Final Report

Challenges in Urban Drinking Water Management in Kerala: Case Study of Kochi Municipal Corporation

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Challenges in Urban Drinking Water Management in Kerala: Case Study of Kochi Municipal Corporation

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About the Report

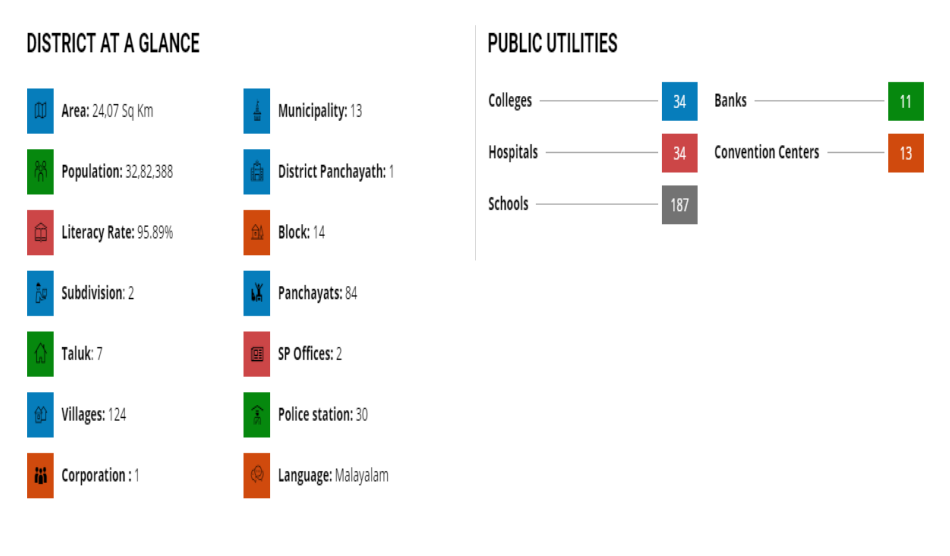
A project on **"Challenges in Urban Drinking Water Management in Kerala: Case Study of Kochi Municipal Corporation"** was carried out to assess the problems faced by urban areas with reference to supply and management of drinking water. The pilot study was carried out in Kochi urban area. The objective of this present study were to (i) To analyze the present status of drinking water availability and usage of drinking water in Kochi Municipal Corporation (ii) To undertake a descriptive analysis of the present water supply system in Kochi Municipal Corporation and to provide policy recommendations (iii) To test whether the performance efficiency of the water supply schemes meets the Government norms in terms of quantity and quality of the supplied water. While detailed consumer research and water quality testing was done in all the wards of Kochi Municipal Corporation, the overall report builds on the field investigation and discussions with various officials of Kerala Water Authority (KWA) and Kochi Municipal Corporation (KMC).

The whole report is divided into five chapters. First chapter discusses the details of the project, its objectives etc. The report provides background on Kochi- its economy and demography- followed by details of water supply to the Kochi Municipal Corporation and is included in the chapter 1. The second chapter provides the details of the major water source (Periyar river basin) of Kochi Municipal Corporation, the water quality studies of the river basin etc. Chapter 3 covers the water quality status of 74 wards of Kochi Municipal Corporation. The fourth chapter provides the sanitation survey data collected from the 74 wards of Kochi Municipal Corporation. The fifth chapter reports major issues in water supply and suggestions for proper water management in Kochi Municipal Corporation.

CHAPTER 1
INTRODUCTION

Ernakulam district occupies the central part of Kerala State and is bound by Trissur district on the north, Idukki on the east and south east, Kottayam and Alappuzha districts on the south and the Lakshadweep Sea on the west. The district is spread over an area of 3068 Sq. km. Earlier the district covered an area of only 2408 sq. km. But, later on Kuttampuzh apanchayat of the Nedumkandam block, Idukki district was also attached to it and the district attained the present area. Kochi, known as the Queen of Arabian Sea is the headquarters of Ernakulam district. It is a major port city on the west coast of India. The district is well connected with a good network of roads and railways. The Nedumbassery International airport is located in the district.

District at a glance



Kochi is a major port city on the south-west coast of India bordering Laccadive Sea. It is part of the district of Ernakulam in the state of Kerala. With a population of 612,343(KMC) and metropolitan population of 2.1 million, Kochi city is also a part of the Greater Cochin region, which is the largest urban agglomeration in Kerala and is classified as a Tier-II city by the Government of India.

1.0 Study Area

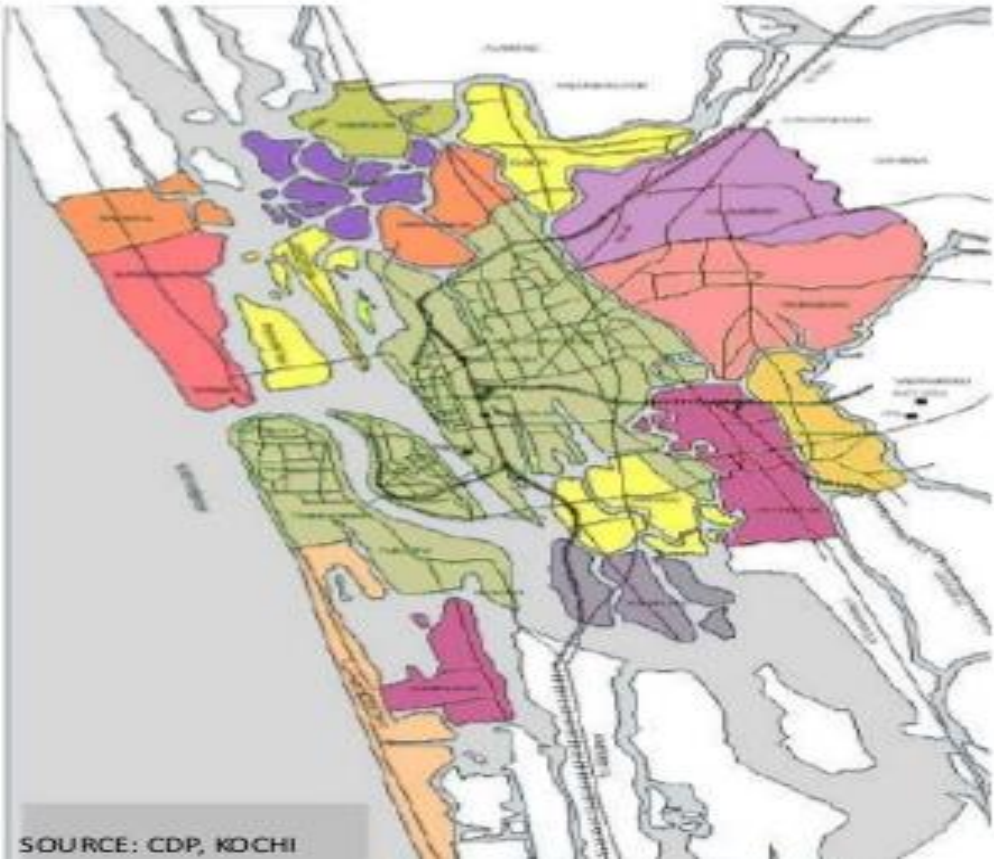


Fig 1.1 **Map of Kochi City**

2.0 Kochi Municipal Corporation

Kochi Municipal Corporation, with population of about 6.3 lakh is in Ernakulam district of the Kerala State in India. Total geographical area of Kochi Municipal Corporation is 94.88 km^2. The population density of the city is 7139 persons per km^2. There are 74 wards in the Kochi Municipal Corporation.

Yearly average rainfall of the city is 2810 mm. Maximum temperature here reaches up to 36.3°C and minimum temperature goes down to 23.1°C.

Table 1.1. Overview of Kochi Municipal Corporation

Basics	
Country	India
State	Kerala
District	Ernakulam
Area	94.88 km^2
No of wards	74
Rainfall	2810mm
Temperature	Max 36.3°C; Min 23.1°C
District HQ	Kakkanad (33 km)
Demographics	
Population(2011 census)	677381
Population density	7139/ km^2
Sex Ratio	1028
Sex Ratio Child	957
Literacy Rate	95.5 %

3.0 Kochi Corporation- History and Background

The Corporation of Kochi is the largest Municipal Corporation in Kerala both in area and population. The Corporation has a harbor, railway junction, international airport, the Naval Base and various industries in its command area and its peripheries. The history of the Corporation dates back to the second half of the 19th century. Fort Kochi, Mattancherry and Ernakulam were the three Municipalities, which were in existence then in Kochi area. Fort Kochi became a Municipality on the 1st of November 1866.

In 1896 the Maharaja of Kochi formed sanitary boards separately for Mattancherry and Ernakulam and thus local administration came into existence in these places for the first time. The Government provided funds for the functioning of the boards. The town councils of Mattancherry and Ernakulam were formed as per the above regulation. In 1956 the Elamkulam panchayat and a portion of Cheranellur panchayat (Pachalam – Vaduthala) were amalgamated to the Ernakulam Municipality. In 1962 a portion of Palluruthy panchayat (Mundamveli area) was amalgamated to the then Mattancherry municipality.

Edappally panchyat was formed in 1946 and Palluruthy and Vyttila in 1953. In 1952 the then Edappally panchayat was bifurcated and a new panchayat, Vennala was formed. On the 1st July 1967, the Kerala Assembly approved the formation of Kochi Corporation. Subsequently, Govt. of Kerala notified the formation of the Corporation of Kochi by amalgamating the three ancient Municipalities of the state, viz. Ernakulam, Mattancherry and Fort Kochi, the Willingdon Island and four panchayats viz. Palluruthy, Vennala, Vytiila and Edappally and the small islands of Gundudeepu and Ramanthuruth. Newborn Corporation came into existence on 1st November 1967.

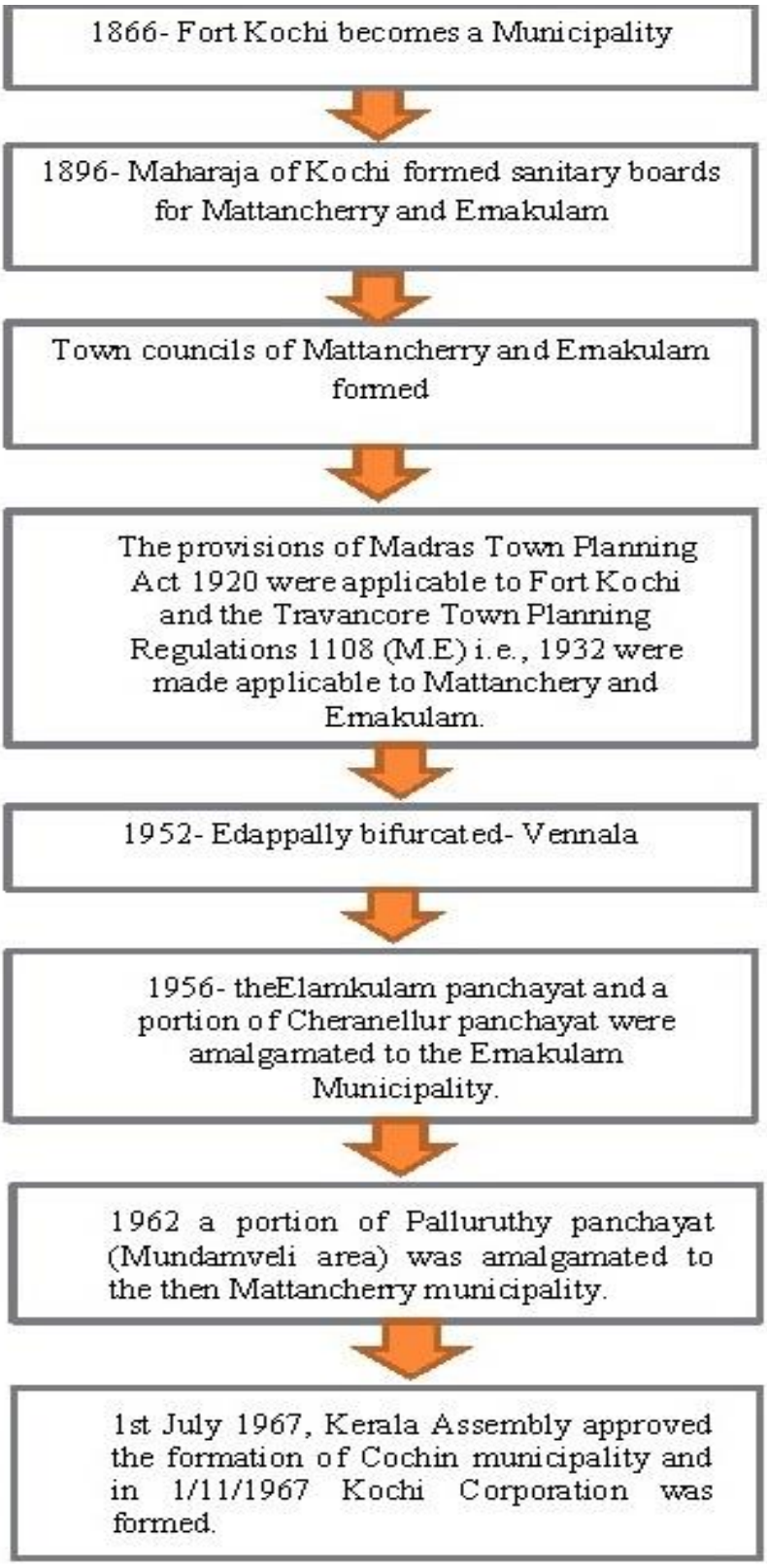


Fig 1.2. **Flow chart showing the formation of KMC**

The Kochi Municipal Corporation consists of 74 wards. Details of Kochi Municipal Corporation Ward are given in Table 2.

Table 1.2: Kochi Municipal Corporation Ward details

Ward Number	Ward Name
1.	FortKochi
2.	Kalvathy
3.	Earaveli
4.	Karippalam
5.	Mattanchery
6.	Kochangadi
7.	Cheralayi
8.	Panayappilly
9.	Chakkamadom
10.	Karuvelippady
11.	Thoppumpady
12.	Tharebhagam
13.	Kadebhagam
14.	Thazhuppu
15.	Eadakochi north
16.	Edakochi south
17.	Perumbadappu
18.	Konam
19.	Palluruthy-kacheripady
20.	Nambyapuram
21.	Pullardesam
22.	Mundamvelly
23.	Manasserry
24.	Moolamkuzhy
25.	Chullickal

26.	Nazreth
27.	Fortkochi veli
28.	Amaravathy
29.	Island north
30.	Island south
31.	Vaduthala west
32.	Vaduthala east
33.	Elamakkara north
34.	Puthukkalavattam
35.	Ponekkara
36.	Kunnumpuram
37.	Edappally
38.	Dhevankulangara
39.	Karukappilli
40.	Mamangalam
41.	Padivattam
42.	Vennala
43.	Palarivattam
44.	Karanakkodam
45.	Thammanam
46.	Chakkaraparambu
47.	Chalikkavattam
48.	Ponnurunni east
49.	Vyttila
50.	Chambakkara
51.	Poonithura
52.	Vyttila janatha

53.	Ponnurunni
54.	Elamkulam
55.	Girinagar
56.	Panampilli nagar
57.	Kadavanthra
58.	Konthuruthy
59.	Thevara
60.	Perumanur
61.	Ravipuram
62.	Ernakulam south
63.	Gandhi nagar
64.	Kathrikadavu
65.	Kaloor south
66.	Ernakulam central
67.	Ernakulam north
68.	Ayyappankavu
69.	Thrikkanarvattom
70.	Kaloor north
71.	Elamakkara south
72.	Pottakuzhy
73.	Pachalam
74.	Thattazham

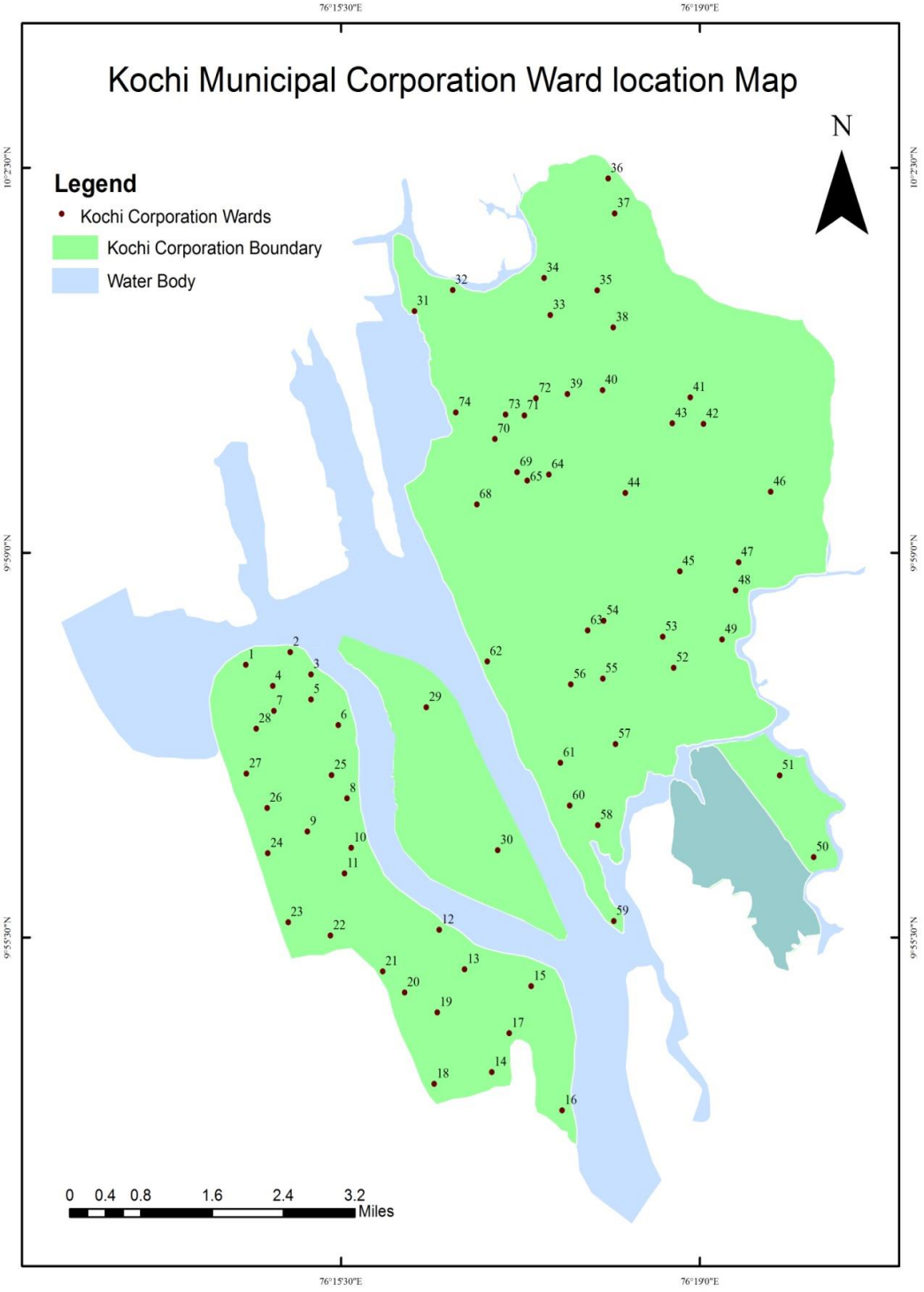


Fig 1.3 **Map of KMC showing the wards**

4.0 Objectives of the Study

1. To analyze the present status of drinking water availability and usage of drinking water in Kochi Municipal Corporation.
2. To undertake a descriptive analysis of the present water supply system in Kochi Municipal Corporation and to provide policy recommendations.
3. To test whether the performance efficiency of the water supply schemes meets the Government norms in terms of quantity and quality of the supplied water.

5.0 Population

The Kochi Municipal Corporation has a population of 596,473 as per Indian Census 2001and 377381 in 2011. Kochi witnessed a rapid population growth during the past 30 years. The average decadal growth in Kochi Corporation is 7.83% whereas the nearby municipal areas registered decadal average of 18.65%, and the adjoining panchayath had an average decadal growth of 12.13%. The sub-urban areas around the city is showing high rate of population growth and also fast developing trends. The literacy rate is 95.5%.

Demographically the state enjoys a very advanced status with rapidly declining birth and death rates, low infant mortality and very high literacy and health delivery system. Kochi, the largest urban agglomeration in Kerala, consists of the Municipal Corporation of Kochi, adjoining Municipalities and Grama Panchayaths.

In the recent years due to many large scale development projects, especially in the construction sector and information technology, substantial employment opportunities are generated in Kochi and this is a positive factor for migration. However, sharp increase in land values and scarcity of developable land prevent lower and middle income group families from buying land within the city for residential purposes. This has made a good percentage of people to opt for residences in the outskirts of the city. Though the trend reduces migration, it increases floating population in the city.

Population projection in the Kochi City Region has also to take account of the effect of the large scale investment proposals and infrastructure requirements in and around Kochi city. The contributing factors of population growth in the area are mainly the natural increase and the migration from nearby rural areas for trade and employment. Even though the natural growth rate of population does not show exorbitant increase, floating

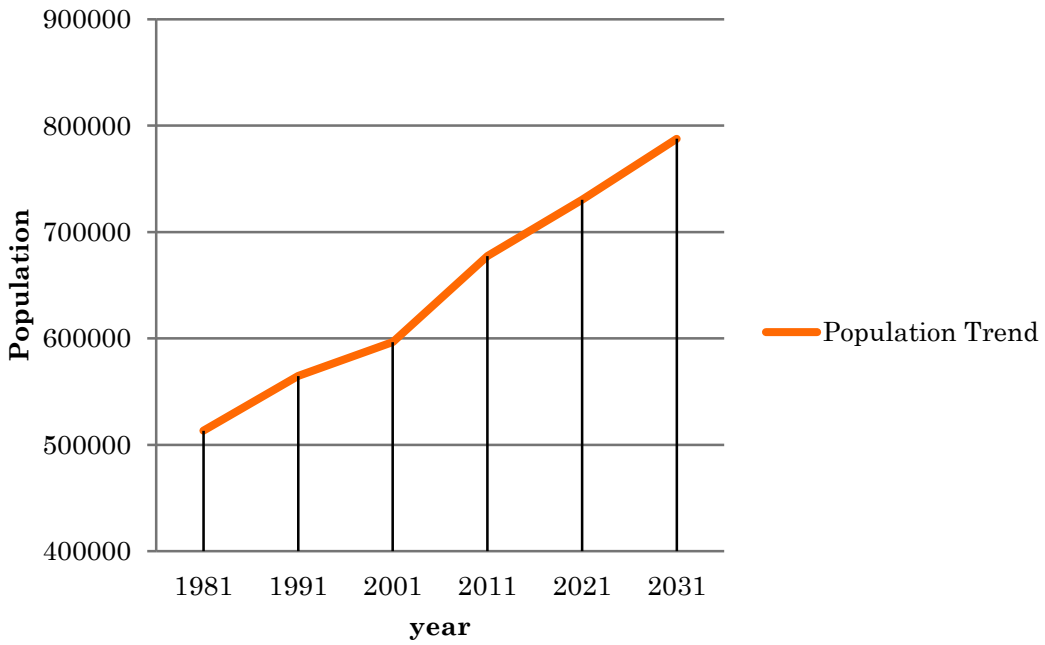
population and migration in Kochi are to be considered while proposing infrastructure requirements. Facility for daily commutation from the region around adds to the increased number of floating population in the city. A transportation study conducted shows that nearly 2.5 lakh of people commute daily to the city thereby increasing the stress on civic infrastructure and congestion on major traffic corridors.

Kochi City Region has higher population growth rate compared to the state average. In the coming two decades it is expected to touch two million mark. Most of the growth is taking place just outside of the Kochi city area but within the Kochi City Region. This coupled with the high level of floating population necessitates integrated planning, development and service delivery.

Table 1.3: Kochi Municipal Corporation Predicted Population growth

Predicted population growth based on trend						
Kochi Municipal Corporation	Population (in Lakhs)					
	1981	1991	2001	2011	2021(Projected)	2031(projected)
	513249	564589	596473	677381	730414	787605

Source: City Development Plan Kochi



In addition to the natural growth, there will also be migration from other areas to the city. The large scale projects already in progress and those envisaged in this area may also considerably influence population increase. The rate of migration and floating population assumed for each local body and the final population of Kochi Municipal Corporation region for the year 2031 (including migration and floating population) is as follows.

Table 1.4. **Projected Population of Kochi Municipal Corporation for the year 2031**

Sl.No	Name of the Local body	Population projected for the year 2031	Assumed% of Migration	Assumed % of Floating population	Population projection(2031)+ Migration+ Floating population
1	Kochi Municipal Corporation	787605	10	20	10,23886

Source: City Development Plan Kochi

Table 1.5**. Kochi Municipal Corporation Ward wise Population growth**

Ward No	Ward Name	Ward Area (Hectare)	Population 2001	Population 2011	Population 2021 (Projection)	Population 2031 (Projection)
1.	FortKochi	143.58	12608	13742	14491	14882
2.	Kalvathy	38.23	8236	8977	9466	9721
3.	Earaveli	17.39	9074	9890	10429	10710
4.	Karippalam	39.62	10733	11698	12336	12668
5.	Mattanchery	62.11	12984	14152	14923	15325
6.	Kochangadi	31.71	8035	8758	9235	9484
7.	Cheralayi	60.96	10186	11102	11707	12023
8.	Panayappilly	71.43	11385	12409	13085	13438
9.	Chakkamadom	29.84	5382	5866	6186	6353
10.	Karuvelippady	59.01	8307	9054	9548	9805
11.	Thoppumpady	98.71	9757	10635	11214	11516
12.	Tharebhagam	83.81	8526	9293	9799	10063
13.	Kadebhagam	61.75	9705	10578	11154	11455
14.	Thazhuppu	90.09	10285	11210	11821	12140
15.	Eadakochi north	104.4	7915	8627	9097	9342
16.	Edakochi south	148.13	8532	9300	9806	10071
17.	Perumbadappu	70.81	9074	9890	10429	10710
18.	Konam	87.57	9176	10001	10546	10831
19.	Palluruthy-	70.6	10114	11024	11624	11938

	Kacheripady					
20.	Nambyapuram	56.58	8122	8853	9335	9587
21.	Pullardesam	76.22	10563	11513	12141	12468
22.	Mundamvelly	118.91	7808	8510	8974	9216
23.	Manasserry	62.01	8076	8802	9282	9532
24.	Moolamkuzhy	59	7688	8380	8836	9074
25.	Chullickal	43.28	8017	8738	9214	9463
26.	Nazreth	32.88	7140	7782	8206	8428
27.	Fortkochi veli	57.36	6788	7399	7802	8012
28.	Amaravathy	47.64	11240	12251	12919	13267
29.	Island north	595.68	3060	3335	3517	3612
30.	Island south	244.95	2729	2974	3137	3221
31.	Vaduthala west	109.9	10290	11216	11827	12146
32.	Vaduthala east	83.02	7229	7879	8309	8533
33.	Elamakkara north	94	8939	9743	10274	10551
34.	Puthukkalavattam	116.43	7880	8589	9057	9301
35.	Ponekkara	112.59	8060	8785	9264	9513
36.	Kunnumpuram	206.58	8040	8763	9241	9490
37.	Edappally	161.08	8185	8921	9407	9661
38.	Dhevankulangara	177.59	9323	10162	10715	11004
39.	Karukappilli	113.88	8185	8921	9407	9661
40.	Mamangalam	98.31	6003	6543	6899	7085
42.	Vennala	201.59	10465	11406	12028	12352
43.	Palarivattam	123.02	12087	13174	13892	14267
44.	Karanakkodam	131.56	9672	10542	11116	11416
45.	Thammanam	129.53	7821	8524	8989	9231
46.	Chakkaraparambu	200.4	7991	8710	9184	9432
47.	Chalikkavattam	82.39	5120	5581	5885	6043
48.	Ponnurunni east	111.14	5407	5893	6215	6382
49.	Vyttila	174.98	7855	8562	9028	9271
51.	Poonithura	127.75	7122	7763	8186	8406
52.	Vyttila janatha	136.7	7913	8625	9095	9340
53.	Ponnurunni	117.91	8376	9129	9627	9886
54.	Elamkulam	130.33	8841	9636	10161	10435
55.	Girinagar	93.49	7398	8063	8503	8732
56.	Panampilli nagar	81.83	5885	6414	6764	6946
57.	Kadavanthra	185.82	9268	10102	10652	10939
58.	Konthuruthy	73.05	7321	7980	8414	8641
59.	Thevara	92.54	4737	5163	5445	5591
60.	Perumanur	103.5	8526	9293	9799	10063
61.	Ravipuram	147.55	6093	6641	7003	7192
62.	Ernakulam south	155.92	7821	8524	8989	9231
63.	Gandhi nagar	158.08	9915	10807	11396	11703
64.	Kathrikadavu	118.92	9076	9892	10432	10713
65.	Kaloor south	113.44	7625	8311	8764	9000

66.	Ernakulam central	159.71	12002	13082	13794	14166
67.	Ernakulam north	82.41	5017	5468	5766	5922
68.	Ayyappankavu	163.21	6718	7322	7721	7929
69.	Thrikkanarvattom	68.4	9345	10186	10741	11030
70.	Kaloor north	103.29	8424	9182	9682	9943
71.	Elamakkara south	96.72	13057	14231	15007	15412
73.	Pachalam	109.07	8044	8768	9245	9495
74.	Thattazham	111.52	8152	8885	9369	9622

Source: City Development Plan Kochi, 2010

6.0 Land Utilization

The characteristic feature of the land utilization pattern in Kochi is the predominance of water bodies and wetlands. The water body consists of canals and backwaters. These canals and backwaters served the purpose of transportation of men and materials earlier. Nowadays, a numbers of such canals have deteriorated as mere drainage channels. The total area of canals has reduced due to encroachment or siltation. The share of the backwater alone constitutes almost 95% of the water sheet. Vast stretches of this water is navigable, but adjoining the land mass and tiny island, it is very shallow. Unplanned reclamation is likely to affect the ecological balance. In addition, there is restriction in reclamation of water body as per Coastal Regulation Zone (CRZ) Rules except for port related activity. However, encroachment of water bodies continues, especially by those who have their properties adjoining the water bodies. Most of the water bodies lie contiguous to the paddy fields/farms and hence the clear boundary is not visible. The land utilization study shows that the land under water and paddy/ fish farm is getting converted to developed land.

Existing Land use – Kochi Corporation Area

The land use pattern of Kochi Municipal Corporation area for 1981 and 2001 is given in the Table: 5

Table: 1.6. **Land use pattern in Kochi Municipal Corporation (%)**

Sl.No	Land Use	1981	2001
1	Residential	50.08	52.68
2	Commercial	1.65	3.29
3	Industrial	1.71	3.32
4	Public and Semi-Public	4.16	5.76
5	Open space and Recreation	0.67	1.27
6	Transport	5.73	7.33
7	Paddy/ Prawn Farm/ Wetland	12.6	8.05
8	Water body	23.4	18.3
	Total	100%	100%

Source: City Development Plan Kochi, 2010

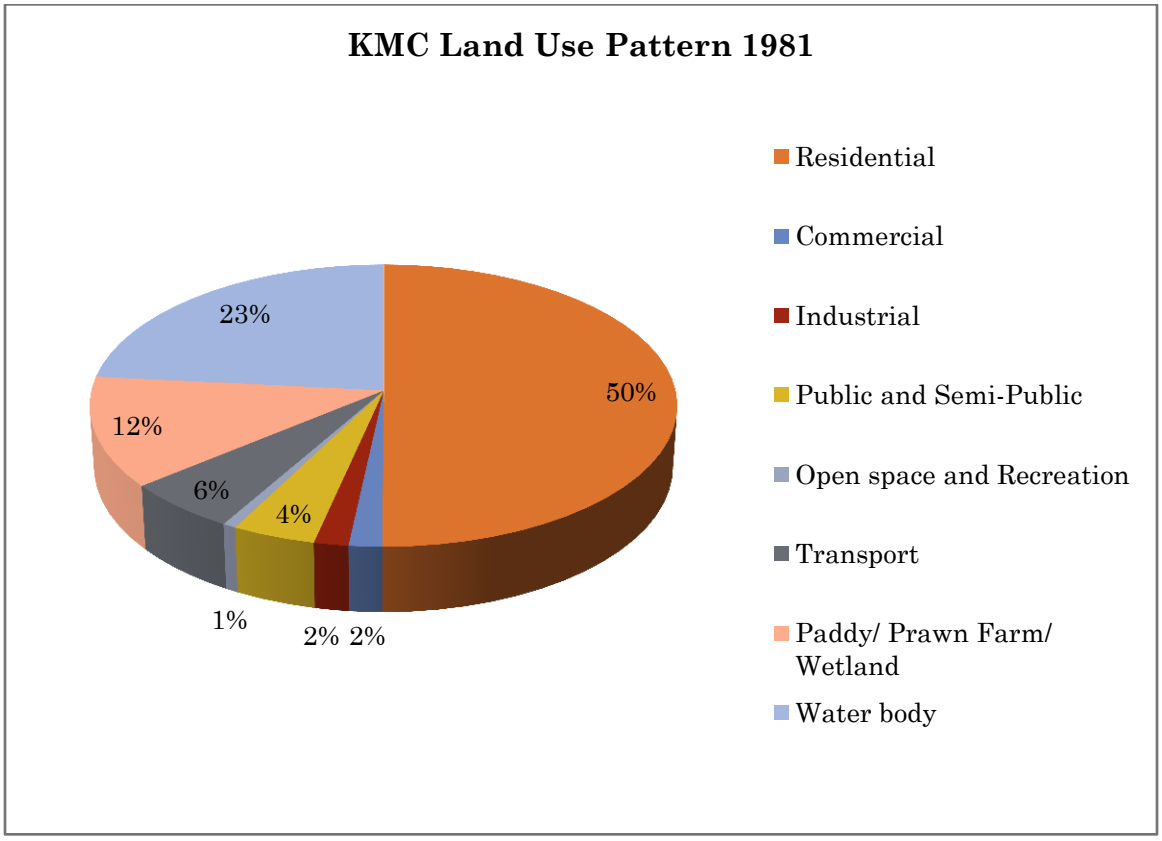


Fig 1.4. **KMC land use pattern 1981**

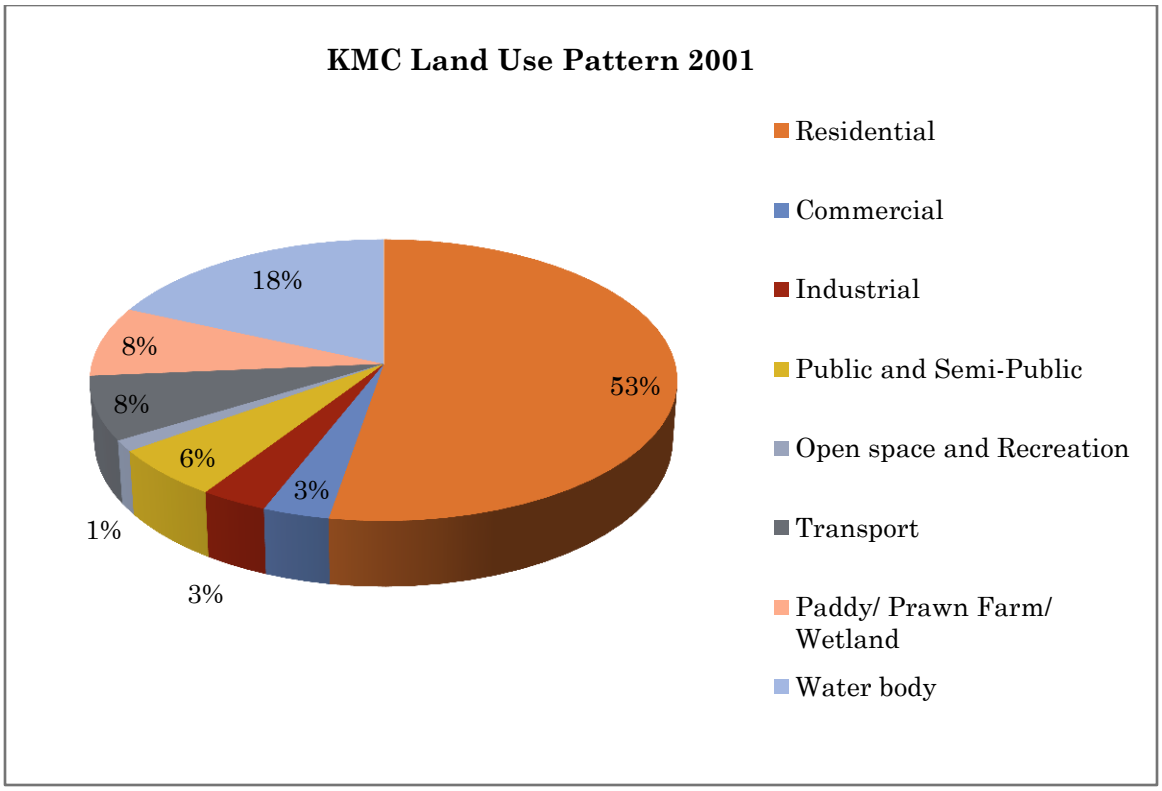


Fig 1.5 **KMC land use pattern 2001**

The land use analysis of KMC for the 2 periods show that the percentage of land use under water body and wet land is getting reduced. Urban expansion and the need for land are likely to further reduce the water bodies which will have repercussions on the environmental characteristics of the area. Hence, a judicious approach is to be adopted in allowing land use conversions. Though the percentage of open space is very low the vast expanse of water bodies makes up this deficiency to an extent. It is imperative to conserve the available water resources.

7.0 Rainfall

Ernakulam district has wet monsoon type of climate. The district experiences heavy rainfall during southwest monsoon season followed by northeast monsoon. During the other months the rainfall is considerably less. March, April and May are the hottest months. December to February is the coldest months. Cochin features a tropical monsoon climate. Starting April - May the rainy season kicks in and this lasts until the end of October.

Table 1.7. **Average Monthly Rainfall (mm) of Ernakulam District (2004 -2017)**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2004	2.5	8.4	36.9	87	711.6	650	424.4	424.6	215.1	507.2	135.8	0	3203.5
2005	52.1	1.2	8.2	237.2	121.9	840.5	820.2	355.3	472.8	279	193.1	20.4	3401.9
2006	12.7	0	62	42.9	622.5	654	583.9	498.4	505.6	478.4	394.5	3.1	3858.0
2007	1.9	1.4	9.2	146.5	193.5	815	1132.8	480.1	667.3	522.1	66.1	9.8	4045.7
2008	3	30.8	319.6	129.1	137.7	455.1	539	326.2	555.1	304.3	37.4	36.9	2874.2
2009	10.4	0	45.8	89.5	315.7	615.1	838.8	312.2	497.4	176.6	290	70.1	3261.6
2010	9.8	0	30.5	233.8	239.9	849.9	690.5	356.5	456.9	624.7	517.5	63.2	4073.2
2011	26	98	37	201	187	896	619	593	528	161	120	34	3500
2012	7.1	18	43	401.8	100.9	414.1	370.9	494.7	274.6	299.4	176	9.7	2610.2
2013	6.3	65.3	48.8	37.8	151	1258.7	826.5	374.7	314.2	318.7	211	45.2	3658.2
2014	0	11.1	22.4	90.7	287.9	550.1	650.2	877	298.8	434.8	118.5	94	3435.5
2015	2.4	0.5	37.2	229.3	176.2	573.9	367.2	241.2	393.8	355	332.5	182.3	2891.5
2016	0.4	91.4	3.4	43.8	322.8	624.6	620.4	238.7	85.7	160.5	115.1	19.5	2326.3
2017	16.8	0	97.9	31.4	306	706.3	435.4	415.8	445.3	293	217.8	28.1	2993.8

Source: **Indian Meteorological Department (IMD)**

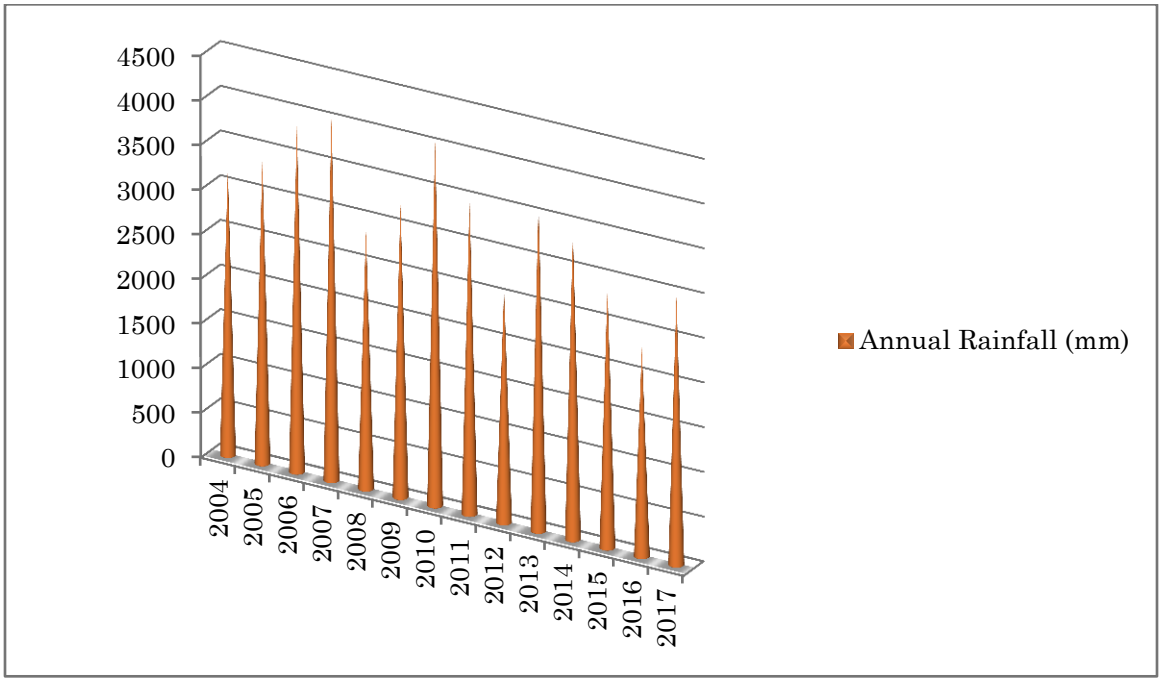


Fig. 1.6 **Performance of south west monsoon over Ernakulam June- September 2018**

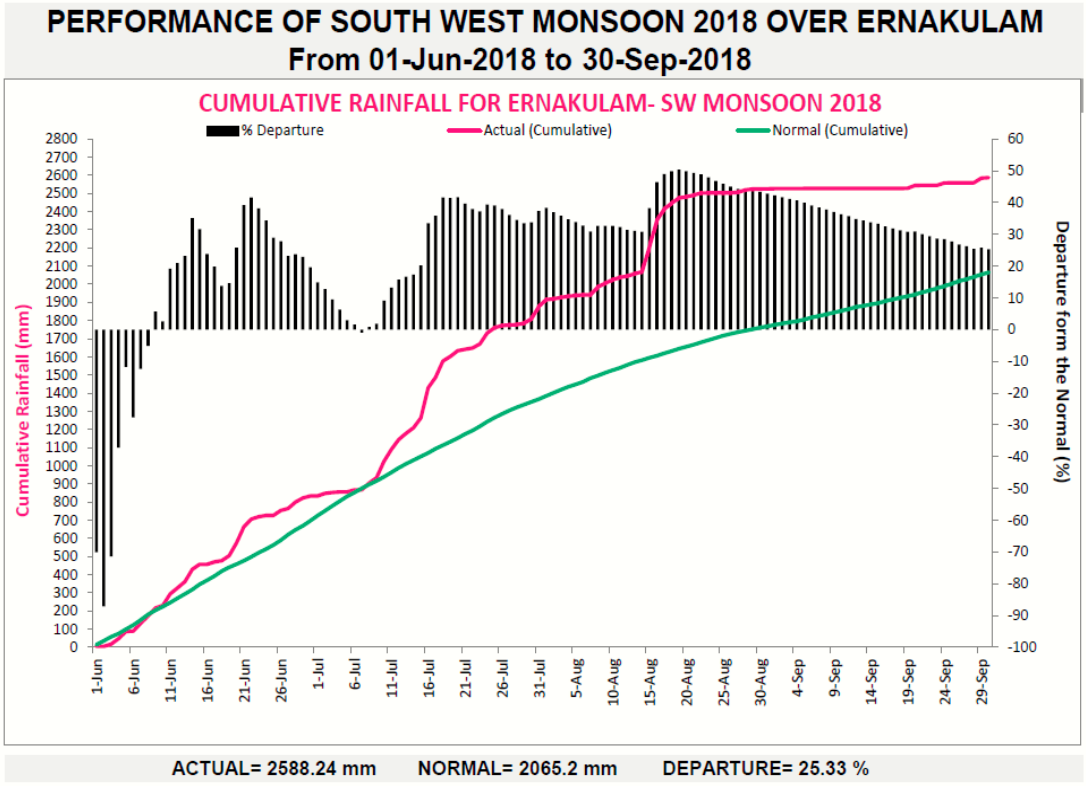


Fig.1.7. **Performance of South West Monsoon over Ernakulam**

8.0 Temperature, Winds and Humidity

Temperature, Winds and Humidity Temperatures begin increasing after February. March and April are generally the hottest months. In the interiors the day temperature may be a little higher than the coastal region. The relative humidity is generally over 90%. In the South-West Monsoon season the winds are mainly Westerly or North -Easterly. During the rest of the year winds is North-Easterly in the morning and from between South-West and North-West in the afternoon.

9.0 City topography and water flows (including existing water ways)

Kochi is characterized by an almost-flat topography and a very high water table. On average, the eastern parts of the city are situated approximately 7.5 metres above mean sea level, while much of the Corporation area lies between 1 metre and 2.5 metres above mean sea level. Moreover, the city has sand bars running from the north to the south, with several tidal canals in between. Further, the city has narrow roads and narrow drains. The

southwest monsoon, which usually lasts between June and September, brings around 60% of the annual precipitation, while the Northeast monsoon, which takes place between October and mid-November, typically brings about 25% of the annual rainfall in the region. All of the above factors imply that drainage is a problem in the city. The recent study of the run off of the catchment and discharge efficiency of the drains in the Kathrikadavu - Pullepady area (CBD) in Kochi Corporation, it was seen that, the average efficiency of the drain is only 43.31%. Out of the 34 catchment areas 12 have less than 25% efficiency and only one has 100% efficiency among the secondary, tertiary drains. The hydrological characteristics of the region make surface water drainage, an important element of urban renewal efforts.

Vembanad, although called a lake, is actually an estuary, into which Muvattupuzha, Periyar and four other rivers discharge. It is separated from the Arabian Sea by a narrow barrier island. Its wetland system is the largest of its kind on the Indian west coast, and when included with its drainage basins, covers an area of approximately 16,200 square kilometres, which is 40% of Kerala's area.

The Periyar River is one of the longest perennial rivers in Kerala, with a length of 244 km between the areas of Angamaly and Kochi. The river has an average annual discharge of about 7266Mm^3. Along the Periyar River, an industrial zone has been developed, which is home to over 50 large and medium-scale industries. The branch of the Periyar, Edayar, which runs through this industrial zone, provides water supply to these industries. During the monsoon, its flow is estimated at around 150-250 cubic metres per second, while in the dry season, its flow ranges between 80 and 100 cubic metres per second. The industrial zone of Edayar and Eloor is estimated to consume approximately 189 Million Liter per Day (MLD) of water per day, and generate approximately 80% of waste water, which is typically discharged into the river, polluting it. Moreover, recently, there has been an incursion of salt water in the upstream part of the river, which is rendering the water from the river unsuitable for domestic or industrial use.

The Muvattupuzha River has a length of about 121km and a catchment area of about 1554sq.km. The river discharge ranges from 50m^3/sec (Pre monsoon) to 400m^3/sec (Monsoon) with peak discharge during June to October. After the commissioning of Idukki hydroelectric powerproject in 1976, the tail- race water (19.83 to 78.5m^3/sec) has

been diverted into Thodupuzha (tributary of Muvattupuzha River) from Moolamattam Power Station. Out of the total tail- race discharge of about 1700Mm^3,the discharge during non- monsoon season (December- May) is about 950 Mm^3. The increased freash water flow in Muvattupuzha River helped in commissioning several water supply schemes.

10. Water supply

Though the rainfall is high, proximity to the sea and pollution from industrial and domestic sources makes the surface and groundwater not usable, especially in the western parts of Kochi. Being a coastal district, majority of the Kochi region is within the low land regions of the State. The terrain features have adverse influence on the sewerage and drainage system of the area. Percolation of effluent from septic tank and dispersion trenches pollute the groundwater. Commercial wastes are mostly directed to open surface drains. This ultimately results in environmental deterioration and public health hazards.

The primary source of water supply in Kochi Municipal Corporation is the Periyar River and Muvattupuzha River. There are two head works and treatment plants, one at Aluva with an installed capacity of 225 mld and the other at Maradu which has an installed capacity of 100 mld (www.kwa.kerala.gov.in).

Plate 1.1. **Maradu Water Treatment Plant**

The total water consumption comprises of domestic and non domestic consumption, including water requirements for industrial, commercial and institutional uses, hospitals, hotels, theatres, gardens etc. To this total consumption unaccounted water which includes requirement for firefighting and appropriate allowances for leakage losses and water treatment plant losses are also added to get the total raw water demand. Both urban and rural areas of Kochi City Region have to depend mainly on protected water supply. The total installed capacity of Aluva Treatment plant is 225 mld in which an average of 290 mld is produced (over production) and the supply area from the plant caters to Kochi Corporation, 4 Municipalities & 27 Panchayath. The daily catering from Aluva treatment Plant to Kochi Municipal Corporation is about 170- 190 mld. The total installed capacity of Maradu Treatment plant is 100 mld in which the daily production is only about 85 mld and the supply area from the plant caters to Kochi Corporation, one Municipality & five Panchayath. The daily catering from Maradu treatment Plant to Kochi Municipal Corporation is about 40- 60 mld. There is a daily supply of about 210- 230 mld to Kochi Municipal Corporation from both treatment plants. In Kochi Municipal Corporation there are some bulk users such as Cochin Port, Naval Base, Cochin Shipyard, Hospitals, University, Colleges, and Schools etc. According to KWA the total demand of water supply in 2046 will be 405 mld alone from Aluva water treatment Plant. At present, there are about 1,26,639 domestic pipeline connections, 20,764 non- domestic connections and 230 industrial connections in Kochi Municipal Corporation area.

The coastal areas of Kochi are characterized by high density of population and scarcity of good drinking water source. As the groundwater sources are saline, coastal people depend mainly on piped water supply and supply through barges and lorries. As the coastal areas lie away from water sources in Periyar, the supplied water does not always reach these coastal areas. Hence the supply is often limited to a few hours a day resulting in long queues waiting for collection of water from public taps located in these areas (City sanitation plan for Kochi, 2010).

Public water supply system was planned long back without properly considering future needs which are quite inadequate now. Water need and water availability are not proportional to rise in population. Changing life style necessitates more water. Availability of reliable water sharply decreases with population rise because of the

degradation of resources. There are thousands of people travelling daily to the city in daytime for jobs from nearby area and their water use and need are not accounted. Kochi generates employment for thousands of people from rural areas. Though not in a large scale, migrants, mostly poor and illiterate from other states also come here in search of job and they create slums (City Sanitation Plan for Kochi - Draft Report. Volume 1, Main Report, 2011).

CHAPTER 2

PERIYAR RIVER

2.1 Introduction

Periyar is the longest river and the river with the largest discharge potential in the Indian state of Kerala. Periyar has a total length of approximately 244 kilometres (152 mi) and a catchment area of 5,398 square kilometres (2,084 sq mi), of which 5,284 square kilometres (2,040 sq mi) is in Kerala and 114 square kilometres (44 sq mi) is in Tamil Nadu. It originates from Western Ghats and catchment area includes the remote forests of the Periyar Tiger Reserve. Various sources indicate the origin of the river to be Chokkampatti Mala, a peak on the southern boundary of the Periyar Tiger Reserve. It is one of the few perennial rivers in the region and provides drinking water for several major towns.

The Periyar is of utmost significance to the economy of Kerala. It generates a significant proportion of Kerala's electrical power via the Idukki Dam and flows along a region of industrial and commercial activity. The river also provides water for irrigation and domestic use throughout its course besides supporting a rich fishery. Due to these reasons, the river has been named the "Lifeline of Kerala". Kochi city, in the vicinity of the river mouth draws its water supply from Aluva, an upstream site sufficiently free of seawater intrusion. Twenty five percent of Kerala's industries are along the banks of river Periyar. These are mostly crowded within a stretch of 5 kilometres (3 mi) in the Eloor-Edayar region (Udhyogamandal), about 10 kilometres (6 mi) north of Kochi harbor.

Plate 2.1. **Periyar River**

2.2 Physico Chemical and Bacteriological Characteristics of Samples collected from Periyar River (Aluva area)

Analysis was carried out for various water quality parameters as per the standard procedure. A total of 12 samples (6 surface water and 6 tap water samples) were collected from different stations. About twenty four Physico chemical and microbiological parameters were taken into account to determine the water quality status of the Periyar river basin in Aluva region. Details of samples collected from different stations are shown in the table 2.1.

Table 2.1 **Details of sampling stations (Tap water)**

SL.NO	CODE	NAME OF SAMPLING STATIONS	LATITUDE	LONGITUDE
1	PR3T	Marampally Pump house	10.11381	76.41836
2	PR4T	Water Treatment plant, Vazhakulam, Chembaraky	10.08970	76.42724
3	PR5T	Aluva water treatment plant ,near railway station	10.11081	76.36102

4	PR6T	Aluva Sree Krishna swami Temple	10.11385	76.35262
5	PR7T	P C Mathew, Padamadan(H), pulinchode, Thaikattukara	10.09701	76.34626
6	PR8T	Balakrishna menon, soubaghya(H), periyar nagar No:33,Thaikattukara P.O,Aluva	10.09699	76.34415

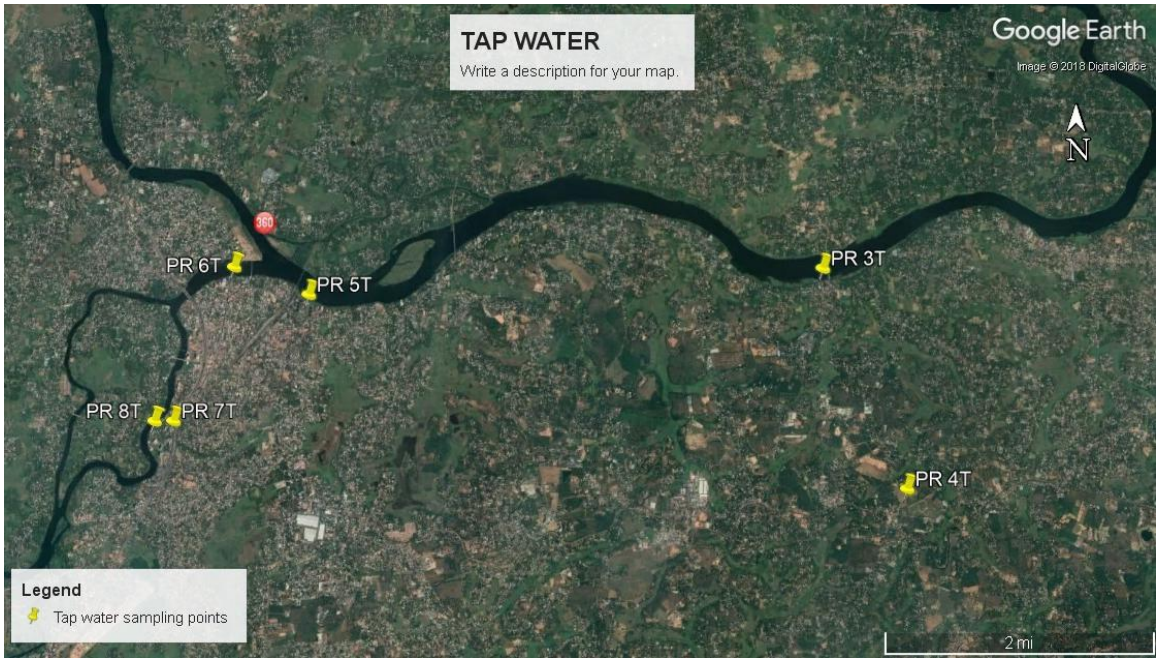


Fig 2.1. **Tap water sampling points**

Table 2.2 Water quality characteristics of Tap water samples

Sl. No.	PARAMETERS	Sample code					
		PR3T	PR4T	PR5T	PR6T	PR7T	PR8T
1	pH	7.33	6.63	6.57	6.83	6.41	6.57
2	Temperature (◦C)	27.6	28.1	28.4	28.1	27.7	29.3
3	Turbidity,(NTU)	15.1	4.6	0.5	5	4.1	0.3
4	Electrical conductivity(µS/cm)	69.4	104.15	56	72.1	66.7	74.2
5	Salinity (ppt)	0.03	0.05	0.03	0.03	0.03	0.03
6	Total dissolved solids,(mg/l)	49.3	74.7	39.6	51.2	47.4	52.6

7	Total hardness,(mg/l)	23.29	38.83	19.41	27.18	27.18	34.94
8	Total alkalinity,(mg/l)	12	16	12	16	12	20
9	Chloride ,(mg/l)	12.33	18.5	14.39	10.28	10.28	12.33
10	Sulphate,(mg/l)	7.52	22.16	7.32	10.32	9.08	10
11	Nitrate-N,(mg/l)	0.98	1.39	0.88	1.53	1.3	1.07
12	Phosphate-P,(mg/l)	BDL	BDL	BDL	BDL	BDL	BDL
13	Calcium,(mg/l)	9.316	12.42	6.21	9.31	9.31	9.31
14	Magnesium,(mg/l)	BDL	1.88	0.94	0.94	0.94	2.83
15	Sodium(mg/l)	2.98	3.15	2.85	2.7	2.5	3.38
16	Potassium,(mg/l)	0.69	0.71	0.61	0.62	0.58	0.7
17	Iron,(mg/l)	1.5	1.12	0.33	0.74	0.41	0.06
18	Zinc, (mg/l)	BDL	0.01	BDL	BDL	BDL	BDL
19	Manganese, (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL
20	Cadmium, (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL
21	Lead, (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL
22	Copper, (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL
23	Total Coliforms, (CFU/100ml)	2800	3900	700	6400	A	A
24	E.coli,(CFU/100ml)	A	A	A	A	A	A

BDL- Below Detection Level

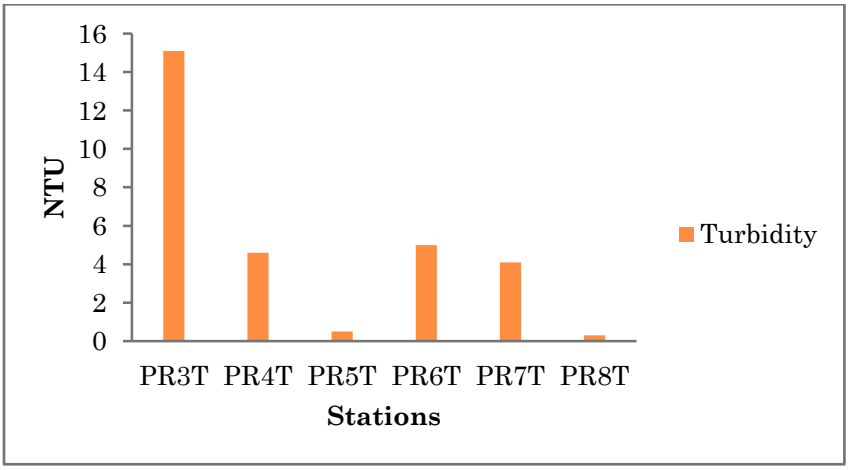


Fig 2.2. **Concentration of turbidity at various sampling stations**

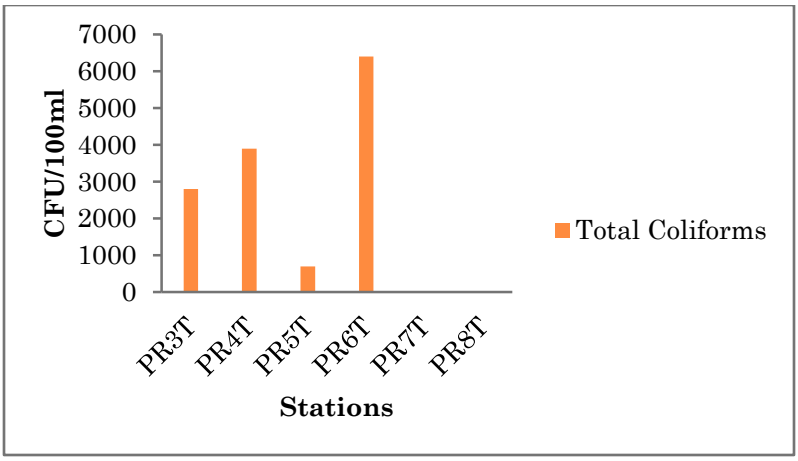


Fig 2.3 **Total coliforms present in water samples**

The turbidity of 67% samples of the tap water samples were above the acceptable limit. Two samples PR3T and PR4T showed the presence of Iron which is above the acceptable limit. According to the bacteriological studies the tap water samples PR3T, PR4T, PR5T and PR6T are not fit for drinking purpose due to the presence of Total Coliforms. Even the sample collected directly from the Aluva treatment plant showed the presence of Total Coliforms.

Table 2.3 **Details of sampling stations (Surface water)**

SL.NO	CODE	NAME OF SAMPLING STATIONS	LATITUDE	LONGITUDE
1	PR1	Kaladi bridge,near M C road, Kaladi	10.16098	76.44254
2	PR2	Vallom pump house	10.13071	76.45829
3	PR3	Marampally pump house	10.11381	76.41836
4	PR5	Near Aluva water treatment plant	10.11081	76.36102
5	PR6	Near Sree Krishna swami Temple, Aluva	10.11385	76.35262
6	PR8	Near Periyar nagar, Thaikattukara	10.09699	76.34415

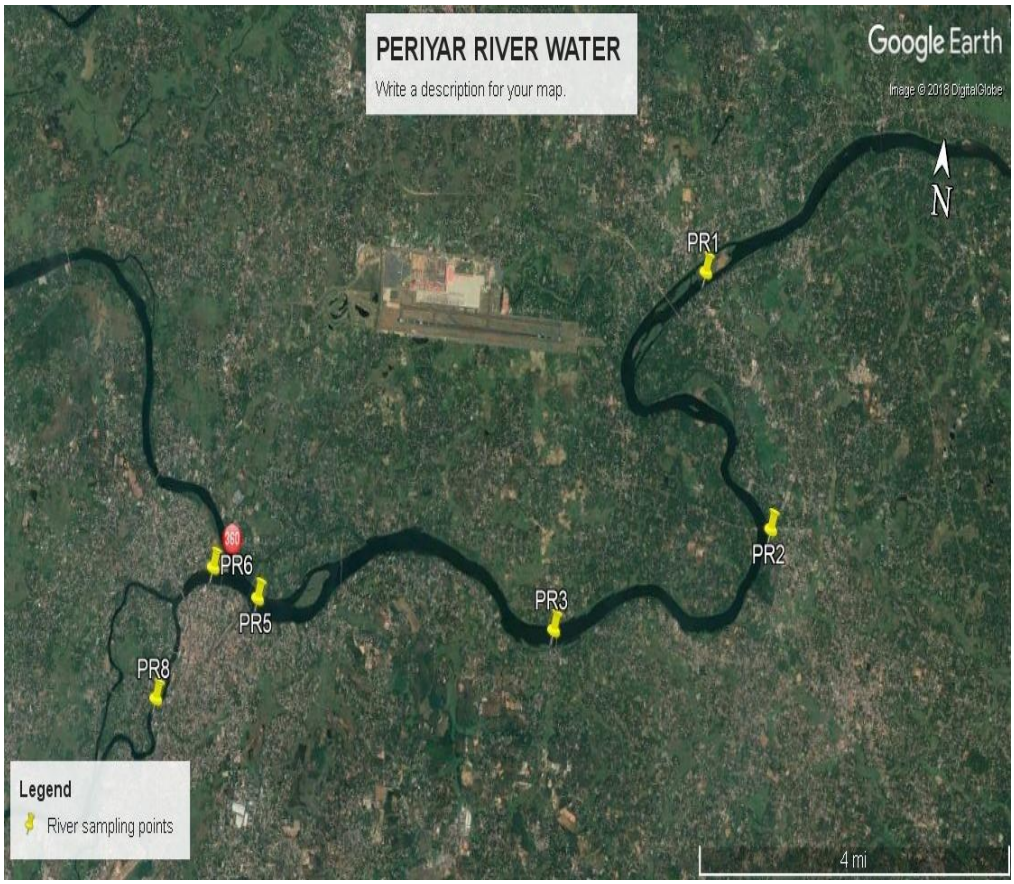


Fig 2.4 **Surface water sampling points**

Table 2.4 Water Quality Parameters of Surface water samples

Sl.No.	PARAMETERS	Sample code					
		PR1	PR2	PR3	PR5	PR6	PR8
1	pH	6.34	6.68	6.64	6.76	6.74	6.66
2	Temperature (^{0}C)	29	27.9	29.8	27.8	28	27.4
3	Turbidity,(NTU)	24.1	4.4	13.3	11.4	19.5	12.3
4	Electrical conductivity(µS/cm)	61.3	45.7	49.9	42	52.2	42.9
5	Salinity (ppt)	0.03	0.02	0.02	0.02	0.03	0.02
6	Total dissolved solids,(mg/l)	43.7	32.5	35.5	30.1	37	30.6
7	Total hardness,(mg/l)	19.41	19.41	23.29	15.53	27.18	19.41
8	Total alkalinity,(mg/l)	20	12	16	12	16	12

9	Chloride ,(mg/l)	10.28	12.33	10.28	8.22	10.28	12.33
10	Sulphate,(mg/l)	10.72	3	5.12	3.76	3.72	5.2
11	Nitrate-N,(mg/l)	1.78	0.72	1.02	1.38	1.62	1.36
12	Phosphate-P,(mg/l)	BDL	BDL	0.1	BDL	0.1	BDL
13	Calcium,(mg/l)	6.21	3.1	3.1	3.1	4.65	4.65
14	Magnesium,(mg/l)	0.94	2.83	3.77	1.88	3.77	1.88
15	Sodium(mg/l)	3.52	2.81	2.98	2.41	2.58	2.46
16	Potassium,(mg/l)	1.03	0.82	0.8	0.62	0.62	0.64
17	Dissolved oxygen,(mg/l)	6.07	6.53	6.99	6.86	6.40	6.66
18	Biochemical oxygen demand,(mg/l)	3.24	3.04	3.03	2.97	2.77	2.84
19	COD, (mg/l)	63.48	7.93	7.93	7.93	87.29	23.8
20	Iron,(mg/l)	5.26	1.85	BDL	1.18	3.12	0.7
21	Zinc, (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL
22	Manganese, (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL
23	Cadmium, (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL
24	Lead, (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL
25	Copper, (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL
26	Total coliforms, (CFU/100ml)	1100	1500	6400	400	1100	6400
27	E.coli,(CFU/100ml)	A	A	100	A	400	100

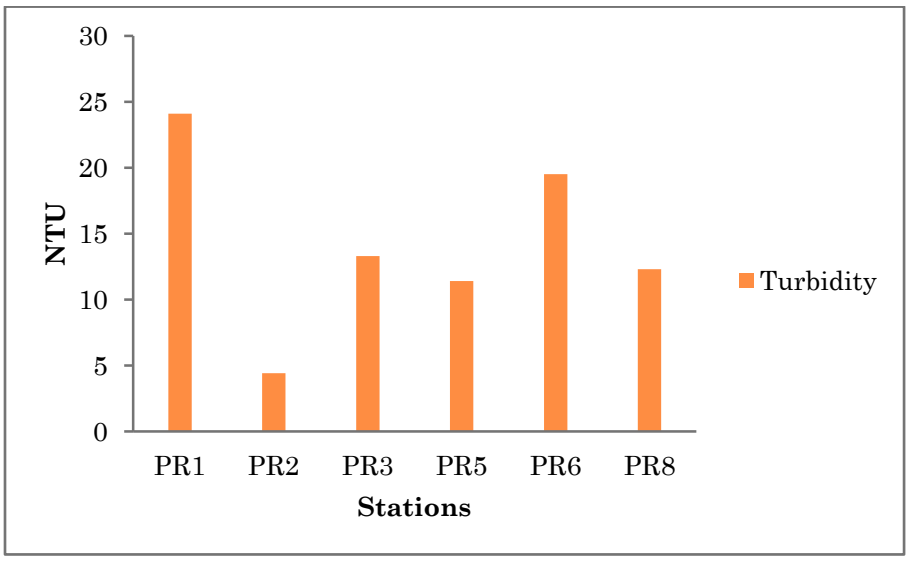


Fig 2.5 **Turbidity present in Periyar water samples**

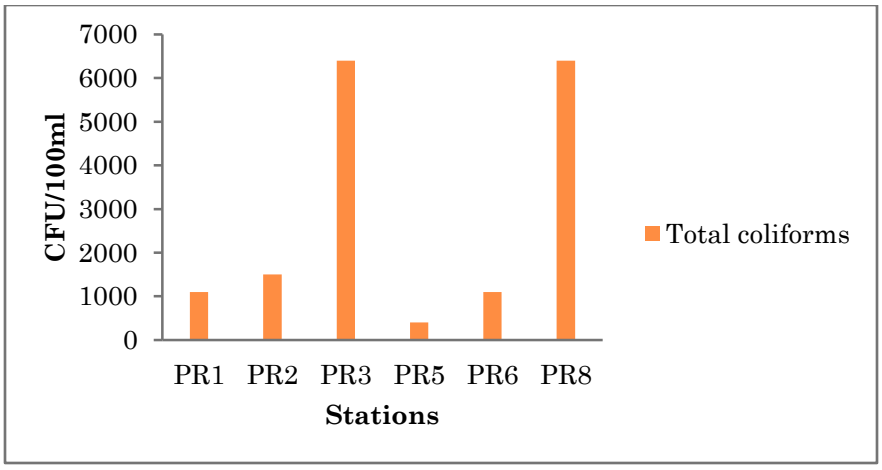


Fig 2.6 **Total coliforms present in Periyar water samples**

The turbidity of all samples was above the acceptable limit of BIS (2012). The flood water might have caused the high value. 67% of the surface samples showed the presence of Iron which was above the acceptable limit. According to the bacteriological studies 100% showed the presence of Total Coliforms and Samples PR3, PR6 and PR8 reported the presence of E.*coli* also.

The results obtained from the analysis indicated that, majority of the samples are contaminated with both Total coliform and E.*coli*. This requires continuous monitoring and treatment process if the water is to be used for drinking purposes. The consumption of bacteriologically contaminated water may lead to various water borne diseases. Most of the surface water samples and two tap water samples have high concentration of iron. The collected samples were subjected to heavy metal analysis and metals were not detected.

2.3 Central Pollution Control Board classification for best designated use

A well planned and well managed water quality monitoring system is required to control or predict changes or trends of changes in the quality of a particular water body, so that curative or preventive measures can be taken to restore and maintain ecological balance in the water body. Central Pollution Control Board (CPCB) classified the inland surface water into five i.e, from A to E on the basis of their designated best use and desired class

(Table 3). The classification has been made in such a manner that with the degradation in quality, the water quality requirement becomes progressively lower from A to E.

Table 2.5: Use based classification of water of Indian rivers (CPCB)

Designated Best Use	Class of water	Criteria
Drinking water source without conventional treatment but after disinfection	A	1. Total coliforms organism MPN/100ml shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved oxygen 6mg/l or more 4. Biochemical Oxygen Demand 5 days 20^0C 2mg/l or less
Outdoor bathing (Organized)	B	1. Total coliforms organism MPN/100ml shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved oxygen 5mg/l or more 4. Biochemical Oxygen Demand 5 days 20^0C 3 mg/l or less
Drinking water source after conventional treatment and disinfection	C	1. Total coliforms organism MPN/100ml shall be 5000 or less 2. pH between 6 to 9 3. Dissolved oxygen 4mg/l or more 4. Biochemical Oxygen Demand 5 days 20^0C 3 mg/l or less
Propagation of wild life and fisheries	D	1. pH between 6.5 and 8.5 2. Dissolved oxygen 4 mg/l or more 3. Free Ammonia (as N)1.2 mg/l or less
Irrigation, Industrial cooling, Controlled waste disposal	E	1. pH between 6 to 8.5 2. Electrical Conductivity at 25^0C micro mhos/cm Max.2250 3. Sodium absorption Ratio Max. 26 4. Boron Max. 2mg/l

2.4 CPCB Classification of Periyar River Basin

Classification of the Periyar River basin based on best designated use prescribed by Central Pollution Control Board (CPCB) is summarized in Table 3.1

Table 2.6: Designated use of Periyar River basin as per CPCB classification

SL.NO	CODE	NAME OF SAMPLING STATIONS	Class
1	PR1	Kaladi bridge,near M C road, Kaladi	C
2	PR2	Vallom pump house	C
3	PR3	Marampally pump house	C
4	PR5	Near Aluva water treatment plant	C
5	PR6	Near Sree Krishna temple, Aluva	C
6	PR8	Near Periyar nagar, Thaikattukara	C

The CPCB classification of Periyar River water based on designated best use revealed that all the surface water samples from Periyar can be used as drinking water sources only after conventional treatment and disinfection.

CHAPTER 3

STUDY CARRIED OUT IN KOCHI MUNICIPAL CORPORATION (KMC) AREA

3.1 Materials and Methods

3.1.1 Data Collection

Secondary data on the local bodies and water supply schemes were collected and documented. The parameters to evaluate the water supply schemes were collected through an interview schedule and through PRA exercise from a sample of project beneficiaries, LSGD officials and the Departments involved in the scheme.

3.1.2 Survey

A total of 250 houses were surveyed. The objective of the exercise was to ensure a well-represented coverage across the 74 wards while conducting a perception based survey of the service levels across the Kochi Municipal Corporation for water supply. This survey helped in understanding the issues and constraints faced by the Kochi Municipal Corporation and included suggestions for improvements in the water supply service levels.

In the preparatory stage, Draft questionnaires, detailed data collection and data entry formats were made for each of these categories and field test surveys were conducted in certain wards of the Kochi Municipal Corporation. Feedback was collected during those field surveys to introduce local context and bring about improvements in the questionnaire and survey methodology. Based on these revised questionnaires, survey was being conducted across the wards of the Kochi Municipal Corporation.

254 houses were covered across 74 wards of the Kochi Municipal Corporation. Data was collected from those houses in the desired formats so as to assess and analyse the information. Format used for the survey is enclosed as Annexure1.

3.1.3 Sampling Design

Multi stage random sampling method was adopted. Primary sampling units were the water supply schemes which were selected randomly. Secondary sampling units were from individual households, beneficiary households through stratified random sampling based on socio-economic status.

3.1.4 Sample Collection and Characterization

Water samples were collected from various sources and household outlet of water supply schemes and analyzed for various Physico-chemical and bacteriological analysis as per the standard procedure (APHA, 2017). Efficiency of the existing water treatment systems was monitored.

3.2 Physico chemical and Bacteriological characteristics of samples collected from different wards of KMC

A total of 162 samples (which includes Tap water and groundwater) were collected from 74 wards of Kochi Municipal Corporation. Major Physico chemical parameters were taken into account to determine the water quality status of the samples collected from different wards of Kochi Municipal Corporation. Details of samples collected from different wards are shown in the Table 1. The bacteriological analysis of the samples was carried out as per the procedure described in APHA (2017).

Table 3.1 **Details of samples collected from KMC area**

Sl. No	Ward number	Sample code	Latitude	Longitude
1	1	CH154G CH156T	9.961871 9.960103	76.240990 76.245429
2	2	CH158T	9.964308	76.246352
3	3	CH142G CH135T	9.966442 9.966233	76.251002 76.252449
4	4	CH140G CH141T	9.959303 9.961597	76.253179 76.251057
5	5	CH133T	9.956042	76.258998

6	6	CH132T	9.951733	76.259182
		CH134T	9.953677	76.257957
7	7	CH138G	9.954220	76.255704
		CH162T	9.979297	76.286535
8	8	CH137G	9.946705	76.254147
		CH139T	9.950832	76.255177
9	9	CH136T	9.945958	76.256427
		CH131G	9.944988	76.260737
10	10	CH130T	9.942456	76.261325
		CH129T	9.939470	76.259198
11	11	CH120G	9.934722	76.258889
		CH124T	9.933667	76.258722
12	12	CH114T	9.926139	76.274278
		CH115T	9.927972	76.273944
		CH121T	9.925056	76.267556
13	13	CH104T	9.921472	76.280083
14	14	CH103T	9.916417	76.284417
15	15	CH97G	9.914444	76.292944
		CH98T	9.915852	76.289793
16	16	CH95T	9.895083	76.296417
		CH96G	9.898778	76.29425
17	17	CH99T	9.912	76.280222
		CH100T	9.9105	76.285667
18	18	CH101T	9.902833	76.273472
		CH102G	9.904472	76.272889
19	19	CH122G	9.910167	76.270556
		CH123T	9.907944	76.2715
20	20	CH117G	9.916667	76.268667
		CH125T	9.915167	76.271056
21	21	CH116G	9.919861	76.265139
		CH118T	9.916833	76.268806
22	22	CH119T	9.928556	76.254139
23	23	CH160T	9.916775	76.252060

24	24	CH147T	9.936973	76.246783
		CH148G	9.937726	76.248660
25	25	CH149T	9.941352	76.251793
26	26	CH150G	9.942248	76.246306
		CH151T	9.945374	76.245417
27	27	CH152T	9.948211	76.244919
		CH153G	9.955735	76.241849
28	28	CH155T	9.959805	76.243165
		CH157G	9.95302	76.245444
29	29	CH143T	9.968922	76.260773
		CH144G	9.968922	76.260773
30	30	CH145T	9.937551	76.279396
		CH146G	9.936627	76.275673
31	31	CH60G	10.023306	76.273917
		CH64T	10.019917	76.270278
		CH66T	10.021944	76.272361
32	32	CH67T	10.023083	76.276472
		CH68G	10.021472	76.2760
		CH69T	10.043611	76.277306
33	33	CH79T	10.018389	76.289333
34	34	CH76T	10.019253	76.291082
		CH77G	10.019253	76.291082
		CH78T	10.024917	76.291333
35	35	CH85T	10.023056	76.299972
		CH86T	10.025944	76.297944
36	36	CH87T	10.008139	76.297583
		CH88G	10.040778	76.298778
37	37	CH1G	10.03473	76.302811
		CH4T	10.017386	76.302026
		CH5G	10.017386	76.302026
38	38	CH2T	10.017462	76.302582
		CH3G	10.017462	76.302582
		CH34G	9.944180	76.293737
				76.293737

		CH35G	9.944180	
39	39	CH89T	10.007361	76.295139
40	40	CH83T	10.008389	76.301278
		CH84T	10.009167	76.303111
41	41	CH52G	10.010830	76.317273
		CH53G	10.011055	76.31405
		CH54T	10.011055	76.31405
42	42	CH55G	10.002806	76.31725
		CH17F	9.99744	76.32441
43	43	CH50T	10.004028	76.31244
		CH51G	9.99975	76.31175
44	44	CH93T	9.992361	76.304528
		CH94T	9.989667	76.305889
45	45	CH7G	10.01320	76.31006
		CH8G	9.980476	76.313398
		CH9T	9.98276	76.31295
		CH10T	9.98434	76.31596
46	46	CH12G	9.99179	76.32771
		CH15G	9.995337	76.325785
		CH16G	9.99254	76.32818
47	47	CH11G	9.98187	76.32295
		CH13S	9.99088	76.32786
		CH14T	9.99242	76.32721
48	48	CH110T	9.977611	76.322472
		CH111G	9.98075	76.31925
49	49	CH113T	9.970167	76.320278
50	50	CH37G	9.948825	76.333416
		CH41T	9.953443	76.329658
		CH42G	9.953443	76.329658
51	51	CH38G	9.943232	76.331908
		CH39T	9.946540	76.331178
		CH40G	9.949565	76.329613

52	52	CH112T	9.962944	76.314778
53	53	CH109T	9.978694	76.306556
54	54	CH107G	9.973	76.301028
		CH108T	9.972806	76.303889
55	55	CH18G	9.964280	76.299979
		CH19G	9.958485	76.300413
		CH20T	9.958485	76.300413
56	56	CH21T	9.963352	76.295680
		CH47G	9.959305	76.294677
57	57	CH48T	9.955347	76.302808
		CH49G	9.953987	76.302979
58	58	CH26G	9.942018	76.300063
		CH27G	9.942218	76.299912
		CH28G	9.944175	76.236048
		CH29T	9.944175	76.236048
		CH36G	9.938005	76.303023
59	59	CH31T	9.930265	76.300093
		CH32G	9.930265	76.300093
		CH33G	9.930265	76.300093
60	60	CH22T	9.945616	76.301752
		CH23G	9.945616	76.301752
		CH24G	9.945418	76.292829
		CH25T	9.945418	76.292829
		CH46T	9.544945	76.293974
61	61	CH43T	9.955035	76.292827
		CH44G	9.951158	76.294060
		CH45T	9.951158	76.294060
62	62	CH128T	9.973512	76.282178
63	63	CH105T	9.976889	76.294056
		CH106G	9.9725	76.297778

64	64	CH91T CH92G	9.984109 9.984109	76.299137 76.299137
65	65	CH70T	9.994222	76.288611
66	66	CH127G CH159T	9.979297 9.984267	76.286535 76.274399
67	67	CH126T	9.990540	76.283913
68	68	CH56T CH57G CH58T	9.991861 9.990639 9.987916	76.280416 76.280416 76.275667
69	69	CH71T CH72G	9.995833 9.99850	76.28725 76.2870
70	70	CH81T CH82T	10.004417 10.002221	76.295611 76.296472
71	71	CH74T CH75G CH80G	10.004111 10.012139 10.0085	76.288139 76.291167 76.287889
72	72	CH73T CH90G	10.006139 10.006194	76.288139 76.290139
73	73	CH161T	10.013341	76.276840
74	74	CH59T CH61T CH63T	10.004556 10.001028 10.023306	76.2770 76.280416 76.273917

Plate 3.1 Collection of water sample from a Public Tap

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Plate 3.2 A Public Well in KMC

Table 3.2 **Drinking water standards as per BIS 10500:2012**

Sl.No	Parameters	Acceptable limit
1	pH at 25^0C	6.50- 8.50
2	Colour, Hazen	5.0
3	Turbidity, NTU	1.0
4	Total Dissolved Solids, mg/l	500.0
5	Total Hardness as $CaCO_3$, mg/l	200.0
6	Total Alkalinity as $CaCO_3$, mg/l	200.0
7	Chloride as Cl^-, mg/l	250.0
8	Sulphate as SO_4^{2-}, mg/l	200.0
9	Calcium as Ca, mg/l	75.0
10	Magnesium as Mg, mg/l	30.0
11	Iron as Fe, mg/l	1.0
12	Total Coliforms, MPN/100ml	Shall not be present in 100 ml sample
13	*E.coli*, MPN/100ml	Shall not be present in 100 ml sample
14	Fecal Coliform, MPN/100ml	Shall not be present in 100 ml sample

BDL: Below Detection Limit

3.2.1 Physico chemical characteristics of water samples collected from various wards

Table 3.3 Ward 1- Fort Kochi

SL.No	PARAMETERS	SAMPLE CODE	
		CH154G (Groundwater)	CH156T (Tap water)
1	pH	7.33	8.05
2	Temperature (^{0}C)	27.9	28
3	Turbidity,(NTU)	3.7	BDL
4	Electrical Conductivity(µS/cm)	812	63.2
5	Salinity (ppt)	0.34	0.03
6	Total Dissolved Solids,(mg/l)	575	44.8
7	Total Hardness,(mg/l)	364.32	23.76
8	Total Alkalinity,(mg/l)	293.88	14.88
9	Chloride ,(mg/l)	75.16	11.86
10	Sulphate,(mg/l)	20.72	2.48
11	Calcium,(mg/l)	114.04	4.75
12	Magnesium,(mg/l)	19.24	2.88
13	Sodium(mg/l)	30.44	2.29
14	Potassium,(mg/l)	4.54	1.21
15	Iron (mg/l)	1.13	BDL
16	Total Coliforms, (CFU/100ml)	9300	A
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity, TDS, TH, TA, Ca and Fe of groundwater sample was above the acceptable limit. The bacteriological analysis of the groundwater sample showed the presence of Total Coliforms. All other parameters of Tap water sample were within the acceptable limit.

Table 3.4 Ward 2- Kalvathy

SL.No	PARAMETERS	SAMPLE CODE
		CH158T (Tap water)
1	pH	7.76
2	Temperature (^{0}C)	27.9

3	Turbidity,(NTU)	BDL
4	Electrical Conductivity(µS/cm)	71
5	Salinity (ppt)	0.03
6	Total Dissolved Solids,(mg/l)	50.4
7	Total Hardness,(mg/l)	31.68
8	Total Alkalinity,(mg/l)	18.6
9	Chloride ,(mg/l)	7.91
10	Sulphate,(mg/l)	2.8
11	Calcium,(mg/l)	6.33
12	Magnesium,(mg/l)	3.84
13	Sodium(mg/l)	2.06
14	Potassium,(mg/l)	1.04
15	Iron (mg/l)	BDL
16	Total Coliforms, (CFU/100ml)	A
17	E.coli,(CFU/100ml)	A

BDL: Below Detection Limit

All the parameters were within the acceptable limit.

Table 3.5. Ward 3- Earaveli

SL.No	PARAMETERS	SAMPLE CODE	
		CH142G (Ground water)	**CH135T (Tap water)**
1	pH	7.48	8.52
2	Temperature (^{0}C)	28.5	28.6
3	Turbidity,(NTU)	0.7	1.1
4	Electrical Conductivity(µS/cm)	1191	60.8
5	Salinity (ppt)	0.56	0.03
6	Total Dissolved Solids,(mg/l)	844	43.3
7	Total Hardness,(mg/l)	257.4	23.76
8	Total Alkalinity,(mg/l)	338.52	18.6
9	Chloride ,(mg/l)	31.64	11.86
10	Sulphate,(mg/l)	30.52	2.32
11	Calcium,(mg/l)	17.42	3.16
12	Magnesium,(mg/l)	51.96	3.84
13	Sodium(mg/l)	103.4	2.95
14	Potassium,(mg/l)	31.2	1.32
15	Iron (mg/l)	BDL	BDL

16	Total Coliforms, (CFU/100ml)	9300	A
17	E.coli,(CFU/100ml)	200	A

BDL: Below Detection Limit

The TDS, TH, TA of groundwater sample was above the acceptable limit. The bacteriological analysis of the groundwater sample indicated the presence of Total Coliforms as well as E.*coli*. All other parameters of Tap water sample were within the acceptable limit.

Table 3.6. Ward 4- Karippalam

SL.No	PARAMETERS	SAMPLE CODE	
		CH140G (Ground water)	**CH141T (Tap water)**
1	pH	7.37	7.4
2	Temperature (^{0}C)	28.5	28.5
3	Turbidity,(NTU)	4.2	1.1
4	Electrical Conductivity(µS/cm)	1225	57.5
5	Salinity (ppt)	0.57	0.03
6	Total Dissolved Solids,(mg/l)	872	40.9
7	Total Hardness,(mg/l)	297	27.72
8	Total Alkalinity,(mg/l)	360.84	14.88
9	Chloride ,(mg/l)	47.47	11.86
10	Sulphate,(mg/l)	2.56	1.84
11	Calcium,(mg/l)	19	6.33
12	Magnesium,(mg/l)	60.62	2.88
13	Sodium(mg/l)	131.6	2.7
14	Potassium,(mg/l)	25.3	1.25
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	700	A
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity, TDS, TH, TA of groundwater sample was above the acceptable limit. The bacteriological analysis of the groundwater sample indicated the presence of Total Coliforms. All other parameters of Tap water sample were within the acceptable limit.

Table 3.7. Ward 5- Mattanchery

SL.No	PARAMETERS	SAMPLE CODE
		CH133T (Tap water)
1	pH	7.78
2	Temperature (^{0}C)	28.5
3	Turbidity,(NTU)	1.2
4	Electrical Conductivity(µS/cm)	62.8
5	Salinity (ppt)	0.03
6	Total Dissolved Solids,(mg/l)	44.4
7	Total Hardness,(mg/l)	27.72
8	Total Alkalinity,(mg/l)	26.04
9	Chloride ,(mg/l)	11.86
10	Sulphate,(mg/l)	2.52
11	Calcium,(mg/l)	7.92
12	Magnesium,(mg/l)	1.92
13	Sodium(mg/l)	2.95
14	Potassium,(mg/l)	1.23
15	Iron (mg/l)	0.03
16	Total Coliforms, (CFU/100ml)	1100
17	E.*coli*,(CFU/100ml)	A

BDL: Below Detection Limit

The turbidity of Tap water sample is above the acceptable limit. The bacteriological analysis of the Tap water sample indicated the presence of Total Coliforms. All other parameters of Tap water sample were within the acceptable limit.

Table 3.8. Ward 6- Kochangadi

SL.No	PARAMETERS	SAMPLE CODE	
		CH132T (Tap water)	CH134T (Tap water)
1	pH	7.49	7.18
2	Temperature (^{0}C)	28.6	28.5
3	Turbidity,(NTU)	1.5	1.2
4	Electrical Conductivity(µS/cm)	59.1	58.5
5	Salinity (ppt)	0.03	0.03
6	Total Dissolved Solids,(mg/l)	42.1	41

7	Total Hardness,(mg/l)	23.76	15.84
8	Total Alkalinity,(mg/l)	26.04	18.6
9	Chloride ,(mg/l)	11.86	11.86
10	Sulphate,(mg/l)	2.24	2.6
11	Calcium,(mg/l)	6.33	4.75
12	Magnesium,(mg/l)	1.92	0.96
13	Sodium(mg/l)	3.16	2.99
14	Potassium,(mg/l)	1.27	1.31
15	Iron (mg/l)	0.19	BDL
16	Total Coliforms, (CFU/100ml)	1500	9300
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity of Tap water samples was above the acceptable limit. The bacteriological analysis of the both Tap water samples had the presence of Total Coliforms. All other parameters were within the acceptable limit.

Table 3.9. Ward 7- Cheralayi

SL.No	PARAMETERS	SAMPLE CODE	
		CH138G (Ground water)	**CH162T (Tap water)**
1	pH	7.03	8.18
2	Temperature (^{0}C)	28.5	27.9
3	Turbidity,(NTU)	4.3	1.6
4	Electrical Conductivity(µS/cm)	473	54.7
5	Salinity (ppt)	0.21	0.05
6	Total Dissolved Solids,(mg/l)	335	36.24
7	Total Hardness,(mg/l)	198	15.84
8	Total Alkalinity,(mg/l)	200.88	20.4
9	Chloride ,(mg/l)	27.69	14.37
10	Sulphate,(mg/l)	8.48	3.16
11	Calcium,(mg/l)	76.03	4.72
12	Magnesium,(mg/l)	1.92	0.98
13	Sodium(mg/l)	17.32	5.42
14	Potassium,(mg/l)	9.12	1.34
15	Iron (mg/l)	0.09	BDL
16	Total Coliforms, (CFU/100ml)	2800	A
17	E.*coli*,(CFU/100ml)	800	A

BDL: Below Detection Limit

The Turbidity and TA of groundwater sample is above the acceptable limit. The bacteriological analysis of the groundwater sample reported the presence of Total Coliforms as well as E.*coli*. Except turbidity, all other physico chemical parameters of Tap water sample were within the acceptable limit.

Table 3.10 Ward 8- Panayappilly

SL.No	PARAMETERS	SAMPLE CODE	
		CH137G (Ground water)	**CH139T (Tap water)**
1	pH	7.13	6.93
2	Temperature (^{0}C)	28.6	28.6
3	Turbidity,(NTU)	1.6	1.3
4	Electrical Conductivity(µS/cm)	530	59.5
5	Salinity (ppt)	0.24	0.03
6	Total Dissolved Solids,(mg/l)	375	41.6
7	Total Hardness,(mg/l)	194.04	19.8
8	Total Alkalinity,(mg/l)	234.36	14.88
9	Chloride ,(mg/l)	31.64	7.91
10	Sulphate,(mg/l)	1.04	2.16
11	Calcium,(mg/l)	60.19	6.33
12	Magnesium,(mg/l)	10.58	0.96
13	Sodium(mg/l)	20.92	2.9
14	Potassium,(mg/l)	11.53	1.15
15	Iron (mg/l)	0.38	0.37
16	Total Coliforms, (CFU/100ml)	A	200
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The Turbidity and TA of groundwater sample is above the acceptable limit. The bacteriological analysis of the Tap water sample showed the presence of Total Coliforms.

Table 3.11 Ward 9- Chakkamadom

SL.No	PARAMETERS	SAMPLE CODE	
		CH136T (Tap water)	CH131G (Ground water)
1	pH	7.66	6.71
2	Temperature (^{0}C)	28.5	28.6
3	Turbidity,(NTU)	1.2	0.8
4	Electrical Conductivity(µS/cm)	61.9	420
5	Salinity (ppt)	0.03	0.19
6	Total Dissolved Solids,(mg/l)	43.9	297
7	Total Hardness,(mg/l)	31.68	178.2
8	Total Alkalinity,(mg/l)	18.6	126.48
9	Chloride ,(mg/l)	7.91	23.73
10	Sulphate,(mg/l)	1.92	19.16
11	Calcium,(mg/l)	11.08	53.85
12	Magnesium,(mg/l)	0.96	10.58
13	Sodium(mg/l)	2.91	16.1
14	Potassium,(mg/l)	1.21	5.87
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	2400	1400
17	E.coli,(CFU/100ml)	A	100

BDL: Below Detection Limit

The turbidity of tap water sample was above the acceptable limit. The bacteriological analysis of the Tap water and groundwater sample reported the presence of Total Coliforms. The groundwater sample had the presence of E.*coli*.

Table 3.12 Ward 10- Karuvelippady

SL.No	PARAMETERS	SAMPLE CODE	
		CH130T (Tap water)	CH129T (Tap water)
1	pH	7.27	6.8
2	Temperature (^{0}C)	28.6	28.5
3	Turbidity,(NTU)	1.1	1.2
4	Electrical Conductivity(µS/cm)	74.3	82
5	Salinity (ppt)	0.03	0.04
6	Total Dissolved Solids,(mg/l)	52.8	56.7

7	Total Hardness,(mg/l)	23.76	23.76
8	Total Alkalinity,(mg/l)	33.48	26.04
9	Chloride ,(mg/l)	11.86	7.91
10	Sulphate,(mg/l)	2.64	3.12
11	Calcium,(mg/l)	6.33	6.33
12	Magnesium,(mg/l)	1.92	1.92
13	Sodium(mg/l)	3.92	5.49
14	Potassium,(mg/l)	1.23	1.7
15	Iron (mg/l)	BDL	0.06
16	Total Coliforms, (CFU/100ml)	900	3900
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity of both the tap water samples was above the acceptable limit. The bacteriological analysis of the Tap water samples showed the presence of Total Coliforms.

Table 3.13 Ward 11- Thoppumpady

SL.No	PARAMETERS	SAMPLE CODE	
		CH120G (Ground water)	**CH124T (Tap water)**
1	pH	8.24	8.4
2	Temperature (^{0}C)	29.4	29.5
3	Turbidity,(NTU)	0.9	1.3
4	Electrical Conductivity(µS/cm)	52.07	53.97
5	Salinity (ppt)	0.04	0.05
6	Total Dissolved Solids,(mg/l)	33.96	35.14
7	Total Hardness,(mg/l)	23.76	15.84
8	Total Alkalinity,(mg/l)	16.32	16.32
9	Chloride ,(mg/l)	14.37	12.31
10	Sulphate,(mg/l)	2.8	2.88
11	Calcium,(mg/l)	4.75	4.72
12	Magnesium,(mg/l)	2.88	0.98
13	Sodium(mg/l)	1.43	1.73
14	Potassium,(mg/l)	1.29	1.34
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	9300	400
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The Turbidity of Tap water sample is above the acceptable limit. The bacteriological analysis of the samples shows the presence of Total Coliforms. All other parameters are within the acceptable limit.

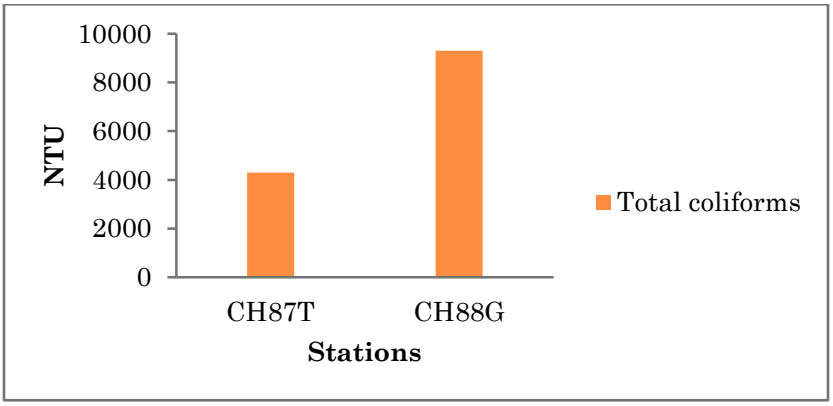

Fig 3.1 **Turbidity of collected water samples**

Table 3.15 Ward 12- Tharebhagam

SL.No	PARAMETERS	SAMPLE CODE		
		CH114T (Tap water)	**CH115T (Tap water)**	**CH121T (Tap water)**
1	pH	8.37	8.32	8.42
2	Temperature (^{0}C)	28.8	28.9	29.5
3	Turbidity,(NTU)	0.4	0.4	0.4
4	Electrical Conductivity(µS/cm)	72.24	51.28	74.51
5	Salinity (ppt)	0.06	0.04	0.06
6	Total Dissolved Solids,(mg/l)	47.09	33.41	48.42
7	Total Hardness,(mg/l)	31.68	23.76	31.68
8	Total Alkalinity,(mg/l)	20.4	16.32	24.48
9	Chloride ,(mg/l)	16.42	14.37	14.37
10	Sulphate,(mg/l)	6.16	2.44	6.4
11	Calcium,(mg/l)	9.50	4.75	7.92
12	Magnesium,(mg/l)	1.92	2.88	2.88
13	Sodium(mg/l)	2.12	1.69	1.67
14	Potassium,(mg/l)	1.06	1.46	1.37
15	Iron (mg/l)	BDL	BDL	BDL
16	Total Coliforms, (CFU/100ml)	7500	2800	900
17	E.*coli*,(CFU/100ml)	300	A	A

BDL: Below Detection Limit

All the tested physic chemical and biological parameters were within the acceptable limit. The bacteriological analysis of the samples showed the presence of Total Coliforms.

Table 3.16 Ward 13- Kadebhagam

SL.No	PARAMETERS	SAMPLE CODE
		CH104T (Tap water)
1	pH	7.73
2	Temperature (^{0}C)	28.6
3	Turbidity,(NTU)	1.6
4	Electrical Conductivity(µS/cm)	58.92
5	Salinity (ppt)	0.05
6	Total Dissolved Solids,(mg/l)	38.4
7	Total Hardness,(mg/l)	19.8
8	Total Alkalinity,(mg/l)	20.4
9	Chloride ,(mg/l)	18.47
10	Sulphate,(mg/l)	4.24
11	Calcium,(mg/l)	6.33
12	Magnesium,(mg/l)	0.96
13	Sodium(mg/l)	1.94
14	Potassium,(mg/l)	1.76
15	Iron (mg/l)	BDL
16	Total Coliforms, (CFU/100ml)	A
17	E.*coli*,(CFU/100ml)	A

BDL: Below Detection Limit

The turbidity of Tap water sample is above the acceptable limit. All other parameters were within the acceptable limit.

Table 3.17 Ward 14- Thazhuppu

SL.No	PARAMETERS	SAMPLE CODE
		CH103T (Tap water)
1	pH	7.24
2	Temperature (^{0}C)	29.1
3	Turbidity,(NTU)	0.7
4	Electrical Conductivity(µS/cm)	101.4
5	Salinity (ppt)	0.08
6	Total Dissolved Solids,(mg/l)	65.93
7	Total Hardness,(mg/l)	23.76
8	Total Alkalinity,(mg/l)	20.4
9	Chloride ,(mg/l)	20.53
10	Sulphate,(mg/l)	4.96
11	Calcium,(mg/l)	6.33
12	Magnesium,(mg/l)	1.92
13	Sodium(mg/l)	2.42
14	Potassium,(mg/l)	1.11
15	Iron (mg/l)	BDL
16	Total Coliforms, (CFU/100ml)	1500
17	E.coli,(CFU/100ml)	A

BDL: Below Detection Limit

All the physicochemical parameters were within the acceptable limit. The bacteriological analysis of the Tap sample showed the presence of Total Coliforms.

Table 3.18 Ward 15- Edakochi North

SL.No	PARAMETERS	SAMPLE CODE	
		CH97G (Ground water)	CH98T (Tap water)
1	pH	6.88	7.95
2	Temperature (^{0}C)	28.5	28.4
3	Turbidity,(NTU)	BDL	1.2
4	Electrical Conductivity(µS/cm)	391.7	66.16
5	Salinity (ppt)	0.39	0.06
6	Total Dissolved Solids,(mg/l)	296	43.04
7	Total Hardness,(mg/l)	122.76	19.8
8	Total Alkalinity,(mg/l)	138.72	20.4

9	Chloride ,(mg/l)	94.43	16.42
10	Sulphate,(mg/l)	15.44	5.08
11	Calcium,(mg/l)	47.52	6.33
12	Magnesium,(mg/l)	0.96	0.96
13	Sodium(mg/l)	36.4	2.86
14	Potassium,(mg/l)	7.7	1.08
15	Iron (mg/l)	0.5	0.49
16	Total Coliforms, (CFU/100ml)	400	9300
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity of Tap water sample was above the acceptable limit. The bacteriological analysis of the samples show the presence of Total Coliforms in groundwater as well as tap water sample and tap water sample contains high count of Total Coliforms.

Table 3.19 Ward 16- Edakochi South

SL.No	PARAMETERS	SAMPLE CODE	
		CH95T (Tap water)	CH96G (Ground water)
1	pH	7.85	7.02
2	Temperature (^{0}C)	28.7	28.7
3	Turbidity,(NTU)	0.8	5.1
4	Electrical Conductivity(µS/cm)	65.16	1045
5	Salinity (ppt)	0.05	1.10
6	Total Dissolved Solids,(mg/l)	42.5	790
7	Total Hardness,(mg/l)	23.76	332.64
8	Total Alkalinity,(mg/l)	24.48	424.32
9	Chloride ,(mg/l)	18.47	172.45
10	Sulphate,(mg/l)	5.04	34.28
11	Calcium,(mg/l)	6.33	104.54
12	Magnesium,(mg/l)	1.92	17.32
13	Sodium(mg/l)	2.94	89.6
14	Potassium,(mg/l)	2.22	44
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	4300	9300
17	E.*coli*,(CFU/100ml)	A	100

BDL: Below Detection Limit

Turbidity, TDS, TH, TA and Ca of groundwater sample was above the acceptable limit. Except Total coliforms, all other tested parameters in the tap water were with in the acceptable limit.

Table 3. 20 Ward 17- Perumbadappu

SL.No	PARAMETERS	SAMPLE CODE	
		CH99T (Tap water)	CH100T (Tap water)
1	pH	8.02	8.34
2	Temperature (^{0}C)	28.5	28.4
3	Turbidity,(NTU)	1.5	0.9
4	Electrical Conductivity(µS/cm)	63.18	64.9
5	Salinity (ppt)	0.05	0.05
6	Total Dissolved Solids,(mg/l)	41.06	42.19
7	Total Hardness,(mg/l)	27.72	23.76
8	Total Alkalinity,(mg/l)	20.4	20.4
9	Chloride ,(mg/l)	14.37	22.58
10	Sulphate,(mg/l)	4.36	5.2
11	Calcium,(mg/l)	4.75	7.92
12	Magnesium,(mg/l)	3.84	0.96
13	Sodium(mg/l)	2.46	2.76
14	Potassium,(mg/l)	1.16	2.64
15	Iron (mg/l)	0.26	BDL
16	Total Coliforms, (CFU/100ml)	900	7500
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity of one of the Tap water samples was above the acceptable limit. The bacteriological analysis of the tap water samples showed the presence of Total Coliforms tap water sample. All other parameters were within the acceptable limit.

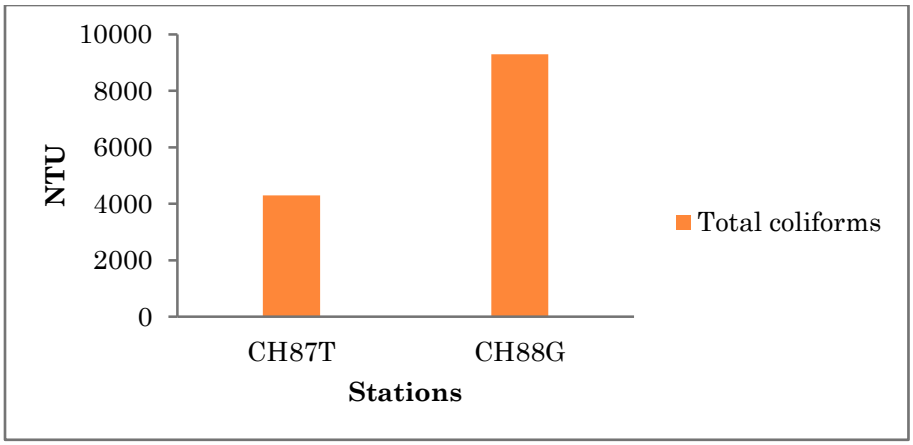

Fig 3.2 **Turbidity of collected water samples of ward 17**

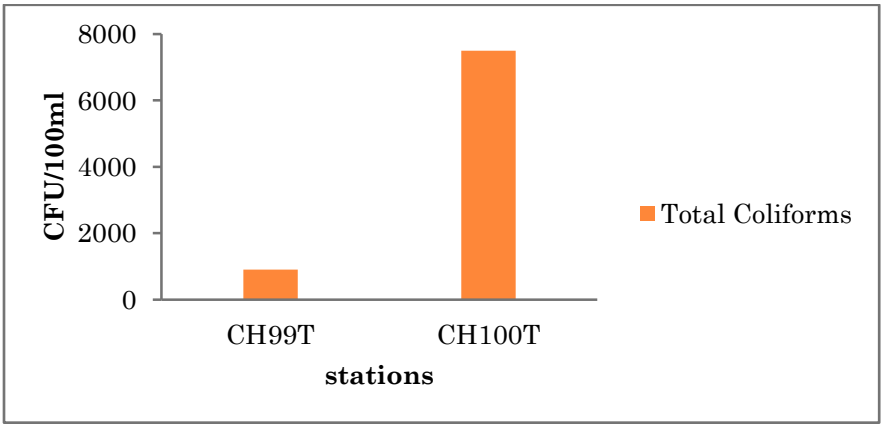

Fig 3.3 **Total coliforms of collected water samples of ward 17**

Table 3.21 Ward 18- Konam

SL.No	PARAMETERS	SAMPLE CODE	
		CH101T (Tap water)	**CH102G (Ground water)**
1	pH	8.13	7.18
2	Temperature (^{0}C)	28.4	28.4
3	Turbidity,(NTU)	1	8.4
4	Electrical Conductivity(µS/cm)	69.81	345.2
5	Salinity (ppt)	0.06	0.35

6	Total Dissolved Solids,(mg/l)	45.58	261
7	Total Hardness,(mg/l)	27.72	138.6
8	Total Alkalinity,(mg/l)	16.32	122.4
9	Chloride ,(mg/l)	16.42	41.06
10	Sulphate,(mg/l)	4.96	13.68
11	Calcium,(mg/l)	7.92	42.76
12	Magnesium,(mg/l)	1.92	7.69
13	Sodium(mg/l)	2.32	18.99
14	Potassium,(mg/l)	1.75	3.06
15	Iron (mg/l)	BDL	4.65
16	Total Coliforms, (CFU/100ml)	4300	9300
17	E.*coli*,(CFU/100ml)	A	A

BDL: Below Detection Limit

The Turbidity and Iron of groundwater samples were above the acceptable limit. The bacteriological analysis of the samples shows the presence of Total Coliforms in groundwater as well as tap water sample. All other parameters were within the acceptable limit.

Table 3.22 Ward 19- Palluruthy- Kacheripady

SL.No	PARAMETERS	SAMPLE CODE	
		CH122G (Ground water)	**CH123T (Tap water)**
1	pH	7.19	8.47
2	Temperature (^{0}C)	29.4	29.4
3	Turbidity,(NTU)	13	1.4
4	Electrical Conductivity(µS/cm)	1046	57.77
5	Salinity (ppt)	1.10	0.05
6	Total Dissolved Solids,(mg/l)	790.1	37.57
7	Total Hardness,(mg/l)	320.76	19.8
8	Total Alkalinity,(mg/l)	326.4	20.4
9	Chloride ,(mg/l)	131.39	14.37
10	Sulphate,(mg/l)	57.84	3.16
11	Calcium,(mg/l)	106.12	6.33
12	Magnesium,(mg/l)	13.47	0.96
13	Sodium(mg/l)	92.3	1.48
14	Potassium,(mg/l)	23.7	1.19

15	Iron (mg/l)	1.54	0.22
16	Total Coliforms, (CFU/100ml)	4300	1500
17	E.*coli*,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity of both sample are above the acceptable limit. TDS, TH, TA, Ca and iron of groundwater sample were above the acceptable limit. The bacteriological analysis of the samples showed the presence of Total Coliforms in groundwater as well as tap water sample. All other parameters were within the acceptable limit.

Table 3. Table 3.23 Ward 20- Nambyapuram

SL.No	PARAMETERS	SAMPLE CODE	
		CH117G (Ground water)	**CH125T (Tap water)**
1	pH	7.86	8.12
2	Temperature (^{0}C)	28.6	29.6
3	Turbidity,(NTU)	BDL	1.2
4	Electrical Conductivity(µS/cm)	838.4	58.23
5	Salinity (ppt)	0.88	0.05
6	Total Dissolved Solids,(mg/l)	634.1	37.92
7	Total Hardness,(mg/l)	245.52	23.76
8	Total Alkalinity,(mg/l)	285.6	16.32
9	Chloride ,(mg/l)	88.27	16.42
10	Sulphate,(mg/l)	43.36	3.88
11	Calcium,(mg/l)	87.12	7.92
12	Magnesium,(mg/l)	6.73	0.96
13	Sodium(mg/l)	86.9	1.53
14	Potassium,(mg/l)	21.3	1.15
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	900	3900
17	E.*coli*,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity of Tap water sample is above the acceptable limit. TDS, TH, TA and Ca of groundwater sample are above the acceptable limit. The bacteriological analysis of the samples shows the presence of Total Coliforms in groundwater as well as tap water sample. All other parameters were within the acceptable limit.

Table 3.24 Ward 21- Pulardesam

SL.No	PARAMETERS	SAMPLE CODE	
		CH116G (Ground water)	CH118T (Tap water)
1	pH	7.99	8.68
2	Temperature (^{0}C)	28.6	28.6
3	Turbidity,(NTU)	0.6	0.8
4	Electrical Conductivity(µS/cm)	981.9	65.32
5	Salinity (ppt)	1.03	0.05
6	Total Dissolved Solids,(mg/l)	742.6	42.59
7	Total Hardness,(mg/l)	344.52	23.76
8	Total Alkalinity,(mg/l)	420.24	4.08
9	Chloride ,(mg/l)	114.96	18.47
10	Sulphate,(mg/l)	16.08	3.64
11	Calcium,(mg/l)	88.70	6.33
12	Magnesium,(mg/l)	29.83	1.92
13	Sodium(mg/l)	64.7	1.71
14	Potassium,(mg/l)	39.2	1.4
15	Iron (mg/l)	0.3	BDL
16	Total Coliforms, (CFU/100ml)	2400	9300
17	E.*coli*,(CFU/100ml)	A	A

BDL: Below Detection Limit

The TDS, TH, TA, Ca of Groundwater samples was above the acceptable limit. The bacteriological analysis of the tap water and groundwater samples indicated the presence of Total Coliforms. All other parameters were within the acceptable limit.

Table 3.25 Ward 22- Mundamvelly

SL.No	PARAMETERS	SAMPLE CODE
		CH119T (Tap water)
1	pH	7.51
2	Temperature (^{0}C)	29.4
3	Turbidity,(NTU)	1
4	Electrical Conductivity(µS/cm)	134.4
5	Salinity (ppt)	0.1162
6	Total Dissolved Solids,(mg/l)	86.54

7	Total Hardness,(mg/l)	19.8
8	Total Alkalinity,(mg/l)	16.32
9	Chloride ,(mg/l)	14.371
10	Sulphate,(mg/l)	2.56
11	Calcium,(mg/l)	6.33
12	Magnesium,(mg/l)	0.96
13	Sodium(mg/l)	1.64
14	Potassium,(mg/l)	0.88
15	Iron (mg/l)	0.2
16	Total Coliforms, (CFU/100ml)	3900
17	E.coli,(CFU/100ml)	A

BDL: Below Detection Limit

The bacteriological analysis of the tap water sample shows the presence of Total Coliforms. All other parameters are within the acceptable limit.

Table 3.26 Ward 23- Manasserry

SL.No	PARAMETERS	SAMPLE CODE
		CH160T (Tap water)
1	pH	7.25
2	Temperature (^{0}C)	28
3	Turbidity,(NTU)	1
4	Electrical Conductivity(µS/cm)	60.9
5	Salinity (ppt)	0.03
6	Total Dissolved Solids,(mg/l)	43.3
7	Total Hardness,(mg/l)	23.29
8	Total Alkalinity,(mg/l)	16
9	Chloride ,(mg/l)	10.28
10	Sulphate,(mg/l)	19.2
11	Calcium,(mg/l)	6.21
12	Magnesium,(mg/l)	1.89
13	Sodium(mg/l)	4.7
14	Potassium,(mg/l)	1.4
15	Iron (mg/l)	BDL
16	Total Coliforms, (CFU/100ml)	A
17	E.*coli*,(CFU/100ml)	A

BDL: Below Detection Limit

All parameters are within the acceptable limit.

Table 3.27 Ward 24- Moolamkuzhy

SL.No	PARAMETERS	SAMPLE CODE	
		CH147T (Tap water)	CH148G (Ground water)
1	pH	7.83	6.91
2	Temperature (^{0}C)	27.9	28
3	Turbidity,(NTU)	1.5	23.4
4	Electrical Conductivity(µS/cm)	59.2	412
5	Salinity (ppt)	0.031	0.176
6	Total Dissolved Solids,(mg/l)	42	292
7	Total Hardness,(mg/l)	15.84	174.24
8	Total Alkalinity,(mg/l)	11.16	156.24
9	Chloride ,(mg/l)	7.91	31.64
10	Sulphate,(mg/l)	3.04	14.4
11	Calcium,(mg/l)	4.75	58.6
12	Magnesium,(mg/l)	0.96	6.73
13	Sodium(mg/l)	3.38	14.54
14	Potassium,(mg/l)	1.26	3.35
15	Iron (mg/l)	BDL	2.28
16	Total Coliforms, (CFU/100ml)	A	700
17	E.*coli*,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity of both the samples was above the acceptable limit. The bacteriological analysis of the groundwater sample showed the presence of Total Coliforms. All other parameters were within the acceptable limit.

Table 3.28 Ward 25- Chullickal

SL.No	PARAMETERS	SAMPLE CODE
		CH149T (Tap water)
1	pH	7.85
2	Temperature (^{0}C)	28
3	Turbidity,(NTU)	BDL
4	Electrical Conductivity(µS/cm)	61.8
5	Salinity (ppt)	0.032

6	Total Dissolved Solids,(mg/l)	43.9
7	Total Hardness,(mg/l)	23.76
8	Total Alkalinity,(mg/l)	11.16
9	Chloride ,(mg/l)	7.91
10	Sulphate,(mg/l)	2.96
11	Calcium,(mg/l)	4.75
12	Magnesium,(mg/l)	2.88
13	Sodium(mg/l)	2.88
14	Potassium,(mg/l)	1.25
15	Iron (mg/l)	BDL
16	Total Coliforms, (CFU/100ml)	A
17	E.coli,(CFU/100ml)	A

BDL: Below Detection Limit

All parameters were within the acceptable limit.

Table 3.29 Ward 26- Nazareth

SL.No	PARAMETERS	SAMPLE CODE	
		CH150G (Ground water)	CH151T (Tap water)
1	pH	7.1	7.74
2	Temperature (^{0}C)	28.1	28.1
3	Turbidity,(NTU)	21.6	0.2
4	Electrical Conductivity(µS/cm)	199.8	61.1
5	Salinity (ppt)	0.08	0.03
6	Total Dissolved Solids,(mg/l)	142	43.3
7	Total Hardness,(mg/l)	63.36	23.76
8	Total Alkalinity,(mg/l)	52.08	14.88
9	Chloride ,(mg/l)	15.82	11.86
10	Sulphate,(mg/l)	3.72	2.72
11	Calcium,(mg/l)	22.17	6.33
12	Magnesium,(mg/l)	1.92	1.92
13	Sodium(mg/l)	8.03	2.59
14	Potassium,(mg/l)	3.3	1.29
15	Iron (mg/l)	1.01	BDL
16	Total Coliforms, (CFU/100ml)	400	A
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity and iron of groundwater samples was above the acceptable limit. The bacteriological analysis of the groundwater sample shows the presence of Total Coliforms. All other parameters are within the acceptable limit.

Table 3.30 Ward 27- Fort Kochi-veli

SL.No	PARAMETERS	SAMPLE CODE	
		CH152T (Tap water)	CH153G (Ground water)
1	pH	7.41	7.44
2	Temperature (^{0}C)	28	28
3	Turbidity,(NTU)	0.4	BDL
4	Electrical Conductivity(µS/cm)	62.1	668
5	Salinity (ppt)	0.03	0.28
6	Total Dissolved Solids,(mg/l)	44.2	474
7	Total Hardness,(mg/l)	27.72	261.36
8	Total Alkalinity,(mg/l)	14.88	234.36
9	Chloride ,(mg/l)	11.86	83.07
10	Sulphate,(mg/l)	2.72	3.12
11	Calcium,(mg/l)	4.75	63.36
12	Magnesium,(mg/l)	3.84	25.01
13	Sodium(mg/l)	2.53	26.84
14	Potassium,(mg/l)	1.29	8.84
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	100	A
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The TA and TH of the groundwater sample were above the acceptable limit. The bacteriological analysis of the tap water sample showed the presence of Total Coliforms. All other parameters were within the acceptable limit.

Table 3.31 Ward 28- Amaravathy

SL.No	PARAMETERS	SAMPLE CODE	
		CH155T (Tap water)	CH157G (Ground water)
1	pH	8.1	6.56
2	Temperature (^{0}C)	27.9	28
3	Turbidity,(NTU)	0.3	BDL
4	Electrical Conductivity(µS/cm)	61	568
5	Salinity (ppt)	0.03	0.24
6	Total Dissolved Solids,(mg/l)	43.3	403
7	Total Hardness,(mg/l)	27.72	297
8	Total Alkalinity,(mg/l)	18.6	100.44
9	Chloride ,(mg/l)	11.86	75.16
10	Sulphate,(mg/l)	2.52	29.8
11	Calcium,(mg/l)	3.16	53.85
12	Magnesium,(mg/l)	4.81	39.45
13	Sodium(mg/l)	2.51	28.24
14	Potassium,(mg/l)	1.17	18.41
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	A	A
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The TH of the Groundwater sample was above the acceptable limit. All other parameters were within the acceptable limit.

Table 3.32 Ward 29- Island North

SL.No	PARAMETERS	SAMPLE CODE	
		CH143T (Tap water)	CH144G (Ground water)
1	pH	8.01	7.13
2	Temperature (^{0}C)	28	28
3	Turbidity (NTU)	0.1	4.2
4	Electrical Conductivity (µS/cm)	64	3760
5	Salinity (ppt)	0.03	1.71
6	Total Dissolved Solids (mg/l)	45.7	2650
7	Total Hardness (mg/l)	15.84	633.6
8	Total Alkalinity,(mg/l)	14.88	100.44

9	Chloride ,(mg/l)	11.86	1578.44
10	Sulphate,(mg/l)	2.64	67.2
11	Calcium,(mg/l)	3.16	158.4
12	Magnesium,(mg/l)	1.92	57.73
13	Sodium(mg/l)	3.45	535.4
14	Potassium,(mg/l)	1.41	26
15	Iron (mg/l)	BDL	0.4
16	Total Coliforms, (CFU/100ml)	A	A
17	E.*coli*,(CFU/100ml)	A	A

BDL: Below Detection Limit

The Turbidity, TDS, TH, Chloride and Ca of groundwater sample were above the acceptable limit. All other parameters were within the acceptable limit.

Table 3.33 Ward 30- Island South

SL.No	PARAMETERS	SAMPLE CODE	
		CH145T (Tap water)	**CH146G (Ground water)**
1	pH	7.45	8
2	Temperature (^{0}C)	27.9	27.9
3	Turbidity,(NTU)	0.1	1.1
4	Electrical Conductivity(µS/cm)	59.8	504
5	Salinity (ppt)	0.03	0.21
6	Total Dissolved Solids,(mg/l)	42.5	359
7	Total Hardness,(mg/l)	19.8	217.8
8	Total Alkalinity,(mg/l)	18.6	193.44
9	Chloride ,(mg/l)	7.91	27.69
10	Sulphate,(mg/l)	2.56	15.6
11	Calcium,(mg/l)	6.33	63.36
12	Magnesium,(mg/l)	0.96	14.43
13	Sodium, (mg/l)	2.84	15.17
14	Potassium,(mg/l)	1.39	5.81
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	A	A
17	E.*coli*, (CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity and TH of the groundwater sample were above the acceptable limit. All other parameters were within the acceptable limit.

Table 3.34 Ward 31- Vaduthala West

SL.No	PARAMETERS	SAMPLE CODE		
		CH60G (Ground water)	**CH64T** (Tap water)	**CH66T** (Tap water)
1	pH	7.41	7.75	7.46
2	Temperature (^{0}C)	28.8	28.7	7.46
3	Turbidity,(NTU)	0.9	3.2	5
4	Electrical Conductivity(µS/cm)	93.52	75.19	55.95
5	Salinity (ppt)	0.08	0.06	0.05
6	Total Dissolved Solids,(mg/l)	60.79	48.92	36.45
7	Total Hardness,(mg/l)	36.36	32.32	28.28
8	Total Alkalinity,(mg/l)	28	16	16
9	Chloride ,(mg/l)	17.99	19.99	17.99
10	Sulphate,(mg/l)	6.64	8.56	8.36
11	Calcium,(mg/l)	11.31	8.08	9.69
12	Magnesium,(mg/l)	1.96	2.94	0.98
13	Sodium(mg/l)	27.81	27.99	27.81
14	Potassium,(mg/l)	19.33	20.07	20.17
15	Iron (mg/l)	BDL	BDL	BDL
16	Total Coliforms, (CFU/100ml)	6400	7500	9300
17	E.*coli*,(CFU/100ml)	A	A	A

BDL: Below Detection Limit

The turbidity of Tap water samples were above the acceptable limit. The bacteriological analysis of the samples showed the presence of Total Coliforms. All other parameters were within the acceptable limit.

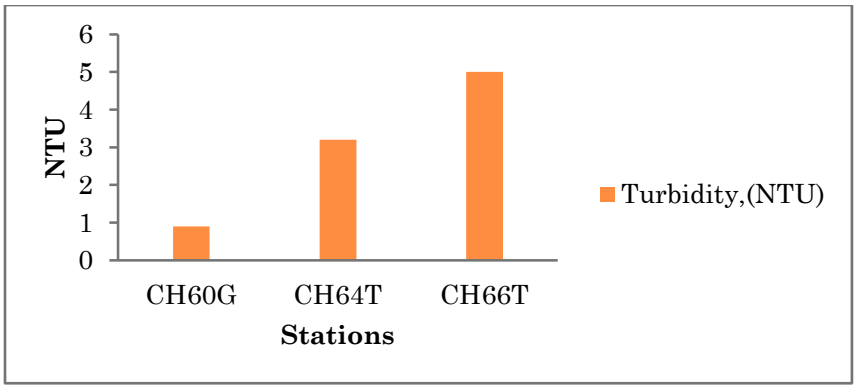

Fig 3.4 **Turbidity of collected water samples of ward 31**

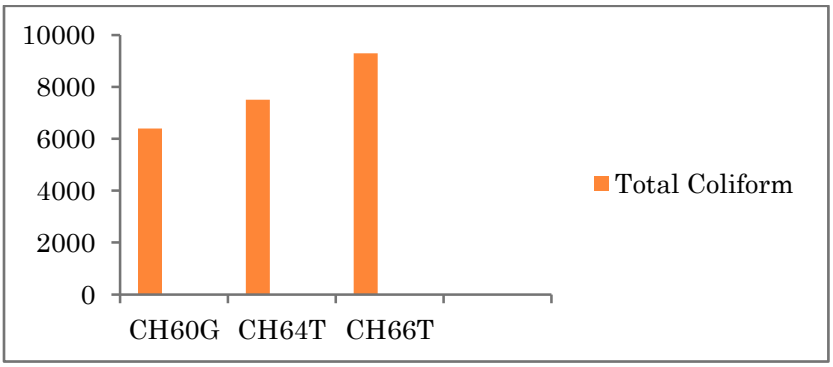

Fig 3.5 **Total coliform of collected water samples of ward 31**

Table 3.35 Ward 32- Vaduthala East

SL.No	PARAMETERS	SAMPLE CODE		
		CH67T (Tap water)	**CH68G** (Ground water)	**CH69T** (Tap water)
1	pH	7.24	6.93	7.43
2	Temperature (^{0}C)	28.5	28	27.8
3	Turbidity,(NTU)	4.7	1.3	5.8
4	Electrical Conductivity(µS/cm)	56.94	342.3	57.32
5	Salinity (ppt)	0.05	0.31	0.05
6	Total Dissolved Solids,(mg/l)	37.01	233.4	37.26
7	Total Hardness,(mg/l)	28.28	117.16	32.32

8	Total Alkalinity,(mg/l)	16	96	12
9	Chloride ,(mg/l)	15.99	35.98	15.99
10	Sulphate,(mg/l)	8.36	26.44	7.96
11	Calcium,(mg/l)	8.08	17.77	8.08
12	Magnesium,(mg/l)	1.96	17.67	2.94
13	Sodium(mg/l)	28.14	22.39	28.12
14	Potassium,(mg/l)	20.22	11.91	20.2
15	Iron (mg/l)	BDL	BDL	BDL
16	Total Coliforms, (CFU/100ml)	9300	9300	A
17	E.*coli*,(CFU/100ml)	A	A	A

BDL: Below Detection Limit

The turbidity of Tap water samples were above the acceptable limit. The bacteriological analysis of two samples indicated the presence of Total Coliforms. All other parameters were within the acceptable limit.

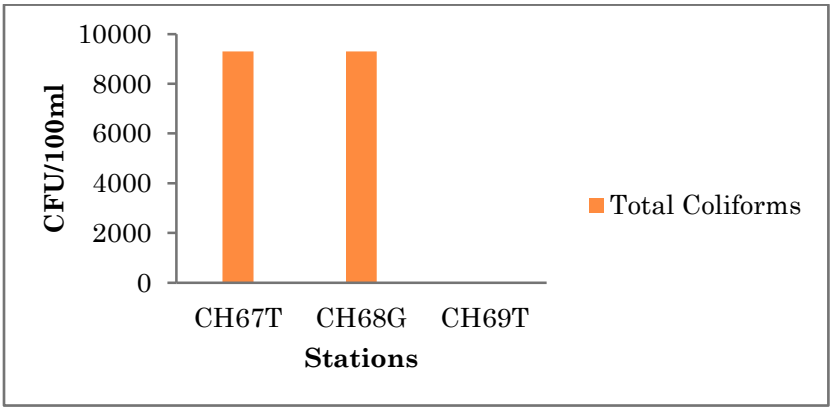

Fig 3.6 **Total coliform of collected water samples of ward 32**

Table 3.36 Ward 33- Elamakkara North

SL.No	PARAMETERS	SAMPLE CODE
		CH79T (Tap water)
1	pH	7.45
2	Temperature (^{0}C)	27.7
3	Turbidity,(NTU)	3.1
4	Electrical Conductivity(µS/cm)	66.15
5	Salinity (ppt)	0.06

6	Total Dissolved Solids,(mg/l)	43.09
7	Total Hardness,(mg/l)	24.24
8	Total Alkalinity,(mg/l)	12
9	Chloride ,(mg/l)	15.99
10	Sulphate,(mg/l)	8.84
11	Calcium,(mg/l)	8.08
12	Magnesium,(mg/l)	0.98
13	Sodium (mg/l)	28.1
14	Potassium,(mg/l)	20.12
15	Iron (mg/l)	BDL
16	Total Coliforms, (CFU/100ml)	A
17	E.*coli*, (CFU/100ml)	A

BDL: Below Detection Limit

The Turbidity of Tap water sample was above the acceptable limit. All other parameters were within the acceptable limit. The bacteriological analyses of the samples showed that the absence of Total Coliforms as well as E.*coli*.

Table 3.37 Ward 34- Puthukkalavattam

SL.No	PARAMETERS	SAMPLE CODE		
		CH76T (Tap water)	**CH77G** (Ground water)	**CH78T** (Tap water)
1	pH	7.29	6.58	7.4
2	Temperature (^{0}C)	27.7	27.7	27.8
3	Turbidity,(NTU)	3.1	0.7	1.7
4	Electrical Conductivity(µS/cm)	66.29	1014	75.02
5	Salinity (ppt)	0.06	0.96	0.06
6	Total Dissolved Solids,(mg/l)	43.05	691.1	48.8
7	Total Hardness,(mg/l)	24.24	238.36	44.44
8	Total Alkalinity,(mg/l)	16	64	20
9	Chloride ,(mg/l)	19.99	95.95	17.99
10	Sulphate,(mg/l)	7.6	46.56	10.2
11	Calcium,(mg/l)	8.08	90.49	9.69
12	Magnesium,(mg/l)	0.98	2.94	4.9
13	Sodium(mg/l)	28.05	259.5	28
14	Potassium,(mg/l)	20.1	183.7	20.07
15	Iron (mg/l)	BDL	BDL	BDL

16	Total Coliforms, (CFU/100ml)	100	A	6400
17	E.*coli*,(CFU/100ml)	A	A	A

BDL: Below Detection Limit

The turbidity of the two Tap water samples was above the acceptable limit. The bacteriological analysis of two Tap water samples showed the presence of Total Coliforms. All other parameters were within the acceptable limit.

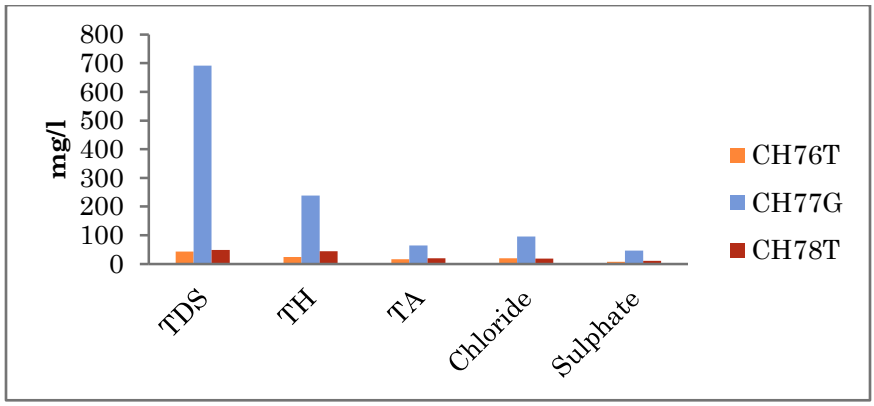

Fig 3.7 **Physicochemical parameters of collected water samples of ward 34**

Table 3.38 Ward 35- Ponekkara

SL.No	PARAMETERS	SAMPLE CODE	
		CH85T (Tap water)	**CH86T** (Tap water)
1	pH	7.43	7.39
2	Temperature (^{0}C)	27.8	28
3	Turbidity,(NTU)	1.5	4.2
4	Electrical Conductivity(µS/cm)	63.87	67.99
5	Salinity (ppt)	0.05	0.06
6	Total Dissolved Solids,(mg/l)	41.55	44.23
7	Total Hardness,(mg/l)	32.32	28.28
8	Total Alkalinity,(mg/l)	12	16
9	Chloride ,(mg/l)	13.99	15.99
10	Sulphate,(mg/l)	8.68	9.6
11	Calcium,(mg/l)	6.46	8.08
12	Magnesium,(mg/l)	3.92	1.96

13	Sodium(mg/l)	28.15	28.16
14	Potassium,(mg/l)	20.26	20.27
15	Iron (mg/l)	BDL	0.26
16	Total Coliforms, (CFU/100ml)	A	9300
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity of the two Tap water samples was above the acceptable limit (BIS). The bacteriological analysis of one of the tap water sample contains high count of Total Coliforms. All other parameters are within the acceptable limit.

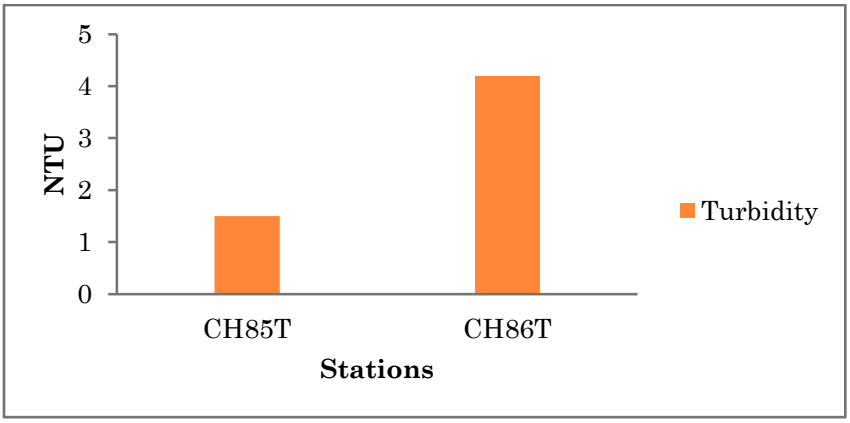

Fig 3.8 **Turbidity of collected water samples of ward 35**

Table 3.39 Ward 36- Kunnumpuram

SL.No	PARAMETERS	SAMPLE CODE	
		CH87T (Tap water)	**CH88G** (Ground water)
1	pH	7.56	7.01
2	Temperature (^{0}C)	27.9	28.1
3	Turbidity,(NTU)	2.9	0.9
4	Electrical Conductivity(µS/cm)	76.42	370.6
5	Salinity (ppt)	0.06	0.33
6	Total Dissolved Solids,(mg/l)	49.69	252.6
7	Total Hardness,(mg/l)	28.28	157.56
8	Total Alkalinity,(mg/l)	20	104
9	Chloride ,(mg/l)	17.99	25.98
10	Sulphate,(mg/l)	7.84	25.76

11	Calcium,(mg/l)	9.69	46.86
12	Magnesium,(mg/l)	0.98	9.81
13	Sodium(mg/l)	28.12	23.04
14	Potassium,(mg/l)	19.98	12.28
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	4300	9300
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The Turbidity of Tap water samples were above the acceptable limit. The bacteriological analysis of both the Tap water as well as Groundwater sample contains high count of Total Coliforms. All other parameters were within the acceptable limit

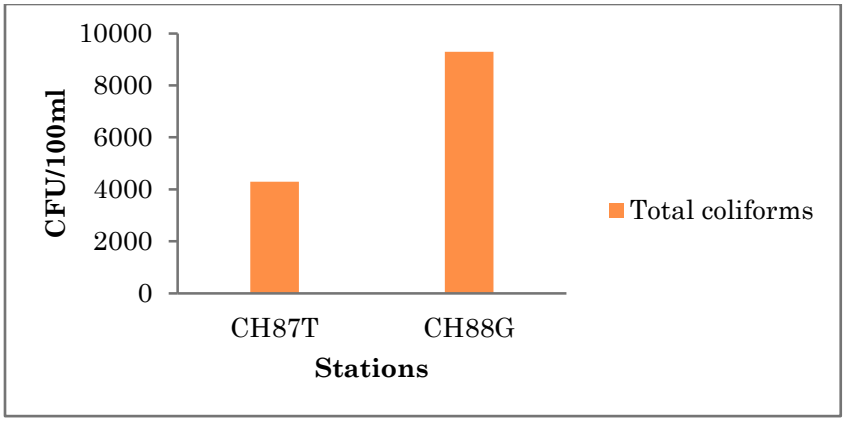

Fig 3.9 **Total coliform of collected water samples of ward 36**

Table 3.40 Ward 37- Edappally

SL.No	PARAMETERS	SAMPLE CODE		
		CH1G (Ground water)	**CH4T (Tap water)**	**CH5G (Ground water)**
1	pH	6.09	6.98	7.1
2	Temperature (^{0}C)	28.2	28.1	28.1
3	Turbidity,(NTU)	2.9	1.9	1.1
4	Electrical Conductivity(µS/cm)	272	46	544
5	Salinity (ppt)	0.125	0.0279	0.251
6	Total Dissolved Solids,(mg/l)	193	32.7	388
7	Total Hardness,(mg/l)	104.84	23.29	236.86

8	Total Alkalinity,(mg/l)	68	12	204
9	Chloride ,(mg/l)	26.72	8.22	41.12
10	Sulphate,(mg/l)	23.92	5.4	34.4
11	Calcium,(mg/l)	32.61	4.65	69.89
12	Magnesium,(mg/l)	5.66	2.83	15.09
13	Sodium(mg/l)	13.74	3.82	21.47
14	Potassium,(mg/l)	4.48	0.7	9.32
15	Iron (mg/l)	0.4	0.22	0.3
16	Total Coliforms, (CFU/100ml)	6400	A	900
17	E.*coli*, (CFU/100ml)	900	A	A

BDL: Below Detection Limit

Total hardness and Total Alkalinity of one of the groundwater samples was above the limit. The bacteriological analysis of both groundwater samples shows the presence of Total Coliforms. All other parameters were within the acceptable limit.

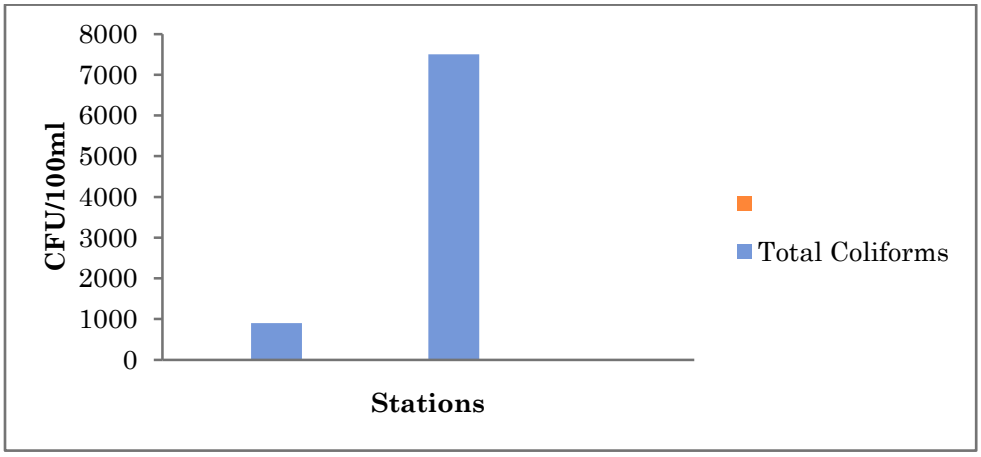

Fig 3.10 **Total coliform of collected water samples of ward 37**

Table 3.41 Ward 38- Dhevankulangara

SL.No	PARAMETERS	SAMPLE CODE			
		CH2T (Tap water)	**CH3G (Ground water)**	**CH34G (Ground water)**	**CH35G (Ground water)**
1	pH	6.54	6.81	7.24	7.14
2	Temperature (^{0}C)	28.1	28.2	28.1	28.2
3	Turbidity,(NTU)	2.1	131	1.1	1.8
4	Electrical Conductivity(µS/cm)	47.8	788	672	409

5	Salinity (ppt)	0.028	0.363	0.265	0.16
6	Total Dissolved Solids,(mg/l)	34	558	477	289
7	Total Hardness,(mg/l)	19.41	264.04	209.68	143.67
8	Total Alkalinity,(mg/l)	12	312	164	124
9	Chloride ,(mg/l)	8.22	61.68	69.9	37
10	Sulphate,(mg/l)	4.44	43.4	40.72	28.8
11	Calcium,(mg/l)	4.65	66.78	66.78	49.7
12	Magnesium,(mg/l)	1.88	23.59	10.38	4.71
13	Sodium(mg/l)	3.98	27.36	24.43	14.61
14	Potassium,(mg/l)	0.72	9.27	19.92	8.09
15	Iron (mg/l)	0.24	30	BDL	BDL
16	Total Coliforms, (CFU/100ml)	A	1500	2800	A
17	E.*coli*,(CFU/100ml)	A	A	A	A

BDL: Below Detection Limit

Total hardness and Total Alkalinity of two groundwater samples were above the limit. The groundwater sample CH3G had the presence of Iron and TDS of the sample was also above the acceptable limit. Tap water sample meets the drinking water quality standards.

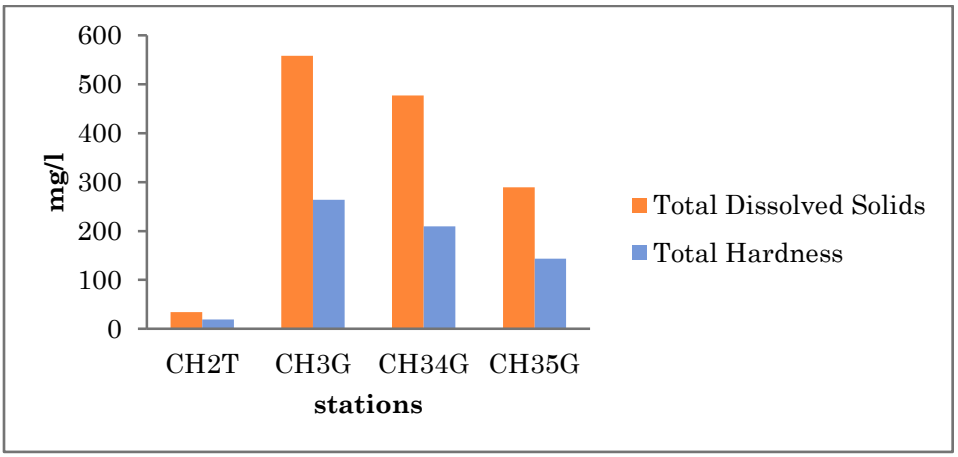

Fig 3.11 **TDS and TH of collected water samples of ward 38**

Table 3.42 Ward 39- Karukappilli

SL.No	PARAMETERS	SAMPLE CODE
		CH89T (Tap water)
1	pH	7.73
2	Temperature (^{0}C)	28.8
3	Turbidity,(NTU)	3.5
4	Electrical Conductivity(µS/cm)	71.54
5	Salinity (ppt)	0.06
6	Total Dissolved Solids,(mg/l)	46.43
7	Total Hardness,(mg/l)	24.24
8	Total Alkalinity,(mg/l)	16
9	Chloride ,(mg/l)	15.99
10	Sulphate,(mg/l)	7.64
11	Calcium,(mg/l)	4.84
12	Magnesium,(mg/l)	2.94
13	Sodium(mg/l)	28.14
14	Potassium,(mg/l)	20.05
15	Iron (mg/l)	BDL
16	Total Coliforms, (CFU/100ml)	9300
17	E.coli,(CFU/100ml)	A

BDL: Below Detection Limit

All physicochemical parameters were within the acceptable limit except turbidity. The bacteriological analysis of the samples showed the presence of Total Coliforms.

Table 3.43 Ward 40- Mamangalam

SL.No	PARAMETERS	SAMPLE CODE	
		CH83T (Tap water)	CH84T (Tap water)
1	pH	7.5	7.49
2	Temperature (^{0}C)	27.8	27.7
3	Turbidity,(NTU)	3.1	2.2
4	Electrical Conductivity(µS/cm)	59.64	67.83
5	Salinity (ppt)	0.05	0.06
6	Total Dissolved Solids,(mg/l)	38.7	44.02
7	Total Hardness,(mg/l)	28.28	28.28

8	Total Alkalinity,(mg/l)	12	16
9	Chloride ,(mg/l)	15.99	19.99
10	Sulphate,(mg/l)	9.56	8.08
11	Calcium,(mg/l)	6.46	9.69
12	Magnesium,(mg/l)	2.94	0.98
13	Sodium(mg/l)	28.29	28.15
14	Potassium,(mg/l)	20.29	20.17
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	9300	9300
17	E.*coli*,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity of the two Tap water samples was above the acceptable limit. The bacteriological analysis of the Tap water sample showed presence of Total Coliforms. All other parameters were within the acceptable limit.

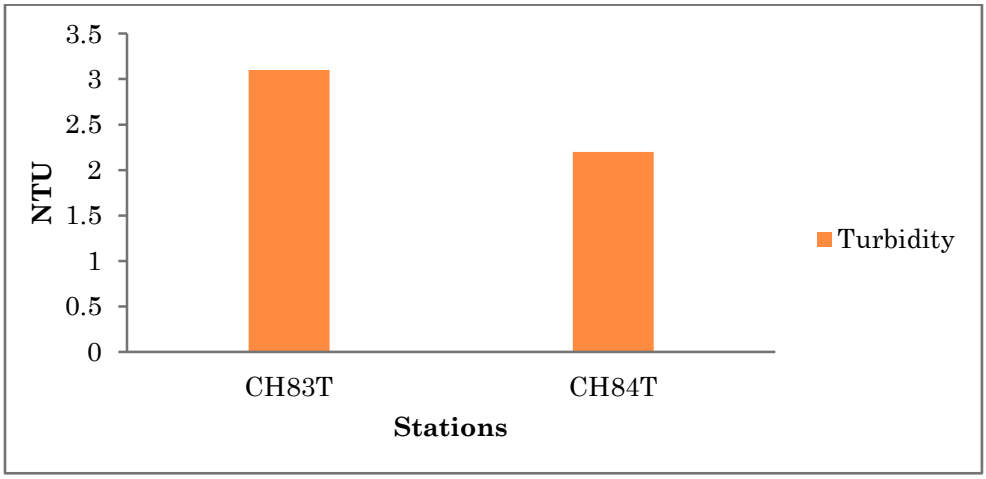

Fig 3.12 **Turbidity of collected water samples of ward 40**

Table 3.44 Ward 41- Padivattam

SL.No	PARAMETERS	SAMPLE CODE		
		CH52G (Groundwater)	CH53G (Groundwater)	CH54T (Tap water)
1	pH	7.06	6.66	7.48
2	Temperature (^{0}C)	28.2	28	28.1
3	Turbidity,(NTU)	2.4	9.6	2

4	Electrical Conductivity(µS/cm)	724.7	611.6	76.82
5	Salinity (ppt)	0.67	0.56	0.06
6	Total Dissolved Solids,(mg/l)	494	417.1	49.98
7	Total Hardness,(mg/l)	165.64	218.16	28.28
8	Total Alkalinity,(mg/l)	160	140	16
9	Chloride ,(mg/l)	29.98	63.96	19.99
10	Sulphate,(mg/l)	30.84	51.28	9.32
11	Calcium,(mg/l)	59.79	58.17	9.69
12	Magnesium,(mg/l)	3.92	17.67	0.98
13	Sodium(mg/l)	28.05	38.95	27.82
14	Potassium,(mg/l)	10.87	15.14	20.3
15	Iron (mg/l)	BDL	0.55	BDL
16	Total Coliforms, (CFU/100ml)	4300	1400	9300
17	E.*coli*,(CFU/100ml)	A	A	A

BDL: Below Detection Limit

The turbidity of all the water samples was above the acceptable limit. The bacteriological analysis of the water samples indicated the presence of Total Coliforms, especially in Tap water sample. All other parameters were within the acceptable limit.

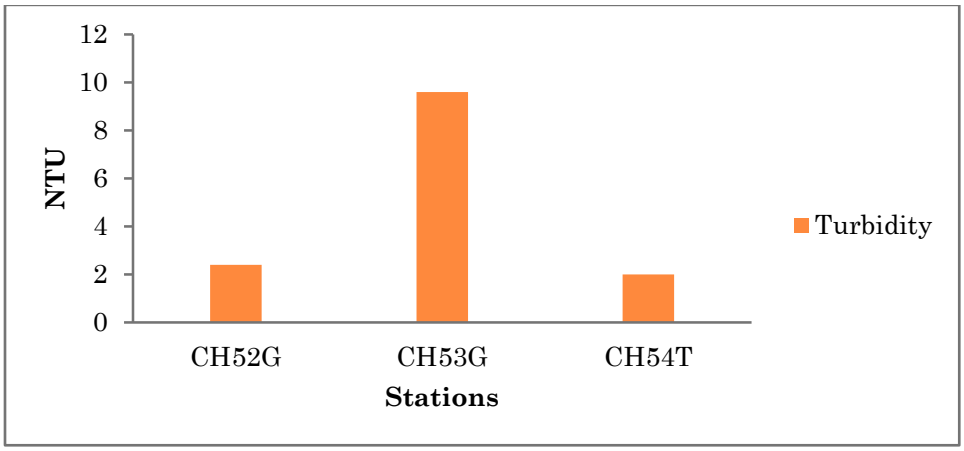

Fig 3.13 **Turbidity of collected water samples of ward 41**

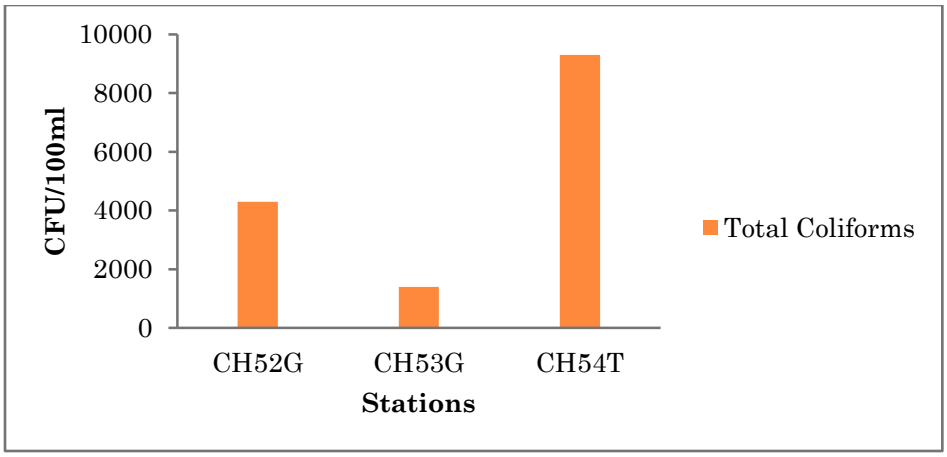

Fig 3.14 **Total coliform of collected water samples of ward 40**

Table 3.45 Ward 42- Vennala

SL.No	PARAMETERS	SAMPLE CODE	
		CH17G (Groundwater)	CH55G (Groundwater)
1	pH	6.45	7.08
2	Temperature (^{0}C)	28.5	28.1
3	Turbidity,(NTU)	BDL	0.6
4	Electrical Conductivity(µS/cm)	51.2	273.9
5	Salinity (ppt)	0.03	0.24
6	Total Dissolved Solids,(mg/l)	36.4	186.7
7	Total Hardness,(mg/l)	7.76	105.04
8	Total Alkalinity,(mg/l)	20	88
9	Chloride ,(mg/l)	8.22	19.99
10	Sulphate,(mg/l)	2.4	27.12
11	Calcium,(mg/l)	3.1	37.16
12	Magnesium,(mg/l)	BDL	2.94
13	Sodium(mg/l)	8.18	23.19
14	Potassium,(mg/l)	1	15.06
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	200	9300
17	E.*coli*,(CFU/100ml)	A	A

BDL: Below Detection Limit

All parameters were within the acceptable limit except bacteriological analysis. Both the groundwater samples showed the presence of Total Coliforms.

Table 3.46 Ward 43- Palarivattam

SL.No	PARAMETERS	SAMPLE CODE	
		CH50T (Tap water)	CH51G (Groundwater)
1	pH	6.92	6.78
2	Temperature (^{0}C)	29	28.9
3	Turbidity,(NTU)	9.5	1.3
4	Electrical Conductivity(µS/cm)	57.17	367.6
5	Salinity (ppt)	0.05	0.33
6	Total Dissolved Solids,(mg/l)	37.15	250.6
7	Total Hardness,(mg/l)	28.28	129.28
8	Total Alkalinity,(mg/l)	12	112
9	Chloride ,(mg/l)	15.99	31.98
10	Sulphate,(mg/l)	7.36	26.76
11	Calcium,(mg/l)	9.69	45.24
12	Magnesium,(mg/l)	0.98	3.92
13	Sodium(mg/l)	27.58	21.47
14	Potassium,(mg/l)	20.13	11.85
15	Iron (mg/l)	0.61	BDL
16	Total Coliforms, (CFU/100ml)	6400	9300
17	E.*coli*, (CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity of all the water samples was above the acceptable limit, especially in the case of Tap water. The bacteriological analysis of the water samples showed presence of Total Coliforms.

Table 3.47 Ward 44- Karanakkodam

SL.No	PARAMETERS	SAMPLE CODE	
		CH93T (Tap water)	CH94T (Tap water)
1	pH	7.65	7.76
2	Temperature (^{0}C)	28.9	28.7
3	Turbidity,(NTU)	8	1.2
4	Electrical Conductivity(µS/cm)	70.19	62.39
5	Salinity (ppt)	0.06	0.05
6	Total Dissolved Solids,(mg/l)	45.83	40.47
7	Total Hardness,(mg/l)	23.76	23.76

8	Total Alkalinity,(mg/l)	20.4	16.32
9	Chloride ,(mg/l)	12.31	16.42
10	Sulphate,(mg/l)	5.12	4.92
11	Calcium,(mg/l)	7.92	7.92
12	Magnesium,(mg/l)	0.96	0.96
13	Sodium(mg/l)	2.57	3.28
14	Potassium,(mg/l)	1.21	2.1
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	1500	2800
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The Turbidity of one of the tap water samples was above the acceptable limit. The bacteriological analysis of the water samples showed the presence of Total Coliforms. All other parameters were within the acceptable limit.

Table 3.48 Ward 45- Thammanam

SL.No	PARAMETERS	SAMPLE CODE			
		CH7G (Ground water)	CH8G (Ground water)	CH9T (Tap water)	CH10T (Tap water)
1	pH	7.26	6.24	6.67	6.4
2	Temperature (^{0}C)	28.1	28.2	28.3	28.3
3	Turbidity,(NTU)	0.4	3.8	2	1.4
4	Electrical Conductivity(µS/cm)	400	136.6	46.8	58.1
5	Salinity (ppt)	0.18	0.06	0.02	0.03
6	Total Dissolved Solids,(mg/l)	284	97	33.3	41.3
7	Total Hardness,(mg/l)	151.43	54.36	19.41	27.18
8	Total Alkalinity,(mg/l)	136	52	8	16
9	Chloride ,(mg/l)	24.67	8.22	10.28	6.16
10	Sulphate,(mg/l)	31	12.8	3.56	4.64
11	Calcium,(mg/l)	49.7	20.18	6.21	9.31
12	Magnesium,(mg/l)	6.6	0.94	0.94	1.88
13	Sodium(mg/l)	15.33	6.33	4.34	4.14
14	Potassium,(mg/l)	6.38	0.97	0.87	0.82
15	Iron (mg/l)	BDL	0.22	0.28	BDL
16	Total Coliforms, (CFU/100ml)	900	300	A	A
17	E.coli,(CFU/100ml)	A	A	A	A

BDL: Below Detection Limit

In one of the Tap water samples pH was below the acceptable limit. Among the 4 samples, the turbidity of three water samples were above the acceptable limit. The bacteriological analysis Groundwater sample showed the presence of Total Coliforms. All other parameters were within the acceptable limit.

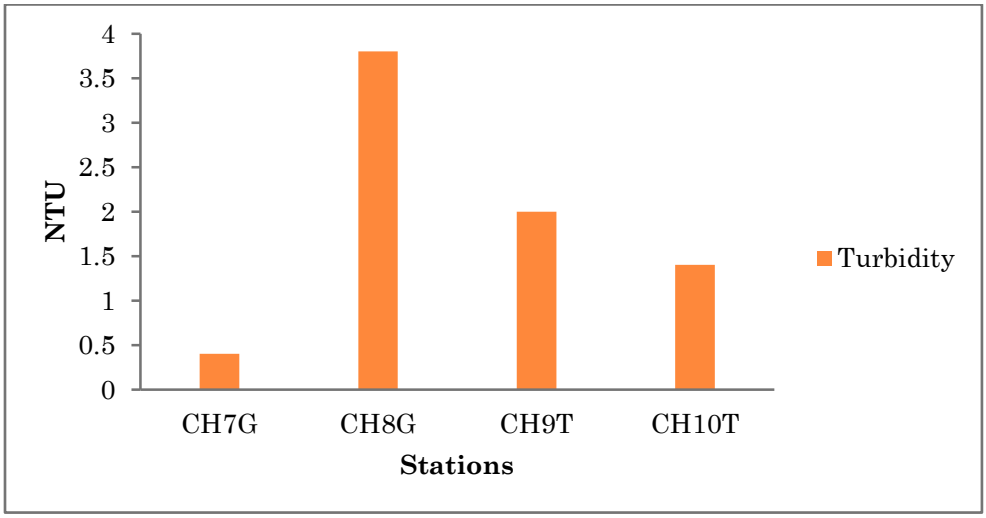

Fig 3.15 **Turbidity of collected water samples of ward 45**

Table 3.49 Ward 46- Chakkaraparambu

SL.No	PARAMETERS	SAMPLE CODE		
		CH12G (Groundwater)	CH15G (Groundwater)	CH16G (Groundwater)
1	pH	6.52	7.19	6.8
2	Temperature (^{0}C)	28.2	28.5	28.4
3	Turbidity,(NTU)	6.2	2.4	0.5
4	Electrical Conductivity(µS/cm)	466	72.2	193.1
5	Salinity (ppt)	0.21	0.03	0.09
6	Total Dissolved Solids,(mg/l)	331	51.3	137
7	Total Hardness,(mg/l)	194.15	23.29	73.77
8	Total Alkalinity,(mg/l)	96	16	48
9	Chloride ,(mg/l)	34.95	8.22	14.39
10	Sulphate,(mg/l)	76.52	9.44	21.24
11	Calcium,(mg/l)	63.68	7.76	26.4
12	Magnesium,(mg/l)	8.49	0.94	1.88
13	Sodium(mg/l)	18.67	4.87	7.82
14	Potassium,(mg/l)	4.74	1.09	3.23

15	Iron (mg/l)	BDL	BDL	BDL
16	Total Coliforms, (CFU/100ml)	A	A	100
17	E.coli,(CFU/100ml)	A	A	A

BDL: Below Detection Limit

The turbidity of two groundwater samples was above the acceptable limit. The bacteriological analysis of one of the groundwater samples showed the presence of Total Coliforms.

Table 3.50 Ward 47- Chalikkavattam

SL.No	PARAMETERS	SAMPLE CODE	
		CH11G (Groundwater)	CH14T (Tap water)
1	pH	7.15	6.53
2	Temperature (^{0}C)	28.3	28.2
3	Turbidity,(NTU)	13	BDL
4	Electrical Conductivity(µS/cm)	565	534
5	Salinity (ppt)	0.25	0.24
6	Total Dissolved Solids,(mg/l)	401	379
7	Total Hardness,(mg/l)	217.44	128.13
8	Total Alkalinity,(mg/l)	260	116
9	Chloride ,(mg/l)	39.06	63.73
10	Sulphate,(mg/l)	17.12	26.6
11	Calcium,(mg/l)	71.44	45.04
12	Magnesium,(mg/l)	9.43	3.77
13	Sodium(mg/l)	32.65	33.09
14	Potassium,(mg/l)	5.31	6.13
15	Iron (mg/l)	1.17	BDL
16	Total Coliforms, (CFU/100ml)	200	200
17	E.*coli*,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity, Iron, TH and TA of groundwater sample were above the acceptable limit. The bacteriological analysis of all the samples showed the presence of Total Coliforms. All other physico chemical parameters were within the acceptable limit.

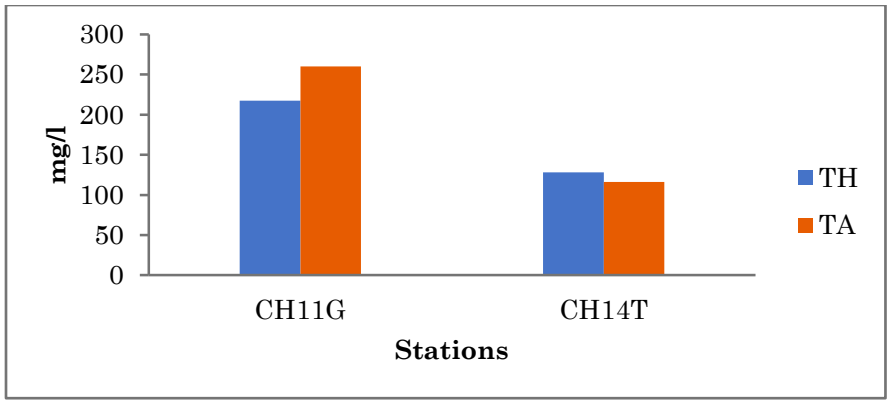

Fig 3.16 **TH and TA of collected water samples of ward 47**

Table 3.51 Ward 48- Ponnurunni East

SL.No	PARAMETERS	SAMPLE CODE	
		CH110T (Tap water)	CH111G (Groundwater)
1	pH	8.33	7.29
2	Temperature (^{0}C)	28.6	28.6
3	Turbidity,(NTU)	0.6	21.4
4	Electrical Conductivity(µS/cm)	67.75	543.8
5	Salinity (ppt)	0.06	0.56
6	Total Dissolved Solids,(mg/l)	44.12	411.6
7	Total Hardness,(mg/l)	23.76	205.92
8	Total Alkalinity,(mg/l)	20.4	228.48
9	Chloride ,(mg/l)	16.42	43.11
10	Sulphate,(mg/l)	4.96	17.96
11	Calcium,(mg/l)	7.92	71.28
12	Magnesium,(mg/l)	0.96	6.7
13	Sodium(mg/l)	2.97	13.6
14	Potassium,(mg/l)	2.24	25.6
15	Iron (mg/l)	BDL	5.13
16	Total Coliforms, (CFU/100ml)	A	4300
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity, TH, TA and Iron of groundwater sample were above the acceptable limit. The bacteriological analysis of groundwater sample showed the presence of Total Coliforms. All other parameters were within the acceptable limit.

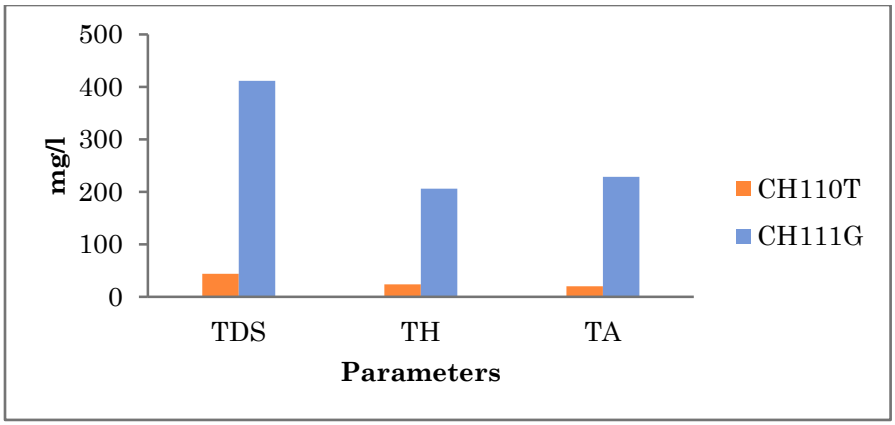

Fig 3.17 **TDS, TH, TA of collected water samples of ward 48**

Table 3.52 Ward 49- Vyttila

SL.No	PARAMETERS	SAMPLE CODE
		CH113T (Tap water)
1	pH	7.91
2	Temperature (^{0}C)	28.6
3	Turbidity,(NTU)	BDL
4	Electrical Conductivity(µS/cm)	259
5	Salinity (ppt)	0.26
6	Total Dissolved Solids,(mg/l)	195.9
7	Total Hardness,(mg/l)	130.68
8	Total Alkalinity,(mg/l)	110.16
9	Chloride ,(mg/l)	18.47
10	Sulphate,(mg/l)	15.88
11	Calcium,(mg/l)	47.52
12	Magnesium,(mg/l)	2.88
13	Sodium(mg/l)	4.92
14	Potassium,(mg/l)	3.15
15	Iron (mg/l)	BDL
16	Total Coliforms, (CFU/100ml)	100
17	E.*coli*,(CFU/100ml)	A

BDL: Below Detection Limit

All parameters were within the acceptable limit except Total Coliforms.

Table 3.53 Ward 50- Chambakkara

SL.No	PARAMETERS	SAMPLE CODE		
		CH37G (Groundwater)	CH41T (Tap water)	CH42G (Groundwater)
1	pH	7.83	8.11	7.89
2	Temperature (^{0}C)	28.3	28.3	28.4
3	Turbidity,(NTU)	3.5	4.2	1.3
4	Electrical Conductivity(µS/cm)	3020	69.6	1088
5	Salinity (ppt)	1.26	0.03	0.43
6	Total Dissolved Solids,(mg/l)	2130	49.1	772
7	Total Hardness,(mg/l)	563.03	19.41	213.56
8	Total Alkalinity,(mg/l)	220	16	236
9	Chloride ,(mg/l)	1398.08	26.72	244.66
10	Sulphate,(mg/l)	147.2	8.84	2.8
11	Calcium,(mg/l)	60.57	4.65	51.25
12	Magnesium,(mg/l)	100	1.88	20.75
13	Sodium(mg/l)	372.8	2.15	115.2
14	Potassium,(mg/l)	30.2	1.39	13.6
15	Iron (mg/l)	BDL	BDL	1.43
16	Total Coliforms, (CFU/100ml)	7500	A	A
17	E.*coli*,(CFU/100ml)	A	A	A

BDL: Below Detection Limit

The parameters such as TDS, TH and TA of both the groundwater samples were above the acceptable limit. Magnesium of one of the groundwater sample (CH37G) and Iron of CH42G were also above the acceptable limit. The bacteriological analysis of one of the groundwater samples (CH37G) showed high count of Total Coliforms.

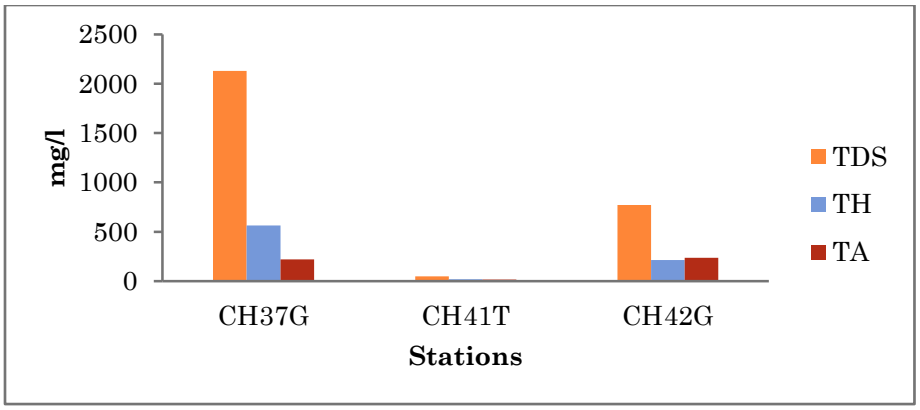

Fig 3.18 **TDS, TH, TA of collected water samples of ward 50**

Table 3.54 Ward 51- Poonithura

SL.No	PARAMETERS	SAMPLE CODE		
		CH38G (Groundwater)	CH39T (Tap water)	CH40G (Groundwater)
1	pH	8.27	7.86	7.78
2	Temperature (^{0}C)	28.5	28.5	28.3
3	Turbidity,(NTU)	3	3.2	1
4	Electrical Conductivity(µS/cm)	74	73	464
5	Salinity (ppt)	0.03	0.03	0.18
6	Total Dissolved Solids,(mg/l)	52.6	52.3	330
7	Total Hardness,(mg/l)	23.29	27.18	174.73
8	Total Alkalinity,(mg/l)	20	20	156
9	Chloride ,(mg/l)	22.61	12.33	41.12
10	Sulphate,(mg/l)	9.96	8.88	20.44
11	Calcium,(mg/l)	7.76	7.76	60.57
12	Magnesium,(mg/l)	0.94	1.88	5.66
13	Sodium(mg/l)	2.34	2.27	13.33
14	Potassium,(mg/l)	1.34	1.38	4.92
15	Iron (mg/l)	BDL	BDL	BDL
16	Total Coliforms, (CFU/100ml)	A	400	9300
17	E.*coli*,(CFU/100ml)	A	A	600

BDL: Below Detection Limit

The turbidity of two water samples was above the acceptable limit, especially Tap water sample. All other parameters were within the acceptable limit. The bacteriological

analysis of two samples groundwater as well as Tap water sample showed the presence of Total Coliforms and one of the groundwater sample showed the presence of E.*coli* also.

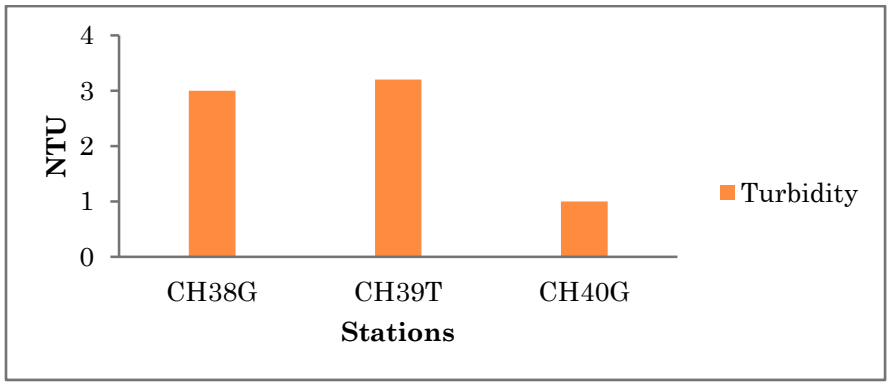

Fig 3.19 **Turbidity of collected water samples of ward 51**

Table 3.55 Ward 52- Vyttila Janatha

SL.No	PARAMETERS	SAMPLE CODE
		CH112T (Tap water)
1	pH	8.37
2	Temperature (^{0}C)	28.5
3	Turbidity,(NTU)	0.7
4	Electrical Conductivity(µS/cm)	62.73
5	Salinity (ppt)	0.05
6	Total Dissolved Solids,(mg/l)	40.83
7	Total Hardness,(mg/l)	27.72
8	Total Alkalinity,(mg/l)	20.4
9	Chloride ,(mg/l)	16.42
10	Sulphate,(mg/l)	4.28
11	Calcium,(mg/l)	6.33
12	Magnesium,(mg/l)	2.88
13	Sodium(mg/l)	2.03
14	Potassium,(mg/l)	1.67
15	Iron (mg/l)	BDL
16	Total Coliforms, (CFU/100ml)	900
17	E.*coli*,(CFU/100ml)	A

BDL: Below Detection Limit

All parameters were within the acceptable limit except Total Coliforms.

Table 3.56 Ward 53- Ponnurunni

SL.No	PARAMETERS	SAMPLE CODE
		CH109T (Tap water)
1	pH	8.18
2	Temperature (^{0}C)	28.8
3	Turbidity,(NTU)	0.7
4	Electrical Conductivity(µS/cm)	78.49
5	Salinity (ppt)	0.07
6	Total Dissolved Solids,(mg/l)	51.11
7	Total Hardness,(mg/l)	31.68
8	Total Alkalinity,(mg/l)	24.48
9	Chloride ,(mg/l)	18.47
10	Sulphate,(mg/l)	6.12
11	Calcium,(mg/l)	11.08
12	Magnesium,(mg/l)	0.96
13	Sodium(mg/l)	2.09
14	Potassium,(mg/l)	2.03
15	Iron (mg/l)	BDL
16	Total Coliforms, (CFU/100ml)	A
17	E.*coli*,(CFU/100ml)	A

BDL: Below Detection Limit

All parameters were within the acceptable limit.

Table 3.57 Ward 54- Elamkulam

SL.No	PARAMETERS	SAMPLE CODE	
		CH107G (Groundwater)	CH108T (Tap water)
1	pH	7.15	8.12
2	Temperature (^{0}C)	28.6	28.8
3	Turbidity,(NTU)	13.3	1
4	Electrical Conductivity(µS/cm)	419.7	56.63
5	Salinity (ppt)	0.42	0.05
6	Total Dissolved Solids,(mg/l)	317.2	36.92
7	Total Hardness,(mg/l)	126.72	23.76
8	Total Alkalinity,(mg/l)	106.08	16.32
9	Chloride ,(mg/l)	41.06	18.47

10	Sulphate,(mg/l)	19.56	2.72
11	Calcium,(mg/l)	44.35	3.16
12	Magnesium,(mg/l)	3.84	3.84
13	Sodium(mg/l)	19.32	1.91
14	Potassium,(mg/l)	8.13	0.85
15	Iron (mg/l)	1.27	0.2
16	Total Coliforms, (CFU/100ml)	9300	400
17	E.*coli*,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity and iron of groundwater sample were above the acceptable limit.The bacteriological analysis of both the water sample showed the presence of Total Coliforms.

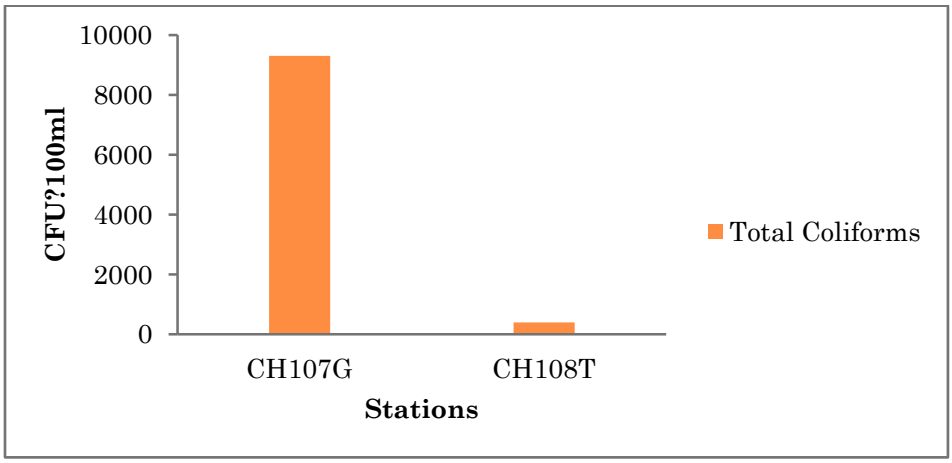

Fig 3.20 **Total coliforms of collected water samples of ward 54**

Table 3.58 Ward 55- Girinagar

SL.No	PARAMETERS	SAMPLE CODE		
		CH18G (Groundwater)	CH19G (Groundwater)	CH20T (Tap water)
1	pH	7.54	7.32	7.59
2	Temperature (^{0}C)	28.4	28.4	28.4
3	Turbidity,(NTU)	1.6	1.7	4.3
4	Electrical Conductivity(µS/cm)	1970	693	86.5
5	Salinity (ppt)	0.82	0.28	0.03
6	Total Dissolved Solids,(mg/l)	1400	502	61.8
7	Total Hardness,(mg/l)	481.49	260.16	27.18
8	Total Alkalinity,(mg/l)	696	276	24
9	Chloride ,(mg/l)	462.6	53.45	18.5
10	Sulphate,(mg/l)	40.2	36.92	11.8
11	Calcium,(mg/l)	48.14	100.95	7.76
12	Magnesium,(mg/l)	87.75	1.88	1.88
13	Sodium(mg/l)	254.4	33.95	4.6
14	Potassium,(mg/l)	53.4	16.1	1.58
15	Iron (mg/l)	BDL	0.23	BDL
16	Total Coliforms, (CFU/100ml)	A	4300	A
17	E.*coli*,(CFU/100ml)	A	A	A

BDL: Below Detection Limit

The parameters such as TDS, TH and TA of both the groundwater samples were above the acceptable limit. Chloride of one of the groundwater sample was also above the acceptable limit. The bacteriological analysis of one of the groundwater samples showed presence of Total Coliforms.

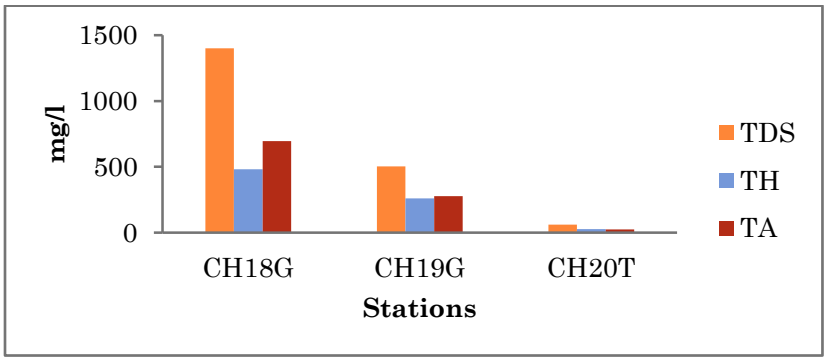

Fig 3.21 **TDS, TH and TA of collected water samples of ward 55**

Table 3.59 Ward 56- Panampilli Nagar

SL.No	PARAMETERS	SAMPLE CODE	
		CH21T (Tap water)	CH47G (Groundwater)
1	pH	7.55	6.68
2	Temperature (^{0}C)	28.4	28.7
3	Turbidity,(NTU)	3.3	142
4	Electrical Conductivity(µS/cm)	97.8	4420
5	Salinity (ppt)	0.04	1.82
6	Total Dissolved Solids,(mg/l)	67.8	3050
7	Total Hardness,(mg/l)	27.18	1211.49
8	Total Alkalinity,(mg/l)	24	136
9	Chloride,(mg/l)	18.5	2426.08
10	Sulphate,(mg/l)	10.96	153.2
11	Calcium,(mg/l)	9.31	177.06
12	Magnesium,(mg/l)	0.94	186.82
13	Sodium(mg/l)	3.4	590.4
14	Potassium,(mg/l)	1.48	39.6
15	Iron (mg/l)	BDL	7.6
16	Total Coliforms, (CFU/100ml)	A	1100
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The Turbidity of all the water samples was above the acceptable limit. The parameters such as TDS, TH, Mg, Chloride, and Calcium of groundwater samples were above the acceptable limit. The bacteriological analysis of the groundwater samples showed the presence of Total Coliforms.

Table 3.60 Ward 57- Kadavanthra

SL.No	PARAMETERS	SAMPLE CODE	
		CH48T (Tap water)	CH49G (Groundwater)
1	pH	7.49	7.33
2	Temperature (^{0}C)	28.7	28.7
3	Turbidity,(NTU)	2.4	13.6
4	Electrical Conductivity(µS/cm)	85	717
5	Salinity (ppt)	0.03	0.28

6	Total Dissolved Solids,(mg/l)	60.5	509
7	Total Hardness,(mg/l)	27.18	298.99
8	Total Alkalinity,(mg/l)	20	320
9	Chloride ,(mg/l)	22.61	82.24
10	Sulphate,(mg/l)	12.4	8.8
11	Calcium,(mg/l)	6.21	55.91
12	Magnesium,(mg/l)	2.83	38.68
13	Sodium(mg/l)	2.89	16.53
14	Potassium,(mg/l)	1.6	9.64
15	Iron (mg/l)	BDL	0.78
16	Total Coliforms, (CFU/100ml)	A	A
17	E.*coli*,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity of all the water samples was above the acceptable limit. The parameters such as TDS, TH, TA and Mg of groundwater sample were above the acceptable limit. Total Coliforms and E.*coli*. were absent in both samples.

Table 3.61 Ward 58- Konthuruthy

SL.No	PARAMETERS	SAMPLE CODE				
		CH26G (Ground water)	**CH27G (Ground water)**	**CH28G (Ground water)**	**CH29T (Tap water)**	**CH36G (Ground water)**
1	pH	7.83	7.59	7.22	8.02	7.48
2	Temperature (^{0}C)	28.2	28.1	28.1	28.3	28.2
3	Turbidity,(NTU)	0.9	12.8	3.8	5.6	3.4
4	Electrical Conductivity(µS/cm)	2.25	867	698	56.3	314
5	Salinity (ppt)	0.92	0.34	0.27	0.02	0.12
6	Total Dissolved Solids,(mg/l)	1590	616	490	39.9	223
7	Total Hardness,(mg/l)	260.16	229.09	213.56	15.53	116.49
8	Total Alkalinity,(mg/l)	604	380	204	28	116
9	Chloride ,(mg/l)	668.2	76.07	67.84	14.39	24.67
10	Sulphate,(mg/l)	13.92	8.48	36.32	5.04	18.2
11	Calcium,(mg/l)	26.4	10.87	68.34	3.1	40.38
12	Magnesium,(mg/l)	47.17	49.06	10.37	1.88	3.77
13	Sodium(mg/l)	16.41	37.71	35.13	2.77	10.16

14	Potassium,(mg/l)	1.86	17.72	14.51	1.4	6.29
15	Iron (mg/l)	BDL	1.34	0.22	BDL	BDL
16	Total Coliforms, (CFU/100ml)	A	9300	6400	300	400
17	E.coli,(CFU/100ml)	A	A	A	A	A

BDL: Below Detection Limit

Among the 5 samples the turbidity of four water samples was above the acceptable limit. The TDS, TH and TA of three groundwater samples were above the acceptable limit. The bacteriological analysis of Tap water and three Groundwater samples showed the presence of Total Coliforms

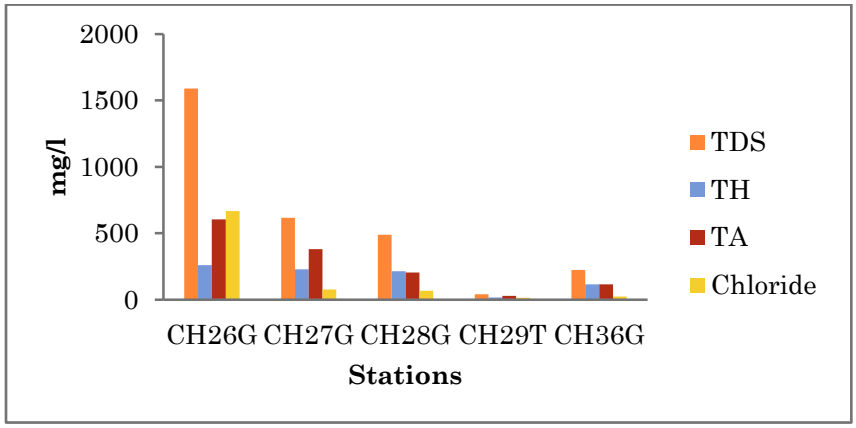

Fig 3.22 **TDS, TH, TA and chloride of collected water samples of ward 58**

Table 3.62 Ward 59- Thevara

SL.No	PARAMETERS	SAMPLE CODE		
		CH31T (Tap water)	CH32G (Groundwater)	CH33G (Groundwater)
1	pH	7.25	6.83	6.98
2	Temperature (^{0}C)	28.4	28.2	28.1
3	Turbidity,(NTU)	4.4	1.2	1.4
4	Electrical Conductivity(µS/cm)	60	711	1020
5	Salinity (ppt)	0.03	0.28	0.40
6	Total Dissolved Solids,(mg/l)	43.4	504	723
7	Total Hardness,(mg/l)	15.53	151.43	201.91

8	Total Alkalinity,(mg/l)	16	280	356
9	Chloride ,(mg/l)	20.56	80.18	162.42
10	Sulphate,(mg/l)	5.76	1.12	2.36
11	Calcium,(mg/l)	4.65	26.4	38.82
12	Magnesium,(mg/l)	0.94	20.75	25.47
13	Sodium(mg/l)	3.35	70.6	118.2
14	Potassium,(mg/l)	1.63	11.8	13.6
15	Iron (mg/l)	BDL	BDL	0.41
16	Total Coliforms, (CFU/100ml)	1500	A	A
17	E.*coli*,(CFU/100ml)	A	A	A

BDL: Below Detection Limit

The TDS of two groundwater samples were above the acceptable limit. TH of CH33G was above the acceptable limit. TA of CH32G and CH33G were also above the acceptable limit. The bacteriological analysis of Tap water sample showed the presence of Total Coliforms.

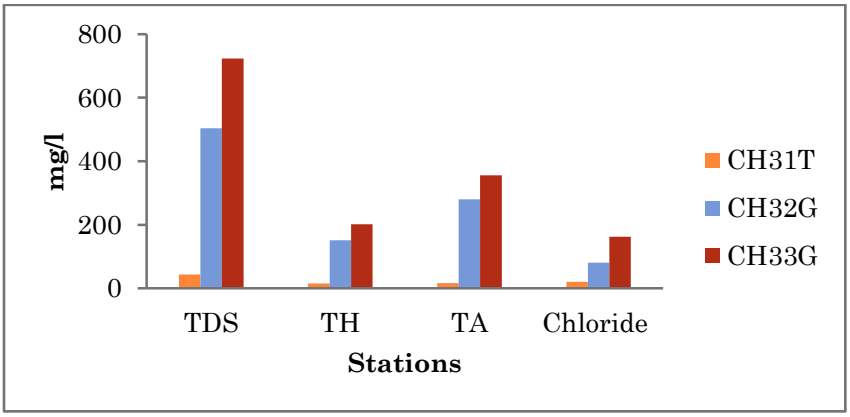

Fig 3.23 **TDS, TH, TA and chloride of collected water samples of ward 59**

Table 3.63 Ward 60- Perumanur

SL.No	PARAMETERS	SAMPLE CODE				
		CH22T (Tap water)	CH23G (Ground water)	CH24G (Ground water)	CH25T (Tap water)	CH46T (Tap water)
1	pH	7.49	7.24	7.21	7.43	7.62
2	Temperature (^{0}C)	28.4	28.4	28.5	28.4	28.7
3	Turbidity,(NTU)	5.8	2	1	0.5	3.8

4	EC(µS/cm)	80.5	564	446	82.5	84.7
5	Salinity (ppt)	0.03	0.22	0.17	0.03	0.03
6	TDS,(mg/l)	57.4	403	317	58.6	59.5
7	Total Hardness,(mg/l)	23.29	194.15	178.61	27.18	23.29
8	Total Alkalinity,(mg/l)	20	168	176	24	16
9	Chloride ,(mg/l)	16.44	53.45	37	18.5	24.67
10	Sulphate,(mg/l)	10.76	29.68	16.24	5.08	11.76
11	Calcium,(mg/l)	7.76	63.68	65.23	6.21	6.21
12	Magnesium,(mg/l)	0.94	8.49	3.77	2.83	1.88
13	Sodium(mg/l)	3.17	32.64	17.85	2.97	2.38
14	Potassium,(mg/l)	1.46	9.15	3.79	1.28	1.53
15	Iron (mg/l)	BDL	BDL	BDL	BDL	0.23
16	TC, (CFU/100ml)	A	6400	A	700	A
17	E.coli,(CFU/100ml)	A	A	A	A	A

BDL: Below Detection Limit

The turbidity of all the water samples was above the acceptable limit except CH25T. The bacteriological analysis of one of the Groundwater samples and Tap water samples show the presence of Total Coliforms.

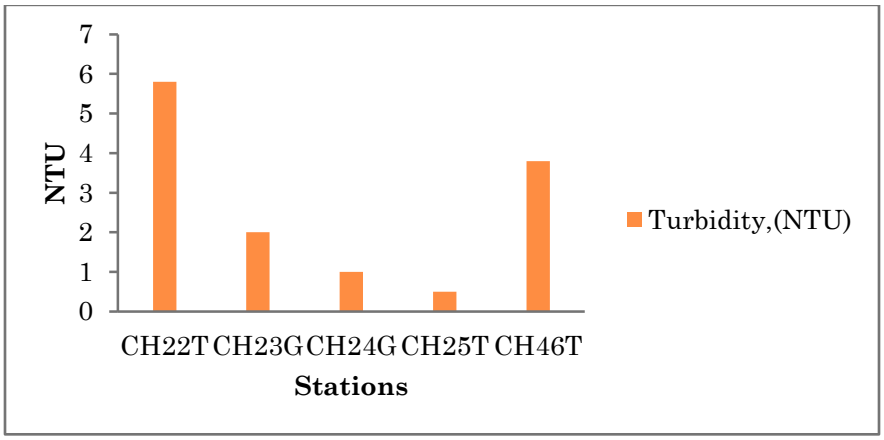

Fig 3.24 **Turbidity of collected water samples of ward 60**

Table 3.64 Ward 61- Ravipuram

SL.No	PARAMETERS	SAMPLE CODE		
		CH43T (Tap water)	CH44G (Groundwater)	CH45T (Tap water)
1	pH	7.79	7.51	8.12
2	Temperature (^{0}C)	28.5	28.5	28.8
3	Turbidity,(NTU)	2.4	4.4	4.1
4	Electrical Conductivity(µS/cm)	83.7	563	83.4
5	Salinity (ppt)	0.03	0.22	0.03
6	Total Dissolved Solids,(mg/l)	59.5	395	59.1
7	Total Hardness,(mg/l)	27.18	217.44	27.18
8	Total Alkalinity,(mg/l)	24	240	20
9	Chloride ,(mg/l)	20.56	94.57	22.61
10	Sulphate,(mg/l)	11.36	2.32	10.56
11	Calcium,(mg/l)	7.76	59.02	7.76
12	Magnesium,(mg/l)	1.88	16.98	1.88
13	Sodium(mg/l)	3.1	10.48	2.04
14	Potassium,(mg/l)	1.55	7.44	1.36
15	Iron (mg/l)	BDL	BDL	BDL
16	Total Coliforms, (CFU/100ml)	A	A	A
17	E.coli,(CFU/100ml)	A	A	A

BDL: Below Detection Limit

The TH, TA of groundwater sample was above the acceptable limit. Both Total Coliforms and E.coli. were absent in samples

Table 3.65 Ward 62- Ernakulam South

SL.No	PARAMETERS	SAMPLE CODE
		CH128T (Tap water)
1	pH	7.51
2	Temperature (^{0}C)	28.5
3	Turbidity,(NTU)	1.5
4	Electrical Conductivity(µS/cm)	66.4
5	Salinity (ppt)	0.03
6	Total Dissolved Solids,(mg/l)	47
7	Total Hardness,(mg/l)	27.72

8	Total Alkalinity,(mg/l)	26.04
9	Chloride ,(mg/l)	7.912
10	Sulphate,(mg/l)	2.24
11	Calcium,(mg/l)	6.336
12	Magnesium,(mg/l)	2.88
13	Sodium(mg/l)	2.97
14	Potassium,(mg/l)	1.38
15	Iron (mg/l)	0.08
16	Total Coliforms, (CFU/100ml)	700
17	E.coli,(CFU/100ml)	A

BDL: Below Detection Limit

The turbidity of the water samples was above the acceptable limit. The bacteriological analysis of water samples showed the presence of Total Coliforms.

Table 3.66 Ward 63- Gandhi nagar

SL.No	PARAMETERS	SAMPLE CODE	
		CH105T (Tap water)	**CH106G (Groundwater)**
1	pH	8.2	7.42
2	Temperature (^{0}C)	29.8	28.6
3	Turbidity,(NTU)	0.8	0.3
4	Electrical Conductivity(µS/cm)	65.67	501.9
5	Salinity (ppt)	0.06	0.515
6	Total Dissolved Solids,(mg/l)	42.74	379.6
7	Total Hardness,(mg/l)	27.72	225.72
8	Total Alkalinity,(mg/l)	24.48	179.52
9	Chloride ,(mg/l)	14.37	43.11
10	Sulphate,(mg/l)	4.68	12.16
11	Calcium,(mg/l)	7.92	68.11
12	Magnesium,(mg/l)	1.92	13.47
13	Sodium(mg/l)	2.05	15.58
14	Potassium,(mg/l)	1.64	9.33
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	3900	7500
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The TH of groundwater sample was above the acceptable limit. All other parameters were within the acceptable limit. The bacteriological analysis of both water samples showed the presence of Total Coliforms.

Table 3.67 Ward 64- Kathrikadavu

SL.No	PARAMETERS	SAMPLE CODE	
		CH91T (Tap water)	CH92G (Groundwater)
1	pH	7.53	7.02
2	Temperature (^{0}C)	29	28.9
3	Turbidity,(NTU)	0.6	7.7
4	Electrical Conductivity(µS/cm)	75.74	103.8
5	Salinity (ppt)	0.06	0.09
6	Total Dissolved Solids,(mg/l)	49.75	67.64
7	Total Hardness,(mg/l)	23.76	43.56
8	Total Alkalinity,(mg/l)	16.32	44.88
9	Chloride ,(mg/l)	18.47	12.31
10	Sulphate,(mg/l)	6.4	4.04
11	Calcium,(mg/l)	7.92	14.25
12	Magnesium,(mg/l)	0.96	1.92
13	Sodium(mg/l)	2.35	3.18
14	Potassium,(mg/l)	1.25	2.68
15	Iron (mg/l)	BDL	6.03
16	Total Coliforms, (CFU/100ml)	6400	9300
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

All parameters were within the acceptable limit except Turbidity and Iron in case of groundwater sample. The bacteriological analysis of both water samples showed the presence of Total Coliforms.

Table 3.68 Ward 65- Kaloor South

SL.No	PARAMETERS	SAMPLE CODE
		CH70T (Tap water)
1	pH	7.31
2	Temperature (^{0}C)	27.8
3	Turbidity,(NTU)	6.6
4	Electrical Conductivity(µS/cm)	54.58
5	Salinity (ppt)	0.05
6	Total Dissolved Solids,(mg/l)	35.52
7	Total Hardness,(mg/l)	16.16
8	Total Alkalinity,(mg/l)	16
9	Chloride ,(mg/l)	15.99
10	Sulphate,(mg/l)	6.44
11	Calcium,(mg/l)	3.23
12	Magnesium,(mg/l)	1.96
13	Sodium(mg/l)	28.01
14	Potassium,(mg/l)	20.28
15	Iron (mg/l)	0.24
16	Total Coliforms, (CFU/100ml)	9300
17	E.coli,(CFU/100ml)	A

BDL: Below Detection Limit

All the physicochemical parameters except turbidity were within the acceptable limit. The bacteriological analysis of the sample showed the presence of Total Coliforms.

Table 3.69 Ward 66- Ernakulam Central

SL.No	PARAMETERS	SAMPLE CODE	
		CH127G (Groundwater)	CH159T (Tap water)
1	pH	7.09	7.34
2	Temperature (^{0}C)	28.5	27.9
3	Turbidity,(NTU)	15.76	1.4
4	Electrical Conductivity(µS/cm)	530	66.14
5	Salinity (ppt)	0.24	0.03
6	Total Dissolved Solids,(mg/l)	378	46.04
7	Total Hardness,(mg/l)	237.6	27.18

8	Total Alkalinity,(mg/l)	226.92	20
9	Chloride ,(mg/l)	27.69	16.44
10	Sulphate,(mg/l)	3.96	20.4
11	Calcium,(mg/l)	76.03	6.21
12	Magnesium,(mg/l)	11.54	2.83
13	Sodium(mg/l)	16.48	13.71
14	Potassium,(mg/l)	6.53	4.18
15	Iron (mg/l)	1.52	BDL
16	Total Coliforms, (CFU/100ml)	3900	A
17	E.*coli*, (CFU/100ml)	A	A

BDL: Below Detection Limit

The TH and TA of groundwater sample were above the acceptable limit. The bacteriological analysis of the groundwater sample showed the presence of Total Coliforms.

Table 3.70 Ward 67- Ernakulam North

SL.No	PARAMETERS	SAMPLE CODE
		CH126T (Tap water)
1	pH	7.38
2	Temperature (^{0}C)	28.5
3	Turbidity,(NTU)	1.4
4	Electrical Conductivity(µS/cm)	62.2
5	Salinity (ppt)	0.03
6	Total Dissolved Solids,(mg/l)	42.4
7	Total Hardness,(mg/l)	19.8
8	Total Alkalinity,(mg/l)	18.6
9	Chloride ,(mg/l)	3.95
10	Sulphate,(mg/l)	1.92
11	Calcium,(mg/l)	6.33
12	Magnesium,(mg/l)	0.96
13	Sodium(mg/l)	3.34
14	Potassium,(mg/l)	1.51
15	Iron (mg/l)	BDL
16	Total Coliforms, (CFU/100ml)	A
17	E.*coli*,(CFU/100ml)	A

BDL: Below Detection Limit

All the physicochemical parameters except turbidity were within the acceptable limit.

Table 3.71 Ward 68- Ayyappankavu

SL.No	PARAMETERS	SAMPLE CODE		
		CH56T (Tap water)	CH57G (Groundwater)	CH58T (Tap water)
1	pH	7.4	7.22	7.06
2	Temperature (^{0}C)	28.4	28.5	28.1
3	Turbidity,(NTU)	3.1	10.4	0.5
4	Electrical Conductivity(µS/cm)	62.71	264.8	432.2
5	Salinity (ppt)	0.05	0.23	0.39
6	Total Dissolved Solids,(mg/l)	40.8	180	294.6
7	Total Hardness,(mg/l)	20.2	125.24	153.52
8	Total Alkalinity,(mg/l)	12	108	140
9	Chloride ,(mg/l)	17.99	21.98	45.97
10	Sulphate,(mg/l)	8.76	11.36	11.12
11	Calcium,(mg/l)	6.46	42.01	58.17
12	Magnesium,(mg/l)	0.98	4.9	1.96
13	Sodium(mg/l)	27.93	26.49	22.81
14	Potassium,(mg/l)	20.13	17.12	15.58
15	Iron (mg/l)	BDL	BDL	0.54
16	Total Coliforms, (CFU/100ml)	9300	3900	9300
17	E.coli,(CFU/100ml)	A	A	A

BDL: Below Detection Limit

The turbidity of all the water samples was above the acceptable limit except in CH58T. The bacteriological analysis indicated the the presence of Total Coliforms in both the Tap water as well as in Groundwater sample.

Table 3.71 Ward 69- Thrikkanarvattom

SL.No	PARAMETERS	SAMPLE CODE	
		CH71T (Tap water)	CH72G (Groundwater)
1	pH	7.26	7.39
2	Temperature (^{0}C)	27.8	27.7
3	Turbidity,(NTU)	2.5	1.7

4	Electrical Conductivity(µS/cm)	65.63	811
5	Salinity (ppt)	0.06	0.76
6	Total Dissolved Solids,(mg/l)	42.65	553
7	Total Hardness,(mg/l)	24.24	246.44
8	Total Alkalinity,(mg/l)	16	268
9	Chloride ,(mg/l)	19.99	83.95
10	Sulphate,(mg/l)	8.88	6.12
11	Calcium,(mg/l)	6.46	59.79
12	Magnesium,(mg/l)	1.96	23.56
13	Sodium(mg/l)	28.03	35.02
14	Potassium,(mg/l)	20.15	11.37
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	A	2800
17	E.*coli*, (CFU/100ml)	A	A

BDL: Below Detection Limit

TDS, TH, and TA of groundwater sample were above the acceptable limit. The bacteriological analysis of water samples indicated the presence of Total Coliforms in groundwater sample.

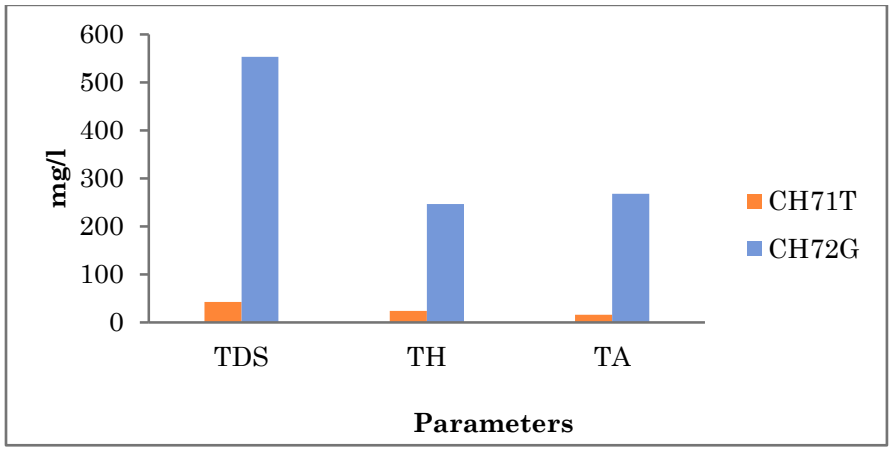

Fig 3.25 **TDS, TH and TA of collected water samples of ward 69**

Table 3.73 Ward 70- Kaloor North

SL.No	PARAMETERS	SAMPLE CODE	
		CH81T (Tap water)	CH82T (Tap water)
1	pH	7.54	7.61
2	Temperature (^{0}C)	28.6	27.8
3	Turbidity,(NTU)	2.8	3.3
4	Electrical Conductivity(µS/cm)	64.48	72.92
5	Salinity (ppt)	0.05	0.06
6	Total Dissolved Solids,(mg/l)	41.98	47.37
7	Total Hardness,(mg/l)	20.2	36.36
8	Total Alkalinity,(mg/l)	12	16
9	Chloride ,(mg/l)	13.99	15.99
10	Sulphate,(mg/l)	8.08	8.24
11	Calcium,(mg/l)	8.08	11.31
12	Magnesium,(mg/l)	BDL	1.96
13	Sodium(mg/l)	28.07	28.18
14	Potassium,(mg/l)	20.17	20.16
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	A	9300
17	E.*coli*,(CFU/100ml)	A	A

BDL: Below Detection Limit

All the physico chemical parameters were within the acceptable limit except turbidity. The bacteriological analysis of one of the Tap water sample showed the presence of Total Coliforms.

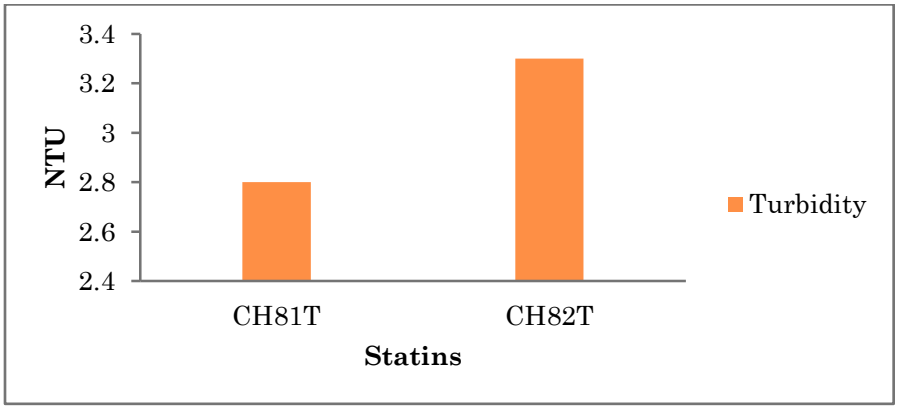

Fig 3.26 **Turbidity of collected water samples of ward 70**

Table 3.74 Ward 71- Elamakkara South

SL.No	PARAMETERS	SAMPLE CODE		
		CH74T (Tap water)	CH75G (Groundwater)	CH80G (Groundwater)
1	pH	7.94	6.66	6.9
2	Temperature (^{0}C)	27.9	27.8	27.8
3	Turbidity,(NTU)	1.1	1.1	1
4	Electrical Conductivity(µS/cm)	65.96	381.4	370.2
5	Salinity (ppt)	0.06	0.34	0.33
6	Total Dissolved Solids,(mg/l)	42.87	260.1	252.5
7	Total Hardness,(mg/l)	28.28	117.16	133.32
8	Total Alkalinity,(mg/l)	24	68	80
9	Chloride ,(mg/l)	15.99	31.98	39.98
10	Sulphate,(mg/l)	4	40.8	34.8
11	Calcium,(mg/l)	6.46	35.55	43.63
12	Magnesium,(mg/l)	2.94	6.87	5.89
13	Sodium(mg/l)	28.07	20.1	22.62
14	Potassium,(mg/l)	20.21	10.61	11.23
15	Iron (mg/l)	BDL	BDL	BDL
16	Total Coliforms, (CFU/100ml)	6400	4300	9300
17	E.coli,(CFU/100ml)	A	A	A

BDL: Below Detection Limit

All the physico chemical parameters were within the acceptable limit but bacteriological analysis indicated the presence of Total Coliforms.

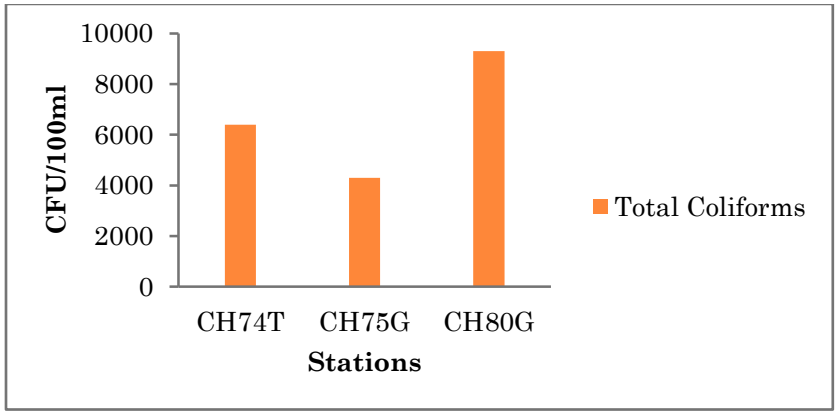

Fig 3.27 **Total coliforms of collected water samples of ward 71**

Table 3.75 Ward 72- Pottakuzhy

SL.No	PARAMETERS	SAMPLE CODE	
		CH73T (Tap water)	CH90G (Groundwater)
1	pH	8.52	7.58
2	Temperature (^{0}C)	27.7	28.8
3	Turbidity,(NTU)	3	2
4	Electrical Conductivity(µS/cm)	72.5	464.6
5	Salinity (ppt)	0.06	0.42
6	Total Dissolved Solids,(mg/l)	47.2	316.6
7	Total Hardness,(mg/l)	36.36	202
8	Total Alkalinity,(mg/l)	20	184
9	Chloride ,(mg/l)	15.99	23.98
10	Sulphate,(mg/l)	7.8	22.24
11	Calcium,(mg/l)	9.69	58.17
12	Magnesium,(mg/l)	2.94	13.74
13	Sodium(mg/l)	28.07	23.59
14	Potassium,(mg/l)	19.99	12.1
15	Iron (mg/l)	BDL	BDL
16	Total Coliforms, (CFU/100ml)	2400	200
17	E.coli,(CFU/100ml)	A	A

BDL: Below Detection Limit

The turbidity of both the water samples and TH of groundwater sample were above the acceptable limit. The bacteriological analysis of both the samples showed the presence of Total Coliforms.

Table 3.76 Ward 73- Pachalam

SL.No	PARAMETERS	SAMPLE CODE
		CH161T (Tap water)
1	pH	8.04
2	Temperature (^{0}C)	28
3	Turbidity,(NTU)	1.1
4	Electrical Conductivity(µS/cm)	61.8
5	Salinity (ppt)	0.03

6	Total Dissolved Solids,(mg/l)	43.6
7	Total Hardness,(mg/l)	27.7
8	Total Alkalinity,(mg/l)	26.04
9	Chloride ,(mg/l)	15.86
10	Sulphate,(mg/l)	5.6
11	Calcium,(mg/l)	6.33
12	Magnesium,(mg/l)	3.1
13	Sodium(mg/l)	3.24
14	Potassium,(mg/l)	1.32
15	Iron (mg/l)	BDL
16	Total Coliforms, (CFU/100ml)	A
17	E.coli,(CFU/100ml)	A

BDL: Below Detection Limit

All parameters were within the acceptable limit.

Table 3.77 Ward 74- Thattazham

SL.No	PARAMETERS	SAMPLE CODE		
		CH59T (Tap water)	**CH61T (Tap water)**	**CH63T (Tap water)**
1	pH	8.01	7.75	7.48
2	Temperature (^{0}C)	28.1	28	28.8
3	Turbidity,(NTU)	4.4	2.5	3.5
4	Electrical Conductivity(µS/cm)	73.47	69.32	66.35
5	Salinity (ppt)	0.06	0.06	0.06
6	Total Dissolved Solids,(mg/l)	47.85	45.04	43.1
7	Total Hardness,(mg/l)	28.28	28.28	28.28
8	Total Alkalinity,(mg/l)	20	16	16
9	Chloride ,(mg/l)	19.99	15.99	11.99
10	Sulphate,(mg/l)	8.24	7.6	7.92
11	Calcium,(mg/l)	9.69	8.08	8.08
12	Magnesium,(mg/l)	0.98	1.96	1.96
13	Sodium(mg/l)	27.89	27.91	27.97
14	Potassium,(mg/l)	20.04	20.13	20.15
15	Iron (mg/l)	BDL	BDL	BDL
16	Total Coliforms, (CFU/100ml)	9300	A	9300
17	E.coli,(CFU/100ml)	A	A	A

BDL: Below Detection Limit

All the physicochemical parameters except turbidity were within the acceptable limit. The bacteriological analysis of the samples showed the presence of Total Coliforms except in CH61T.

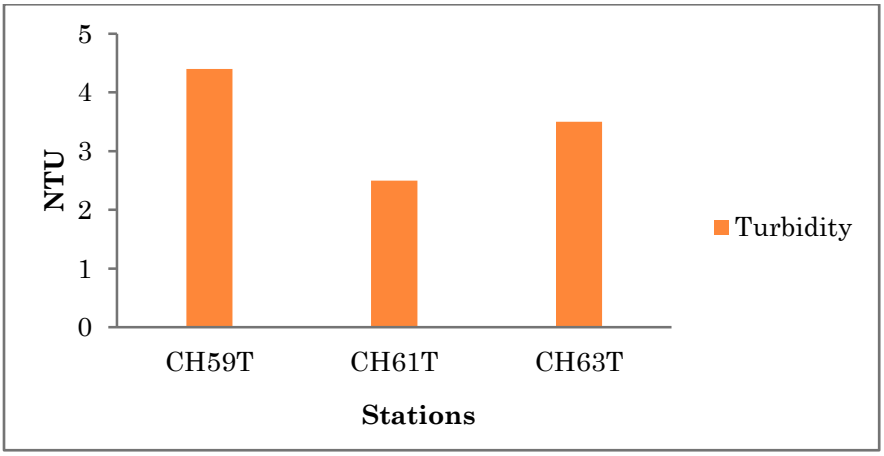

Fig 3.28 **Turbidity of collected water samples of ward 74**

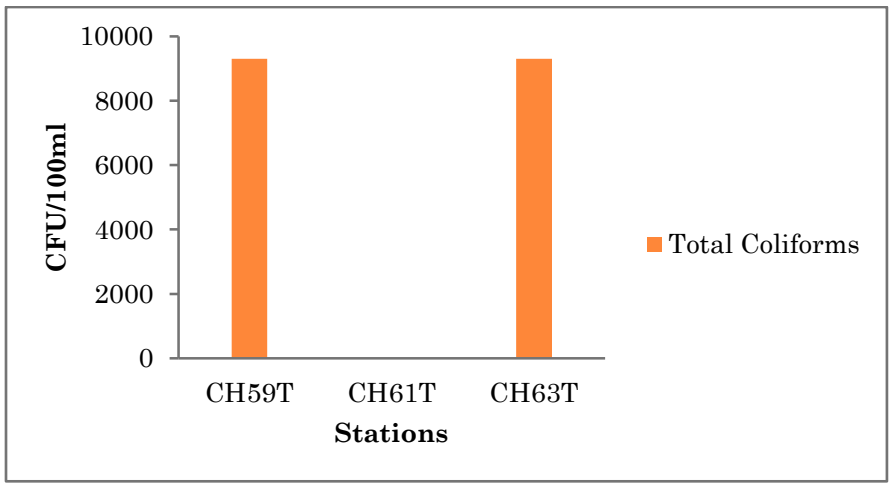

Fig 3.29 **Total coliforms of collected water samples of ward 74**

3.3 Analytical Report of Water Samples

A total of 162 samples (which includes Tap water and groundwater) were collected from 74 wards of Kochi Municipal Corporation. Physico chemical parameters were taken into account to determine the water quality status of the samples collected from different wards of Kochi Municipal Corporation.

The physicochemical and microbiological analysis of the samples collected from Kochi Municipal Corporation indicated that 71% Tap water samples had turbidity more than the acceptable limit and the bacteriological study indicated that 61% of the tap water is contaminated with Total Coliforms. Parameters such as TDS, TH, and TA of groundwater sample were above the acceptable limit and almost all the groundwater samples shows the presence of Total Coliforms and had the presence of E.*coli* also.

Among the 162 water samples collected, 64 samples are groundwater (open well, bore well and public well) and 98 samples were tap water supplied by KWA. The physico chemical and bacteriological analysis of groundwater shows that only 14% meet the standards for drinking water specified by (IS 10500:2012). and in the case of tap water, only 29% meet the standards for drinking water.

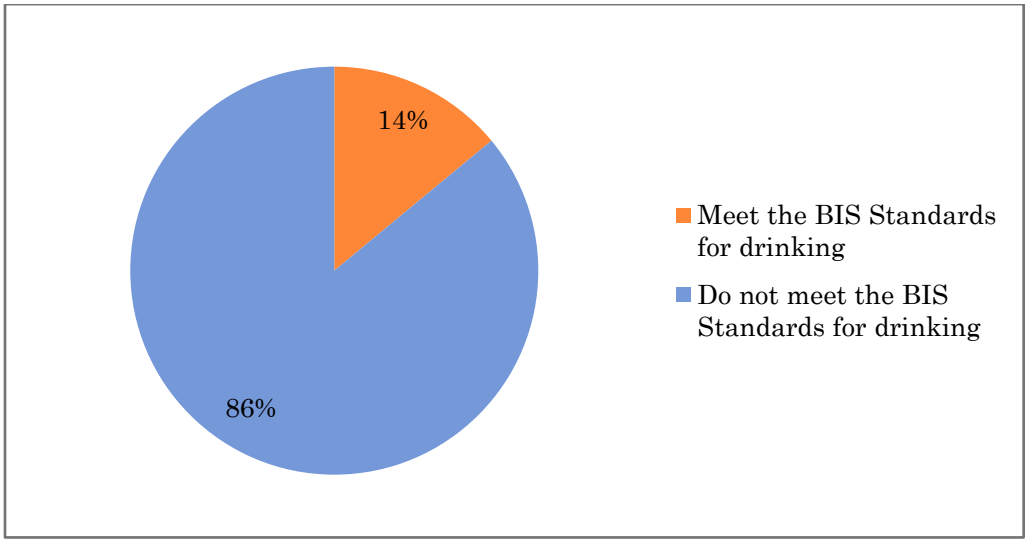

Fig. 3.30 Water quality status of groundwater in KMC

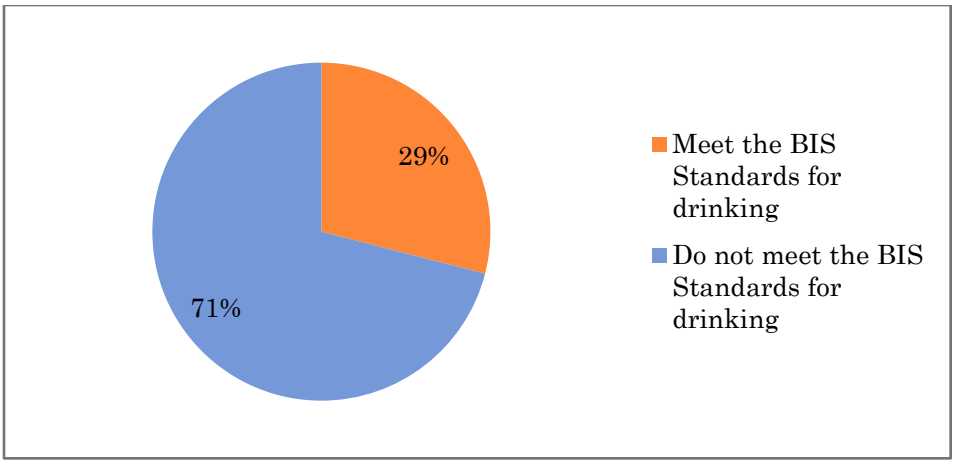

Fig. 3.31 Water quality status of Tap water in KMC

3.4 Results of Combined water sampling with KWA officials in KMC area

As per the suggestions of experts of Kerala State Planning Board combined sampling was carried out in selected sampling locations. The results indicated that all the physico chemical parameters were meeting the standards except residual chlorine. The residual chlorine concentration was above the acceptable limit of 0.1mg/l but below the permissible limit in the absence of alternate source (1.0mg/l). The authorities should regularly check the residual chlorine level.

Sl. No.	Parameters	CHN 1	CHN 2	CHN 3	CHN 4	CHN 5	CHN 6
1	pH at 25°C	6.61	6.75	6.73	6.66	6.78	6.88
2	Colour, Hazen	1.00	1.00	1.00	1.00	1.00	1.00
3	Turbidity, NTU	0.27	0.35	0.21	0.30	0.47	0.24
4	Total Dissolved Solids, mg/l	31.70	28.20	30.70	30.60	30.80	30.90
5	Total Hardness as $CaCO_3$, mg/l	16.00	16.00	16.00	24.00	16.00	20.00
6	Total Alkalinity as $CaCO_3$, mg/l	12.24	8.16	12.24	8.16	4.08	4.08
7	Chloride as Cl^-, mg/l	11.53	11.53	7.69	19.22	30.75	49.97
8	Sulphate as SO_4^{2-}, mg/l	3.24	3.40	2.96	3.00	3.28	3.44
9	Calcium as Ca, mg/l	4.80	4.80	4.80	4.80	4.80	4.80
10	Magnesium as Mg, mg/l	0.97	0.97	0.97	2.92	0.97	1.94
11	Iron as Fe, mg/l	BDL	BDL	BDL	BDL	BDL	BDL
12	Residual chlorine	0.60	0.20	0.40	0.80	0.20	0.80
13	Total Coliforms, MPN/100ml	Absent	Absent	Absent	Absent	Absent	Absent
14	*E.coli*, MPN/100ml	Absent	Absent	Absent	Absent	Absent	Absent

3.5 GIS based analysis of quality of Groundwater in different wards

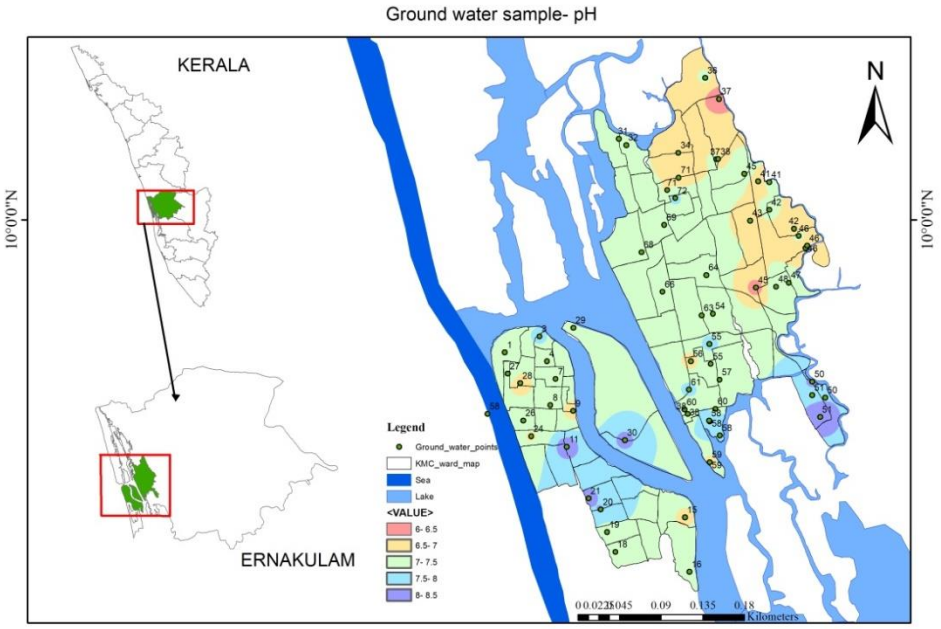

Fig. 3.32 Variation in pH of groundwater samples of different wards

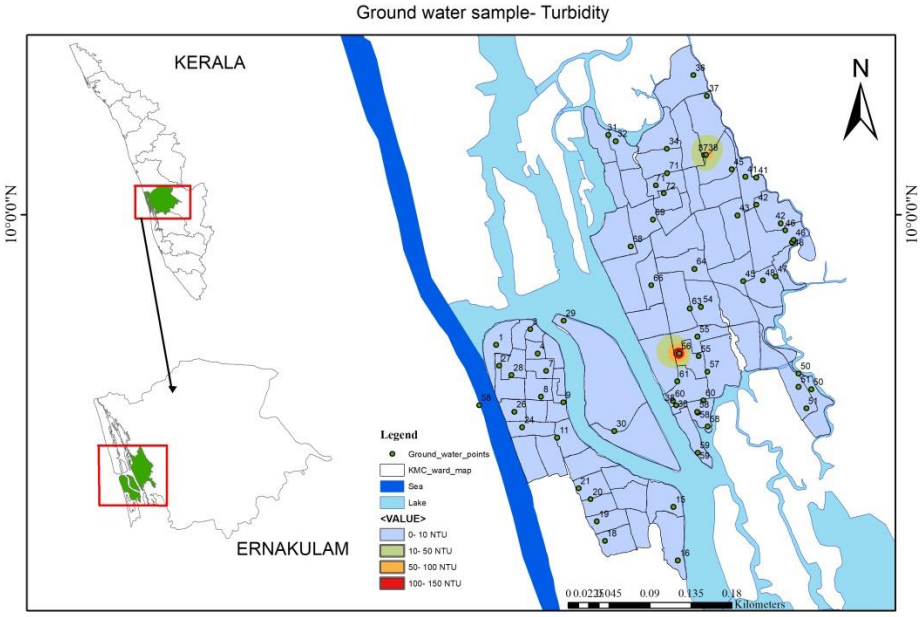

Fig. 3.33 Variation in Turbidity of groundwater samples of different wards

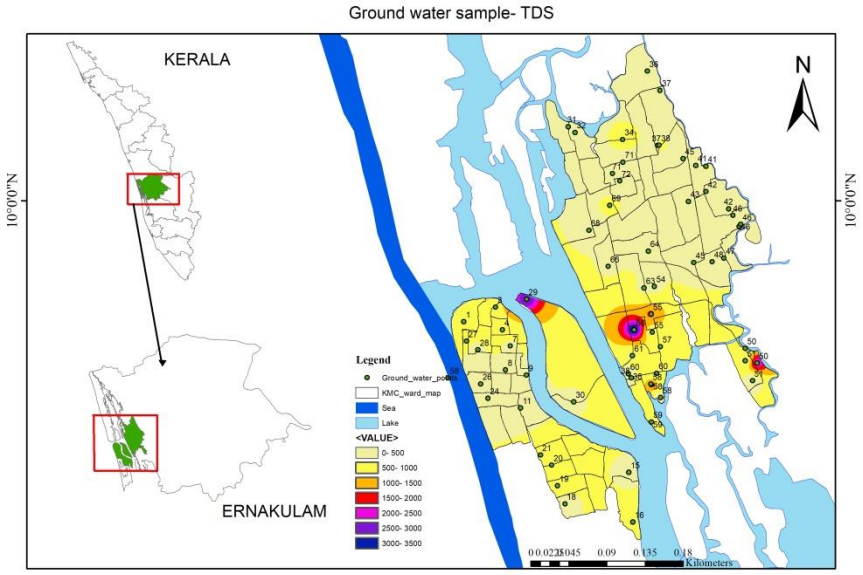

Fig. 3.34 Variation in TDS in groundwater samples of different wards

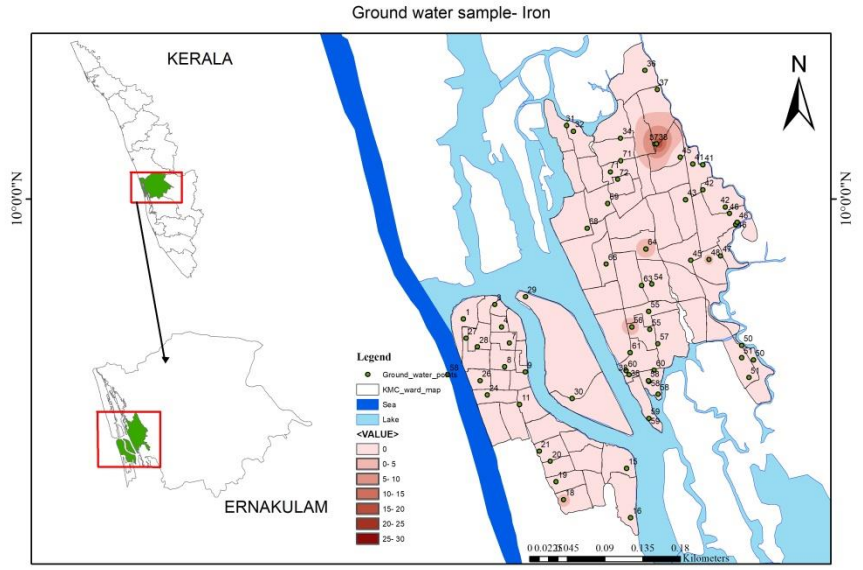

Fig. 3.35 Variation in Iron in groundwater samples of different wards

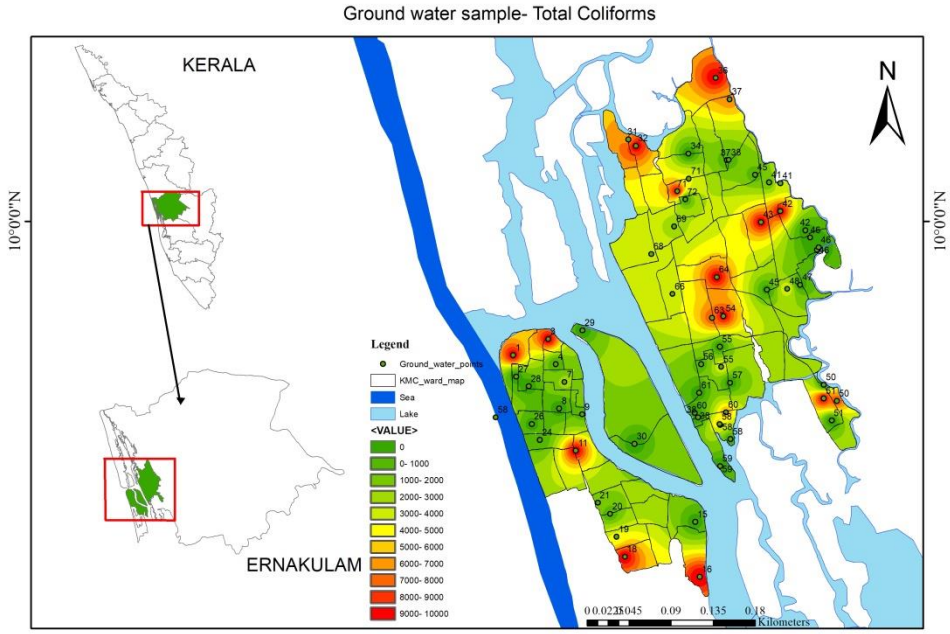

Fig. 3.36 Variation in total coliforms in groundwater samples of different wards

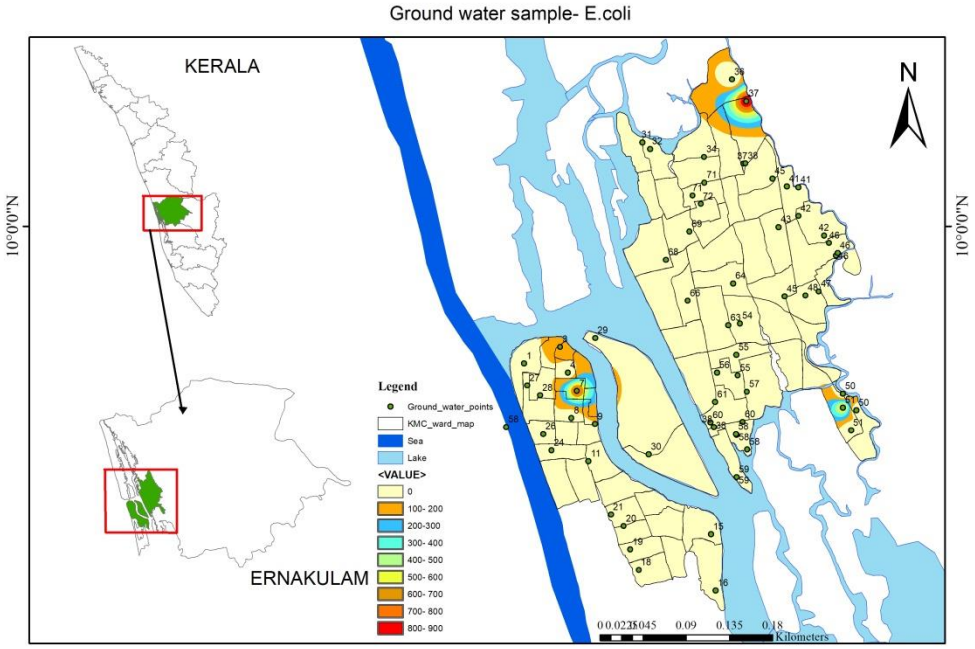

Fig. 3.37 Variation in E.coli of groundwater samples of different wards

GIS based analysis of quality of Tap water in different wards

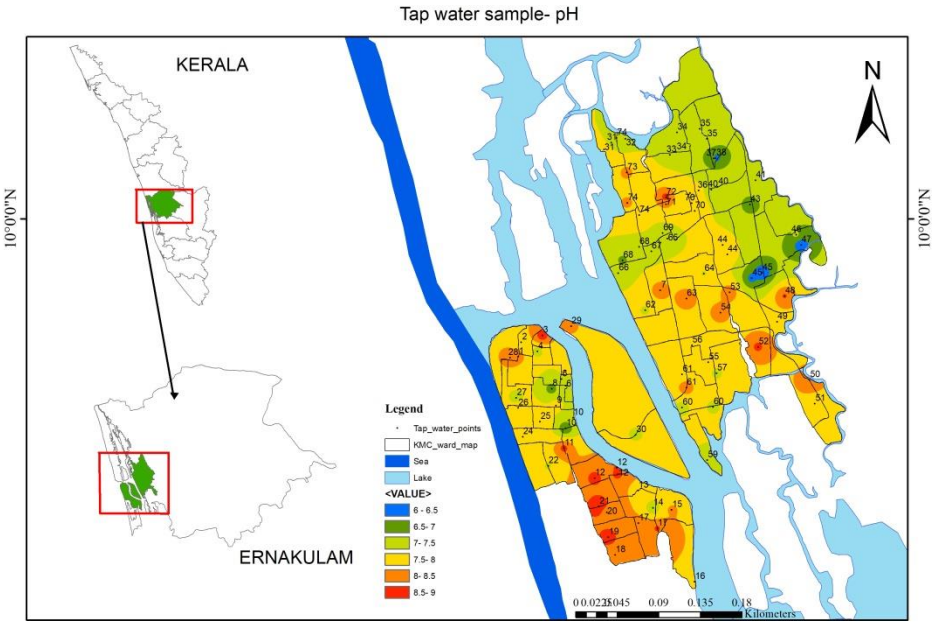

Fig. 3.38 Variation in pH in Tap water samples of different wards

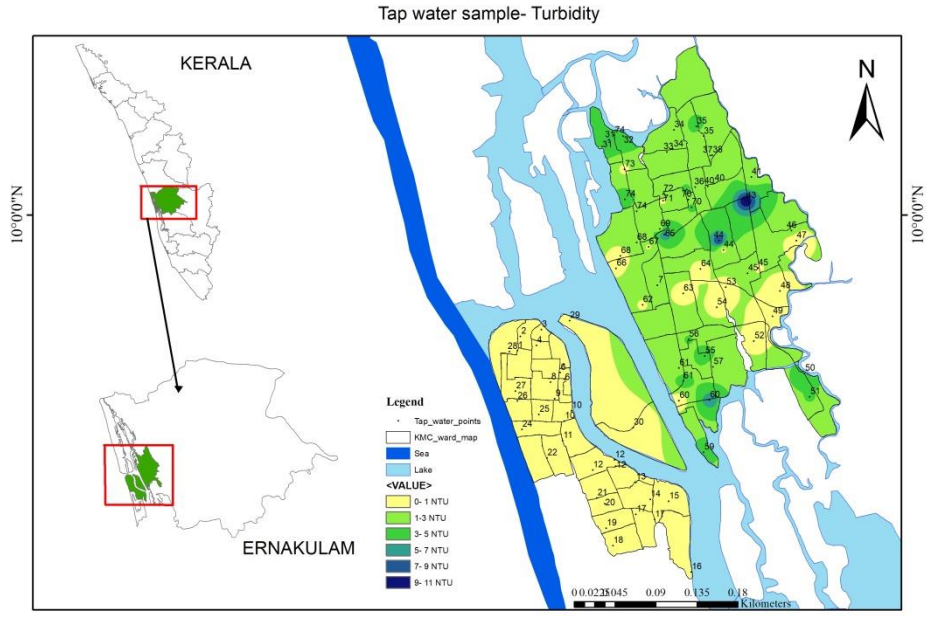

Fig. 3.39 Variation in Turbidity in Tap water samples of different wards

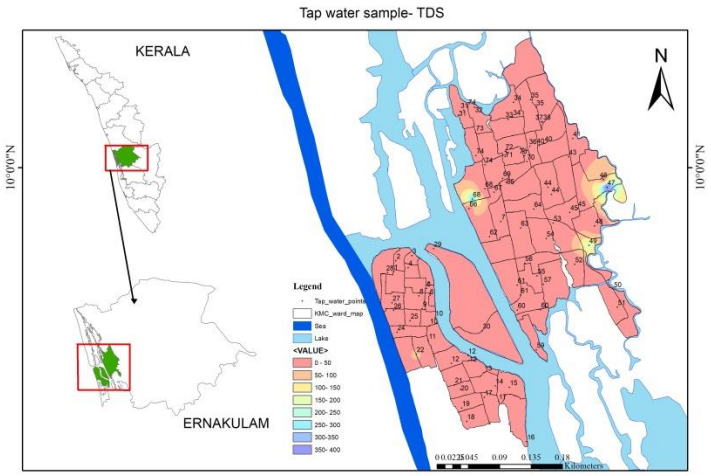

Fig. 3.40 Variation in TDS in Tap water samples of different wards

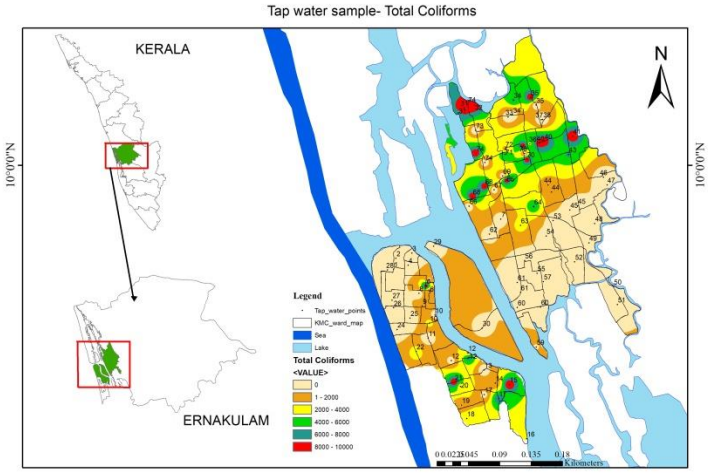

Fig. 3.41 Variation in Total coliform in Tap water samples of different wards

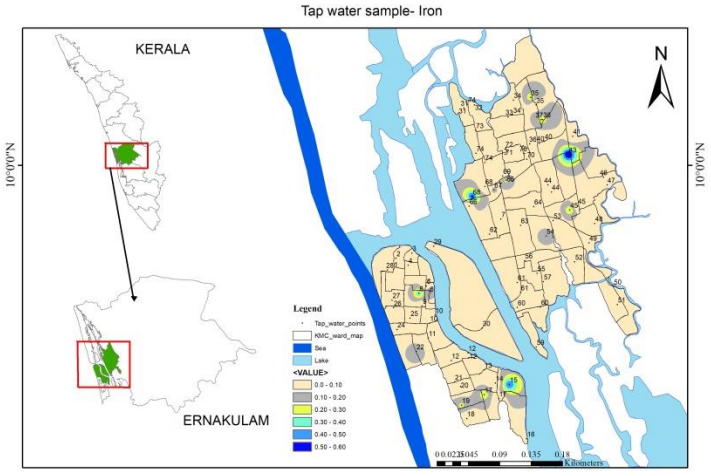

Fig. 3.42 Variation in Iron in Tap water samples of different wards

CHAPTER 4

Ward wise Survey Details

4.1 Primary Survey findings

4.1.1 Perceptions of Water Quality supplied by KWA: About 18% of respondents to the household-level primary survey felt that the water quality was good and about 57% felt that quality was average. About 25% of respondents felt that water quality was occasionally or always poor. Since a majority (82%) considers water quality as average or poor, this perception needs to be rectified by visible and tangible actions on priority.

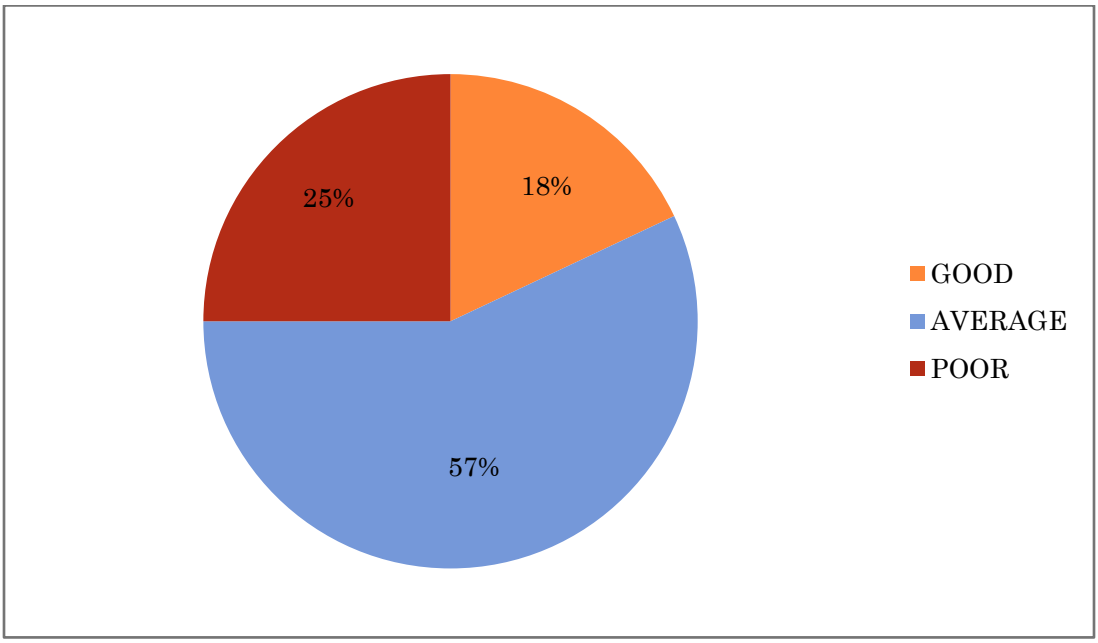

Fig. 4.1 **Peoples perceptions on water quality**

4.1.2 Perceptions of Water Supply by KWA: About 15% of respondents of the household-level primary survey felt that the water supply was good and about 48% felt that water supply was average. About 37% of respondents felt that water supply was occasionally or always poor. Since a majority (85%) considers water supply as average or poor, this perception needs to be rectified by visible and tangible actions on priority.

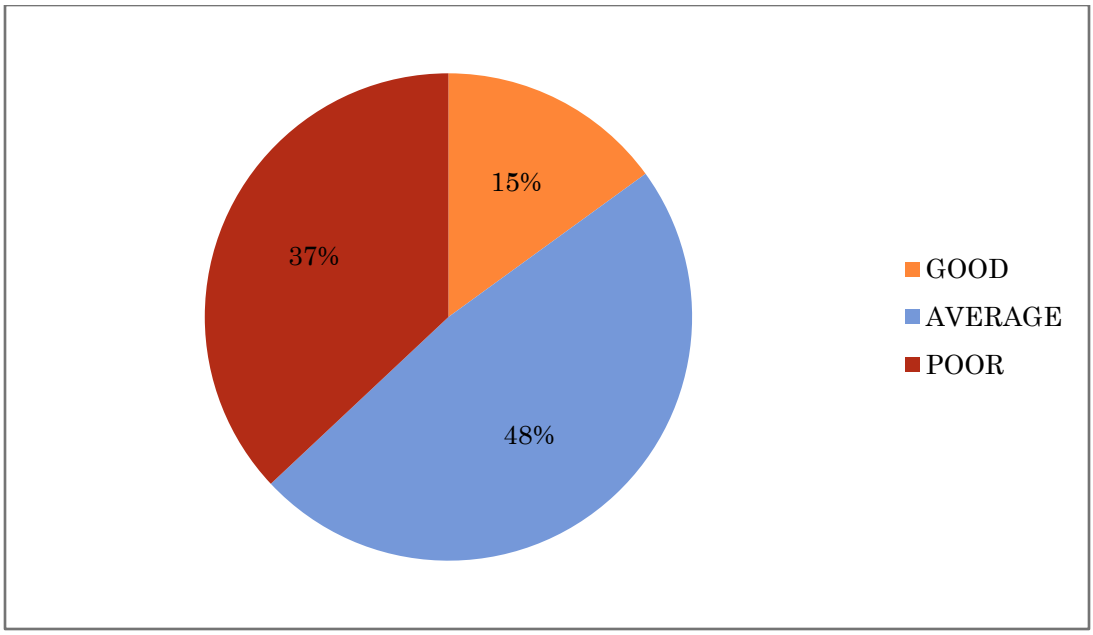

Fig. 4.2 **Satisfactory level with respect to water supply by KWA**

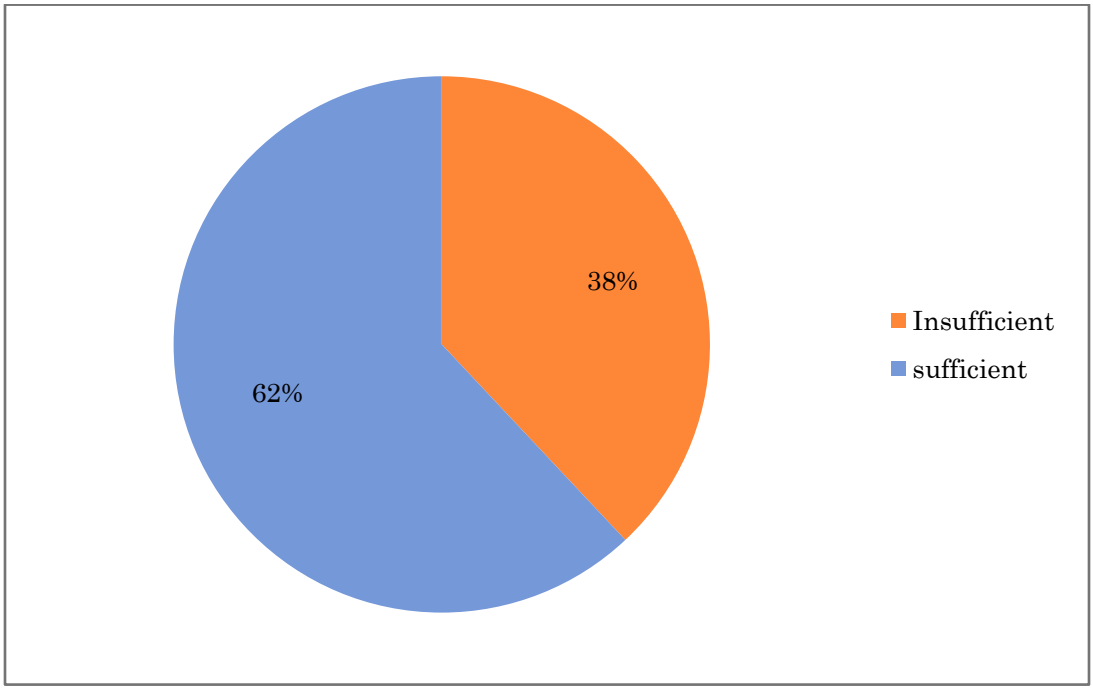

Fig. 4.3 **Satisfactory level with respect to water supply**

4.2 Ward wise detailed survey report

We had carried out a survey of 254 houses which covered across 74 wards of the Kochi Municipal Corporation. Data was collected from the houses in the desired formats so as to assess and analyze the information.

Although the entire Kochi Municipal Corporation area is said to be covered with piped water supply network, households seem to have supplementary sources of water supply. As per the primary survey findings while more than 88% of households rely on Kochi municipal water supply, about 12% of respondents supplemented with other sources which includes bore-wells, open well, public well and other private sources. In most of the wards depends on Tap Water for drinking, cooking and well water is for other purposes. If there is shortage and other issues in tap water then only they depend on Groundwater and tanker water which is supplied by KMC.

Salient features of the survey is provided in the table 4.1

Table 4.1. **Survey findings in 74 wards of KWA**

Wards	**Major issues**
Ward 1	Issues regarding Groundwater in these areas are color and Turbidity.
Ward 2	Most of the houses have sump.
Ward 3	Most of the houses have no sump facility. Most of them are directly pumping water from pipeline. Other issues are low pressure and irregular water supply
Ward 4	Most of the houses have sump facility. Other issues are low pressure and irregular water supply.
Ward 5	Some of the houses have sump facility. Other issues are low pressure and irregular water supply, turbidity and Chlorine smell.
Ward 6	Some of the houses have sump facility. Other issues are turbidity and Chlorine smell.
Ward 7	Some of the houses have sump facility. Other issues are turbidity and Chlorine smell.

Ward 8	Some of the houses have sump facility. Others pump water directly from pipeline. Other issues are presence of iron due to old pipeline, sometimes turbid.
Ward 9	Mostly depending on Tap Water for drinking and cooking purpose. Some of the houses have sump facility. Others pump water directly from pipeline. Other issues are sometimes irregular water supply, bad smell, and low pressure.
Ward 10	Some of the houses have no pipeline connection. Other issues are sometimes Chloride smell in certain areas and low pressure.
Ward 11	Most of them are using sump for collecting Tap water. Issues regarding Groundwater in these areas are smell, colour and rarely Turbid. During flood time they depend on Tankers for drinking water.
Ward 12	Most of them are depending on Public Tap, more than 27 houses in Nadakadavu colony is depending on Public Tap for drinking water. Water supply is in alternative days only. Only two public taps are there, which is not sufficient for this colony. Other issues are irregular water supply and Chlorine smell. Only 5 houses in these areas have bore well.
Ward 13	Issues regarding Tap water were Chlorine smell, colour and Turbidity.
Ward 14	Groundwater is used for other purposes such as gardening, washing etc. If there is any issue in pipeline they buy water from water suppliers. Issues regarding Tap water are Chlorine smell, colour and Turbidity.
Ward 15	Mostly depending on Tap Water for drinking and cooking. Groundwater is used for other purposes such as gardening, washing etc. If there is any issue in pipeline Tanker water is supplied by Corporation. Issues regarding Tap water are Turbidity, presence of earthworm, colour and salinity (rarely)
Ward 16	Most of the families are depending on Public tap, those have household connection collect water in sump. Groundwater is used for other purpose. Issues regarding Tap water are Turbidity, low pressure and Chlorine smell.
Ward 17	Groundwater is used for other purposes. Some of them buy water from water suppliers for drinking purpose. Issues regarding Tap water are Turbidity and Chlorine smell.

Ward 18	Issues regarding Tap water are irregular water supply. Groundwater issues after flood are Turbidity, colour, taste and odour.
Ward 19	Mostly depending on Tap Water for drinking and cooking. If there is any shortage in water supply tanker water supply are arranged by Corporation. No issues were reported except Chlorine smell.
Ward 20	If there is water shortage they depend on bore well which is connected to hand pump. Issues regarding tap water are turbidity, low pressure and Chlorine smell.
Ward 21	Mostly depending on Tap Water for drinking and cooking. Groundwater is mainly used for washing and other purposes
Ward 22	Incident of waterborne disease were mentioned (2 years back) in Valummal Colony. Issues regarding Public tap was mentioned, there is only 5 public tap for about 50 houses and the water supply is only for 1 hour per day. More public tap is needed in this area.
Ward 23	Groundwater is mainly used for washing and other purposes. Other issues are sometimes turbid due to the maintenance work in pipeline and low pressure.
Ward 24	Mostly depending on Tap Water for drinking and cooking. Most of them have sump facility others directly pump water from pipelines. Groundwater is mainly used for washing and other purposes. Other issues mentioned are turbidity and Chlorine smell rarely.
Ward 25	Mostly depending on Tap Water for drinking and cooking. Most of them have sump facility others directly pump water from pipelines. If there are shortage issues they arrange water from suppliers. Groundwater is mainly used for washing and other purposes. Other issues mentioned are turbidity and Chlorine smell in certain areas only.
Ward 26	Mostly depending on Tap Water for drinking and cooking. Groundwater is mainly used for washing and other purposes. No other issues were reported.
Ward 27	Groundwater is mainly used for washing and other purposes. Most of them have sump facility; others pump water directly from pipeline. In certain areas some are depending on public taps. Other issues mentioned are turbidity and Chloride smell rarely.

Ward 28	Groundwater is mainly used for washing and other purposes. Most of them have sump facility. No other issues are mentioned
Ward 29	Mostly depending on Tap Water for drinking and cooking. Groundwater is mainly used for washing and other purposes. No other issues are mentioned.
Ward 30	There are about 600 families in Vathuruthy areas. Most of the families depend on public tap for water. Less than 10 houses have direct pipe connections. Groundwater (Public well) is mainly used for washing and other purposes.
Ward 31	Some are using filters. Issues regarding Groundwater in these areas are Salinity, smell and colour.
Ward 32	Mostly depending on Tap Water for drinking, cooking and for all other purpose. Most of them are using sump for collecting Tap water. Some are using filters. The main issues regarding Tap water is Turbidity.
Ward 33	Some of them are using sump for collecting Tap water. Issues regarding Groundwater in Ramakkodan line areas are hardness and iron so open well water is using only for gardening purposes. No health issues related to water borne diseases.
Ward 34	Mostly depending on Tap Water for drinking, cooking and well water is for other purposes. Most of them are using sump for collecting Tap water. The main issues regarding Tap water is chlorine smell. Problem in pipeline were mentioned because of the root penetration into the pipeline
Ward 35	Some of them are using sump for collecting Tap water. For those who have sump has no water shortage issues, others depending on public tap faces irregular water supply. The main issues regarding Tap water is chlorine smell and turbidity.
Ward 36	Mostly depending on Tap Water for drinking, cooking and well water is for other purposes. Most of them are using sump for collecting Tap water. The main issues regarding Tap water is turbidity.
Ward 37	Most of them are using sump for collecting Tap water. Most of the families use filter. The main issues regarding Tap water is low pressure.
Ward 38	Mostly depending on Tap Water for drinking, cooking and well water is for

	other purposes. Most of them are using sump for collecting Tap water. The main issues regarding Tap water is low pressure.
Ward 39	Mostly depending on Tap Water for drinking, cooking and for all other purpose. Most of them are using sump for collecting Tap water.
Ward 40	Most of them are using sump for collecting Tap water. For those who have sump has no water shortage issues. The main issue regarding Tap water is irregular water supply, turbidity, colour and one of the families mentioned about the incorrect water billing.
Ward 41	Some of the issues regarding water supply in these areas are water getting only in night, chlorine smell and turbidity. Families don't have pipe connection depends on water suppliers for drinking water.
Ward 42	Some are using well water for drinking purpose after filtering. The main issue regarding Tap water is irregular water supply and low pressure.
Ward 43	The main issue regarding Tap water is irregular water supply, Chlorine smell and Turbidity.
Ward 44	Mostly depending on Tap Water for drinking, cooking and well water is for other purposes. Pipe water is collecting in sump. The main issue regarding Tap water is low pressure, colour, Chlorine smell and Turbidity.
Ward 45	Mostly depending on Tap Water for drinking, cooking and well water is for other purposes. Most of them are using sump for collecting Tap water. The main issue regarding Tap water is Chlorine smell and Turbidity.
Ward 46	Faces high water scarcity, not getting sufficient water for daily use. People in this ward are mostly depending on Tap Water for drinking, cooking and well water is for other purposes. Most of them are using sump for collecting Tap water. The main issue regarding Tap water is low pressure and irregular water supply. Due to low pressure they are slightly getting water.
Ward 47	Those who have no pipe connection collect water from nearby public tap. The main issue regarding Tap water is low pressure and irregular water supply.
Ward 48	Mostly depending on Tap Water for drinking, cooking and well water is for

	other purposes. Most of them collect water in sump. The main issue regarding Tap water is Chlorine smell.
Ward 49	Depend on private tanker water suppliers in case there is no water supply. No issues were reported.
Ward 50	The main issue regarding Tap water is irregular water supply, (getting once in two days) unusual smell, colour, Chlorine smell and Turbidity.
Ward 51	The main issue regarding Tap water is Chlorine smell and Turbidity.
Ward 52	Mostly depending on Tap Water for drinking, cooking and for all other purposes. Most of them have sump for collecting water. The main issue regarding Tap water is irregular water supply (getting thrice in a week).
Ward 53	Water supply is once in two days. In case of water shortage they depend on tanker water service. Most of them have sump for collecting water. The main issue regarding Tap water is Chlorine smell.
Ward 54	In case of water shortage they depend on tanker water service. Most of them have sump for collecting water. No issues were reported.
Ward 55	Mostly depending on Tap Water for drinking, cooking and well water is for other purposes. Most of them are using sump to collect water. The main issues regarding Tap water is irregular water supply, (getting once in two days) and low pressure. Usually these area faces water shortage issues.
Ward 56	Most of them are using sump to collect water. No issues were reported.
Ward 57	Mostly depending on Tap Water for drinking, cooking and well water is for other purposes. Most of them are using sump to collect water others collect and store in household vessels. No issues were reported.
Ward 58	Most of them are using sump to collect water. No issues were reported.
Ward 59	People depend on Tap Water for drinking, cooking and well water is for other purposes. Some are using Tap water for all household purposes. Most of them are using sump to collect water. Water shortage issues are rare.
Ward 60	Some are using Tap water for all household purposes. Most of them are using sump to collect water. No issues were reported.
Ward 61	Mostly depending on Tap Water for drinking, cooking and well water is for

	other purposes. Most of them are using sump to collect water. No issues were reported.
Ward 62	Most of them are depending on water suppliers for drinking and cooking purposes. Main issue claimed by them is the bad quality of water.
Ward 63	People depend on Tap Water for drinking, cooking and well water is for other purposes like gardening, washing etc. Most of them are using sump to collect water. No issues were reported.
Ward 64	Mostly depending on Tap Water for drinking, cooking and well water is for other purposes like gardening, washing etc. Most of them are using sump to collect water. An issue in this area is irregular water supply. Most of them are collecting rain water in well.
Ward 65	People depend on Tap Water for drinking, cooking and for all other purpose. Most of them are using sump for collecting Tap water. The main issue regarding Tap water is Chlorine smell and Turbidity and sometimes low pressure issues are there.
Ward 66	Most of them are using sump for collecting Tap water. Sometimes turbidity of tap water is an issue.
Ward 67	Turbidity of tap water is an issue, other issues are low pressure and foul smell rarely.
Ward 68	People depend on Tap Water for drinking, cooking and well water is for other purposes. Some depends on Tap water for whole household purposes. Families don't have pipe connection collect water from Public Taps
Ward 69	In case of water shortage they depend on well water. Some depends on Tap water for whole household purposes. Most of them are using sump for collecting Tap water. The main issue regarding Tap water is Chlorine smell and Turbidity.
Ward 70	Mostly depending on Tap Water for drinking, cooking and well water is for other purposes. Some depends on Tap water for whole household purposes. Most of them are using sump for collecting Tap water. In this area water supply is only in morning. The main issue regarding Tap water is Chlorine smell and Turbidity.

Ward 71	Some people depend on Tap water for whole household purposes. Some are depending on water suppliers for drinking water. Most of them are using sump for collecting Tap water. The main issues regarding Tap water are irregular water supply, Chlorine smell and Turbidity. In case of water shortage they use well water.
Ward 72	Some depends on Tap water for whole household purposes. Most of them are using sump for collecting Tap water. The main issues regarding Tap water are irregular water supply, low pressure. These areas have very old pipeline connections. In case of water shortage they depends well water.
Ward 73	Most of the people depends on Tap water for whole household purposes. Most of them are using sump for collecting Tap water. The main issues regarding Tap water are Chlorine smell, Turbidity, low pressure and irregular water supply. In case of water shortage they depends groundwater or depend on water suppliers.
Ward 74	Some of them collect rain water and is used for washing purposes. Most of them are using sump for collecting Tap water. The main issues regarding Tap water are Turbidity and Chlorine smell.

4.3 GIS Based Report on Survey details

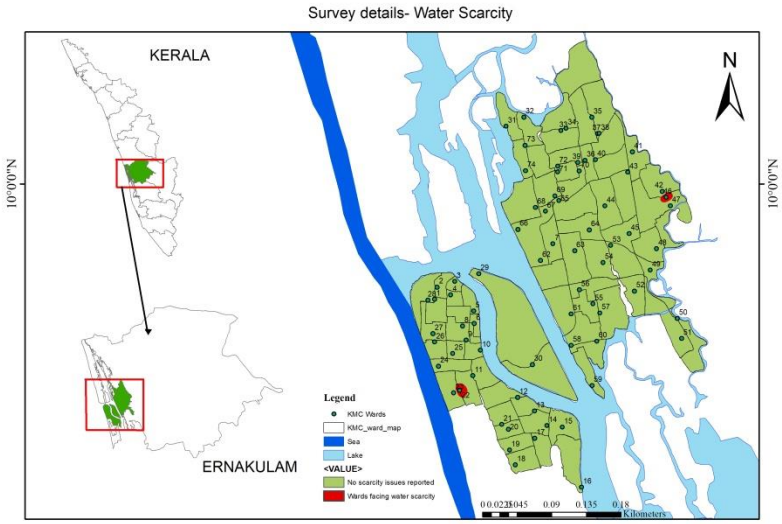

Fig. 4.4 **Wards having Water scarcity as per survey**

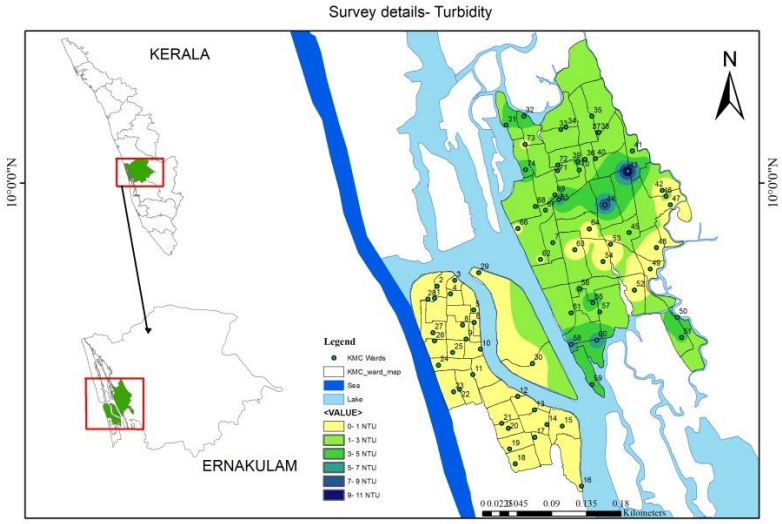

Fig. 4.5 **Wards having turbid Water problems as per survey**

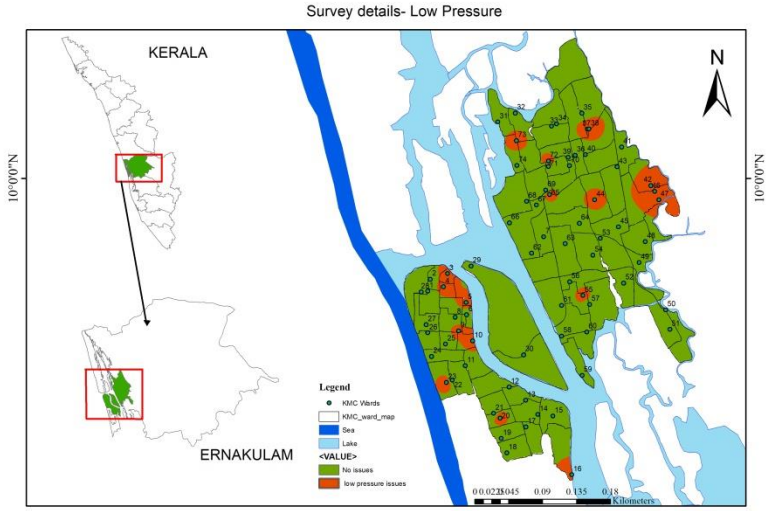

Fig. 4.6 **Wards having low pressure in supply as per survey**

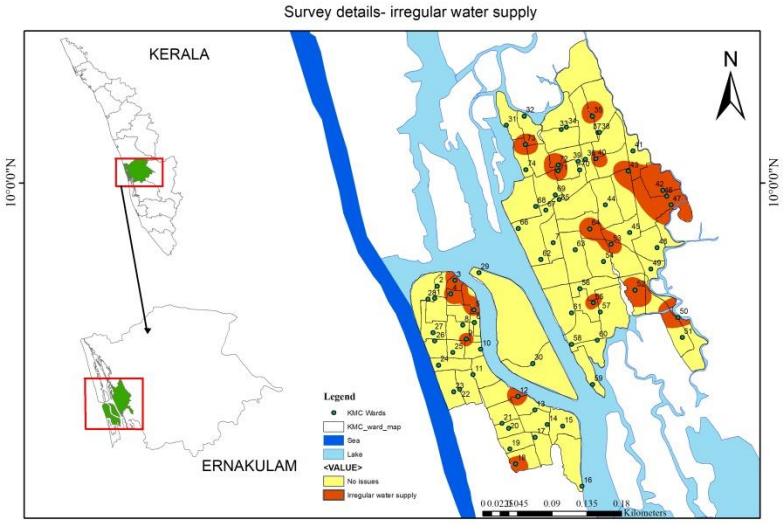

Fig. 4.7 **Wards having irregular water supply as per survey**

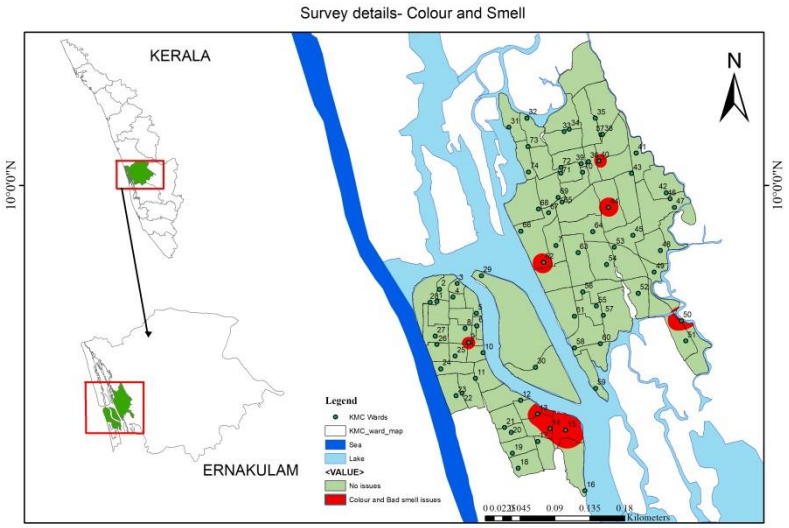

Fig. 4.8 **Wards having color and smell of water as per survey**

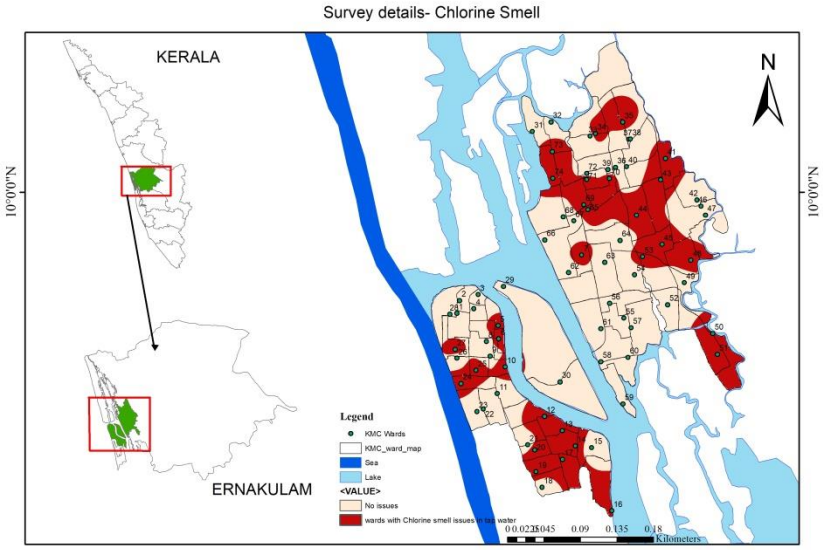

Fig. 4.9 **Wards having chlorine smell in Water as per survey**

CHAPTER 5

Municipal Water Management in Kochi

5.1 Water Demand projections

The primary source of water supply in Kochi Municipal Corporation is the Periyar River and Muvattupuzha River. There are two head works and treatment plants, one at Aluva with an installed capacity of 225 mld and the other at Maradu which has an installed capacity of 100 mld.

The total water consumption comprises of domestic and non domestic consumption, including water requirements for industrial, commercial and institutional uses, hospitals, hotels, theatres, gardens etc. To this total consumption unaccounted water which includes requirement for firefighting and appropriate allowances for leakage losses and water treatment plant losses are also added to get the total raw water demand. Both urban and rural areas of Kochi City Region have to depend mainly on protected water supply. The total installed capacity of Aluva Treatment plant is 225 mld in which an average of 290 mld is produced (over production) and the supply area from the plant caters to Kochi Corporation, four Municipalities & 27 panchayath. The daily catering from Aluva treatment Plant to Kochi Municipal Corporation is about 170- 190 mld. The total installed capacity of Maradu Treatment plant is 100 mld in which the daily production is only about 85 mld and the supply area from the plant caters to Kochi Corporation, one Municipality & five Panchayath. The daily catering from Maradu treatment Plant to Kochi Municipal Corporation is about 40- 60 mld. Altogether there is a daily supply of about 210- 230 mld to Kochi Municipal Corporation from both treatment plants. In Kochi Municipal Corporation there are some bulk users such as Cochin Port, Naval Base, Cochin Shipyard, Hospitals, University, Colleges, and Schools etc. According to KWA the total demand of water supply in 2046 will be 405 mld alone from Aluva water treatment Plant.

At present, there are about 1,26,639 domestic pipeline connections, 20,764 Non-domestic connections and 230 industrial Connections in Kochi Municipal Corporation area.

The total water consumption comprises, domestic and non-domestic use, including water requirements for industrial, commercial and institutional uses, hospitals, hotels, theaters, gardens etc. To this total consumption, unaccounted water, which includes requirement for fire fighting and an appropriate allowance for leakage losses, is added to calculate the filtered water demand. Water Treatment Plant (WTP) losses are further added to obtain the total raw water demand. As per JNNURM guidelines, the domestic demand is taken as 150 lpcd which is in line with the CPHEEO norms for clearing water supply and sewerage projects funded by Government of India. The non – domestic, and other Industrial demand and provision for losses are also as per JNNURM guidelines.

The likely growth in population water demand in Kochi Municipal Corporation is projected to increase.

5.2 On-going initiatives by KMC and KWA to enhance water supply

5.2.1 AMRUT

AMRUT is a Centrally Sponsored Scheme under Ministry of Urban Development, Government of India. The Mission was launched on 25thJune 2015 by Hon. Prime Minister Sri. Narendra Modi.

Kochi is one of the Amrut City in Kerala. As per the Amrut guidelines a City Mission Management Unit has been setup for co-coordinating the activities of Amrut Projects.

Purpose of AMRUT

- The National Priority is to create infrastructure
- To provide basic services to households
- To build amenities
- This will improve the quality of life of all, especially the poor and the disadvantaged.
- The infrastructure should lead to provision of better services to people

Coverage

AMRUT aims to support 500 cities having a population greater than one lakh (100,000) during the five year Mission Period – from 2015 – 2020.

Highlights

- Cooperative federalism – Freedom to States/ULBs to design and implement.
- Service Delivery – Focus on infrastructure that leads to delivery of services to citizens.
- Reforms Incentivised – 10% incentive for Achievement of Reforms.
- Capacity building strategy – Individual and Institutional
- O&M of infrastructure built-in at Planning stage itself.
- Focus on Planning before hand
- Service Level Improvement Plans (SLIP)
- State Annual Action Plan (SAAP)

Fund allotment: As per SAAP (State Annual Action Plan) 2015-16-Rs 75.91Cr

1.	Water Supply	7.89
2.	Sewerage	33.78
3.	Drainage	24.56
4.	Urban transport	9.21
5.	Park	0.38

Ongoing Projects under Amrut to enhance Water supply

- Replacement of existing 525mm distribution cum pumping main with 600mm rider main from Karuvelippady to Koovappadam in Kochi Corporation.
- Construction of 15L Ltrs. Capacity GL tank at Karuvelippady in Kochi Corporation
- Replacement of 250mm CI pipe by 300mm DI K9 pipe along Konthuruthi road of Kochi Corporation 2016- 17

- Replacement of 100mm AC pipe by laying rider line of 160mm PVC (6kg/cm2) along both side of Pandit Karupan road of Kochi Corporation 2016- 17
- Replacement of 100mm CI pipe by laying 160mm and 110mm PVC Class 5 along both side of pipes from Valanjambalam to Ravipuramin Kochi Corporation 16-17
- Replacement of 5000 damaged serviced water connections
- Construction of 17 LL capacity OHSR and CWR at Pachalam.
- Construction of 15LL OHSR and 2 LL CWR at Vadathode, Cheranalloor.
- Construction of 10LL OHSR at Thevara.
- Construction of 13LL capacity OHSR at Edakochi
- Construction of 25 LL OHSR at Karuvelippady
- Construction of 40 LL capacity OHSR at Kaloor

(Source*- Kochi Municipal Corporation website)

5.3 Smart City Mission

Ministry of Urban Development launched the Smart Cities Mission on 25th June 2015. The purpose of the Smart Cities Mission is to drive economic growth and improve the quality of life of people by enabling local area development and harnessing technology, especially technology that leads to Smart outcomes.

Objectives of Smart city mission

- Provide Basic infrastructure
- Improved quality of life
- Clean and sustainable environment
- Apply Smart Solutions
- Set examples to be replicated both within and outside the Smart City and catalyze the creation of similar Smart Cities.

5.4 Pan-city Solution (II)

Pan- city Solution (II) is the Implementation of Intelligent water management solutions for the proposed 24*7 Water supply scheme under Smart city mission in Kochi. This solution seeks to complement the proposed initiative to provide city-wide 24x7 water

supply and equip the proposed distribution infrastructure creation with smart water management solution like smart meters equipped with GPS/GPRS based meter reading.

The solution is a vital component towards the Government of Kerala's initiative to implement a city wide 24x7 water supply in Kochi city. Kochi region is geographically endowed with an extensive system of rivers and water bodies and also has plentiful rains for around 6 months a year.

The proposed solution will complement the proposed initiative of Government of Kerala through supporting financing and implementation of intelligent smart water management solutions for the system. The solution would contribute significantly to the efforts of Kochi towards provision of universal and efficient 24x7 water supply to its citizens and bring down the NRW to less than 10 percent. For example, the systems help predict potential delivery disruption, better forecast long-term demand, and coordinate resources to protect water supply The proposed intervention shall also provide real time information on the efficiency of operations including pressure and leak management, quality management, and work scheduling.

The Intelligent water management solution is critical ingredient to make the vision of 24x7 water supply a reality. This is proposed to be implemented with a progressive metered tariff structure while ensuring availability of lifeline supply at affordable levels. This initiative will significantly contributed to the goal of inclusive, fair and equitable water supply.

The smart metering initiative of Kochi under the pan city solution is inspired by recent successes achieved by several other Indian cities including Mumbai and Delhi that have opted for smart meters. In some cases, installation of smart meters led to reduction in water.

KMC and KWA recognise that water metering is not a stand-alone initiative. Significant upfront work in the form of creation of Discrete Metering Areas (DMAs) and network isolation, creation of adequate overhead storage/pumping capacity and a revamped

distribution network are critical. Further, for a truly end-to-end 24x7 solution, it is critical to plug leakages at house-level through awareness programs.

AMRUT and State schemes (Pan-City Solution (II))

The Smart Metering initiative under the Pan City Proposal will support and complement the proposed 24x7 water supply that is envisaged for implementation through a combination of funds from AMRUT and State Schemes. The Total Capital Cost of the SCP (Smart city plan) is Rs. 2076 crore. The outlay towards Area Development Plan is 1386 crore and Rs 690 crore is towards the Pan-city Solution. Under the Pan-city Solution, the 24*7 Water supply system provides for universal access as well as improved quality of life for the citizens.

PANCITY - Under pan-city solution the specific components include

a) 24/7 Water Supply pan city - Rs 621 crore

b) Integrated City APP - Rs 25 crore

Benefits

Pan-city proposal (II) can be measured directly in terms of reduced NRW and an ability to better monitor and plug leakages. Further, the system coupled with independently regulated and appropriate tariffs, could also support an improvement in water supply finances.

Impacts on Governance of the proposed pan-city solution (II) are summarized below

- Reduction in NRW
- Improved user charge realizations
- Better monitoring
- Assured supply and value for user charges paid (in terms of linkage with consumption)
- Ease of payment and information access (online hassle free meter-reading)

(Source*-http://cidco-smartcity.niua.org/wp-content/uploads/2016/11/kochi.pdf and KSUDP website)

5.5 Major issues in water supply

5.5.1 No service reservoir based system

There is no proper facility to distribute water from storage tank. Right now there are about five storage tanks in Kochi Corporation area, but unfortunately none of them are in working condition. Right now the water supply is based on the pumping system. So in case of domestic water supply one of the major problems is that, the end line consumers are not getting enough water.

5.5.2. Direct pumping of water from pipeline by the domestic consumers

Those who have sump facility, store water in sump and from there they are pumping to over head tanks so there is no pressure issue. Insufficiency of space is the main reason for the absence of sump in most of the houses. Those who have no sump facility, have connection directly from the main pipeline to the household taps. Some of them pump water directly from the main pipelines to the over head tanks this causes pressure issues in the end line consumers. If there is any breakage in the pipeline, the water gets contaminated or get turbid.

Plate 5.1 **Unhygienic public taps in KMC area**

Plate 5.2 **Collecting water from Public Taps in low pressure areas**

5.5.3 Water meter issues

The leakages in underground sump in the houses of individual customers go unnoticed. They are identified only when the consumer receives huge water bills, which is disproportionate to the usage of water. Incorrect reading of water meter by the official. If the level of sump is above the main pipeline there is a chance for the reverse flow of water from sump to main pipeline. This causes disproportionate water bill.

Plate 5.3 **Water meter**

5.5.4 Non-Revenue water

In many places, the KWA's distribution network dates back to 40 years and above, and it is extremely difficult to trace many of their underground pipelines. The difficulty in tracing underground pipes and identifying the exact locations of leak causes delay in maintenance. Water pipeline bursts have increased in recent times leading to water shortage, accidents and traffic snarls in cities. The increase in non-revenue water in the urban water supply system is a growing challenge considering the scarceness of the resource. Un-billing of the authorized and un-authorized users, apparent losses such as customers meter inaccuracy, un-authorized consumption, meter reading errors, data handling and accounting errors, water theft and illegal siphoning from main pipelines etc also comes under non- revenue water.

Plate 5.4 **Water leakage in KMC area**

Plate 5.5 **Water loss from public taps**

5.5.6 Contaminated drinking water

The supply chains with broken or porous rusted pipes would contaminate the drinking water. In many areas, the KWA's water supply pipeline goes along with or inside the drains. “When, there is less water in the KWA pipeline, water from the drains would gush in to the pipes. This has led to water contamination in many places in the state including West Kochi area.

Plate 5.6 **Domestic Pipeline connection through drainage**

Plate 5.6 **Rusted Hand Pump adjacent to drainage**

5.6 Suggestions for Water Management in KMC

5.6.1 Capacity Building of different Urban Bodies

- Desperately need to build capacity to take managerial and technological decisions an essential public service like water supply and to implement and deliver these services to all.
- Systematic planning, resource allocation, or skill enhancement programmers.
- One of the major underlying reasons for the poor performance of water utilities is lack of trained professional cadre. If so they had a positive impact on governance, reforms initiatives, attracting external funding and technological innovation.
- Coordination between different Government Department like KWA, Irrigation, PWD, LSGD

5.6.2 Recycling and Reuse of Waste Water

- The need to tackle water and waste water together, with primacy being given to the treatment of sewage. Sewage invariably goes into streams, ponds, lakes and rivers or groundwater, causing pollution that compromises health.
- Decentralised waste water management systems can overcome many of these problems in the following ways:

  (i)Catering to the unserved areas and minimising the pressure of transporting to a single location.

  (ii)Reducing the cost of treatment and operation and maintenance (O&M) costs.

  (iii) Adopting site-specific treatment technologies based on land use.

  (iv) Minimising the land required for treatment

5.6.3 Reducing Bulk users Water Footprint

- A rapidly emerging element of urban water, which requires much greater focus on recycling and reuse, is Bulk users of water. They are currently excessively dependent on freshwater and tends to dump its untreated waste into rivers and groundwater.
- Water audit of Bulk users such as Cochin port trust, Universities, Indian Navy: so that this builds experience and confidence on the best practices.

5.6.4 Integrated Urban Water Management

- IUWM approach must be adopted which involves managing freshwater, wastewater, and storm water, using an urban area as the unit of management. It helps in

  a. **Sustainability**

  Closing the urban water loop and integrating all aspects of water from source to sink.

  b. **Good governance**

  Balancing the demand, supply, and resource availability. People's participation in all stages. Universal access to water and sanitation facilities.

  c. **Empowering local government**

  Empowering, strengthening, and building local institutions to be able to carry out these functions

5.6.5 A Good Distribution System

- Water quality should not get deteriorated in the distribution pipes.
- It should be capable of supplying water at all the intended places with sufficient pressure head.
- It should be capable of supplying the requisite amount of water during firefighting.
- The layout should be such that no consumer would be without water supply, during the repair of any section of the system.
- All the distribution pipes should be preferably laid one metre away or above the sewer lines.
- It should be fairly water-tight as to keep losses due to leakage to the minimum.
- Implementation of service reservoir based systems in areas having low pressure issues (Zoning)

5.6.6 Promoting Water conservation

- Surface water sources may sometimes fail to meet the rising demands of water supply in urban areas. This precarious situation needs to be rectified by promoting Rain water harvesting at household level.

- KMC /KWA should undertake installation and maintenance of Bulk Meters and record water flows at Intake points, Treatment Plants, Storage and Pumping points.

- Proper maintenance of depilated pipes

- Water literacy at household level.

- Regular monitoring of water pressures where low water pressure issues are prevailing

5.6.7 Reduce Water theft

- Water theft is a political and social issue. Reducing this part of commercial losses is neither technically difficult nor costly, but it requires making difficult and unpleasant managerial decisions that may be politically unpopular. The reason is that illegal connections are nearly always wrongly associated with mainly in the urban poor and informal settlements.

- Have to be vigilant against widespread water theft and illegal siphoning from main pipelines.

5.6.8 Sustainable Groundwater Management

- Developing a framework of regulatory norms around urban groundwater use and protection of urban aquifers by preserving natural recharge areas.

- Understanding changes in river flows and quality, and the precise relationship between aquifers, aquifer systems and the river flowing through a town or city.

5.6.9 Protect and Prioritise Local Water bodies

- The first priority for cities when planning water supply should be the protection, restoration and recharge of their traditional water bodies.

- This would reduce costs of supply from a distance and also preserve the ecology of the city.

5.6.10 Climate change issues

- Climate change is also predicted to further impact the availability of water due to its effects on the hydrological cycle leading to more extreme rates of precipitation and evapo-transpiration, which will exacerbate the adverse effects of floods and droughts.

- More intense, extreme, and variable rainfall, combined with the lack of proper drainage will lead to flooding on the roads in urban areas adding to filth and disease.

- Conflicts across competing uses and users of water, agriculture and industry, town and country will continue to grow over the years.

5.6.11 Role of Municipality

- Municipalities may also work together with Water Authority on water quality and wastewater treatment.
- Main thrust of Municipal Developmental Projects should be of water management.
- The protection, restoration and recharge of traditional water bodies like ponds and lakes should be done by the KMC
- KMC can actively involve in water management; projects like Ayyankali Urban Employment Guarantee Scheme (AUEGS)can be used for the Water conservation and water harvesting, Basic Services to Urban Poor (BSUP) should be focused on water supply and storm water and drainage management
- Rain water harvesting should be made mandatory for the buildings of both private and public

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ANNEXURE 1 Survey format

Centre for Water Resources Development and Management (CWRDM)

Kunnamangalam
Kozhikode
www.cwrdm.org

Name of the project**: Challenges in urban drinking water management in Kerala: case study of Cochin Corporation**

Funded by: **Kerala State Planning Board, Pattom, Thiruvanathapuram**

QUESTIONNAIRE

NAME OF INVESTIGATOR: DATE :

STARTING TIME: LATITUDE :

ENDING TIME: LONGITUDE:

1. **Name of the respondent:**
2. **Address:**
3. **Ward Name/No:**
4. **Locality:**
5. **Total No. of people:**
6. **Type of family: Nuclear/ Joint**
7. **Type of residence: Flat/Individual House/Shops/Hotels/ Others**
8. **Ownership of the house: Owned/ Rented**
9. **What is your main source of drinking water?**
    a) Public tap

b) Tankers
c) Household water supply/ piped
d) Public wells
e) Other, specify(Bore well/ hand pump, Packaged mineral water, Pond, Open well, Rain water etc…)

Public Tap

10. **How far (in meters) is the public tap that you use? :**
……
11. **What is the frequency of water supply?**
a) More than once a day b) Once a day c) Once in two days d) Once in three days e) Once a week f) Other
12. **Duration and Timing of Water Supply**
Morning: _____ to _____
Noon: _____ to _____
Evening: _____ to _____
13. **Is this frequency sufficient for your needs?**
a) Yes b) No
14. **Is the quantity of water that you receive adequate?**
a)Yes b) No
15. **How long could you survive without water?**
a) Less than a day b) A day c) 2 days d) More than 2 days
16. **Is water available from public tap throughout the year?**
a) Yes b) No
17. **Has the public tap broken down in the past one year?**
a) Yes b) No
18. **Is the public tap fixed promptly when it breaks down?**
a) Yes b) No
19. **Generally, how does the water smell?**
a) No smell b) Foul smell
20. **Generally, does the water have a taste?**
a) Yes b) No (tasteless)
21. **Generally, what does the water look like?**
a) Clear b) Cloudy/ dirty
22. **Do you pay for water?**
a) Yes b) No
23. **Have you made a complaint related to your drinking water service?**
a) Yes b) No
24. **What was the result of the complaint?**
a) Prompt action taken b) Delayed action taken c) No action taken
25. **Overall, are you satisfied with your drinking water service?**
a) Satisfied b) Dissatisfied
26. **Are you concerned about the quality of your water?**
a) Yes b) No
27. **How much drinking water (in liters) does your household consume each day?**
……

28. **Are there any water-saving measures practiced in the household?**
    a) Yes b) No
    If yes, please explain:_____

29. **General Problem in water supply system in selected locality:**

Problem	Summer	Rainy	Winter
Low Pressure			
Erratic Water Supply			

30. **Do you use this water for any other purpose other than drinking?**
    a) Yes b) No
31. **If yes,**
    a) Bathing b) Animals c) Cooking d) Gardening e) Laundry
    f) Cleaning house g) Other……..

Tankers

32. **What is the frequency of Tanker water supply?**
    a) More than once a day b) Once a day c) Once in two days d) Once in three days e) Once a week f) Other
33. **Duration and Timing of Water Supply**
    Morning: _____ to _____
    Noon: _____ to _____
    Evening: _____ to _____
34. **Is this frequency sufficient for your needs?**
    a) Yes b) No
35. **Is the quantity of water that you receive adequate?**
    a) Yes b) No
36. **How long could you survive without water?**
    a) Less than a day b) A day c) 2 days d) More than 2 day
37. **Generally, how does the tanker water smell?**
    a) No smell b) Foul smell
38. **Generally, does the tanker water have a taste?**
    a) Yes b) No (tasteless)
39. **Generally, what does the tanker water look like?**
    a) Clear b) Cloudy/ dirty
40. **Do you pay for tanker water?**
    a) Yes b) No
41. **How much do you pay a month? …….**

42. **Have you made a complaint related to your drinking water service in the past one year?**
    a) Yes b) N

43. **What was the result of the complaint?**
a) Prompt action taken b) Delayed action taken c) No action taken

44. **Overall, are you satisfied with your drinking water service?**
a) Satisfied b) Dissatisfied

45. **Do you use this water for any other purpose other than drinking?**
a) Yes b) No

46. **If yes,**
a) Bathing b) Animals c) Cooking d) Gardening e) Laundry
f) Cleaning house g) other……..

Household water supply (piped)

47. **What is the frequency of water supply?**
a) More than once a day b) Once a day c) Once in two days
d) Once in three days e) Once a week f) Other

48. **Are you experiencing water shortages in the area where you live?**
a) Yes b) No c) Don't know

49. **Do you face an irregular water supply?**
a) Yes b) No

50. **Is this frequency sufficient for your needs?**
a) Yes b) No

51. **Is the quantity of water that you receive adequate?**
a) Yes b) No

52. **How long could you survive without water?**
a) Less than a day b) A day c) 2 days d) More than 2 days

53. **Is water available from household water supply throughout the year?**
a) Yes b) No

54. **Has the household water supply pipe broken down in the past one year?**
a) Yes b) No

55. **Is the household water supply fixed promptly when it breaks down?**
a) Yes b) No

56. **Generally, how does the water smell?**
a) No smell b) Foul smell

57. **Generally, does the water have a taste?**
a) Yes b) No (tasteless)

58. **Generally, what does the water look like?**
a) Clear b) Cloudy/ dirty

59. **Do you pay for water?**
a) Yes b) No

60. **How much do you pay a month?**

61. **Have you made a complaint related to your drinking water service?**

a) Yes b) No

62. **What was the result of the complaint?**

a) Prompt action taken b) Delayed action taken c) No action taken

63. **Overall, are you satisfied with your drinking water service?**

a) Satisfied b) Dissatisfied

64. **Are you concerned about the quality of your drinking water?**

a) Yes b) No

65. **Do you use this water for any other purpose other than drinking?**

a) Yes b) No

66. **If yes,**

a) Bathing b) Animals c) Cooking d) Gardening e) Laundry
f) Cleaning house g) other……..

Well/Public Well

67. **How far (in meters) is the Public well that you use? : ……..**

68. **How long is your well from septic tank?**
……..

69. **Generally, how does the water smell?**

a) No smell b) Foul smell

70. **Generally, does the water have a taste?**

a) Yes b) No (tasteless)

71. **Generally, what does the water look like?**

a) Clear b) Cloudy/ dirty

72. **Are you concerned about the quality of your drinking water?**

a) Yes b) No

73. **What are steps taken to improve the quality of drinking water?**
……..
……..
……..
…….....

74. **What is the frequency of cleaning the well?**

a) Once in a quarter b) Once in six months c) Once a year
d) Not cleaned in the last year

75. **How frequently do you chlorinate your well?**
……..

76. **Is water available throughout the year?**

a) Yes b) No

77. **Which seasons do you face scarcity?**
……..

78. **Do you use this water for any other purpose other than drinking?**

a) Yes b)No

79. **If yes,**

a) Bathing b) Animals c) Cooking d) Gardening e) Laundry
f) Cleaning house g) other……..

Common questions

80. **Do you buy drinking water from a store?**
a) Yes b) No c) Sometimes
81. **Are you confident that the drinking water, which you buy from a store is suitable for drinking?**
a) Yes b) No c) Never think about it d) I don't know
82. **Are you satisfied with the quality of drinking water?**
a) Yes b) Could be better c) No
83. **Among those which one do you think will possess highest quality?**
a) From wells b) Bottled water c) From water taps
84. **In your opinion, who should be responsible for drinking water quality?**
a) Society at large b)Corporation/Municipality/Panchayaths c)Water suppliers
85. **Are there any water-saving measures practiced in the household?**
a) Yes b) No
If yes, please explain:_____
86. **Have you ever had any medical problems in your area connected with bad quality of drinkable water?**
a) Never b) Very seldom c) Quite often d) I don't know
87. **The incidence of water borne diseases**
a) Malaria b) Dengue c) Jaundice d) Cholera e) Typhoid f) Diarrhea
g) Tuberculosis h) Skin infection i) Leptospirosis j) others
88. **Where do you store your water?**
……..
89. **Do You Do Anything To Your Water Before You Drink It?**
a) Yes b) No
90. **Coping Mechanisms for unsafe water:**
a) Boiling b) Filtering by cloth c) Filtering by Mechanical Devices d) R.O
f) Others
91. **Are you aware of any significant water pollution in the area where you live?**
a) Yes b) No c) Don't Know
92. **What are the reasons for water pollution in your area?**
a) Pesticides and Insecticides b) Industrial effluents c) Domestic Sewage
d) Any others……..
93. **How was the impact of flooding by the last 5 years?**
a) Increased b) decreased c) unchanged

94. **How was the impact of flooding by the last 5 years?**

a) Increased b) decreased c) unchanged

95. **Do you collect rain water for your household?**

a) No b) sometimes c) often

96. **Do you have a rain water harvesting tank?**

a) Yes b) No

If yes, please specify how many tanks and their capacity……

97. **How do you utilize the collected rain water?**

a) For drinking purposes b) for car washing c) for gardening d) others

98. **What kind of toilet do you use?**

……

99. **What kind of a sewage system do you have?**

…….

100. **Do you perceive that you can save water?**

a) Yes b) No

If yes :

Water Saving In	How it can be saved	Efforts done to save water
a) Toilet water b) Bath water c) Clothes Washing d) Utensils Cleaning e) Drinking and Cooking f) Watering the garden g) House Cleaning h) Car Washing i) Others : 1 2 3		

Signature

Drinking Water Management in KMC

Actions	To be done by
Capacity Building of different Urban Bodies	**Government, KMC, KWA, LSGD, PWD**
Recycling and Reuse of Waste Water	**KWA, Beneficiaries (end users)**
Reducing Bulk users Water Footprint	**KWA, Beneficiaries (end users)**
Integrated Urban Water Management	**KWA, Beneficiaries (end users)**
A Good Distribution System	**KWA**
Reduce Water theft	**KWA, KMC, Police Department**
Sustainable Groundwater Management	**Ground Water Department, KMC**
Protect and Prioritise Local Water bodies	**Government, KMC**
Climate change issues	**Government, KMC**
Promoting Water conservation	**KMC, KWA**