0 AWARENESS AND TRAINING ACTIVITY

The Central Ground Water Board, Kerala Region conducted Water Management Training programmes at Kozhikode to impart training on rainwater harvesting. The training programmes have been found very useful by the participants as was evident by the number of queries and discussions that followed the lectures. The training programmes witnessed gathering of 85 to 95 delegates from all walks of like viz. $NGO_{s,}$ farmers, housewives, students, officers and staff of State Government departments.

8.0 AREAS NOTIFIED BY CGWA/SGWA

The stage of ground water development in the district, Balussery and Kunnamangalam blocks are under semi-critical and rest of the ten blocks are in safe category. In Kozhikode district no block has been notified.

9.0 RECOMMENDATION

- Geologically the district forms a part of peninsular shield. Crystalline rocks of Archaean age comprising of hornblende biotite gneiss, garnet biotite gneiss, granites and charnockite are occurring over most part of the district.
- Laterite of Sub-recent origin is seen over most of the area. Recent alluvium is seen along coast and by the side of major rivers. The Vaikom beds of Tertiary sediments are underlying the coastal alluvium in the northern coastal area.
- Groundwater occurs under phreatic and semi-confined to confined condition in the district. In the hard rock areas unconfined phreatic aquifer occur in weathered portion and semi-confined to confined aquifer in the deeper fractured and fissured parts.
- The shallow aquifers can be developed by dug-wells and have yield ranging from 5 to 10 m^3 /day. However it is reduced during summer.
- The deeper aquifer is developed by bore-wells. They are potential aquifers. The NE-SW fractures in the biotite gneiss are the most potential, followed by NS. The exploration in the

hard rock areas indicates that potential fractures are found between 10.6 and 169 mbgl. The bore-wells are yielding up to 20 lps.

- The groundwater in the district is of excellent quality and EC ranges from 50 to 661 µ/cm at 25°C and chloride ranges from 4.3 to 94 mg/L.
- An integrated approach for groundwater development along with surface water and rainwater harvesting can be adopted for better management. The rainwater harvesting structure should be practiced through out the district. Suitable artificial recharge schemes to be formulated to check the surface run off from rainfall as 80% of the rainfall is flowing off as surface runoff.
- Depending upon the present condition, minor irrigation schemes are more suitable than major dams and people participatory programmes may be encouraged to develop the watershed.
- Mass awareness programme should be arranged in panchayat level to create maximum awareness among people to conserve the precious ground water, for once it is polluted then it is difficult to reclaim.

Figure 1: Index map of Kozhikode District

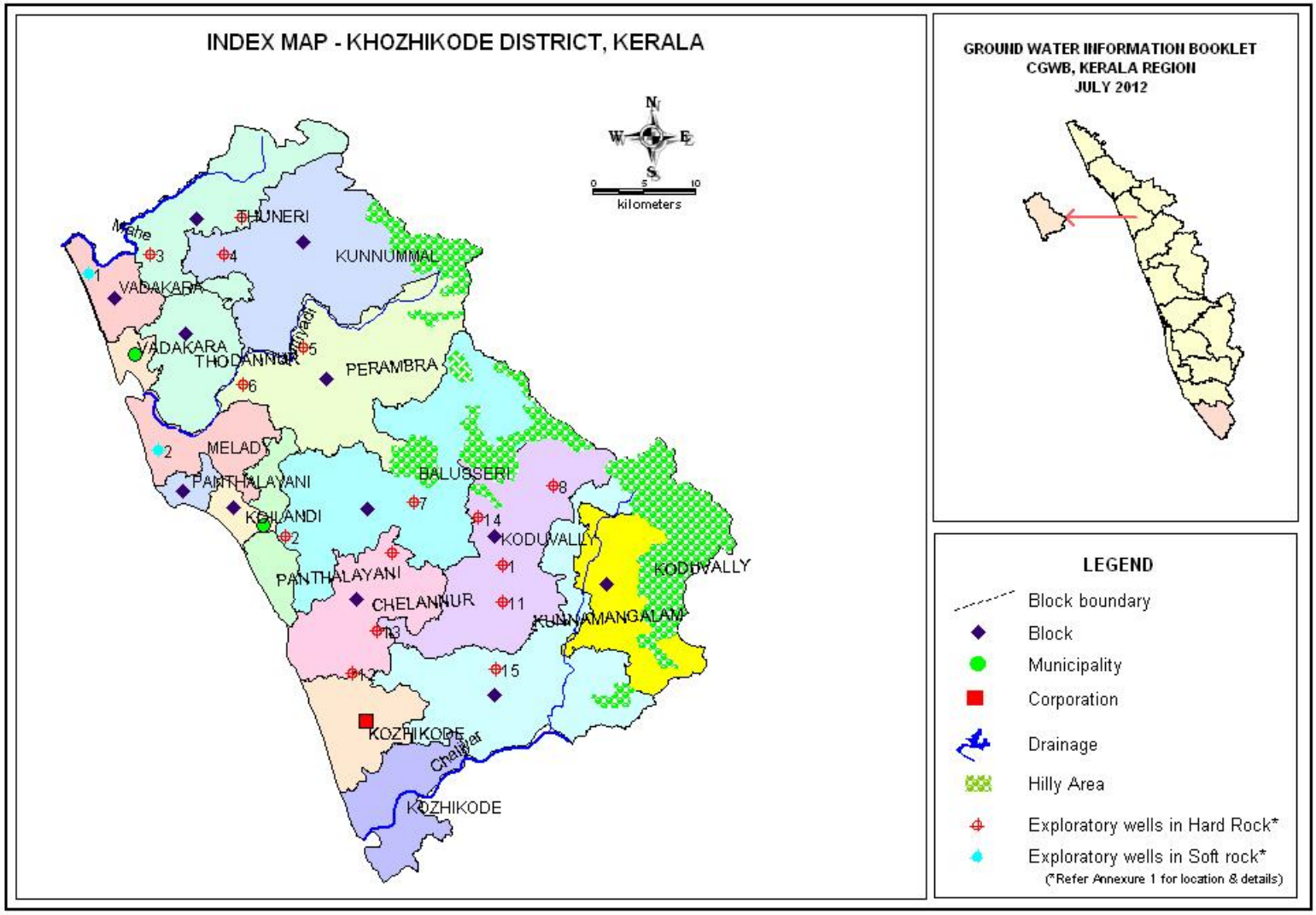


Figure 2: Depth to Decadal Average Water Level - Premonsoon (April 2002-11)

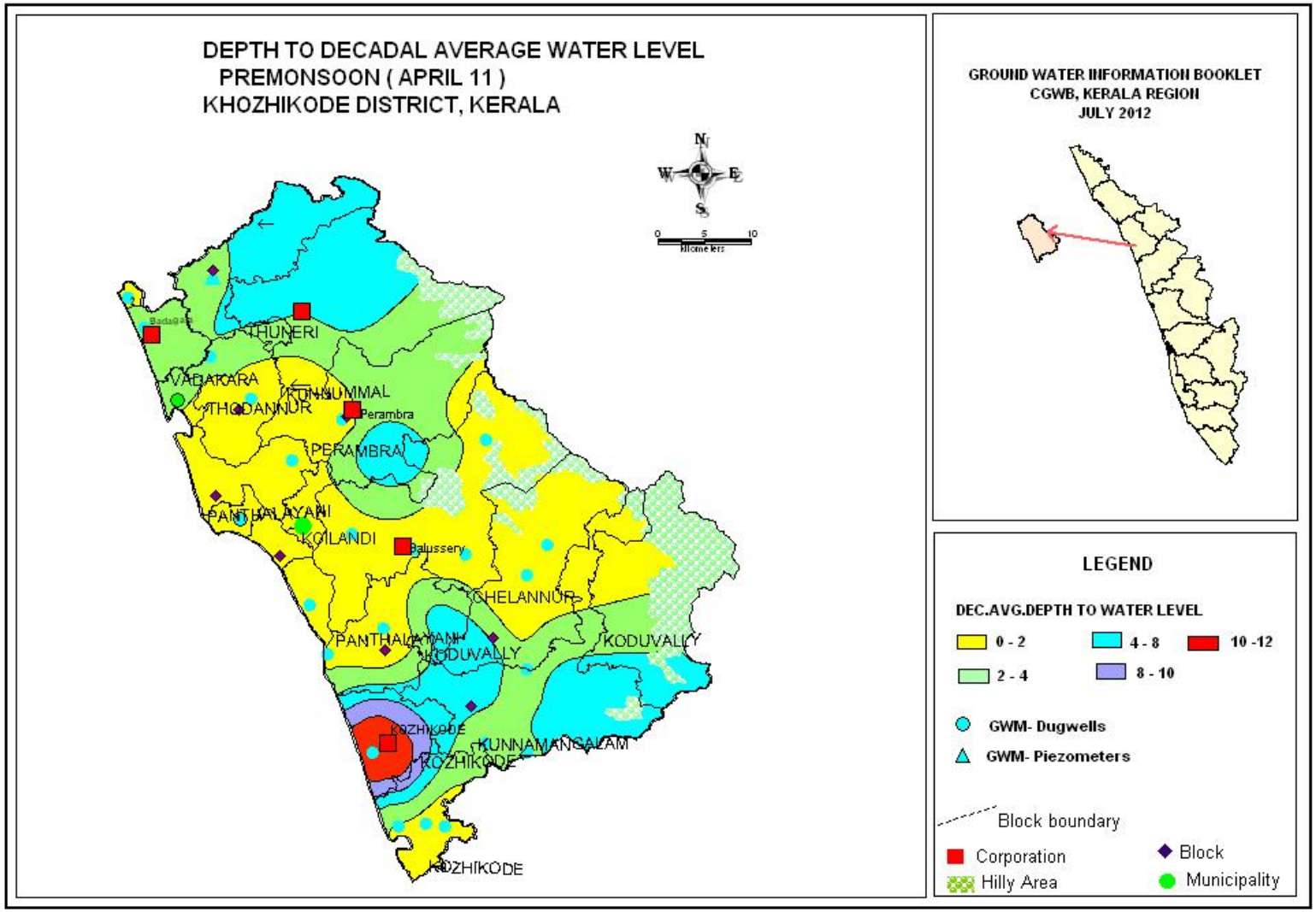


Figure 3: Depth to Decadal Average Water Level – Post-monsoon (Nov-2002-2011)

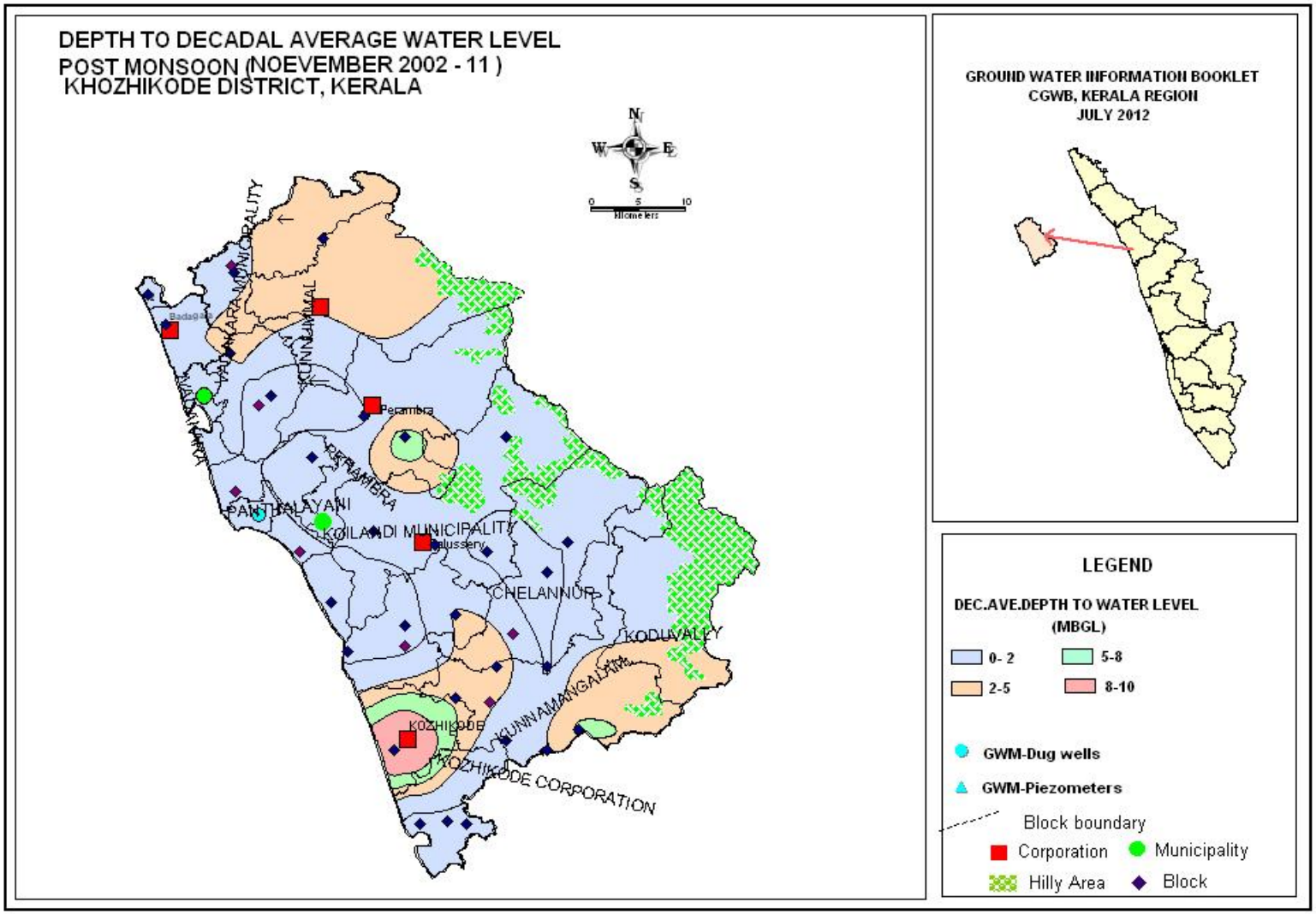


Figure 4: Hydrogeology of Kozhikode District, Kerala State

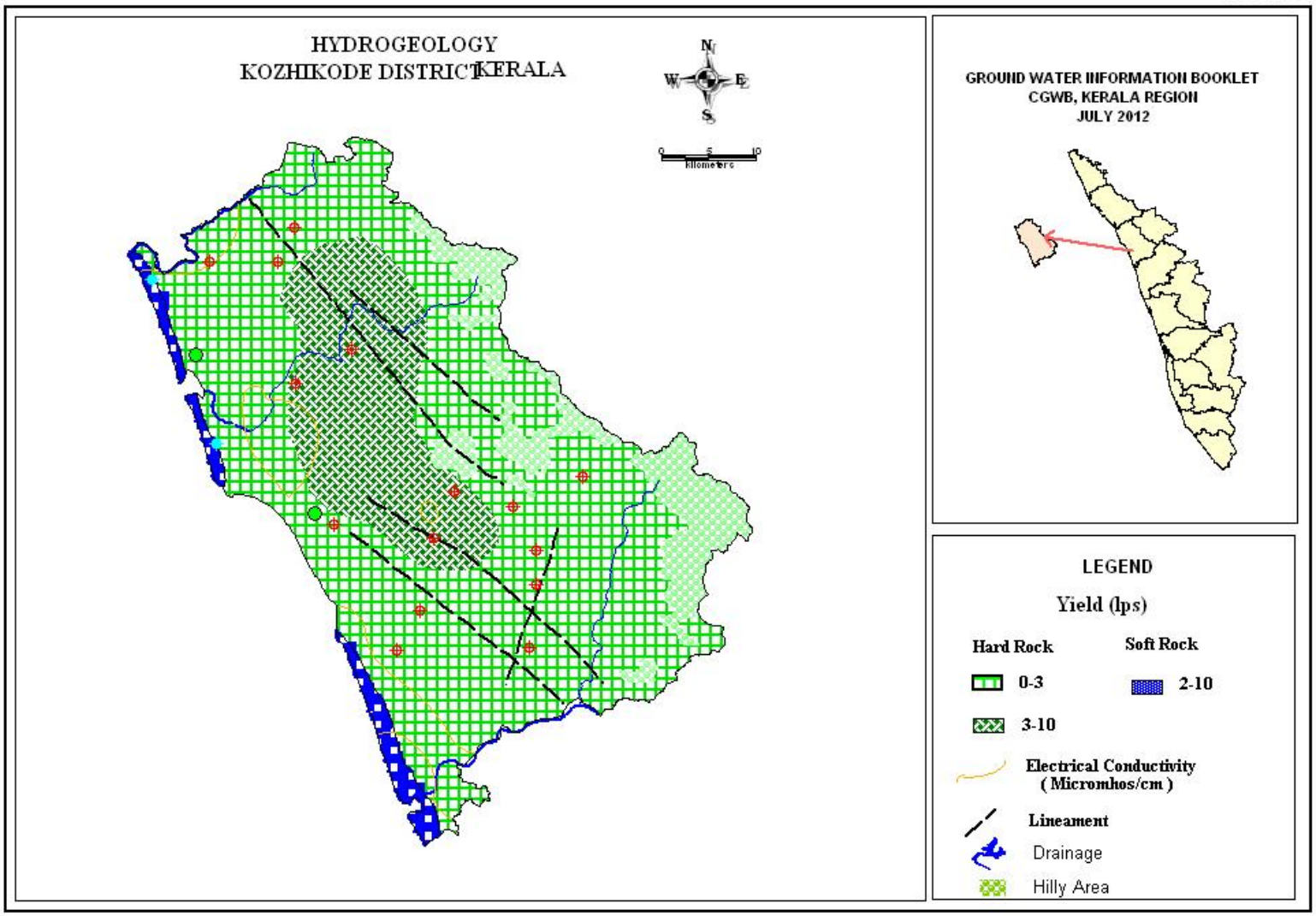


Figure 5: Categorisation of Blocks in Kozhikode District

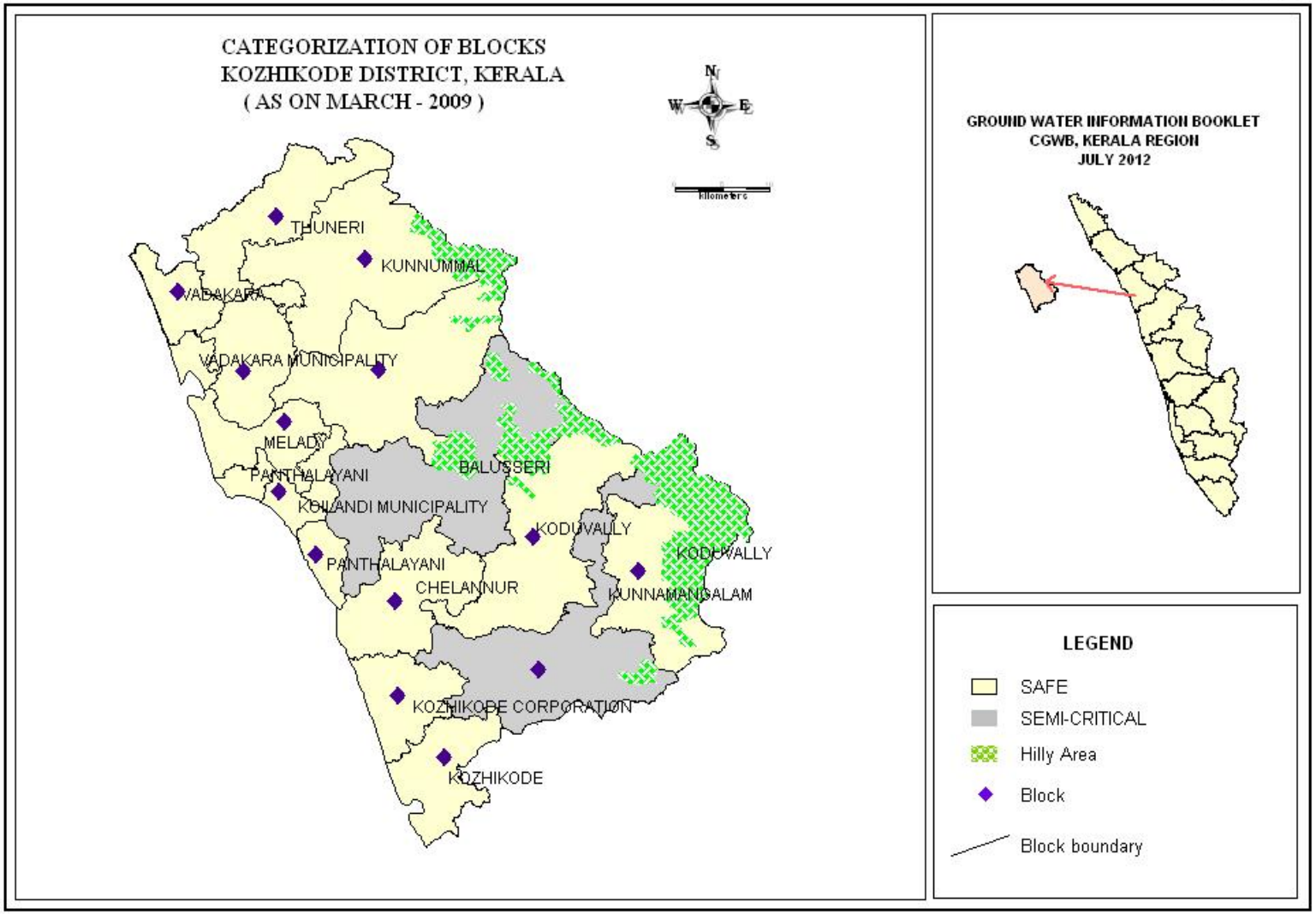
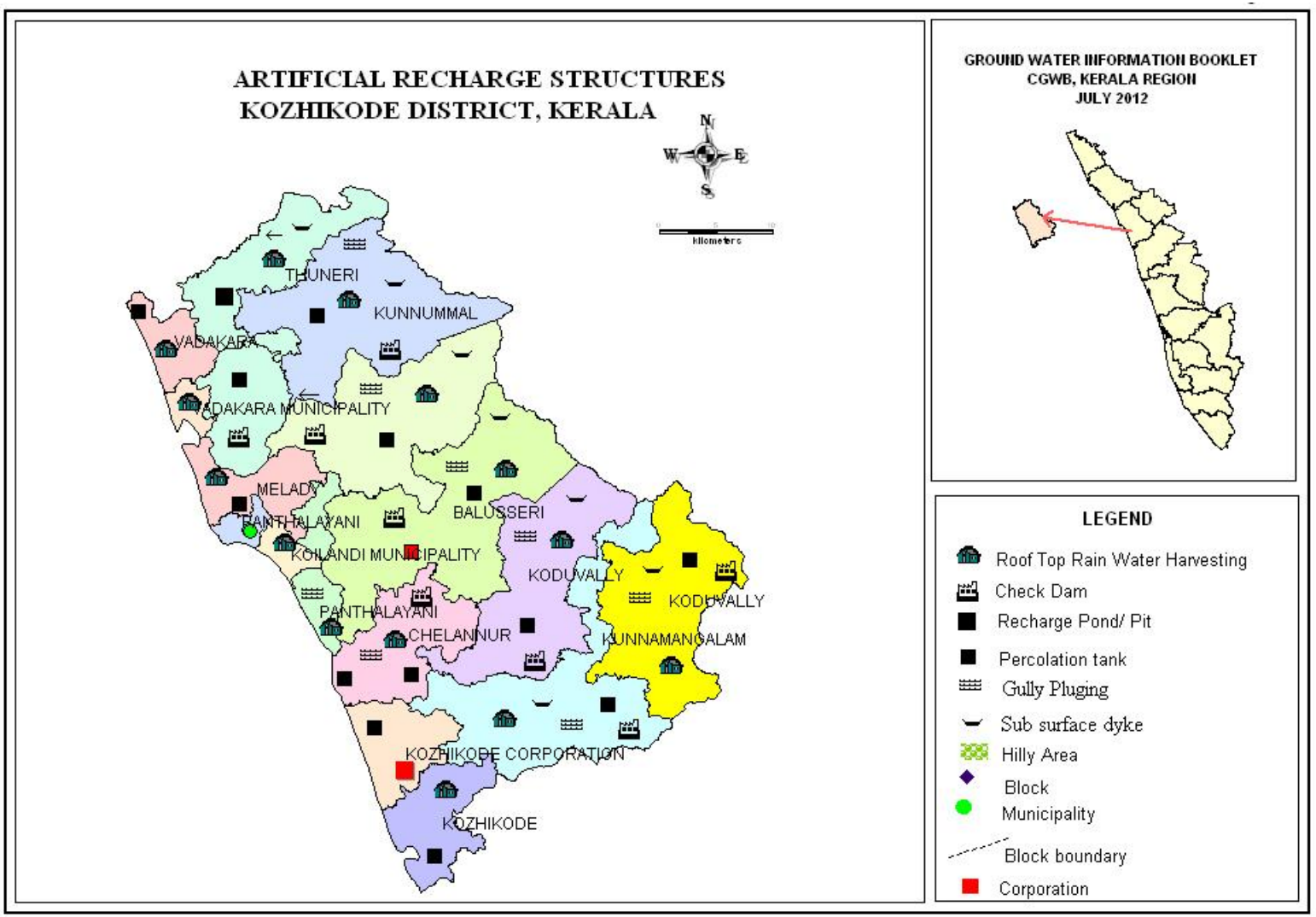


Figure 6: Artificial Recharge Structures proposed in Kozhikode District



Annexure 1: Details of EW drilled in Hard rock area in Kozhikode district

Location, coordinates & toposheet No.	Lineament	Depth & SWL, m bgl	Casing, m bgl	Fracture zones & yield, lpm	Discharge lpm	T m^2/day	EC µS/cm at 25^0 C	Cl ppm	Rock type
Thamarasseri, $11^0$24'30", $75^0$56'10", 49 M/15	NS	135, 13.30	16.70		540		213	43	Charnockite
Kuttoth, $11^0$26'00", $75^0$44'20", 49 M/11	NS	160, 12.67	27.20		420		2930	831	Horneblende biotite gneiss
Edacherri, $11^0$39'40", $75^0$37'00", 49 M/5 & 10	NNW	200	7.25		Dry		-	-	Horneblende biotite gneiss
Chelakkad, $11^0$41'00", $75^0$41'00", M/10		145 5.95	20.00	28-35, 35-60, 90-99	410		300	13	Biotite gneiss
Paleri, $11^0$36'03", $75^0$45'20", 49 M/14	NE-SW	145 7.64	9.3	142-145	1020	21.57	2340	518	Biotite gneiss
Avala Kuttoth, $11^0$34'05", $75^0$42'05"		185, 4.07	15.00	11-17,148-151	150		4630	1253	Biotite gneiss
Kannadipoil, $11^0$27'50", $75^0$51'20", 49 M/15	EW	200.00, 3.30	7.00		240		286	2.1	
Puduppadi, $11^0$28'43", $75^0$58'56", 49 M/15		114.30	21.20		10				Horneblende biotite gneiss
Vanimel, $11^0$43'00", $75^0$42'00", 49 M/10		175.00, 8.90	30.5		12				Horneblende biotite gneiss
Nanminda, $11^0$25'10", $75^0$50'10"	NA	157.0, 11.77	13.7	NA/366	366	18.18	204	8.5	Horneblende-biotite gneiss
Kalaranthri, $11^0$22'30", $75^0$56'10"	NA	152.4, NA	8.5	71.6-77.7/30	30	NA	286	7.1	Charnockite
Chelapuram, $11^0$18'45", $75^0$48'00"	NA	200.0, NA	21.40	56.3-65.5/60	60	NA	82	9.9	Charnockite
Kakkur, $11^0$21'00", $75^0$49'20"	NA	190.0, 1.26	11.00	56.3-80.7 129.5-169.2 /252	252, 402	104.0	292	19.0	Horneblende biotite gneiss
Vettiozhinjathottam, $11^0$27'00", $75^0$54'50"	NA	200.0, 16.33	16.7	65.5-100.0 150.9-160.0/150	150, NA	9.8	207	5.7	Charnockite
REC Chathamangalam, $11^0$18'55", $75^0$55'48", 49 M/15	NA	200.0, 1.97	13.75	50.2-51.2 67.5-68.5/60	60, NA				Charnockite

Annexure 1a: Details of wells drilled in Sedimentary area, Kozhikode district

Location, coordinates & toposheet No	RL(m amsl)	Depth drilled(m bgl)	Depth Constructed (m bgl)	Zones Tapped (m bgl)	Discharge (Lps)	Sp.Capacity (Lpm/m)	T msq/day	Ec µS/Cm at 25oc	Remarks
Vadakara 11 40 00 75 33 40 49 M/6+10	6.01	27	20.00	10.75 – 16.75	10.79	NA	NA	NA	SWL: 4.44 mbgl
Melady 11 30 35 75 37 25 49 M/6+10	2.215	32	31	23 - 28	02.00	NA	NA	NA	SWL: 1.90 mbgl

Annexure- 2: Chemical quality of water samples analysed for GWMS in Kozhikode District

S:No	Location	pH	EC in us/cm at 25^{0}C	TH as $CaCO_3$	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl	F	NO_3
1	Badagara	7.96	399	98	29	6.3	26	8.9	0	56	31	52	0.22	27
2	Balusseri	7.69	239	36	12	1.5	23	4.1	0	17	1.8	45	0.21	21
3	Beypore	8.07	462	94	19	11	51	6.6	0	73	31	48	0.15	60
4	Chelavur	8.16	192	20	8	0	29	2.2	0	20	5.8	26	0.18	38
5	Chemencheri	8.91	248	76	28	1.5	10	2.5	4.8	46	19	23	0.42	19
6	Devarkoil	7.7	121	28	9.6	1	7.3	1	0	9.8	2.9	16	0.21	20
7	Elattur	8.5	276	92	36	0.49	8.3	2.7	2.4	90	17	23	0.52	11
8	Kakkayam	8.08	64	16	5.6	0.5	5.3	1.3	0	24	3.6	4.3	0.39	2.5
9	Kannankara	8.2	175	40	16	0	14	3.8	0	39	10	24	0.05	8.7
10	Koduvalli	9.2	109	32	12	0.5	9	1	9.6	37	1.9	7.1	0.18	0.79
11	Koothali	7.26	42	8	3.2	0	3.2	1.4	0	4.9	2.2	5.7	0.26	4.4
12	Kozhikode	7.42	199	50	18	1	19	1	0	24	9.4	38	0.26	22
13	Malayamma	7.7	73	18	6.4	0.5	6.3	1.1	0	24	2.7	8.5	0.1	3
14	Mattanad	7.74	96	28	10	0.5	6.7	1.1	0	24	5.1	13	0.23	5.2
15	Mavoor I	7.25	49	8	2.4	0.5	5.5	0.9	0	4.9	0.91	8.5	0.15	6.7
16	Mavoor II	8.49	89	16	5.6	0.5	10	1.2	Tr	20	6.5	14	0.24	1.2
17	Meppayur	8	127	26	10	0	9.5	4.1	0	9.8	9.8	18	0.07	13
18	Mukkali	7.72	99	18	6.4	0.5	9.9	2.2	0	12	9.8	16	0.41	4.5
19	Nadapuram	9.33	178	46	16	1.5	15	2.6	7.2	41	11	21	0.41	4.4
20	Perambra	8.25	128	46	18	0	5.6	1.4	Tr	68	2	8.5	0.19	1.7
21	Peruvayal	7.63	82	24	8	1	5.5	0.4	0	27	4.4	8.5	0.17	0.83
22	Pudukayam	7.4	53	12	4	0.5	5	1	0	17	0	5.7	0.35	2.8
23	Pudupadi	7.12	74	12	4	0.5	6.8	1.5	0	4.9	1	13	0.07	7.2
24	Punnasseri	7.73	49	10	2.4	1	4.8	1.3	0	9.8	0	8.5	0.07	1.8
25	Quilandy	8.5	345	102	38	1.9	20	10	4.8	95	24	26	0.33	24
26	Ramanattukara	8.4	411	106	15	17	32	5.3	2.4	88	50	47	0.33	2.8
27	Tamarasseri	8.32	123	32	12	0.5	7.9	3.3	Tr	41	6.3	13	0.12	0.55
28	Thiruvallur	8.18	198	48	15	2.4	18	5.7	0	46	8.7	34	0.08	2.9
29	Tikkodi	7.46	125	20	7.2	0.5	10	3.4	0	2.4	4	23	0.2	16
30	Ulliyeri	7.94	53	10	3.2	0.5	5	0.6	0	7.3	0	9.9	0.38	2.9
31	Unnikulam	6.94	61	8	2.4	0.5	6.9	0.8	0	2.4	0	11	0.18	5.3
32	Villyapalli	7.63	97	20	5.6	1.5	9.2	0.8	0	17	0	17	0.07	8.1
33	Bhoomivathukkal	7.55	68	14	4.8	0.5	6.6	0.8	0	12	0	11	0.14	6.6
34	Valayam	7.85	88	24	6.4	1.9	8	1	0	41	0	7.1	0.36	1.5
35	Tuneri	7.41	56	6	1.6	0.5	7.2	1.2	0	7.3	0	13	0.34	1.3
36	Kayapanachi	8.03	301	44	7.2	6.3	34	0.8	0	9.8	1.8	77	0.21	1.6
37	Farooq	8.04	334	74	22	4.4	26	9.9	0	63	22	41	0.14	16
38	Modern Bazaar	7.67	258	60	18	3.9	18	4.4	0	24	37	33	0.21	6.4
39	Karaparambu	7.9	132	42	14	1.5	8.2	1.3	0	44	12	11	0.21	1.1
40	Chevayur	8.17	156	42	14	1.5	12	1.6	0	44	0	23	0.21	4.6
41	Koodathumpara	7.5	100	26	8.8	1	9	0.8	0	27	2.6	11	0.04	4.6