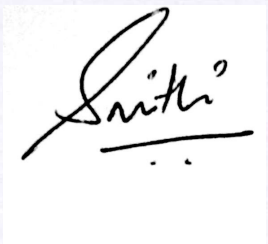
BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
SOUTHERN ZONE, CHENNAI

ORIGINAL APPLICATION NO. 141 of 2021(SZ)

The Tribunal on its own motion based on the news item published in Kerala Kaumudi News Paper web edition dated 6th June 2021 under the caption "A New Ray of Life For Pallikkalar".	:	Applicant
Vs		
The Principal Secretary to Government of Kerala, Department of Environment, Thiruvananthapuram and Ors.	:	Respondent(s)

REPORT FILED BY THE CHIEF ENVIRONMENTAL ENGINEER, KERALA STATE POLLUTION CONTROL BOARD, FOR AND ON BEHALF OF THE RESPONDENT



Adv.RemaSmrithi.V.K

ADDITIONALSTANDINGCOUNSELFOR THE FIFTHRESPONDENT

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
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Dated this the 25th day ofNovember2025

RemaSmrithi. V.K,Advocate

ADDITIONALSTANDINGCOUNSELFOR THE FIFTHRESPONDENT

BEFORE THE HONOURABLE NATIONAL GREEN TRIBUNAL

SOUTH ZONE, CHENNAI

Original Application No.141 of 2021 (SZ)

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Respondents : The Principal Secretary to Government ofKerala, Department of EnvironmentThiruvananthapuram and Ors.

Report filed by Chief Environmental Engineer, Kerala State Pollution Control Board, Regional Office, Thiruvananthapuram on behalf of The Kerala State Pollution Control Board, in Original Application No. 141/2021.

1. This report is filed in continuation to the earlier report submitted by the Kerala State Pollution Control Board on 11.11.2024 and the subsequent status report filed on 24.03.2025.
2. It is respectfully submitted that the National Environmental Engineering Research Institute (NEERI) has completed the 'Feasibility Study on the Development of Process Package for Treatment of Domestic Sewage (Edappally, Perandoor, Patolithot and Valiyat Canals) to meet Environmental Compliance'. NEERI has submitted the draft final report on 22.09.2025 to the Board. A copy of the same is produced herewith and marked as Annexure R5(1).
3. It is further submitted that a detailed discussion on the draft report was held by the Board with officials from NEERI on 19.11.25. Based on the comments and the recommendations made by the Board during the meeting, NEERI was informed to incorporate the required modifications. The final report, incorporating these revisions, is currently awaited.

The above facts are respectfully submitted for the kind consideration of this

KERALA STATE POLLUTION CONTROL BOARD REGIONAL OFFICE THIRUVANANTHAPURAM

SUMITHRA S.
Chief Environmental Engineer

Hon'ble Tribunal.

All that stated above are true to the best of my knowledge and belief.

Dated this the 25th day of November 2025.

KERALA STATE POLLUTION CONTROL BOARD * REGIONAL OFFICE * THIRUVANANTHAPURAM

Chief Environmental Engineer

Kerala State Pollution Control Board

SUMITHRA S.
Chief Environmental Engineer

Solemnly affirmed and signed by the deponent who is known to me on this the 25th day of November 2025.

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
SOUTHERN ZONE, CHENNAI

ORIGINAL APPLICATION NO. 141 of 2021(SZ)

The Tribunal on its own motion based on the news item published in Kerala Kaumudi News Paper web edition dated 6th June 2021 under the caption "A New Ray of Life For Pallikkalar". : Applicant

Vs

The Principal Secretary to Government of Kerala, Department of Environment, Thiruvananthapuram and Ors. : Respondent(s)

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Dated this the 25th day of November 2025

Rema Smrithi. V.K, Advocate

ADDITIONAL STANDING COUNSEL FOR THE FIFTH RESPONDENT

Draft Final Report

Feasibility Study on Development of Process Package for Treatment of Domestic Sewage (Edappally, Thevara-Perandoor, Patolithot and Valiyat Canals) to Meet Environmental Compliance

Sponsor

Kerala State Pollution Control Board,
Thiruvananthapuram

CSIR-National Environmental Engineering Research Institute Nehru Marg, Nagpur – 440 020

September 2025

Draft Final Report

Feasibility Study on Development of Process Package for Treatment of Domestic Sewage (Edappally, Perandoor, Patolithot and Valiyat Canals) to Meet Environmental Compliance

Sponsor

Kerala State Pollution Control Board,
Thiruvananthapuram

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September 2025

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Draft Final Report

Feasibility Study on Development of Process Package for Treatment of Domestic Sewage (Edappally, Thevara-Perandoor, Patolithot and Valiyath Canals) to Meet Environmental Compliance

1.0 Preamble

The Thevara-Perandoor, Edappally, Patolithot, and Valiyath Canals are situated in Kerala of Eranakulam and Kollam Districts, respectively, and provide diverse benefits of transport, recreational opportunities, regeneration, irrigation, fishing, and drainage services. However, these Canals have been converted into drains due to the population increase and infrastructure build-up in the Ernakulam and Kollam Districts. These Canals carry stormwater and domestic sewage through point and nonpoint sources, including solid waste from different Municipalities. Therefore, Kerala State Pollution Control Board (KSPCB), Thiruvananthapuram, requested vide letter [No. PCB/HO/EE3/ O.A/ No.27 / 2021 (SZ)/ 2021] dated May 08, 2023, regarding the site visit of two experts from CSIR-NEERI, Nagpur, to examine the feasibility of the Phytorid Wastewater Treatment Technology or any other similar technology for liquid waste management of the above-mentioned Canals and submit the site visit report.

Accordingly, a two-member team from CSIR-NEERI, Nagpur, and officials of different Departments of Kerala visited the concerned sites during May 11-13, 2023. Canal/Drain/Nallah/River/Lake locations were identified during this visit, which carry untreated domestic wastewater and solid and plastic wastes from different locations or Municipal areas. Based on the site visit and preliminary discussions with the officials of KSPCB and other Government Departments, the Site Visit Report based on observations, including way forward for managing the discharge of untreated domestic sewage/septage, and effluent from the respective Municipalities, Houseboats, and Prawn peeling industries into different water bodies was submitted to the KSPCB, Thiruvananthapuram on May 30, 2023. Thereafter, based on the CSIR-NEERI's Site Visit Report, KSPCB requested CSIR-NEERI, Nagpur vide letter [No. PCB/HO/EE3/OA. No. 27/2021(SZ)/2021] dated July 04, 2023, to submit the Project Proposal with the scope of the work and financial budget. The Project Proposal for a

feasibility study for developing a process package for domestic sewage to meet Environmental Compliance was submitted to KSPCB on July 28, 2023.

Later, the Member Secretary of the KSPCB requested through email, dated August 23, 2023, to submit a proposal for a feasibility study on the development of a process package for domestic sewage to meet environmental compliance for two sites, Patolithot and Valiyath Canals, discharging sewage into Pallikalar River, and Edappally and Thevara Perandoor Canals. Accordingly, CSIR-NEERI submitted the proposal and subsequently issued a work order by KSPCB to conduct a feasibility study on developing a process package for treating the domestic sewage of Edappally, Thevara Perandoor, Patolithot, and Valiyath Canals to meet the Environmental Compliance. A complete Project chronology is given in **Table 1.**

Table 1: Project Chronology

Sr. No.	Description	Dates
1.	Request from Member Secretary of Kerala State Pollution Control Board (KSPCB), Thiruvananthapuram, for site visit of CSIR-NEERI Scientist	May 08, 2023
2.	Thesite visit is carried out by CSIR-NEERI	May 11-13, 2023
3.	The Site Visit Report submitted to KSPCB, Thiruvananthapuram	May 30, 2023
4.	Request for submitting the project proposal based on site visit Report	July 04, 2023
5.	Submission of three project proposals for domestic sewage, septage, and prawn peeling industries	July 28, 2023
6.	Out of three proposals, accept one proposal on domestic sewage and request to add the site of Pallikalar (Karunagapally municipality)	August 23, 2023
7.	Submission of the revised proposal	September 22, 2023
8.	Work order issue date	September 23, 2023
9.	Requesting CSIR-NEERI to reduce the time period of the project from 15 months to 12 months	October 30, 2023
10.	Letter from CSIR-NEERI for trying to complete the study in 12 months	November 6, 2023
11.	Draft MoA submitted to KSPCB	November 28, 2023
12.	Final project proposal submission to sponsor	January 24, 2024
13.	Invoice raised by CSIR-NEERI	January 24, 2024
14.	MoA final	February 19, 2024
15.	First instalment received	February 26, 2024
16.	First monitoring started by CSIR-NEERI	April 14-19, 20024
17.	Submission of Progress Report based on the first round of monitoring to KSPCB, Trivandrum	April 25, 2024

18.	Request letter and email for secondary data sent to official KSPCB, Trivandrum	May 1, 2024
19.	Shapefile received from the KSPCB	June 15, 2024
20.	Request for secondary data sent to official of KSPCB, Trivandrum by Whatsapp	August 28, 2024
21.	Submission of Draft Interim Report	September 12, 2024
22.	Received secondary data regarding the STPs/FASTs/CETPs facility at Ernakulum	September 23, 2024
23.	The invoice raised by CSIR-NEERI for the second installment of the project fees	September 24, 2024
24.	Kochi Corporation Drainage Network -Map	October 8, 2024
25.	The second round of monitoring	October 15-21, 2024
26.	Irrigation department document	January 2, 2025
27.	The third round of monitoring	February 7-11, 2025
28.	Meeting and discussion with the Irrigation Department, Kochi, Kalamassery, and Thripunithura Municipal Corporations	March 22, 2025
29.	Meeting and discussion with the Municipalities and Local Bodies, including Kerala Water Authority, for the wards population covered in the watershed of the respective Municipalities and Local Bodies.	May 24, 2025
30.	Providing information by KSPCB, the Irrigation Department has published a report on flood mitigation in Kochi, which includes details about several canals, including the Edapally canal. The report is available on the official website of the Irrigation Department (https://irrigation.kerala.gov.in/sites/default/files/2021-08/kochiflood.pdf)	May 27, 2025
31.	Request from KSPCB, Trivendrum, regarding the submission of Draft Final Report	August 26, 2025

1.1 Need for feasibility study

Development of a process package for the treatment of domestic wastewater in natural systems is a complex task, as it has to address:

- Variation in wastewater flow and characteristics, which are diurnal and seasonal.
- Different sources of pollution and their contributions.
- Selection of appropriate technology or combinations thereof to ensure compliance with the prescribed norms by the National Green Tribunal (NGT).
- Decision on single or multiple decentralized treatment units
- Delineation of an appropriate treatment scheme/train, sludge management, treated water discharge, etc.

Therefore, a detailed feasibility study, essentially covering data in the pre-monsoon, winter, and post-winter seasons (representing the worst scenario), is essential for the

development of a scientific and technically sound process package that would ensure environmental compliance in the long term. It also assesses the performance viability of various treatment processes and delineates the most appropriate treatment scheme with design specifications, including tentative capital cost (CAPEX) and operating and maintenance costs required to treat wastewater for environmental compliance. A detailed project report (DPR) has to be prepared based on the feasibility report for its full-scale implementation. A process package thus developed, based on a scientific feasibility study, will be key for the successful implementation of the techno-economically viable scheme for treating domestic sewage to meet Environmental Compliance.

1.2 Objective

The project aims to prepare the feasibility report for developing the process package for domestic sewage from the various Canals to meet Environmental Compliance.

1.3 Scope of work:

Based on the above objective, the following is the project scope of work:

- Delineation of the stormwater and raw sewage catchment area discharged into the Canal/Nallah/Drain.
- Physico-chemical characterization of two seasons (based on the primary data) and quantification (based on the secondary data) of domestic sewage from different municipalities flowing into the Canal/Nallah/Drain.
- Population forecasting for designing the hydraulic load on the treatment scheme.
- Estimation of pollution loads of sewage discharge from different areas of municipalities.
- Evaluation of Drain/Canal/Nallah configuration for the feasibility of In-situ or Ex-situ treatment.
- Delineation of the site-specific In-situ or Ex-situ treatment scheme to meet Environmental Compliance.
- Delineation of conceptual frame design of the recommended treatment scheme with basic engineering design details and specifications (excluding the detailed engineering) for treating the domestic sewage flowing into the Nallah /drain/Canal.
- Tentative cost estimation of the recommended In-situ or Ex-situ treatment schemes.

- Project implementation strategy and schedule for in-situ or Ex-situ treatment
- Preparation of process package for Ex-situ treatment for sewage from the different municipalities flowing into Nallah/Canal/drain.
- Submission of Report.

2.0 Study area

The study area lies in the Ernakulam and Kollam Districts of Kerala State. The base map of the study area is prepared based on Survey of India topo sheets [Nos. 58B/4, 58B/10, and 58C/5] for Ernakulam and Kollam 58C/12 Districts, and the base maps of the study areas are shown in **Figures 1 and 2**, respectively. The Edappally and Thevara-Perandoor Canals are in the Ernakulam District. The length of the Edappally Canal is approximately 12 km, which originates from the Periyar/Muttar River and the confluence with the Chambakkara Canal. Both Canals receive stormwater and domestic sewage from four Municipalities and are discharged into different water bodies (**Figure 1)**. The Patolithot and the Valiyath Canals are situated in the Kollam Districts, which also receive stormwater and domestic sewage from the Karunagapally Municipality area and three Local Bodies, such as Thodiyoor, Thazhava, and Kulasekharapuram. The Canals finally discharged into the Pallikalar River (**Figure 2)**. The brief description of the four major Canals, Edappally, Thevara-Perandoor, Patolithot, and Valiyath, is as follows:

2.1 Edappally Canal (EC)

The Edappally Canal (EC) was used by the Royal family and ancient people for transportation and other purposes. This Canal forms the boundary of Kochi Corporation on the eastern side, and on the western side, TPC flows. The EC is approximately 12 km long in Kochi, Kerala, and connects the Chithrapuzha River to the Muttar River. The Canal passes through the Kochi Corporation, Thrikkakara, Kalamassery, and Thripunithura Municipalities. The configuration of the Canal throughout its length is not uniform in terms of width and depth. There are low and high tidal effects in the Canal, which allows the flow of water/wastewater in both directions, and the central portion of the Canal is seen to be almost stagnant due to the two main water bodies connected on either side of the Canal.

2.2 Thevara-Perandoor Canal (TPC)

The Thevara-Perandoor Canal (TPC) originates between the interconnection of the Thevara Canal and is discharged into Kyhal through Chittur near Perandoor. TPC was previously used for business purposes, namely, navigation and trading. Stormwater

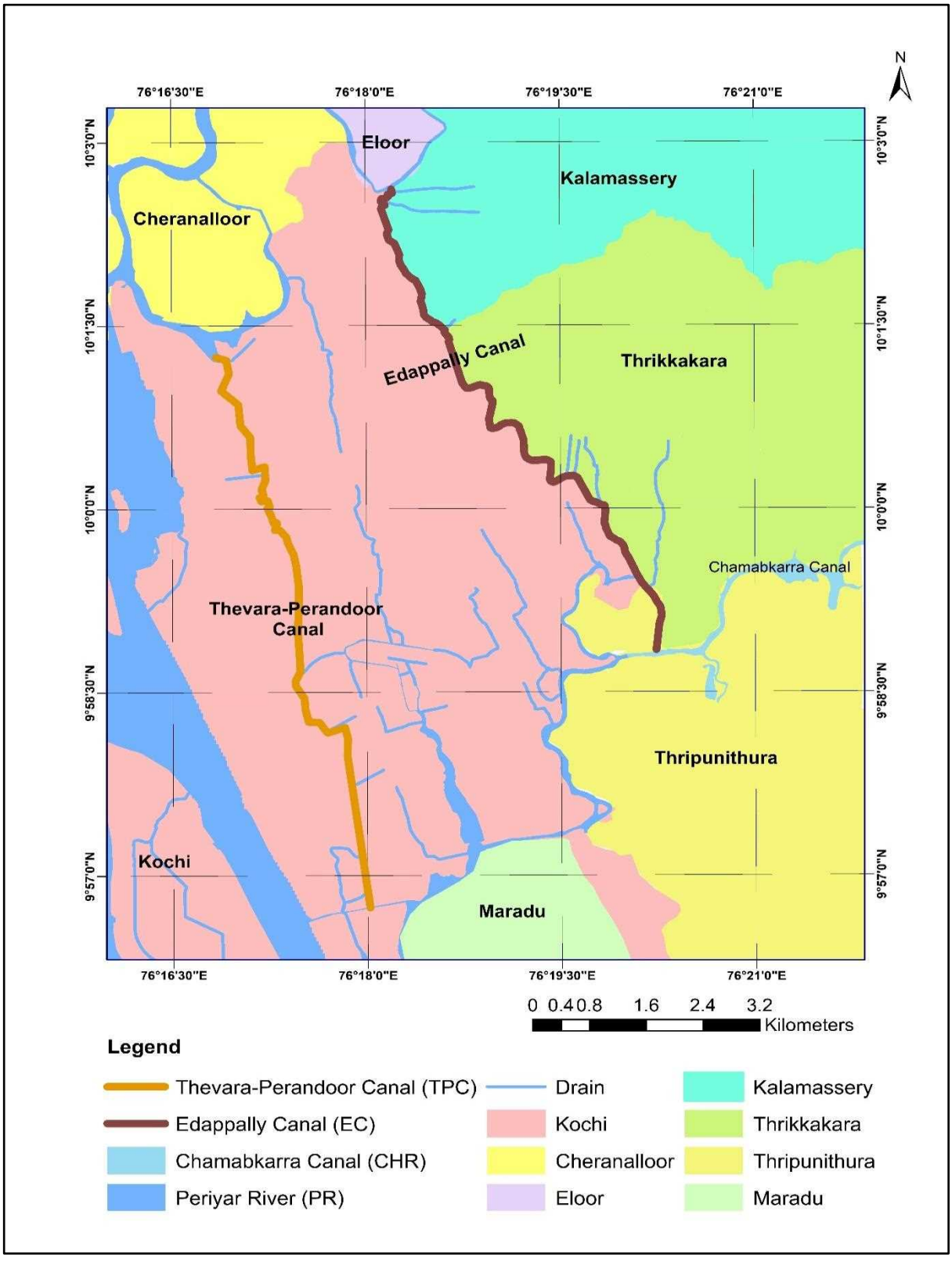

Figure 1: Base map of Edappally Canal (EC) and Thevara-Perandoor Canal (TPC)

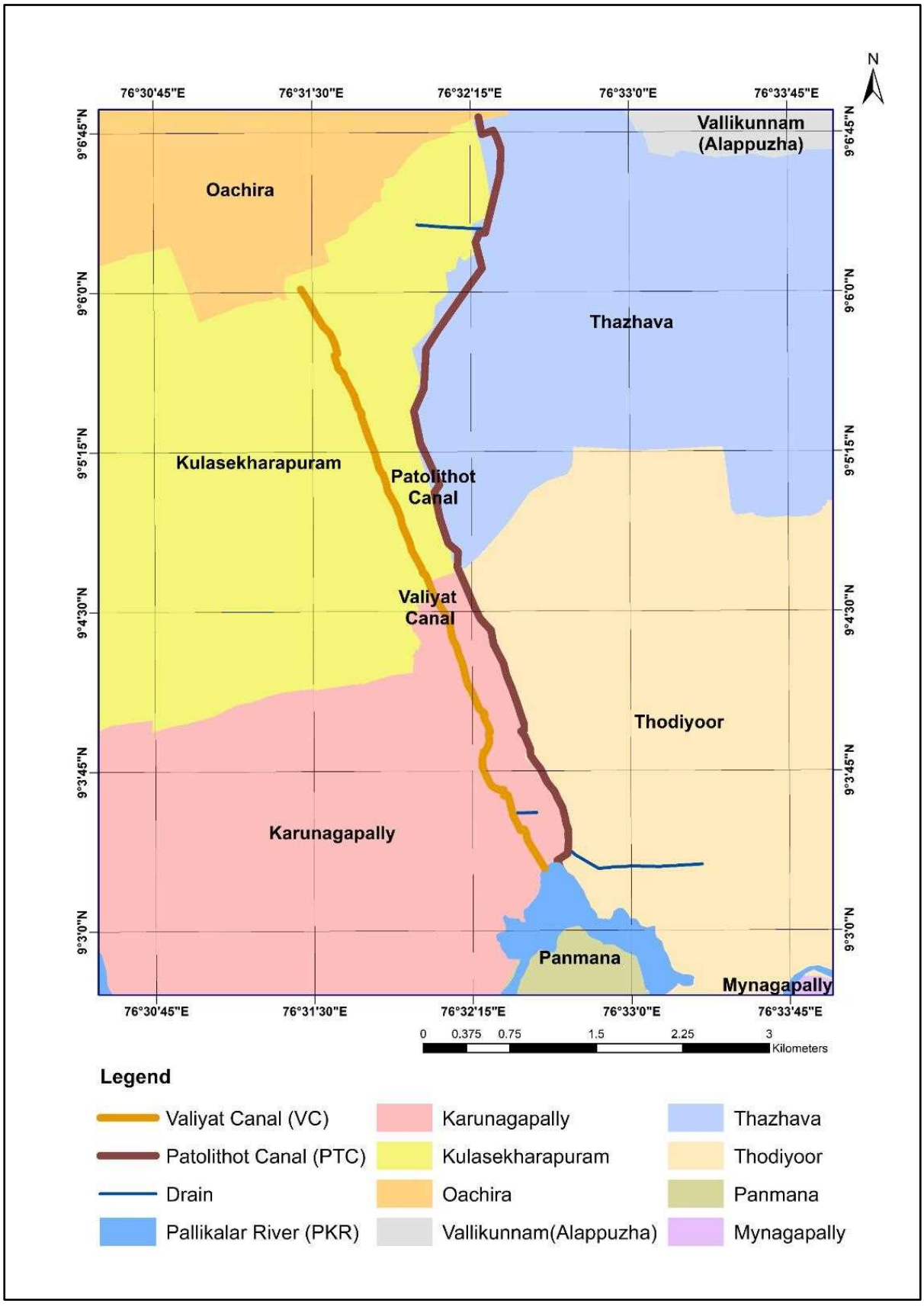

Figure 2: Base map of Patolithot Canal (PTC) and Valiyat Canal (VC)

and domestic sewage flow through the TPC, thus preventing the Kochi Corporation areas from flooding. It passes through the city's centre, covering prime and thickly populated places such as Panampilly Nagar, Kadavanthra, and Kaloor. It also passes adjacent to the Ernakulam Junction Railway Station and the Kerala State Road Transport Corporation (KSRTC) bus stand. The Canal starts as a more than 10 m wide stretch, ensuring a steady and healthy water flow. However, as it traverses a few kilometres, the Canal gradually decreases by a couple of meters towards the Panampilly Nagar area, which is considered a posh locality in Kochi. Moving a few kilometres further, the Canal near the Ernakulam Junction Railway station or the Kerala Road Transport Bus Stand stretches almost to the size of a drain. The catchment area of TPC is ~30 sq. km, and storm /drainage water reaches TPC even from a distance of 1.5 km on both sides of the Canal as per the Report on Flood Mitigation Kochi, 2021 (Irrigation Department Eranakulam 2021. This indicated the watershed of the TPC Canal lies~ 1.5 km from it.

2.3 Patolithot Canal (PTC)

Patolithot Canal (PTC) is situated between the Valiyath Canal (VC) on the western side and the Karungapally Municipality and Kulesharapuram local bodies, and on the eastern side, Thazhava and Thodiyoor Local Bodies. The direction of the Canal flow is from north to south, which carries stormwater and domestic sewage from the Karungapally Municipality, including Kulesharapuram, Thazhava, and Thodiyoor Local Bodies, and finally discharges into the Pallikalar River. The configuration of the Canal varies in width and depth. The two point sources (drains) discharge into the Pattolitot Canal, one at the upstream and another at the downstream, before the confluence with the Pallikalar River. The stormwater and untreated domestic sewage from Patolithot Canal are discharged into Pallikalar River.

2.4 Valiyath Canal (VC)

Valiyath Canal (VC) flows parallel to National Highway 66, which carries stormwater and untreated domestic sewage from the Kulesharapuram Local Body and Karungapally Municipality. The entire content of this Canal is discharged into the Pallikalar River. The configuration of the Canal varies in width and depth, and some portions of it are covered with a concrete slab and become a walkway for the pedestal.

2.5 Site observations/ Infrastructure facility

The study area, comprising Ernakulam and Kollam Districts of Kerala State, was undertaken to identify the existing infrastructure facilities available for conveyance, collection, treatment, and disposal of the domestic sewage and fecal sludge generated from the above-mentioned area. The following are site-specific observations of the Edappally and Thevara-Perandoor Canals situated in Ernakulam District, and Patolithot and Valiyath Canals located in Kollam District:

- The aerial length of the Edappally Canal (EC) is approximately 12 km, which originates from the Periyar/Muttar River and the confluence with the Chambakkara Canal. The configuration of the Canal throughout its length is not uniform in terms of width and depth. The Canal has a tidal effect, allowing the flow of water/wastewater in both directions. The main purpose of the Canal was navigation and trading. It carries stormwater and domestic sewage from the Kochi Municipal Corporation (KMC) area and the three Local Bodies.
- The EC adjacent to Lulu Mall was covered with water hyacinth on the top surface and sludge deposited at the bottom. Therefore, monitoring the flow and collecting the wastewater samples was difficult. However, the sample collection and flow monitoring were shifted to 40m upstream from the bridge near the Lulu Mall.
- Fish harvesting by the local people was carried out during monitoring near the confluence of Edappally and Chambakkara Canals.
- The Thevara-Perandoor Canal (TPC) originates between the interconnection of the Thevara Canal, and at approximately an aerial distance of 9.83 km downstream, the Canal is the confluence with the Perandoor Canal within Kochi City. This Canal was previously used for business purposes such as navigation and trading. The Canal's configuration throughout its length is not uniform. The tidal effect in the Canal allows for the flow of water/wastewater in both directions. Presently, it carries stormwater and domestic sewage generated from the KMC area.
- As per the secondary data received from the Minor Irrigation Central Circle, Ernakulam, the catchment area of the TPC is ~30 sq km, which gets the stormwater and domestic sewage from 1.5 km on both sides of the Canal for a total length of 9.95 km, a width of 15 m, and a depth of 3 m.
- The three existing sewage treatment plants (STPs) visited during the second monitoring round are located near the TPC. Out of three STPs, one STP with 0.45 MLD capacity is situated in Ward No. 67 (Ernakulam North) on the Eastern side of

the TPC, and two STPs of 5 and 0.75 MLD are located in Ward 54 (Ernakulam) and 39 (Dhevankulangara), respectively, on the Western side of the TPC.

- The 5 MLD STP installed by the Kerala Water Authority site at Elamkulam in Kochi covers five divisions, such as Elamkulam (54), Kadavandra (57), Eranakulam South (62), Gandhi Nagar (63), and Eranakulam Central (66). The STP covers a population of 30000, and the treatment plant benefits a projected population of 41000. The treatment scheme of 5 MLD STP comprised a screen, grit chamber, equalization basin, and moving bed bioreactor I & II, followed by the secondary clarifier. The clarified effluent is routed to the pressure sand filter, activated carbon column, and finally disinfected. The final treated sewage from this STP is being discharged into the Chettithara Canal. The secondary sludge is thickened in a gravity thickener, followed by a centrifuge for dewatering.
- During the site visit, it was informed that the existing 5 MLD STP was operated at 50 per cent of its capacity. An additional 2.5 MLD of sewage can be accommodated to operate the STP at full capacity.
- The unit operations and processes of 0.45 MLD of M/s Greater Cochin Development Authority (GCDA), Marine Drive, Kochi, comprise the screen, grit chamber, and collection tank. The preliminarily treated sewage is subjected to the activated sludge process, followed by the pressure sand filter and activated carbon column.
- Another STP of 0.75 MLD of M/s Greater Cochin Development Authority (GCDA), near International Stadium Kaloor, comprises a screen, oil, grease trap, and equalization basin followed by the moving bed bioreactor, flash mixer, flocculator, and secondary clarifier. The biologically and chemically treated sewage is subjected to a pressure sand filter and an activated carbon column.
- There is no sewage treatment plant to treat sewage that is being discharged from the different areas into the Edappally Canal. However, the secondary data received from KSPCB, the domestic sewage, septage, and industrial effluent generated from Ernakulam city are treated in the four sewage treatment plants (STPs), two fecal sludge treatment plants (FSTPs), and three common effluent treatment plants (CETPs), respectively. The details of the existing STPs, FSTPs, and CETPs with hydraulic flow capacity are presented in **Table 2**.

Table 2: Details of the existing STPs, FSTPs, and CETPs with hydraulic flow capacity

Sr. No.	Treatment facility	Process	Capacity, MLD
Sewage Treatment Plants (STPs)			
1.	STP owned by Greater Cochin Development Authority, Marine Drive, Kochi (0.45 MLD)	Activated Sludge Process (ASP)	0.9
2.	STP at Elamkulam, Kochi (AMRUT-1.0)	Moving bed bioreactor (MBBR)	5
3.	STP is owned by GCDA, International Stadium Kaloor	Activated Sludge Process (ASP)	0.75
4.	STP at Kalamassery, Market, Kalamassery Municipality (PRS)	-	10
Fecal sludge treatment plants (FSTPs)			
5.	Septage Treatment Plant at Brahmapuram, Kochi Corporation, Ernakulam	Moving bed bioreactor (MBBR)	0.1
6.	Septage Treatment Plant at Wellington Island, Kochi Corporation	Moving bed bioreactor (MBBR)	0.1
Common effluent treatment plants (CETPs)			
7.	CETP at Kinfra Small Industries Park Nellad, Mazhuvanoor	-	0.4
8.	CETP at Rubber Park India Private Limited (New Plant Valayanchirangara, Ernakulam	-	0.25
9.	CETP at CSEZ, Kakkanad, Cochin Special Economic Zone, Ernakulam	-	1

Source: Kerala State Pollution Control Board (KSPCB), Trivandrum.

- Patolithot and Valiyath Canals carry stormwater and untreated domestic sewage from the inhabitants of the Karunagapally Municipality area, which is finally discharged into the Pallikalar River. The configuration of both Canals, as monitored, is not uniform in terms of width and depth. During the monitoring, the septic condition and water hyacinth were also observed. Some of the Canals at the top were also covered with concrete slabs.
- As per the KSPCB, Kollam households have been facilitated with a septic tank, and its overflow is discharged into the Canal. This indicates that there is no sewerage system or sewage treatment plant to carry and treat domestic sewage generated by households. Therefore, the sewage is discharged into the above-mentioned Canals.

2.6 Secondary data received from KSPCB

The secondary data received from the Kerala State Pollution Control Board (KSPCB), Trivandrum, has been critically reviewed for water requirement, domestic sewage generation, existing treatment facility, population, desilting of the Canals, and a project in the pipeline for treating the domestic sewage generated, including the maps of the study area. The review of the secondary data is as follows:

- The review of details provided by the Kerala Water Authority (KWA), Jalabhava, Thiruvananthapuram, is as follows:
  - The raw water sources of Kochi Corporation are the Periyar River (Aluva) and the Moovattupuzha River. Aluva and Maradu water treatment plants (WTPs) supplied treated water to the Kochi Corporation. Kochi Corporation's water supply demand for the year 2024 is 270 MLD. In addition to the existing water supply, the Kerala Water Authority has proposed a new 190 MLD WTP at Aluva. However, the corporation can supply 77.77 per cent of the total demand (210 MLD), with 35 per cent being lost due to water supply through the old conveyance system.
  - Sewage generated from the Kochi Corporation area is connected to the sewerage collection network, which is approximately 28 km long. Some sewage is received and treated in the 5, 0.75, and 0.45 MLD sewage treatment plants, respectively. However, as per KWA 161.8 MLD sewage finds its way to the different water bodies, finally reaching the Arabian Sea.
  - M/s Kochi Metro Rail Ltd, as a part of Canal rejuvenation (Thevera-Perandoor Canal, Chilavannoor Canal, and Edappally Thodu/Canal), has designed a sewerage collection network and STPs (at Elamkulam, Vennala, Muttar, and Perandoor), and the DPR for the same has already been submitted. The left-out area of the Kochi Corporation has been taken by KWA, and the DPR for the same has already been submitted. The capacity of the proposed STP is not mentioned.
- The details provided by the Suchita Mission, Local Self-Government, Government of Kerala, are as follows:
  - Details of the entire Ernakulam and Kollam District populations have been provided. However, the population of the wards coming under the watershed Edappally, Thevara-Perandoor, Patolithot, and Valiyath Canals is not mentioned. The list of the population in the ward of the watershed of the

Edappally, Thevara-Perandoor, Canals is handed over to the officer of KSPCB, Ernakulam.

- Six STPs have been proposed, and one STP is ongoing for the Ernakulam District, and two STPs are ongoing for the Kollam District. The status of the ongoing and proposed sewage treatment plants (STPs) in Ernakulam and Kollam Districts is presented in **Table 3**.

Table 3: Status of the ongoing and proposed STPs in Ernakulam District

S.N.	Agency	Project Name	Capacity	Status
Ernakulam District-ongoing STP				
1.	AMRUT	Ambedkar colony	1.1	Work in progress. Physical progress 41%. Civil works of the plant are expected to be completed by 30.11.2024.
Proposed STP				
2.	AMRUT	Elamkulam	5 with 24 KLD Co-treatment	KWA split the work into 5 sub-works and issued TS. TS of the STP is being revised by KWA. Tender to be floated by KWA for the STP & network packages. Expected to be tendered by 31.10.2024.
3.		Ray Flats Fort Kochi	0.105	MoHUA's approval was received on 01.10.2024. DPR of the project to be submitted by the ULB for placing in the SLTC / SHPSC for approval of AS. DPR is expected to be submitted by 26.10.2024.
4.	IMPACT	Cochin Marine Drive	2	Awaiting KIIFB approval
5.		Life Mission Site	1	
6.		Kaloor Market	0.25	
7.		Kadavanthra Market	0.03	
Kollam Districts-ngoing STP				
8.	AMRUT	Kureepuzha	12 with 50 KLD Co-treatment	work in progress. Physical progress -90%. In the meeting held on 19.09.2024 at the Kollam Corporation by the Hon'ble Minister of LSGs, the KWA was directed to complete the STP works by 31.10.2024 so that the

				inauguration of the STP can be done on 01.11.2024.
9.	IMPACT	Mayyanad	0.59	Work in progress.

Source: Suchita Mission, Local Self-Government, Government of Kerala.

The locations and coordinates of the ongoing and proposed sewage treatment plants in Ernakulam and Kollam Districts are not mentioned. This will help identify whether these STPs come under the watershed of the Edappally, Thevara-Perandoor, Patolithot, and Valiyath Canals. This will aid in proposing the new sewage treatment plants within the study area.

3.0 Water quality assessment of the Canal

An extensive water quality survey of these Canals, including the inflow drains to the Canals, was conducted to assess the water quality of the Canals and drains. The sampling locations of the Canals and drains, including the River, were identified in consultation with KSPCB, along with the topography and hydrogeology of the area and the secondary information available. The events of the field monitoring are presented hereunder.

3.1 Field monitoring

Field monitoring comprises flow measurement and on-site monitoring of physical parameters of collected samples from different water bodies. The three monitoring events were carried out from April 15-18, 2024, October 15-20, 2024, and February 7-11, 2025, to determine the water/wastewater quality and quantity and to identify various issues of the Canals. The on-site flow measurement of different Canals was carried out using an area velocity flow meter. The grab samples were collected from different locations of the four significant Canals, namely Edappally, Thevara-Perandoor, Patolithot, and Valiyath Canals, including incoming drains of these Canals and one water body, such as the Periyar/Muttar River and Chambakkara Canal.

The sampling locations were identified as discussed above and considering the probable locations of the four Canals and the incoming drains to the Canals. The samples collected from the Periyar/Muttar and Pallikalar Rivers, Chambakkara, Edappally, Thevara-Perandoor, Patolithot, and Valiyath Canals, and drain discharging into the Canals during the first, second, and third events of monitoring are presented in **Table 4**.

Table 4: Samples collected from the River, Canal, and Drain

Sr. No.	Rivers/Canals	Sample collected within the River and Canal			Drain discharged into the Canal		
		First	*Second*	*Third*	*First*	*Second*	*Third*
1.	Periyar River	1	1	1	-	-	-
2.	Pallikalar River	0	1	1	-	-	-
3.	Chambakkara Canal	0	1	1	-	-	-
4.	Edappally Canal	3	6	8	0	1	7
5.	Thevara-Perandoor	3	8	8	0	4	5
6.	Patolithot Canal	5	8	10	0	1	2
7.	Valiyath Canal	6	8	9	-	1	1
		18	**33**	**38**	**0**	**7**	**15**

The total samples collected in the first, second, and third monitoring rounds are 18, 40, and 53, respectively.

- No incoming drain to the River and Canal. Summer-First event of monitoring, Post-monsoon-Second event of monitoring, Post-winter-Third round of monitoring.

The details of the sampling locations, along with coordinates of the Periyar & Pallikalar Rivers, Chambakkara, Edappally, Thevara-Perandoor, Patolithot, and Valiyath Canals, including incoming drains to the Canals, are presented in **Table 5.** The pictorial view of the above-mentioned sample locations are shown in **Plates 1 through 52**. **Figures 3 and 4** present the Geographic Information System (GIS) based map indicating the corresponding sampling location of the respective study area.

Table 5: Details of the sampling location of Periyar and Pallikalar River and Chambakkara, Edappally, Thevara-Perandoor, Patolithot, and Valiyath Canals

S.N.	Sample ID	Particulars	Latitude (N)	Longitude (E)
Periyar River (PR)				
1.	PR-01 (1,2 & 3)	Located at 10 m upstream of the confluence of the Edappally Canal and Pariyar River and 50 m from the starting point of EC-01 of the Edappally Canal.	10° 2'36.71"	76°18'11.51"
Edappally Canal (EC)				
2.	EC-01 (1,2 & 3)	Located at 30 m downstream of the confluence of the Periyar River and Edappally Canal near Muttar Kadava Road. (River Side Bridge, 28V3+887, Muttar, Vattekunnam, Edappally, Kochi)	10° 2'36.01"	76°18'12.08"
3.	DoEC-01 (2 & 3)	Drain from Muttar, Vattekunnam, Eddappally, located at 7.60 m downstream of the EC-01 and 36.0 m downstream of the confluence of the Periyar River and Edappally Canal.	10° 2'35.86"	76°18'12.26"
4.	EC-01A (3)	Located at 0.18 km downstream of the EC-01 and 0.19 km downstream of the confluence of the Periyar River and Edappally Canal near Mr. K.A. Akber, Kattilaparambil House.	10° 2'32.32"	76°18'9.16"
5.	DoEC-01A (3)	Located at 40 m downstream of the EC-01A and 0.23 km downstream of the confluence of the Periyar River and Edappally Canal. (Mkrab-28A Muttar, Vattekunnam, Edappaliy, Kochi).	10° 2'30.60"	76°18'16.10"

S.N.	Sample ID	Particulars	Latitude (N)	Longitude (E)
6.	EC-02 (1,2 & 3)	Located at 2.0 km downstream of the EC-01A and 40 m upstream of the bridge near Lulu Mall.	10°1’36”	76°18’26”
7.	DoEC-02A (3)	Located at 0.41 km downstream of· the EC-02 and 2.61 km downstream of the confluence of the Periyar River and Edappally Canal, near PMRA/15A, Paruthelil lane, Kalamassery.(Trinity Castle Edappally NH47-opposite Lulu Mall, Edappally, Kochi).	10°1'29.41"	76°18'37.41"
8.	EC-02A (3)	Located at 0.13 km downstream of the DoEC-02A and 2.74 km downstream of the confluence of the Periyar River and Edappally Canal, Near Marottichuvadu Thoppil Road.	10° 1 '23.49"	76°18'37.86"
9.	EC-03 (2 & 3)	Located at 0.36 km downstream of the EC-02A and 3.12 km downstream of the confluence of the Periyar River and Edappally Canal.	10° 1'11.97"	76°18'40.48"
10.	EC-04 (2 & 3)	Located at 1.90 km downstream of the EC-03 and 4.02 km downstream of the confluence of the Periyar River and Edappally Canal.	10° 0'38.64"	76°19'11.19"
11.	DoEC-04A (3)	Located at 1.36 km downstream of the EC-04 and 5.38 km downstream of the confluence of the Periyar River and Edappally Canal. (Pulikalam West Road, 283g+v66, Chembumukku Edappally, Ernakulam)	10° 0' 17 .11"	76°19'33.06"
12.	DoEC-04B (3)	Located at 1.41 km downstream of the EC-04 and 5.84 km downstream of the confluence of the Periyar River and Edappally Canal, near KRA/21, MK lane.(Kra-16a,Chembumukku Edappally, Kochi).	10° 0'22.25"	76°19'34.74"
13.	DoEC-04C (3)	Located at 1.65 km downstream of the EC-04 and 6.46 km downstream of the confluence of the Periyar River and Edappally Canal, near Moolepadam Padamugal Road.(Moolepadam Padamugal Road, Kochi.)	10° 0'12.20"	76°19'46.46"
14.	EC-05 (2 & 3)	Located at 2.12 km downstream of the EC-04 and 6.77 km downstream of the confluence of the Periyar River and Edappally Canal.	9°59'58.66"	76°19'50.17"
15.	DoEC-05A (3)	Located at 1.35 km downstream of the EC-05 and 8.12 km downstream of the confluence of the Periyar River and Edappally Canal, near Moolepadam Padamugal Road1.27 km down steam of the Ezhumavil Ambalappara Dharmasastha TempleX8VP+C7, Thuthiyoor, Kochi.	9°59'21.34"	76°20'10.91"
16.	EC-06 (1,2 & 3)	Located at 2.38 km downstream of EC-05 and 0.1km upstream of the Chambakkara Canal.	9°58'51"	76°20'14"
Chambakara Canal				
17.	CHR-01 (2 & 3)	Located at 0.38 km eastern side of the EC-03.	9°58'50.51”	6°20'22.68"

S.N.	Sample ID	Particulars	Latitude (N)	Longitude (E)
Thevara-Perandoor Canal/Drain (TPC)				
18.	TPC-01 (1,2 & 3)	Located at 0.1 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line.	9°56’46”	76°18’1”
19.	DoTPC-02 (2 & 3)	Located at 0.81 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 0.71 km from TPC-01.(27/1768, VC Canaan Road, Kochi).	9°57'9.71"	6°17'56.96"
20.	TPC-02 (2 & 3)	Located at 0.91 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 0.1 km upstream of DoTPC-02.	9°57'12.21"	6°17'57.62"
21.	DoTPC-03 (2 & 3)	Located at 1.86 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 15 m upstream of TPC-02.(Giri Nagar, Canal Road, Giri Nagar housing society, Kochi).	9°57'44.38"	6°17'53.39"
22.	TPC-03 (2 & 3)	Located at 1.92 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 50m upstream of DoTPC-03.	9°57'45.61"	6°17'53.28"
23.	TPC-04 (1,2 & 3)	Located at 3.06 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 1.14km upstream of TPC-03.	9°58’11”	76°17’41”
24.	DoTPC-04 (2 & 3)	Located at 3.078 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 15.8 m upstream of TPC-04.(61/306 Purushu Menon Road Tagore Nagar, Gandhi Nagar, Ernakulam South, Ernakulam).	9°58'11.42"	6°17'41.69"
25.	TPC-05 (2 & 3)	Located at 4.87 8km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 1.80 km upstream of D0TPC-04.	9°58'58.67"	76°17'28.35”
26.	TPC-06 (1,2 & 3)	Located at 6.278 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 1.40 km upstream of TPC-05.	9°59’43”	76°17’24”
27.	TPC-07 (2 & 3)	Located at 7.02 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 1.43 km upstream of TPC-06.	10° 0'16.15"	6°17'14.23"
28.	DoTPC-07 (2 & 3)	Located at 7.721 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 12.5 m upstream of TPC-07. (Mirah Sorvino Events,Pottakuzhy Road, Kochi).	10° 0'16.53"	76°17'14.19"
29.	TPC-08 (2 & 3)	Located at 9.83 km downstream of the interconnection of the Thevara Canal near the Thevara Railway line and 2.11 km upstream of DoTPC-07.	10° 1'12.22"	6°16'55.86"
30.	DoTPC-08 (3)	Located at 9.93 km downstream of the interconnection of the Thevara Canal near the Thevara Railway line and 60m upstream of TPC-08.(Perandoor Bridge Road, Kochi).	10° 1'12.65"	76°16'57.69"

S.N.	Sample ID	Particulars	Latitude (N)	Longitude (E)
Pallikalar River (PKR)				
	PKR-01 (2 & 3)	Located at 0.5 km downstream of PTC-01.	9° 3'4.28"	76°32'45.02"
Patolithot Canal/Drain (PTC)				
31	PTC-01 (1,2 & 3)	Located at 0.1 km upstream of the Pallikalar River.	9° 3'20.01"	76°32'38.72"
32.	DoPTC-01 (2 & 3)	Located at 0.25 km upstream of the PTC-01.(Adoor, Sasthamkotta Road, Kallelibhagom).	9° 3'22.45"	76°32'43.12"
33.	PTC-02 (1,2 & 3)	Located at 0.9 km upstream of the Pallikalar River.	9° 3'41.48"	76°32'36.39"
34.	PTC-03 (1,2 & 3)	Located at 1.7 km upstream of the Pallikalar River	9° 4'8.31"	76°32'26.05"
35.	PTC-04 (1,2 & 3)	Located at 2.9 km upstream of the Pallikalar River.	9° 4'42.39	76°32'11.10"
36.	PTC-05 (1,2 & 3)	Located at 3.4 km upstream of the Pallikalarl River.	9° 4'55.62"	76°32'6.25"
37.	PTC-06 (2 & 3)	Located at 3.75 km upstream of the Pallikalar River.	9° 5'5.22"	76°32'5.40"
38.	PTC-07 (2 & 3)	Located at 5.17 km upstream of the Pallikalar River.	9° 5'49.22"	76°32'5.29"
39.	PTC-08 (2 & 3)	Located at 6.07 km upstream of the Pallikalar River.	9° 6'12.41"	76°32'16.62
40.	DoPTC-09 (3)	Located at 6.135 km upstream of the Pallikalar River. (Vavvakkavu, Thazhava Road, Kulasekharapuram).	9° 6'14.63"	76°32'16.55"
41.	PTC-09 (3)	Located at 6.15 km upstream of the Pallikalar River.	9° 6'14.63"	76°32'16.55"
42.	PTC-10 (3)	Located at 7.30 km upstream of the Pallikalar River.	9° 6'49.10"	76°32'17.20"
Valiyath Canal/Drain (VC)				
43.	VC-01 (1,2 & 3)	Located at 0.1 km upstream of the Pallikalar River.	9° 3'25.04"	76°32'30.56"
44.	VC-02 (1,2 & 3)	Located at 0.75 km upstream of the Pallikalar River.	9° 3'38.09"	76°32'23.61"
45.	DoVC-02 (2 & 3)	Located at 0.85 km upstream of the Pallikalar River.	9° 3'39.57"	6°32'23.62"
46.	VC-03 (1,2 & 3)	Located at 1.10 km upstream of the Pallikalar River.	9° 3'46.10"	76°32'17.59"
47.	VC-04 (1,2 & 3)	Located at 1.30 km upstream of the Pallikalar River.	9° 3'51.00"	76°32'19.00"
48.	VC-05 (1,2 & 3)	Located at 1.80 km upstream of the Pallikalar River.	9° 4'8.17"	76°32'14.20"
49.	VC-06 (1,2 & 3)	Located at 3.0 km upstream of the Pallikalar River.	9° 4'38.76"	76°32'2.30"
51.	VC-07 (2 & 3)	Located at 3.5 km upstream of the Pallikalar River.	9° 4'52.67"	76°31'55.76"
52.	VC-08 (2 & 3)	Located at 4.6 km upstream of the Pallikalar River.	9° 5'24.78"	76°31'43.70”
52.	VC-09 (2 & 3)	Located at 5.88 km upstream of the Pallikalar River.	9° 6'0.98"	76°31'26.53"

1,2 &3- First (summer 2024), second (post-mansoon 2024), and third (post-winter 2025) events of monitoring.

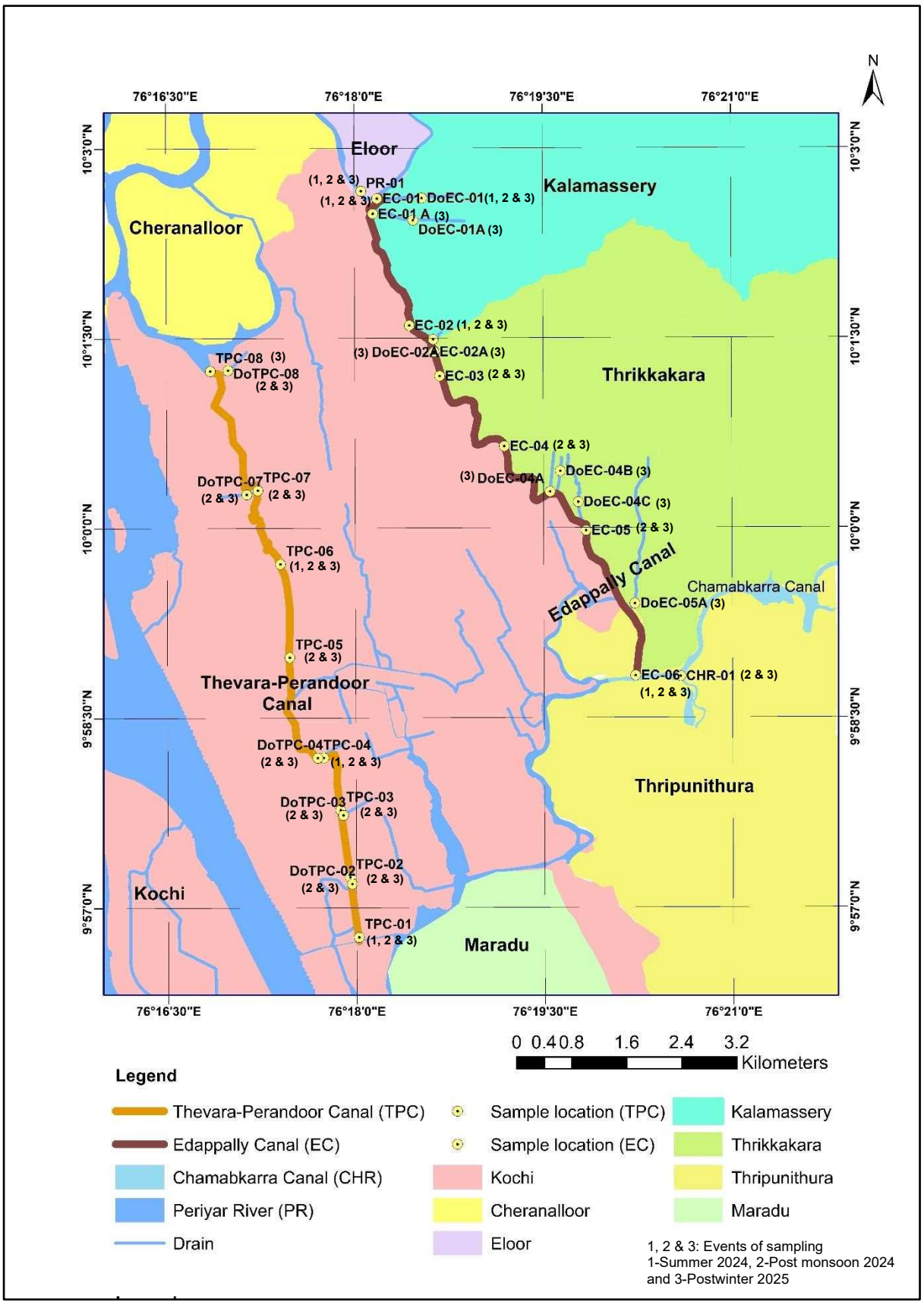

Figure 3: Sampling location of Thevara-Perandoor Canal (TPC) and Edappally Canal (EC) and drain discharging into Canal

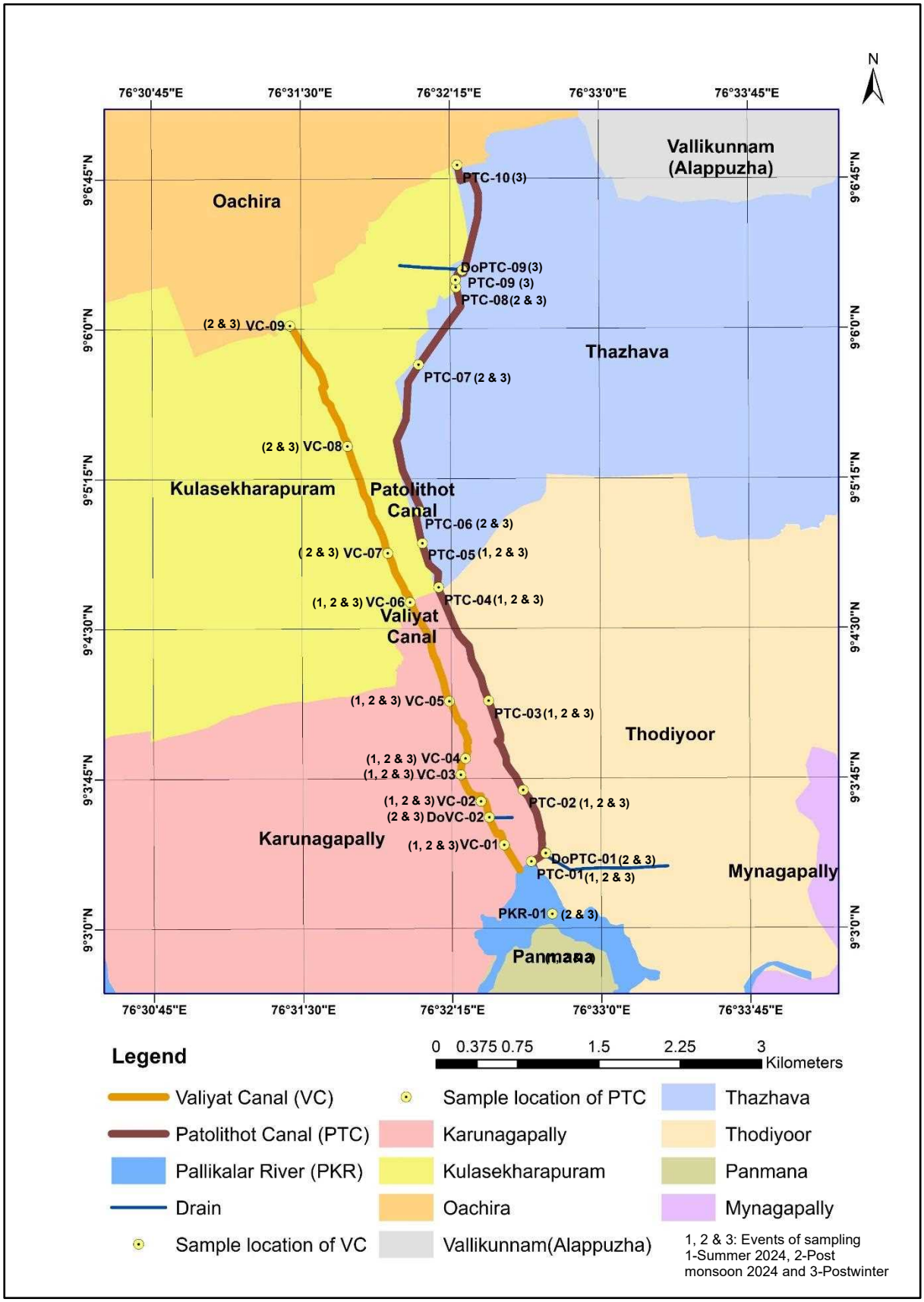

Figure 4: Sampling location of Patolithot Canal (PTC) and Valiyath Canal (VC) and drain discharging into Canal

3.2 Physico-chemical characteristics, including heavy metals

Measurements of pH, temperature, and total dissolved solids (TDS) were made onsite. Further analysis of these samples for physicochemical parameters is initiated at CSIR-NEERI, Nagpur, and is being analyzed according to Standard Methods for the Examination of Water and Wastewater, 23rd. Ed., American Public Health Association, American Water Works Association, & Water Environment Federation, Washington, DC, 2017 (APHA 2017). Heavy metals were quantified using inductively coupled plasma optical emission spectrometry (ICP-OES).

3.3 Bacteriological characteristics

The Fecal coliforms (FC) and Total coliforms (TC) in the Canals, such as Edappally, Thevara-Perandoor, Patolithot, and Valiyath Canals, drain, and river water samples were estimated using the Membrane Filter (MF) method for more accurate and direct quantification. The MF technique (APHA 2017) is a simple, rapid, and direct method of detecting and enumerating FC and TC in water samples. This technique is used when the sample volume is relatively large. The analysis results and observations are presented source-wise in the following sections.

4.0 Data analysis

The results of three sampling events conducted on April 15-18, 2024 (Summer), October 15-20, 2024 (Winter), and February 7-11, 2025 (Post-Winter), for Canals/drains and Rivers, are discussed in the following sections.

4.1 Summer (April 2024) (First event of monitoring)

4.1.1 Physicochemical characteristics and heavy metals of Canals and River

The physicochemical characteristics, heavy metals, of water /wastewater samples collected, including flow from Edappally, Thevara-Perandoor, Patolithot, and Valiyath Canals and Periyar River, are presented in **Tables 6 through 9**. The results of the sampling events conducted during April 15-18, 2024, are detailed hereunder.

4.1.2 Edappally Canal (EC) and Periyar River

The water quality of the Edappally Canal (EC) was monitored at three locations (EC–01 to EC–03), as delineated in **Table 6**. The observed pH values of the water samples at different locations varied from acidic to alkaline (6.4–7.3), with temperatures of 32.6

Table 6: Physicochemical characteristics and heavy metals of water samples of Periyar River and Edappally Canal
(Summer-First event of monitoring 15-16 April 2024)

Sr. No.	Parameters	Water samples: Periyar River & Edappally Canal			
		PR-01	EC-01	EC-02	EC-03
1.	pH	6.7	7.3	6.4	6.5
2.	Temperature (℃)	31.8	32.6	33.4	35.1
3.	Oil & Grease	10	16	18	15
4.	Suspended solids	312	276	368	372
5.	Total dissolved solids	410	760	500	1990
6.	Chemical oxygen demand	97	110	282	91
7.	BOD	12	30	120	10
8.	TKN	8	12	21	15
9.	Ammonical nitrogen	BDL	BDL	4	2
10.	Nitrate	1.0	3.4	0.54	0.87
11.	Phosphorous	0.81	1.6	8.1	3.5
Heavy metals					
12.	Aluminum (Al)	0.142	0.193	0.167	0.152
13.	Arsenic (As)	BDL	BDL	BDL	BDL
14.	Cadmium (Cd)	BDL	BDL	BDL	BDL
15.	Chromium (Cr)	BDL	BDL	BDL	BDL
16.	Cobalt (Co)	BDL	BDL	BDL	BDL
17.	Copper (Cu)	0.002	0.002	0.003	0.002
18.	Iron (Fe)	0.012	BDL	BDL	BDL
19.	Lead (Pb)	0.058	0.087	0.048	0.040
20.	Manganese (Mn)	0.004	BDL	BDL	BDL
21.	Nickel (Ni)	0.010	0.012	BDL	0.004
22.	Zinc (Zn)	0.158	0.103	0.066	0.127
23.	Flow, m^3/sec	NM	0.438	0.271	7.71

PR- Periyar River; EC- Edappally Canal; All values are expressed in mg/L except pH and temperature; BDL- Below detectable limit. Monitoring of the second event in October 2024, EC-03 becomes EC-06.

to 35.1°C. The high suspended solids content in the water samples registered at locations EC–01, EC–02, and EC–03 was 276, 368, and 372 mg/L, respectively. The O&G concentrations in the three locations of water samples ranged between 15–18 mg/L. TDS of the samples at EC–01 to EC–03 ranged between 500-1990 mg/L. The measured organic content in the water samples concerning COD and BOD values at (EC-01, EC-02, and EC-03) was 110 & 30, 282 & 120, and 91 & 10 mg/L, respectively. TKN (as N), ammonical nitrogen (NH_3-N), nitrate (as NO_3-), and phosphorus

concentrations of the samples were in the range of 12–21, BDL–4, 0.54–3.4, and 1.6–8.1 mg/L, respectively.

The heavy metal analysis of these three samples indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), iron (as Fe), and manganese (as Mn), were below the detectable limit. Low concentrations range aluminium (as Al), Copper (as Cu), lead (as Pb), nickel (as Ni), and zinc (as Zn) were found in the range 0.152–0.193, 0.002–0.003**,** 0.040–0.087, BDL–0.012, and 0.066–0.127 mg/L, respectively.

The physicochemical characteristics of the EC water samples (EC–01 to EC–03) were low in organics, inorganic, and nutrients, and thus classified as low-strength. The heavy metal analysis of these water samples indicates they are below the detectable limit or present in extremely low concentrations. The water quality of the Periyar River at sample location PR–01, i.e., upstream of the Edappally Canal, was similar to that of EC–01 due to the impact of the tidal effect.

4.1.3 Thevara-Perandoor Canal (TPC)

The water quality of the TPC was monitored at three different locations (TPC–01 to TPC–03), as presented in **Table 7**. The observed pH values at various locations varied from acidic to alkaline (6.3 – 7.3), with temperatures ranging from 30.6 to 34.5°C. The O&G concentration in the three locations of water samples ranged between 08-18 mg/L. The high suspended solids content in the water sample registered at locations TPC–01, TPC–02, and TPC–01 was 316, 393, and 272 mg/L, respectively. TDS of the samples at TPC–01 was very high, 9450 mg/L, due to the tidal effect, and at the remaining two locations, it was 300 mg/L. The measured organic content in the water samples concerning COD and BOD values at (TPC–01, TPC–02, and TPC–03) was 300 & 80, 134 & 30, and 200 & 40 mg/L, respectively. TKN (as N), ammonical nitrogen (NH_3-N), nitrate (as NO_3-), and phosphorus concentrations of the samples were in the range of 12–22, 1.0–4.0, 0.25–2.54, and 1.7–2.5 mg/L, respectively.

Table 7: Physicochemical characteristics and heavy metals of the water sample of Thevara-Perandoor Canal

(Summer-First event of monitoring 15-16 April 2024)

Sr. No.	Parameters	Water sample: Thevara-Perandoor Canal		
		TPC-01	TPC-02	TPC-03
1.	pH	6.3	6.6	7.3
2.	Temperature (℃)	34.5	32.5	30.6
3.	Oil & Grease	08	12	18
4.	Suspended solids	316	393	272
5.	Total dissolved solids	9450	300	300
6.	Chemical oxygen demand	300	134	200
7.	BOD	80	30	40
8.	TKN	12	22	12
9.	Ammonical nitrogen	2	4	1
10.	Nitrate	0.49	2.54	0.25
11.	Phosphorous	2.0	1.7	2.5
Heavy metals				
12.	Aluminum (Al)	0.149	0.132	0.145
13.	Arsenic (As)	BDL	BDL	BDL
14.	Cadmium (Cd)	BDL	BDL	BDL
15.	Chromium (Cr)	BDL	BDL	BDL
16.	Cobalt (Co)	BDL	BDL	BDL
17.	Copper (Cu)	BDL	BDL	BDL
18.	Iron (Fe)	BDL	BDL	BDL
19.	Lead (Pb)	BDL	0.017	0.001
20.	Manganese (Mn)	BDL	BDL	BDL
21.	Nickel (Ni)	BDL	0.002	0.004
22.	Zinc (Zn)	0.079	0.070	0.127
23.	Flow, m^3/sec	2.02	2.08	1.371

TPC- Thevara-Perandoor Canal; All values are expressed in mg/L except pH and temperature; BDL- Below detectable limit
Monitoring of October, TPC-03 becomes TPC-08.

The heavy metal analysis of these three samples indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), copper (as Cu), iron (as Fe), and manganese (as Mn), were below the detectable limit. Low concentrations of aluminium (as Al), lead (as Pb), nickel (as Ni), and zinc (as Zn) were found in the range 0.132–0.149, BDL–0.017, BDL–0.004, and 0.070–0.127 mg/L, respectively. The physicochemical characteristics of the TPC water samples (TPC–01 to TPC–03) were low in organics, inorganic, except at TPC–01, and nutrients, thus classified as low-strength. The heavy metal analysis of these water samples indicates below the detectable limit or present in extremely low concentrations.

4.1.4 Patolithot Canal (PTC)

The water quality of the Patolithot Canal (PTC) was monitored at five locations (PTC–01 to PTC–05), as shown in **Table 8**. The observed pH values at different locations

varied from acidic to alkaline (6.4–7.1), with temperatures of 30.0 to 33.2°C. The high suspended solids content in the water sample registered at five locations PTC–01 to PTC–05) ranged from 256–412 mg/L, respectively. The O&G concentration in the five different locations of water samples ranged between 04–20 mg/L. TDS of the samples at PTC–01 to PTC–05 ranged between 180–610 mg/L. The measured low organic content in the water samples concerning COD values at PTC–01, PTC–02, PTC–03, PTC–04, was 48, 64, 78, and 64 mg/L, respectively, and at PTC–05 was 132 mg/L.

Table 8: Physicochemical characteristics and heavy metals of water sample of Patolithot Canal

(Summer-First event of monitoring 16-17 April 2024)

Sr. No.	Parameters	Water sample: Patolithot Canal				
		PTC-01	PTC-02	PC-03	PTC-04	PC-05
1.	pH	7.1	6.8	6.5	6.7	6.4
2.	Temperature (℃)	31.3	33.2	30	30.2	30
3.	Oil & Grease	15	20	04	08	10
4.	Suspended solids	256	408	396	412	404
5.	Total dissolved solids	610	180	200	190	180
6.	Chemical oxygen demand	48	64	78	64	132
7.	BOD	<10	<10	<10	<10	20
8.	TKN	2	5	9	5	10
9.	Ammonical nitrogen	BDL	BDL	BDL	BDL	BDL
10.	Nitrate	2.3	2.8	3.6	2.5	3.0
11.	Phosphorus	1.3	1.3	2.7	1.6	1.8
Heavy metals						
12.	Aluminum (Al)	0.194	0.145	0.139	0.132	0.147
13.	Arsenic (As)	BDL	BDL	BDL	BDL	BDL
14.	Cadmium (Cd)	BDL	BDL	BDL	BDL	BDL
15.	Chromium (Cr)	BDL	BDL	BDL	BDL	BDL
16.	Cobalt (Co)	BDL	BDL	BDL	BDL	BDL
17.	Copper (Cu)	BDL	BDL	BDL	BDL	BDL
18.	Iron (Fe)	BDL	BDL	BDL	BDL	BDL
19.	Lead (Pb)	BDL	BDL	BDL	BDL	BDL
20.	Manganese (Mn)	BDL	BDL	BDL	BDL	BDL
21.	Nickel (Ni)	BDL	BDL	BDL	BDL	BDL
22.	Zinc (Zn)	0.106	0.123	0.139	0.129	0.113
23.	Flow,m^3/sec	NP	NP	NP	0.005	NP

PC- Patolithot Canal. All values are expressed in mg/L except pH and temperature; BDL- Below detectable limit. NP-Flow was not possible.

Meanwhile, BOD values from PTC–01 to PTC–04 were less than 10, and PTC–05 was 20 mg/L. TKN (as N), nitrate (as NO_3-), and phosphorus concentrations of the samples were in the range of 2–10, 2.3–3.6, and 1.3 –2.7 mg/L, respectively. Ammonical nitrogen (NH_3-N) registered in all the sample locations was below detectable limits.

Heavy metal analysis of these five samples indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), copper (as Cu), iron (as Fe), lead (as Pb), manganese (as Mn), and nickel (as Ni) were below the detectable limit. Low concentrations of aluminium (as Al) and zinc (as Zn) were found in the range 0.132–0.194 and 0.106–0.139 mg/L, respectively. The physicochemical characteristics of the PTC water samples (PTC–01 to PTC–05) were low in organics, inorganic, and nutrients, thus classified as low strength.

4.1.5 Valiyath Canal (VC)

The water quality of the Valiyath Canal (VC) was monitored at six locations (VC–01 to VC–06), as delineated in **Table 9**. The observed pH values at different locations varied from acidic (6.3–6.8), with temperatures of 30.0 to 35.0ºC. The O&G concentrations in the six different locations of water samples ranged between 06–14 mg/L. The high suspended solids content in the water sample registered at VC–01 and VC–03 locations was 632 and 508 mg/L, respectively. However, at VC–02: 384 mg/L, VC–04 to VC–06, it ranged between 232–420 mg/L. TDS of the water samples at VC–01 to VC–06 ranged between 200–480 mg/L. The measured low organic content in the water samples concerning COD and BOD values at VC–01 to VC–06 ranged from 80–160 and <10 to 18 mg/l, respectively. TKN (as N), nitrate (as NO_3-), and phosphorus concentrations of the water samples were in the range of 4–18, BDL–5.2, and 1.5 – 2.7 mg/L, respectively. Ammonical nitrogen (NH_3-N) registered in all the sample locations was below detectable limits.

Table 9: Physicochemical characteristics and heavy metals of Valiyath Canal
(Summer-First event of monitoring 17-18 April 2024)

Sr. No.	Parameters	Water sample: Valiyath Canal					
		VC-01	VC-02	VC-03	VC-04	VC-05	VC-06
1.	pH	6.3	6.8	6.7	6.5	6.5	6.4
2.	Temperature (℃)	35	30	32	30	32	33.1
3.	Oil & Grease	06	10	12	14	10	08
4.	Suspended solids	632	384	508	384	420	232
5.	Total dissolved solids	480	260	220	200	200	260
6.	Chemical oxygen demand	80	85	144	124	160	84
7.	BOD	<10	<10	16	13	18	<10
8.	TKN	6	4	10	18	5	5
9.	Ammonical nitrogen	BDL	BDL	BDL	BDL	BDL	BDL
10.	Nitrate	BDL	4.3	5.2	2.1	3.4	2.2
11.	Phosphorous	2.1	2.7	1.5	2.5	2.3	2.2
Heavy Metals							
12.	Aluminum (Al)	0.161	0.151	0.145	0.134	0.143	0.145
13.	Arsenic (As)	BDL	BDL	BDL	BDL	BDL	BDL

14.	Cadmium (Cd)	BDL	BDL	BDL	BDL	BDL	BDL
15.	Chromium (Cr)	BDL	BDL	BDL	BDL	BDL	BDL
16.	Cobalt (Co)	BDL	BDL	BDL	BDL	BDL	BDL
17.	Copper (Cu)	BDL	BDL	BDL	BDL	BDL	BDL
18.	Iron (Fe)	BDL	BDL	BDL	BDL	BDL	BDL
19.	Lead (Pb)	BDL	BDL	BDL	BDL	BDL	BDL
20.	Manganese (Mn)	BDL	BDL	BDL	BDL	BDL	BDL
21.	Nickel (Ni)	BDL	BDL	BDL	BDL	BDL	BDL
22.	Zinc (Zn)	0.159	0.156	0.083	0.097	0.076	0.160
23.	Flow, m^3/sec	0.080	NP	NF	0.015	MF	NF

VC- Valiyath Canal; All values are expressed in mg/L except pH and temperature; BDL- Below detectable limit. NP-Flow not possible; NF-No flow; MF-Meger flow.

The heavy metal analysis of these six samples indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), copper (as Cu), iron (as Fe), lead (as Pb), manganese (as Mn), and nickel (as Ni) were below the detectable limit. Low concentrations of aluminium (as Al) and zinc (as Zn) were found in the range 0.134–0.161 and 0.076–0.160 mg/L, respectively. The physicochemical characteristics of the VC water samples (VC–01 to VC–06) were low in organics, inorganic, and nutrients and thus classified as low-strength. The heavy metal analysis of these water samples indicates below the detectable limit or present in extremely low concentrations.

The spatial distribution of major physicochemical characteristics (first event) of water samples of Edappally, Thevara-Perandoor, Patolithot, and Valiyath Canals, including Periyar River, is presented in **Figures 5 and 6,** indicating that there is a discharge of stormwater and domestic sewage from the households of the different Municipalities and Local Bodies into Canals and the River.

4.2 Post-monsoon (October 2024) (Second event monitoring)

4.2.1 Physicochemical characteristics, heavy metals of Canals and River

The physicochemical characteristics, heavy metals, of wastewater/ water samples collected, including flow from Edappally, Thevara-Perandoor, Patolithot, and Valiyath, Chambakkar Canals, and Periyar River, are presented in **Tables 10 through 12**. The results of the sampling events conducted during October 15–20, 2024, are detailed hereunder.

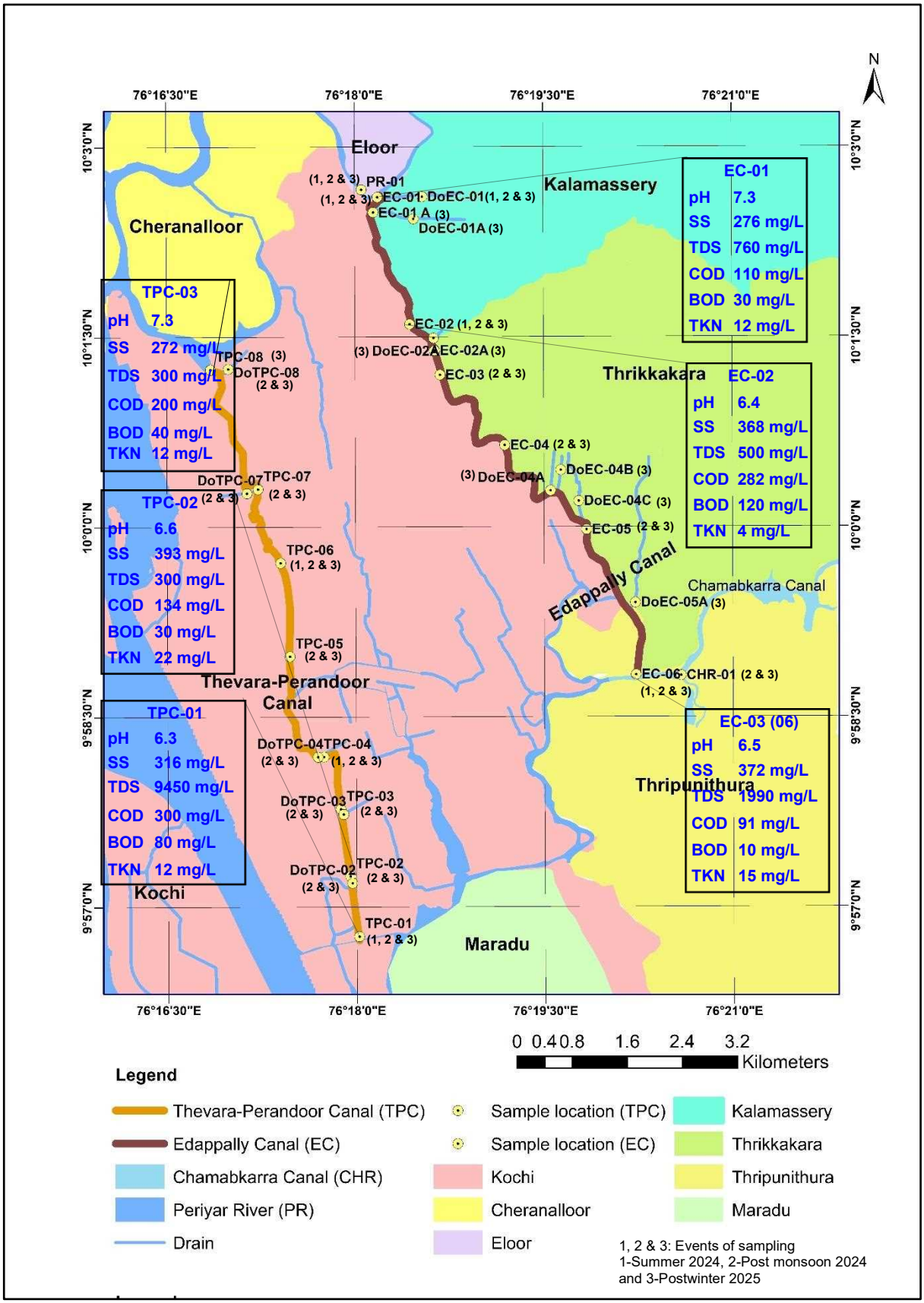

Figure 5: Spatial distribution of Edappally Canal (EC) and Thevara-Perandoor Canal (TP) and Periyar River water quality concerning critical parameters (Summer: First event of monitoring)

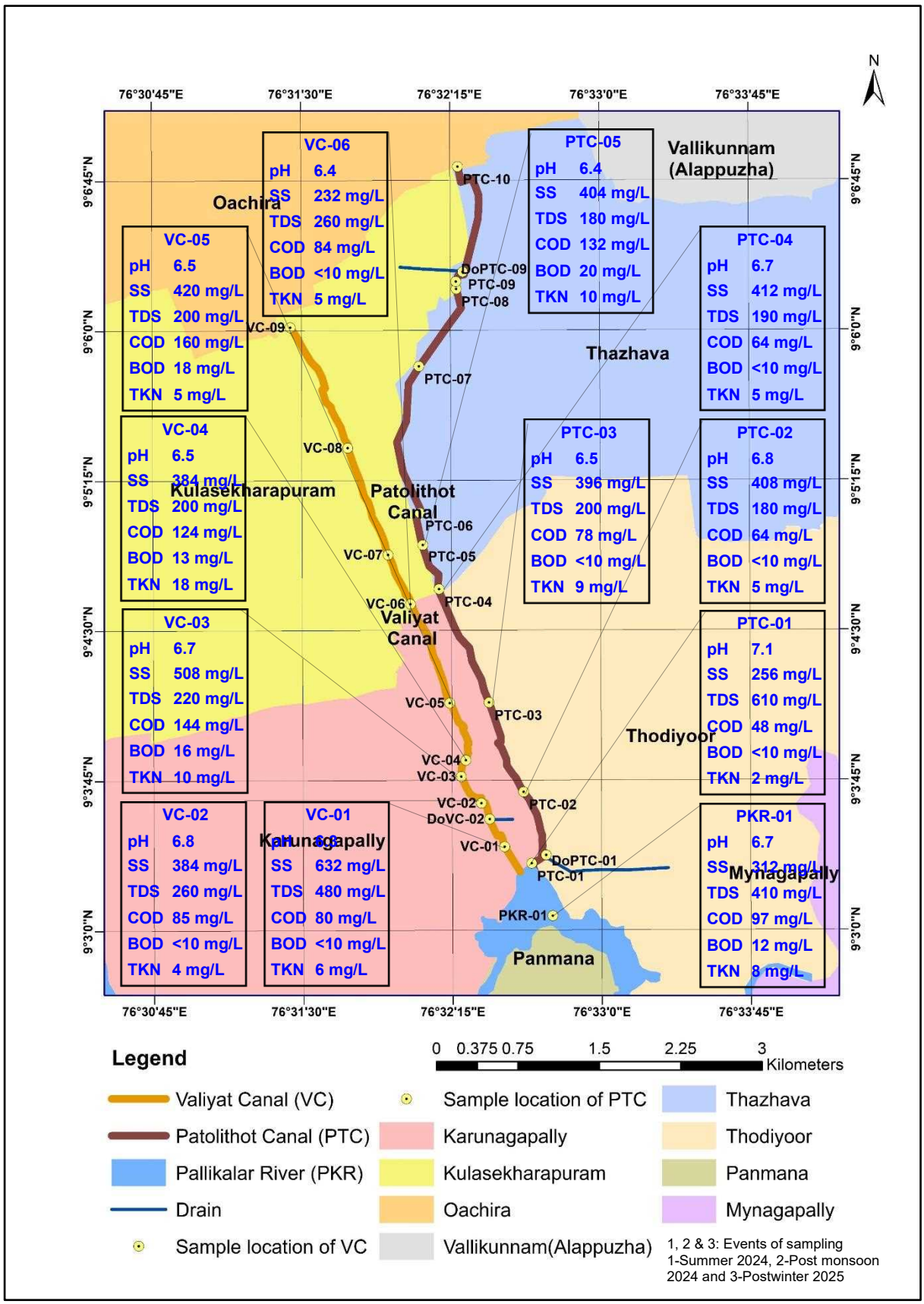

Figure 6: Spatial distribution of Patolithot (PTC), Valiyath C**anal (VC), and Periyar River water quality concerning critical parameters (Summer: First event of monitoring)**

4.2.2 Edappally and Chambakkar Canals and Periyar River

The water quality of the Edappally Canal (EC) was monitored at six locations (EC–01 to EC–06), as delineated in **Table 10**. The monitored pH values of the samples at different locations varied from acidic to alkaline (6.6–7.1), with temperatures of 27.6 to 32°C. The high suspended solids (SS) content in the water samples registered at locations EC–01, EC–03, EC–04, and EC–06 was 364, 488, 240, and 328 mg/L, respectively, and less than 200 mg/L in samples EC–02 and EC–05. The O&G concentrations in the six different locations of samples ranged between <05–16 mg/L. TDS of the water samples at EC–01 to EC–06 ranged between 112–648 mg/L. The measured organic content in the water samples concerning COD and BOD values at (EC–01 to EC–06) was varied between 50–158 and <10–12mg/L, respectively. The dissolved oxygen (DO) concentration at E–01 (near Periyar River) and EC–02 (adjacent to Lulu Mall) was 7.0 and Nil mg/L, respectively, and the rest of the sample locations ranged between 1 and 3.2 mg/L. TKN (as N), ammonical nitrogen (NH_3-N), nitrate (as NO_3-), and phosphorus concentrations of the samples were in the range of 6–12, BDL–1.0, 0.05–0.32, and 1.3–2.5 mg/L, respectively.

The heavy metal analysis of these three samples indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), copper (cu), lead (Pb), nickel (Ni), were below the detectable limit. Low concentrations of aluminium (as Al), iron (as Fe), manganese (as Mn), and zinc (as Zn) were found in the range 0.076–0.273, 0.152–0.289, 0.035–0.257, and 0.109–0.187 mg/L, respectively. The fecal coliforms (FC) in the canal water samples at the six different locations (EC–01 to EC–06) were counted in the range from 800 to TNC CFU/100 mL. The highest FC was obtained at location EC–01, where sewage discharge from DoEC–01 into the Canal, while the lowest count was observed at EC–06 near the confluence point of Eadapally and Chambakara Canals.

The physicochemical characteristics of the EC samples (EC–01 to EC–06) were low in organics, inorganic, and nutrients and thus classified as low-strength. The heavy metal analysis of these water samples indicates below the detectable limit or present in extremely low concentrations. The water quality of Periyar River at sample location PR–01, i.e., upstream of the EC, was less than EC–01 due to the impact of rain. The water quality of Chambakra Canal at sample location CHR–01, i.e., downstream of the EC, was less concentrated from EC–01 to EC–06.

Table 10: Physicochemical characteristics and heavy metals of water samples of Periyar River, Edappally Canal, Drain, and Chambakara Canal
(Post-monsoon:Second event of monitoring 16-17 October 2024)

Sr. No.	Parameters	Water Samples: Periyar River, Edappally Canal, Drain and Chambakara Canal								
		PR-01	EC-01	DoEC-01	EC-02	EC-03	EC-04	EC-05	EC-06	CHR-01
1.	pH	7.4	6.9	6.6	6.8	6.9	7.1	7.0	6.6	6.6
2.	Temperature (℃)	27.4	27.6	27.9	29.8	29.9	30.9	30.5	32	32
3.	Oil & Grease	5	05	15	<05	09	16	06	<05	BDL
4.	Suspended solids	276	364	412	120	488	240	152	328	100
5.	Total dissolved solids	80	128	340	192	184	180	648	112	166
6.	Chemical oxygen demand	16	50	200	158	80	60	70	75	20
7.	BOD	<5	<10	20	12	<10	<10	<10	<10	<5
8.	DO	7.0	7.0	Nil	NIL	1.0	1.2	3.2	3.0	4.5
8.	TKN	4	6	14	12	10	6.0	6.0	9.0	2.0
9.	Ammonical nitrogen	BDL	BDL	2.0	1.0	BDL	BDL	BDL	BDL	BDL
10.	Nitrate	0.10	0.13	0.24	0.12	0.05	0.32	0.09	0.15	0.34
11.	Phosphorous	1.0	2.0	3.0	1.7	2.5	1.3	1.4	1.6	1.0
Heavy metals										
12.	Aluminum (Al)	0.098	0.14	0.109	0.076	0.138	0.273	0.143	0.124	0.106
13.	Arsenic (As)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
14.	Cadmium (Cd)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDl
15.	Chromium (Cr)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
16.	Cobalt (Co)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
17.	Copper (Cu)	BDL	BDL	0.004	BDL	BDL	BDL	BDL	BDL	BDL
18.	Iron (Fe)	0.061	0.234	0.235	0.168	0.152	0.284	0.169	0.289	0.091
19.	Lead (Pb)	BDL	BDL	0.002	BDL	BDL	BDL	BDL	BDL	0.004
20.	Manganese (Mn)	0.002	0.101	0.013	0.119	0.035	0.257	0.221	0.145	0.164
21.	Nickel (Ni)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
22.	Zinc (Zn)	0.177	0.116	0.167	0.125	0.114	0.187	0.109	0.175	0.149
Bacteriological quality										
23.	TC (CFU per 100 ml)	NM	TNC	NM	TNC	22100	20110	12500	1425	NM
24.	FC(CFU per 100 ml)	NM	TNC	NM	TNC	9125	9850	5000	800	NM
25.	Flow, m^3/sec	NM	0.21	NM	0.53	2.15	4.36	7.96	10.16	NM

PR- Periyar River; EC- Edappally Canal; DoEC- Drain of Edappally Canal; CHR-Chambakkar River; All values are expressed in mg/L except pH and temperature, TC, FC and Flow; BDL- Below detectable limit, NM-Not monitored; TNC-Too Numerous to count, TC-Total coliform; FC-Fecal Coliform.

4.2.2.1 Physicochemical characteristics of drain discharge into Edappally Canal

Physicochemical characteristics and onsite flow monitoring of drain discharge (DoEC–01) into the Edappally Canal (EC) were also carried out post-monsoon (October 2024) and presented in **Table 10**. The flow of this drain at location (DoEC–01) could not be monitored. The monitored pH value of the drain water sample (DoEC–01) was acidic (6.6), with a temperature of 27.9°C. The high SS content of 412 mg/L was registered in the drain water sample (DoEC–01). The O&G, TDS, COD, and BOD concentrations at this location were 15, 340, 200, and 20 mg/L, respectively. The DO concentration at DoEC–01 was Nil. TKN (as N), ammonical nitrogen (NH_3-N), nitrate (as NO_3-), and phosphorus concentration of the drain water sample were 14, 2, 0.24, and 3.0 mg/L, respectively.

The heavy metal analysis of the drain sample location at DoEC–01 indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), and nickel (as Ni) were below the detectable limit. Low concentrations of aluminium (as Al), copper (as Cu), iron (as Fe), lead (as Pb), Manganese (Mn), and zinc (as Zn) were found to be 0.109, 0.004, 0.235, 0.002, 0.013, and 0.167 mg/L, respectively.

4.2.3 Thevara-Perandoor Canal (TPC)

The water quality of the Thevara-Perandoor Canal (TPC) was monitored at eight different locations (TPC–01 to TPC–08), as presented in **Table 11**. The observed pH values at various locations varied from acidic to neutral (6.5–7.0), with temperatures of 26.3 to 30.9°C. The O&G concentration in the eight different locations of water samples ranged between <5–20 mg/L. The high suspended solids content in the sample registered at locations TPC –01, 02, 04, and 05 were 300, 364, 434, and 376 mg/L, respectively as compared to water sample locations (TPC–03: 232 mg/L, TPC–06:168, TPC–07:276 mg/L, and TPC–08: 160 mg/L) TDS of the samples at TPC–01 was very high, 4581 mg/L, due to the tidal effect, and at the remaining seven locations ranged between 152 to 270 mg/L. The measured organic content in the water samples concerning COD and BOD values at (TPC–01 to TPC–08) ranged between 80–120 and <10 –15 mg/L, respectively. DO concentration of water samples from (TPC–01 to TPC–07) was between 1–1.4 mg/L and Nil at TPC–08. TKN (as N), ammonical

nitrogen (NH_3-N), nitrate (as NO_3-), and phosphorus concentrations of the samples were in the range of 3–10, BDL, 0.11–0.30, and 1.0–2.0 mg/L, respectively.

The heavy metal analysis of these eight water samples indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), manganese (as Mn), and nickel (as Ni), were below the detectable limit. Low concentrations of aluminium (as Al), copper (as Cu), iron (as Fe), lead (as Pb), and zinc (as Zn) were found in the range 0.063–0.174, BDL–0.004, 0.032–0.186, BDL–0.013, and 0.071–0.181mg/L, respectively. The fecal coliforms (FC) in the water samples at the six different locations (TPC–01 to TPC–04, TPC–07, and TPC–08) were detected in the magnitude range of 2510 to TNC CFU/100 mL. The FC was detected as Too Numerous to Count (TNC) at four sample locations at TPC–01, TPC–03, TPC–04, and TPC–08, while at two locations (TPC–02 and TPC–07), the magnitudes were 3000 and 2510 CFU/100 mL, respectively.

The physicochemical characteristics of the TPC samples (TPC–01 to TPC–08) were low in organics, inorganic, except at TPC–01, and nutrients, thus classified as low-strength. The heavy metal analysis of these water samples indicates below the detectable limit or present in extremely low concentrations.

4.2.3.1 Physicochemical characteristics of drain discharge into Thevara-Perandoor Canal (TPC)

Physicochemical characteristics and onsite flow monitoring of four drain discharges (DoTPC–02, DoTPC–03, DoTPC–04, and DoTPC–07) into the Thevara-Perandoor Canal were also carried out during the post-monsoon (October 2024) and presented in **Table 11**. The monitored pH value of four drain water samples was acidic to neutral (6.6– 7.0), with a temperature between 25.6 and 32.0°C. The SS content of four drain water samples was registered in the range of 160–538 mg/L. The O&G, TDS, COD, BOD, and DO concentrations at the sample locations (DoTPC–02, DoTPC–03, DoTPC–04, and DoTPC–07) were 6.0–9.0, 196–277, 85–120, <10–16, and Nil–1.0 mg/L, respectively. TKN (as N), ammonical nitrogen (NH_3-N), nitrate (as NO_3-), and phosphorus concentration of the four drain water samples were 8–12, BDL, BDL–0.12, and 1.2–2.2 mg/L, respectively.

Table 11: Physicochemical characteristics and heavy metals of water samples of Thevara-Perandoor Canal, and Drain
(Post-monsoon: Second event of monitoring 16-17 October 2024)*

S.N.	Parameters	Water samples: Thervara Canal and Drain											
		TPC-01	DoTPC-02	TPC-02	DoTPC-03	TPC-03	TPC-04	DoTPC-04	TPC-05	TPC-06	TPC-07	DoTPC-07	TPC-08
1.	pH	6.8	6.6	6.8	6.8	6.8	6.7	6.8	7.0	6.5	7.0	7	7.0
2.	Temperature (℃)	29.6	32	28.8	27.9	30.9	28.2	27.8	27.3	28.1	26.4	25.6	26.3
3.	Oil & Grease	20	07	08	09	10	13	08	<05	13	<05	06	<05
4.	Suspended solids	300	444	364	252	232	434	538	376	168	276	160	160
5.	Total dissolved solids	*4581*	*196*	*270*	*196*	152	*156*	*277*	250	198	171	205	*233*
6.	Chemical oxygen demand	105	85	110	90	80	100	98	95	120	102	120	110
7.	BOD	12	<10	14	<10	<10	<10	<10	<10	15	11	16	13
8.	DO	1.0	1.0	1.0	0.0	1.1	1.4	0.0	1.2	1.2	1.0	0.0	0.0
9.	TKN	3.0	10	10	8.0	3.0	3.0	12	5.0	7.0	6.0	10	9.0
10.	Ammonical nitrogen	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
11.	Nitrate	0.20	0.12	0.11	BDL	0.11	0.18	0.08	0.29	0.12	0.11	0.10	0.3
12.	Phosphorous	1.2	1.6	1.4	1.2	1.0	1.4	1.5	1.4	2.0	1.5	2.2	1.0
Heavy metals													
13.	Aluminum (Al)	0.174	0.138	0.106	0.181	0.106	0.063	0.161	0.151	0.118	0.167	0.169	0.125
14.	Arsenic (As)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
15.	Cadmium (Cd)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
16.	Chromium (Cr)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
17.	Cobalt (Co)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
18.	Copper (Cu)	BDL	BDL	BDL	0.001	BDL	0.004	0.001	BDL	BDL	BDL	BDL	0.002
19.	Iron (Fe)	0.032	0.138	0.186	0.147	0.068	0.083	0.141	0.165	0.107	0.133	0.241	0.145
20.	Lead (Pb)	0.004	0.002	0.013	0.004	BDL	BDL	0.003	0.002	0.003	0.003	0.005	0.003
21.	Manganese (Mn)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
22.	Nickel (Ni)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
23.	Zinc (Zn)	0.071	0.143	0.175	0.202	0.136	0.178	0.100	0.171	0.136	0.176	0.238	0.181
Bacteriological quality													
24.	TC (CFU/100 ml)	TNC	NM	8000	NM	TNC	TNC	NM	NM	NM	7890	NM	TNC
25.	FC(CFU/100 ml)	TNC	NM	3000	NM	TNC	TNC	NM	NM	NM	2510	NM	TNC
26.	Flow, m^3/sec	1.37	0.42	1.67	9.8	NM	NM	NM	0.143	NM	NM	0.03	NM

TPC- Thevara-Perandoor Canal; DoTPC- Drain of Thevara-Perandoor Canal; All values are expressed in mg/L except pH and temperature, TC, FC, and Flow; BDL- Below detectable limit.
NM- Not monitored; TNC-Too numerous to count; TC-Total coliform; FC-Fecal Coliform.

The heavy metal analysis of the four drain sample locations indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), copper (as Cu), manganese (Mn), and nickel (as Ni) were below the detectable limit. Low concentrations of aluminium (as Al), iron (as Fe), Lead (as Pb), and zinc (as Zn) concentrations, were found in the range of 0.138–0.181, 0.138–0.241, 0.002–0.005, and 0.100–0.238 mg/L, respectively.

4.2.4 Patolithot Canal (PTC)

The water quality of the Patolithot Canal (PTC), as monitored at eight locations (PTC–01 to PTC–08), is shown in **Table 12**. The observed pH values at different locations varied from acidic to alkaline (6.4–7.2), with temperatures of 28.6 to 30.4°C. The high suspended solids (SS) content in the water sample registered at all locations ranged from 300–572 mg/L, except at PTC–06: 150 mg/L. The O&G concentration in the eight different locations of samples ranged between BDL–18 mg/L. TDS of the water samples at PTC–01 to PTC–08 ranged between 100–368 mg/L. The measured low organic content in the water samples concerning COD and BOD values at PTC–01 to PTC–08 was 16–48 and <5–10 mg/L, respectively. DO concentration of water samples from (PTC–01 to PTC–08) was between 2.6–7.2 mg/L. TKN (as N), nitrate (as NO_3-), and phosphorus concentrations of the samples were in the range of 3–5, 0.15–0.73, and 1.1–2.7 mg/L, respectively. Ammonical nitrogen (NH_3-N) registered in all the sample locations was below detectable limits.

Heavy metal analysis of these eight samples indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), copper (as Cu), iron (as Fe), lead (as Pb), manganese (as Mn), and nickel (as Ni) were below the detectable limit. Low concentrations of aluminium (as Al) and zinc (as Zn) were found in the range 0.047–0.251 and 0.064–0.236 mg/L, respectively. The fecal coliform (FC) in the eight water samples (PTC–01 to PTC–08) was counted in the range from not found (NF) to 1500 CFU/100 mL.

The fecal coliforms (FC) in the Canal water samples at the three different locations (PTC–01, PTC–04, and PTC–08) were counted in the range from 150 to 1500 CFU/100 mL. The highest FC was obtained at location PTC–08, while the lowest count

was observed at PTC–04. In two water samples, PTC–02 and PTC–03, FC were not present.

The physicochemical characteristics of the PTC water samples (PTC–01 to PTC–08) were low in organics, inorganic, and nutrients, thus classified as low-strength. The heavy metal analysis of these water samples indicates below the detectable limit or present in extremely low concentrations.

4.2.4.1 Physicochemical characteristics of drain discharge into Patolithot Canal (PTC)

Physicochemical characteristics and onsite flow monitoring of drain discharge (DoPTC–01) into the PTC were carried out post–monsoon (October 2024) and presented in **Table 12**. The drain flow at the sample location (DoPTC–01) was 0.25 m^3/sec. The monitored pH value of the drain water sample (DoPTC–01) was acidic (6.6), with a temperature of 30.8°C. The high SS content of 423 mg/L was registered in the drain water sample (DoPTC–01). The O&G, TDS, COD, and BOD concentrations at this location were 16, 292, 24, and <5 mg/L, respectively. The DO concentration at DoPTC–01 was 3.6 mg/L. TKN (as N), ammonical nitrogen (NH_3-N), nitrate (as NO_3-), and phosphorus concentration of the drain water sample were 4, BDL, 0.35, and 1.9 mg/L, respectively.

The heavy metal analysis of the drain water sample location at DoPTC–01 indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), and nickel (as Ni), were below detectable limit. Low concentrations of aluminium (as Al), copper (as Cu), iron (as Fe), lead (as Pb), manganese (Mn), and zinc (as Zn) were found at 0.140, 0.011, 0.164, 0.003, 0.025, and 0.081 mg/L, respectively.

4.2.5 Valiyath Canal (VC)

The water quality of the Valiyath Canal (VC) is monitored at eight locations (VC–01 to VC–08, as delineated in Table 13. The observed pH values at different locations varied from acidic to alkaline (6.5–7.2), with temperatures of 28.7 to 30.4°C. The O&G concentrations in the eight different locations of water samples ranged between 07–

Table 12: Physicochemical characteristics and heavy metals of water samples of Pallikar River, Patolithot Canal, and Drain

(Post-monsoon: Second event of monitoring 19-20 October 2024)

Sr. No.	Parameters	Water samples: Pallikar River, Patolithot Canal and Drain									
		PKR-01	PTC-01	DoPTC-01	PTC-02	PTC-03	PTC-04	PTC-05	PTC-06	PTC-07	PTC-08
1.	pH	7.0	6.6	6.6	6.7	6.6	7.0	7.2	6.7	6.6	6.4
2.	Temperature (℃)	29.2	28.7	30.8	30.4	29.3	29.6	28.7	29.3	29.3	28.6
3.	Oil & Grease	BDL	16	16	18	17	09	15	BDL	<05	08
4.	Suspended solids	24	544	423	572	508	536	436	150	440	300
5.	Total dissolved solids	204	224	292	364	248	125	110	100	368	100
6.	Chemical oxygen demand	10	40	24	32	16	32	40	48	48	32
7.	BOD	<5	<10	<5	<5	<5	<5	<10	<10	<10	<5
8.	DO	4.5	2.6	3.6	6.2	4.2	7.2	4.4	4.2	5.8	3.0
8.	TKN	1.0	4.0	4.0	4.0	3.0	4.0	5.0	4.0	5.0	5.0
9.	Ammonical nitrogen	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
10.	Nitrate	0.29	0.73	0.35	0.33	0.29	0.27	0.24	0.22	0.15	0.23
11.	Phosphorous	1.7	1.1	1.9	1.6	1.4	1.3	1.8	2.0	2.7	1.7
Heavy metals											
12.	Aluminum (Al)	0.186	0.067	0.140	0.047	0.072	0.079	0.06	0.111	0.251	0.115
13.	Arsenic (As)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
14.	Cadmium (Cd)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
15.	Chromium (Cr)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
16.	Cobalt (Co)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
17.	Copper (Cu)	BDL	BDL	0.011	BDL	BDL	BDL	BDL	BDL	BDL	BDL
18.	Iron (Fe)	BDL	BDL	0.164	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19.	Lead (Pb)	BDL	BDL	0.003	BDL	BDL	BDL	BDL	BDL	BDL	BDL
20.	Manganese (Mn)	BDL	BDL	0.025	BDL	BDL	BDL	BDL	BDL	BDL	BDL
21.	Nickel (Ni)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
22.	Zinc (Zn)	0.069	0.102	0.081	0.105	0.106	0.151	0.064	0.194	0.208	0.236
Bacteriological quality											
23.	Total coliform(CFU per 100 ml)	NM	1200	NM	NF	NF	300	700	900	1800	2560
24.	Fecal coliform (CFU per 100 ml)	NM	400	NM	NF	NF	150	250	400	900	1500
25.	Flow, m^3/sec	NP	0.48	0.25	1.03	0.90	0.23	0.65	0.43	0.39	0.11

PKR- Palilikar River; PTC- Patolithot Canal; DoPTC- Drain of Patolithot Canal.

All values are expressed in mg/L except pH and temperature, TC, FC and Flow; BDL- Below detectable limit. NP-Flow not possible; NM-Not monitored and NF-Not found

20 mg/L. The high and low suspended solids content in the water sample registered at locations VC–01 to VC–06 and VC–07 and VC–08 ranged between 288–532 and 64–72 mg/L, respectively. TDS of the water samples at VC–01 to VC–08 ranged between 175–336 mg/L. The measured low organic content in the samples concerning COD and BOD values at VC–01 to VC–08 ranged from 16–56 and <5 to 10 mg/L, respectively. TKN (as N), nitrate (as NO3-), and phosphorus concentrations of the water samples were in the range of 2–5, 0.12–0.72, and 1.5–2.8 mg/L, respectively. Ammonical nitrogen (NH3-N) registered in all the sample locations was below detectable limits.

The heavy metal analysis of these eight samples indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), copper (as Cu), iron (as Fe), lead (as Pb), manganese (as Mn), and nickel (as Ni) were below the detectable limit. Low concentrations of aluminium (as Al) and zinc (as Zn) were found in the range of 0.083–0.184 and 0.002–0.097 mg/L, respectively. The fecal coliform (FC) in the five water samples (VC–02 to VC–06) was not found (NF). Whereas in water sample locations VC–01, VC–07, and VC–08, it was found 70, 1760, and 4568 CFU/100 ml, respectively.

The physicochemical characteristics of the VC samples (VC–01 to VC–08) were low in organics, inorganic, and nutrients and thus classified as low-strength. The heavy metal analysis of these water samples indicates below the detectable limit or present in extremely low concentrations.

4.2.5.1 Physicochemical characteristics of drain discharge into Valiyath Canal

Physicochemical characteristics and onsite flow monitoring of drain discharge (DoVC–02) into the VC were carried out during post-monsoon (October 2024) and presented in **Table 13**. The flow of the drain at the sample location (DoVC–02) could not be monitored. The monitored pH value of the drain water sample (DoVC–02) was acidic (6.6), with a temperature of 30.8°C. The high SS content of 444 mg/L was registered in the drain water sample (DoVC–02). The O&G, TDS, COD, and BOD concentrations at this location were 20, 468, 40, and <10 mg/L, respectively. The DO concentration at DoVC–02 was 3.6 mg/L. TKN (as N), ammonical nitrogen (NH_3-N), nitrate (as NO_3-), and phosphorus concentration of the drain water sample were 6, BDL, 0.55, and 1.8 mg/L, respectively.

Table 13: Physicochemical characteristics and heavy metals of samples of Pallikalar River and Valiyath Canal

(Post-monsoon: Second event of monitoring 19-20 October 2024)

Sr. No.	Parameters	Water samples: Valiyath Canal and drain									
		PKR-01	VC-01	DoVC-02	VC-02	VC-03	VC-04	VC-05	VC-06	VC-07	VC-08
1.	pH	7.0	6.6	6.6	6.7	6.6	7.1	6.5	7.2	6.6	6.5
2.	Temperature (℃)	29.2	28.7	30.8	30.4	29.3	29.6	28.7	29.3	29.3	29.6
3.	Oil & Grease	BDL	07	20	18	17	19	19	16	16	20
4.	Suspended solids	24	376	444	452	512	532	408	288	72	64
5.	Total dissolved solids	204	276	468	312	308	332	336	175	288	290
6.	Chemical oxygen demand	10	16	40	40	24	16	32	56	32	32
7.	BOD	<5	<5	<10	<10	<5	<5	<5	<10	<5	<5
8.	DO	4.5	2.6	3.6	6.2	4.2	7.2	4.4	4.2	5.8	3.0
8.	TKN	1.0	2.0	6.0	5.0	3.0	2.0	4.0	5.0	3.0	3.0
9.	Ammonical nitrogen	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
10.	Nitrate	0.29	0.44	0.55	0.56	0.72	0.5	0.72	0.68	0.42	0.12
11.	Phosphorous	1.7	1.5	1.8	1.9	2.8	2.5	2.6	2.4	1.7	2.8
Heavy metals											
12.	Aluminum (Al)	0.186	0.167	0.227	0.134	0.160	0.184	0.120	0.160	0.083	0.164
13.	Arsenic (As)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
14.	Cadmium (Cd)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
15.	Chromium (Cr)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
16.	Cobalt (Co)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
17.	Copper (Cu)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
18.	Iron (Fe)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19.	Lead (Pb)	BDL	BDL	0.007	BDL	BDL	BDL	BDL	BDL	BDL	BDL
20.	Manganese (Mn)	0.028	BDL	0.017	BDL	BDL	BDL	BDL	BDL	BDL	BDL
21.	Nickel (Ni)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
22.	Zinc (Zn)	0.069	0.008	0.159	0.097	0.084	0.002	0.035	0.092	0.031	0.039
Bacteriological quality											
23.	Total coliform (CFU per 100 ml)	NM	500	NM	NF	NF	NF	NF	NF	3000	6000
24.	Fecal coliform (CFU per 100 ml)	NM	70	NM	NF	NF	NF	NF	NF	1760	4568
25.	Flow, m^3/sec	NP	0.39	NP	0.15	0.068	0.09	0.024	0.03	0.01	NP

PKR- Pallikalar River; VC- Valiyath Canal; DoVC- Drain of Valiyath Canal; All values are expressed in mg/L except pH and temperature, TC, FC and Flow; BDL- Below detectable limit. NP- Flow not possible, NM- Not monitored, and NF- Not found.

The heavy metal analysis of the drain water sample location at DoVC–02 indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), copper (Cu), Iron (Fe), and nickel (as Ni) were below the detectable limit. Low concentrations of aluminium (as Al), lead (as Pb), manganese (Mn), and zinc (as Zn) were found to be 0.227, 0.007, 0.017, and 0.159 mg/L, respectively.

The spatial distribution of major physicochemical characteristics (second event) of water samples of Edappally, Thevara-Perandoor, Patolithot, Valiyath, and Chambakkara Canals, including Periyar & Pallikalar Rivers, is presented in **Figures 7 and 10,** indicating that the water samples collected at different locations of the four canals show a discharge of stormwater and domestic sewage from the households of the different municipalities.

4.3 Post-Winter (February 2025) (Third event of monitoring)

4.3.1 Physicochemical characteristics and heavy metals of Canals and River

The physicochemical characteristics, heavy metals, of water/wastewater samples collected, including flow from Edappally, Thevara-Perandoor, Patolithot, Valiyath, and Chambakkara Canals, and Periyar & Pallikalar Rivers, are presented in **Tables 14 through 17**. The results of the sampling events conducted during February 7-11, 2025, are detailed hereunder.

4.3.2 Edappally and Chambakkara Canals and Periyar River

The water quality of the Edappally Canal (EC) was monitored at eight locations (EC–01 to EC–06) and one in the Periyar River and Chambakkara Canal, as delineated in **Table 14**. The monitored pH values of the water samples at different locations varied from acidic to alkaline (6.8–7.4), with temperatures of 22.2 to 28.8°C. The low suspended solids (SS) content in the eight water samples registered from locations EC–01 to EC–06 was in the range of 24 –170 mg/L. The O&G concentrations in the eight different locations of water samples ranged between <05–18 mg/L. TDS of the samples at EC–01 to EC–06 ranged between 177–864 mg/L. The measured organic content in the water samples concerning COD and BOD values at (EC–01 to EC–06) was varied between 40–144 and <05 –38mg/L, respectively. The DO concentration at EC–01 (near Periyar River), EC–02 (adjacent to Lulu Mall), and EC–03 was 2.8, 1.4 mg/L, and NIL, respectively, and the rest of the water sample locations ranged

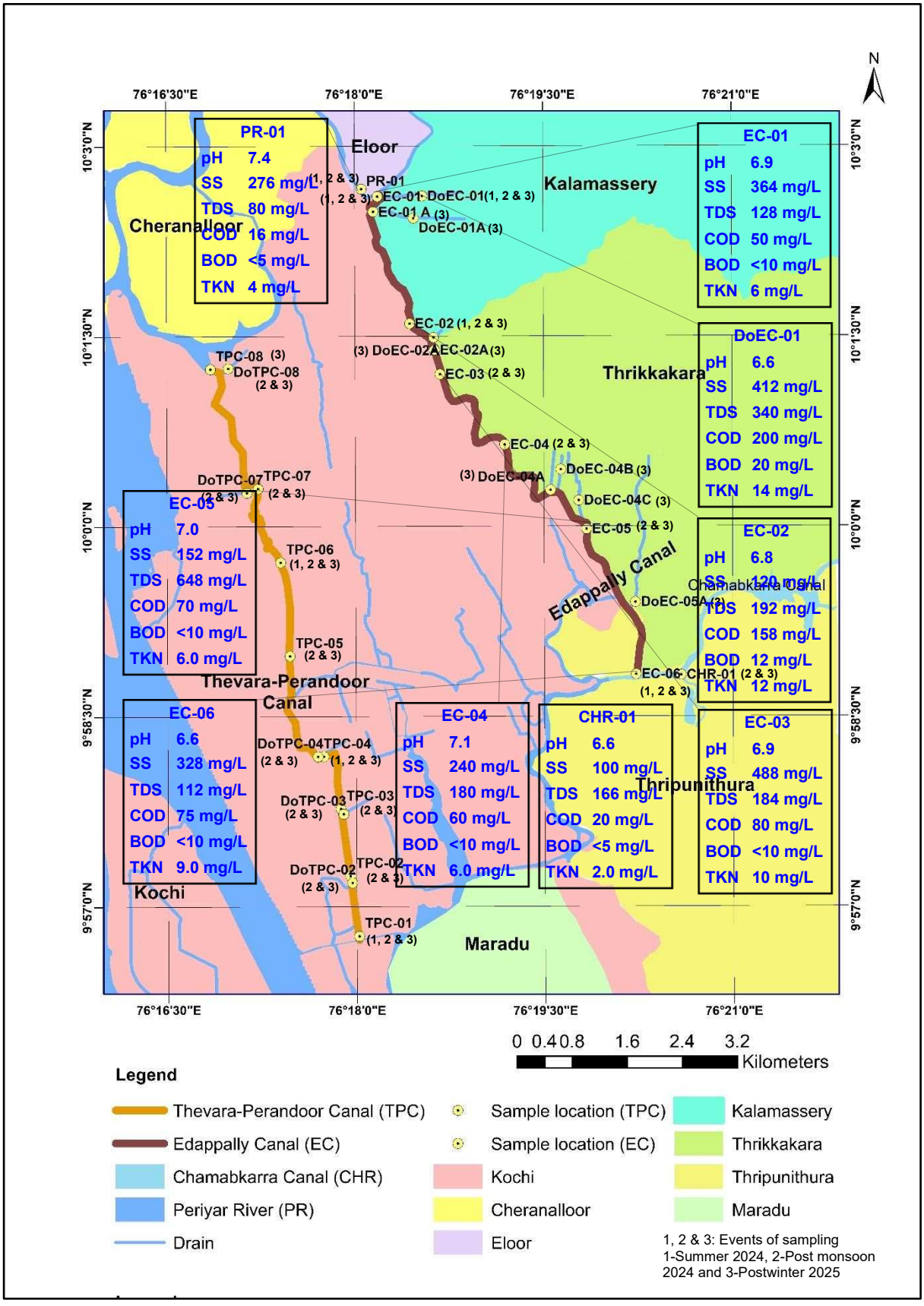

Figure 7: Spatial distribution of Edappally Canal (EC) (incoming Drain to EC) and Periyar River water quality concerning critical parameters (Post monsoon: Second event of

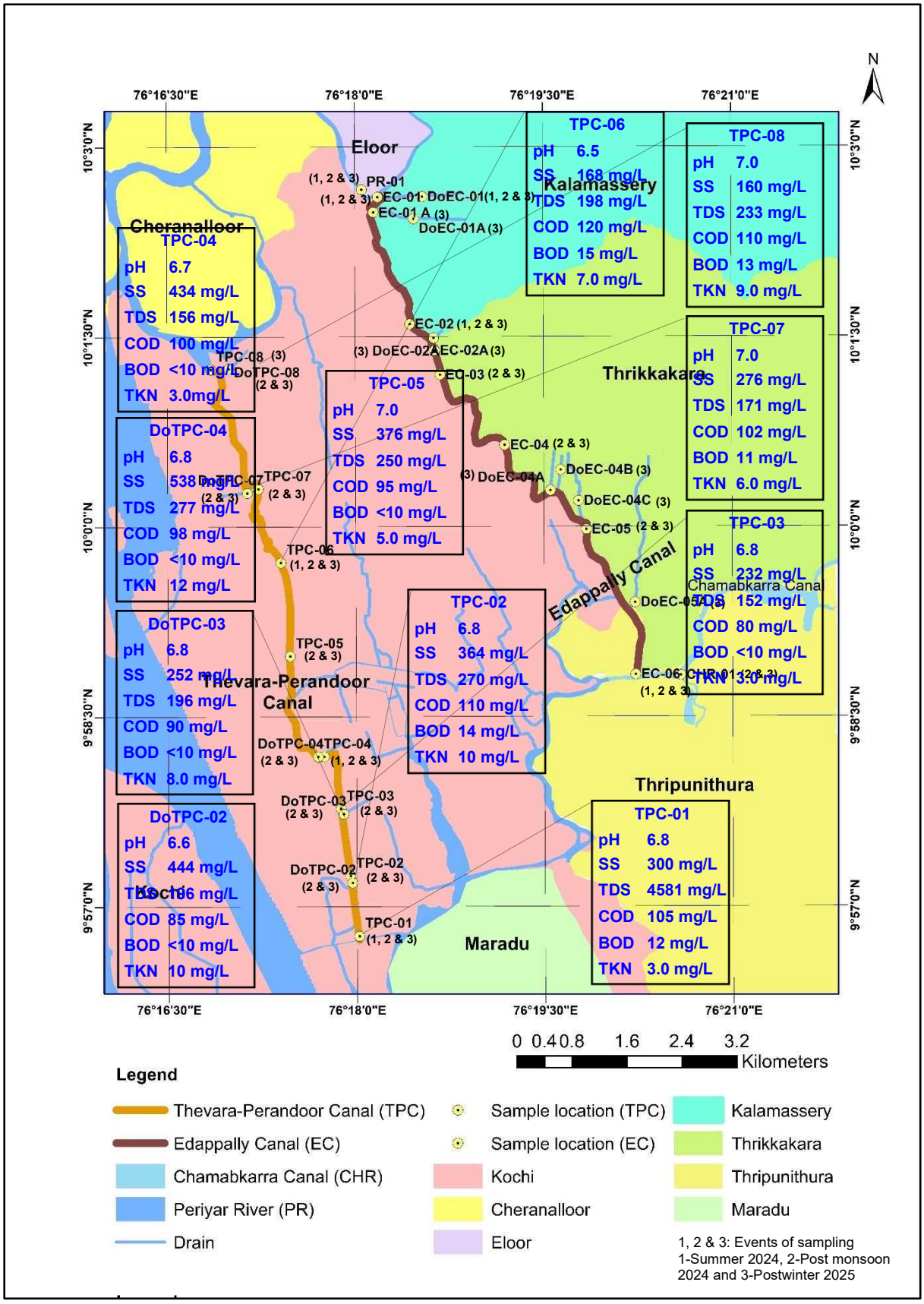

Figure 8: Spatial distribution of Thevera Perandoor Canal (TPC) and its incoming Drain water quality concerning critical parameters (Post monsoon:Second event of

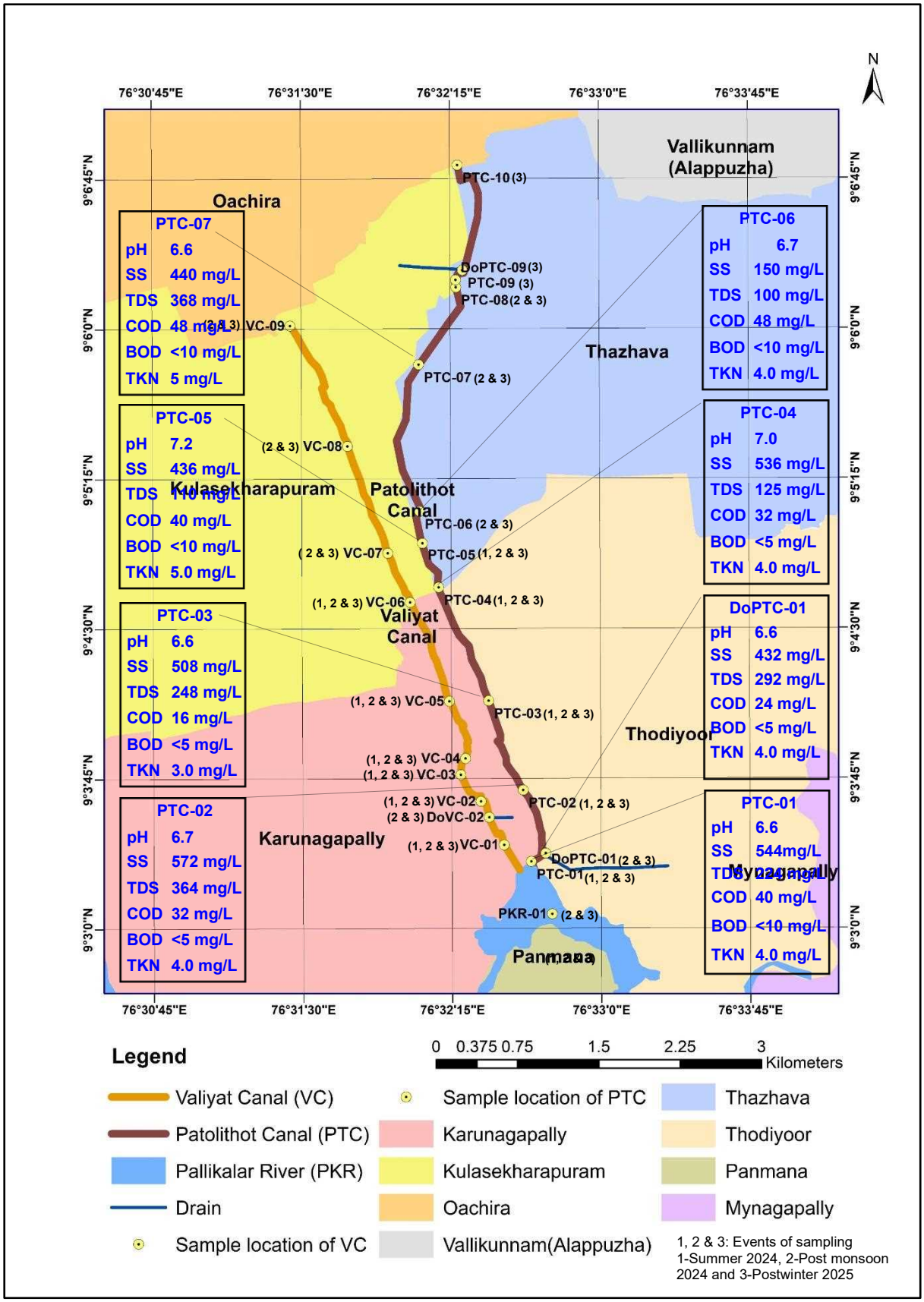

Figure 9: Spatial distribution of Patolithot Canal (PTC) water quality concerning critical parameters (Winter:Second event of monitoring)

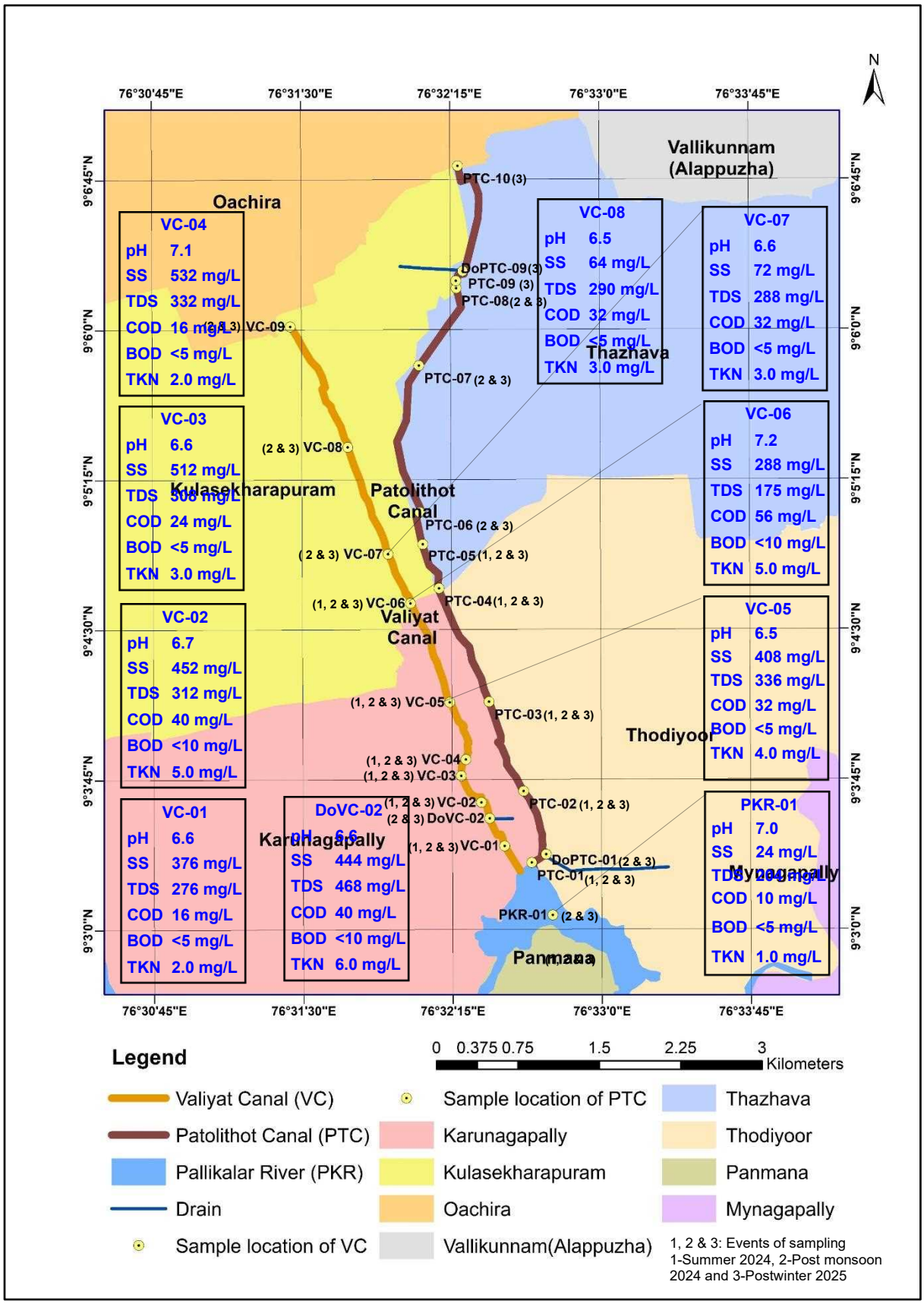

Figure 10: Spatial distribution of Valiyath Canal and its incoming Drain water quality concerning critical parameters (Post monsoon:Second event of monitoring)

Table 14: Physicochemical characteristics and heavy metals of water samples of Periyar River and Edappally Canal Drain
(Post-winter: Third event of monitoring 07 -08 February 2025)

Parameters	Water samples: Periyar River, Edappally Canal, Drain and Chambakkara River																
	PR -01	EC -01	DoEC-01	EC -01A	DoEC -01A	EC -02	DoEC -02A	EC -02A	EC -03	EC -04	DoEC-04A	DoEC-04B	DoEC-04C	EC -05	DoEC-05A	EC-06	CHR-01
pH	7.4	7.1	6.6	7.0	7.3	6.8	7.0	6.9	7.1	7.4	7.1	7.2	7.1	7.0	7.0	7.0	6.9
Temp. (℃)	24.3	26.9	24.0	23.4	22.7	23.6	24	22.3	25.5	22.2	21.2	29.7	29	28.8	29.3	28.7	21.4
Oil & Grease	4.2	<5	19	15	18	18	17.8	16	15	9.2	15.2	19	2.4	11	18	10	10
SS	68	76	272	76	156	60	160	24	128	132	152	172	104	144	152	170	464
TDS	160	308	252	177	348	300	268	184	292	224	152	576	336	864	576	268	560
COD	32	72	340	56	240	40	190	144	120	96	178	196	275	104	172	104	40
BOD	<5	<10	180	<5	125	<5	78	35	30	20	80	85	140	38	83	30	<5
DO	4.8	2.8	1.9	2.0	2.0	1.4	1.6	2.2	BDL	1.6	2.1	1.8	2.0	1.2	2.0	6.8	2.6
TKN	5.6	20.2	25	23	20	8.4	22	20	22	21	18	14	20	14	12	18	19.6
NH_3-N	2.8	7.2	4.8	BDL	5.6	9.6	8.4	2.8	BDL	BDL	8.2	BDL	2.8	BDL	BDL	5	BDL
Nitrate	0.06	0.01	0.06	BDL	0.05	0.04	0.04	0.06	0.03	0.01	BDL	BDL	BDL	0.06	0.03	BDL	0.5
Phosphorous	2.0	2.6	3.6	3.51	4.2	4.81	2.5	2.0	2.2	3.4	4.3	4.16	4.13	4.12	4.3	3.33	3.2
Heavy metals																	
Aluminum (Al)	0.023	0.067	0.116	0.085	0.104	0.047	0.148	0.130	0.15	0.224	0.235	0.023	0.064	0.128	0.056	0.033	BDL
Arsenic (As)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cadmium (Cd)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chromium (Cr)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cobalt (Co)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0BDL	BDL
Copper (Cu)	BDL	0.02	0.013	BDL	BDL	0.015	0.051	0.043	0.031	0.028	0.017	BDL	BDL	0.011	BDL	0.202	0.001
Iron (Fe)	0.044	0.32	0.311	0.33	0.436	0.38	0.25	0.32	0.214	0.137	0.346	0.079	0.322	0.246	0.52	0.044	BDL
Lead (Pb)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Manganese (Mn)	BDL	0.122	0.072	0.121	0.051	0.049	0.185	0.05	0.105	0.143	0.094	0.179	0.073	0.098	0.208	BDL	0.074
Nickel (Ni)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Zinc (Zn)	0.126	0.134	0.281	0.074	0.094	0.146	0.234	0.102	0.216	0.53	0.231	0.088	0.125	0.106	0.107	0.136	0.089
Bacteriological quality																	
TC CFU/100 mL	NM	TNC	3200	2200	NM	31000	TNC	NM	NM	32180	11020	NM	NM	2120	NM	10610	NM
FC CFU/100 mL	NM	TNC	1018	1560	NM	20022	TNC	NM	NM	2150	1058	NM	NM	210	NM	1022	NM
Flow, m^3/sec	NM	1.64	0.041	0.64	0.037	0.14	0.27	NM	1.10	NM	NM	0.11	0.052	NM	0.44	9.132	NM

EC- Edappally Canal; DoEC - Drain of Edappally Canal; CHR-Chambakkara River, PR-Periya River; TC - Total coliform and FC - Fecal coliform; NM - Not monitored; TNC- Too numerous to count. All values are expressed in mg/L except pH and Temperature, TC, FC, and Flow.

between 1.2–6.8 mg/L. TKN (as N), ammonical nitrogen (NH_3-N), nitrate (as NO_3-), and phosphorus concentrations of the water samples were in the range of 8.4–23, BDL–9.6, BDL–0.06, and 2.0–4.81 mg/L, respectively.

The heavy metal analysis of these eight samples indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), lead (Pb), and nickel (Ni), were below detectable limit. Low concentrations of aluminium (as Al), copper (cu), iron (as Fe), manganese (as Mn), and zinc (as Zn) were registered in the range 0.033–0.224, BDL–0.202, 0.044–0.38, BDL–0.143, and 0.074–0.216 mg/L, respectively.

The Fecal coliform (FC) in the water samples at the EC–01 was Too Numerous to Count (TNC), and at other locations, EC–01A, EC–02, EC–04, EC–05, and EC–06 were 1560, 20022, 2150, 210, and 1022 CFU/100 mL, respectively.

4.3.2.1 Physicochemical characteristics of drain discharge into Edappally Canal

Physicochemical characteristics and onsite flow monitoring of seven drain discharges (DoEC–01, DoEC–01A, DoEC–02A, DoEC–04A, DoEC–04B, DoEC–04C, and DoEC–05A) into the Edappally Canal were also carried out during the summer (February 2025) and presented in **Table 14**. The monitored pH value of all the drain water samples (DoEC–01 to DoEC–05A) was acidic to alkaline (6.6–7.3), with a temperature between 21.2 and 29.7°C. The SS content of seven drain water samples was registered in the range of 104–272 mg/L. The O&G, TDS, COD, BOD, and DO concentrations at the sample locations (DoEC–01, DoEC–01A, DoEC–02A, DoEC–04A, DoEC–04B, DoEC–04C, and DoEC–05A) were 2.4–19, 152–576, 172–340, 78–180, and 1.6–2.1mg/L, respectively. TKN (as N), ammonical nitrogen (NH_3-N), nitrate (as NO_3-), and phosphorus concentration of the seven drain water samples were 12–25, BDL–8.4, BDL–0.06, and 2.5–4.30 mg/L, respectively.

The heavy metal analysis of the seven drain sample locations indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), lead (as Pb), and nickel (as Ni) were below detectable limit. Low concentrations of aluminium (as Al), copper (as Cu), iron (as Fe), Manganese (Mn), and zinc (as Zn) concentrations, were found in the range to be 0.023–0.235, BDL–0.051, 0.079–0.520, 0.051–0.208, and 0.088–0.281mg/L, respectively.

Table 15: Physicochemical characteristics and heavy metals of water samples of Thevara-Perandoor Canal and Drain
(Post-winter: Third event of monitoring 08- 09 February 2025)

Parameter	Water samples: Thevara-Perandoor Canal and Drain												
	TPC -01	Do TPC-02	TPC -02	Do TPC-03	TPC -03	TPC -04	Do TPC-04	TPC -05	TPC -06	TPC -07	Do TPC-07	TPC -08	Do TPC-08
pH	6.8	6.6	7.2	7.2	7.1	7.3	7.0	6.9	7.1	7.2	7.5	7.5	6.8
Temp. (℃)	26.8	27.4	25.6	25.9	24.2	26.1	25.2	25.6	26.5	23.4	24.2	24.1	25.2
Oil & Grease	16.0	15.6	13.6	20	15	8.4	8.7	20	10.8	20	5.6	16.2	20
SS	196	396	352	320	200	316	304	204	300	204	324	114	308
TDS	1120	128	128	225	884	316	972	188	212	209	172	184	104
COD	280	325	64	225	72	32	272	80	88	96	350	112	252
BOD	50	130	<10	120	<10	<5	145	20	22	22	175	30	150
DO	BDL	BDL	0.8	1.2	0.4	0.6	1.2	3	0.6	1.8	0.6	3.2	BDL
TKN	BDL	16.8	5.6	14	5.0	5.6	14	2.8	5.6	16.8	12.4	15.8	5.6
NH_3-N	BDL	4.0	8.4	4	2.4	2.6	5.2	1.6	1.5	5.6	4.8	4.4	1.2
Nitrate	0.25	0.13	0.14	0.12	0.13	0.11	BDL	0.07	0.14	0.13	0.12	0.11	0.12
Phosphorous	1.89	3.16	2.88	2.3	2.92	2.43	2.93	3.73	2.28	2.79	3.56	3.16	2.02
Heavy metals													
Aluminum (Al)	0.276	0.229	0.096	0.142	0.167	0.361	0.435	0.270	0.136	0.131	0.388	0.242	0.327
Arsenic (As)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cadmium (Cd)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chromium (Cr)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cobalt (Co)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Copper (Cu)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Iron (Fe)	0.022	0.131	0.156	0.137	0.048	0.024	0.165	0.175	0.109	0.103	0.141	0.155	0.022
Lead (Pb)	0.009	BDL	0.002	0.002	0.002	0.004	0.007	0.005	0.002	BDL	BDL	BDL	0.001
Manganese (Mn)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Nickel (Ni)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Zinc (Zn)	0.454	0.164	0.229	0.188	0.188	0.341	0.397	0.255	0.199	0.244	0.248	0.128	0.239
Bacteriological quality													
TC CFU/mL	TNC	NM	10250	NM	TNC	TNC	NM	NM	NM	9580	NM	TNC	NM
FC CFU/mL	TNC	NM	8525	NM	TNC	TNC	NM	NM	NM	1030	NM	TNC	NM
Flow, m^3/sec	NM	NM	0.458	NM	0.60	0.073	NM	0.083	0.189	NM	0.060	NM	NM

TPC- Thevara-Perandoor Canal; DoTPC- Drain of - Thevara-Perandoor Canal TC-TotalColiform and FC-Fecal Coliform. All values are expressed in mg/L except pH and Temperature, TC, FC, and Flow; BDL- Below detectable limit; NM- Not monitored; TNC- Too numerous to count

4.3.3 Thevara-Perandoor Canal (TPC)

The water quality of the Thevara-Perandoor Canal (TPC) was monitored at eight different locations (TPC–01 to TPC–08), as presented in **Table 15.** The observed pH values at different locations varied from acidic to alkaline (6.8–7.5), with temperatures ranging from 23.4 to 26.8°C. The O&G concentration in the eight different locations of water samples ranged between 8.4–20 mg/L. The suspended solids content in the water sample registered at locations (TPC–01 to TPC–08) was 114–352 mg/L. TDS of the samples at TPC–01 to TPC–08 ranged between 128–1120 mg/L. The measured organic content in the water samples concerning COD and BOD values at (TPC–01 to TPC–08) ranged between 32–280 and <5–50 mg/L, respectively. DO concentration of water samples from (TPC–01 to 08) was between BDL–3.2 mg/L. TKN (as N), ammonical nitrogen (NH_3-N), nitrate (as NO_3-), and phosphorus concentrations of the samples were in the range of BDL–16.8, BDL–8.4, 0.07–0.25, and 1.89–3.73 mg/L, respectively.

The heavy metal analysis of these eight samples indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), copper (as Cu), manganese (as Mn), and nickel (as Ni) were below the detectable limit. Low concentrations of aluminium (as Al), iron (as Fe), lead (Pb), and zinc (as Zn) were registered in the range of 0.096–0.361, 0.022–0.175, BDL–0.009, and 0.128–0.454 mg/L, respectively. The Fecal coliform (FC) in the water samples at the TPC–01, TPC–03, TPC–04, and TPC–08 was Too Numerous to Count (TNC), and at other locations, TPC–02 and TPC–07 were 8525 and 1030 CFU/100 mL, respectively.

4.3.3.1 Physicochemical characteristics of drain discharge into Thevara-Perandoor Canal (TPC)

Physicochemical characteristics and onsite flow monitoring of five drain discharges (DoTPC–02, DoTPC–03, DoTPC–04, DoTPC–07, and DoTPC–08) into the TPC were also carried out during the summer (February 2025) and presented in **Table 15**. The monitored pH value of five drain water samples was acidic to alkaline (6.6–7.5), with a temperature between 24.2 and 27.4°C. The SS content of five drain water samples was registered in the 304–396 mg/L range. The O&G, TDS, COD, BOD, and DO concentrations at the sample locations (DoTPC–02, DoTPC–03, DoTPC–04, DoTPC–07, and DoTPC–08) were 5.6–20, 104–972, 225–350, 120–175, and BDl –1.2 mg/L,

respectively. TKN (as N), ammonical nitrogen (NH_3-N), nitrate (as NO_3-), and phosphorus concentration of the five drain water samples were 5.6–16.8, 1.2–5.2, BDL–0.13, and 2.02–3.56 mg/L, respectively.

The heavy metal analysis of the five drain sample locations indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), chromium (as Cr), cobalt (as Co), copper (as Cu), manganese (Mn), and nickel (as Ni) were below the detectable limit. Low concentrations of aluminium (as Al), iron (as Fe), lead (as Pb), and zinc (as Zn) concentrations, were found in the range of 0.142–0.435, 0.022–0.165, BDL–0.007, and 0.164–0.397 mg/L, respectively.

4.3.4 Patolithot Canal (PTC)

The water quality of the Patolithot Canal (PTC) was monitored at ten locations (PTC–01 to PTC–10), as shown in **Table 16**. The observed pH values at different locations varied from acidic to alkaline (6.2–7.1), with temperatures of 24.6 to 31.2°C. The suspended solids content in the water sample registered at locations (PTC–01 to PTC–10) was 16–380 mg/L. TDS of the samples at PTC–01 to PTC–10 ranged between 184 to 788 mg/L. The O&G concentration in the ten different locations of water samples ranged between 1.8–28.8 mg/L. The measured organic content in the water samples concerning COD and BOD values at PTC–01 to PTC–10 was 28–450 and <5–220 mg/L, respectively. DO concentration of water samples from (PTC–01 to 10) was between BDL–4.8 mg/L. TKN (as N), nitrate (as NO_3-), and phosphorus concentrations of the samples were in the range of BDL–20, BDL–0.44, and 0.35–2.57 mg/L, respectively. Ammonical nitrogen (NH_3-N) registered in all the water sample locations was below BDL–3.4 mg/L.

Heavy metal analysis of these ten samples indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), cobalt (as Co), copper (as Cu), lead (as Pb), and nickel (as Ni), were below detectable limit. Low concentrations of aluminium (as Al), chromium (as Cr), iron (as Fe), manganese (as Mn), and zinc (as Zn) were found in the range of 0.03–2.400, 0.049–0.642, 0.100–0.226, 0.109–0.210, and 0.084–0.236 mg/L, respectively. The fecal coliform (FC) concentration in the water samples at PTC–01 to PTC–09 was 85–3500 CFU/100 mL.

Table 16: Physicochemical characteristics and heavy metals of water samples of Pallikalar River and Patolithot Canal, and Drain
(Post-winter: Third event of monitoring 10 -11 February 2025)

Parameter	Water samples: Pallikalar River, Patolithot Canal and Drain												
	PKR -01	**PTC -01**	**Do PTC-01**	**PTC -02**	**PTC -03**	**PTC -04**	**PTC -05**	**PTC -06**	**PTC -07**	**PTC -08**	**Do PTC-09**	**PTC -09**	**PTC -10**
pH	6.7	7.1	7.1	6.8	7.0	7.0	6.8	6.7	6.8	6.3	6.7	7.0	6.2
Temp.(℃)	26.4	29.9	27.5	28.4	26.2	27.6	28.3	27.7	27.9	31.2	28.5	24.6	27.9
Oil & Grease	10.6	14.8	17.4	5.6	1.8	18.6	2.4	5.6	12.8	20.2	12.6	16.4	28.8
SS	68	80	200	16	100	360	120	380	132	356	392	332	316
TDS	106	376	256	368	440	552	464	788	280	340	272	500	184
COD	20	40	250	28	112	40	32	36	96	352	180	36	450
BOD	<5	<5	130	<5	40	<5	<5	<5	25	156	80	<5	220
DO	3.4	1.2	3	4.8	4	3.8	2.4	1.2	4.2	BDL	2.2	3.4	BDL
TKN	1.0	8.4	10	5.6	BDL	2.8	BDL	BDL	8.4	16.6	19.6	14	20
NH_3-N	BDL	2.4	2.0	BDL	BDL	BDL	BDL	BDL	BDL	3.4	4.2	1.6	2.2
Nitrate	BDL	0.04	0.6	0.04	0.44	0.34	0.33	0.16	BDL	BDL	BDL	BDL	0.3
Phosphorous	1.2	1.56	4.17	2.16	0.43	2.57	0.35	0.72	2.2	2.4	0.6	0.5	1.9
Heavy metals													
Aluminum (Al)	0.025	0.041	0.046	0.192	0.118	0.033	0.03	0.043	0.407	2.400	0.043	0.051	0.73
Arsenic (As)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cadmium (Cd)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chromium (Cr)	0.221	0.085	0.432	0.094	0.642	0.217	0.049	0.131	0.424	0.318	0.187	0.162	0.295
Cobalt (Co)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Copper (Cu)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Iron (Fe)	0.145	0.100	2.632	0.210	0.120	0.150	0.130	0.189	0.226	0.162	2.51	0.152	0.200
Lead (Pb)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Manganese (Mn)	0.159	0.210	0.481	0.195	0.200	0.109	0.166	0.179	0.200	0.180	0.124	0.126	0.190
Nickel (Ni)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Zinc (Zn)	0.084	0.14	0.178	0.144	0.134	0.216	0.09	0.236	0.178	0.105	0.151	0.084	0.157
Bacteriological quality													
TC CFU/100mL	NM	948	NM	NF	125	832	414	232	2120	3250	NM	4250	NM
FC CFU /100mL	NM	212	NM	NF	85	202	212	125	900	2500	NM	3500	NM
Flow, m^3/sec	NM	0.402	0.007	2.455	0.015	0.015	0.024	NM	NM	NM	NM	NM	NM

PKR- Pallikalar River; PTC- Patolithot Canal, DoPTC-Drain of Patolithot Canal TC-TotalColiform and FC-Fecal Colifom; NF-Not found, NM- Not monitored; All values are expressed in mg/L except pH and Temperature, TC, FC and Flow.

4.3.4.1 Physicochemical characteristics of drain discharge into Patolithot Canal (PTC)

Physicochemical characteristics and onsite flow monitoring of drain discharge (DoPTC–01 and 09) into the Patolithot Canal (PTC) were carried out during summer (February 25) and presented in **Table 16**. The monitored pH value of the drain water sample (DoPTC–01 and 09) was acidic to neutral (6.7 to 7.1), with a temperature of 27.5–28.5ºC. The SS content of two drain water samples was registered in the 200–392 mg/L range. The O&G, TDS, COD, and BOD concentrations at these locations were 12.6–17.4, 256–272, 180–250 80–130 mg/L, respectively. The DO concentration at two locations was in the range of 2.2 –3.0 mg/L. TKN (as N), ammonical nitrogen (NH_3–N), nitrate (as NO_3-), and phosphorus concentration of the drain sample ranged between 10–19.6, 2.0–4.2, BDL–0.6, and 0.6–4.17 mg/L, respectively.

The heavy metal analysis of the drain sample locations at DoPTC–01 and 09 indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), cobalt (as Co), copper (as Cu), lead (as Pb), and nickel (as Ni) were below detectable limit. Low in concentrations of aluminium (as Al), chromium (as Cr), iron (as Fe), manganese (Mn), and zinc (as Zn) were found in the range between 0.043–0.046, 0.187–0.432, 2.51–2.632, 0.124–0.481, and 0.151–0.178 mg/L, respectively.

4.3.5 Valiyath Canal (VC)

The water quality of the Valiyath Canal (VC) is monitored at nine locations (VC–01 to VC–09), as delineated in **Table 17**. The observed pH values at different locations varied from acidic to alkaline (6.6–7.2), with temperatures of 25.7 to 31.0°C. The O&G concentrations in the nine different locations of water samples ranged between 2.8–22.6 mg/L. The suspended solids content in the water sample registered at locations VC–01 to VC–09 ranged between 164–304 mg/L, respectively. TDS of the water samples at VC–01 to VC–09 ranged between 188–444 mg/L. The measured low organic content in the water samples concerning COD, BOD, and DO values at VC–01 to VC–09 ranged from 50–300 and <10 to 156 and BDL–4.6 mg/L, respectively. TKN (as N), nitrate (as NO_3-), and phosphorus concentrations of the water samples were in the range of BDL–16.8, BDL–0.17, and 0.98–3.5 mg/L, respectively. Ammonical nitrogen (NH_3-N) registered in all the sample locations was in the range of BDL–5.6 mg/L.

Table 17: Physicochemical characteristics and heavy metals of water samples of Valiyath Canal, Drain, and Pallikalar River
(Post-winter: Third event of monitoring 10 -11 February 2025)

Parameter	Water samples: Valiyath Canal, Drain and Pallikalar River										
	PKR -01	**VC-01**	**VC-02**	**DoVC-02**	**VC-03**	**VC-04**	**VC-05**	**VC-06**	**VC-07**	**VC-08**	**VC-09**
pH	6.7	6.7	7.1	7.2	6.6	7.0	7.1	7.1	7.2	7.2	6.8
Temp. (℃)	26.4	28	26	28	31	25.7	31	26.6	25.9	26.6	26.6
Oil & Grease	10.6	8.8	11.8	8	21.2	5.0	10.2	19	2.8	20.8	22.6
SS	68	224	168	200	164	200	180	304	280	264	192
TDS	106	292	300	350	188	196	236	308	312	444	188
COD	20	90	80	120	50	55	62	80	95	125	300
BOD	<5	28	25	40	<10	<10	<10	<10	<10	40	156
DO	3.4	1	2	2.5	4.6	1.8	1.5	1.8	1.8	3.8	BDL
TKN	1.0	4.0	5.6	12	BDL	16.8	BDL	16.8	5.6	2.8	10
NH_3-N	BDL	1.2	2.8	2.2	BDL	5.6	BDL	5.2	2.4	1.2	4
Nitrate	BDL	BDL	0.13	0.6	0.17	0.11	0.04	BDL	BDL	BDL	0.10
Phosphorus	1.2	0.98	1.17	0.7	1.5	1.4	1.9	2.4	2.17	1.21	3.5
Heavy metals											
Aluminum (Al)	0.025	0.088	0.146	0.234	0.275	0.027	0.019	0.048	0.035	0.020	0.300
Arsenic (As)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cadmium (Cd)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chromium (Cr)	0.221	0.058	0.081	0.092	0.170	0.155	0.069	0.017	0.020	0.050	0.027
Cobalt (Co)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Copper (Cu)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Iron (Fe)	0.145	0.253	0.675	0.425	0.528	1.587	1.447	0.163	1.217	0.960	1.187
Lead (Pb)	BDL	BDL	BDL	0.08	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Manganese (Mn)	0.159	0.496	0.306	0.020	0.450	0.185	0.157	0.207	0.033	0.022	0.052
Nickel (Ni)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Zinc (Zn)	0.084	0.298	0.120	0.168	0.318	0.040	0.057	0.194	0.038	0.033	0.036
Bacteriological quality											
TC CFU/100mL	NM	960	NF	NF	NF	NF	110	NM	TNC	TNC	TNC
FC CFU/100mL	NM	120	NF	NF	NF	NF	50	NM	4210	9450	424
Flow, m^3/sec	NM	0.060	NM	NM	NM	0.008	0.002	NM	0.002	NM	NM

PKR- Pallikalar River; VC-Valiyath Canal- TC-Total Coliform and FC-Fecal Coliform. All values are expressed in mg/L except pH and Temperature, TC-Total coliform, FC-fecal coliform and Flow; NF-Not found, NM- Not monitored; Below detectable limit; TNC- Too numerous to count.

The heavy metal analysis of these nine samples indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), cobalt (as Co), copper (as Cu), lead (as Pb), and nickel (as Ni), were below the detectable limit. The low concentrations of aluminium (as Al), chromium (as Cr), iron (as Fe), manganese (Mn), and zinc (as Zn) were found in the range 0.019–0.30, 0.017–0.17, 0.253–1.587, 0.022–0.496, and 0.033–0.318 mg/L, respectively. The fecal coliform (FC) concentration in the water samples at the VC–01, VC–05, VC–07, VC–08, and VC–09 ranged between 50 – 9450 CFU/100 mL. However, no fecal coliform (FC) was found in a water sample at locations (VC–02, VC–03, and VC–04)

4.3.5.1 Physicochemical characteristics of drain discharge into Valiyath Canal (VC)

Physicochemical characteristics of drain discharge (DoVC–02) into the Valiyath Canal (VC) were carried out during summer (February 25) and presented in **Table 17**. The monitored pH value of the drain water sample (DoVC–01) was neutral (7.2), with a temperature of 28.0^{o}C. The SS content of the drain water samples was registered at 200 mg/L. The O&G, TDS, COD, and BOD concentrations at this location were 8, 350, 120, and 40 mg/L, respectively. The DO concentration at DoVC–02 was 2.5 mg/L. TKN (as N), ammonical nitrogen (NH_3-N), nitrate (as NO_3-), and phosphorus concentration of the drain sample were 12, 2.2, 0.6, and 0.7 mg/L, respectively.

The heavy metal analysis of the drain sample locations at DoPTC–01 indicates that toxic elements, namely arsenic (as As), cadmium (as Cd), cobalt (as Co), copper (as Cu), and nickel (as Ni) were below detectable limit. Low concentrations of aluminum (as Al), chromium (as Cr), iron (as Fe), lead (Pb), Manganese (as Mn), and zinc (as Zn) were found to be 0.234, 0.092, 0.425, 0.08, 0.020, and 0.168 mg/L, respectively.

The spatial distribution of major physicochemical characteristics (third event) of water samples of Edappally, Thevara-Perandoor, Patolithot, Valiyath and Chambakkara Canals, including Periyar & Pallikalar Rivers, is presented in **Figures 11 and 16,** indicating that the water samples collected at different locations of the four canals show a discharge of stormwater and domestic sewage from the households of the different municipalities.

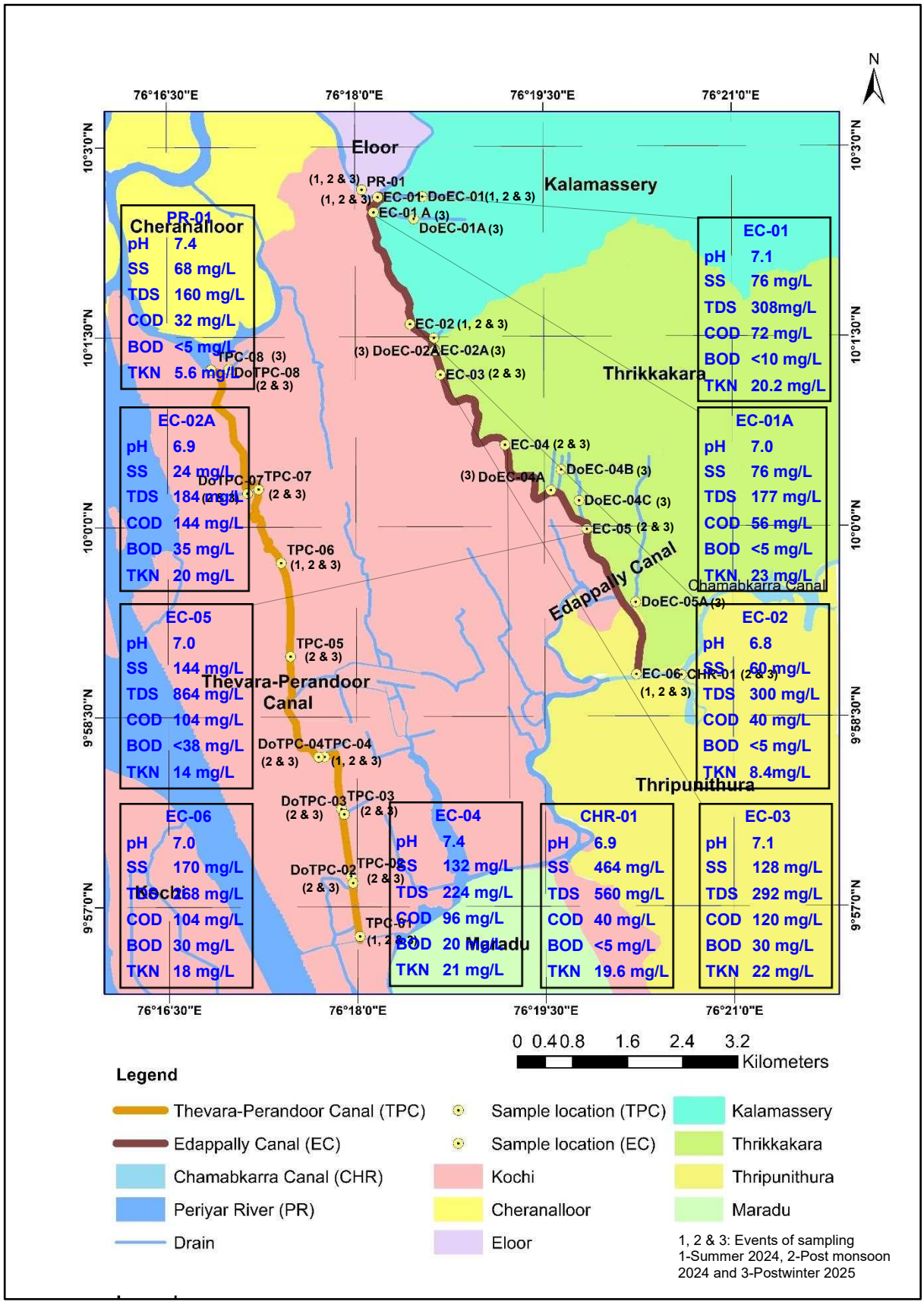

Figure 11: Spatial distribution of Edapally Canal and Chambhakara Canal water quality concerning critical parameters (Post-winter:Third event of monitoring)

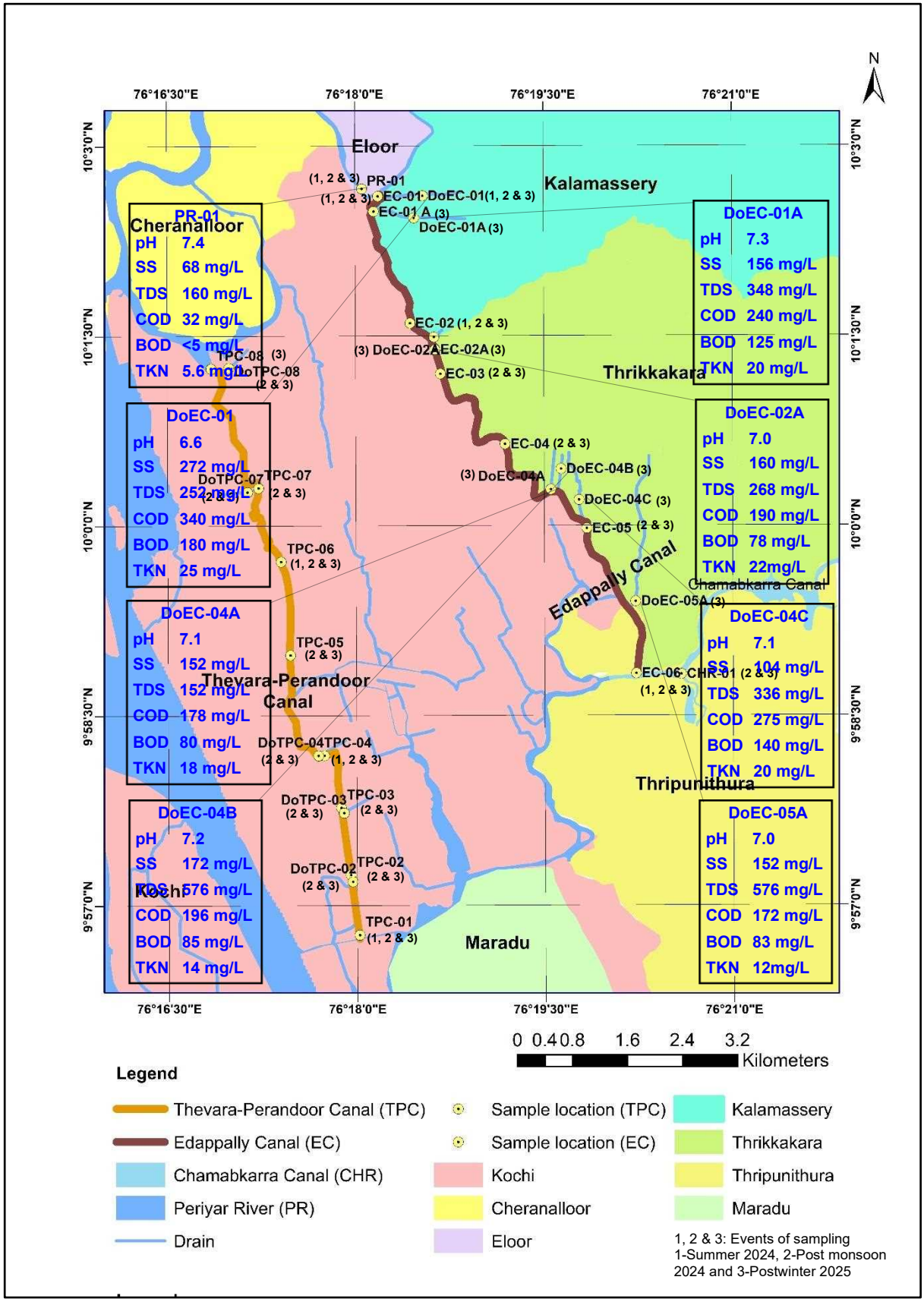

Figure 12: Spatial distribution of incoming Drain of Edapally Canal (EC) water quality concerning critical parameters (Post-Winter:Third event of monitoring)

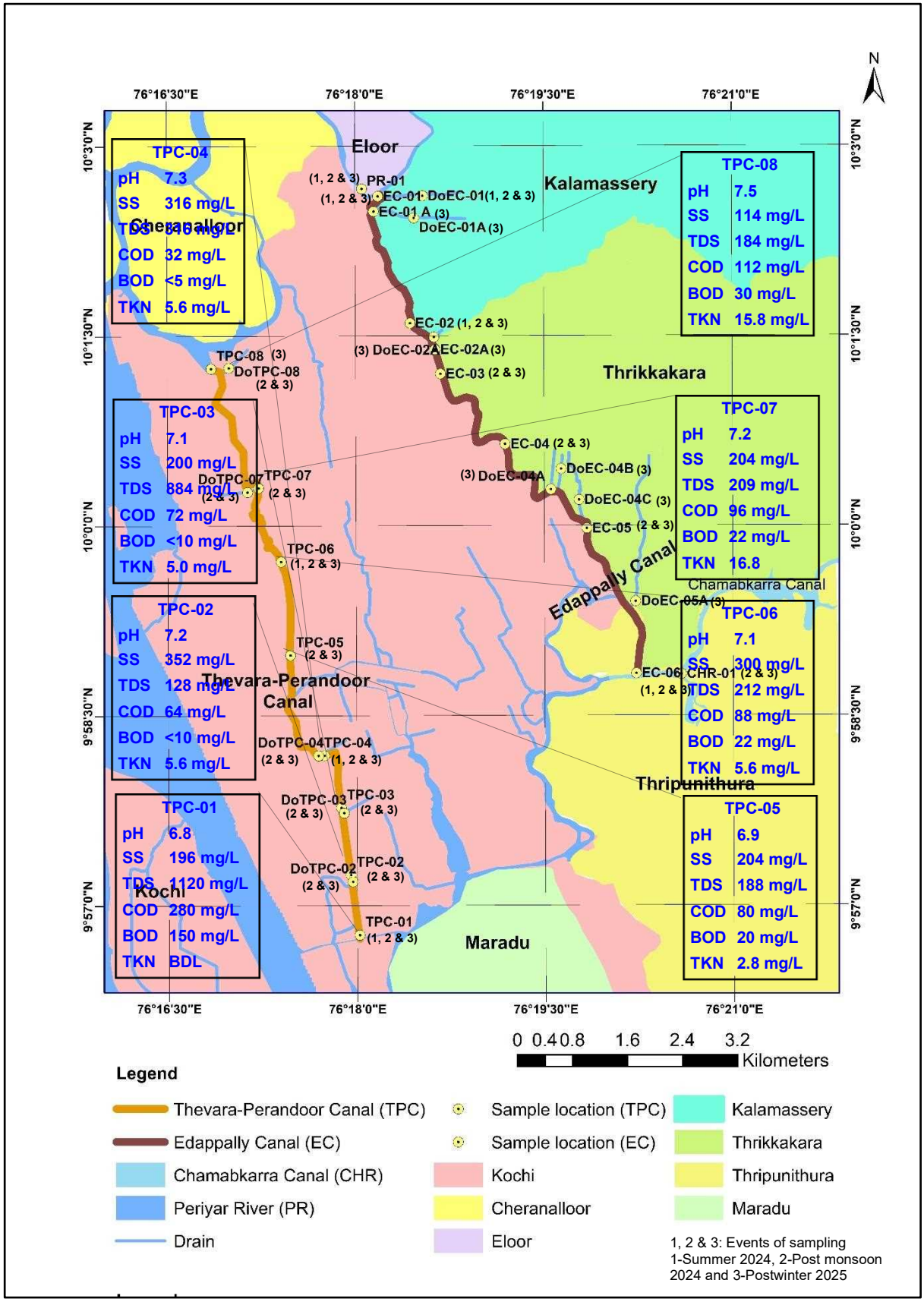

Figure 13: Spatial distribution of Thevara-Perandoor Canal (TPC) water quality concerning critical parameters (Post-winter:Third event of monitoring)

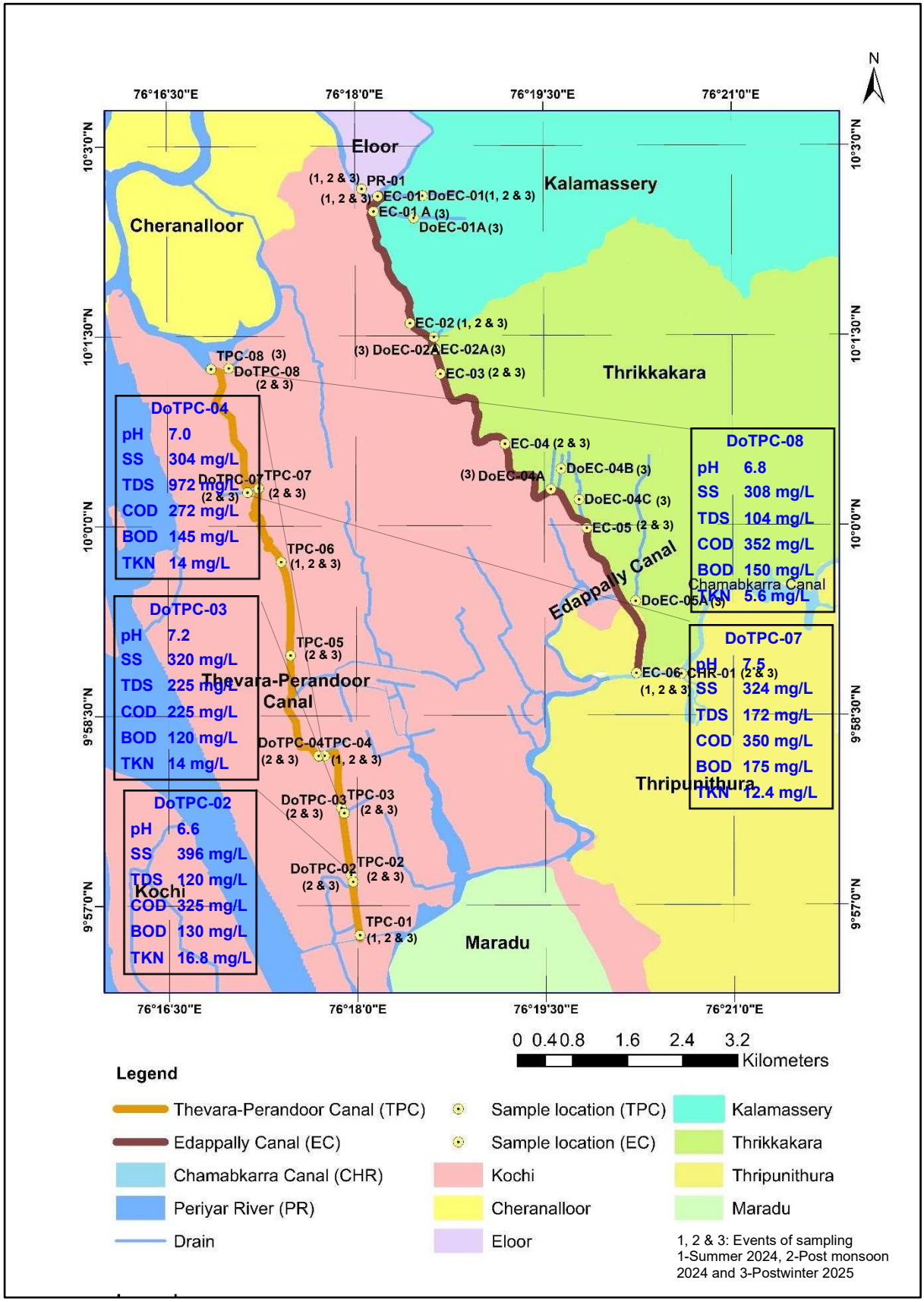

Figure 14: Spatial distribution incoming Drain of Thevara-Perandoor Canal (TPC) water quality concerning critical parameters (Post-winter:Third event of monitoring)

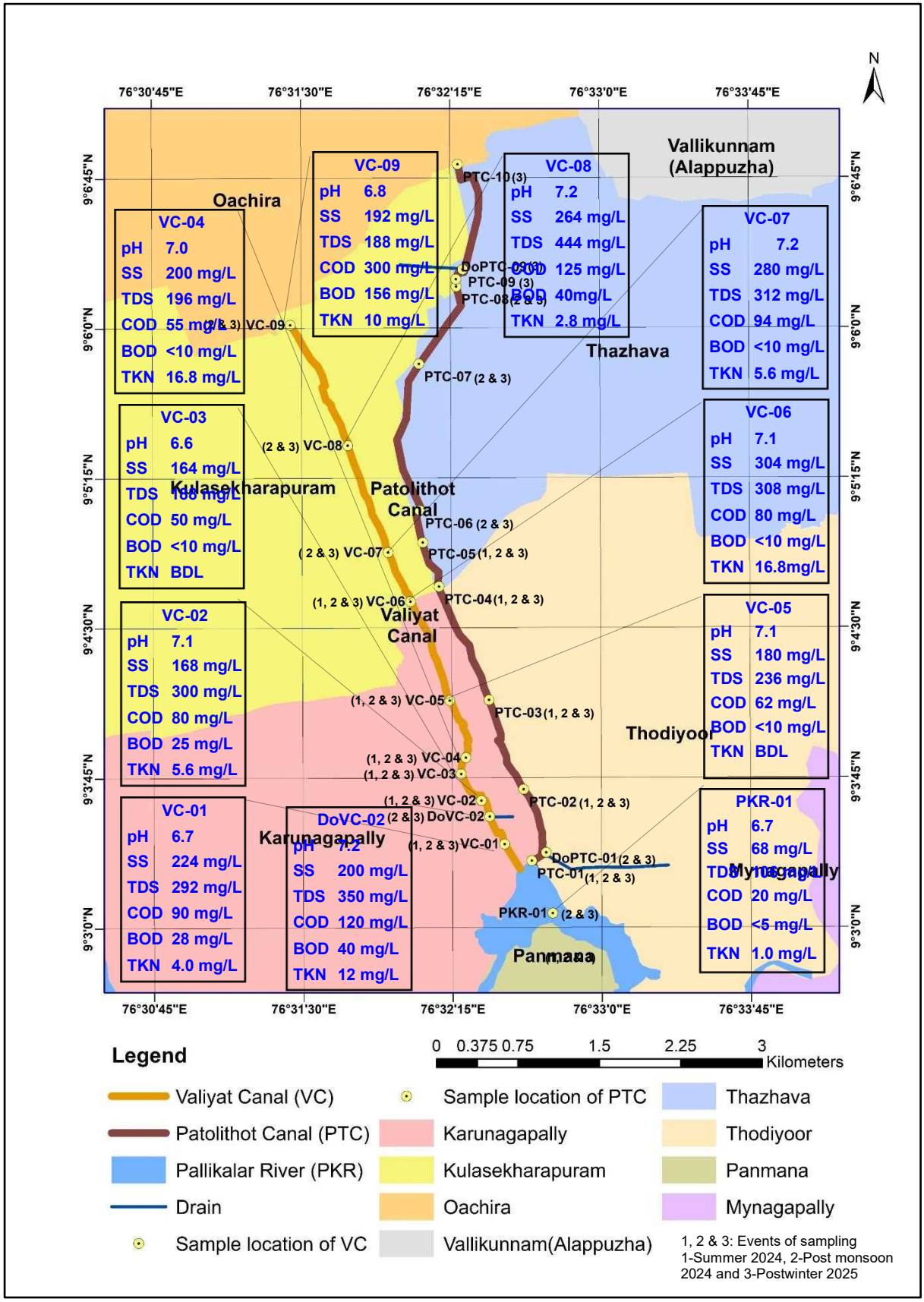

Figure 15: Spatial distribution of incoming Drain of Valiyath Canal (VC) and its water quality concerning critical parameters (Post-winter:Third event of monitoring)

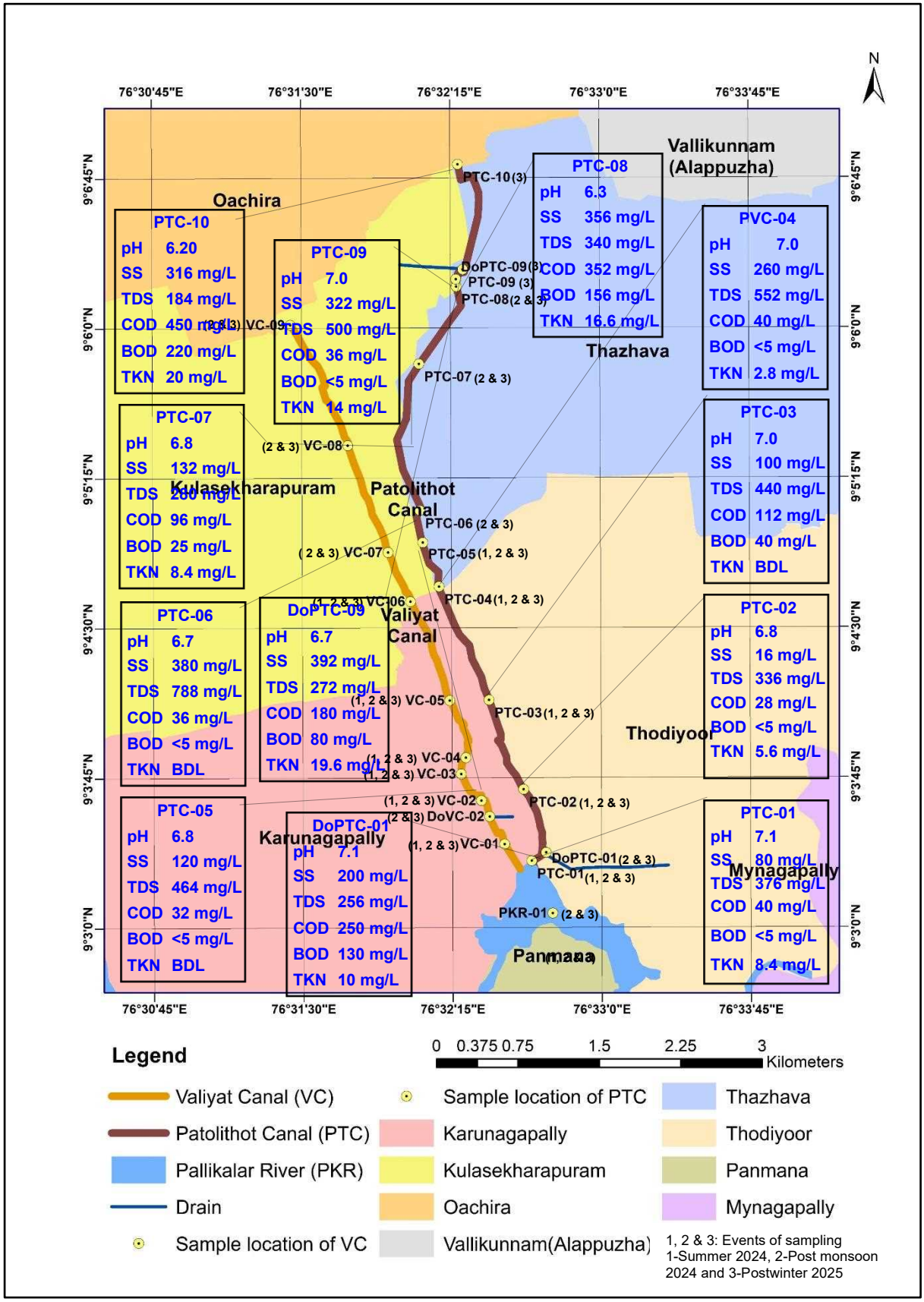

Figure 16: Spatial distribution of incoming Drain of Patolithot Canal (PTC) and its water quality concerning critical parameters (Post-Winter:Third event of monitoring)

5.0 Water quality of Canals and the drains discharged into Canals

Water quality (range) of significant parameters based on three events of monitoring of the Edappally, Thevara-Perandoor, Patolithot, and Valiyath Canals, and drain discharge into four Canals is presented in **Table 18.**

Table 18: Water quality (range) of the significant parameters of the Canal and the drain

Parameters	Canal			
	Edappally	Thevara-Perandoor	Patolithot	Valiyath
Canals				
− pH	6.4–7.4	6.3–7.5	**6.4–7.2**	**6.3–7.2**
− Temp.	22.2–35.1	23.4–34.5	**24.6–33.2**	**25.7–35**
− Oil & Grease	5–27.2	05–24.6	**BDL–28**	**2.8–22.6**
− SS	24–488	114–393	**16–572**	**64–632**
− TDS	112–1990	128–9430	**100–788**	**175–480**
− COD	40–282	32–300	**16–450**	**16–300**
− BOD(3d;27^{0}C)	05–120	05–60	**05–220**	**5–156**
− TKN	6–23	BDL–22	**BDL–20**	**BDL–16.8**
− NH_3–N	BDL–9.6	BDL–8.4	**BDL–3.4**	**BDL–5.6**
− Phosphorus	1.3–8.1	1.0–3.73	**0.35–2.57**	**0.98–2.8**
− Fecal coliforms				
Strength	Low strength	Low strength	Medium strength	Medium strength
Drains discharge into Canal				
− pH	**6.6–7.3**	**6.6–7.5**	6.6–7.1	6.6–7.2
− Temp.	**21.2–29.7**	**24.2–32.0**	27.5–30.8	28–30.8
− Oil & Grease	**2.4–23.8**	**5.6–20.6**	12.6–17.4	8–20
− SS	**101–412**	**160–538**	200–423	200–444
− TDS	**152–576**	**104–972**	256–292	350–468
− COD	**172–340**	**85–350**	24–250	40–120
− BOD (3d;27^{0}C)	**20–180**	**10–175**	5–130	10–40
− TKN	**12–25**	**5.6–16.8**	4.0–19.6	6–12
− NH_3-N	**BDL–8.4**	**BDL–5.2**	BDL–4.2	BDL–2.2
− Phosphorus	**2.5–4.3**	**1.2–3.56**	0.6–4.17	0.7–1.8
− Fecal coliforms				
Strength	Medium strength	Medium strength	Low strength	Low strength

All values are expressed in mg/L except pH and Temperature. BDL-below detectable limit.
Edapally Canal (Drain-DoEC-01,DoEC-01A, DoEC–02A,DoEC–04A, DoEC–04B,DoEC–04C and DoEC–05A).
Thevara–Perandoor Canal (Drain–DoTPC–02, DoTPC–03, DoTPC–04, DoTPC–07 and DoTPC–08).
Patolithot Canal (Drain–DoPTC–01 and DoPTC–09).
Valiyath Canal (Drain-DoVC–02).

The water quality of Edapally, Thevara-Perandoor, Patolithot & Valiyath Canals is based on three events of monitoring. The data indicate that the Canals' water quality has been threatened or impaired due to discharges of stormwater and domestic

sewage from the catchment area. There is no existing or inadequate sewage treatment facility along the entire stretch of the Canals. These Canals have turned into collectors of the pollutants that emanate from various drain discharges. Therefore, the Edapally & Thevara-Perandoor resulted in low strength, and the Patolithot & Valiyath Canals are medium strength. The sewage quality of the drain discharges into Edapally & Thevara-Perandoor and Patolithot & Valiyath Canals is classified as medium and low strength, respectively. The pollution loads discharged from the watershed of the respective Canals are delineated in **Section 5.2**. These pollution loads discharged into the Canals need to be adequately treated in the well-designed proposed sewage treatment plants before being discharged into the Inland Surface Water.

5.1 Watershed

Watershed identifies the area of the Municipality/Local Bodies that have been draining /discharging stormwater and sewage into the Canals. Further, this area can be used to identify the specific ward and the population responsible for discharging domestic sewage into the Canals. The watersheds of the Eadapally and Patolithot Canals (**Figures 17 and 18**) were received from KSPCB, Trivendrum. These figures represent the area of Municipalities and Local Bodies along their wards that come under the watershed. The population of these wards covered under the watershed was considered to forecast the 30-year population and quantify sewage generation.

The catchment area of TPC is ~30 sq. km, and storm/ drainage water reaches TPC from 1.5 km on both sides of the Canal as per the Report on Flood Mitigation Kochi, 2021 (Irrigation Department Eranakulam 2021). The Kochi Municipality area's wards, from both sides (1.5 km) of the TPC (**Figure 17**), were considered to discharge domestic sewage into the TPC. The watershed of the Patolithot Canal covers the wards of the Karunagapally Municipality, including three Local Bodies, comprising Thodiyoor, Thazhava, and Kulasekharapuram (**Figure 18),** which were considered for the discharge of domestic sewage into the Patolithot Canal. The wards of the Karunagapally Municipality and Kulasekharapuram Local Body that discharge domestic sewage into the Valiyath Canal are presented in **Figure 18**. The watershed of the Canal helps to find the exact Municipality, Local Bodies area, and their ward to be considered for population forecasting.

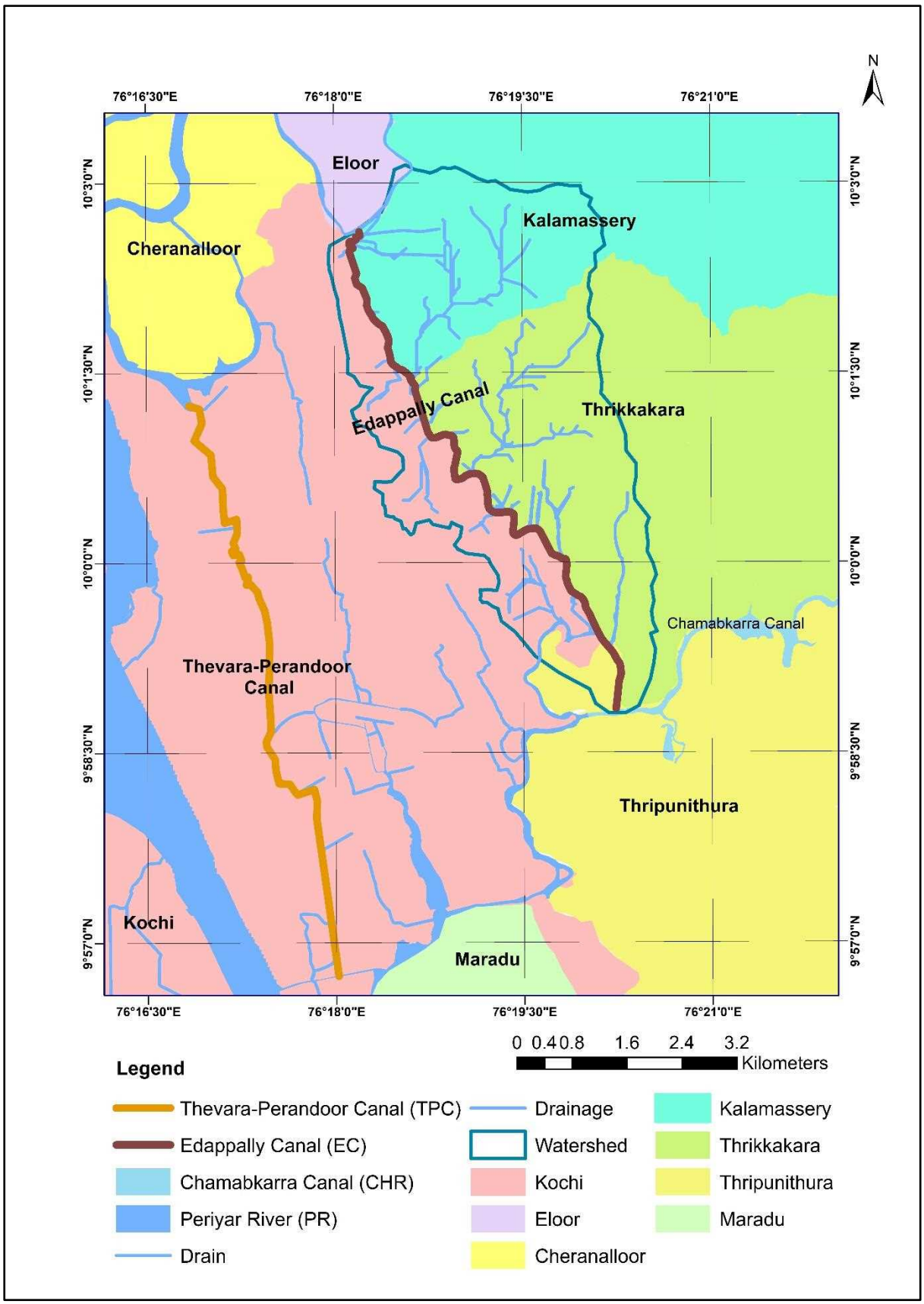

Figure 17: Watershed of Edapally Canal (EC) for the four Municipal Coporations

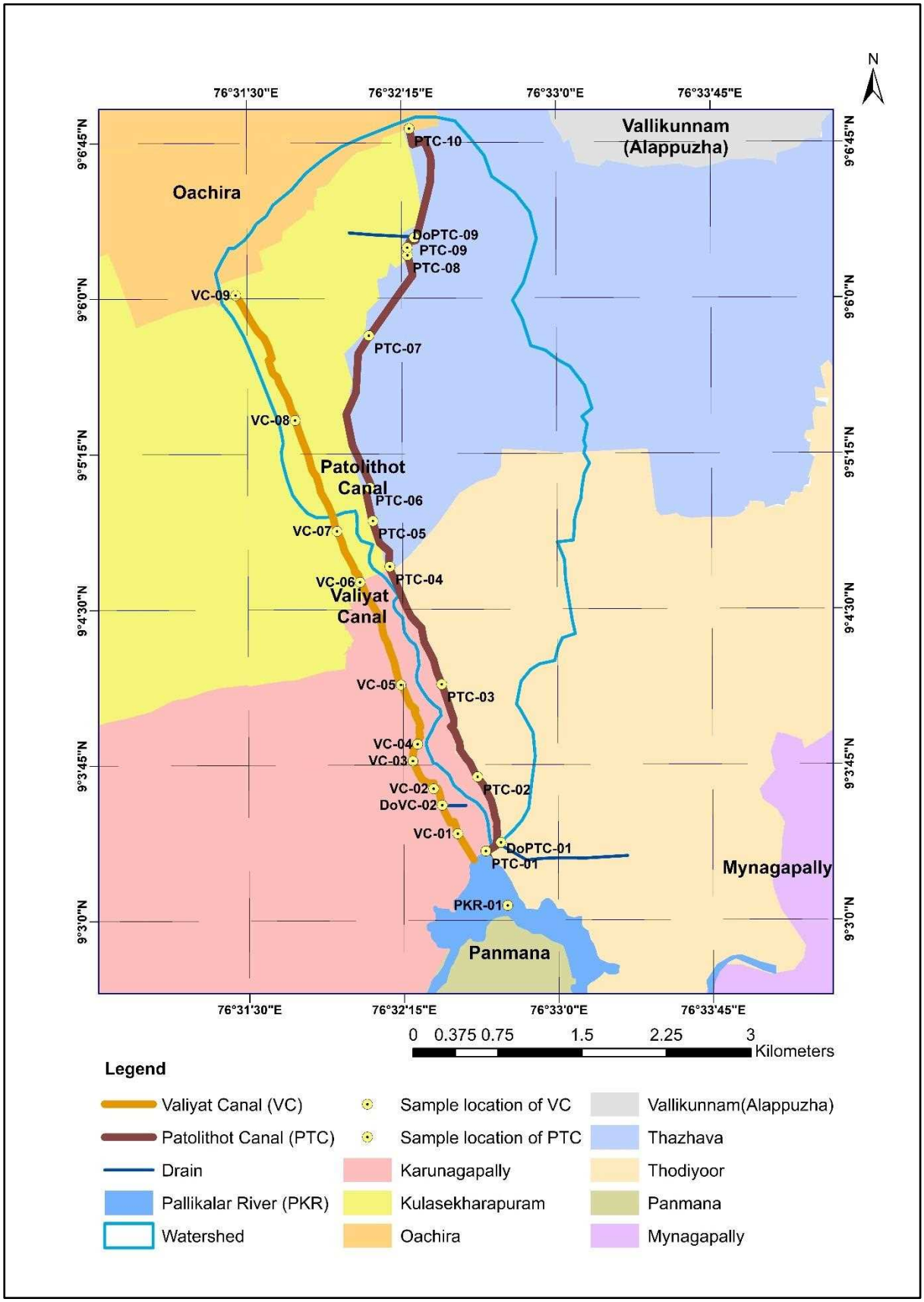

Figure 18: Watershed of Patolithot Canal (PTC) for Municipality and the three Local Bodies

5.2 Population forecast

The design population for proposing the capacity of the sewage treatment plants has been estimated based on the future growth and development of the study area. There are various methods for estimating population forecasting: arithmetic mean, geometric increase, incremental increase, simple graphical, and logistic curve. These methods depend on various factors and assumptions. The Edapally Canal (EC) watershed covers partial wards/ areas of Kochi, Thrikkakara, Kalamassery, and Thripunithura Municipalities. The wards/ areas discharging domestic sewage into the EC from the four Municipalities based on the watershed are shown in **Figure 19.** TPC areas/ wards from Kochi Municipality that are at least 1.5 km from the sides of the Canal are considered for population forecasting (**Figure 19)**.

The population data of Kochi from 1981 to 2001 was obtained from the Master Plan for Kochi Municipal Corporation Area 2040, and from 2011 to 2021, the Suchitwa Mission Local Self Government Department (SMLSGD), Government of Kerala. The population data of Thrikkakara, Kalamassery, and Thripunithura Municipalities were considered from the three Censuses of 1981 to 2001 and from 2011 to 2021, SMLSGD, Government of Kerala.

The watershed of the Patolithot Canal (PTC) covers the wards/areas of the Karunagapally Municipality, including three Local Bodies, comprising Thodiyoor, Thazhava, and Kulasekharapuram, as shown in **Figure 20**. The Karunagapally wards, including three Local Bodies that discharged domestic sewage, are considered for population forecasting. The population data of three Census from 1981 to 2001, and also data of SMLSGD, Government of Kerala, from 2011 to 2021 are used for population forecasting. The population data of the respective Municipalitie's wards from 1981 to 2001 and even 2021 are not available except for 2011. Therefore, the population data of the specific wards for the respective Census year is calculated considering the total population of the Municipalities and Local Bodies.

Based on the three methods (Arithmetic mean, Geometric increase, and Incremental increase), the population of the different wards covering the watershed areas of the four different Canals is forecasted for the next 3.5 decades (2021-2055), considering the base year 2021. The forecasted population of the specific wards of Municipalities

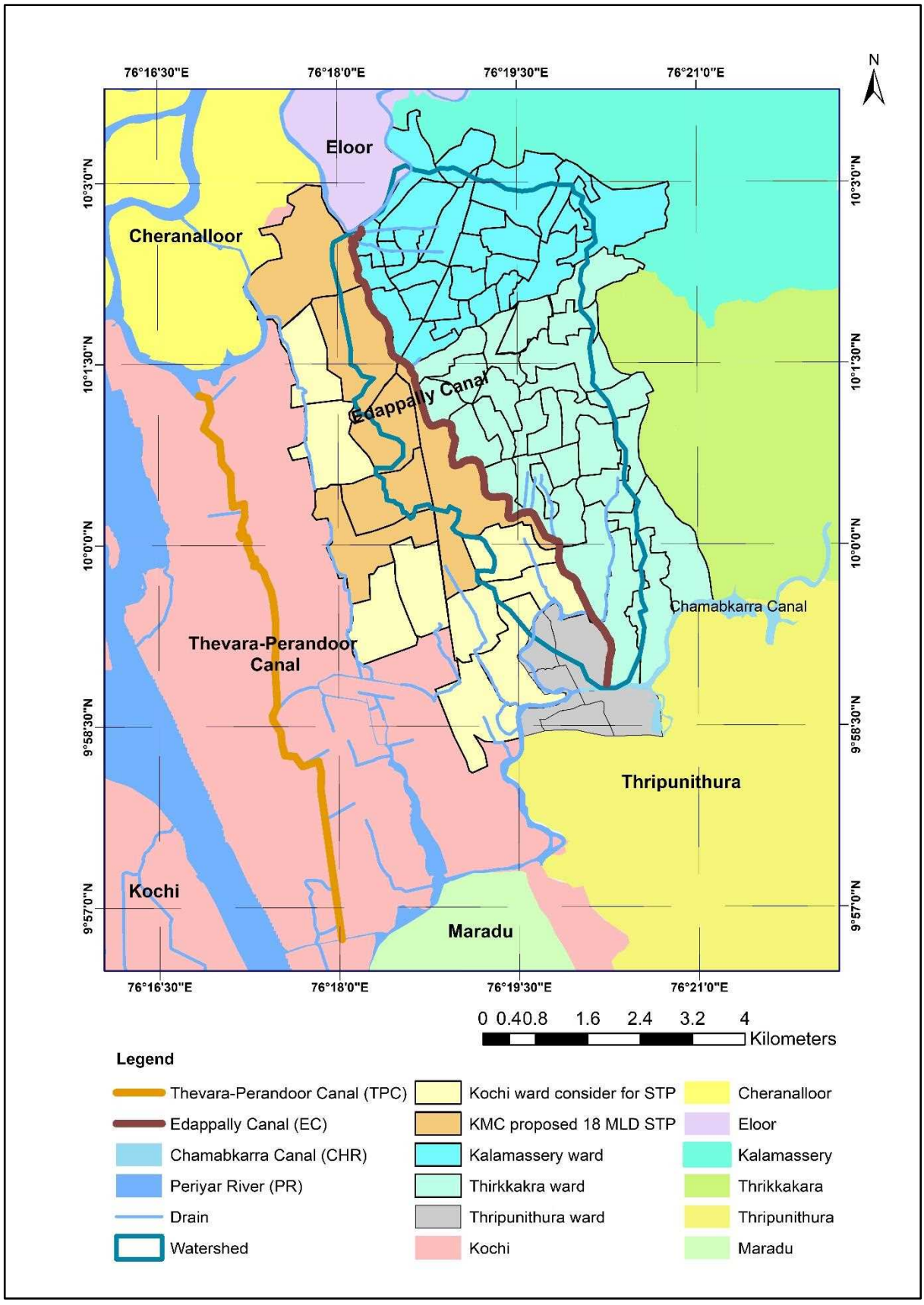

Figure 19: Municipal Corporations and Local Bodies ward considered for Population forecasting of Edappally Canal

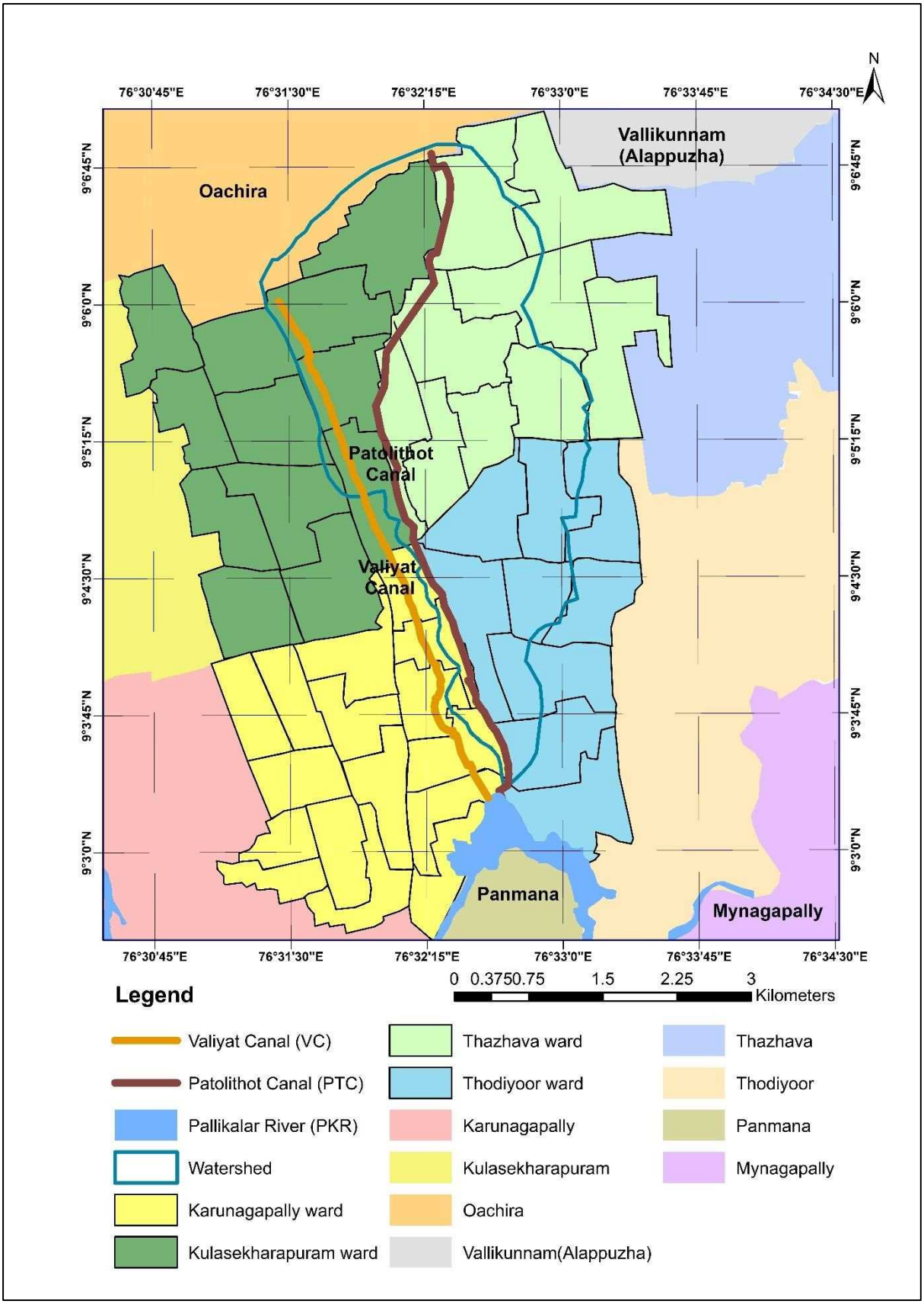

Figure 20: Municipal Corporations and Local Bodies ward considered for Population forecasting of Patolithot Canal (PTC) and Valiyath Canal (VC)

and Local Bodies that discharged sewage into the Edapally, Thevra-Peroondoor, Patolithot, and Valiyath Canals is presented in **Tables 19 through 22**. The maximum population is considered from the above methods for calculating the pollution loads and hydraulic flow of the sewage.

Table 19: Population forecast for wards of Municipalities that discharge sewage into Edappally Canal

Municipalty	Specific No. of wards	Population forecast method	Population		Total Population
			2021	*2055*	*2055*
Edappally Canal					
Kochi	08	Arithmetic mean	68410	79741	**266555**
		Geometric increase		74876	
		Incremental increase		**87628**	
Thrikkakara	28	Arithmetic mean	52919	77390	
		Geometric increase		**91909**	
		Incremental increase		62179	
Kalamassery	26	Arithmetic mean	46222	62959	
		Geometric increase		**69956**	
		Incremental increase		51670	
Thripunithura	05	Arithmetic mean	8777	12926	
		Geometric increase		**17062**	
		Incremental increase		14288	

Table 20: Population forecast for wards of Koch Municipality that discharge sewage into Thevara-Perandoor Canal

Local bodies	No. of wards	Population forecast method	Population		Total Population
			2021	*2055*	*2055*
Thevara-Perandoor Canal					
Kochi	4	Arithmetic mean	34205	39871	**43814**
		Geometric increase		37438	
		Incremental increase		**43814**	

Table 21: Population forecast for wards of Local Bodies that discharge sewage into Patolithot Canal

Local bodies	Specific No. of wards	Population forecast method	Population		Total Population
			2021	*2055*	*2055*
Patolithot Canal					
Thodiyoor	09	Arithmetic mean	18954	23372	**64735**
		Geometric increase		**23574**	
		Incremental increase		19033	
Karunagapally	06	Arithmetic mean	8652	10354	
		Geometric increase		**10412**	
		Incremental increase		8687	
Thazhava	09	Arithmetic mean		19859	

		Geometric increase	16887	**19978**	
		Incremental increase		17158	
Kulasekharapuram	04	Arithmetic mean	8705	10626	
		Geometric increase		**10771**	
		Incremental increase		9195	

Table 22: Population forecast for wards of local bodies that discharge sewage into Valiyath Canal

Local bodies	Specific No. of wards	Population forecast method	Population		Total Population
			2021	2055	2055
Valiyath Canal					
Karunagapally	10	Arithmetic mean	14420	17257	**38890**
		Geometric increase		**17355**	
		Incremental increase		14480	
Kulasekharapuram	08	Arithmetic mean	17409	21249	
		Geometric increase		**21535**	
		Incremental increase		18387	

5.3 Estimation of pollution load

The population of the specific ward coming under Municipalities and Local Bodies that discharge domestic sewage, directly or indirectly, contributes to the point and non-point sources of the four Canals, such as Edappally, Thevara-Perandoor, Patolithot, and Valiyath Canals. Seven, five, two, and one drains were identified as point sources that discharge into Edappally Canal (EC), Thevara-Perandoor, Patolithot, and Valiyath Canals, respectively. The drain flow was monitored instantly, not for twenty-four hours, during three monitoring events. Therefore, this flow cannot be considered for estimating the pollution load. The present population was forecasted for 2025, considering the base year 2021, the quantity of domestic sewage directly or indirectly discharged from the different wards of Municipalities and Local Bodies into the four Canals is delineated in **Table 23.** The major critical parameters (range) of the drain sewage discharge into the respective Canals are considered for the estimation of pollution load (**Table 24**).

Table 23: Details of the quantity of sewage discharged into four Canals from different wards of Municipalities and Local Bodies

Canal	Municipalities/Local bodies	Wards	Quantity (m^3/d)
Edappally	– Kochi	08	8398
	– Thrikkakara	28	6764
	– Kalamassery	26	5816
	– Thripunithura	05	1136
Thevara-Perandoor	– Kochi	04	4199
Patolithot	– Thodiyoor	09	1557
	– Karunagapally	06	1062
	– Thazhava	09	1378

	− Kulasekharapuram	04	714
Valiyath	− Karunagapally	10	1769
	− Kulasekharapuram	08	1428

The water supply rate for Kochi and Karunagapally municipalities is 150 LPCD, and for local bodies, it is 100 LPCD. The pollution load from Kochi wards will be diverted to the KMC proposed 4 STPs with a total capacity of 70 MLD, and the remaining 8 and 4 wards are considered for the quantification of flow for Edappally and Thevara-Perandoor, respectively.

Table 24: Details of drain discharge quality(range) for estimation of pollution load

Parameters	Drains discharging into Canals			
	Edappally	Thevara-Perandoor	Patolithot	Valiyath
− SS	101–412	160–538	200–423	200–444
− TDS	152–576	104–972	256–292	350–468
− COD	172–340	85–350	24–250	40–120
− BOD	20–180	10–175	5–130	10–40
− TKN	12–25	5.6–16.8	4.0–19.6	6–12
− Phosphorus	2.5–4.3	1.2–3.56	0.6–4.17	0.7–1.8

All values are expressed in mg/L.

The pollution load was determined based on the estimated flow and the major critical parameter (range) of the drain sewage discharge into the respective Canals. The pollution load received in the four Canals in terms of SS, TDS, COD, BOD, and TKN is presented in **Table 25**.

Table 25: Details of pollution load (range) received into the four Canals

Parameters	Pollution load, t/d				
	SS	TDS	COD	BOD	TKN
➢ **Edappally EC)**					
− Kochi	**0.85–3.46**	**1.28–4.84**	**1.44–2.86**	**0.17–1.15**	**0.10–0.21**
− Thrikkakara	0.68–2.79	1.03–3.90	1.16–2.30	0.14–1.22	0.08–0.17
− Kalamassery	0.59–2.40	0.88–3.35	1.00–1.98	0.12–1.05	0.07–0.15
− Thripunithura	0.11–0.47	0.17–0.65	0.20–0.39	0.02–0.20	0.01–0.03
➢ **Thevara–Perandoor (TPC)**					
− Kochi	0.67–2.26	0.44–4.08	0.36–1.47	0.04–0.73	0.02–0.07
− Kochi	13.04–43.84	8.48–79.21	6.93–28.52	0.81–14.26	0.46–1.37
➢ **Patolithot (PTC)**					
− Thodiyoor	**0.31–0.66**	**0.40–0.45**	**0.04–0.39**	**0.01–0.20**	**0.01–0.03**
− Karunagapally	0.21–0.45	0.27–0.31	0.03–0.27	0.01–0.14	0.004–0.02
− Thazhava	0.28–0.58	0.35–0.40	0.03–0.38	0.01–0.18	0.01–0.03
− Kulasekharapuram	0.14–0.30	0.18–0.21	0.02–0.18	0.004–0.092	0.003–0.01
➢ **Valiyath (VC)**					
− Karunagapally	**0.35–0.79**	**0.62–0.83**	**0.07–0.21**	**0.02–0.07**	**0.01–0.02**
− Kulasekharapuram	0.29–0.63	0.50–0.67	0.06–0.17	0.01–0.06	0.01–0.02

The pollution load from Kochi wards will be diverted to the KMC proposed 4 STPs with a total capacity of 70 MLD, and the remaining 8 and 5 wards are considered for the estimation of pollution load for Edappally and Thevara–Perandoor Canals, respectively.

The minimum and maximum pollution load received by the EC, TPC, PTC, and VC concerning SS, TDS, COD, BOD, and TKN is presented in **Table 26**.

Table 26: Minimum and maximum pollution load discharged into the Canals

Parameters	Pollution load t/d				
	SS	TDS	COD	BOD	TKN
− Edappally	2.23–9.12	3.36–12.74	3.80–7.53	0.45–3.62	0.26–0.56
− Thevara–Perandoor	0.67–2.26	0.44–4.08	0.36–1.47	0.04–0.73	0.02–0.07
− Patolithot	0.94–1.99	1.20–1.37	0.12–1.22	0.034–0.62	0.027–0.09
− Valiyath	0.64–1.42	1.12–1.50	0.13–0.38	0.03–0.13	0.02–0.04

The pollution load received from the four wards in the TPC can be accommodated by the nearby four STPs proposed by the Kochi Municipal Corporation. The pollution load from Kochi, Thrikkakara, Kalamassery, and Thripunithura has to be addressed to safeguard the EC by proposing sewage treatment plants (STPs). Similarly, Thodiyoor, Thazhava, and Kulasekharapuram need sewage treatment plants to protect the Patolithot and Valiyath Canals.

6.0 Approach towards mitigation of pollution impact on the Canal

Identification of the pollution sources indicates that domestic wastewater is a significant contaminant source of the four Canals. It is, therefore, imperative to provide an adequate wastewater management system by implementing appropriate treatment facilities to safeguard the Canals from domestic sewage.

Sanitation facilities are treated as a State subject per the Federal Constitution of India; therefore, at the State level, the Public Health Engineering Department (PHED) is the principal agency vested with planning, implementation, operation & maintenance of sanitation projects. At the local level, the responsibility is generally entrusted by legislation to local bodies like Municipal Corporations, Municipalities, Municipal Councils, and notified area committees/authorities for towns or, on a state/regional basis, to specialized agencies. The Karunagapally Municipality has not proposed a plan to address the issues related to sewage discharge from households and commercial complexes into the Canals. In contrast, the Kochi Municipal Corporation has already proposed four sewage treatment plants with designated sites, as described in the following section.

7.0 Kochi Municipality Corporation (KMC) proposed sewage treatment plant

According to the Kochi Municipal Corporation Area-2040 Master Plan, the Kochi Municipal Corporation (KMC) has proposed four sewage treatment plants (STPs) with

a total capacity of 70 MLD (**Figures 21 and 22**), located at Elamkulam, Vennala, Muttar, and Perandoor. The details of the KMC proposed four STPs are presented in **Table 27**.

Table 27: Details of the KMC proposed four STPs

KMC Proposed for STPs	Sewage treatment plants (STPs) detailed
Vennala	A 14 MLD STP is proposed in Edapally South Village at the eastern end of Chakkarapparambu division, encapsulating the eastern parts of the corporation area in Zone 6. This facility is designed to serve the eastern parts of the corporation area, covering regions such as Vennala, Chalikkavattom, Ponnurunni, Thammanam, Palarivattom, and the southern areas of Kaloor.
Muttar	An 18 MLD STP is planned in Edapally North Village near Muttar within the Kunnumpuram division. This plant will partially serve Zone 5, catering primarily to the northeastern sections of the corporation, including Kunnumpuram, Edappally, Devankulangara, Mamangalam, Padivattom, and Karukappilly.
Perandoor	A 15 MLD STP is proposed in Cheranallur Village, situated in the Vaduthala East Division. This facility will also serve parts of Zone 5, focusing on the northern and northwestern mainland regions such as Vaduthala, Pachalam, Elamakkara, Thrikkanaravattom, Thattazham, and Ayyappankavu.
Elamkulam	A 23 MLD STP is proposed to be established in Elamkulam Village, serving Ernakulam city and its surrounding areas, including Gandhi Nagar, Panampilly Nagar, Girinagar, Vyttila, Perumanoor, Konthuruthy, and Thevara. This plant will cover the main residential zones of Kochi Corporation, possibly including Poonithura and Chambakkara in the future. The site proposed for this STP is the land of Kerala Water in Elamkulam Village.

Sources: Kochi Municipal Corporation Area-2040 Master Plan, the Kochi Municipal Corporation (KMC).

8.0 Centralized/ decentralized treatment system for drain discharges

Domestic sewage is either treated in a centralized or decentralized treatment system. The centralized treatment system collects a large volume of sewage from different parts of the area and requires major excavation, large pipes, and manholes. This system also requires pumps & piping material and energy, thereby increasing the cost of the system. On the other hand, the decentralized system treats sewage near thesource point. The issues related to the discharge of sewage into the Canals from the wards of the respective Municipalities and the Local Bodies through drains as point sources and nonpoint sources have to be addressed either through the centralized or

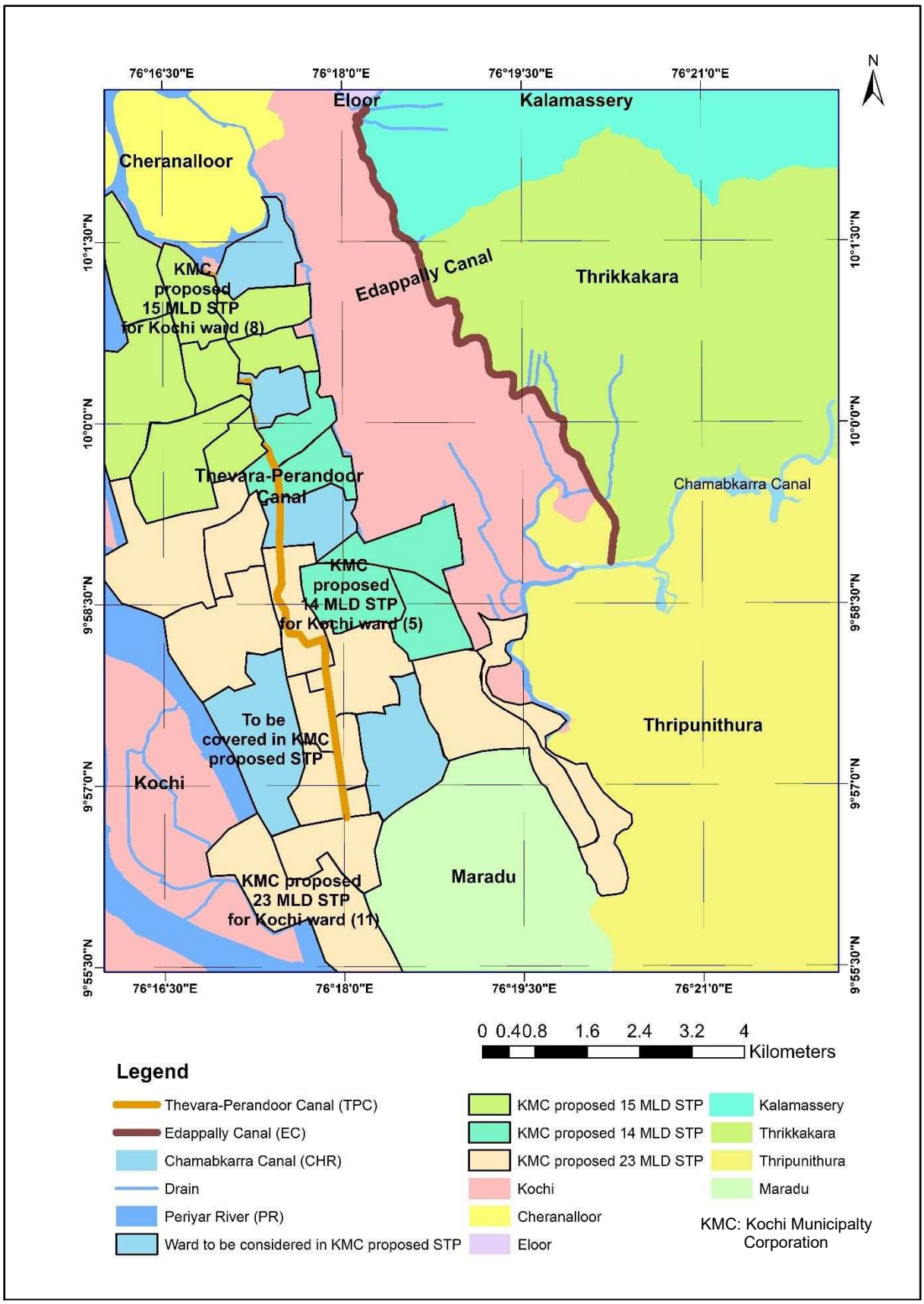

Figure 21: Kochi Municipal Corporation proposed three sewage treatment plants for Thevera-Perandoor Canal (TPC)

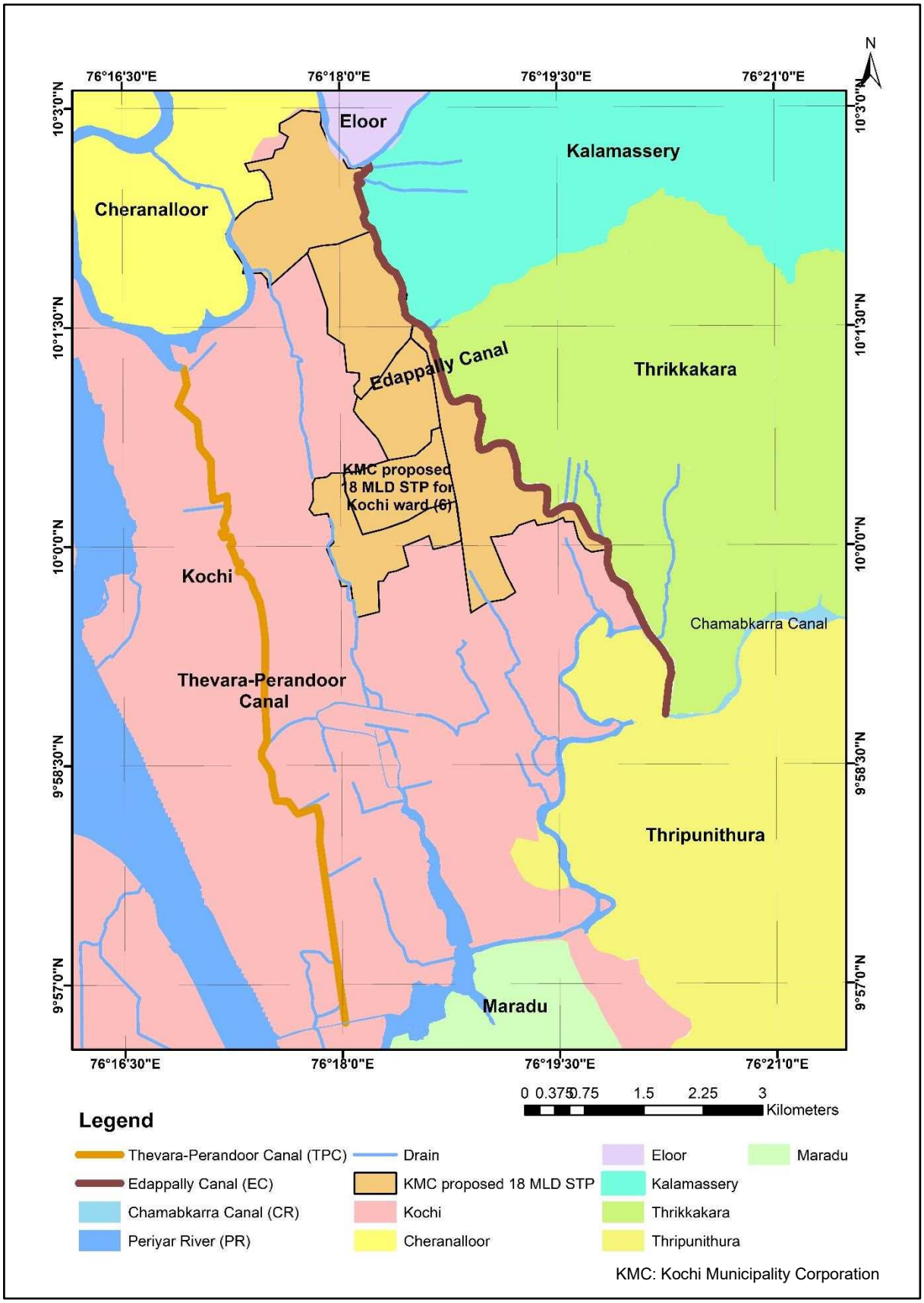

Figure 22: Kochi Municipal Corporation proposed one sewage treatment plant for Eadappally Canal (EC)

decentralized treatment system. A decentralized treatment system is more appropriate for the treatment of sewage generated within the jurisdiction of the individual Municipality and Local Bodies. The sewage must be intercepted and transported to the decentralized treatment system.

9.0 Conceptual plan for sewage discharging into four Canals

The water quality of the four Canals would be improved if untreated sewage received in them through different drains (point source) and non-point sources is halted, intercepted, collected, and diverted for the ex-situ proposed sewage treatment plants. After meeting the discharge standard, the treated sewage is discharged into the Inland Surface Water (ISW). Household sewage that flows into drains (point source) and nonpoint sources contaminates the Canals. Local Governing Bodies and Municipalities are crucial in managing and treating this sewage.

9.1 Existing and new proposed plan for sewage discharging into Edapally & Thervara-Perandoor Canals

Kochi Municipal Corporation (KMC) has an Existing Proposed Plan (EPP) to improve the water quality of the TPC. The four decentralized sewage treatment plants of 14, 18, 15, and 23 MLD capacities at Elamkulam, Vennala, Muttar, and Perandoor have been proposed to address the issue of treating domestic sewage. The details of the KMC proposed STPs are delineated in **Section 7.0**. The four proposed STPs would cover 87–90 % of the sewage generated from the Kochi Municipality area. Thevara-Perandoor Canal will still receive the sewage from the remaining four wards of Kochi. Therefore, the sewage generated from the four wards shall be accommodated in the four KMC proposed STPs, depending on their locations.

The Kochi, Thrikkakara, Kalamassery, and Thripunithura Municipalities have been discharging sewage into the Edapally Canal (EC). The specific wards and their population that discharge sewage to the EC are presented in **Table 19,** which indicates that a decentralized sewage treatment plant is essential for treating domestic sewage. No existing proposed plan is available for treating domestic sewage generated from the Thrikkakara, Kalamassery, and Thripunithura Municipalities. Therefore, the New Proposed Plan (NPP), which consists of four decentralized sewage treatment plants (STPs), has been proposed for the uncovered wards of Kochi and three Municipalities

as presented in **Figure 23.** This will stop the discharge of untreated sewage into the EC. The details of NPP for treating the sewage from four Municipalities and enhancing the water quality (WQ) of the EC are presented in **Table 28.**

The ward populations, water supply rate, and sewage generation from the four Municipalities and proposed decentralized sewage treatment plants, along with their capacity, considered for NPP, are also presented in **Table 28**. The sewage generated from the wards that lie in the watersheds of the respective Municipalities was estimated based on the 2055 forecasted population, and assuming 80% of the water supply being discharged as sewage into the Canal (as per Central Public Health and Environmental Engineering Organization (CPHEEO) Manual on Sewage and Sewage Treatment). The decentralized STPs are feasible and viable for the four Municipalities for selecting a suitable site and establishing within the area of their jurisdiction. The block diagram of the NPP for treating the sewage from four Municipalities is shown in **Figure 24**:

9.2 Existing and new proposed plan for sewage discharging into Patolithot & Valiyath Canals

No details of the Existing Proposed Plan (EPP) are available with the Karunagapally Municipality and Local Bodies, such as Thodiyoor, Kulasekharapuram, and Thazhava, for treating the domestic sewage discharging into the Patolithot and Valiyath Canals. The water quality of Patolithot and Valiyath Canals would be enhanced by restricting the discharge of sewage from the Karunagapally Municipality (KM) and three Local Bodies into the Canals and establishing a New Proposed Plan (NPP).

Therefore, the NPP, considering two alternatives, is proposed for treating the domestic sewage before being discharged into the Canals, and is presented in **Figures 25 and 26**. Four decentralized sewage treatment plants (STPs) as Alternative I and one centralized STP as Alternative II are proposed for treating the sewage generated from the KM and three Local Bodies. The details of Alternatives I and II are presented in **Tables 28 and 30**, respectively. Alternative I is more feasible and viable for the Municipality and Local Bodies to select a suitable site and establish the decentralized STPs within the area of their jurisdiction.

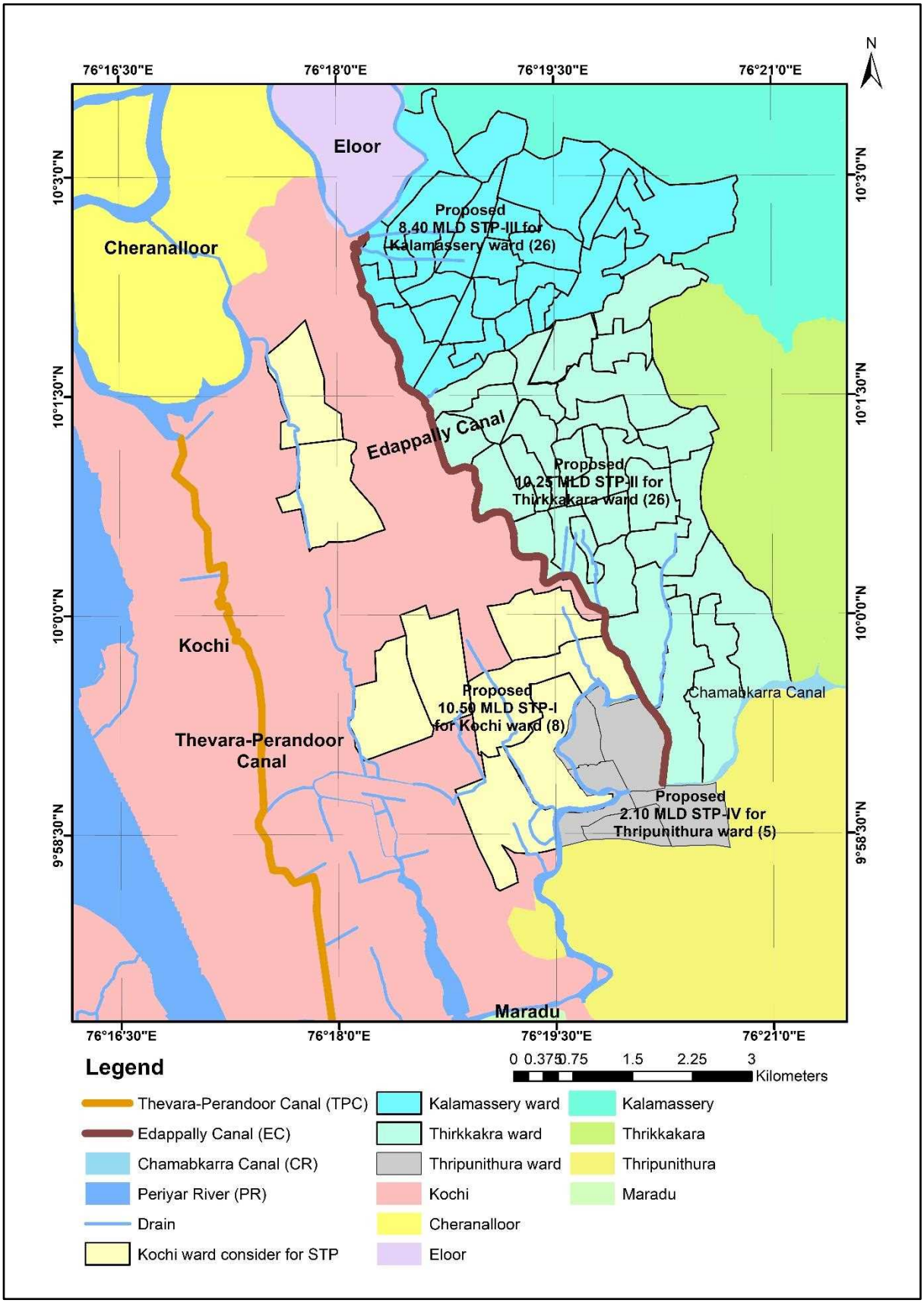

Figure 23: New Proposed Plan for uncovered wards of Kochi and three Municipalities of Eddapally Canal

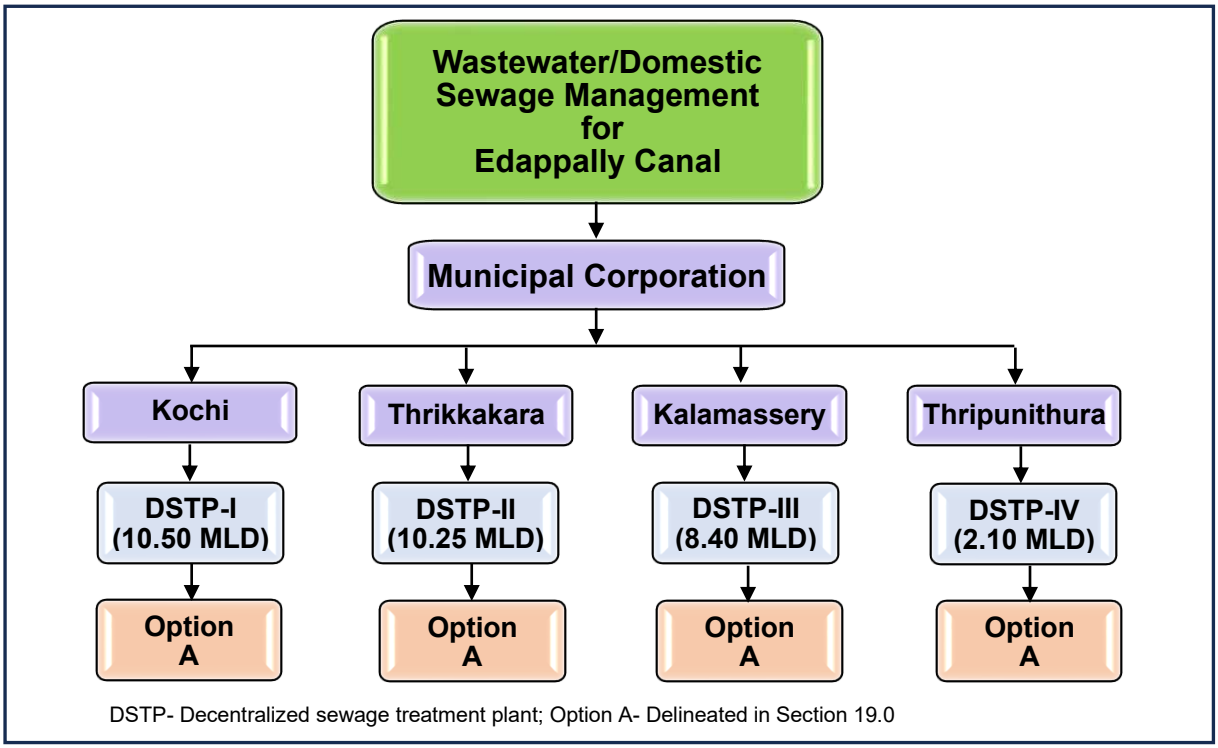

Figure 24: Bock diagram of the NPP for treating the sewage from four Municipalities

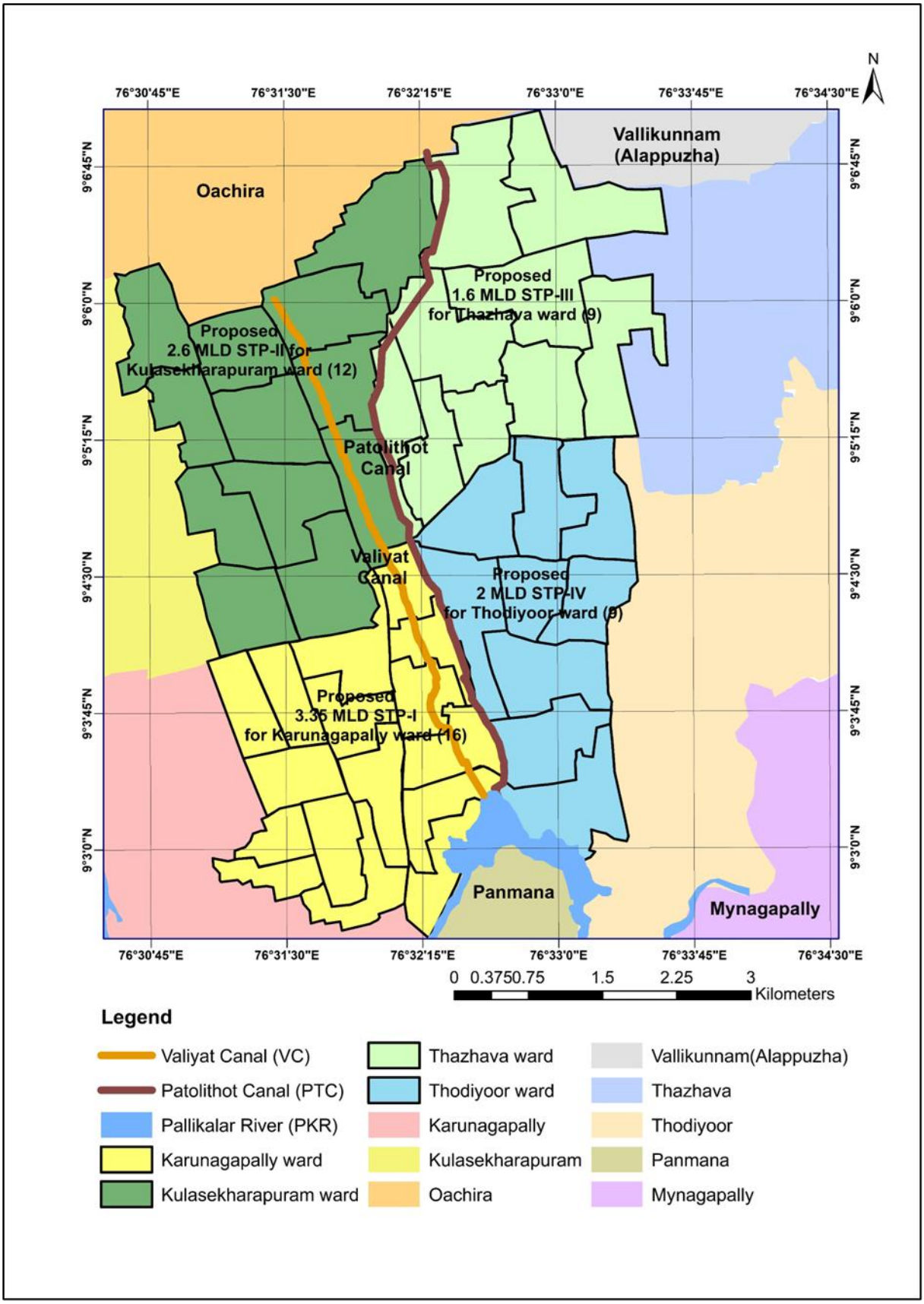

Figure 25: New proposed plan for one Municipality and three Local Bodies (Four decentralized STPs: Alternative-I) (PTC and VC)

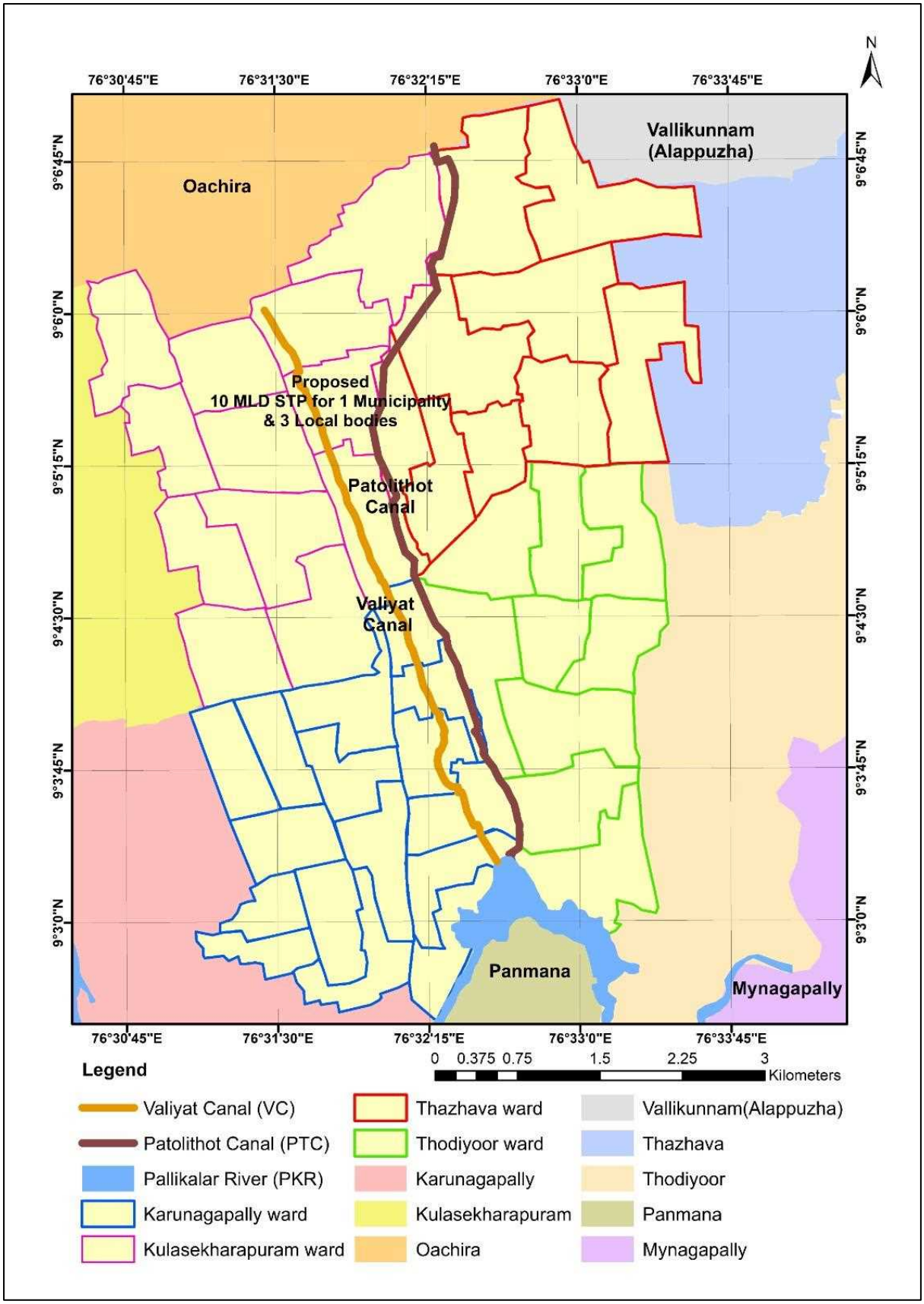

Figure 26: New proposed plan for one Municipality and three Local Bodies (Centralized STP: Alternative-II) (PTC and VC)

The ward populations, water supply rate, sewage generation from the one Municipality and three Local Bodies, and proposed centralized and decentralized sewage treatment plants, along with their capacity, considered for NPP with two alternatives, are presented in **Tables 28 and 30**. The sewage generated from the wards that lie in the watersheds of the one Municipality and three Local Bodies was estimated as delineated in **Section 9.1**. The block diagram of the NPP for treating the sewage from one Municipalty and three Local Bodies as Alternatives, I and II, is shown **Figure 27**.

Table 28: Details of the new proposed plan (NPP) for enhancing WQ of the EC

Local bodies	Specific No. of wards	Population (2055)	WSR (LPCD)	Sewage generated (80% of WSR)@	STP capacity (MLD)
Sewage Treatment Plant-I					
Kochi	8	87628	150	120	10.50
Sewage Treatment Plant-II					
Thrikkakara	26	85344	150	120	10.25
Sewage Treatment Plant-III					
Kalamassery	26	69956	150	120	8.40
Sewage Treatment Plant-IV					
Thripunithura	5	17062	150	120	2.10

WSR-Water supply rate; LPCD-Liter per capita per day. WQ-Water quality;EC-Edappally Canal
@Central Public Health and Environmental Engineering Organization (CPHEEO) Manual on Sewage and Sewage Treatment.

Table 29: Details of the NPP for enhancing WQ of the PTC and VC (Alternative-I)

Local bodies	Specific No. of wards	Population (2055)	WSR (LPCD)	Sewage generated (80% of WSR)	STP capacity (MLD)
Alternative-I					
Sewage Treatment Plant-I					
Karunagapally	10	17355	150	120	3.35
	6	10412			
Total population		**27767**			
Sewage Treatment Plant-II					
Kulasekharapuram	8	21535	100	80	2.6
	4	10771			
Total population		**32306**			
Sewage Treatment Plant-III					
Thazhava	9	19978	100	80	1.6
Total population		**19978**			
Sewage Treatment Plant-IV					
Thodiyoor	9	23574	100	80	2.0
Total population		**23574**			

WSR-Water supply rate; LPCD-Liter per capita per day. NPP-New proposed plan; WQ-Water quality. PTC-Patolithot Canal; VC-Valiyath Canal.@Central Public Health and Environmental Engineering Organization (CPHEEO) Manual on Sewage and Sewage Treatment.

Table 30: Details of the NPP for enhancing WQ of PTC and VC (Alternative-II)

Local bodies	Specific No. of wards	Population (2055)	WSR (LPCD)	Sewage generated (80% of WSR)	STP capacity (MLD)
Alternative-II					
Sewage Treatment Plant-I					
Karunagapally	16	27767	150	120	3.35
Kulasekharapuram	12	32306	100	80	2.6
Thazhava	9	19978	100	80	1.6
Thodiyoor	9	23574	100	80	2.0
				Total	**9.55~10.0**

WSR-Water supply rate; LPCD-Liter per capita per day.NPP-New proposed plan; WQ-Water quality. PTC-Patolithot Canal; VC-Valiyath Canal. @Central Public Health and Environmental Engineering Organization (CPHEEO) Manual on Sewage and Sewage Treatment.

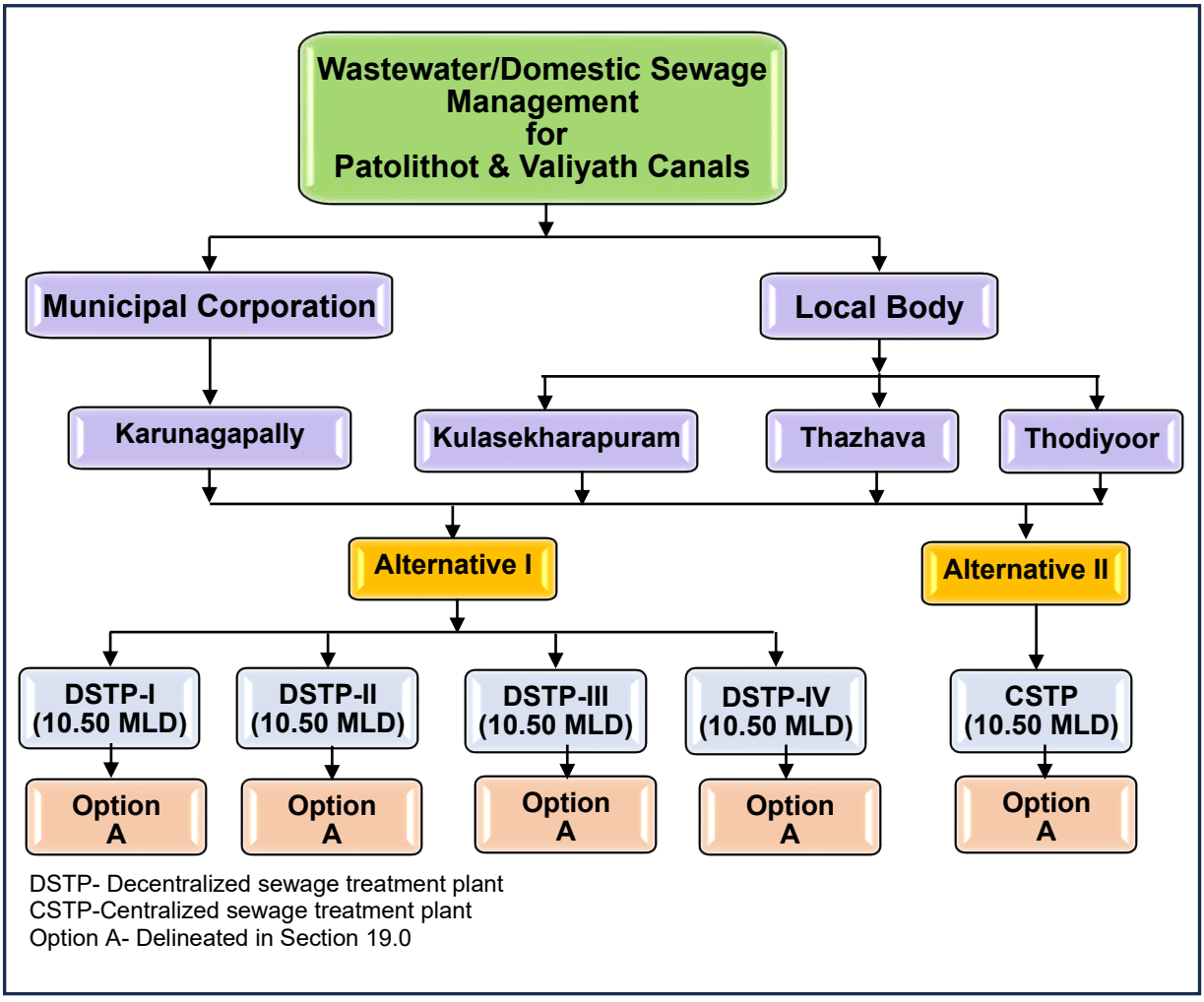

Figure 27: Block diagram of the NPP for treating the sewage from one Municipalty and three Local Bodies as Alternatives I and II

10.0 Sewage interception

Notably, due to the absence of an organized sewerage conveyance system, raw sewage from wards of the Municipalities and Local Bodies is discharged into drains directly or indirectly finds its way into the four Canals through different drains (point sources) and, randomly, through non-point sources. Therefore, it is necessary to intercept such sewage inflow to the Canals from the drains (point sources) before it gets discharged. The major drains identified (tentative) for sewage interception are presented in **Table 31**.

Table 31: Details of the major drain identified for sewage interception

Edappally Canal's drain:	
− DoEC–01	River Side Bridge, 28V3+887, Muttar, Vattekunnam, Edappally, Kochi.
− DoEC–01A	Mkrab-28A Muttar, Vattekunnam, Edappally, Kochi
− DoEC–02A	Trinity Castle Edappally NH47-opposite Lulu Mall, Edappally, Kochi
− DoEC–04A	Pulikalam West Road, 283g+v66, Chembumukku Edappally, Ernakulam
− DoEC–04B	Kra-16a, Chembumukku Edappally, Kochi.
− DoEC–04C	Moolepadam Padamugal Road, Kochi.
− DoEC–05A	1.27 km downstream of the Ezhumavil Ambalappara Dharmasastha TempleX8VP+C7, Thuthiyoor, Kochi
Thevara Perandoor Canal's drain:	
− DoTPC–02	27/1768, VC Canaan Road, Kochi
− DoTPC–03	Giri Nagar, Canal Road, Giri Nagar housing society
− DoTPC–04	61/306 Purushu Menon Road, Tagore Nagar, Gandhi Nagar, Ernakulam South, Ernakulam,
− DoTPC–07	Mirah Sorvino Events, Pottakuzhy Road, Kochi
− DoTPC–08	Perandoor Bridge Road, Kochi
Patolithot Canal's drain:	
− DoPTC–01	Adoor, Sasthamkotta Road, Kallelibhagom
− DoPTC–09	Vavvakkavu, Thazhava Road, Kulasekharapuram
Valiyath Canal's drain	
− DoVC–02	Railway Station Road, Karunagapally.

DoEC-Drain of Edappally; DoTPC-Drain of Thevara Perandoor Canal; DoPTC-Drain of Patolithot Canal DoVC-Drain of Valiyath Canal.

However, it will not be possible to intercept sewage inflow from the non-point sources into the Canals. Therefore, a comprehensive sewerage network plan must be delineated so that all discharges from the wards of the Municipalities and Local Bodies are trapped and conveyed to the proposed STPs for treatment.

11.0 Delineation of the proposed treatment scheme

The combination of unit operations and processes comprising a treatment process package depends upon influent sewage characteristics and the treated quality to be achieved based on the final mode of disposal/proposed end use. The most appropriate treatment scheme selected for sewage treatment must ensure sewage characteristics meet the quality for discharge into Inland Surface Water (IWS) and the desired end use. The worst inflow characteristics and anticipated final treated sewage are considered for delineating the proposed treatment scheme.

The sequence of the proposed treatment scheme is a raw pumping station, which includes a receiving chamber, a coarse screen channel, and a raw sewage sump. The raw sewage will be pumped to a stilling chamber, followed by fine screens and a grit chamber at the preliminary stage to remove smaller particles and grit from the raw sewage. The primary stage of the proposed wastewater treatment is a sequential batch reactor (SBR). The SBR operation would be Programmable Logic Controller (PLC) based and operated in cyclic mode, comprising filling & aeration, followed by settling and decanting. The bio-oxidized effluent would be routed to a pressure sand filter and an activated carbon column followed by chlorination as the secondary stage for removal of suspended silids and disinfection.

The biological sludge generated would first be thickened in a sludge thickener and then dewatered in a filter press/ centrifuge. The final treated water from the proposed treatment scheme is anticipated to meet the National Green Tribunal (NGT) standards for discharge into Inland Surface Waters. The dewatered sludge from the filter press/ centrifuge shall be used as manure after treatment and meeting the norms. The schematic of the proposed treatment scheme as Option A is presented in **Figure 28**.

12.0 Basic engineering design for the proposed sewage treatment scheme

The quantification and characterization of sewage discharges into the four Canals are essential for properly designing the proposed treatment scheme's unit operations and unit processes (UO&UP). Both arrived based on the estimated sewage quantity and the worst quality observed in the Canals and various drain discharges into it during three events. The inlet and anticipated final treated sewage quality of the proposed

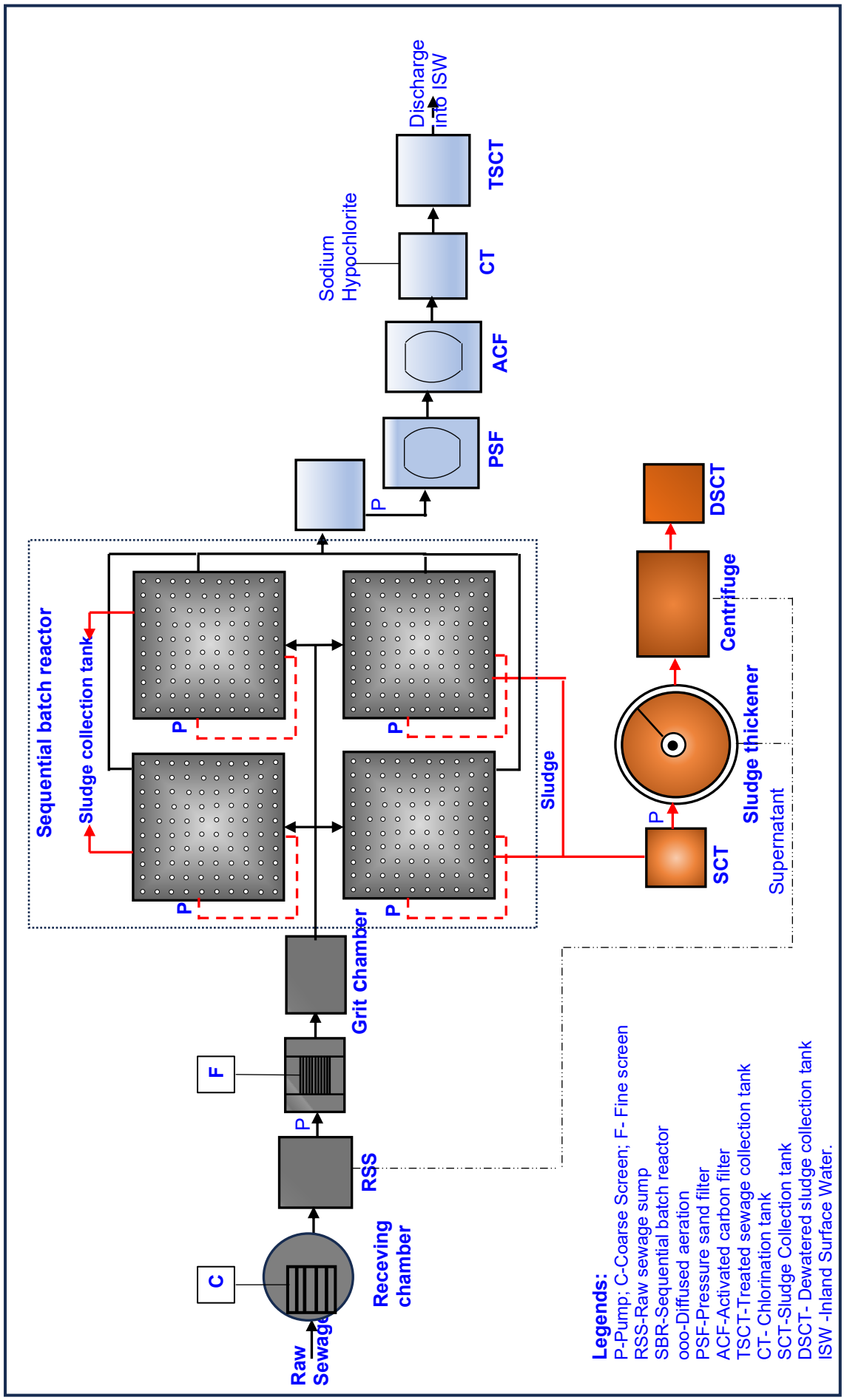

Figure 28: Schematic of the proposed sewage treatment plant for Edappally Canal (EC) Patolithot Canal (PTC), and Valiyath Canal (VC)

sewage treatment plants scheme for respective Municipalities and Local Bodies discharging their sewage into the Canals are presented in **Table 32**.

Table 32: Details of inlet & anticipated final treated sewage quality of the proposed STPs scheme

Parameters	Inlet sewage	Proposed treatment scheme	ATS for discharge into the ISW
− pH	6.4-8.0	➢ **Sewage treatment**	5.5-9.0
− Oil & Grease	≤20	Receiving chamber→ Course Screen →Raw	-
− SS	≤300	sewage sump →Stilling tank →Fine screen →	20
− COD	≤400	Grit chamber → Sequential batch reactor →	50
− BOD(3d;27°C)	≤220	Pressure sand filter → Activated carbon column	10
− TKN	≤30	→ Chlorination	10
− Phosphorus	≤10	➢ **Sludge treatment**	1.0
		Sludge thickener → Filtrer press/ Centrifuge	

All values are in mg/L except pH; ATS-Anticipated treated sewage; ISW-Inland Surface Water.

The design flow for the eight decentralized sewage treatment plants (STPs) and a centralized STP of the respective Municipalities and Local Bodies has been arrived at based on the population forecast of 2055, considering the 2021 base year, including the water supply and sewage generation rate, as presented in **Table 33**.

Table 33: Details of the designed and peak flow for decentralized and centralized STPs

Municipality (M)/ Local Body (LB)	Sewage treatment plant (STP)	Design flow (MLD)	Peak factor	Peak design flow (MLD)
Thevara Perandoor and Edappally Canals (Decentralized STPs)				
- Kochi (M)	I	10.50	2.25	23.63
- Thrikkakara (M)	II	10.25	2.25	23.10
- Kalamassery (M)	III	8.40	2.25	19.00
- Thripunithura(M)	IV	2.10	3.0	6.30
Patolithot and Valiyath Canals (Decentralized STPs)				
- Karunagapally (M)	I	3.35	2.5	8.40
- Kulasekharapuram (LB)	II	2.60	2.5	6.50
- Thazhava (LB)	III	1.60	3.0	4.80
- Thodiyoor (LB)	IV	2.00	2.5	5.00
Patolithot and Valiyath Canals (Centralized STP)				
- Karunagapally (M)	I	3.35	2.25	22.50
- Kulasekharapuram (LB)		2.60		
- Thazhava (LB)		1.60		
- Thodiyoor (LB)		2.00		
	Total	9.55~ 10		

The peak factor was considered based on the population of the respective Municipalities and Local Bodies as per the CPHEEO Manual.

The raw sewage from the respective Municipalities and Local Bodies will be received in the receiving chamber of the proposed sewage treatment plant (STP). The objective

of the receiving chamber is to reduce the turbulence of the flow to achieve better efficiency in screening. The larger-sized particles will be removed by the coarse screen and routed to the raw sewage sump (wet well). The sewage from the raw sewage sump will be pumped to the stilling tank, followed by the fine screen, grit chamber, and bio-oxidation process as a sequential batch reactor (SBR).

The SBR operation would be Programmable Logic Controller (PLC) based and operated in cyclic mode, comprising filling & aeration, followed by settling and decanting. The SBR is proposed to be operated in four cycles per day, with operational cycles as follows: feeding and aeration time: 4.5h, settling time: 0.75h, and decanting time: 0.75h. The bio-oxidized effluent would be routed to a pressure sand filter and an activated carbon column, followed by chlorination as the secondary stage for removal of residual suspended solids and disinfection.

The biological sludges shall be collected in the sludge collection sump and pumped to the gravity thickener for sludge concentration, which will be further routed to a filter press/ centrifuge for dewatering. The schematic of the proposed treatment scheme for STPs is presented in **Figure 27**. Based on the basic design, the sizes of the individual treatment units have been worked out employing the design criteria, excluding the detailed engineering, and delineated along with the unit sizes in **Tables 34 through 42**. The sizes of various units mentioned in **Tables 34 through 42** are tentative and may change during the implementation of the STPs.

Table 34: Design details of various unit operations and processes for the proposed 10.5 MLD DSTP (Kochi)

Particulars	Unit	Size
Receiving Chamber		
Flow	MLD	10.5
Peak factor	-	2.25
Peak flow	MLD	23.63
Detention time	Sec.	40
Size of Chamber	m	2.1 m × 2.1 m × 2.5 m
Free board	m	0.5
No. of Chamber	Nos.	1
Material of construction	-	RCC, epoxy coated
Mechanical Coarse Screen Channel		
Flow	MLD	10.5
Peak factor	-	2.25
Type	-	Mechanical
Screen size	m	0.32 m x 0.8 m
Bar size	mm	10
No. of bars	Nos.	10
No. of spacing	Nos.	11
No. of screen	Nos.	2
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m × 0.7 m × 0.8 m
Free board	m	0.5
No. of units	Nos.	2
Material of construction	-	RCC, epoxy coated
Manual Coarse Screen Channel		
Type	-	Manual
Screen size	m	0.32 m x 0.8 m
Bar size	mm	10
No. of bars	Nos.	10
No. of spacing	Nos.	11
No. of screen	Nos.	1
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75°
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m × 0.5 m × 0.8 m
Free board	m	0.5
No. of units	Nos.	1
Material of construction	-	RCC, epoxy coated

Particulars	Unit	Size
Raw Sewage Sump		
Flow	MLD	10.50
Size of tank	m	8.5 m Ø × 1.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Sec.	300
Raw Sewage Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	hp	As per site-specific
No. of pump	Nos.	(4+1 Standby)
Material of construction		SS
Stilling Tank		
Size of tank	m	2.1 m × 2.1 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	min	40
Mechanical Fine Screen Channel		
Type	-	Mechanical
Screen size	m	0.23 m x 0.75 m
Bar size	mm	2
No. of bars	Nos.	28
No. of spacing	Nos.	29
No. of screen	Nos.	2
Clear opening between bars	mm	6
Inclination with horizontal	Degree	40°
Flow through velocity (Qpeak)	m/s	1.1
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	6 m × 0.5 m × 0.8 m
Free board	m	0.3
No. of units	Nos.	2
Material of construction	-	RCC, epoxy-coated
Manual Fine Screen Channel		
Type	-	Manual
Screen size	m	0.334 m x 0.75 m
Bar size	mm	8
No. of bars	Nos.	18
No. of spacing	Nos.	19
No. of screen	Nos.	1
Clear opening between bars	mm	10
Inclination with horizontal	Degree	45°
Flow through velocity (Qpeak)	m/s	1
Flow through velocity (QAvg)	m/s	0.6

Particulars	Unit	Size
Size of channel	m	6 m × 0.5 m × 0.75 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Grit Chamber		
No. of Chambers	Nos.	2
D.T (sec)	sec	60
Free board (m)	m	0.3
Size of chamber	m	3.5 m × 3.5 m × 0.85 m
Material of construction	-	RCC, epoxy-coated
Sequential batch reactor (SBR)		
Flow	MLD	10.5
No of cycle	Nos.	4
Flow for each cycle	MLD	2.625
SBR cyclic period		
Feeding + aeration	hr	4.5
Settling	hr	0.75
Decanting	hr	0.75
Total cycle period	hr	6
Influent BOD	mg/L	220
Effluent BOD	mg/L	20
MLSS	mg/L	4000
MLVSS	mg/L	3200
Size of tank	m	23 m × 23 m × 5 m
Free board	m	0.5
No. of tanks	Nos.	4
F/M	d^{-1}	0.07
Volumetric loading rate	$kg/m^3/d$	0.22
Oxygen requirement	$kg/O_2/d$	157
Sludge wastage	m^3/d	400
SRT	days	10
HRT	hr	24
Material of construction	-	RCC, epoxy-coated
Blower		
Air required	m^3/min	130
Power required for blower	hp	200
No. of blower	Nos.	4+1Standby
Power of each blower	hp	50
Blower efficiency	%	75
Sludge recycled pump		
Type	-	Horizontal non-clogging pump
Power required for pump	hp	As per site-specific

Particulars	Unit	Size
No. of pump	Nos.	(1+1 Standby)
Material of construction	-	SS
Treated sewage collection tank		
Size of tank	m	12.25 m × 12.25 m × 3 m
Free board	m	0.5
No. of tank	Nos.	1
Detention time	hr	1
Material of construction	-	RRC, epoxy-coated
Pump		
Type	-	Horizontal non-clogging pump
Power required for pump	hp	As per site-specific
No. of pump	Nos.	(1+1 Standby)
Material of construction		SS
Pressure Sand Filter		
Flow	MLD	10.5
Filtration rate	$m^3/m^2/hr$	12
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	9+1Standby
Media type	-	Sand
Material of construction	-	MS, epoxy-coated
Activated Carbon Column		
Flow	MLD	10.5
Filtration rate	$m^3/ m^2.hr$	12
Contact time	Min.	30
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	9+1 Standby
Media type	-	Activated carbon
Material of construction	-	MS, epoxy-coated
Chlorination Tank		
Flow	MLD	10.5
Size of tank	m	9.5 m × 9.5 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Min.	30
Material of construction	-	RCC, epoxy-coated
Treated Sewage Tank		
Flow	MLD	10.5
Size of tank	m	12.25 m × 12.25 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Sludge Collection Tank		

Particulars	Unit	Size
Sludge Flow	m^3/d	400
Size of tank	m	6.5 m × 6.5 m × 2 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	5
Material of construction	-	RCC, epoxy-coated
Pump		
Type	-	Horizontal non-clogging pump
Power required for pump	hp	As per site-specific
No. of pump	Nos.	(1+1 Standby)
Material of construction		SS
Gravity Thickener		
No. of tanks	Nos.	1
Size of tank	m	9 m Ø × 3 m
Free board	m	0.5
HRT	hr	12.6
Solid loading rate (SLR)	$kg/m^2/d$	50
Hydraulic loading rate (HLR)	$m^3/m^2/d$	6.16
Bottom slope	-	1in 5
Polyelectrolyte Dosing Tank		
Storage capacity	L	2500
Size of tank	m	1.80 m Ø × 1.0 m
Free board	m	0.3
No. of tanks	Nos.	2
Material of construction	-	RCC, epoxy-coated
Centrifuge		
Centrifuge/Filter press	-	Vendor specific design

Table 35: Design details of various unit operations and processes for the proposed 10.25 MLD DSTP (Thrikkakara)

Particulars	Unit	Size
Receiving Chamber		
Flow	MLD	10.25
Peak factor	-	2.25
Peak Flow	MLD	23.10
Detention time	Sec.	40
Size of Chamber	m	2.1 m × 2.1 m × 2.5 m
Free board	m	0.5
No. of Chamber	Nos.	1
Material of construction	-	RCC, epoxy-coated
Mechanical Coarse Screen Channel		
Flow	MLD	10.25
Peak factor	-	2.25
Peak Flow	MLD	23.10
Type	-	Mechanical
Screen size	m	0.32 m × 0.8 m
Bar size	mm	10
No. of bars	Nos.	10
No. of spacing	Nos.	11
No. of screen	Nos.	2
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m × 0.65 m × 0.8 m
Free board	m	0.5
No. of units	Nos.	2
Material of construction	-	RCC, epoxy-coated
Manual Coarse Screen Channel		
Type	-	Manual
Screen size	m	0.32 m × 0.8 m
Bar size	mm	10
No. of bars	Nos.	10
No. of spacing	Nos.	11
No. of screen	Nos.	1
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75°
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	6 m × 0.5 m × 0.8 m
Free board	m	0.3
No. of units	Nos.	1

Particulars	Unit	Size
Material of construction	-	RCC, epoxy-coated
Raw Sewage Sump		
Flow	MLD	10.25
Size of tank	m	8.3 m × 1.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Sec.	300
Raw Sewage Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	Hp	As per site-specific
No. of pump	Nos.	(4+1 Standby)
Material of construction	-	SS
Stilling Tank		
Size of tank	m	2.1 m × 2.1 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	min	40
Mechanical Fine Screen Channel		
Type	-	Mechanical
Screen size	m	0.214 m × 0.75 m
Bar size	mm	2
No. of bars	Nos.	26
No. of spacing	Nos.	27
No. of screen	Nos.	2
Clear opening between bars	mm	6
Inclination with horizontal	Degree	40°
Flow through velocity (Qpeak)	m/s	1.1
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	6 m × 0.5 m × 0.8 m
Free board	m	0.3
No. of units	Nos.	2
Material of construction	-	RCC, epoxy-coated
Manual Fine Screen Channel		
Type	-	Manual
Screen size	m	0.316 m × 0.75 m
Bar size	mm	8
No. of bars	Nos.	17
No. of spacing	Nos.	18
No. of screen	Nos.	1
Clear opening between bars	mm	10
Inclination with horizontal	Degree	45°
Flow through velocity (Qpeak)	m/s	1
Flow through velocity (QAvg)	m/s	0.6

Particulars	Unit	Size
Size of channel	m	6 m × 0.5 m × 0.75 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Grit Chamber		
No. of Chambers	Nos.	2
D.T (sec)	sec	60
Free board (m)	m	0.3
Size of chamber	m	3.5 m × 3.5 m × 0.85 m
Material of construction	-	RCC, epoxy-coated
Sequential batch reactor (SBR)		
Flow	MLD	10.25
No of cycle	Nos.	4
Flow for each cycle	MLD	2.56
SBR cyclic period		
Feeding + aeration	hr	4.5
Settling	hr	0.75
Decanting	hr	0.75
Total cycle period	hr	6
Influent BOD	mg/L	220
Effluent BOD	mg/L	20
MLSS	mg/L	4000
MLVSS	mg/L	3200
Size of tank	m	23 m × 23 m × 5 m
No. of tanks	Nos.	4
Free board	m	0.5
F/M	d^{-1}	0.07
Volumetric loading rate	$kg/m^3/d$	0.22
Oxygen requirement	$kg/O_2/d$	2760
Sludge wastage	m^3/d	400
SRT	days	10
HRT	hr	24
Blower		
Air required	m^3/Min.	130
Power required for blower	hp	200
No. of blowers	Nos.	(4+1Standby)
Power of each blower	hp	50
Blower efficiency	%	75
Sludge Recycled Pump		
Type	-	Horizontal non-clog pump
Power required for pump	hp	As per site specific
No. of pump	Nos.	(1+1 standby)
Material of construction	-	SS

Particulars	Unit	Size
Feed to Pressure Sand Filter		
Size of tank	m	12 m × 12 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	hp	As per site-specific
No. of pump	Nos.	(1+1 Standby)
Material of construction	-	SS
Pressure Sand Filter		
Flow	MLD	10.25
Filtration rate	$m^3/m^2/hr$	12
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	9+1 Standby
Media type	-	Sand
Material of construction	-	MS, epoxy-coated
Activated Carbon Column		
Flow	MLD	10.25
Filtration rate	$m^3/ m^2.hr$	12
Contact time	Min.	30
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	9+1 Standby
Media type	-	Activated carbon
Material of construction	-	MS, epoxy-coated
Chlorination Tank		
Flow	MLD	10.25
Size of tank	m	9.3 m × 9.3 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Min.	30
Material of construction	-	RCC, epoxy-coated
Treated Sewage Tank		
Flow	MLD	10.25
Size of tank	m	12 m × 12 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Sludge Collection Tank		
Sludge Flow	m^3/d	400
Size of tank	m	6.5 m × 6.5 m × 2 m

Particulars	Unit	Size
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	5
Material of construction	-	RCC, epoxy-coated
Gravity Thickener		
No. of tanks	Nos.	1
Size of tank	m	9 m Ø × 3 m
Free board	m	0.5
HRT	hr	12.6
Solid loading rate (SLR)	kg/m²/d	50
Hydraulic loading rate (HLR)	m³/m²/d	6.16
Bottom slope	-	1 in 5
Polyelectrolyte Dosing Tank		
Storage capacity	L	2500
Size of tank	m	1.8 m Ø× 1.0 m
Free board	m	0.3
No. of tanks	Nos.	2
Material of construction	-	HDPE/PE
Polyelectrolyte Dosing Pump		
Type	LPH	Plunger metering pump
Power required by pump	hp	As per site-specific
Nos. of pump	Nos.	(1+1 Standby)
Material of construction	-	Polypropylene (PP)
Centrifuge		
Centrifuge/Filter press	-	Vendor specific design

Table 36: Design details of various unit operations and processes for the proposed 8.40 MLD DSTP (Kalamassery)

Particulars	Unit	Size
Receiving Chamber		
Flow	MLD	8.4
Peak factor	-	2.25
Peak Flow	MLD	18.9
Detention time	Sec.	40
Size of Chamber	m	1.9 m × 1.9 m × 2.5 m
Free board	m	0.5
No. of Chamber	Nos.	1
Material of construction	-	RCC, epoxy-coated
Mechanical Coarse Screen Channel		
Flow	MLD	8.4
Peak factor	-	2.25
Peak Flow	MLD	18.9
Type	-	Mechanical
Screen size	m	0.17 m × 0.8 m
Bar size	mm	10
No. of bars	Nos.	5
No. of spacing	Nos.	6
No. of screen	Nos.	2
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m × 0.5 m × 0.8 m
Free board	m	0.5
No. of units	Nos.	2
Material of construction	-	RCC, epoxy-coated
Manual Coarse Screen Channel		
Type	-	Manual
Screen size	m	0.17 m × 0.8 m
Bar size	mm	10
No. of bars	Nos.	5
No. of spacing	Nos.	6
No. of screen	Nos.	1
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75°
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m × 0.35 m × 0.8 m
Free board	m	0.5
No. of units	Nos.	1

Particulars	Unit	Size
Material of construction	-	RCC, epoxy-coated
Raw Sewage Sump		
Flow	MLD	8.4
Size of tank	m	7.5 m Ø× 1.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Sec.	300
Raw Sewage Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	Hp	As per site-specific
No. of pump	Nos.	(4+1 Standby)
Material of construction	-	SS
Stilling Tank		
Size of tank	m	2 m × 2 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	min	40
Mechanical Fine Screen Channel		
Type	-	Mechanical
Screen size	m	0.182 m × 0.75 m
Bar size	mm	2
No. of bars	Nos.	22
No. of spacing	Nos.	23
No. of screen	Nos.	2
Clear opening between bars	mm	6
Inclination with horizontal	Degree	40°
Flow through velocity (Qpeak)	m/s	1.1
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	6 m × 0.45 m × 0.8 m
Free board	m	0.3
No. of units	Nos.	2
Material of construction	-	RCC, epoxy-coated
Manual Fine Screen Channel		
Type	-	Manual
Screen size	m	0.262 m × 0.75 m
Bar size	mm	8
No. of bars	Nos.	14
No. of spacing	Nos.	15
No. of screen	Nos.	1
Clear opening between bars	mm	10
Inclination with horizontal	Degree	45°
Flow through velocity (Qpeak)	m/s	1
Flow through velocity (QAvg)	m/s	0.6

Particulars	Unit	Size
Size of channel	m	6 m × 0.43 m × 0.75 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Grit Chamber		
No. of Chambers	Nos.	2
D.T (sec)	sec	60
Free board (m)	m	0.3
Size of chamber	m	3.1 m × 3.1 m × 0.85 m
Material of construction	-	RCC, epoxy-coated
Sequential batch reactor (SBR)		
Flow	MLD	8.4
No of cycle	Nos.	4
Flow for each cycle	MLD	2.1
SBR cyclic period		
Feeding + aeration	hr	4.5
Settling	hr	0.75
Decanting	hr	0.75
Total cycle period	hr	6
Influent BOD	mg/L	220
Effluent BOD	mg/L	20
MLSS	mg/L	4000
MLVSS	mg/L	3200
Size of tank	m	21 m × 21 m × 5 m
No. of tanks	Nos.	4
Free board	m	0.5
F/M	d^{-1}	0.07
Volumetric loading rate	$kg/m^3/d$	0.22
Oxygen requirement	$kg/O_2/d$	2260
Sludge wastage	m^3/d	315
SRT	days	10
HRT	hr	24
Blower		
Air required	**m^3/Min.**	**160**
Power required for blower	hp	160
No. of blowers	Nos.	(4+1Standby)
Power of each blower	hp	40
Blower efficiency	%	%
Sludge Recycled Pump		
Type	-	Horizontal non-clog pump
Power required for pump	hp	As per site-specific
No. of pump	Nos.	(1+1 standby)
Material of construction	-	SS

Particulars	Unit	Size
Feed to Pressure Sand Filter		
Size of tank	m	11 m × 11 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Pump		
Type		Horizontal Submersible Pump
Power required for pump		As per site-specific
No. of pump		(1+1 Standby)
Material of construction		SS
Pressure Sand Filter		
Flow	MLD	8.4
Filtration rate	$m^3/m^2/hr$	12
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	(7+1 Standby)
Media type	-	Sand
Material of construction	-	MS, epoxy-coated
Activated Carbon Column		
Flow	MLD	8.4
Filtration rate	$m^3/ m^2.hr$	12
Contact time	Min.	30
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	(7+1 Standby)
Media type	-	Activated carbon
Material of construction	-	MS, epoxy-coated
Chlorination Tank		
Flow	m^3/d	8.4
Size of tank	m	8.5 m × 8.5 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Min.	30
Material of construction	-	RCC, epoxy-coated
Treated Sewage Tank		
Flow	m^3/d	8.4
Size of tank	m	11 m × 11 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Sludge Collection Tank		
Sludge Flow	m^3/d	315
Size of tank	m	5.8 m × 5.8 m × 2 m

Particulars	Unit	Size
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	5
Material of construction	-	RCC, epoxy-coated
Gravity Thickener		
No. of tanks	Nos.	1
Size of tank	m	8 m Ø× 3 m
Free board	m	0.5
HRT	hr	12.5
Solid loading rate (SLR)	kg/m²/d	50
Hydraulic loading rate (HLR)	m³/m²/d	6.16
Bottom slope	-	1 in 5
Polyelectrolyte Dosing Tank		
Storage capacity	L	2010
Size of tank	m	1.6 m Ø× 1.0 m
Free board	m	0.3
No. of tanks	Nos.	2
Material of construction	-	RCC, epoxy-coated
Polyelectrolyte Dosing Pump		
Type	LPH	Plunger metering pump
Power required by pump	hp	As per site-specific
Nos. of pump	Nos.	(1+1 Standby)
Material of construction	-	Polypropylene (PP)
Centrifuge		
Centrifuge/Filter press	-	Vendor specific design

Table 37: Design details of various unit operations and processes for the proposed 2.10 MLD DSTP (Thripunithura)

Particulars	Unit	Size
Receiving Chamber		
Flow	MLD	2.1
Peak factor	-	3
Peak Flow	MLD	6.30
Detention time	Sec.	40
Size of Chamber	m	1.1 m × 1.1 m × 2.5 m
Free board	m	0.5
No. of Chamber	Nos.	1
Material of construction	-	RCC, epoxy-coated
Mechanical Coarse Screen Channel		
Flow	MLD	2.1
Peak factor	-	3
Peak Flow	MLD	6.30
Type	-	Mechanical
Screen size	m	0.26 m × 0.35 m
Bar size	mm	10
No. of bars	Nos.	8
No. of spacing	Nos.	9
No. of screen	Nos.	1
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m × 0.45 m × 0.35 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Manual Coarse Screen Channel		
Type	-	Manual
Screen size	m	0.17 m × 0.30 m
Bar size	mm	10
No. of bars	Nos.	5
No. of spacing	Nos.	6
No. of screen	Nos.	1
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75°
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m × 0.35 m × 0.3 m
Free board	m	0.3
No. of units	Nos.	1

Particulars	Unit	Size
Material of construction	**-**	**RCC, epoxy-coated**
Raw Sewage Sump		
Flow	MLD	2.1
Size of tank	m	4.5 m Ø × 1.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Sec.	300
Raw Sewage Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	hp	As per site-specific
No. of pump	Nos.	(4+1 Standby)
Material of construction	-	SS
Stilling Tank		
Size of tank	m	1.1 m × 1.1 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	min	40
Mechanical Fine Screen Channel		
Type	-	Mechanical
Screen size	m	0.3 m × 0.3 m
Bar size	mm	2
No. of bars	Nos.	36
No. of spacing	Nos.	37
No. of screen	Nos.	1
Clear opening between bars	mm	6
Inclination with horizontal	Degree	40°
Flow through velocity (Qpeak)	m/s	1.1
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	6 m × 0.55 m × 0.35 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Manual Fine Screen Channel		
Type	-	Manual
Screen size	m	0.25 m × 0.3 m
Bar size	mm	8
No. of bars	Nos.	12
No. of spacing	Nos.	13
No. of screen	Nos.	1
Clear opening between bars	mm	10
Inclination with horizontal	Degree	45°
Flow through velocity (Qpeak)	m/s	1
Flow through velocity (QAvg)	m/s	0.6

Particulars	Unit	Size
Size of channel	m	6 m × 0.23 m × 0.3 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Grit Chamber		
No. of Chambers	Nos.	2
D.T (sec)	sec	60
Free board (m)	m	0.3
Size of chamber	m	1.8 m × 1.8 m × 0.85 m
Material of construction	-	RCC, epoxy-coated
Sequential batch reactor (SBR)		
Flow	MLD	2.1
No of cycle	Nos.	4
Flow for each cycle	MLD	0.525
SBR cyclic period		
Feeding + aeration	hr	4.5
Settling	hr	0.75
Decanting	hr	0.75
Total cycle period	hr	6
Influent BOD	mg/L	220
Effluent BOD	mg/L	20
MLSS	mg/L	4000
MLVSS	mg/L	3200
Size of tank	m	10.5 m × 10.5 m × 5 m
No. of tanks	Nos.	4
Free board	m	0.5
F/M	d^{-1}	0.07
Volumetric loading rate	$kg/m^3/d$	0.22
Oxygen requirement	$kg/O_2/d$	565
Sludge wastage	m^3/d	80
SRT	days	10
HRT	hr	24
Blower		
Air required	m^3/Min.	26
Power required for blower	hp	50
No. of blowers	Nos.	(2+1Standby)
Power of each blower	hp	25
Blower efficiency	%	75
Sludge Recycled Pump		
Type	-	Horizontal non-clog pump
Power required for pump	hp	As per site-specific
No. of pump	Nos.	(1+1 standby)
Material of construction	-	SS

Particulars	Unit	Size
Feed Tank (Pressure Sand Filter)		
Size of tank	m	5.5 m × 5.5 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	-	As per site-specific
No. of pump	-	(1+1 Standby)
Material of construction	-	SS
Pressure Sand Filter		
Flow	MLD	2.1
Filtration rate	$m^3/m^2/hr$	12
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	(2+1 Standby)
Media type	-	Sand
Material of construction	-	MS, epoxy-coated
Activated Carbon Column		
Flow	MLD	2.1
Filtration rate	$m^3/ m^2.hr$	12
Contact time	Min.	30
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	2+1 Standby
Media type	-	Activated carbon
Material of construction	-	MS, epoxy-coated
Chlorination Tank		
Flow	m^3/d	2.1
Size of tank	m	4.3 m × 4.3 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Min.	30
Material of construction	-	RCC, epoxy-coated
Treated Sewage Tank		
Flow	m^3/d	2.1
Size of tank	m	5.5 m × 5.5 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Sludge Collection Tank		
Sludge Flow	m^3/d	80
Size of tank	m	3 m × 3 m × 2 m

Particulars	Unit	Size
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	5
Material of construction	-	RCC, epoxy-coated
Gravity Thickener		
No. of tanks	Nos.	1
Size of tank	m	4 m Ø × 3 m
Free board	m	0.5
HRT	hr	11.8
Solid loading rate (SLR)	kg/m²/d	50
Hydraulic loading rate (HLR)	m³/m²/d	6.16
Bottom slope	-	1 in 5
Polyelectrolyte Dosing Tank		
Storage capacity	L	1000
Size of tank	m	1.1 m Ø× 1.0 m
Free board	m	0.3
No. of tanks	Nos.	1
Material of construction	-	RCC, epoxy-coated
Polyelectrolyte Dosing Pump		
Type	LPH	Plunger metering pump
Power required by pump	hp	As per site-specific
Nos. of pump	Nos.	(1+1 Standby)
Material of construction	-	Polypropylene (PP)
Centrifuge		
Centrifuge/Filter press	-	Vendor specific design

Table 38: Design details of various unit operations and processes for the proposed 3.35 MLD DSTP (Karunagapally)

Particulars	Unit	Size
Receiving Chamber		
Flow	MLD	3.35
Peak factor	-	2.5
Peak Flow	MLD	8.40
Detention time	Sec.	40
Size of Chamber	m	1.2 m × 1.2 m × 2.5 m
Free board	m	0.5
No. of Chamber	Nos.	1
Material of construction	-	RCC, epoxy-coated
Mechanical Coarse Screen Channel		
Flow	MLD	3.35
Peak factor	-	2.5
Peak Flow	MLD	8.40
Type	-	Mechanical
Screen size	m	0.2 m × 0.3 m
Bar size	mm	10
No. of bars	Nos.	6
No. of spacing	Nos.	7
No. of screen	Nos.	2
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m × 0.45 m × 0.3 m
Free board	m	0.3
No. of units	Nos.	2
Material of construction	-	RCC, epoxy-coated
Manual Coarse Screen Channel		
Type	-	Manual
Screen size	m	0.2 m × 0.3 m
Bar size	mm	10
No. of bars	Nos.	6
No. of spacing	Nos.	7
No. of screen	Nos.	1
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75°
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m × 0.35 m × 0.3 m
Free board	m	0.5
No. of units	Nos.	1

Particulars	Unit	Size
Material of construction	-	RCC, epoxy-coated
Raw Sewage Sump		
Flow	MLD	3.35
Size of tank	m	5 m Ø× 1.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Sec.	300
Raw Sewage Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	hp	As per site-specific
No. of pump	Nos.	(4+1 Standby)
Material of construction	-	SS
Stilling Tank		
Size of tank	m	1.3 m × 1.3 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	min	40
Mechanical Fine Screen Channel		
Type	-	Mechanical
Screen size	m	0.198 m × 0.3 m
Bar size	mm	2
No. of bars	Nos.	24
No. of spacing	Nos.	25
No. of screen	Nos.	2
Clear opening between bars	mm	6
Inclination with horizontal	Degree	40°
Flow through velocity (Qpeak)	m/s	1.1
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	6 m × 0.45 m × 0.35 m
Free board	m	0.3
No. of units	Nos.	2
Material of construction	-	RCC, epoxy-coated
Manual Fine Screen Channel		
Type	-	Manual
Screen size	m	0.298 m × 0.3 m
Bar size	mm	8
No. of bars	Nos.	16
No. of spacing	Nos.	17
No. of screen	Nos.	1
Clear opening between bars	mm	10
Inclination with horizontal	Degree	45°
Flow through velocity (Qpeak)	m/s	1
Flow through velocity (QAvg)	m/s	0.6

Particulars	Unit	Size
Size of channel	m	6 m × 0.45 m × 0.3 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Grit Chamber		
No. of Chambers	Nos.	2
D.T (sec)	sec	60
Free board (m)	m	0.3
Size of chamber	m	2.1 m × 2.1 m × 0.85 m
Material of construction	-	RCC, epoxy-coated
Sequential batch reactor (SBR)		
Flow	m^3/d	3350
No of cycle	Nos.	4
Flow for each cycle	m^3/d	837.5
SBR cyclic period		
Feeding + aeration	hr	4.5
Settling	hr	0.75
Decanting	hr	0.75
Total cycle period	hr	6
Influent BOD	mg/L	220
Effluent BOD	mg/L	20
MLSS	mg/L	4000
MLVSS	mg/L	3200
Size of tank	m	13 m × 13 m × 5 m
No. of tanks	Nos.	4
Free board	m	0.5
F/M	d^{-1}	0.07
Volumetric loading rate	$kg/m^3/d$	0.22
Oxygen requirement	$kg/O_2/d$	901
Sludge wastage	m^3/d	130
SRT	days	10
HRT	hr	24
Blower		
Air required	m^3/Min.	42
Power required for blower	hp	70
No. of blowers	Nos.	(2+1Standby)
Power of each blower	hp	35
Blower efficiency	%	75
Sludge Recycled Pump		
Type	-	Horizontal non-clog pump
Power required for pump	hp	As per site specific
No. of pump	Nos.	(1+1 standby)
Material of construction	-	SS

Particulars	Unit	Size
Feed Tank (Pressure Sand Filter)		
Size of tank	m	7 m × 7 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	-	As per site-specific
No. of pump	-	(1+1 Standby)
Material of construction	-	SS
Pressure Sand Filter		
Flow	MLD	3.35
Filtration rate	$m^3/m^2/hr$	12
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	3+1 Standby
Media type	-	Sand
Material of construction	-	MS, epoxy-coated
Activated Carbon Column		
Flow	MLD	3.35
Filtration rate	$m^3/ m^2.hr$	12
Contact time	Min.	30
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	3+1 Standby
Media type	-	Activated carbon
Material of construction	-	MS, epoxy-coated
Chlorination Tank		
Flow	m^3/d	3.35
Size of tank	m	5.3 m × 5.3 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Min.	30
Material of construction	-	RCC, epoxy-coated
Treated Sewage Tank		
Flow	m^3/d	3.35
Size of tank	m	7 m × 7 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Sludge Collection Tank		
Sludge Flow	m^3/d	130
Size of tank	m	3.7 m × 3.7 m × 2 m

Particulars	Unit	Size
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	5
Material of construction	-	RCC, epoxy-coated
Gravity Thickener		
No. of tanks	Nos.	1
Size of tank	m	5.2 m Ø × 3 m
Free board	m	0.5
HRT	hr	12.4
Solid loading rate (SLR)	kg/m²/d	50
Hydraulic loading rate (HLR)	m³/m²/d	6.16
Bottom slope	-	1in 5
Polyelectrolyte Dosing Tank		
Storage capacity	L	800
Size of tank	m	1.0 m Ø× 1.0 m
Free board	m	0.3
No. of tanks	Nos.	2
Material of construction	-	RCC, epoxy-coated
Polyelectrolyte Dosing Pump		
Type	LPH	Plunger metering pump
Power required by pump	hp	As per site-specific
Nos. of pump	Nos.	(1+1 Standby)
Material of construction	-	Polypropylene (PP)
Centrifuge		
Centrifuge/Filter press	-	Vendor specific design

Table 39: Design details of various unit operations and processes for the proposed 2.60 MLD DSTP (Kulasekharapuram)

Particulars	Unit	Size
Receiving Chamber		
Flow	MLD	2.6
Peak factor	-	2.5
Peak Flow	MLD	6.50
Detention time	Sec.	40
Size of Chamber	m	1.1 m × 1.1 m × 2.5 m
Free board	m	0.5
No. of Chamber	Nos.	1
Material of construction	-	RCC, epoxy-coated
Mechanical Coarse Screen Channel		
Flow	MLD	2.6
Peak factor	-	2.5
Peak Flow	MLD	6.50
Type	-	Mechanical
Screen size	m	0.32 m × 0.3 m
Bar size	mm	10
No. of bars	Nos.	10
No. of spacing	Nos.	11
No. of screen	Nos.	1
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m × 0.65 m × 0.3 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Manual Coarse Screen Channel		
Type	-	Manual
Screen size	m	0.26 m × 0.35 m
Bar size	mm	10
No. of bars	Nos.	8
No. of spacing	Nos.	9
No. of screen	Nos.	1
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75°
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m × 0.45 m × 0.35 m
Free board	m	0.3
No. of units	Nos.	1

Particulars	Unit	Size
Material of construction	-	RCC, epoxy-coated
Raw Sewage Sump		
Flow	MLD	2.6
Size of tank	m	4.5 m Ø× 1.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Sec.	300
Raw Sewage Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	hp	As per site-specific
No. of pump	Nos.	(4+1 Standby)
Material of construction	-	SS
Stilling Tank		
Size of tank	m	1.1 m × 1.1 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	min	40
Mechanical Fine Screen Channel		
Type	-	Mechanical
Screen size	m	0.30 m × 0.3 m
Bar size	mm	2
No. of bars	Nos.	37
No. of spacing	Nos.	38
No. of screen	Nos.	1
Clear opening between bars	mm	6
Inclination with horizontal	Degree	40°
Flow through velocity (Qpeak)	m/s	1.1
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	6 m × 0.6 m × 0.35 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Manual Fine Screen Channel		
Type	-	Manual
Screen size	m	0.25 m × 0.3 m
Bar size	mm	8
No. of bars	Nos.	12
No. of spacing	Nos.	13
No. of screen	Nos.	1
Clear opening between bars	mm	10
Inclination with horizontal	Degree	45°
Flow through velocity (Qpeak)	m/s	1
Flow through velocity (QAvg)	m/s	0.6

Particulars	Unit	Size
Size of channel	m	6 m × 0.4 m × 0.3 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Grit Chamber		
No. of Chambers	Nos.	2
DT	sec	60
Free board	m	0.3
Size of chamber	m	1.8 m × 1.8 m × 0.85 m
Material of construction	-	RCC, epoxy-coated
Sequential batch reactor (SBR)		
Flow	m^3/d	2600
No of cycle	Nos.	4
Flow for each cycle	m^3/d	650
SBR cyclic period		
Feeding + aeration	hr	4.5
Settling	hr	0.75
Decanting	hr	0.75
Total cycle period	hr	6
Influent BOD	mg/L	220
Effluent BOD	mg/L	20
MLSS	mg/L	4000
MLVSS	mg/L	3200
Size of tank	m	11.5 m × 11.5 m × 5 m
No. of tanks	Nos.	4
Free board	m	0.5
F/M	d^{-1}	0.07
Volumetric loading rate	$kg/m^3/d$	0.22
Oxygen requirement	$kg/O_2/d$	700
Sludge wastage	m^3/d	100
SRT	days	10
HRT	hr	24
Blower		
Air required	m^3/Min.	32
Power required for blower	hp	50
No. of blowers	Nos.	(2+1Standby)
Power of each blower	hp	25
Blower efficiency	%	75
Sludge Recycled Pump		
Type	-	Horizontal non-clog pump
Power required for pump	hp	As per site specific
No. of pump	Nos.	(1+1 standby)
Material of construction	-	SS

Particulars	Unit	Size
Feed to Pressure Sand Filter		
Size of tank	m	6.1 m × 6.1 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	hp	As per site-specific
No. of pump	Nos.	(1+1 Standby)
Material of construction	-	SS
Pressure Sand Filter		
Flow	MLD	2.6
Filtration rate	$m^3/m^2/hr$	12
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	3+1 Standby
Media type	-	Sand
Material of construction	-	MS, epoxy-coated
Activated Carbon Column		
Flow	MLD	2.6
Filtration rate	$m^3/ m^2.hr$	12
Contact time	Min.	30
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	**Nos.**	**3+1 Standby**
Media type	-	Activated carbon
Material of construction	-	MS, epoxy-coated
Chlorination Tank		
Flow	m^3/d	2.6
Size of tank	m	4.7 m × 4.7 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Min.	30
Material of construction	-	RCC, epoxy-coated
Treated Sewage Tank		
Flow	m^3/d	2.6
Size of tank	m	6 m × 6 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Sludge Collection Tank		
Sludge Flow	m^3/d	100
Size of tank	m	3.25 m × 3.25 m × 2 m

Particulars	Unit	Size
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	5
Material of construction	-	RCC, epoxy-coated
Gravity Thickener		
No. of tanks	Nos.	1
Size of tank	m	4.6 m Ø × 3 m
Free board	m	0.5
HRT	hr	12.6
Solid loading rate (SLR)	kg/m²/d	50
Hydraulic loading rate (HLR)	m³/m²/d	6.16
Bottom slope	-	1in 5
Polyelectrolyte Dosing Tank		
Storage capacity	L	1500
Size of tank	m	1.4 m Ø × 1 m
Free board	m	0.3
No. of tanks	Nos.	1
Material of construction	-	RCC, epoxy-coated
Polyelectrolyte Dosing Pump		
Type	LPH	Plunger metering pump
Power required by pump	hp	As per site-specific
Nos. of pump	Nos.	(1+1 Standby)
Material of construction	-	Polypropylene (PP)
Centrifuge		
Centrifuge/Filter press	-	Vendor specific design

Table 40: Design details of various unit operations and processes for the proposed 2.00 MLD DSTP (Thodiyoor)

Particulars	Unit	Size
Receiving Chamber		
Flow	MLD	2
Peak factor	-	2.5
Peak flow	MLD	5
Detention time	Sec.	40
Size of Chamber	m	1 m × 1 m × 2.5 m
Free board	m	0.5
No. of Chamber	Nos.	1
Material of construction	-	RCC, epoxy-coated
Mechanical Coarse Screen Channel		
Flow	MLD	2
Peak factor	-	2.5
Peak flow	MLD	5
Type	-	Mechanical
Screen size	m	0.26 m × 0.3 m
Bar size	mm	10
No. of bars	Nos.	8
No. of spacing	Nos.	9
No. of screen	Nos.	1
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg.)	m/s	0.6
Size of channel	m	5 m × 0.45 m × 0.3 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Manual Coarse Screen Channel		
Type	-	Manual
Screen size	m	0.17 m × 0.3 m
Bar size	mm	10
No. of bars	Nos.	5
No. of spacing	Nos.	6
No. of screen	Nos.	1
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75°
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m × 0.35 m × 0.3 m
Free board	m	0.3
No. of units	Nos.	1

Particulars	Unit	Size
Material of construction	-	RCC, epoxy-coated
Raw Sewage Sump		
Flow	MLD	2
Size of tank	m	4 m Ø× 1.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Sec.	300
Raw Sewage Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	hp	As per site-specific
No. of pump	Nos.	(4+1 Standby)
Material of construction	-	SS
Stilling Tank		
Size of tank	m	1 m × 1 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	min	40
Mechanical Fine Screen Channel		
Type	-	Mechanical
Screen size	m	0.246 m × 0.3 m
Bar size	mm	2
No. of bars	Nos.	30
No. of spacing	Nos.	31
No. of screen	Nos.	1
Clear opening between bars	mm	6
Inclination with horizontal	Degree	40°
Flow through velocity (Qpeak)	m/s	1.1
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	6 m × 0.5 m × 0.35 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Manual Fine Screen Channel		
Type	-	Manual
Screen size	m	0.19 m × 0.3 m
Bar size	mm	8
No. of bars	Nos.	10
No. of spacing	Nos.	11
No. of screen	Nos.	1
Clear opening between bars	mm	10
Inclination with horizontal	Degree	45°
Flow through velocity (Qpeak)	m/s	1
Flow through velocity (QAvg)	m/s	0.6

Particulars	Unit	Size
Size of channel	m	6 m × 0.35 m × 0.3 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Grit Chamber		
No. of Chambers	Nos.	2
D.T (sec)	sec	60
Free board (m)	m	0.3
Size of chamber	m	1.6 m × 1.6 m × 0.85 m
Material of construction	-	RCC, epoxy-coated
Sequential batch reactor (SBR)		
Flow	m^3/d	2000
No of cycle	Nos.	4
Flow for each cycle	m^3/d	500
SBR cyclic period		
Feeding + aeration	hr	4.5
Settling	hr	0.75
Decanting	hr	0.75
Total cycle period	hr	6
Influent BOD	mg/L	220
Effluent BOD	mg/L	20
MLSS	mg/L	4000
MLVSS	mg/L	3200
Size of tank	m	10 m × 10 m × 5 m
No. of tanks	Nos.	4
Free board	m	0.5
F/M	d^{-1}	0.07
Volumetric loading rate	$kg/m^3/d$	0.22
Oxygen requirement	$kg/O_2/d$	538
Sludge wastage	m^3/d	75
SRT	days	10
HRT	hr	24
Blower		
Air required	$m^3/Min.$	26
Power required for blower	hp	50
No. of blowers	Nos.	(2+1Standby)
Power of each blower	hp	25
Blower efficiency	%	75
Sludge Recycled Pump		
Type	-	Horizontal non-clog pump
Power required for pump	hp	As per site specific
No. of pump	Nos.	(1+1 standby)
Material of construction	-	SS

Particulars	Unit	Size
Feed to Pressure Sand Filter		
Size of tank	m	5.5 m × 5.5 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Pump		
Type		Horizontal Submersible Pump
Power required for pump		As per site-specific
No. of pump		(1+1 Standby)
Material of construction		SS
Pressure Sand Filter		
Flow	m^3/d	2
Filtration rate	$m^3/m^2/hr$	12
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	2+1 Standby
Media type	-	Sand
Material of construction	-	MS, epoxy-coated
Activated Carbon Column		
Flow	m^3/d	2
Filtration rate	$m^3/ m^2.hr$	12
Contact time	Min.	30
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	2+1 Standby
Media type	-	Activated carbon
Material of construction	-	MS, epoxy-coated
Chlorination Tank		
Flow	m^3/d	2
Size of tank	m	4.1 m × 4.1 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Min.	30
Material of construction	-	RCC, epoxy-coated
Treated Sewage Tank		
Flow	m^3/d	2
Size of tank	m	5.3 m × 5.3 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Sludge Collection Tank		
Sludge Flow	m^3/d	75
Size of tank	m	2.8 m × 2.8 m × 2 m

Particulars	Unit	Size
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	5
Material of construction	-	RCC, epoxy-coated
Gravity Thickener		
No. of tanks	Nos.	1
Size of tank	m	4 m Ø × 3 m
Free board	m	0.5
HRT	hr	12.6
Solid loading rate (SLR)	kg/m²/d	50
Hydraulic loading rate (HLR)	m³/m²/d	6.16
Bottom slope	-	1in 5
Polyelectrolyte Dosing Tank		
Storage capacity	L	1000
Size of tank	m	1.1 m Ø × 1.0 m
Free board	m	0.3
No. of tanks	Nos.	1
Material of construction	-	RCC, epoxy-coated
Polyelectrolyte Dosing Pump		
Type	LPH	Plunger metering pump
Power required by pump	hp	As per site-specific
Nos. of pump	Nos.	(1+1 Standby)
Material of construction	-	Polypropylene (PP)
Centrifuge		
Centrifuge/Filter press	-	Vendor specific design

Table 41: Design details of various unit operations and processes for the proposed 1.60 MLD DSTP (Thazhava)

Particulars	Unit	Size
Receiving Chamber		
Flow	MLD	1.6
Peak factor	-	3
Peak flow	MLD	4.80
Detention time	Sec.	40
Size of Chamber	m	0.9 m x 0.9 m x 2.5 m
Free board	m	0.5
No. of Chamber	Nos.	1
Material of construction	-	RCC, epoxy-coated
Mechanical Coarse Screen Channel		
Flow	MLD	1.6
Peak factor	-	3
Peak flow	MLD	4.80
Type	-	Mechanical
Screen size	m	0.23 m × 0.3 m
Bar size	mm	10
No. of bars	Nos.	7
No. of spacing	Nos.	8
No. of screen	Nos.	1
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m x 0.40 m x 0.3 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Manual Coarse Screen Channel		
Type	-	Manual
Screen size	m	0.17 m × 0.3 m
Bar size	mm	10
No. of bars	Nos.	5
No. of spacing	Nos.	6
No. of screen	Nos.	1
Clear opening between bars	mm	20
Inclination with horizontal	Degree	45°
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m x 0.35 m x 0.3 m
Free board	m	0.3

Particulars	Unit	Size
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Raw Sewage Sump		
Flow	MLD	1.6
Size of tank	m	3.8 m Ø× 1.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Sec.	300
Raw Sewage Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	hp	As per site-specific
No. of pump	Nos.	(4+1 Standby)
Material of construction	-	SS
Stilling Tank		
Size of tank	m	1 m x 1 m x 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	min	2.5
Mechanical Fine Screen Channel		
Type	-	Mechanical
Screen size	m	0.246 m × 0.3 m
Bar size	mm	2
No. of bars	Nos.	30
No. of spacing	Nos.	31
No. of screen	Nos.	1
Clear opening between bars	mm	6
Inclination with horizontal	Degree	40°
Flow through velocity (Qpeak)	m/s	1.1
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	6 m x 0.5 m x 0.35 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Manual Fine Screen Channel		
Type	-	Manual
Screen size	m	0.19 m × 0.3 m
Bar size	mm	8
No. of bars	Nos.	10
No. of spacing	Nos.	11
No. of screen	Nos.	1
Clear opening between bars	mm	10
Inclination with horizontal	Degree	45°
Flow through velocity (Qpeak)	m/s	1

Particulars	Unit	Size
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	6 m x 0.35 m x 0.3 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Grit Chamber		
No. of Chambers	Nos.	2
DT	sec	60
Free board	m	0.3
Size of chamber	m	1.6 m x 1.6 m x 0.85 m
Material of construction	-	RCC, epoxy-coated
Sequential batch reactor (SBR)		
Flow	m^3/d	1600
No of cycle	Nos.	4
Flow for each cycle	m^3/d	400
SBR cyclic period		
Feeding + aeration	hr	4.5
Settling	hr	0.75
Decanting	hr	0.75
Total cycle period	hr	6
Influent BOD	mg/L	220
Effluent BOD	mg/L	20
MLSS	mg/L	4000
MLVSS	mg/L	3200
Size of tank	m	9 m × 9 m × 5 m
No. of tanks	Nos.	4
Free board	m	0.5
F/M	d^{-1}	0.07
Volumetric loading rate	$kg/m^3/d$	0.22
Oxygen requirement	kg/O2/d	430
Sludge wastage	m^3/d	60
SRT	days	10
HRT	hr	24
Blower		
Air required	m^3/Min.	20
Power required for blower	hp	30
No. of blowers	Nos.	(1+1Standby)
Power of each blower	hp	30
Blower efficiency	%	75
Sludge Recycled Pump		
Type	-	Horizontal non-clog pump
Power required for pump	hp	As per site specific
No. of pump	Nos.	(1+1 standby)

Particulars	Unit	Size
Material of construction	-	SS
Feed (Pressure Sand Filter)		
Size of tank	m	5 m × 5 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	-	As per site-specific
No. of pump	-	(1+1 Standby)
Material of construction	-	SS
Pressure Sand Filter		
Flow	MLD	1.6
Filtration rate	$m^3/m^2/hr$	12
Size of each filter	m	2.5 m Øx 2.5 m
No. of filters	Nos.	2+1 Standby
Media type	-	Sand
Material of construction	-	MS, epoxy-coated
Activated Carbon Column		
Flow	MLD	1.6
Filtration rate	$m^3/ m^2.hr$	12
Contact time	Min.	30
Size of each filter	m	2.5 m Øx 2.5 m
No. of filters	Nos.	(2+1 Standby)
Media type	-	Activated carbon
Material of construction	-	MS, epoxy-coated
Chlorination Tank		
Flow	m^3/d	1600
Size of tank	m	3.7 m x 3.7 m x 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Min.	30
Material of construction	-	RCC, epoxy-coated
Treated Sewage Tank		
Flow	m^3/d	1.6
Size of tank	m	4.8 m x 4.8 m x 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Sludge Collection Tank		
Sludge Flow	m^3/d	60

Particulars	Unit	Size
Size of tank	m	2.5 m x 2.5 m x 2 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	5
Material of construction	-	RCC, epoxy-coated
Gravity Thickener		
No. of tanks	Nos.	1
Size of tank	m	3.6 m Ø × 3 m
Free board	m	0.5
HRT	hr	12.7
Solid loading rate (SLR)	kg/m²/d	50
Hydraulic loading rate (HLR)	m³/m²/d	6.16
Bottom slope	-	1 in 5
Polyelectrolyte Dosing Tank		
Storage capacity	L	1000
Size of tank	m	1.1 m Ø× 1.0 m
Free board	m	0.5
No. of tanks	Nos.	1
Material of construction	-	RCC, epoxy-coated
Polyelectrolyte Dosing Pump		
Type	LPH	Plunger metering pump
Power required by pump	hp	As per site-specific
Nos. of pump	Nos.	(1+1 Standby)
Material of construction	-	Polypropylene (PP)
Centrifuge		
Centrifuge/Filter press	-	Vendor specific design

Table 42: Design details of various unit operations and processes for the proposed 10 MLD STP (Thodiyoor+Thazhava+Kulasekharapuram+Karunagapally) Centralized

Particulars	Unit	Size
Receiving Chamber		
Flow	MLD	10
Peak factor	-	2.25
Peak flow	MLD	22.50
Detention time	Sec.	40
Size of Chamber	m	2 m × 2 m × 2.5 m
Free board	m	0.5
No. of Chamber	Nos.	1
Material of construction	-	RCC, epoxy-coated
Mechanical Coarse Screen Channel		
Flow	MLD	10
Peak factor	-	2.25
Peak flow	MLD	22.50
Type	-	Mechanical
Screen size	m	0.32 m × 0.8 m
Bar size	mm	10
No. of bars	Nos.	10
No. of spacing	Nos.	11
No. of screen	Nos.	2
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m × 0.65 m × 0.8 m
Free board	m	0.5
No. of units	Nos.	2
Material of construction	-	RCC, epoxy-coated
Manual Coarse Screen Channel		
Type	-	Manual
Screen size	m	0.32 m × 0.8 m
Bar size	mm	10
No. of bars	Nos.	10
No. of spacing	Nos.	11
No. of screen	Nos.	1
Clear opening between bars	mm	20
Inclination with horizontal	Degree	75°
Flow through velocity (Qpeak)	m/s	1.2
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	5 m × 0.5 m × 0.8 m
Free board	m	0.5

Particulars	Unit	Size
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Raw Sewage Sump		
Flow	MLD	10
Size of tank	m	8 m Ø× 1.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Sec.	300
Raw Sewage Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	hp	As per site-specific
No. of pump	Nos.	(4+1 Standby)
Material of construction	-	SS
Stilling Tank		
Size of tank	m	2 m × 2 m × 2.5 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	min	2.5
Mechanical Fine Screen Channel		
Type	-	Mechanical
Screen size	m	0.21 m × 0.75 m
Bar size	mm	2
No. of bars	Nos.	25
No. of spacing	Nos.	26
No. of screen	Nos.	2
Clear opening between bars	mm	6
Inclination with horizontal	Degree	40°
Flow through velocity (Qpeak)	m/s	1.1
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	6 m × 0.5 m × 0.8 m
Free board	m	0.3
No. of units	Nos.	2
Material of construction	-	RCC, epoxy-coated
Manual Fine Screen Channel		
Type	-	Manual
Screen size	m	0.3 m × 0.75 m
Bar size	mm	8
No. of bars	Nos.	16
No. of spacing	Nos.	17
No. of screen	Nos.	1
Clear opening between bars	mm	10
Inclination with horizontal	Degree	45°
Flow through velocity (Qpeak)	m/s	1

Particulars	Unit	Size
Flow through velocity (QAvg)	m/s	0.6
Size of channel	m	6 m × 0.5 m × 0.75 m
Free board	m	0.3
No. of units	Nos.	1
Material of construction	-	RCC, epoxy-coated
Grit Chamber		
No. of Chambers	Nos.	2
DT	sec	60
Free board	m	0.3
Size of chamber	m	3.4 m × 3.4 m × 0.85 m
Material of construction	-	RCC, epoxy-coated
Sequential batch reactor (SBR)		
Flow	MLD	10
No of cycle	Nos.	4
Flow for each cycle	m^3/d	2500
SBR cyclic period		
Feeding + aeration	hr	4.5
Settling	hr	0.75
Decanting	hr	0.75
Total cycle period	hr	6
Influent BOD	mg/L	220
Effluent BOD	mg/L	20
MLSS	mg/L	4000
MLVSS	mg/L	3200
Size of tank	m	23 m × 23 m × 5 m
No. of tanks	Nos.	4
Free board	m	0.5
F/M	d^{-1}	0.07
Volumetric loading rate	$kg/m^3/d$	0.22
Oxygen requirement	$kg/O_2/d$	2690
Sludge wastage	m^3/d	375
SRT	days	10
HRT	hr	24
Blower		
Air required	m^3/Min.	124
Power required for blower	hp	200
No. of blowers	Nos.	(4+1Standby)
Power of each blower	hp	50
Blower efficiency	%	75
Sludge Recycled Pump		
Type	-	Horizontal non-clog pump
Power required for pump	hp	As per site-specific
No. of pump	Nos.	(1+1 standby)

Particulars	Unit	Size
Material of construction	-	SS
Feed to Pressure Sand Filter		
Size of tank	m	12 m × 12 m × 3 m
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Pump		
Type	-	Horizontal Submersible Pump
Power required for pump	-	As per site-specific
No. of pump	-	(1+1 Standby)
Material of construction	-	SS
Pressure Sand Filter		
Flow	MLD	10
Filtration rate	$m^3/m^2/hr$	12
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	(9+1 Standby)
Media type	-	Sand
Material of construction	-	MS, epoxy-coated
Activated Carbon Column		
Flow	MLD	10
Filtration rate	$m^3/ m^2.hr$	12
Contact time	Min.	30
Size of each filter	m	2.5 m Ø× 2.5 m
No. of filters	Nos.	(9+1 Standby)
Media type	-	Activated carbon
Material of construction	-	MS, epoxy-coated
Chlorination Tank		
Flow	MLD	10
Size of tank	m	9.2 m × 9.2 m ×2.5
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	Min.	30
Material of construction	-	RCC, epoxy-coated
Treated Sewage Tank		
Flow	MLD	10
Size of tank	m	12.0 m × 12.0 m ×3.0
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	1
Material of construction	-	RCC, epoxy-coated
Sludge Collection Tank		
Sludge Flow	m^3/d	360

Particulars	Unit	Size
Size of tank	m	6.2 m × 6.2 m ×2.0
Free board	m	0.5
No. of tanks	Nos.	1
Detention time	hr	5
Material of construction	-	RCC, epoxy-coated
Gravity Thickener		
No. of tanks	Nos.	1
Size of tank	m	8.8 m Ø × 3 m
Free board	m	0.5
HRT	hr	13.4
Solid loading rate (SLR)	kg/m²/d	50
Hydraulic loading rate (HLR)	m³/m²/d	6.16
Bottom slope	-	1in 5
Polyelectrolyte Dosing Tank		
Storage capacity	L	2500
Size of tank	m	1.70 m × 1.0 m
Free board	m	0.3
No. of tanks	Nos.	2
Material of construction	-	RCC, epoxy-coated
Polyelectrolyte Dosing Pump		
Type	LPH	Plunger metering pump
Power required by pump	hp	As per site-specific
Nos. of pump	Nos.	(1+1 Standby)
Material of construction	-	Polypropylene (PP)
Polyelectrolyte Dosing Pump		
Type	LPH	Plunger metering pump
Power required by pump	hp	As per site-specific
Nos. of pump	Nos.	(1+1 Standby)
Material of construction	-	Polypropylene (PP)
Centrifuge		
Centrifuge/Filter press	-	Vendor specific design

12.1 Area requirement for new proposed DSTPs and CSTP

The estimation of area requirement for the proposed treatment scheme for DSTPs and CSTP is based on basic design details, unit sizes of various unit operations and processes. In addition, the area requirement for associated facilities required for operating the DSTPs and CSTP, including an administrative cum laboratory building, electrical and instrumentation panel rooms, was also taken into consideration. The total area requirement for the proposed treatment scheme of DSTPs and CSTP, as estimated, is presented in **Table 43**.

Table 43: Area requirement for deccetralized and centralized STPs

Edappally Canal	*Sewage treatment plant*			
	DSTP-I	*DSTP- II*	*DSTP- III*	*DSTP- IV*
Flow (MLD)	*10.5*	*10.25*	*8.40*	*2.10*
Area requirement* (ha)	**0.417**	**0.414**	**0.360**	**0.109**

Patolithot & Valiyath Canals	*Sewage treatment plant*				
	Alternative-I				Alterntaive-II
	DSTP-I	*DSTP- II*	*DSTP-III*	*DSTP- IV*	CSTP
Flow (MLD)	3.35	2.60	2.00	1.60	10.00
Area requirement* (ha)	**0.154**	**0.126**	**0.103**	**0.090**	**0.411**

*The projected area requirement is tentative and may have minor changes based on detailed engineering.

13.0 Cost estimate

The tentative capital cost is based on the basic engineering design of unit operations & processes for the proposed treatment scheme for decentralized and centralized sewage treatment plants. The capital cost has been estimated considering the Current Schedule of Rates (CSR)-2023, with a cost index of 135 (Kochi and Kollam) for civil works only and prevailing market rates for electro-mechanical works. The sizes of various treatment units/ facilities arrived at on the basis of basic design details of STPs, as detailed in **Tables 34 through 42**, and the rate of individual units for each treatment scheme formed the basis for the cost estimation of civil works. The projected costs are tentative and may change during detailed engineering as per the site.

The capital cost estimation comprised the cost of civil works, mechanical equipment, instrumentation facilities, electrical works, including MCC unit, LT& HT panels, cable laying, pipe laying-jointing, etc. The civil cost includes various unit operations and processes and their associated facilities, namely, centrifuge housing building, administrative cum laboratory building, and electrical and instrumentation panel room. The mechanical equipment includes pumps, blowers, scraper mechanisms, agitators, mixers, vendor-specific sand filters, activated carbon columns, centrifuge mechanisms, etc. The details of capital cost estimation are presented in **Tables 44 through 81** for the proposed DSTPs and CSTP.

Table 44 : Cost estimate of civil works for 10.5 MLD DSTP (Kochi Municipality)

Sr. No.	Particulars	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Receiving chamber	01	9.12	9.12
2.	Coarse screen	03	4.08	12.24
3.	Raw sewage sump	01	93.45	93.45
4.	Stilling tank	01	4.84	4.84
5.	Fine screen	03	1.69	5.08
6.	Grit chamber	02	2.41	4.82
7.	Sequential batch reactor (SBR)	04	283.25	1133
8.	Feeding Tank for PSF & ACF	01	103.79	103.79
9.	PSF& ACF (Base slab)	01	37.35	37.35
10.	Chlorination tank	01	72.84	72.84
11.	Treated sewage tank	01	103.79	103.79
12.	Sludge collection tank-I	01	21.54	21.54
13.	Gravity thickener	01	29.79	29.79
14.	Sludge collection tank-II	01	21.54	21.54
15.	Polyelectrolyte dosing system	02	0.25	0.50
16.	Chlorine dosing tank	02	0.11	0.22
17.	Lab cum admin	01	30	30
18.	Centrifuge building	01	20	20
19.	MCC room	01	26	26
				1729.90

PCF-Pressure sand filter; ACF-Activated carbon filter.

Table 45: Cost estimate of mechanical works for 10.50 MLD DSTP (Kochi Municipality)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Coarse screen-mechanical	2	8	16
2.	Coarse screen-manual	1	1	1
3.	Sewage Feed pump	5*	4.43	22.15
4.	Fine screen-mechanical	2	7	14
5.	Fine screen-manual	1	1.25	1.25
6.	Sequential batch reactor (SBR)			
	- Compressor/blower	5*	6.8	34
	- Decanter	4	35.50	142
7.	Pressure sand filter (PSF)			
	- Filter	10*	8	80
	- Feed pump for PSF	2*	3.3	6.6
8.	Activated carbon filter (ACF)			
	- Filter	10*	9	90
	- Filter blower	2*	2.8	5.6
9.	Chlorine dosing tank			
	- Agitator	1	2.2	2.2

	- Dosing pump	3*	1.5	4.5
10.	Sludge transfer pump-I	2*	0.5	1
11.	Sludge agitator-I	1	2	2
12.	Gravity thickener			
	- Scrapper mechanism biological	1	15	15
13.	Sludge transfer pump-II	2*	0.5	1
14.	Sludge agitato-II	1	2	2
15.	Polyelectrolyte dosing system			
	- Dosing pump	3*	2	6
	- Agitator	2	2	4
16.	Centrifuge feed pump	2*	2.25	4.5
17.	Centrifuge mechanism	1	40	40
			Mechanical cost	**494.8**

*One standby.

Table 46: Cost estimate of instrumentation works for 10.5 MLD DSTP (Kochi Municipality)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Pressure gauges	52	3000	156000
2.	Level switch (LS)	7	14000	98000
3.	Flow meter	2	400000	800000
4.	Pressure switch	5	84000	420000
5.	Level gauges	7	6000	42000
6.	Isolation ball valves for all instruments	150	600	90000
7.	Do meter	1	280000	280000
8.	Miscellaneous	Lumpsum	300000	300000
9.	Cables, trays, etc.	Lumpsum	280000	280000
10.	PLC, UPS, relays, protection, SCADA etc.	Lumpsum	1600000	1600000
11.	Solenoid valves	15	30000	450000
			Total cost	**4516000**
			Total cost in Lakhs	**45.16**

Table 47: Summary of capital cost for 10.50 MLD DSTP (Kochi Municipality)

Sr. No.	Items	Basis	Total Cost, ₹ Lakhs
A.	Total cost of civil works	-	**1729.91**
B.	Total cost of mechanical works	-	**494.8**
C.	Total cost of civil & mechanical works	**(A+B)**	**2224.71**
D.	Electrical works comprising MCC unit, LT & HT panels, cables, including laying in trenches, starter and illumination etc.	15% of **(B)**	**74.22**
E.	Piping, laying, jointing, valve fittings, and level indicator, etc.	12% of **(B)**	**59.38**
F.	Instrumentation		**45.16**
G.	Detailed engineering & construction supervision etc.	3% of **(C+D+E)**	**70.75**
H.	Contingencies	10% of **(C+D+E+F)**	**240.35**
		Total cost (₹) Lakh	**2714.57**

Table 48: Cost estimate of civil works for 10.25 MLD DSTP (Thrikkakara Municipality)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Receiving chamber	01	9.21	9.21
2.	Coarse screen	03	4.01	12.03
3.	Raw sewage sump	01	90.84	90.84
4.	Stilling tank	01	4.84	4.84
5.	Fine screen	03	1.69	5.07
6.	Grit chamber	02	2.41	4.82
7.	Sequential batch reactor (SBR)	04	283.25	1133
8.	Feeding tank for PSF& ACF	01	100.79	100.79
9.	PSF& ACF (foundation)	01	37.35	37.35
10.	Chlorination tank	01	70.81	70.81
11.	Treated sewage tank	01	100.79	100.79
12.	Sludge collection tank-I	01	21.54	21.54
13.	Gravity thickener	01	29.79	29.79
14.	Sludge collection tank-II	01	21.54	21.54
15.	Polyelectrolyte dosing system	02	0.25	0.50
16.	Chlorine dosing tank	02	0.11	0.22
17.	Lab cum admin	01	30	30
18.	Centrifuge building	01	20	20
19.	MCC room	01	26	26
			Civil Cost	**1719.14**

PSF- Pressure sand filter; ACF- Activated carbon filter.

Table 49: Cost estimate of mechanical works for 10.25 MLD DSTP (Thrikkakara Municipality)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Coarse screen-mechanical	2	8	16
2.	Coarse screen-manual	1	1	1
3.	Sewage transfer pump	5*	4.43	22.15
4.	Fine screen-mechanical	2	7	14
5.	Fine screen-manual	1	1.25	1.25
6.	SBR			
	- Compressor/blower	5*	6.8	34
	- Decanter	4	35.50	142
7.	Pressure Sand filter (PSF)			
	- Filter	10*	8	80
	- Feed pump for PSF	2*	3.3	6.6
8.	Activated carbon filter(ACF)			
	- Filter	10*	9	90
	- Filter blower	2*	2.8	5.6
9.	Chlorine dosing tank			
	- Agitator	1	2.2	2.2
	- Dosing pump	3*	1.5	4.5
10.	Sludge transfer pump-I	2*	0.5	1
11.	Sludge agitator-I	1	2	2
12.	Gravity thickener			
	Scrapper mechanism biological	1	15	15
13.	Sludge transfer pump-II	2*	0.5	1
14.	Sludge agitator-II	1	2	2
15.	Polyelectrolyte dosing system			
	- Dosing pump	3*	2	6
	- Agitator	2	2	4
16.	Centrifuge feed pump	2*	2.25	4.5
17.	Centrifuge mechanism	1	40	40
			Mechanical cost	**494.8**

*Onestandby.

Table 50: Cost estimate of instrumentation works for 10.25 MLD DSTP (Thrikkakara Municipality)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total Cost, ₹ Lakhs
1.	Pressure gauges	52	3000	156000
2.	Level switch (LS)	7	14000	98000
3.	Flow meter	2	400000	800000
4.	Pressure switch	5	84000	420000
5.	Level gauges	7	6000	42000
6.	Isolation ball valves for all instruments	150	600	90000
7.	Do meter	1	280000	280000
8.	Miscellaneous	Lump sum	300000	300000
9.	Cables, trays, etc.	Lump sum	280000	280000
10.	PLC, UPS, relays, protection, SCADA etc.	Lump sum	1600000	1600000
11.	Solenoid valves	15	30000	450000
			Instrumentation cost	**4516000**
			Cost in Lakhs	**45.16**

PLC-Programmable Logic Controller; UPS-Uninterruptible Power Supply.

Table 51: Summary of capital cost for 10.25 MLD DSTP (Thrikkakara Municipality)

Sr. No.	Particular	Basis	Total cost, ₹ Lakhs
A.	Total cost of civil works	-	**1719.14**
B.	Total cost of mechanical works	-	**494.8**
C.	Total cost of civil & mechanical works	**(A+B)**	**2213.94**
D.	Electrical works comprising MCC unit, LT & HT panels, cables, including laying in trenches, starter and illumination etc.	15% of **(B)**	**74.22**
E.	Piping, laying, jointing, valve fittings and level indicator etc.	12% of **(B)**	**59.38**
F.	Instrumentation	-	**45.16**
G.	Detailed engineering & construction supervision etc.	3% of **(C+D+E)**	**70.43**
H.	Contingencies	10% of **(C+D+E+F)**	**239.27**
		Total cost, (₹) Lakh	**2702.4**

Table 52: Cost estimate of civil works for 8.40 MLD DSTP (Kalamassery Municipality)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Receiving chamber	01	8.41	8.41
2.	Coarse screen	03	3.80	11.40
3.	Raw sewage sump	01	80.36	80.36
4.	Stilling tank	01	4.63	4.63
5.	Fine screen	03	1.66	4.99
6.	Grit chamber	02	2.05	4.10
7.	Sequential batch reactor (SBR)	04	245.46	981.85
8.	Feeding Tank for PSF& ACF	01	89.20	89.20
9.	PSF& ACF (Foundation)	01	37.35	37.35
10.	Chlorination tank	01	62.96	62.96
11.	Treated sewage tank	01	89.20	89.20
12.	Sludge collection tank-I	01	18.49	18.49
13.	Gravity thickener	01	26.54	26.54
14.	Sludge collection tank-II	01	18.49	18.49
15.	Polyelectrolyte dosing system	02	0.20	0.40
16.	Chlorine dosing tank	02	0.08	0.16
17.	Lab cum admin	01	30	30
18.	Centrifuge building	01	20	20
19.	MCC room	01	26	26
			Civil Cost	**1514.53**

PSF- Pressure sand filter; ACF- Activated carbon filter.

Table 53: Cost estimate of mechanical works for 8.40 MLD DSTP (Kalamassery Municipality)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Coarse screen-mechanical	2	8	16
2.	Coarse screen-manual	1	1	1
3.	Sewage transfer pump	5*	3.75	18.75
4.	Fine screen-mechanical	2	7	14
5.	Fine screen-manual	1	1.25	1.25
6.	SBR			
	- Compressor/blower	5*	6	30
	- Decanter	4	34	136
7.	Pressure sand filter (PSF)			
	- Filter	8*	8	64
	- Feed pump for PSF	2*	2.90	5.8
8.	Activated carbon filter(ACF)			
	- Filter	8*	9	72
	- Filter blower	2*	2.4	4.8
9.	Chlorine dosing tank			
	- Agitator	1	2.2	2.2
	- Dosing pump	3*	1.5	4.5
10.	Sludge transfer pump-I	2*	0.5	1
11.	Sludge agitator-I	1	2	2

12.	Gravity thickener			
	- Scrapper mechanism biological	1	10	10
13.	Sludge transfer pump-II	2*	0.5	1
14.	Sludge agitator-II	1	2	2
15.	Polyelectrolyte dosing system			
	- Dosing pump	3*	2	6
	- Agitator	2	2	4
16.	Centrifuge feed pump	2*	2.25	4.5
17.	Centrifuge mechanism	1	40	40
			Mechanical cost	**440.8**

*Onestandby.

Table 54: Cost estimate of instrumentation works for 8.40 MLD DSTP (Kalamassery Municipality)

Sr. No.	Particulars	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Pressure gauges	52	3000	156000
2.	Level switch (LS)	7	14000	98000
3.	Flow meter	2	350000	700000
4.	Pressure switch	5	84000	420000
5.	Level gauges	7	6000	42000
6.	Isolation ball valves for all instruments	150	600	90000
7.	Do meter	1	280000	280000
8.	Miscellaneous	Lump sum	300000	300000
9.	Cables, trays, etc.	Lump sum	280000	280000
10.	PLC, UPS, relays, protection, SCADA etc.	Lump sum	1500000	1500000
11.	Solenoid valves	15	30000	450000
			Instrumentation cost	**4316000**
			Cost in Lakhs	**43.16**

PLC: Programmable Logic Controller, UPS: Uninterruptible Power Supply.

Table 55: Summary of capital cost for 8.40 MLD DSTP (Kalamassery Municipality)

Sr. No.	Particular	Basis	Total cost, ₹ Lakhs
A.	Total cost of civil works	-	**1514.53**
B.	Total cost of mechanical works	-	**440.8**
C.	Total cost of civil & mechanical works	**(A+B)**	**1955.33**
D.	Electrical works comprising MCC unit, LT & HT panels, cables, including laying in trenches, starter and illumination etc.	15% of **(B)**	**66.12**
E.	Piping, laying, jointing, valve fittings and level indicator etc.	12% of **(B)**	**52.9**
F.	Instrumentation		**43.16**
G.	Detailed engineering & construction supervision etc.	3% of **(C+D+E)**	**62.23**
H.	Contingencies	10% of **(C+D+E+F)**	**211.75**
		Total cost, (₹) Lakh	**2391.49**

Table 56: Cost estimate of civil works for 2.10 MLD DSTP (Thripunithura Municipality)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Receiving chamber	01	4.30	4.30
2.	Coarse screen	02	4.53	9.06
3.	Raw sewage sump	01	28.72	28.72
4.	Stilling tank	01	2.81	2.81
5.	Fine screen	02	1.68	3.37
6.	Grit chamber	02	2.23	4.46
7.	Sequential batch reactor (SBR)	04	72.34	289.36
8.	Feeding Tank for PSF&ACF	01	20.26	20.26
9.	PSF& ACF (foundation)	01	15.45	15.45
10.	Chlorination tank	01	15.51	15.51
11.	Treated sewage tank	01	20.26	20.26
12.	Sludge collection tank-I	01	7.27	7.27
13.	Gravity thickener	01	9.68	9.68
14.	Sludge collection tank-II	01	7.27	7.27
15.	Polyelectrolyte dosing system	01	0.10	0.10
16.	Chlorine dosing tank	01	0.05	0.05
17.	Lab cum admin	01	20	20
18.	Centrifuge building	01	5.5	5.5
19.	MCC room	01	7.15	7.15
			Civil cost	**470.58**

PSF- Pressure sand filter; ACF- Activated carbon filter.

Table 57: Cost estimate of mechanical works for 2.10 MLD DSTP (Thripunithura Municipality)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Coarse screen-mechanical	1	5	5
2.	Coarse screen-manual	1	0.75	0.75
3.	Sewage transfer pump	5*	2.24	11.2
4.	Fine screen-mechanical	1	4.5	4.5
5.	Fine screen-manual	1	0.9	0.9
6.	SBR			
	- Compressor/blower	3*	5.2	15.6
	- Decanter	4	24.75	99
7.	Pressure sand filter (PSF)			
	- Filter	3*	8	24
	- Feed pump for PSF	2*	0.7	1.4
8.	Activated carbon filter(ACF)			
	- Filter	3*	9	27
	- Filter blower	2*	1.3	2.6
9.	Chlorine dosing tank			
	- Agitator	1	2.2	2.2
	- Dosing pump	2*	0.55	1.1
10.	Sludge transfer pump-I	2*	0.4	0.8
11.	Sludge agitator-I	1	1.5	1.5
12.	Gravity thickener			
	- Scrapper mechanism biological	1	5	5
13.	Sludge transfer pump-II	2*	0.5	1
14.	Sludge agitator-II	1	1.5	1.5
15.	Polyelectrolyte dosing system			
	- Dosing pump	3*	0.75	2.25
	- Agitator	2	0.75	1.5
16.	Centrifuge feed pump	2*	1	2
17.	Centrifuge mechanism	1	15	15
			Mechanical cost	**225.8**

*Onestandby.

Table 58: Cost estimate of instrumentation works for 2.10 MLD DSTP (Thripunithura Municipality)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Pressure gauges	40	3000	120000
2.	Level switch (LS)	6	14000	84000
3.	Flow meter	2	108000	216000
4.	Pressure switch	4	84000	336000
5.	Level gauges	6	6000	36000
6.	Isolation ball valves for all instruments	150	600	90000
7.	Do meter	1	280000	280000
8.	Miscellaneous	Lump sum	300000	300000
9.	Cables, trays, etc.	Lump sum	280000	280000
10.	PLC, UPS, relays, protectic SCADA etc.	Lump sum	1200000	1200000
11.	Solenoid valves	6	30000	180000
			Instrumentation cost	**3122000**
			Cost in lakhs	**31.22**

PLC- Programmable Logic Controller, UPS-Uninterruptible Power Supply.

Table 59: Summary of capital cost for 2.10 MLD DSTP (Thripunithura Municipality)

Sr. No.	Particular	Basis	Total cost, ₹ Lakhs
A.	Total cost of civil works	-	**470.58**
B.	Total cost of mechanical works	-	**225.8**
C.	Total cost of civil & mechanical works	**(A+B)**	**696.38**
D.	Electrical works comprising MCC unit, LT & HT panels, cables, including laying in trenches, starter and illumination etc.	15% of **(B)**	**33.87**
E.	Piping, laying, jointing, valve fittings and level indicator etc.	12% of **(B)**	**27.09**
F.	Instrumentation		**31.22**
G.	Detailed engineering & construction supervision etc.	3% of **(C+D+E)**	**22.72**
H.	Contingencies	10% of **(C+D+E+F)**	**78.87**
		Total cost, (₹) Lakh	**890.15**

Table 60: Cost estimate of civil works for 3.35 MLD DSTP (Karunagapally Municipality)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total Cost, ₹ Lakhs
1.	Receiving chamber	01	4.90	4.90
2.	Coarse screen	03	3.17	9.52
3.	Raw sewage sump	01	32.46	32.46
4.	Stilling tank	01	3.21	3.21
5.	Fine screen	03	1.17	3.50
6.	Grit chamber	02	1.31	2.62
7.	Sequential batch reactor (SBR)	04	99.60	398.40
8.	Feeding tank for PSF& ACF	01	30.28	30.28
9.	PSF& ACF (foundation)	01	18.40	18.40
10.	Chlorination tank	01	20.26	20.26
11.	Treated sewage tank	01	30.28	30.28
12.	Sludge collection tank-I	01	9.21	9.21
13.	Gravity thickener	01	12.32	12.32
12.	Sludge collection tank-II	01	9.21	9.21
15.	Polyelectrolyte dosing system	02	0.10	0.20
16.	Chlorine dosing tank	01	0.07	0.07
17.	Lab cum admin	01	20	20
18.	Centrifuge building	01	10	10
19.	MCC room	01	13	13
			Civil cost	**627.84**

PSF- Pressure sand filter; ACF- Activated carbon filter.

Table 61: Cost estimate of mechanical works for 3.35 MLD DSTP (Karunagapally Municipality)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total Cost, ₹ Lakhs
1.	Coarse screen-mechanical	1	5	5
2.	Coarse screen-manual	1	0.75	0.75
3.	Sewage transfer pump	5*	2.72	13.6
4.	Fine screen-mechanical	1	4.5	4.5
5.	Fine screen-manual	1	0.9	0.9
6.	SBR			
	- Compressor/blower	3*	5.2	15.6
	- Decanter	4	24.75	99
7.	Pressure sand filter (PSF)			
	- Filter	4*	8	32
	- Feed pump for PSF	2*	2.24	4.48
8.	Activated carbon filter (ACF)			
	- Filter	4*	9	36
	- Filter blower	2*	1.75	3.5
9.	Chlorine dosing tank			
	- Agitator	1	2.2	2.2

	- Dosing pump	2*	0.55	1.1
10.	Sludge transfer pump-I	2*	0.4	0.8
11.	Sludge agitator-I	1	1.5	1.5
12.	Gravity thickener			
	- Scrapper mechanism biological	1	7	7
13.	Sludge transfer pump-II	2*	0.4	0.8
14.	Sludge agitator-II	1	1.5	1.5
15.	Polyelectrolyte dosing system			
	- Dosing pump	3*	0.75	2.25
	- Agitator	2	0.75	1.5
16.	Centrifuge feed pump	2*	1.1	2.2
17.	Centrifuge mechanism	1	25	25
			Mechanical cost	**261.18**

*One standby.

Table 62: Cost estimate of instrumentation works for 3.35 MLD DSTP (Karunagapally Municipality)

Sr. No.	Particular	No.	Cost per unit, ₹	Total cost, ₹
1.	Pressure gauges	45	3000	135000
2.	Level switch (LS)	6	14000	84000
3.	Flow meter	2	108000	216000
4.	Pressure switch	4	84000	336000
5.	Level gauges	6	6000	36000
6.	Isolation ball valves for all instruments	150	600	90000
7.	Do meter	1	280000	280000
8.	Miscellaneous	Lump sum	300000	300000
9.	Cables, trays, etc.	Lump sum	280000	280000
10.	PLC, UPS, relays, protection, SCADA etc.	Lump sum	1200000	1200000
11.	Solenoid valves	6	30000	180000
			Instrumentation cost	**3137000**
			Cost in Lakhs	**31.37**

PLC-Programmable Logic Controller, UPS- Uninterruptible Power Supply.

Table 63: Summary of capital cost for 3.35 MLD DSTP (Karunagapally Municipality)

Sr. No.	Particular	Basis	Total cost, ₹ Lakhs
A.	Total cost of civil works	-	**627.84**
B.	Total cost of mechanical works	-	**261.18**
C.	Total cost of civil & mechanical works	**(A+B)**	**889.02**
D.	Electrical works comprising MCC unit, LT & HT panels, cables, including laying in trenches, starter and illumination etc.	15% of **(B)**	**39.18**
E.	Piping, laying, jointing, valve fittings and level indicator etc.	12% of **(B)**	**31.34**
F.	Instrumentation		**31.37**
G.	Detailed engineering & construction supervision etc.	3% of **(C+D+E)**	**28.79**
H.	Contingencies	10% of **(C+D+E+F)**	**99.09**
		Total cost, (₹) Lakhs	**1118.79**

Table 64: Cost estimate of civil works for 2.60 MLD DSTP (Kulasekharapuram local body)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Receiving chamber	01	4.61	4.61
2.	Coarse screen	02	4.74	9.49
3.	Raw sewage sump	01	28.72	28.72
4.	Stilling tank	01	2.81	2.81
5.	Fine screen	02	1.7	3.41
6.	Grit chamber	02	1.11	2.23
7.	Sequential batch reactor (SBR)	04	76.61	306.45
8.	Feeding tank for PSF& ACF	01	22.63	22.63
9.	PSF& ACF (foundation)	01	18.40	18.40
10.	Chlorination tank	01	17.22	17.22
11.	Treated sewage tank	01	22.63	22.63
12.	Sludge collection tank-I	01	7.95	7.95
13.	Gravity thickener	01	10.98	10.98
14.	Sludge collection tank-II	01	7.95	7.95
15.	Polyelectrolyte dosing system	01	0.15	0.15
16.	Chlorine dosing tank	01	0.05	0.05
17.	Lab cum admin	01	20	20
18.	Centrifuge building	01	6	6
19.	MCC room	01	7.8	7.8
			Civil Cost	**499.48**

PSF- Pressure sand filter; ACF- Activated carbon filter.

Table 65: Cost estimate of mechanical works for 2.60 MLD DSTP(Kulasekharapuram local body)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Coarse screen-mechanical	1	5	5
2.	Coarse screen-manual	1	0.75	0.75
3.	Sewage Feed pump	5*	2.24	11.2
4.	Fine screen-mechanical	1	4.5	4.5
5.	Fine screen-manual	1	0.9	0.9
6.	SBR			
	- Compressor/blower	3*	5.2	15.6
	- Decanter	4	24.75	99
7.	Pressure sand filter (PSF)			
	- Filter	4*	8	32
	- Feed pump for PSF	2*	2.24	4.48
8.	Activated carbon filter (ACF)			
	- Filter	4*	9	36
	- Filter blower	2*	1.65	3.3
9.	Chlorine dosing tank			
	- Agitator	1	2.2	2.2
	- Dosing pump	2*	0.55	1.1
10.	Sludge transfer pump-I	2*	0.4	0.8
11.	Sludge agitator-I	1	1.5	1.5
12.	Gravity thickener			
	- Scrapper mechanism biological	1	5	5
13.	Sludge transfer pump-II	2*	0.4	0.8
14.	Sludge agitator-II	1	1.5	1.5
15.	Polyelectrolyte dosing system			
	- Dosing pump	2*	0.75	2.25
	- Agitator	2	0.75	1.5
16.	Centrifuge feed pump	2*	1	2
17.	Centrifuge mechanism	1	15	15
			Mechanical cost	**246.38**

*One standby.

Table 66: Cost estimate of instrumentation works for 2.60 MLD DSTP (Kulasekharapuram local body)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Pressure gauges	40	3000	120000
2.	Level switch (LS)	6	14000	84000
3.	Flow meter	2	108000	216000
4.	Pressure switch	4	84000	336000
5.	Level gauges	6	6000	36000
6.	Isolation ball valves for all instruments	150	600	90000
7.	Do meter	1	280000	280000
8.	Miscellaneous	Lump sum	300000	300000
9.	Cables, trays, etc.	Lump sum	280000	280000
10.	PLC, UPS, relays, protection, SCADA etc.	Lump sum	1200000	1200000
11.	Solenoid valves	6	30000	180000
Instrumentation cost				**3122000**
Cost in Lakhs				**31.22**

PLC: Programmable Logic Controller, UPS: Uninterruptible Power Supply.

Table 67: Summary of capital cost for 2.60 MLD DSTP (Kulasekharapuram local body)

Sr. No.	Particular	Basis	Total cost, ₹ Lakhs
A.	Total cost of civil works	-	**499.48**
B.	Total cost of mechanical works	-	**246.83**
C.	Total cost of civil & mechanical works	**(A+B)**	**745.86**
D.	Electrical works comprising MCC unit, LT & HT panels, cables, including laying in trenches, starter and illumination etc.	15% of **(B)**	**36.95**
E.	Piping, laying, jointing, valve fittings, and level indicator, etc.	12% of **(B)**	**29.56**
F.	Instrumentation		**31.22**
G.	Detailed engineering & construction supervision etc.	3% of **(C+D+E)**	**24.36**
H.	Contingencies	10% of **(C+D+E+F)**	**84.35**
Total cost, (₹) Lakhs			**952.30**

Table 68: Cost estimate of civil works for 2.00 MLD DSTP (Thodiyoor local body)

Sr. No	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Receiving chamber	01	4.29	4.29
2.	Coarse screen	02	4.47	8.94
3.	Raw sewage sump	01	28.72	28.72
4.	Stilling tank	01	2.62	2.62
5.	Fine screen	02	1.66	3.32
6.	Grit chamber	02	1	2
7.	Sequential batch reactor (SBR)	04	68.68	274.71
8.	Feeding tank for PSF& ACF	01	19.35	19.35
9.	PSF& ACF (foundation)	01	15.45	15.45
10.	Chlorination tank	01	14.68	14.68
11.	Treated sewage tank	01	19.35	19.35
12.	Sludge collection tank-I	01	6.75	6.75
13.	Gravity thickener	01	9.68	9.68
14.	Sludge collection tank-II	01	6.75	6.75
15.	Polyelectrolyte dosing system	01	0.10	0.10
16.	Chlorine dosing tank	01	0.05	0.05
17.	Lab cum admin	01	20	20
18.	Centrifuge building	01	5.6	5.6
19.	MCC room	01	7.3	7.3
			Civil cost	**449.66**

PSF-Pressure sand filter, ACF-Activated carbon filter.

Table 69: Cost estimate of mechanical works for 2.00 MLD DSTP (Thodiyoor local body)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Coarse screen-mechanical	1	5	5
2.	Coarse screen-manual	1	0.75	0.75
3.	Sewage transfer pump	5*	2.24	11.2
4.	Fine screen-mechanical	1	4.5	4.5
5.	Fine screen-manual	1	0.9	0.9
6.	SBR			
	- Compressor/blower	3*	5.2	15.6
	- Decanter	4	24.75	99
7.	Pressure sand filter (PSF)			
	- Filter	4*	8	32
	- Feed pump for PSF	2*	0.7	1.4
8.	Activated carbon filter (ACF)			
	- Filter	4*	9	36
	- Filter blower	2*	1.3	2.6
9.	Chlorine dosing tank			
	- Agitator	1	2.2	2.2
	- Dosing pump	2*	0.55	1.1
10.	Sludge transfer pump-I	2*	0.4	0.8
11.	Sludge agitator-I	1	1.5	1.5
12.	Gravity thickener			
	- Scrapper mechanism biological	1	5	5
13.	Sludge transfer pump-II	2*	0.4	0.8
14.	Sludge agitator-II	1	1.5	1.5
15.	Polyelectrolyte dosing system			
	- Dosing pump	3*	0.75	2.25
	- Agitator	2	0.75	1.5
16.	Centrifuge feed pump	2*	1	2
17.	Centrifuge mechanism	1	15	15
			Mechanical cost	**242.60**

*One standby.

Table 70: Cost estimate of instrumentation works for 2.00 MLD DSTP (Thodiyoor local body)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Pressure gauges	40	3000	120000
2.	Level switch (LS)	6	14000	84000
3.	Flow meter	2	108000	216000
4.	Pressure switch	4	84000	336000
5.	Level gauges	6	6000	36000
6.	Isolation ball valves for all instruments	150	600	90000
7.	Do meter	1	280000	280000
8.	Miscellaneous	Lump sum	300000	300000
9.	Cables, trays, etc.	Lump sum	280000	280000
10.	PLC, UPS, relays, protection, SCADA etc.	Lump sum	1200000	1200000
11.	Solenoid valves	6	30000	180000
Instrumentation cost				**3122000**
Cost in Lakhs				**31.22**

PLC- Programmable Logic Controller; UPS- Uninterruptible Power Supply.

Table 71: Summary of capital cost for 2.00 MLD DSTP (Thodiyoor local body)

Sr. No.	Particular	Basis	Total cost, ₹ Lakhs
A.	Total cost of civil works	-	**449.66**
B.	Total cost of mechanical works	-	**242.60**
C.	Total cost of civil & mechanical works	**(A+B)**	**692.26**
D.	Electrical works comprising MCC unit, LT & HT panels, cables, including laying in trenches, starter and illumination etc.	15% of **(B)**	**36.39**
E.	Piping, laying, jointing, valve fittings and level indicator etc.	12% of **(B)**	**29.11**
F.	Instrumentation	-	**31.22**
G.	Detailed engineering & construction supervision etc.	3% of **(C+D+E)**	**22.73**
H.	Contingencies	10% of **(C+D+E+F)**	**78.89**
Total cost, (₹) Lakhs			**890.60**

Table 72: Cost estimate of civil works for 1.6 MLD DSTP (Thazhava local body)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Receiving chamber	01	3.97	3.97
2.	Coarse screen	02	4.40	8.80
3.	Raw sewage sump	01	23.75	23.75
4.	Stilling tank	01	2.62	2.62
5.	Fine screen	02	1.66	3.31
6.	Grit chamber	02	1.00	2.00
7.	Sequential batch reactor (SBR)	04	59.59	238.37
8.	Feeding tank for PSF& ACF	01	17.14	17.14
9.	PSF& ACF (Foundation)	01	15.45	15.45
10.	Chlorination tank	01	13.08	13.08
11.	Treated sewage tank	01	17.14	17.14
12.	Sludge collection tank-I	01	5.99	5.99
13.	Gravity thickener	01	8.84	8.84
14.	Sludge collection tank-II	01	5.99	5.99
15.	Polyelectrolyte dosing system	01	0.10	0.10
16.	Chlorine dosing tank	01	0.05	0.05
17.	Lab cum admin	01	20.00	20.00
18.	Centrifuge building	01	5.00	5.00
19.	MCC room	01	6.50	6.50
			Civil cost	**398.10**

PSF- Pressure sand filter; ACF-Activated carbon filter.

Table 73: Cost estimate of mechanical works for 1.6 MLD DSTP (Thazhava local body)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Coarse screen-mechanical	1	5	5
2.	Coarse screen-manual	1	0.75	0.75
3.	Sewage transfer pump	5*	2.24	11.2
4.	Fine screen-mechanical	1	4.5	4.5
5.	Fine screen-manual	1	0.9	0.9
6.	SBR			
	- Compressor/blower	2*	5.2	10.4
	- Decanter	4	24.75	99
7.	Pressure sand filter (PSF)			
	- Filter	3*	8	24
	- Feed pump for PSF	2*	0.7	1.4
8.	Activated carbon filter (ACF)			
	- Filter	3*	9	27
	- Filter blower	2*	1.3	2.6
9.	Chlorine dosing tank			
	- Agitator	1	2.2	2.2
	- Dosing pump	2*	0.55	1.1
10.	Sludge transfer pump-I	2*	0.4	0.8
11.	Sludge agitator-I	1	1.5	1.5
12.	Gravity thickener			
	- Scrapper mechanism biological	1	5	5
13.	Sludge transfer pump-II	2*	0.4	0.8
14.	Sludge agitator-II	1	1.5	1.5
15.	Polyelectrolyte dosing system			
	- Dosing pump	3*	0.75	2.25
	- Agitator	2	0.75	1.5
16.	Centrifuge feed pump	2*	1	2
17.	Centrifuge mechanism	1	15	15
			Mechanical cost	**220.40**

*One standby.

Table 74: Cost estimate of instrumentation works for 1.6 MLD DSTP (Thazhava local body)

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Pressure gauges	40	3000	120000
2.	Level switch (LS)	6	14000	84000
3.	Flow meter	2	108000	216000
4.	Pressure switch	4	84000	336000
5.	Level gauges	6	6000	36000
6.	Isolation ball valves for all instruments	150	600	90000
7.	Do meter	1	280000	280000
8.	Miscellaneous	Lump sum	300000	300000
9.	Cables, trays, etc.	Lump sum	280000	280000
10.	PLC, UPS, relays, protection, SCADA etc.	Lump sum	1200000	1200000
11.	Solenoid valves	6	30000	180000
Instrumentation cost				**3122000**
Cost in Lakhs				**31.22**

PLC- Programmable Logic Controller; UPS-Uninterruptible Power Supply.

Table 75: Summary of capital cost for 1.6 MLD DSTP (Thazhava local body)

Sr. No.	Particular	Basis	Total cost, ₹ Lakhs
A.	Total cost of civil works	-	**398.10**
B.	Total cost of mechanical works	-	**220.40**
C.	Total cost of civil & mechanical works	**(A+B)**	**618.50**
D.	Electrical works comprising MCC unit, LT & HT panels, cables, including laying in trenches, starter, illumination, etc.	15% of **(B)**	**33.06**
E.	Piping, laying, jointing, valve fittings and level indicator etc.	12% of **(B)**	**26.45**
F.	Instrumentation		**31.22**
G.	Detailed engineering & construction supervision etc.	3% of **(C+D+E)**	**20.34**
H.	Contingencies	10% of **(C+D+E+F)**	**70.92**
Total cost, (₹) Lakhs			**800.49**

Table 76: Cost estimate of civil works for 10 MLD Centralized STP

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Receiving chamber	01	8.74	8.74
2.	Coarse screen	03	4.01	12.03
3.	Raw sewage sump	01	86.78	86.87
4.	Stilling tank	01	4.63	4.63
5.	Fine screen	03	1.69	5.06
6.	Grit chamber	02	2.32	4.64
7.	Sequential batch reactor (SBR)	04	283.25	1133.00
8.	Feeding tank for PSF& ACF	01	100.79	100.79
9.	PSF& ACF (Foundation)	01	37.35	37.35
10.	Chlorination tank	01	69.80	69.80
11.	Treated sewage tank	01	100.79	100.79
12.	Sludge collection tank-I	01	20.21	20.21
13.	Gravity thickener	01	29.13	29.13
14.	Sludge collection tank-II	01	20.21	20.21
15.	Polyelectrolyte dosing system	02	0.25	0.50
16.	Chlorine dosing tank	02	0.1	0.2
17.	Lab cum admin	01	30	30
18.	Centrifuge building	01	20	20
19.	MCC room	01	26	26
			Civil cost	**1709.95**

PSF- Pressure sand filter; ACF- Activated carbon filter.

Table 77: Cost estimate of mechanical works for 10 MLD Centralized STP

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Coarse screen-mechanical	1	8	8
2.	Coarse screen-manual	1	1	1
3.	Sewage transfer pump	5*	4.43	22.15
4.	Fine screen-mechanical	1	7	7
5.	Fine screen-manual	1	1.25	1.25
6.	SBR			
	- Compressor/blower	5*	6.8	34
	- Decanter	4	35.50	142
7.	Pressure sand filter (PSF)			
	- Filter	10*	8	80
	- Feed pump for PSF	2*	3.30	6.6
8.	Activated carbon filter (ACF)			
	- Filter	10*	9	90
	- Filter blower	2*	2.8	5.6
9.	Chlorine dosing tank			
	- Agitator	1	2.2	2.2
	- Dosing pump	3*	1.5	4.5
10.	Sludge transfer pump-I	2*	0.5	1
11.	Sludge agitator-I	1	2	2
12.	Gravity thickener			
	- Scrapper mechanism biological	1	12	12
13.	Sludge transfer pump-II	2*	0.5	1
14.	Sludge agitator-II	1	2	2
15.	Polyelectrolyte dosing system			
	- Dosing pump	3*	2	6
	- Agitator	2	2	4
16.	Centrifuge feed pump	2*	2.25	4.5
17.	Centrifuge mechanism	1	40	40
			Mechanical cost	**476.80**

*One standby.

Table 78: Cost estimate of instrumentation works for 10 MLD Centralized STP

Sr. No.	Particular	No.	Cost per unit, ₹ Lakhs	Total cost, ₹ Lakhs
1.	Pressure gauges	52	3000	156000
2.	Level Switch (LS)	7	14000	98000
3.	Flow meter	2	400000	800000
4.	Pressure switch	5	84000	420000
5.	Level gauges	7	6000	42000
6.	Isolation ball valves for all instruments	150	600	90000
7.	Do meter	1	280000	280000
8.	Miscellaneous	Lump sum	300000	300000
9.	Cables, trays, etc.	Lump sum	280000	280000
10.	PLC, UPS, relays, protection, SCADA etc.	Lump sum	1500000	1200000
11.	Solenoid valves	15	30000	450000
Instrumentation cost				**4116000**
Cost in Lakhs				**41.16**

PLC- Programmable Logic Controller, UPS- Uninterruptible Power Supply.

Table 79: Summary of Capital Cost for 10 MLD Centralized STP

Sr. No.	Particular	Basis	Total cost, ₹ Lakhs
A.	Total cost of civil works	-	**1709.95**
B.	Total cost of mechanical works	-	**476.08**
C.	Total cost of civil & mechanical works	**(A+B)**	**2186.03**
D.	Electrical works comprising MCC unit, LT & HT panels, cables, including laying in trenches, starter and illumination etc.	15% of **(B)**	**71.41**
E.	Piping, laying, jointing, valve fittings and level indicator etc.	12% of **(B)**	**57.12**
F.	Instrumentation		**41.16**
G.	Detailed engineering & construction supervision etc.	3% of **(C+D+E)**	**69.43**
H.	Contingencies	10% of **(C+D+E+F)**	**235.75**
Total cost, (₹) Lakhs			**2660.90**

The O&M cost for civil and mechanical works has been estimated at the rate of 2% and 7% of the capital investment, respectively. The costs of chemicals, power requirements, and staff have also been worked out based on actual requirements and included in the O&M cost estimation. The capital cost has been annualized over a

period of 30 years for civil works and 15 years for mechanical, electrical works, and instrumentation facilities to evolve a common basis for cost comparison amongst the proposed treatment scheme. A summary of the capital cost for decentralized and centralized treatment systems proposed for the STPs is detailed in **Tables 80 and 81**.

Table 80: Summary of cost estimation for the proposed four STPs of Thevara-perandoor and Edappally Canals (Ernakullam)

STP Flow, MLD	Capital cost (₹, L)				Total capital cost (₹, L)	Ann-ualised capital cost# (₹, L/A)	O&M cost@ (₹, L/A)	Total annualised cost (₹, L/A)
	Civil works	Mech-anical works	Instru-menation	Others*				
Thevara-perandoor Canal								
Kochi Municipality								
10.50	1729.90	494.80	45.16	444.71	2714.57	269.17	103.52	372.69
Edappally Canal								
Thrikkakara Municipality								
10.25	1719.14	494.80	45.16	443.30	2702.40	268.04	103.21	371.26
Kalamassery Municipality								
8.40	1514.53	440.80	43.16	393.00	2391.49	237.40	91.68	329.08
Thripunithura Municipality								
2.10	470.58	225.80	31.22	162.56	890.16	90.98	38.78	129.77

* Includes electrical works, pipe laying, detailed engineering & construction supervision and contingencies.
# Civil cost annualised over a period of 30 years and 15 years for mechanical equipment & others at a rate of interest of 8%
@ O&M for civil works is considered to be 2% and 7% for mechanical equipment & others; chemical, energy & Manpower etc.L- Lakh, A-Annum

Table 81: Summary of cost estimation for proposed STPs of Patolithot and Valiyath Canals (Kollam)

STP Flow, MLD	Capital cost (₹, L)				Total capital cost (₹, L)	Annualised capital cost# (₹, L/A)	O&M cost@ (₹, L/A)	Total ann-ualised cost (₹, L/A)
	Civil works	Mech-anical works	Instru-menation	Others*				
Patolithot and Valiyath Canals								
Alternative-I (Decentralized STPs)								
Karunagapally Municipality								
3.35	627.84	261.18	31.37	198.40	1118.79	113.32	46.92	160.24
Kulasekharapuram local body								
2.60	499.48	245.38	31.22	176.22	952.30	97.43	41.68	139.11
Thazhava local body								
1.60	398.10	220.40	31.22	150.77	800.49	82.51	36.13	118.64
Thodiyoor local body								
2.00	449.66	242.60	31.22	167.12	890.60	91.60	39.86	131.46
Alternative- II (Centralized STP)								
10.00	1709.95	476.80	41.16	432.99	2660.90	263.44	100.76	364.20

* Includes electrical works, pipe laying, detailed engineering & construction supervision and contingencies
# Civil cost annualised over a period of 30 years and 15 years for mechanical equipment & others at a rate of interest of 8%
@ O&M for civil works is considered to be 2% and 7% for mechanical equipment & others; chemical, energy & Manpower etc.L- Lakh, A- Annum

14.0 Project implementation

The implementation strategy and schedule are the keys to successfully executing the project, which deals with the activities and timeline for completing the project. The project's pre-requisite activities should be well defined and run properly to clear all redundancy for the post activities of the project. In the present study, a total of four sewage treatment plants are proposed for Edapally Canal (EC), one each for Kochi, Thrikkakara, Kalamassery, and Thripunithura Municipalities, as presented in **Table 28**. The Kochi Municipal Corporation has already proposed four STPs for the Thevara-Perandoor Canal. A total of four STPs are proposed for the Patolithot and Valiyath Canals, first for Karunagapally Municipality (16 wards), second for Kulasekharapuram local body (12 wards), third for Thazhava local body (9 wards), and fourth for Thodiyoor local body (9 wards) as presented in **Table 29**. The treatment scheme for seven STPs is delineated in **Section 19.0**. The details of the tentative project implementation strategy and schedule for the recommended treatment scheme are delineated in **Table 82**.

Table 82: Details of the tentative project implementation strategy and schedule for the recommended treatment scheme

Particular	Strategy for project implementation	Schedule
Implementation of the recommended treatment scheme	− Site selection for the implementation of the proposed decentralized and centralized sewage treatment plants by the respective Municipalities and Local Bodies. − Plan for interception of sewage from the identified and non-identified drains to the proposed sewage treatment plant sites selected by the respective Municipalities and Local Bodies. − Plan for the conveyance system, including the pumping station, for carrying the domestic sewage from the drains and households to the proposed STP sites of the respective Municipalities and Local Bodies.	Two months
	Preparation of the Detailed Project Reports (DPRs) based on the feasibility report for the recommended treatment scheme, the interception of the drains' sewage and conveyance of domestic sewage to the proposed STP sites selected by the respective Municipalities and Local Bodies.	One month

	Detailed engineering of the treatment scheme, including structural details with approval, site topography & capital cost estimate, etc, for the proposed treatment scheme for implementation of the STPs.	One months
	Approval from the sanctioning authority for the implementation of the treatment scheme.	One month
	Tendering of work.	Two months
	Approval for tendering and award for composite works.	One month
	Implementation of all project activities.	Six months
	Commissioning of the sewage treatment plants.	Two months

15.0 Strategies and recommendations for pollution abatement of Canal

It is imperative that an appropriate strategy be developed with the intention of creating detailed development plans to catalyze the Canal and adjoining areas into an ecological asset. With this aim, the following sections provide key strategies and recommendations for pollution abatement in the Canal. Restoration of a degraded Canal is often considered as returning it to its previously undisturbed condition by reconstructing the structure and function of the pre-disturbance ecosystem. However, due to anthropogenic pressures, it is impractical for most Canal to restore to the pre-disturbed state. In fact, restoring the Canal to a pre-disturbed state is rarely (if ever) possible. For practical purposes, post- and current-human intervention should be considered to achieve a more natural, sustainable canal habitat rich in status. Therefore, urban drainage and public perception must be addressed. The Canal strategies should be associated with watershed-focused enhancement and land management pressures. Any planning and design should interface between the Municipalities and Local Bodies and the course of the Canal to ensure it can be protected. In summary, the strategies for developing a management plan for the Canal are to:

- Implement specific measures for the progressive reduction of discharges of sewage and solid waste disposal into the Canal and the cessation or phasing-out of discharges into the Canal.
- Prevent further deterioration, protect and enhance the status of aquatic ecosystems by improving the water quality of the Canal.

- Integration of urban growth with the existing Canal system in order to create a sustainable and holistic development of the adjoining areas.
- The fencing of Canals on both sides should be done near the habitat.

Based on field monitoring, general observations, and conclusions drawn for immediate remedial measures for various drain discharges as point sources and random discharges as non-point sources, the following recommendations are proposed to safeguard and enhance the Canal water quality of the study areas:

- The status of sewerage systems can also lead to pollution when the Canal watershed areas have inadequate or improperly maintained sewerage systems, or no sewerage system. Therefore, the existing sewer system facilities must be improved to reduce the risk of sewage discharge into the Canal. Provisions should be made to capture all the sewage generated within the watershed areas. This can be achieved through effective interception of wastewater and bringing untreated sewage to the proposed sewage treatment plants. It is imperative that a comprehensive sewerage network plan, including augmentation of existing sewerage systems, be delineated so that all discharges in the catchment area can be trapped and conveyed to the new and KMC proposed, including existing sewage treatment facilities. Taking advantage of the natural slope, the sewage conveyance system should preferably be based on gravity flow, wherever possible. However, depending on the site situation, pumping of sewage to the proposed sewage treatment plants may be required at some locations.
- Encroachment of the Canal banks narrows the canal, intensifies water pollution, and causes the breakdown of the whole ecosystem of the surrounding areas. Therefore, it is necessary to monitor the Canal shoreline regularly. Disposal of garbage and solid wastes into Canals, as observed during monitoring, leads to significant depletion of dissolved oxygen and affects the biotic community in the Canals. Therefore, such waste disposal into Canals and drain discharges should be restricted. This waste must be scientifically treated and disposed of in a Municipal landfill. Additionally, public awareness about the damage to the Canals ecosystem through indiscriminate disposal of waste should be promoted through different public awareness campaigns. Development of the Canal front and plantation along the canal, public participation, and awareness works should also be implemented.

- Kochi Municipal Corporation (KMC) has proposed four decentralized sewage treatment plants (DSTPs) of 14, 18, 15, and 23 MLD capacities at Elamkulam, Vennala, Muttar, and Perandoor for treating domestic sewage being discharged into the Thevara-perandoor Canal. The four proposed DSTPs would cater to (87–90%) of the sewage generated from the Kochi Municipality area. TPC still received the sewage from the remaining four wards of Kochi. Therefore, the four wards' sewage shall be accommodated in the four KMC proposed DSTPs, depending on their locations. The plan for the DSTPs must be implemented along with the development of the sewage network system by the state authorities.
- The domestic sewage from the five different Municipalities and three different Local Bodies of the study area has been directly discharged into the four different Canals through the points and non-point sources. These discharges imperil the Canals' water quality. As pollution abatement measures, the gap between sewage generation and its proper management has to be reduced through upgrading the existing sewage treatment plants and establishing the KMC proposed four decentralized sewage treatment plants for TPC, new proposed four new decentralized sewage treatment plants for Edappally Canal, and a centralized sewage treatment plant for Patolithot and Valiyath Canals. The proposed sewage treatment scheme for the new decentralized and centralized treatment system is delineated in **Table 83**.

Table 83: Details of the proposed treatment scheme for decentralized and centralized STP for Municipalities and Local bodies

<table>
<tr><th>TPC and EC</th><th colspan="2">Proposed DSTP/CSTP</th><th>Proposed Treatment Scheme</th></tr>
<tr><td>`Municipality (M)&Local Body (LB)</td><td colspan="2"></td><td rowspan="10">➢ Sewage treatment
Receiving chamber → Course Screen → Raw sewage sump → Stilling tank → Fine screen → Grit chamber → Sequential batch reactor → Pressure sand filter → Activated carbon column → Chlorination.
➢ Sludge dewatering
Sludge thickener → Filtrer press/Centrifuge..</td></tr>
<tr><td>- Kochi (M)</td><td colspan="2">DSTP (10.50 MLD)</td></tr>
<tr><td>- Thrikkakara (M)</td><td colspan="2">DSTP (10.25 MLD)</td></tr>
<tr><td>- Kalamassery (M)</td><td colspan="2">DSTP (8.40 MLD)</td></tr>
<tr><td>- Thripunithura (M)</td><td colspan="2">DSTP (2.10 MLD</td></tr>
<tr><td>PTC and VC</td><td>Alternative-I</td><td>Alternative-II</td></tr>
<tr><td>- Karunagapally (M)</td><td>DSTP (3.35 MLD)</td><td rowspan="4">CSTP (10 MLD)</td></tr>
<tr><td>- Kulasekharapuram (LB)</td><td>DSTP (2.60 MLD)</td></tr>
<tr><td>- Thazhava (LB)</td><td>DSTP (1.60 MLD)</td></tr>
<tr><td>- Thodiyoor (LB)</td><td>DSTP (2.00MLD)</td></tr>
</table>

TPC-Thevara-Perandoor Cana;l EC-Edappally Canal; PTC-Patolithot Canal; VC-Valiyat Canal.
DSTP-Decentralized sewage treatment plant; CSTP-Centralized sewage treatment plant.

The final treated sewage from the new proposed decentralized and centralized sewage treatment plants will be discharged into the Inland Surface waters.

- The sites identified by the Kochi Municipal Corporation (KMC) for establishing the KMC proposed decentralized sewage treatment plants are delineated in **Section 15.0**. The Municipalities such as Thrikkakara, Kalamassery, Thripunithura, and Karunagapally, and Local Bodies Viz, Kulasekharapuram, Thazhava, and Thodiyoor should identify suitable sites for establishing the new proposed decentralized or centralized sewage treatment plant.
- The remedial measures for sewage control from the five Municipalities and four Local Bodies of the watershed areas could be accomplished through the interception of sewage outfalls joining the respective Canals. Presently, there is no sewerage system for collecting and transporting domestic sewage in the Municipalities and Local Bodies of the study areas, except at the Kochi Municipality for the existing STPs. A comprehensive sewerage plan must be delineated by Municipalities and Local Bodies so that all discharges in the catchment area of the respective watershed and its wards are trapped and conveyed to the new proposed decentralized or centralized sewage treatment plants for their treatment. Thus, domestic sewage from these Municipalities and Local Bodies in the study areas could be treated by establishing decentralized or centralized sewage treatment plant(s) with the proposed treatment scheme. The final treated sewage meeting the statutory norms may be discharged into the Inland Waters Surface.
- The decentralized and centralized systems for the proposed sewage treatment scheme need to be established through a reputed agency/ consultant engaged in the field of wastewater treatment, having experience in the design and execution of projects of similar capacities. In addition, it must also be ensured that after commissioning the DSTP and CSTP, the agency/consultant is entrusted with the operation and maintenance of the plants for a minimum period of 3 years. This will enable the management of the decentralized and centralized treatment facilities to provide training and experience to their plant operators for efficient operation in the future.
- The biological sludges generated by proposed decentralized and centralized treatment systems must be dewatered and dried. The dried sludge should be utilized as manure after treatment and fulfill the norms.
- An independent laboratory facility for physicochemical analysis should be set up. It should be separately established under plant authorities and have space for the following purposes:

- Space for carrying out regular analysis.
- Should be equipped with instrumentation, including computer facilities for database management.
- Space for scientific/managerial and administrative staff.

- Performance evaluation of various unit operations and processes of the proposed decentralized and centralized STP must be carried out regularly through routine sampling and monitoring of the critical parameters. A three-monthly evaluation report must be prepared considering the flow, analytical data, troubleshooting problems, and remedial measures adopted. In addition, a National Level Institute must be engaged to carry out detailed performance evaluations of the sewage treatment plants and water quality analysis of the Canals on a regular basis. This enables the assessment of the treatment plant performance for improved and sustained functioning of all the unit operations and processes, which will safeguard the water quality of the Canals.
- Samples should be collected at regular intervals, depending on the flow variation, and flow composited for characterization. Sample collection and preservation methods should be as per IS: 2488 (1966, 68, 74). "Standard Methods for Examination of Water and Wastewater, prepared and published jointly by American Public Health Association (APHA), American Water Works Association (AWWA), and Water Pollution Control Federation (WPCF), and also Manual on Water and Wastewater Analysis, published by NEERI, Nagpur, must be referred to as a guide for analysis of various parameters.

The potential benefits arising from implementing these pollution control measures shall result in restoring the Canal water quality. This will not only improve the Canal water quality, but also result in intangible benefits in terms of,

- Improvement in the odour nuisance suffered by local residents arising from domestic sewage flowing through the Canal.
- Cessation of surface and groundwater pollution.
- Improving the aesthetic value of the Canal/ region.

Plate 1: Periyar River (PR-01) located at 10 m upstream of the confluence of the Edappally Canal and Pariyar River and 50 m from the starting point of EC-01 of the Edappally Canal. (Lat.: 10° 2'36.71" and Long.: 76°18'11.51")

Plate 2: Edappally Canal (EC-01) located at 30 m downstream of the confluence of the Periyar River and Edappally Canal (Lat.: 10° 2'36.01" and Long.: 76°18'12.08")

Plate 3: Drain of Edappally Canal (DoEC-01) located at 7.60 m downstream of the EC-01 and 36.0 m downstream of the confluence of the Periyar River and Edappally Canal. (Lat.: 10° 2'35.86" and Long.: 76°18'12.26")

Plate 4: Edappally Canal (EC-01A) located at 0.18 km downstream of the EC-01 and 0.19 km downstream of the confluence of the Periyar River and Edappally Canal (Lat.:10° 2'32.32"and Long.:76°18'9.16")

Plate 5: Drain of Edappally Canal (DoEC-01A) located at 40 m downstream of the EC-01A and 0.23 km downstream of the confluence of the Periyar River and Edappally Canal (Lat.: 10° 2'30.60"and Long.: 76°18'16.10")

Plate 6: Edappally Canal (EC-02) located at 2.0 km downstream of the EC-01A and 40 m upstream of the bridge near Lulu Mall. (Lat.:10°1'36" and Long.:76°18'26")

Plate 7: Drain of Edappally Canal (DoEC-01A) located at 0.41 km downstream of the EC-02 and 2.61 km downstream of the confluence of the Periyar River and Edappally Canal (Lat.: 10°1'29.41"and Long.: 76°18'37.41")

Plate 8: Edappally Canal (EC-02A) located at 0.13 km downstream of the DoEC-02A and 2.74 km downstream of the confluence of the Periyar River and Edappally Canal(Lat.: 10° 1 '23.49"and Long.: 76°18'37.86")

Plate 9: Edappally Canal (EC-03) located at 0.36 km downstream of the EC-02A and 3.12 km downstream of the confluence of the Periyar River and Edappally Canal. (Lat.: 10° 1'11.97"and Long.: 76°18'40.48")

Plate 10: Edappally Canal (EC-04) located at 1.90 km downstream of the EC-03 and 4.02 km downstream of the confluence of the Periyar River and Edappally Canal (Lat.: 10° 0'38.64"and Long.: 76°19'11.19")

Plate 11: Drain of Edappally Canal (DoEC-04A) located at 1.36 km downstream of the EC-04 and 5.38 km downstream of the confluence of the Periyar River and Edappally Canal (Lat.: 10° 0' 17 .11"and Long.:76°19'33.06")

Plate 12: Drain of Edappally Canal (DoEC-04B) located at 1.41 km downstream of the EC-04 and 5.84 km downstream of the confluence of the Periyar River and Edappally Canal (Lat.: 10° 0'22.25"and Long 76°19'34.74")

Plate 13: Drain of Edappally Canal (DoEC-04C) located at 1.65 km downstream of the EC-04 and 6.46 km downstream of the confluence of the Periyar River and Edappally Canal (Lat.: 10° 0'12.20" and Long 76°19'46.46")

Plate 14: Edappally Canal (EC-05) located at 2.12 km downstream of the EC-04 and 6.77 km downstream of the confluence of the Periyar River and Edappally Canal. (Lat.: 9°59'58.66"and Long 76°19'50.17")



Plate 15: Drain of Edappally Canal (DoEC-05A) located at 1.35 km downstream of the EC-05 and 8.12 km downstream of the confluence of the Periyar River and Edappally Canal. (Lat.: 9°59'21.34"and Long 76°20'10.91")



Plate 16: Edappally Canal (EC-06) located at 2.38 km downstream of EC-05 and 0.1km upstream of the Chambakkara Canal. (Lat.: 9°58'51"and Long 76°20'14")

Plate 17: Chambakara Canal (CHR-01) located at 0.38 km eastern side of the EC-06 (Lat.: 9°58'50.51"and Long.: 6°20'22.68")



Plate 18: Thevara-Perandoor Canal (TPC-01) located at 0.1 km downstream of the interconnection of the Thevara Canal near the Thevara Railway line (Lat.: 9°56'46" and Long.: 76°18'1")



Plate 19: Drain of Thevara-Perandoor Canal (DoTPC-02) located at 0.81 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 0.71 km from TPC-01 (Lat.: 9°57'9.71" and Long.: 6°17'56.96")



Plate 20: Thevara-Perandoor Canal (TPC-02) located at 0.91 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 0.1 km upstream of DoTPC-02 (Lat.: 9°57'12.21" and Long.: 6°17'57.62")



Plate 21: Drain of Thevara-Perandoor Canal (DoTPC-03) located at 1.86 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 15 m upstream of TPC-02 (Lat.: 9°57'44.38" and Long.: 6°17'53.39")

Plate 22: Thevara-Perandoor Canal (TPC-03) located at 1.86 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 15 m upstream of TPC-02 (Lat.: 9°57'44.38" and Long.: 6°17'53.39")



Plate 23: Thevara-Perandoor Canal (TPC-04) located at 3.06 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 1.14km upstream of TPC-03 (Lat.: 9°58’11” and Long.: 76°17’41”)



Plate 24: Drain of Thevara-Perandoor Canal (DoTPC-04) located at 3.078 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 15.8 m upstream of TPC-04 (Lat.: 9°58'11.42" and Long.: 6°17'41.69")



Plate 25 : Thevara-Perandoor Canal (TPC-05) located at 4.87 8km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 1.80 km upstream of D0TPC-04 (Lat.: 9°58'58.67" and Long.: 76°17'28.35")



Plate 26: Thevara-Perandoor Canal (TPC-06) located at 6.278 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 1.40 km upstream of TPC-05 (Lat.: 9°59'43" and Long.: 76°17'24")



Plate 27 : Thevara-Perandoor Canal (TPC-07) located at 7.02 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 1.43 km upstream of TPC-06 (Lat.: 10°0'16.15" and Long.: 6°17'14.23")



Plate 28: Drain of Thevara-Perandoor Canal (DoTPC-07) located at 7.721 km upstream of the interconnection of the Thevara Canal near the Thevara Railway line and 12.5 m upstream of TPC-07. (Lat.: 10° 0'16.53" and Long.: 76°17'14.19")



Plate 29: Thevara-Perandoor Canal (TPC-08) located at 9.83 km downstream of the interconnection of the Thevara Canal near the Thevara Railway line and 2.11 km upstream of DoTPC-07 (Lat.: 10° 1'12.22"and Long.: 6°16'55.86")



Plate 30: Drain of Thevara-Perandoor Canal (DoTPC-08) located at 9.93 km downstream of the interconnection of the Thevara Canal near the Thevara Railway line and 60m upstream of TPC-08.(Perandoor Bridge Road, Kochi) (Lat.: 10° 1'12.65"and Long.: 76°16'57.69")



Plate31: Pallikalar River (PKR-01) Located at 0.5 km downstream of PTC-01 (Lat.: 9° 3'4.28" and Long76°32'45.02")



Plate 32: Patolithot Canal (PTC-01) located at 0.1 km upstream of the Pallikalar River (Lat.: 9° 3'20.01"and Long 76°32'38.72")

Plate 33: Drain of Patolithot Canal (DoPTC-01) located at 0.25 km upstream of the PTC-01 (Lat.:9° 3'22.45" and Long: 76°32'43.12")

Plate 34: Patolithot Canal (PTC-02) Located at 0.9 km upstream of the Pallikalar River (Lat: 9° 3'41.48" and Long 76°32'36.39")

Plate 35: Patolithot Canal (PTC-03) located at 1.7 km upstream of the Pallikalar River (Lat: 9° 4'8.31"and Long 76°32'26.05")

Plate 36: Patolithot Canal (PTC-04) located at 2.9 km upstream of the Pallikalar River (Lat: 9° 4'42.39and Long 76°32'11.10")



Plate 37: Patolithot Canal (PTC-05) located at 3.4 km upstream of the Pallikalar River (Lat: 9° 4'55.62" and Long 76°32'6.25")



Plate 38: Patolithot Canal (PTC-06) located at 3.75 km upstream of the Pallikalar River (Lat: 9° 5'5.22"and Long 76°32'5.40")

Plate 39: Patolithot Canal (PTC-07) located at 5.17 km upstream of the Pallikalar River (Lat: 9° 5'49.22" and Long 76°32'5.29")

Plate 40: Patolithot Canal (PTC-08) located at 6.07 km upstream of the Pallikalar River (Lat: 9° 6'12.41"and Long 76°32'16.62")

Plate 41: Drain Patolithot Canal (DoPTC-09) Located at 6.135 km upstream of the Pallikalar River (Lat: 9° 6'14.63"and Long: 6°32'16.55")

Plate 42: Patolithot Canal (PTC-09) located at 6.15 km upstream of the Pallikalar River (Lat: 9° 6'14.63"and Long: 76°32'16.55"

Plate 43: Patolithot Canal (PTC-10) located at 7.30 km upstream of the Pallikalar River. (Lat: 9° 6'49.10"and Long: 76°32'17.20")

Plate 44: Valiyath Canal (VC-01) located at 0.1 km upstream of the Pallikalar River (Lat: 9° 3'25.04"and Long: 76°32'30.56")

Plate 45: Valiyath Canal (VC-02) located at 0.75 km upstream of the Pallikalar River (Lat: 9° 3'38.09"and Long: 76°32'23.61")

Plate 46: Drain of Valiyath Canal (DoVC-02) located at 0.85 km upstream of the Pallikalar River (Lat: 9° 3'39.57" and Long: 6°32'23.62")

Plate 47: Valiyath Canal (VC-03) located at 1.10 km upstream of the Pallikalar River (Lat: 9° 3'46.10"and Long: 76°32'17.59")

Plate 48: Valiyath Canal (VC-04) located at 1.30 km upstream of the Pallikalar River (Lat: 9° 3'51.00" and Long: 76°32'19.00")

Plate 49: Valiyath Canal (VC-05) located at 1.80 km upstream of the Pallikalar River (Lat: 9° 4'8.17" and Long: 76°32'14.20")



Plate 50: Valiyath Canal (VC-06) located at 3.0 km upstream of the Pallikalar River (Lat: 9° 4'38.76" and Long: 76°32'2.30")



Plate 51: Valiyath Canal (VC-07) located at 3.5 km upstream of the Pallikalar River (Lat: 9° 4'52.67" and Long: 76°31'55.76")

Plate 52: Valiyath Canal (VC-08) located at 4.6 km upstream of the Pallikalar River (Lat: 9° 5'24.78"and Long: 76°31'43.70")

Plate 53: Valiyath Canal (VC-09) located at 5.88 km upstream of the Pallikalar River (Lat 9° 6'0.98"and Long: 76°31'26.53")